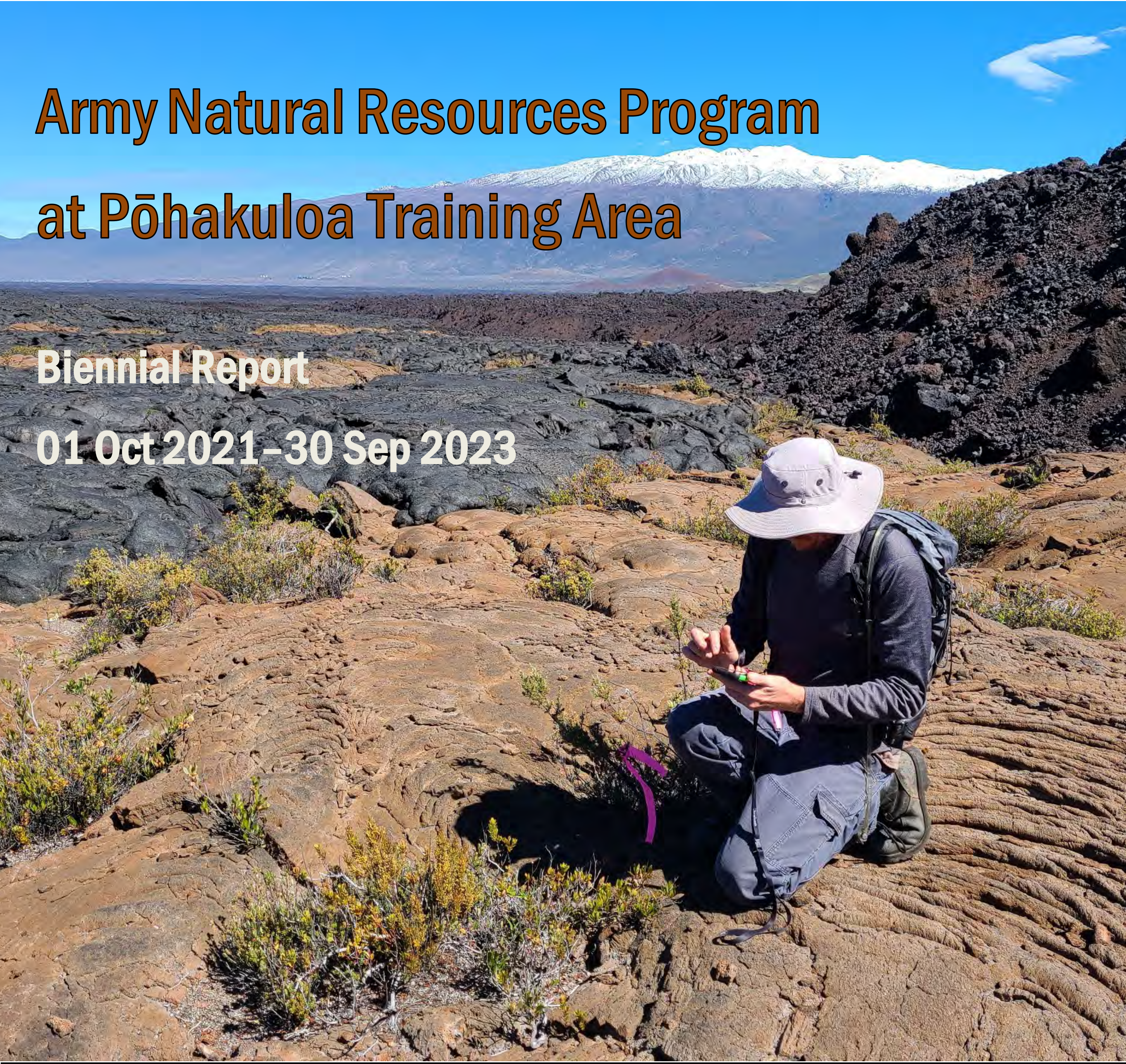
Army Natural Resources Program at Pōhakuloa Training Area

Biennial Report

01 Oct 2021–30 Sep 2023



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Center for Environmental Management of Military Lands

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Prepared for

US Army Garrison, Pōhakuloa Training Area

June 2024

Center for Environmental Management

MILITARY LANDS

COLORADO STATE UNIVERSITY

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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LIST OF ACRONYMS

ASR	Area of Species Recovery
BAAF	Bradshaw Army Airfield
BAX	Battle Area Complex
BO	Biological Opinion
BSTP	Band-rumped Storm Petrel
CEMML	Center for Environmental Management of Military Lands
CI	Confidence Interval
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
EDP	Ecological Data Program
EIS	Environmental Impact Statement
ESA	Endangered Species Act
ESTCP	Environmental Security Technology Certification Program
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
HA	Hectare
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
LZ	Landing Zone
LFA	Little Fire Ant
M	Meter
KM	Kilometer
MATS	Management Actions Tracking System
MBTA	Migratory Bird Treaty Act

MOA	Memorandum of Agreement
MFR	Memorandum for Record
NEPA	National Environmental Policy Act
NVCS	National Vegetation Classification System
OANRP	Oʻahu Army Natural Resources Program
OP	Outplanting Site
PSMS	Plant Survey and Monitoring Section
PTA	Pōhakuloa Training Area
QA	Quality Assurance
QC	Quality Control
REC	Record of Environmental Consideration
REPI	Readiness and Environmental Integration Program
ROD	Rapid ʻŌhiʻa Death
RPPF	Rare Plant Propagation Facility
SAR	Species at Risk
SDSFIE	Spatial Data Standards for Facilities, Infrastructure, and Environment
SERDP	Strategic Environmental Research Development Program
SOO	Statement of Objectives
SOP	Standard Operating Procedure
T	Threatened
TE	Threatened/Endangered
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 Center for Environmental Management of Military Lands (CEMML) and for US Army Garrison, Pōhakuloa Training Area (Army) to support natural resources management at Pōhakuloa Training Area (PTA). It documents CEMML's accomplishments toward Statement of Objectives (SOO) tasks and fulfills the deliverable requirement of Cooperative Agreement W9126G-21-2-0027 to provide a biennial report (see Section 1.2.4). The report also documents the natural resources management activities undertaken to comply with the installation's Integrated Natural Resources Management Plan (INRMP) and regulatory requirements under the Endangered Species Act (ESA), National Environmental Policy Act (NEPA), and Migratory Bird Treaty Act (MBTA).

The report is organized into 3 areas: (1) compliance for regulatory mandates and reporting requirements, (2) technical assistance for military initiatives, and (3) assessments after disturbance events. The first section summarizes achievements by the CEMML Botanical, Invasive Plants, Wildlife, Game Management, and Ecological Data programs to support the Army's Natural Resources Program's regulatory requirements and to achieve the installation's INRMP and Integrated Wildland Fire Management Plan (IWFMP) goals. 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.

CEMML produces a comprehensive biennial report every 2 years. The report includes an appendix with technical information that satisfies annual regulatory reporting requirements for the most recently completed fiscal year. In interim years, a basic standalone technical report is produced for annual regulatory reporting requirements. Annual reporting requirements for FY 2023 (01 October 2020 through 30 September 2023) are contained in Appendix A of this report.

<u>Area 1: Compliance with Regulatory Mandates and Reporting Requirements</u>

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, Vigna o-wahuensis*, and *Zanthoxylum hawaiiense.* We also manage *Tetramolopium stemmermanniae* (formerly referred to as *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, plant species monitoring, and vegetation community 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.

Information derived from plant surveys met INRMP objectives and compliance requirements and provided accurate information on the distribution of ESA-listed plant species. To monitor Tier 1 species, we implemented the new individual-bases monitoring protocol for Tier 1 species. We collected count data from which we can accurately track population patterns and status. In addition, we completed and implemented a second, location-based monitoring protocol for the Tier 2 species based on a random sampling approach. The aim is to survey a random sample of each Tier 2 species population to estimate abundance. Another objective is to survey the entire known distribution of each Tier 2 species at PTA over a 3-year period, thus also refreshing species distribution data.

In 2023, we redefined and mapped the populations of the threatened and endangered plants at PTA per the Hawaiʻi and Pacific Plant Recovery Committee's working definition of a population. We used GIS to group conspecifics greater than 1,000 m apart for each federally listed species at PTA, including wild, outplanted, and mixed groupings. We assigned population identifiers to the grouping and the resultant population maps are presented in Sections 2.5 and 2.6.

We initiated a restoration project at Puʻu Nohona O Hae in the Keʻāmuku Maneuver Area. We controlled vegetation in a 1 hectare (ha) site centered on the endangered plant species *V. o-wahuensis*. After 1 year, vegetation monitoring results confirmed that we met objectives for the vegetation control, but recovery of native shrubs and *V. o-wahuensis* was not apparent in the data. However, native shrubs were visibly larger and healthier 1 year after vegetation control. We plan to monitor *V. o-wahuensis* more frequently next year to better understand life history characteristics of this species, specifically the transitions between age classes.

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, 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 and/or by planting common native species to improve habitat at natural populations of ESA-listed plants or outplanting sites.

We implemented individual-based monitoring for all Tier 1 legacy outplants and all plants outplanted, regardless of tier designation, planted in 2023. We made substantial improvements to past recordkeeping systems and naming conventions to ensure accurate, reliable information is available for inventories and monitoring. We also made significant progress toward overhauling our database, conducting an inventory of species and founders in the ex-situ propagule bank, and streamlining the accounting process to accurately track seeds from collection and storage to propagation and outplanting. We expect the database to be operational in 2024.

We partnered with the US Army Garrison, Hawaiʻi Oʻahu Army Natural Resources Program to test the stored seed viability for 6 endangered plant species. At PTA, we propagated seeds of 2 endangered species and propagated cuttings from 2 additional endangered species. We also propagated seeds from several native species to use at the Puʻu Nohona O Hae restoration site.

In FY 2024, we plan to conduct germination trials on fresh wild-collected seed to determine if temperature scarification influences seed germination in *Haplostachys haplostachya*.

We are in the process of closing out the outplanting projects at Puʻu Waʻawaʻa and Puʻu Huluhulu. To minimize the future management burden to our state partners, we are allowing the sites to return to a composition similar to that of the surrounding plant communities. We submitted reports detailing the planting history and remaining plants for Puʻu Waʻawaʻa and Puʻu Huluhulu and will meet with our state partners on-site in FY 2024 to discuss an acceptable exit strategy.

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 Vegetation Control and IPSM Sections 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 Vegetation Control Section include maintenance of Area of Species Recovery (ASR) weed control buffers (WCBs) and Hawaiian Goose habitat management at Hakalau Forest National Wildlife Refuge (HFNWR). Projects in the IPSM Section include roadside surveys; monitoring and control; site-specific survey and control; and Rapid ʻŌhiʻa Death survey, monitoring, and sampling.

During the reporting period, we made satisfactory progress toward achieving program goals. All ASRs on the current schedule are up to date and meet threshold standards for weed management. We implemented vegetation control in 1 ha at Puʻu Nohona O Hae *V. o-wahuensis*. Our vegetation control actions at HFNWR also appear to be benefitting Hawaiian Geese by providing preferred habitat.

We continue to reduce invasive plant species abundance and distribution in most, if not all, site-specific survey grids. Monitoring data shows that control effort must be consistent over time for effective control. We drafted a preliminary technical report detailing the status, locations, habitat, and phenology of each secondary target weed species at PTA and expect the final report in 2024. In FY 2024, we also 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.

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

During the reporting period, all fuel beaks received maintenance to ensure compliance with standards per the PTA Integrated Wildland Fire Management Plan. In 2022, the Leilani wildland fire occurred at PTA. Although our fuels management efforts did not prevent the fire exiting the installation adjacent to State Land, our actions contributed to a positive outcome for ESA-listed plants located in Training Area 22.

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 hoary bat (*Lasiurus cinereus semotus*), Band-rumped Storm Petrel (*Hydrobates castro)*, Hawaiian Petrel (*Pterodroma sandwichensis*), anthricinan yellow-faced bee (*Hylaeus anthracinus*), and Blackburn's sphinx moth (*Manduca blackburni*). Since 2006, 12 additional bird species protected under the MBTA have been observed at PTA (USAG-PTA 2020).

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 wildlife impacts 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 management, seabird management, avian monitoring, anthricinan yellow-faced bee management, and Blackburn's sphinx moth management. 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.

At PTA, the frequency of reported Hawaiian Goose sightings remains low but consistent. A pair nested near Bradshaw Army Airfield (BAAF) in 2023 and successfully hatched 3 goslings. In partnership with the State of Hawaiʻi, Department of Fish and Wildlife staff, we successfully translocated the family from BAAF to State lands.

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 14 geese during the reporting period.

Acoustic occupancy and activity analyses showed that Hawaiian hoary bats are present across the installation throughout the year and that activity peaks during the autumn months. Work continued to finalize a technical report to summarize trends in activity and occupancy at PTA. In FY 2024 or FY 2025, we plan to re-evaluate the monitoring objectives and update the monitoring protocol.

We continue to improve our monitoring of Band-rumped Storm Petrel (BSTP) burrows and hope to increase detections of adults and chicks by adding cameras and adjusting camera settings. Our year-round trapping for predators in the BSTP colony has increased captures of feral cats throughout the year and contributed to low levels of black rat activity within rodent treatment sites. We continue to improve our knowledge about the Band-rumped Storm Petrel and patterns of colony attendance and breeding activity and success.

We monitor a wide range of bird species annually to gain information on abundance, population trends, and species composition through time. We drafted a manuscript for publication analyzing the bird monitoring dataset from 1998 through 2021. Next report period, we plan to complete a technical report and use the pending data and trend analysis to develop management plans for target species per INRMP objectives and in accordance with the Department of Defense (DoD) Natural Resource Program's *Strategic Plan for Bird Conservation and Management on Department of Defense Lands*.

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, invertebrate management, 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 year-round at the Band-rumped Storm Petrel breeding colony, maintaining an ungulate-free status in all the ungulate exclusion fence units (except Puʻu Koli; see below for discussion), and controlling invasive ants, particularly the early detection and successful control of little fire ants on the cantonment.

In November 2022, Mauna Loa erupted, and lava flows breached the Puʻu Koli fence unit in 2 locations. Ungulates have been slow to enter the fence via the breaches and only 2 ingress events were reported in 2023. We assume latent heat in the lava is deterring sheep from entering the open fence. We are working with the Army to repair the fence, but until the breaches are repaired, we cannot effectively maintain this fence unit ungulate-free.

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 attempted to maximize access for public hunters. Despite these efforts, ungulate density increased on all hunting units. Habitats within the Humuʻula unit (Training Areas 1, 3, and 4) and Ahi unit (Training Areas 9, 12, 13, 14, 15, and 16) visually degraded between 2019 and 2023 as game animal densities increased. Moreover, most hunts over the report period occurred in the Keʻāmuku Maneuver Area (KMA), where habitat impacts from animals are minimal, while few hunts occurred in the Humuʻula and Ahi units, where control is greatly needed.

We continue to explore methods to accurately estimate game bird populations. We also successfully captured 12 Erckel's Spur Fowl, 6 in the KMA and 6 in the Humuʻula units. We fitted each bird with a GPS telemetry device that communicated its position via a cellular network to a centralized database. Preliminary home range estimates are provided, but additional data analysis will be completed during the next reporting cycle.

Ecological Data Program

The Ecological Data Program (EDP) provides support to technical programs for 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 performs the following specific functions:

(1) Develop and maintain ESA-listed and rare plant and animal management actions databases for monitoring, collecting, evaluating, and disseminating ecological data.
(2) Develop algorithms to support queries for planning, monitoring, and reporting purposes.
(3) Maintain all spatial data related to natural resources management activities in geodatabase format.
(4) Prepare graphics and maps that support natural resources management and overall program activities.
(5) Investigate, develop, and implement systems for efficient data collection and analysis for effective operational and resources planning.

The EDP provides a variety of specialized support functions to technical programs, ranging from guidance on project strategy and development to the creation of mobile applications and operational databases to efficiently collect data in the field. These functions also include analysis and technical writing support to meet project objectives. EDP uncovered a data calculation error in the process used to estimate the abundance of 6 Tier 2 species. This error led to overestimation for 5 species and underestimation for 1 species. We have since corrected the process and provide details about the error and its consequences to the abundance estimates for the species in Section 2.2.3 and Appendix B.

The EDP provides high-end cartographic/GIS/spatial analysis support for all natural-resource-related elements of the Army mission at PTA. We provide map and graphics support for reports, regulatory consultations, wildland fire events and assessments, and other Army-initiated data calls. All projects described in this report requiring the use of spatially explicit data products (graphics, maps, spatial analysis) have been supported with assistance and expertise from the EDP. Spatial data are managed with the goal of easily sharing and collaborating with Army and conservation partners (e.g., using appropriate metadata and data transfer protocols). One major initiative recently reinvigorated toward this end is ensuring compliance with federal metadata (SDSFIE) standards. Formatting our data this way is beneficial to the Army and to CEMML as it eliminates the need to compile data each time we receive a request.

We have also taken steps to transition to ArcGIS Enterprise as our primary system of GIS data management and dissemination. To date, we have configured our network systems to support the function of this server-based platform and have tested it by housing versions of our Botanical Program survey and monitoring data collection systems. Moving forward, we will assess the best ways to convert fully to Enterprise. Future work will include curating and transitioning existing data and refining processes and systems to ensure maximum utility of the spatial data we collect and manage.

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 aid 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) INRMP
(2) ESA and NEPA Projects
(3) Permits
(4) Conservation Reimbursable Programs
(5) Collaborations with Partner Agencies
(6) DoD Grant Program Support (SERDP, ESTCP, REPI)
(7) External Research Support
(8) Specialized Services
(9) Direct Assistance to Army Biologist and the PTA Command
(10) Public Outreach
(11) Meetings, Publications and Presentations

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 Integrated

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.

Refer to Section 8.0 (Area 3) of this biennial report for a summary of each disturbance event. During the reporting period, we provided assessments for the following events

(1) Mauna Loa Eruption, Section 8.1
(2) Training Area 21 Fire, Section 8.2
(3) Leilani Brush Fire, Section 8.3
(4) Keʻāmuku Complex Fire, Section 8.4

Conclusion

Ecosystems at PTA are highly complex and the challenges to manage natural resources are multi-faceted. Through our support work to the Natural Resources Program at PTA, we help fulfill 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.

The management of game mammals, primarily sheep, continues to be problematic within designated public hunting units and unfenced areas of PTA. Over the reporting period, sheep densities have increased and habitat conditions have declined, despite efforts to maximize public hunting opportunities. The degraded vegetation impacts the military mission by removing/changing vegetative cover, thus facilitating wind erosion and loss of topsoil and creating dusty conditions that affect troops and equipment. This also has wide-ranging ecological effects on native Hawaiian plants and animals. We recommend adopting a multi-pronged approach to reducing ungulate densities including (1) increasing public hunting, (2) trapping and relocating sheep into accessible hunting areas on and off PTA, (3) adding more fencing on PTA borders to prevent ingress from adjacent lands, (4) driving sheep from areas closed to hunting into accessible hunting areas, and (5) evaluating and potentially implementing professional wildlife control tactics. We recommend maintaining permits that allow the Army to increase take limits for game and to continue to implement ewe-only hunts.

Implementing effective natural resources programs benefits the Army by improving the resiliency of the natural environment for training and other uses, thereby helping ensure an enduring land base to maintain training capacity. For effective natural resources management within 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.

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 Center for Environmental Management of Military Lands (CEMML) and the US Army Garrison, Pōhakuloa Training Area (Army) to support natural resources management at Pōhakuloa Training Area (PTA). It documents CEMML accomplishments toward Statement of Objectives (SOO) tasks and fulfills the deliverable requirement of Cooperative Agreements W9126G-16-2-0014 and W9126G-21-2-0027 to provide a biennial report (see Section 1.2.4). The report also documents natural resource management activities undertaken for 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 to explain the 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 also details the Army's Natural Resources Program accomplishments and regulatory compliance activities at PTA for Army leadership and its regulators. This report covers the 2-year period of FY 2022–FY 2023 (01 October 2021 through 30 September 2023).

Report purposes include:

- Documenting program progress, accomplishments, and compliance with regulatory obligations during the reporting period.
- Summarizing and reflecting on program operation, direction, and data.
- Synthesizing information about work done and relating the actions 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.
- Disseminating 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 standalone document and delivered separately (CEMML 2023c). Annual reporting requirements for FY 2023 (01 October 2022 through 30 September 2023) are contained in Appendix A of this report.

1.2 PTA Natural Resources Program Background

1.2.1 Integrated Natural Resources Planning and Natural Resources Program Authorities

Per the Sikes Act Improvement Act (1997), Department of Defense (DoD) installations with significant natural resources must prepare and implement an Integrated Natural Resources Management Plan (INRMP). The INRMP is a mutual agreement between the DoD, USFWS, and Association of Fish and Wildlife Agencies to conserve, protect, and manage installation natural resources. The Hawaiʻi State Department of Land and Natural Resources, Division of Forestry and Wildlife (DOFAW), partners with the Army and USFWS for the PTA INRMP.

The PTA INRMP (USAG-PTA 2020) is the foundational document of the Army's Natural Resources Program at PTA and sets objectives for managing natural resources, including ESA-listed species. The plan also identifies objectives to manage the ecosystem at the landscape scale to protect habitats that are home to 26 ESA-listed threatened and endangered species (TES). The US Fish and Wildlife Service (USFWS) considers invasive species and their impacts to be major threats to ESA-listed species 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] and, in a proposed rule in 2023, excluded lands at PTA from critical habitat designation for *Schiedea hawaiiensis* (see Section 7.2.2).

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

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

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.

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 (DoD) 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.

For detail about technical support provided to the Army to maintain and update the INRMP and to assist with annual partnership meetings, see Section 7.1.

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 (USFWS 2003a). In 2008, the Army reinitiated formal consultation to address emergent issues and a subsequent BO was issued (USFWS 2008). 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 (USFWS 2013a). 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.

<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 arenarium*, *Vigna o-wahuensis*, *Zanthoxylum hawaiiense*); 1 ESA-listed mammalian species, the Hawaiian hoary bat (*Aeorestes semotus*[2]); and

[2] The USFWS published a name change for the Hawaiian hoary bat from *Lasiurus cinereus semotus* to *Aeorestes semotus* (Fed Reg, February 2, 2023 Vol 88, No. 22, pages 7134 to 7176).

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).

<u>2008 BO</u>

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 covered in the 2008 BO (*Asplenium peruvianum* var. *insulare*, *Silene hawaiiensis*, *Solanum incompletum,* Hawaiian Goose, or Hawaiian hoary bat). 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).

<u>2013 BO</u>

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 of 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 that 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).

The final component to the 2013 document was an informal consultation that evaluated potential impact from the construction and operation of the IPBA to the Hawaiian Petrel and the Hawaiian hoary bat. The Army developed avoidance and minimization measures and the USFWS concurred that with implementation of these measures, the Army's actions were not likely to adversely affect these species.

1.2.3 Upcoming Sec-7 Consultation

The 2003, 2008, and 2013 BOs established conservation measures for 15 species of ESA-listed plants (*A. peruvianum* var. *insulare*, *H. haplostachya*, *I. hosakae*, *K. coriacea*, *L. venosa*, *N. ovata*, *P. sclerocarpa*, *Silene hawaiiensis*[3], *S. lanceolata*, *S. incompletum*, *Spermolepis hawaiiensis*, *S. angustifolia*, *T. arenarium*, *V. o-wahuensis*, and *Z. hawaiiense*) and 3 species of ESA-listed animals at PTA: Hawaiian hoary bat, Hawaiian Goose, and Hawaiian Petrel.

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 (*Hydrobates castro*[4]), and Anthricinan yellow-faced bee (*Hylaeus anthracinus*). Additionally, in July 2019, the endangered Blackburn's sphinx moth (*Manduca blackburni*) 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.

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[3] To avoid confusion, we do not abbreviate the name of the following plant species *Silene hawaiiensis, Schiedea hawaiiensis*, and *Spermolepis hawaiiensis.*

[4] The USFWS published a name change for the Band-rumped Storm Petrel *Oceanodroma castro* to *Hydrobates castro* (Fed Reg, February 2, 2023 Vol 88, No. 22, pages 7134 to 7176).

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 6 animal species). We anticipate the issuance of a BO from the USFWS in FY 2025[5].

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. CEMML Cooperative Agreements typically consist of a base year and 4 option years. The current Cooperative Agreement with CEMML was awarded in August 2021 (W9126G-21-2-0027). The SOO for the Cooperative Agreement includes tasks for coordination and natural resources management activities at PTA. In each section of this report, we identify SOO tasks from Cooperative Agreement W9126G-21-2-0027.

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 Wildlife Program. CEMML currently manages natural resources at PTA in 5 major program areas: Botanical, Invasive Plants, Wildlife, Game Management, and Ecological Data. Approximately 30 CEMML employees work within the Natural Resources Program at PTA.

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

(2) The Invasive Plants Program 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).

[5] The text reflects the status of the PBA during the report period (01 October 2021 through 30 September 2023). Since, the Army has worked to develop additional wildland fire planning and preparedness documents to support the PBA preparation process and the fire model used for the effects analysis was updated with data from wildland fires that occurred in 2021 and 2022.

(3) The Wildlife Program manages 6 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 are required by the 2003 and 2008 BOs.

(4) The Game Management Program 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 public 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 Ecological Data Program 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 effective 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 include planning, implementing, and managing on-site human resources, fiscal actions, facilities, and fleet vehicle maintenance and repair are coordinated by the operations officer who is currently supervised by the Wildlife Program Manager. 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 details for project implementation 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-PTA 2020). 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 at PTA have been discussing strategies to modify CEMML's organizational structure at PTA to address project planning needs more effectively. 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. 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 of 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 hectare (ha) (CEMML 2019b). Follow-up research by Litton et al. (2018) found that fence construction followed by ungulate removal correlated to an increase in TES and mostly insignificant changes to non-native plant distributions. We consistently manage fuels in accordance with standards in the PTA IWFMP (USAG-PTA 2021) in a system of fuel breaks, fire breaks, and fuels monitoring corridors. Additionally, we manage invasive plants, some of which are fine fuels, in weed-control buffers totaling about 88.4 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 wildfire events in 2012, 2018, 2021, and 2022 (CEMML 2014, CEMML 2018, CEMML 2019b, CEMML 2021a, CEMML 2021b, CEMML 2021c, CEMML 2022b).

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 provides 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 most 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. Most 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 Hawaiʻi, which expires on 16 August 2029. Additionally, the Army purchased the 9,340-ha Keʻāmuku Maneuver Area (KMA) from Parker Ranch in 2006. Included with this purchase were 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 Hawaiʻi (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 Reserve, 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.

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. Most of KMA is former pastureland, covered almost entirely with non-native vegetation. Cinder cones are a noticeable topographic feature.

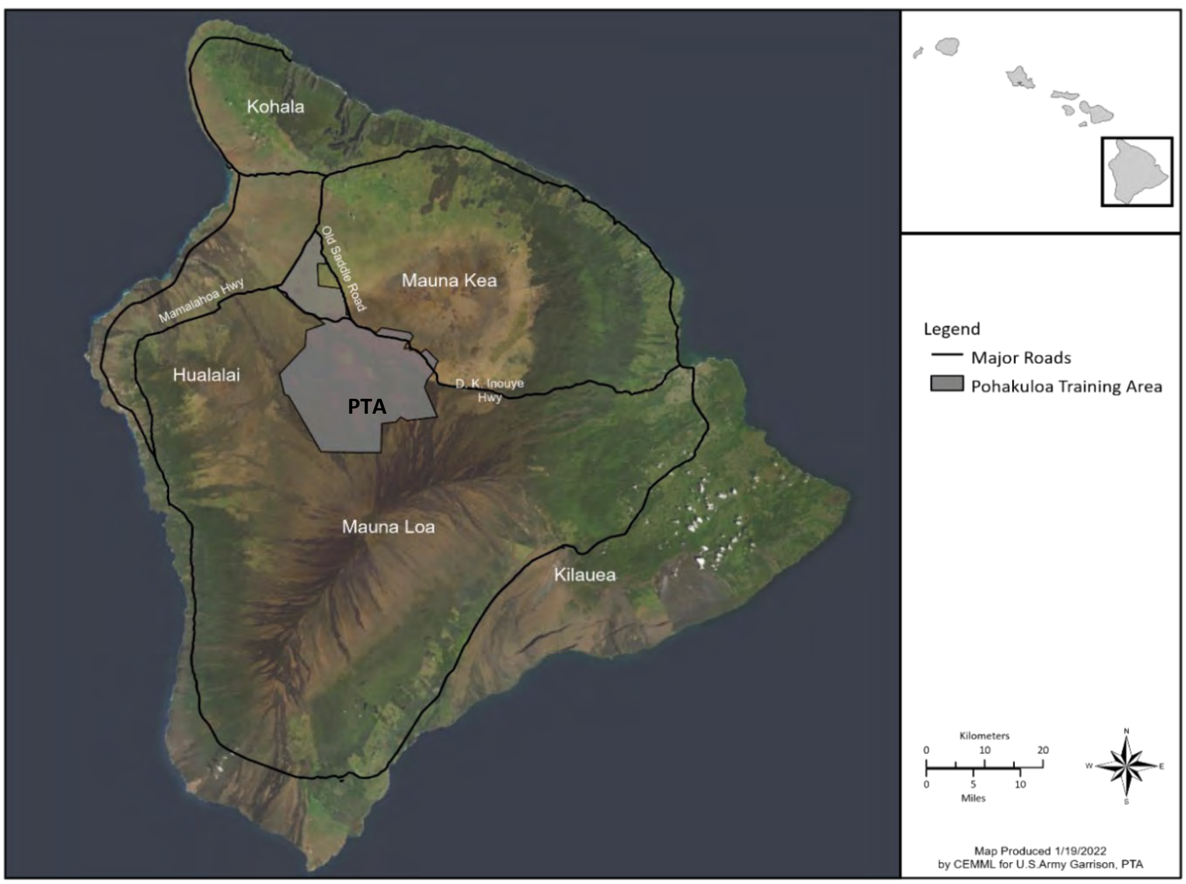


Figure 1. Location of Pōhakuloa Training Area on Hawaiʻi Island.

No surface streams, lakes, or other bodies of water occur 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 the 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 DoD 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, especially more extreme drought and associated wildland fires, are considered during INRMP development. The INRMP identifies several ongoing conservation actions that help retain ecosystem resiliency as climate conditions change such as the following (USAG-PTA 2020):

- 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 of 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. Over the past 2 years, we have developed information to update the INRMP in 2024 with additional climate change considerations including the following:

- 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

- 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

- Utilizing published and in-house vulnerability assessments and climate adaptation plans for the at-risk, threatened, and endangered species at PTA

- 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

1.4.5 Native Hawaiian Species Inventories

We maintain native species inventories to better understand the plant and animal communities at PTA. For plants, we complied a master list of plant species found during biological inventories at PTA since 1977. This master list represents all species ever documented at PTA. Some plant species were mis-identified during these inventories, and we correct mistakes as information was available (e.g., *Lipochaeta subcordata* was mistaken for *L. venosa* in 1991). Also, some plant species were recorded infrequently and may have been misidentified or may no longer persist at PTA.

1.5 Threatened and Endangered Species and Species at Risk

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 26 TES (20 plant species and 6 animal species). Primary threats to ecosystem health, and therefore to TES, at PTA come from direct impacts as well as changes to the landscape by disturbance from feral ungulates, invasive species, wildland fire, and climate change.

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. 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*
(18) *Tetramolopium arenarium*
(19) *Vigna o-wahuensis*
(20) *Zanthoxylum hawaiiense*

1.5.2 Animals Listed under the Endangered Species Act

One mammal species, 3 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 MBTA may use habitat at PTA.

(1) *Hawaiian hoary bat*
(2) *Band-rumped Storm Petrel*
(3) *Hawaiian Goose*
(4) *Hawaiian Petrel*
(5) *Anthricinan yellow-faced bee*

(6) *Blackburn's sphinx moth*

1.5.3 Species at Risk

Habitats at PTA also support many native species, some of which meet the Department of Defense definition of species at risk (SAR)[6]. In 2019, using DoD criteria for designating SAR, we evaluated a comprehensive list of all native Hawaiian plants encountered at PTA during plant surveys between 2011 and 2015. Specifically, we gathered information through literature reviews, state and federal data, NatureServe data, and installation data to identify species meeting DoD's SAR criteria. These data included scientific and common name, ESA status, state status, NatureServe conservation status rank, International Union for Conservation of Nature status, and specific observation, occurrence, and distribution data for PTA and state-wide. The baseline data helped to determine which SAR have a higher priority for management and monitoring. Identifying these specific needs on installations can help maintain the overall biodiversity and health of the ecosystem. We recently revised the list to include plant species found outside the fence units and now 34 plant species meet the SAR criteria (Appendix C).

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 and 2006 via agreements between Army leadership, the Natural Resources Program, 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 in the southeast portion of KMA and encloses a single grouping of *Sicyos macrophyllus.*

Since FY 2017, all the fence units have been mostly ungulate-free, except when ungulates occasionally enter and remain for brief periods until they can be removed. 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 artificial or natural 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

[6] The Department of Defense defines *species at risk* as plant and animal species that are not yet federally listed as threatened or endangered under the Endangered Species Act, but that are federally designated as proposed or candidates for listing, are regarded by NatureServe as critically imperiled or imperiled (G1 or G2) throughout their range, or are birds that are regarded by NatureServe as vulnerable (G3) throughout their range or have an IUCN status of CR, EN, VU, or NT

degradation. Fence units are monitored regularly from the air and ground for ungulate ingress and detected animals are removed. We also ensure all locks are working properly and gates are securely closed and functional.

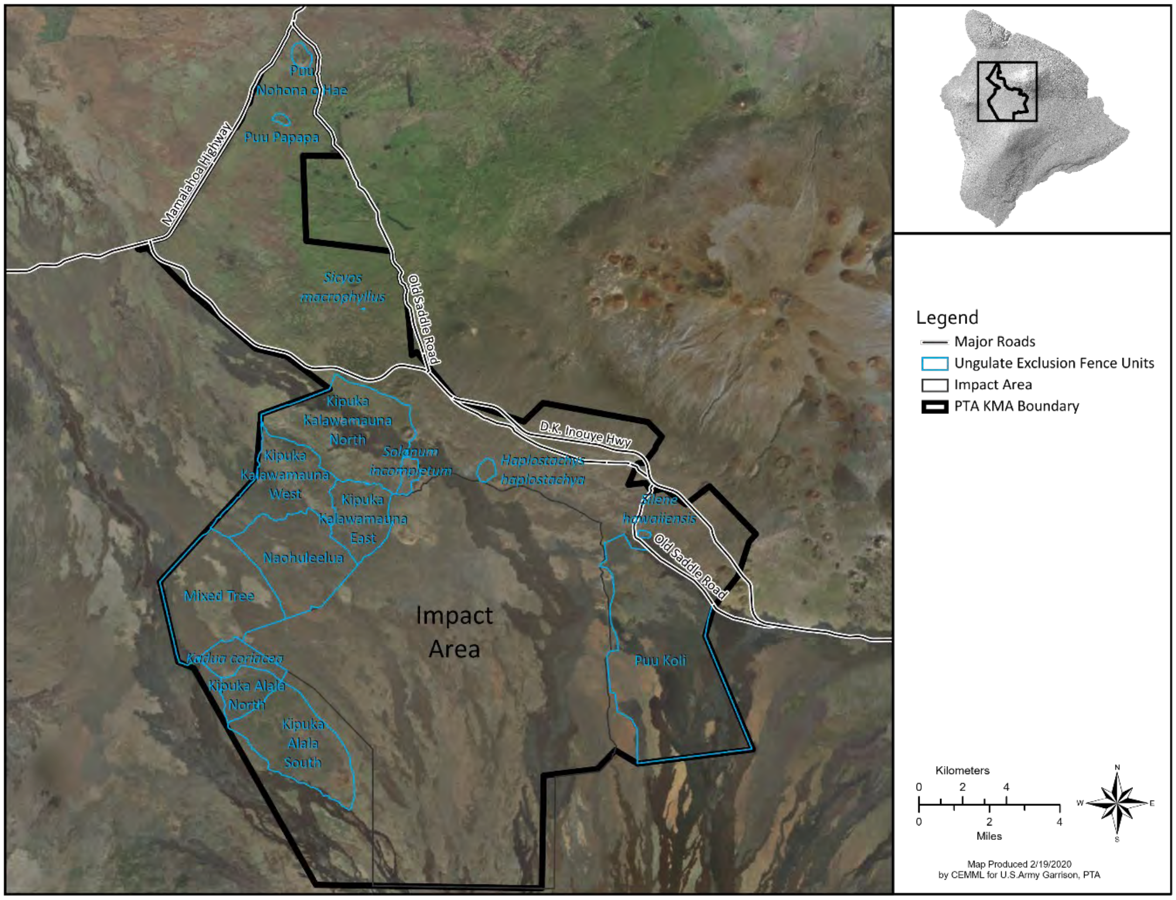


Figure 2. Ungulate exclusion fence units at Pōhakuloa Training Area

1.6.2 Areas of Species Recovery

Within the ungulate exclusion fence units are 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 m to 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, the 45 ASRs at PTA comprise 1,146 ha (Figure 3). The ASR boundaries are periodically reviewed and adjusted as population extent and conditions change. Not all known TES plant locations fall within an ASR, and we are planning to update the ASR boundaries and locations in 2024. 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.

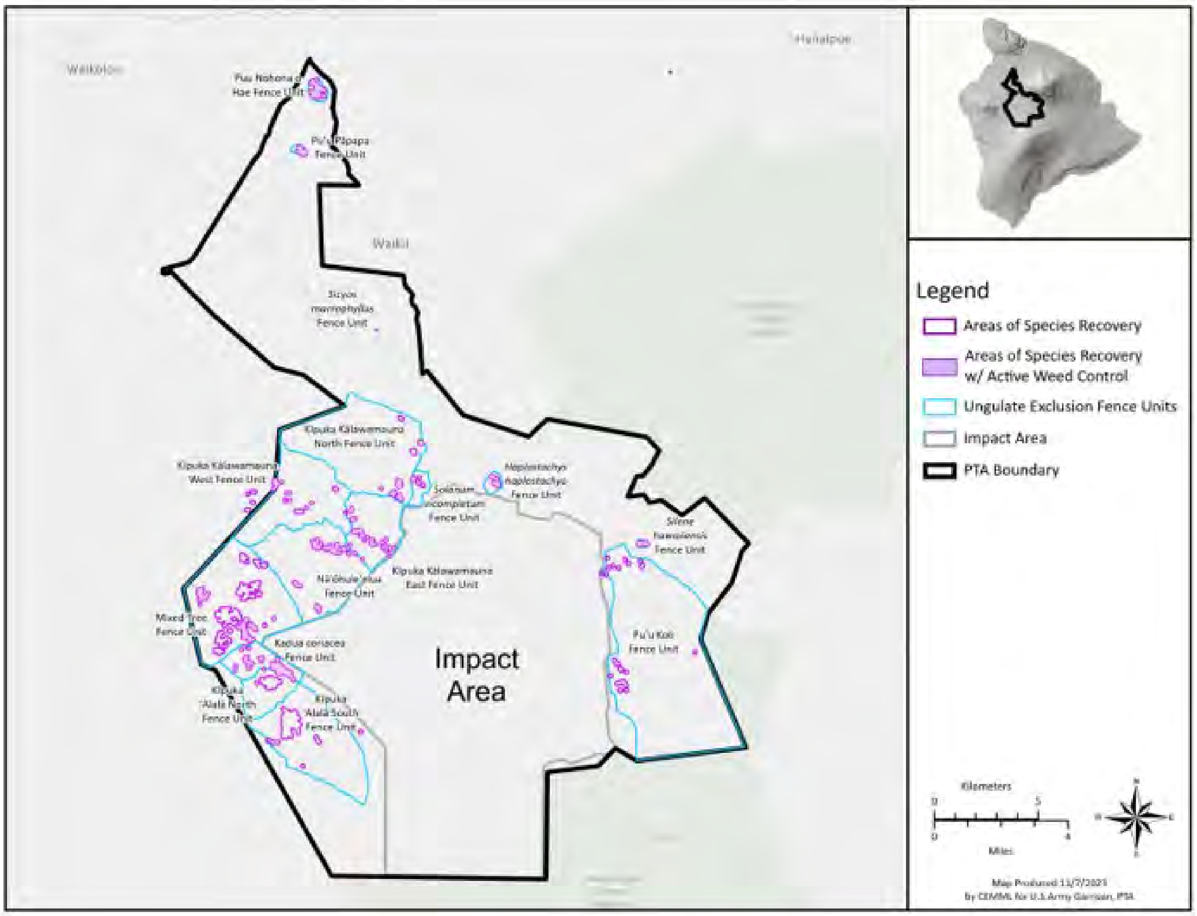


Figure 3. Areas of species recovery with and without active weed control at Pōhakuloa Training Area

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. These data are used to develop and implement appropriate and efficient management approaches to ensure long-term persistence of these species and conservation of their genetic resources 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 and 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 SOO tasks 3.2.1.1 through 3.2.1.5 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), *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* (creeping mint), *Tetramolopium 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 BOs to the Army with conservation measures for 15 ESA-listed plants[7]. 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*

[7] *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, V. o-wahuensis,* and *Z. hawaiiense*.

hawaiiensis [8]. Without an ESA consultation, these species lack formal conservation measures. We also manage *Tetramolopium stemmermanniae* due to its rarity and limited distribution even though this plant is not ESA-listed.

We are preparing documents to formally consult with the USFWS 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 FY 2025.

To work with TES, we obtained state and federal permits authorizing our activities. In 2020, the USFWS issued us a 5-year Endangered Species Recovery permit under section 10(a)(1)(A) of the ESA (Federal Fish and Wildlife Permit TE40123A-3, Native Endangered & Threatened Sp. Recovery–E & T Plants; hereafter referred to as the 2020 PTA recovery permit). We obtained State of Hawaiʻi rare plant permits (I2942, expired 31 December 2022; and I5287, expires 28 February 2024). We also maintain permits that authorize our work on State of Hawaiʻi lands and lands jointly administered by federal and state agencies. Under the permit authorizations, we collect, store, propagate, and outplant propagules, including seeds, inflorescences, spores, fruits, cuttings, and leaves, of the 20 ESA-listed plant species to further their genetic conservation. 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 reported in this section address SOO task 3.2.1 Botanical Program Support. Subtasks relating to threat control for ESA-listed plant species 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 H.

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). Sections 2.5 and 2.6—ESA-listed plant species summaries by management tiers—are arranged by management tiers (Table 1) and then alphabetically by species. Each species-specific summary includes a distribution map.

[8] The text reflects the status of the PBA during the report period (01 October 2021 through 30 September 2023). Since, the Army has worked to develop additional wildland fire planning and preparedness documents to support the PBA preparation process and the fire model used for the effects analysis was updated with data from wildland fires that occurred in 2021 and 2022.

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*), some species with sparser distributions occurring across many thousands of hectares (ha) (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 2 management tiers based on each species' abundance at PTA (Table 1).

- Management Tier 1—Plant species with fewer than 500 adult and juvenile individuals at PTA.
- Management Tier 2—Plant species with more than 500 adult and juvenile individuals at PTA.

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

Table 1. Management tiers for rare plant species at Pōhakuloa Training Area

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

(E) Endangered; (T) Threatened

2.1.1 New Monitoring Approaches

In 2022, we developed 2 new monitoring approaches—an individual plant monitoring framework for Management Tier 1 species and outplants (regardless of tier category) and a location-based monitoring framework to sample populations of the more abundant Management Tier 2 species (hereafter referred to as Tier 1 and Tier 2 species). To optimize efficiency, we plan to collect data for Tier 1 species, Tier 2 species, and outplanted plants concurrently on a regional basis, 1 region per quarter (Table 2 and Figure 4). This allows crews to complete all required survey and monitoring work in each area and minimizes the need to revisit areas. This is important because travel and access to locations is generally the most time-consuming component of survey and monitoring work at PTA.

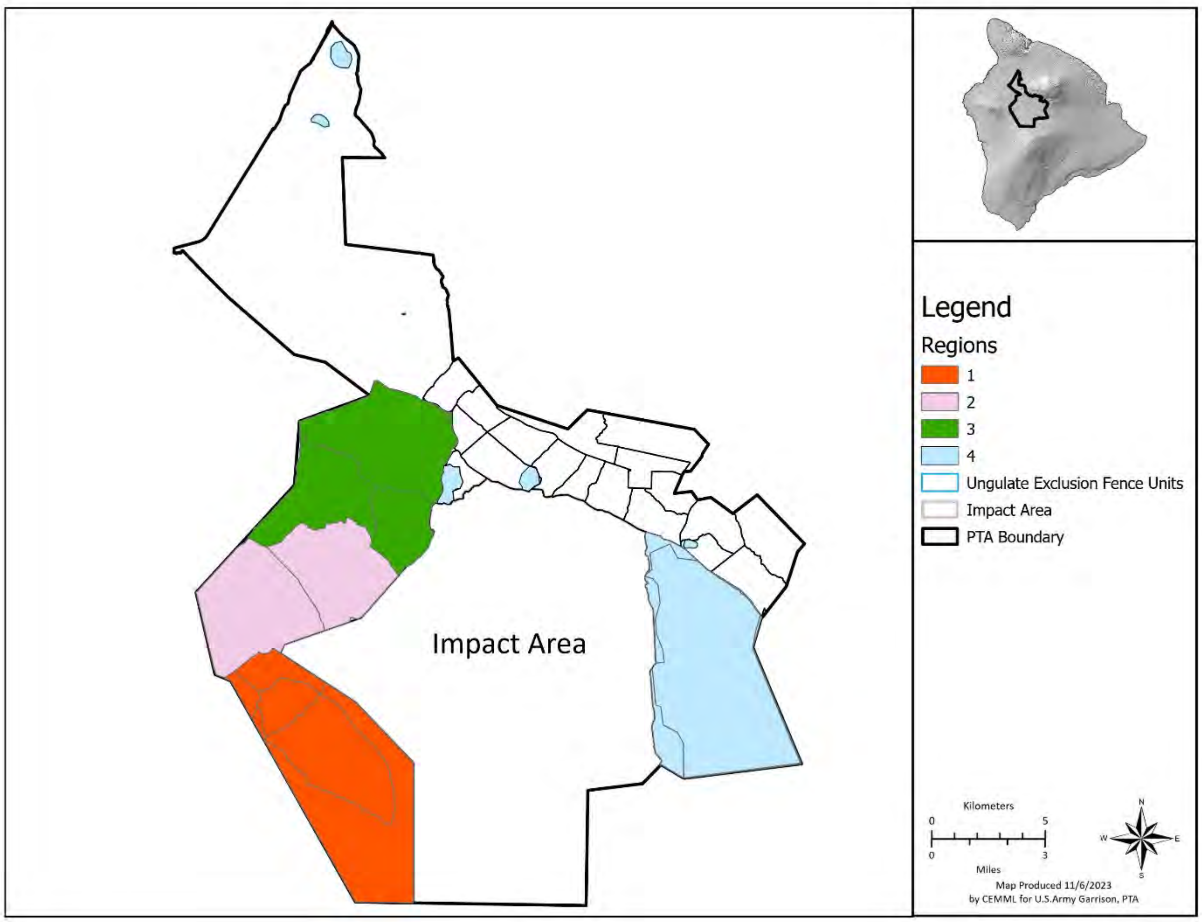


Figure 4. Map of regions of federally listed plants and outplants monitoring at Pōhakuloa Training Area

Table 2. Annual monitoring cycle for federally listed plants and outplants by region and corresponding fence units

Region	Period	Training Area(s): Fence units in each region
1	Apr–Jun	Training Area (TA) 23: Alala South, Alala North, *Kadua coriacea*
2	Jul–Sep	TA 22: Naohuleʻelua, Mixed Tree
3	Oct–Dec	TA 17-19, 22: Kīpuka Kālawamauna (KK) North, KK East, KK West
4	Jan–Mar	TA 2, 13, 18, 21: *Silene hawaiiensis, Haplostachys haplostachya, Solanum incompletum,* Puʻu Koli, Puʻu Kapele; Keʻāmuku Maneuver Area: *Sicyos macrophyllus,* Puʻu Nohona O Hae, Puʻu Pāpapa

2.1.2 Population Designation for Threatened and Endangered Plant Species at PTA

According to the revised recovery objective guidelines developed by the Hawaii and Pacific Plants Recovery Coordinating Committee (HPPRCC 2011), a population is a group of conspecific individuals that are in close spatial proximity to each other (i.e., less than 1,000 m apart). Under this definition, 1 or more individuals of a species found greater than 1,000 m apart is considered its own population. This assumes that most plant species are capable of some degree of sexual (recombinant) reproduction within this distance and presumed to be genetically similar. In 2023, we adopted the HPPRC definition and used GIS to compile all plant locations observed between 2011 and 2023 to delineate groupings of conspecifics greater than 1,000 m apart for each federally listed species at PTA, including wild, outplanted and mixed groupings. We assigned population identifiers to the grouping and the resultant population maps are presented in Sections 2.5 and 2.6. We plan to refresh the population maps every few years following distributional surveys. Populations will grow and contract over time and population boundaries and numbers will be adjusted as needed. We will carefully track changes in population boundaries and numbers to ensure historical continuity.

This first set of population maps is strictly based on the 1,000 m separation criteria, which may create artificial populations for some species. For example, this may occur when some individuals of a species are just beyond the 1,000 m criteria but are likely closely related or still reproductively connected to the neighboring population. Over the next 2 years, we intend to use life history and other species-specific information to evaluate the populations of each species and engage with conservation partners to revise the boundaries in a more biologically meaningful assembly. However, these first iteration population maps set the foundation for more targeted management that aligns with recovery needs for each species and serves as a framework to report progress toward the recovery goals for each species. For example, monitoring data will be summarized by these populations as well as by the USFWS geographic reference areas.

2.1.3 Management of Threatened and Endangered Plant Species at PTA

Based on the newly adopted species' populations, we evaluate the current status of each population by species in relation to the HPPRCC (2011) revised recovery objectives. An assessment is provided for each species in Sections 2.5 and 2.6.

In 2008, we developed 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 browsing. 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. In 2024, we plan to use the new population designations and recovery framework to develop species-specific management plans. This effort will include updating ASR designations to reflect current understanding of ESA-listed plant distributions and changes in other factors. It will help us strategize threat management (weed/predator control), collections for ex-situ storage, and outplanting needs and priorities.

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 definitively conclude that specific management actions caused specific responses.

2.2 Plant Surveys and Monitoring

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) surveying to determine species distribution and derive abundance estimates for Tier 2 species, and (2) monitoring Tier 1 species to track abundance, identify emerging threats, and investigate specific management needs. Together, these projects provide information to assess the status of the ESA-listed plant species and determine if the selected strategies adequately sustain them.

The overall operational goals of the PSMS are as follows:

- Refresh rare plant distributions on an approximately 5-year cycle
- Designate ASRs in which to focus management so species have the highest potential for survival and natural recruitment
- Monitor ESA-listed plant species throughout their distribution on PTA to track changes in abundance over time and to guide management
- Protect ESA-listed plant species directly affected by military activities
- Monitor vegetation communities over time and, where possible, document changes

2.2.2 Plant Surveys

Plant surveys document distributions of ESA-listed plant species, species at risk of listing, and invasive species. We also collect data to estimate the abundances of Tier 2 species. The plant surveys meet SOO task 3.2.1.1 and INRMP and Army Regulation-100 requirements for Planning Level Surveys; however, Planning Level Surveys were funded only in FY 2022. 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.

Before 2011, rare plant surveys occurred in numerous areas on PTA, driven largely by biological interest and regulatory requirements. This survey data was used to design the network of ungulate exclusion fences at PTA, which were completed in 2013.

Between 2011 and 2015, we completed a comprehensive survey within the ungulate exclusion fence units covering 120 km^2 and documenting 13,148 ESA-listed plant locations. However, endangered plants may still occur outside the ungulate exclusion fences in areas that have not been surveyed. We also survey areas to support military operations and construction projects within and outside the ungulate exclusion fences. We may also survey specific areas where a plant of interest has been found to better understand its distribution and abundance.

Plant Surveys in Training Areas 23 and 21 Outside the Ungulate Exclusion Fences

Since 2011, plant surveys have mainly focused inside ungulate exclusion fences due to the presence of feral ungulates (i.e., goats, sheep, and pigs) in unfenced areas. However, some ESA-listed species likely occur in unfenced areas that have not been previously surveyed. For example, *E. menziesii* and *Silene hawaiiensis* have been documented outside the ungulate exclusion fence in TA 23.

To get accurate estimates of ESA-listed plant abundances in unfenced portions of TA 23 and TA 21, we surveyed between June and August 2021, and again between September and December 2021, in habitats likely to support E. *menziesii* and *Silene hawaiiensis*. Although this survey took place prior to this reporting period, it is briefly documented here, since these results contribute substantially to our overall understanding of these species' status at PTA. For more detailed information about this survey, see the *Army Natural Resources Program at Pōhakuloa Training Area, Biennial Report, 01 October 2019–30 September 2021* (CEMML 2022a). We are also completing a Technical Document in 2024 that expands on the results presented here.

Methods

We determined habitats likely to support *E. menziesii* and *Silene hawaiiensis* via GIS by joining National Vegetation Classification System classes and known occurrences of the species within the fence units. We then used the vegetation classes that correlated with the 2 species' occurrences to identify the area to survey outside the fences. Survey transects arranged into macroplots (250 m x 100 m polygons comprising 10 transects per macroplot, totaling 1,138 km) were created. Between June and August 2021, we worked to survey all macroplots. However, due to the remoteness of TA 23 and time and personnel limitations, we shifted to a random sampling approach in September 2021, where 30% of the original macroplots were randomly selected and surveyed. This approach allowed us to estimate abundance more efficiently for species in this area.

GPS-equipped devices were used to navigate transects and record spatial coordinates and abundance of ESA-listed species. A single GPS coordinate was used to represent all individuals within a 5-m radius area; this is referred to as a plant location. At each plant location, up to 25 individuals were counted; if more than 25 individuals were present, they were assigned a count class[9].

Results

From June 2021 through August 2021, we surveyed 326 linear km of unfenced portions of TA23 (Figure 5). From September through December 2021, we implemented the 30% random sampling design and surveyed an additional 127.6 linear km for a total area of 1,112 ha (Figure 6). ESA-listed plant species found during surveys include *A. peruvianum* var. *insulare*, *E. menziesii*, *F. hawaiiensis,* and *Silene hawaiiensis* (Table 3). We also found 2 *Dubautia arborea,* a species that meets Department of Defense criteria for a species at risk (SAR).

Of the species found in sampled plots, only *E. menziesii* was found in sufficient numbers to estimate abundance for the entire survey area (Table 4)

[9] Count classes are defined as 26–50, 51–75, 76–100, and >100 and are totaled using the lowest number of the count class. Therefore, seedling counts are likely underestimated.

Table 3. Counts of ESA-listed species found during surveys in unfenced areas of Training Area 23

Species	Seedlings	Juveniles	Adults	Total[a]
Asplenium peruvianum var. *insulare*	0	53	13	66
Exocarpos menziesii	0	3	2,703	2,706
Festuca hawaiiensis	0	1	7	8
Silene hawaiiensis	0	9	78	87

[a] Totals represent the cumulative number of adults and juveniles found before and after implementation of random sampling design. These numbers do not represent population abundance, but rather how many plants were encountered during surveys.

Table 4. Estimated abundance and confidence intervals of juveniles and adults for *E. menziesii* derived from randomized sampling in unfenced areas of Training Area 23, June and December 2021

Species	Estimated Abundance	1/2 Confidence Interval	Lower 90% Confidence Interval	Upper 90% Confidence Interval
Exocarpos menziesii	3,674	735	2,940	4,410

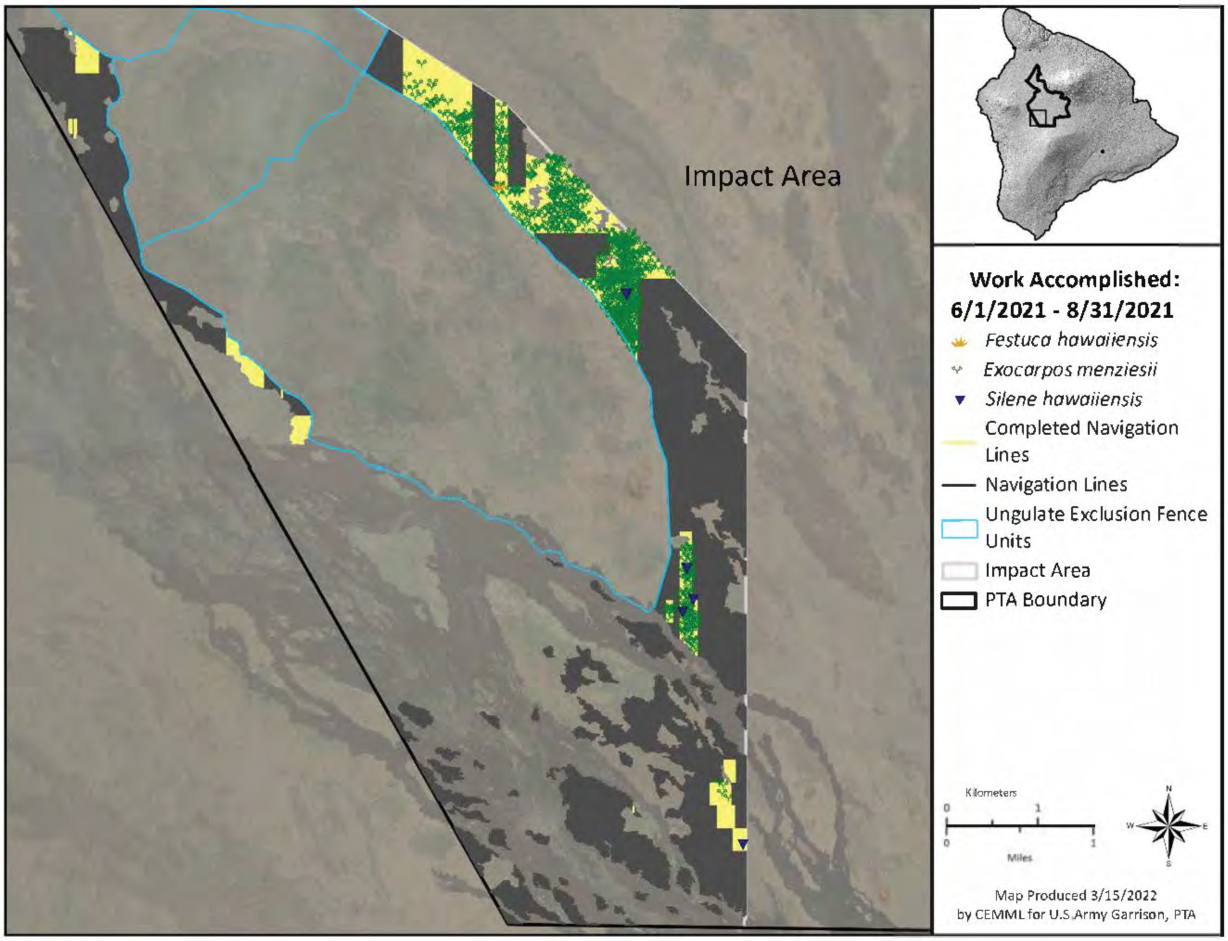


Figure 5. Plant survey in unfenced area in Training Area 23 conducted between June and August 2021. The initial area to survey (1,128 km of linear transects) is shown in dark gray. Survey areas completed between June–August 2021 are shown in yellow with threatened and endangered species locations superimposed

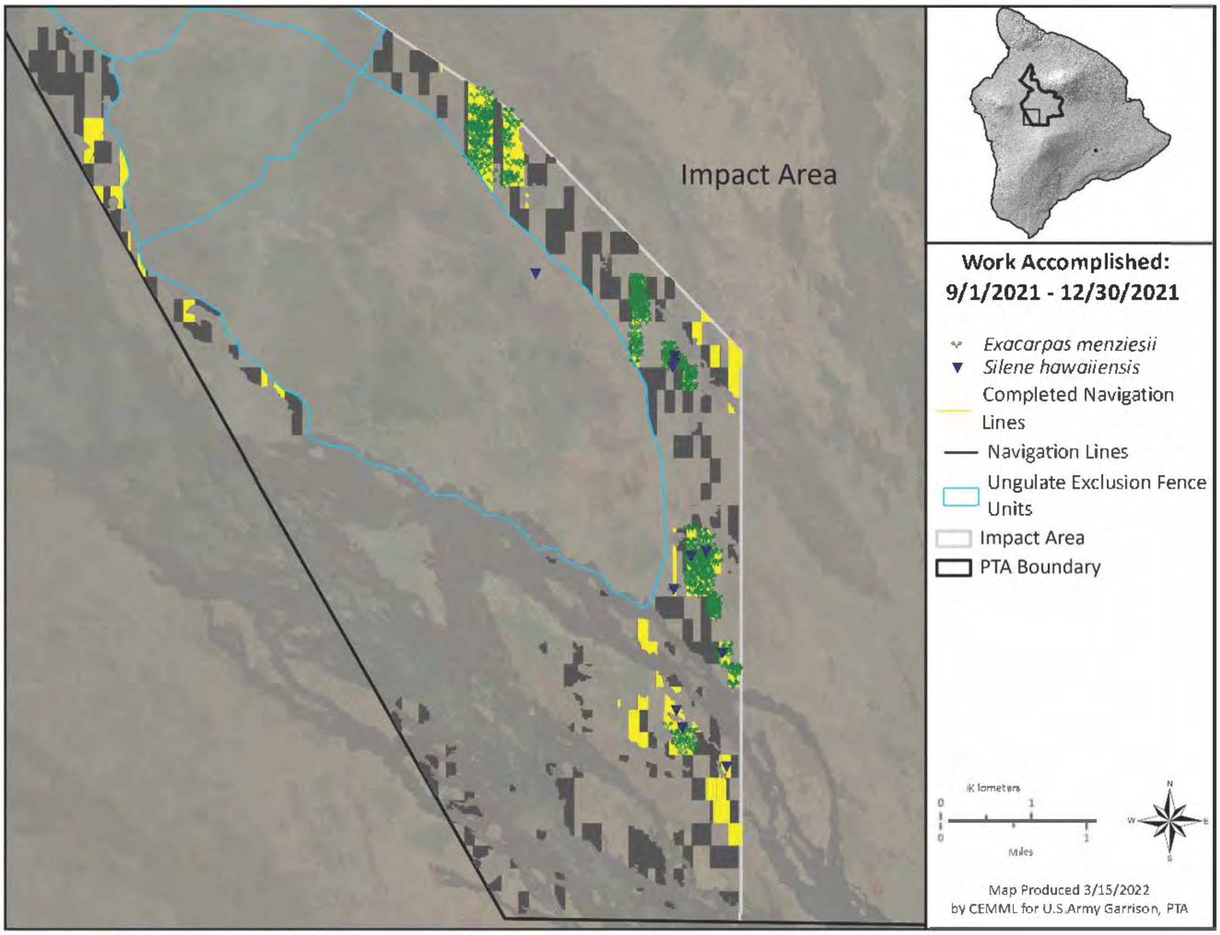


Figure 6. Random macroplot selection of 30% within the unfenced plant survey area in Training Area 23 conducted between September and December 2021. The survey area is shown in dark grey and completed survey areas are shown in yellow with threatened and endangered plant locations superimposed

Discussion

We estimate that approximately 3,674 (90% Confidence Interval [CI]: 2,940–4,410) juveniles and adults of *E. menziesii* are located outside the fence unit in TA 23 (

Table 4), which is 95% greater than the previously estimated abundance of this species within PTA fence units (1,875, 90% CI: 1,458–2,292) (CEMML 2022a, CEMML 2023c). We further investigated the degree to which elevation may affect the presence of this species. Despite many field observations that *E. menziesii* abundance seemed to be strongly and inversely correlated to elevation, the data show no significant relationship. Future work will include investigating the relationship between abundance and other pertinent habitat variables (e.g., lava texture, vegetation type, aspect, rugosity, etc.).

We also encountered *A. peruvianum* var. *insulare*, *D. arborea, F. hawaiiensis,* and *Silene hawaiiensis* outside the fence units, but at a much lower frequency (Table 3). We expected to find low numbers of *Silene hawaiiensis* due to feral ungulates selectively browsing this species to nearly unidentifiable plant material (Figure 7). The other ESA-listed species and SAR present in these areas likely represent remnants of once-larger populations. For the ESA-listed species, excluding *E. menziesii*, most of the individuals found outside the fence do not substantially contribute to the species' overall abundance at PTA.

Figure 7. Browsed *Silene hawaiiensis* outside the fence unit in Training Area 23

For *D. arborea,* the plants found in November 2022 in TA 23 (on Mauna Loa volcano) doubled the known population at PTA (2 to 4 individuals). One plant appeared to be very old; the main trunk had fallen over but had an estimated basal diameter of more than 50 cm. The second plant was also substantial, and its basal diameter was estimated to be 25 to 50 cm. These plants were heavily seeding, so we collected ample seed from each. The *D. arborea* in TA 23 are the only documented occurrences of this species outside of Mauna Kea volcano. The individuals at PTA likely have been separated from the population on Mauna Kea for many decades and their genetic resources may be valuable to reintroduce to the larger Mauna Kea population. We intend to propagate seeds from the individuals at PTA to include in outplanting sites and to make the seed available to other interested conservation agencies.

2.2.3 Plant Monitoring

Annual monitoring is a required conservation measure for most ESA-listed plant species at PTA (USFWS 2003a). To achieve these monitoring requirements, we (1) monitored Tier 1 species to track abundance, identify emerging threats, and investigate specific management needs, (2) estimated abundance of most Tier 2 species based on survey data, and (3) monitored known *Zanthoxylum hawaiiense* and select SAR locations. Together, these projects informed the status of the ESA-listed plant species, which was essential for determining if selected management strategies helped adequately sustain each ESA-listed plant species. Monitoring actions met SOO Tasks 3.2.1.2, INRMP objectives, and conservation measures in the 2003 BO.

2.2.4 Individual Plant Monitoring Framework for Tier 1 Species and Outplant Monitoring

Monitoring Wild Tier 1 Species

The new individual plant monitoring protocol was implemented in April 2022 for wild Tier 1 species. The protocol details a survey and monitoring framework to track each species' distribution and abundance. It includes data collection and analysis methods, as well as a system to tag and track wild individuals over time.

To track species distribution, every 5 years we plan to survey a pre-determined area surrounding all known wild Tier 1 plant locations. This effort will begin in 2024 or 2025, depending on staffing and workload.

To track abundance, we revisit all tagged wild plants annually to record individual survivorship and longevity, determine the number of individuals in each life stage, record reproductive status and plant vigor, and document recruitment of new plants.

Monitoring Outplanted Individuals

For ESA-listed plants planted in 2019 and after, we will use the individual plant monitoring protocol regardless of tier category. Like wild Tier 1 plants, we will annually record individual survivorship and longevity, determine the number of individuals in each life stage, record reproductive status and plant vigor, and document recruitment of new plants. In 2024, we plan to evaluate additional monitoring needs specific to outplants and, if needed, develop an additional monitoring framework.

Various methods have been used to monitor outplantings. Between 2004 and 2014, if an outplant survived about a year, the outplant was tagged with a pin flag near the plant and assigned a number. However, as the years progressed and outplanting sites filled in with recruits, we could not reliably assign individuals to pin flags and identification numbers. The sites were intermittently monitored between 2014 and 2018. Between 2019 and 2022, we visited all legacy sites, counted all remaining individuals, and reported these counts annually to the Service via annual recovery permit reports. In addition, we planted several new sites in 2019 and all outplants were marked with pin flags when planted. We have tracked and reported survivorship of these outplants annually.

Prior to 2023, we last planted at these legacy sites in 2014. Many of the species remaining at these sites are considered short-lived perennials, such as *Asplenium peruvianum* var. *insulare, F. hawaiiensis, Haplostachys haplostachya, Schiedea hawaiiensis, Silene hawaiiensis, Silene lanceolata,* and *Stenogyne angustifolia*. Individuals of these species remaining at the sites today are likely offspring of the outplants planted between 2004 and 2014. Although we are fairly confident that some original outplants of some longer-lived species, such as *Neraudia ovata, Solanum incompletum,* and *Z. hawaiiense*, remain at the legacy sites, we cannot accurately determine their age.

For legacy planting sites, planted prior to 2019, only Tier 1 species will be tagged and monitored annually after December 2022. Because many of the Tier 2 species planted at the legacy sites are considered short-lived perennials, we assume most of the plants remaining at the sites are offspring of the original outplants. Therefore, we will no longer annually monitor for *outplant* survivorship of the Tier 2 species outplants at legacy outplanting sites. Instead, we will track the remaining Tier 2 individuals using the location-based monitoring protocol (see Section 2.3.4). All Tier 2 plants remaining at legacy outplanting sites, and future recruits of Tier 2 species at all outplanting sites, will be counted 1 time over a 3-year period.

Methods

Between January 2022 and March 2023, all known wild and outplanted Tier 1 plants were visited. For some Tier 1 species, such as *L. venosa, S. macrophyllus, S. incompletum,* and *V. o-wahuensis,* distinguishing individuals is challenging. Therefore, field personnel followed specific guidelines for these species to count the number of individuals or units and to identify the life stage of each.

Each juvenile and adult plant received a unique plastic tag with a scannable code. Tags were tied around the base of plants (or around an object as near as possible to the individual for *Portulaca* sp.). Data taken for each tagged plant included: (1) life stage; (2) origin; (3) presence of reproductive structures, buds, flowers, or fruit; and (4) plant vigor.

We use the following life stage definitions to distinguish 3 stages of plant development:

(1) Adult—reproductively mature
(2) Juvenile—no indication of previous reproduction, > 10 cm
(3) Seedling—no indication of previous reproduction, < 10 cm

We use the following definitions of origin to distinguish 3 categories of plants:

(1) Wild—an individual found in the wild (was not planted), offspring of another wild plant
(2) Recruit—an individual in or near an outplanting site, and most likely the offspring of an outplant (within 50 m of another outplant or recruit of same species)
(3) Outplant—an individual that was planted

The term *outplant* will be applied only to plants that are tagged around their base at time of planting, so that we can identify when recruitment is occurring. Plants without a tag during subsequent monitoring are labeled a *recruit*. Individuals at legacy sites are labeled *outplant/recruit* to indicate that we are unable to distinguish the exact origin of an individual; we are certain only that these plants are not wild.

Seedlings were not tagged, but the number of plants and GPS locations (representing their occurrence within a 5.6 m radius circle) was recorded. We counted all individuals up to 25 and assigned count classes when the number of individuals exceeded 25 (25–50, 51–100, and >100). Seedlings that reach the juvenile/adult life stage when monitored in subsequent years will be tagged and tracked over time.

Invasive plants pose a threat to Tier 1 plants via competition for resources and by altering ecosystem processes and regimes. The Invasive Plant Program (IPP) prioritizes invasive plants for control based on their competitiveness, ecosystem-altering properties, and distribution relative to threatened and endangered plants. Two species, *Cenchrus setaceus* (fountain grass) and *Senecio madagascariensis* (fireweed), are considered primary target species due to their competitiveness. In addition, *C. setaceus* facilitates wildland fire. These primary targets are controlled in weed control buffers around most Tier 1 plant locations. Other highly invasive plants, termed secondary target weeds (see Section 3.3, Table 103 for information about secondary target weeds), are evaluated, monitored, and prioritized for control (Management Tiers) based on a series of factors.

To make a rapid assessment of the relative health of individuals and populations for each species, we assigned each plant to 1 of 3 vigor classes (Healthy = foliage that appears green and vigorous, <10% dead leaves or defoliation; Moderate = leaves may have some chlorosis, with 10–50% of the leaves dead or defoliated; Poor = mostly dead or chlorotic leaves, >50% dead leaves or defoliation). We also recorded the presence of any reproductive structures (fruits, flowers, and flower buds). Data on plant vigor and reproductive structures are broken down into individual populations and presented in Section 2.5.

To help prioritize and guide weed control efforts for Tier 1 plants, we estimated the percent cover of all weed species combined (i.e., all introduced or invasive grasses and other plants, including primary and secondary targets combined) and the total percent cover of fine fuels—defined as all grass species, native and introduced. Weed and fine fuel cover were collected as total canopy percent cover classes (< 1%, 1–10%, 10–20%, 20–50%, and 50–100%) for each 10 m x 10 m quadrat occupied by a Tier 1 plant species.

We also listed any secondary target weed species that were observed within the 10 m x 10 m quadrat occupied by a Tier 1 species.

Results

The data in this section are for wild individuals as well as individuals at outplanting sites of the Tier 1 species. We report the number of individuals persisting at each outplanting site in Section 2.5, where observations of the relative vigor and reproductive status of each population are also presented.

Between April 2022 and March 2023, we completed monitoring in Regions 1 through 4 for all Tier 1 species, except for *Z. hawaiiense,* which was monitored between September and November 2023. We had tagged 81 individuals of 4 Tier 1 species[10] between January and March 2022 as a pilot test of the monitoring protocol. These data were deemed appropriate for the first cycle of Tier 1 data analysis. In addition, a substantial number of outplanted *Schiedea hawaiiensis* at 2 locations were missed during monitoring. However, data were collected in December 2022 for these outplants using our previous outplant monitoring framework. Using the data collected in December 2022, we include the exact count when individuals were < 25 and count class data when individuals were >25 for the various life stages (18 adults and 51 juveniles from 1 site, 7 adults from the second) in our results (Table 5).

Table 5. Tier 1 species population size estimates; data collected January 2022 through March 2023

	Wild Individuals				Individuals at Outplant Sites				Wild, Outplants & Recruits
	A	J	S	A & J Total	A	J	S	A & J Total	A & J PTA Total
Isodendrion hosakae	46	197	69	243	4	0	0	4	247
Kadua coriacea	135	7	0	142	11	18	0	29	171
Lipochaeta venosa	54	297	490	351	0	1	0	1	352
Neraudia ovata	38	15	0	53	55	0	0	55	108
Portulaca sclerocarpa	131	33	45	164	4	3	2	7	171
Portulaca villosa	7	0	1	7	0	0	0	0	7
Schiedea hawaiiensis	3	1	0	4	34	53[a]	26	87	91
Sicyos macrophyllus	4	1	26	5	0	0	0	0	5
Solanum incompletum	55	39	25	94	199	329	387	528	622
Tetramolopium arenarium	77	17	37	94	0	0	0	0	94
Tetramolopium stemmermanniae	51	31	42	82	78	185	146	263	345
Vigna o-wahuensis	13	137	168	150	0	0	0	0	150

A = reproductively mature adult; J = juvenile (> 10 cm, no indication of previous reproduction); S = seedling (< 10 cm, no indication of previous reproduction).

[a] 51 of the 53 juveniles reported represent the minimum count of the count class; monitoring methods used are described in Section 2.3.4.

Weed and fine fuels percent cover in 10 m x 10 m cells occupied by 1 or more Tier 1 plants are displayed in Figure 8 and Figure 9. Figure 10 and Figure 11 show the overall proportion of weed and fine fuels percent cover data collected for each of the 5 cover classes. Approximately 13% of all weed percent cover and 17% of all fine fuels percent cover estimations exceeded our 20% cover management thresholds. Most (but not all) of these Tier 1 plant locations receive regular weed control.

[10] (1) *Kadua coriacea*, (2) *N. ovata*, (3) *Portulaca sclerocarpa,* and (4) *S. macrophyllus*

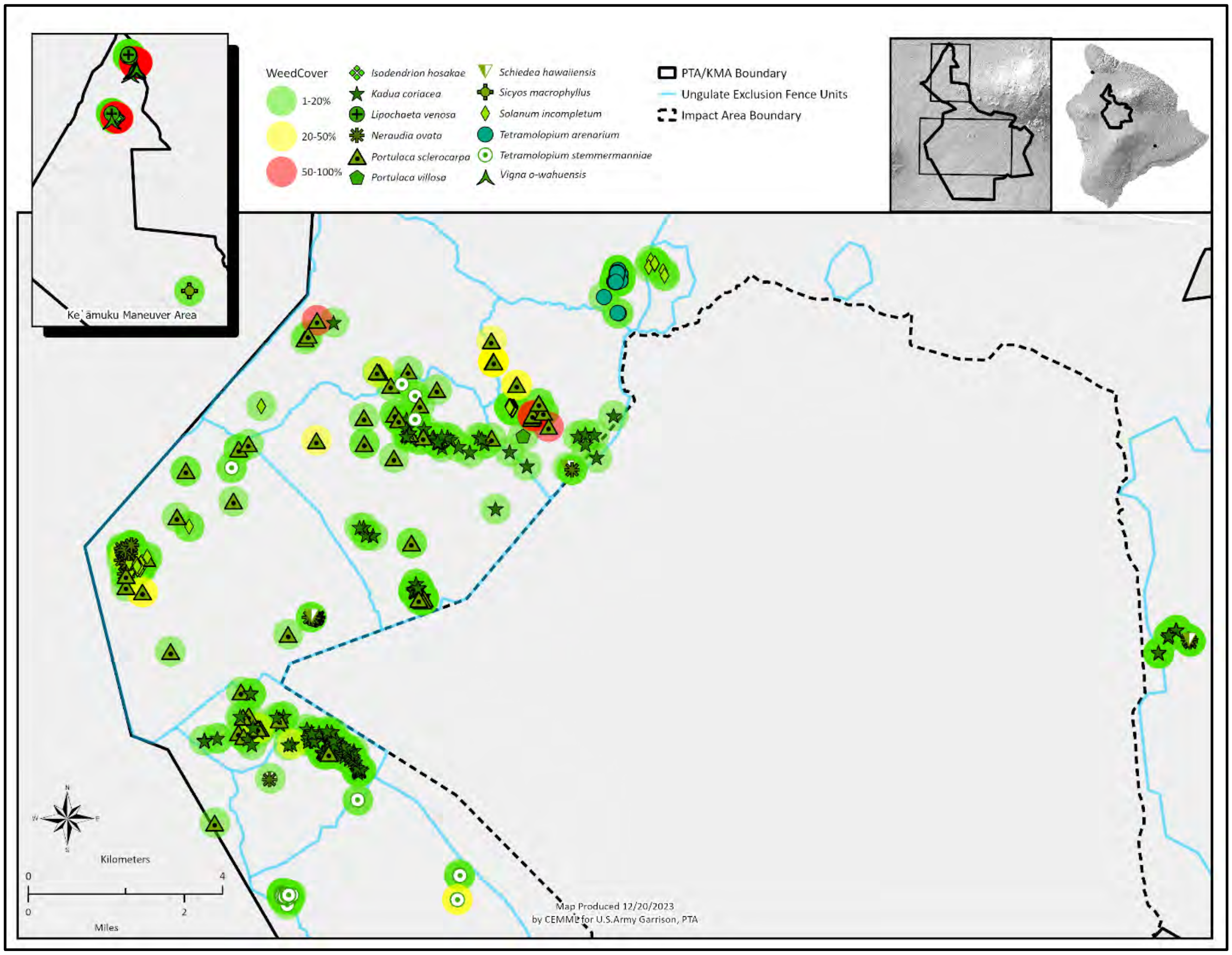


Figure 8. Weed percent cover in 10 x 10 m cells occupied by 1 or more Tier 1 plants

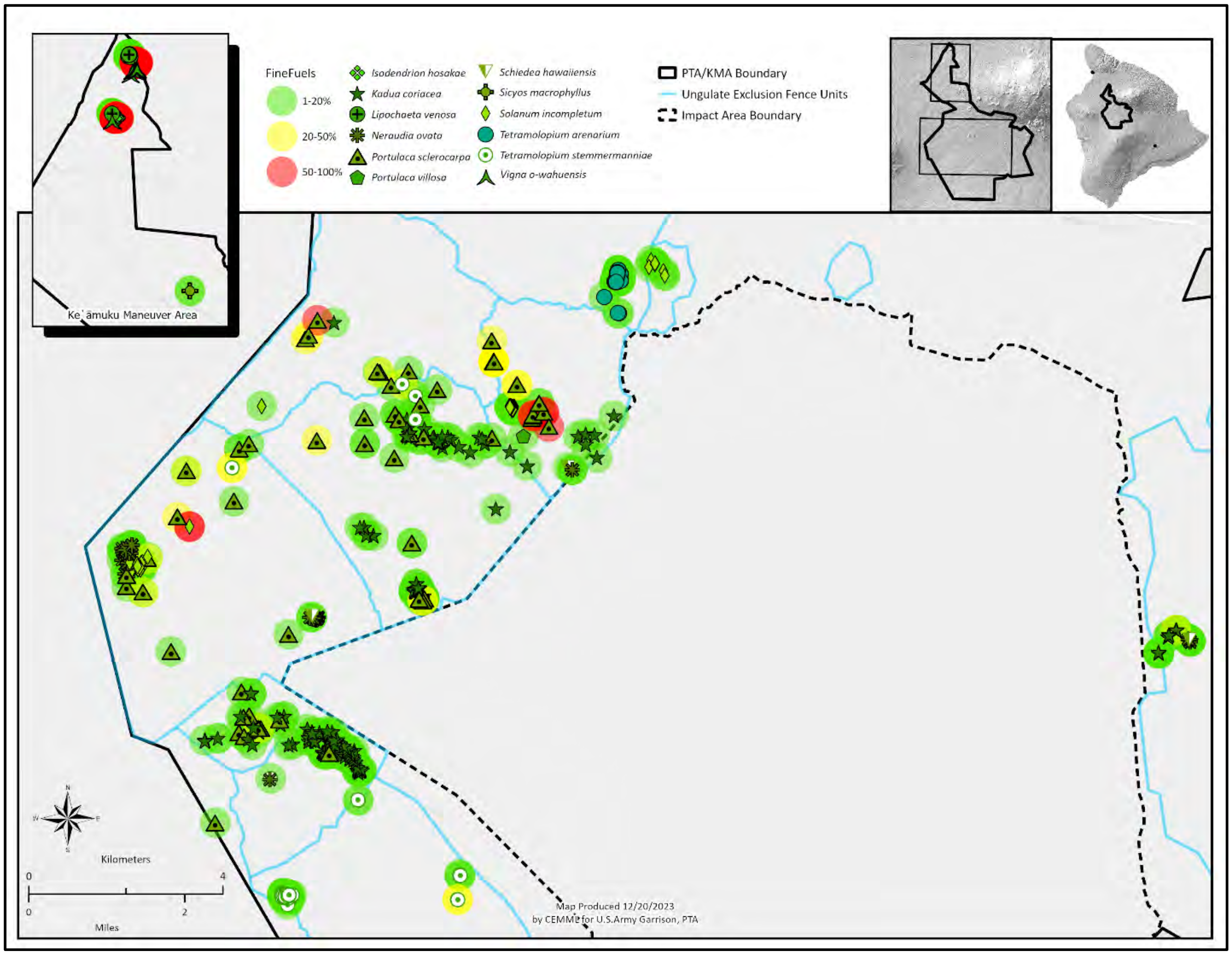


Figure 9. Fine fuels percent cover in 10 x 10 m cells occupied by 1 or more Tier 1 plants

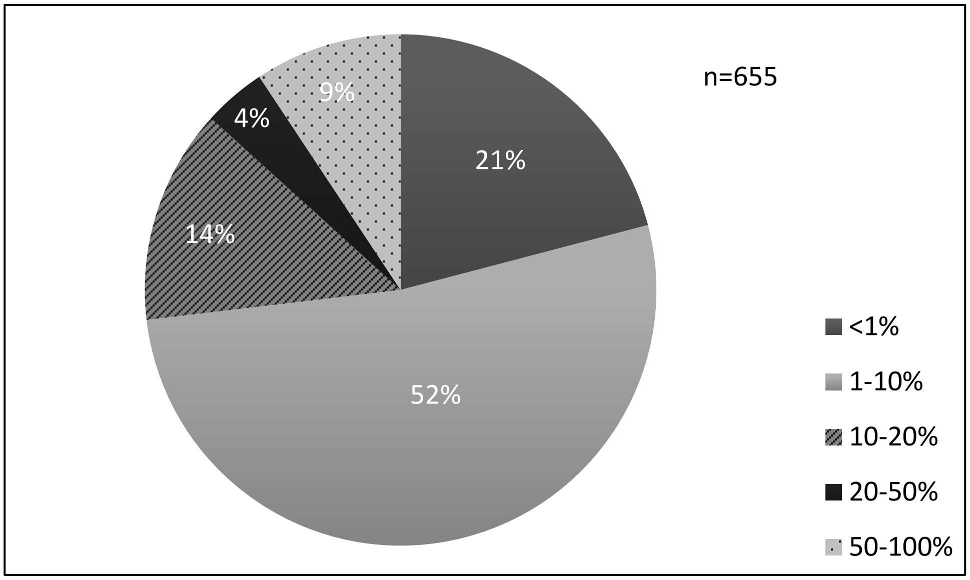


Figure 10. Overall proportion of weed percent cover classes reported for Tier 1 plant locations

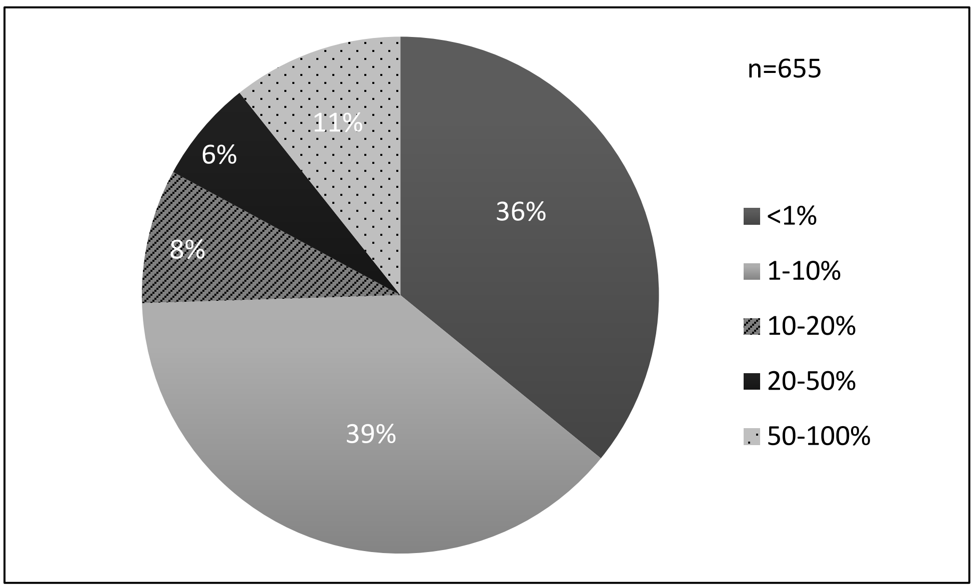


Figure 11. Overall proportion of fine fuels percent cover classes reported for Tier 1 plant locations

Discussion

We implemented refined monitoring approaches in FY 2022 for Tier 1 plant species for wild and outplanted individuals to characterize population status and structure over time more consistently and reliably. By the middle of FY 2023, we completed data collection in all 4 regions. Future monitoring cycles will provide data to better understand Tier 1 species status and structure, and importantly, trends over time. Accompanied by evidence of reproduction occurring over time, annual census data will allow us to assess progress toward population stability goals for these species. A better understanding of species ecology and natural variability over time will support adaptive management at PTA and achievement of species conservation goals.

2.2.5 Location-based Monitoring for Tier 2 Species and Abundance Estimates

In November 2022, we implemented a new strategy to expedite plant monitoring and estimate abundance more reliably for 7 Tier 2 species—*A. peruvianum*, *E. menziesii, F. hawaiiensis, H. haplostachya, Silene hawaiiensis, S. lanceolata,* and *S. angustifolia.* According to the location-based monitoring protocol, we randomly monitor 33% of the known distributions of each Tier 2 species in 1 year, with the aim of completely monitoring the entire population every 3 years. We select 33% of the known locations of each species from each of the 4 regions (Figure 4), enabling us to scale our annual estimates to the regions as well as the entire installation. This protocol collects data for plants occurring within a defined location (5.6-m-diameter circle—the approximate size of a single GPS point), and individual plants are not tagged and tracked over time. However, executing this protocol has taken more time than we originally planned, and PTA-wide abundance estimates for most species will not be available until 2024 when the first cycle of data collection throughout all 4 regions is completed; currently only Regions 3 and 4 are complete. After data collection for the first cycle has been accomplished, we will assess options to alter our sampling intensity so that annual abundance estimates for all Tier 2 species will be more feasible. Because the entire distribution of *H. haplostachya* is contained within Regions 3 and 4, we calculated abundance estimates both by region and PTA-wide. As with the Tier 1 species, we report only completed monitoring datasets.

We did not monitor *Silene hawaiiensis* in Regions 3 and 4 due to an error with sample plot selection. We have corrected the error and plan to begin monitoring in early 2024. *Spermolepis hawaiiensis* is an ephemeral species; while it is an annual, it may not always be present throughout its range each year unless environmental conditions are favorable. Hence, we did not include *Spermolepis hawaiiensis* in the Tier 2 monitoring protocol. As time permits, we plan to explore monitoring methods more suited to its specific life history. However, monitoring for *Spermolepis hawaiiensis* is not stipulated in the 2003 Biological Opinion and beyond fencing and ungulate removal the USFWS did not consider this species as a high priority for additional conservation measures.

Methods

For a detailed description of the location-based sampling framework used to generate the abundance estimates, refer to *FY 2019-2021 Biennial Report, Army Natural Resources Program at Pōhakuloa Training Area* (CEMML 2022a).

Within the 100 m x 250 m macroplots, ten 250 m transects were monitored with observers searching 5 m on either side, thus forming a 10-m-wide search area centered on each transect. When a Tier 2 species was encountered within the search area, a GPS point was taken. This GPS point represents a 5.6-m-radius circle, termed a plant location, and all individuals of the species within the location were counted by life stage (adult, juvenile, or seedling). We counted all individuals by life stage up to 25 and assigned count classes when the number of individuals exceeded 25 (26–50, 51–75, 76–100, and >100).

Counting individuals of some Tier 2 species can be challenging and requires species-specific attention. For example, *S. angustifolia,* reproduces primarily asexually through vegetative propagation via ramets budding from roots, rhizomes, and stems. Other plants grow in clumps, such as *A. peruvianum* var. *insulare,* and attempting to distinguish individuals by counting stems can damage the plants. Therefore, field personnel follow specific guidelines for these species to count the number of individuals or units and to identify the life stage of each.

We also collected data on weed cover and fine fuels cover within a 100 m^2 area surrounding all Tier 2 plant locations.

<u>Puʻu Kapele</u>

Puʻu Kapele's steep cinder-cone slopes pose a challenge for monitoring. Therefore, the monitoring approach has been modified to collect data efficiently and accurately while minimizing negative impacts to *H. haplostachya* and its habitat. We employed belt transects aligned with the contours of the cinder cone as sampling units. Belt transects are 4 m wide by 250 m long and cover all habitat within 10 m of a previously known plant location. Using a random starting point, we selected every third transect for monitoring, resulting in a 33% systematic random sample of all belt transects. Every 3 years, a full census of all known locations will be completed.

Results

Based on the survey data collected in Regions 3 and 4 between November 2022 and May 2023, we estimated the following abundance for each species per region, and independently for *H. haplostachya* on Puʻu Kapele (Table 6).

Table 6. Estimated abundance of adult and juvenile individuals (combined) for ESA-listed plant species sampled at Pōhakuloa Training Area in November 2022 to May 2023

Species	Region	Number of Plots Sampled[a]	Estimated Abundance	Lower Limit 90% CI	Upper Limit 90% CI
Asplenium peruvianum var. *insulare*	3	0	—	—	—
Asplenium peruvianum var. *insulare*	4	4	19	0	46
Asplenium peruvianum var. *insulare*	3–4	4	19	0	46
Exocarpos menziesii	3	0	—	—	—
Exocarpos menziesii	4	55	612	413	811
Exocarpos menziesii	3-4	55	612	413	811
Festuca hawaiiensis	3	18	159	39	279
Festuca hawaiiensis	4	0	—	—	—
Festuca hawaiiensis	3–4	18	159	39	279
Haplostachys haplostachya	3	49	9,323	4,800	13,845
Haplostachys haplostachya	4	5	256	20	492
Haplostachys haplostachya	3-4	54	9,132	4,518	13,746
Haplostachys haplostachya	Puʻu Kapele	100[b]	4,954	3,943	5,965
Silene lanceolata	3	24	3,185	1,532	4,838
Silene lanceolata	4	1	0	0	0
Silene lanceolata	3–4	25	3,145	1,500	4,790
Stenogyne angustifolia	3	96	2,718	1,638	3,799
Stenogyne angustifolia	4	3	7	0	18
Stenogyne angustifolia	3–4	99	2,727	1,641	3,814

CI, Confidence Interval

[a] The number of plots refers to the number of 100 m x 250 m macroplots sampled, each consisting of ten 10 m transects.

[b] The number of plots on Puʻu Kapele refers to the number of 4 m x 250 m belt transects sampled.

Because monitoring to date has been completed only in Regions 3 and 4, we cannot provide PTA-wide abundance estimates for most Tier 2 species at this time.

The entire distribution of *H. haplostachya* is within Regions 3 and 4, so we are able to estimate that approximately 9,132 (90% CI: 4,518–13,746) plants exist. Using different monitoring methods, we estimate there are an additional 4,954 (90% CI: 3,943–5,965) plants on Puu Kapele (Region 4). The sum of the abundance estimates was 14,086 (90% CI: 8,461–13,746) plants.

Weed and fine fuels percent cover in 10 m x 10 m cells occupied by 1 or more Tier 2 plants are displayed in Figure 12 and Figure 13. Figure 14, and Figure 15 show the overall proportion of weed and fine fuels percent cover data collected for each of the 5 cover classes. Approximately 48% of all weed percent cover and 63% of all fine fuels percent cover estimations exceeded our 20% cover management thresholds. Unlike Tier 1 plant locations, most of these Tier 2 plant locations receive little to no weed control management.

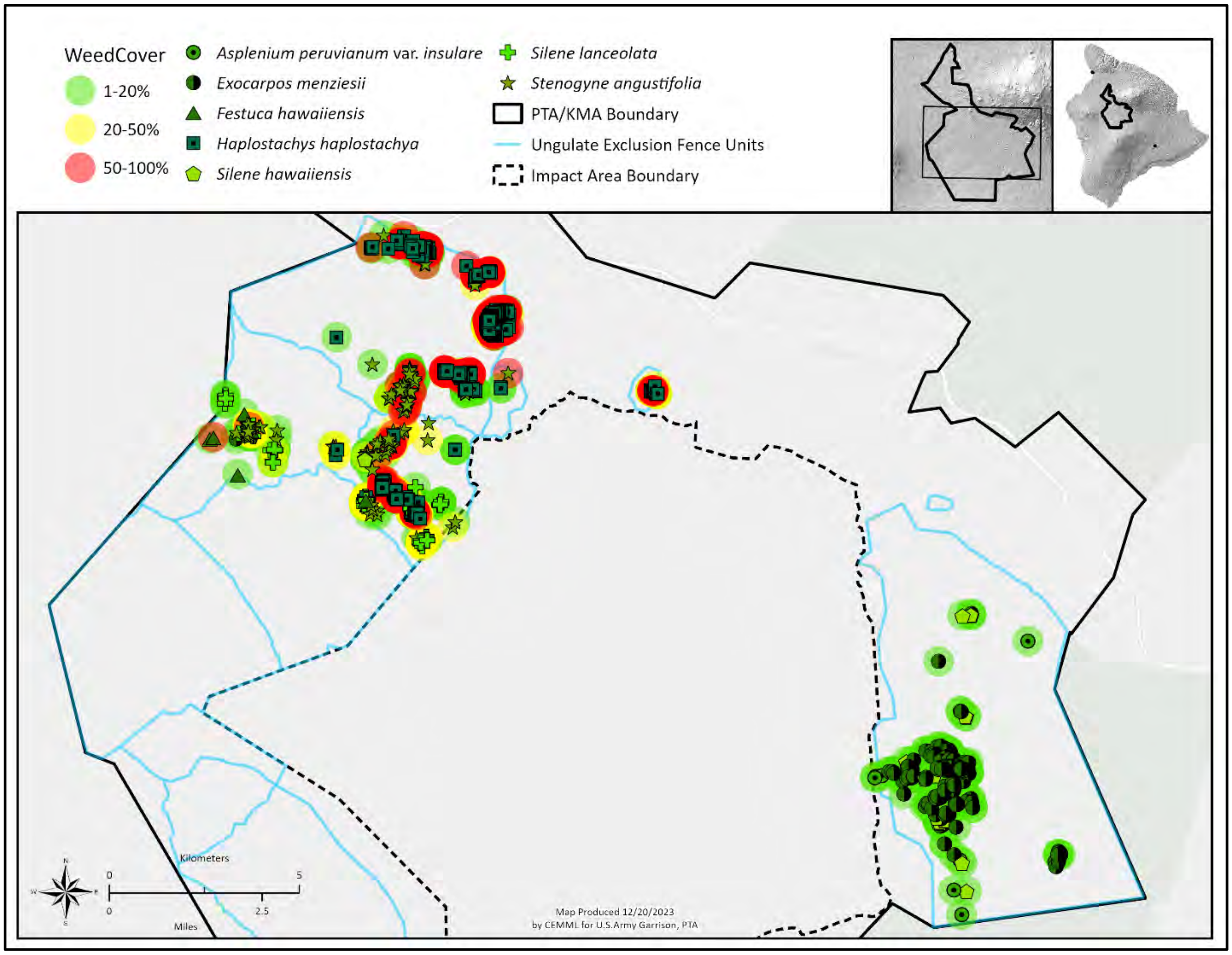


Figure 12. Weed percent cover in 10 x 10 m cells occupied by 1 or more Tier 2 plants

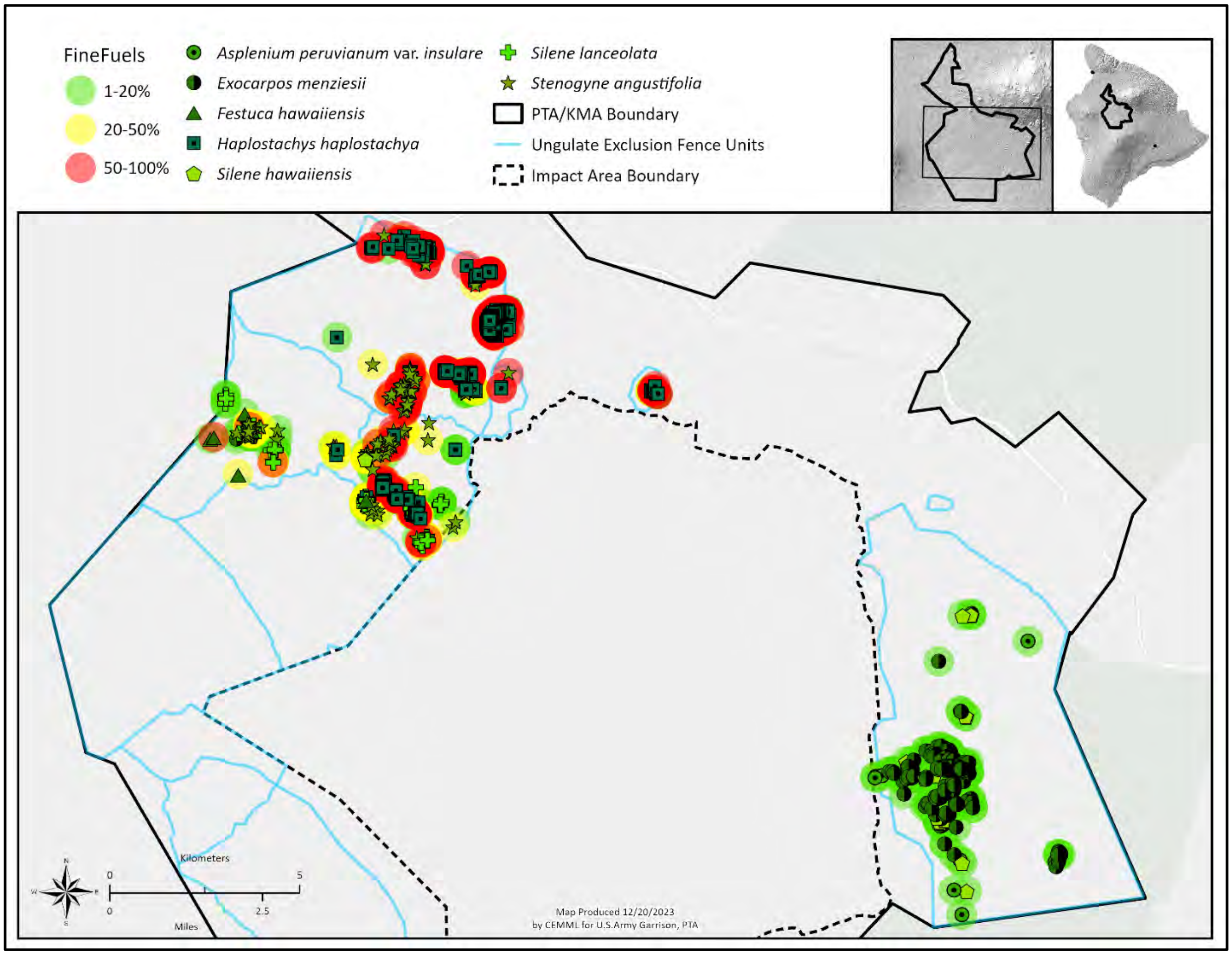


Figure 13. Fine fuels percent cover in 10 x 10 m cells occupied by 1 or more Tier 2 plants

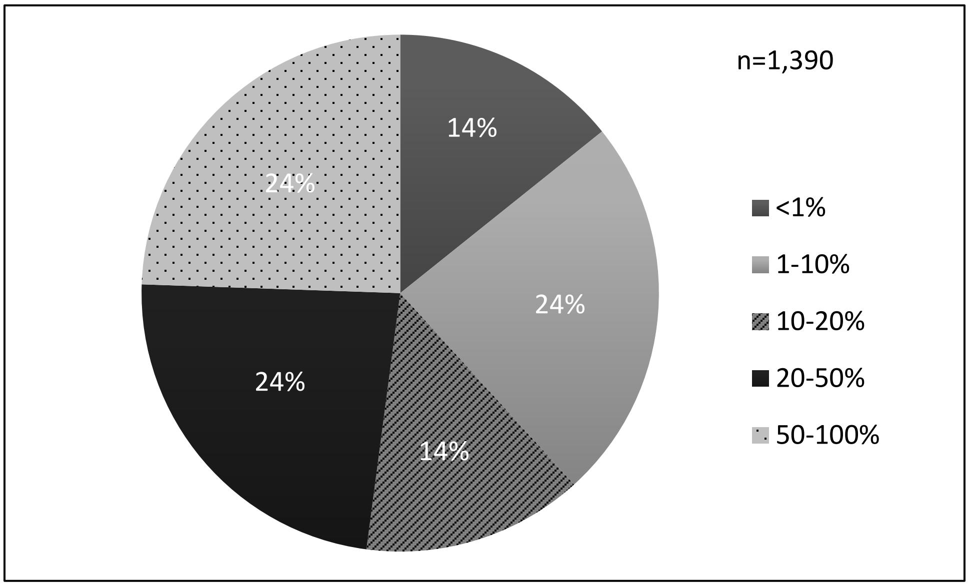


Figure 14. Overall proportion of weed percent cover classes reported for Tier 2 plant locations

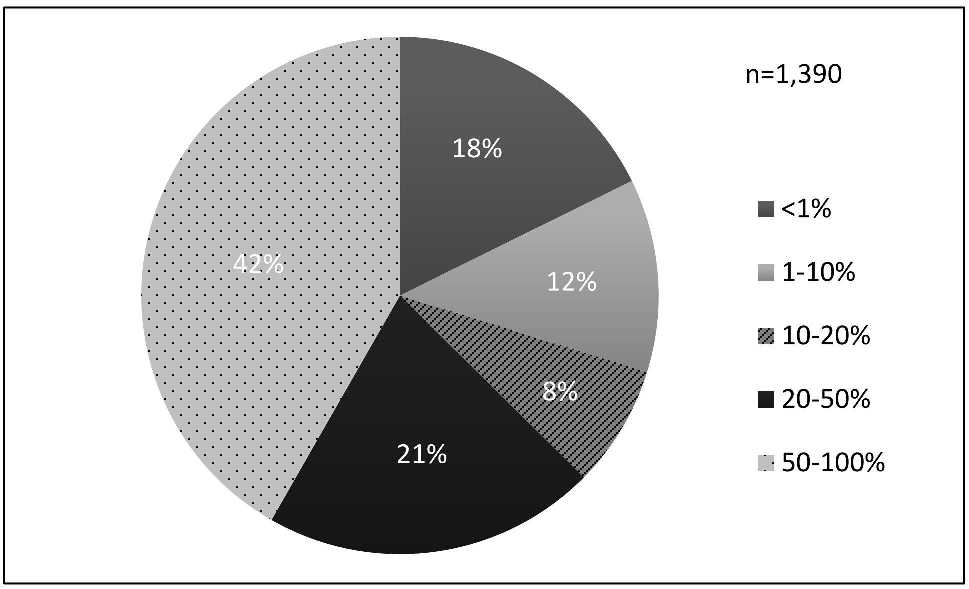


Figure 15. Overall proportion of fine fuels percent cover classes reported for Tier 2 plant locations

Discussion

We implemented a refined monitoring approach in FY 2022 for Tier 2 plant species to estimate their abundance over time. Sampling a portion of the presumed distribution of these species provides an efficient approach to estimating abundance. Future monitoring cycles will enable a complete census of Tier 2 species distributions at PTA, and eventually we will be able to track trends over time. Because our 33% samples are selected from a region, and not a population, we are not able to provide abundance estimates of populations during this reporting period. We anticipate that after 3 years of sampling, we will have finished a complete survey of PTA and can provide numbers of individuals for Tier 2 species at smaller, more biologically relevant scales.

Corrected Abundance Estimates for 6 Tier 2 Species—Errors in Previously Reported Data

In 2023, we discovered an error in the analysis used to estimate abundances for Tier 2 species from previous work. This resulted in inaccurate estimates in several previous reports:

(1) 2019–2021 Biennial Report
(2) 2020 and 2022 Annual Compliance Reports
(3) 2020–2022 Quarterly Progress Reports
(4) 2020, 2021, and 2022 INRMP Update Presentations to Agency Partners
(5) 2020, 2021, and 2022 Recovery Permit Reports
(6) 2023 Post-Disturbance Assessment for the 2022 Leilani Fire in Training Area 22

In summary, due to a required shift in project design during project implementation, key elements of the modified design were not properly accounted for through data extraction and analysis. Appendix B provides a detailed review of the issues and errors, including steps taken to remedy and prevent similar issues in the future. Here we present abundance estimates as originally (incorrectly) reported (Table 7), along with the corrected values (Table 8), and the percent difference in reported abundances (Table 9).

Table 7. INCORRECTLY calculated estimated abundance and 90% confidence intervals for plant species listed under the Endangered Species Act sampled at Pōhakuloa Training Area in 2020

Species	Estimated Abundance	1/2 Confidence Interval	Lower 90% Confidence Interval	Upper 90% Confidence Interval
Exocarpos menziesii	2,068	224.13	1,844	2,292
Festuca hawaiiensis	9,905	1,437	8,468	11,342
Haplostachys haplostachya	24,010	5,336	18,674	29,346
Silene hawaiiensis	9,076	1,125	7,951	10,200
Silene lanceolata	11,772	1,853	9,919	13,624
Stenogyne angustifolia	14,044	3,100	10,945	17,144

Table 8. CORRECTED estimated abundance and 90% confidence intervals for plant species listed under the Endangered Species Act sampled at Pōhakuloa Training Area in 2020

Species	Estimated Abundance	1/2 Confidence Interval	Lower 90% Confidence Interval	Upper 90% Confidence Interval
Exocarpos menziesii	1,875	417	1,458	2,292
Festuca hawaiiensis	11,699	3,334	8,365	15,033
Haplostachys haplostachya	17,215	7,992	9,223	25,206
Silene hawaiiensis	7,479	1,927	5,552	9,406
Silene lanceolata	10,326	3,354	6,972	13,679
Stenogyne angustifolia	12,038	5,354	6,684	17,392

Table 9. PERCENT DIFFERENCE between incorrect and corrected abundance estimates and 90% confidence intervals for plant species listed under the Endangered Species Act sampled at Pōhakuloa Training Area in 2020

Species	Estimated Abundance	Lower 90% Confidence Interval	Upper 90% Confidence Interval
Exocarpos menziesii	-9%	-21%	0%
Festuca hawaiiensis	18%	-1%	33%
Haplostachys haplostachya	-28%	-51%	-14%
Silene hawaiiensis	-18%	-30%	-8%
Silene lanceolata	-12%	-30%	0%
Stenogyne angustifolia	-14%	-39%	1%

Subsequent to these errors, we rebuilt the Botanical Program and have taken necessary steps to more effectively define and design our complex large-scale monitoring projects. We have fully developed these projects and ensured all processes are clearly described, so that goals and objectives can be efficiently and accurately achieved and longer-term organizational-level needs met. New botanical monitoring protocols for Tier 1 and 2 species and outplanted species incorporate detailed Standard Operating Procedures for data collection, QA/QC, management, extraction, and analysis so there is transparency around how we will meet goals with minimal error.

2.2.6 Post-Fire Monitoring—Leilani Fire

In July and August 2022, the Leilani wildland fire occurred at PTA. The fire burned 1,713 ha (4,233 acres [ac], 54%) of the Kīpuka Kālawamauna Endangered Plant Habitat, which comprises 3,177 ha (7,853 ac) in the northwest portion of PTA.

To determine potential impacts of the Leilani Fire on ESA-listed plants at PTA, post-fire monitoring results were compared with the best available pre-fire data. Since the 3 categories of plants (Tier 1, Tier 2, and outplants) were each monitored according to separate protocols both before and after the fire, we provide post-fire monitoring data in separate subsections. Refer to the *Technical Report and Post-Disturbance Assessment, Leilani Fire in Training Area 22 July and August 2022 Pōhakuloa Training Area, Island of Hawaiʻi* (CEMML 2023f) for the complete technical report submitted to USFWS following this fire.

Pre-fire Data Collection Methods for Tier 1 Plant Species

Between 2016 and 2018, we established monitoring plots to encompass all known individuals of each Tier 1 species, except *Zanthoxylum hawaiiense*, which was not considered a Tier 1 species at the time. Monitoring plots were circular with a radius of 5.6 m and total area of 100 m. We marked the plot center with a stake and multiple individuals of given species were sometimes located within a single plot. For each plot, we counted all individuals by life stage (seedling, juvenile, and adult) up to 25 individuals per location and assigned count classes (26–50, 51–100, and >100) where the number of individuals exceeded 25. If new individuals of a Tier 1 species were found outside existing plots, we established new plots for the new locations. The most recent pre-burn monitoring occurred between November and December 2020.

In 2020, we inventoried all known Z. *hawaiiense* locations and tagged all known adult and juvenile trees at PTA. Following this inventory, we categorized *Z. hawaiiense* as a Tier 1 plant species because there were fewer than 500 adult and juvenile plants.

Post-fire Data Collection Methods for Tier 1 Plant Species in the Burned Area

After the fire, in late September 2022, we revisited Tier 1 species plots within the burn area. These plots were last monitored in 2020. In March 2023, we revisited the *Z. hawaiiense* trees located within the burn area that had been tagged in 2020. At each Tier 1 plant species plot and *Z. hawaiiense* location, we counted each juvenile and adult plant found. Seedlings were counted to 25, then assigned to a count class (26–50, 51–100, and >100).

Tier 1 Plant Species Post-fire Monitoring Results

The single wild *K. coriacea* individual present in the burn area in 2020 was found alive in 2022 (Table 10). For *P. sclerocarpa*, before the fire we found 177 adult and juvenile plants across 15 locations and after the fire we found 92 adult and juvenile plants across 14 of the 15 locations, representing a 48% decrease in plants within the burn area (Table 10). We also found 6 seedlings of *P. sclerocarpa* after the fire. Of the 2 *P. villosa* individuals present in the burn area before the fire, 1 was not found (Table 10). A total of 85 *Z. hawaiiense* were present within the burn area prior to the fire compared to 46 trees found after the fire, representing a 45% decrease in total number of trees (Table 10).

Table 10. Pre- and post-fire plant counts by life stage for wild Tier 1 plants within the burn area

	Pre-fire (Jul–Sep 2020)			Post-fire (Sep 2022–Mar 2023)				
Species	**Total**	**Adults**	**Juveniles**	**Total**	**Adults**	**Juveniles**	**Total Post-burn Change**	**Post-burn % Change**
Kadua coriacea	1	1	0	1	1	0	0	0
Portulaca sclerocarpa	177	87	90	92	73	19	-85	-48%
Portulaca villosa	2	2	0	1	1	0	-1	-50%
Zanthoxylum hawaiiense	85	33	52	46	27	19	-39	-45%

Pre-fire Data Collection Methods for Tier 2 Plant Species

The most recent pre-fire sampling of Tier 2 species within the burn perimeter occurred between March 2018 and February 2020 (CEMML 2022a). During this period, a sample of macroplots (250 m x 100 m polygon comprising 10 transects, each 250 m in length and spaced 10 m apart) with known locations for each species was selected at the installation scale. On each macroplot, we counted all individuals by life stage (seedling, juvenile, and adult) up to 25 individuals per stage per location and assigned count classes (26–50, 51–100, and >100) where the number of individuals exceeded 25.

Post-fire Data Collection Methods for Tier 2 Plant Species in the Burned Area

To estimate post-fire abundance of Tier 2 species in the burn area, between November 2022 and February 2023 we randomly sampled 30% of the known distribution of Tier 2 species within the fire footprint. We selected a total of 112 macroplots for sampling. We walked each transect searching for Tier 2 plants and counted/estimated the number of individuals within a 5.6 m radius (100 m^2). The number of individuals was recorded by life stage up to 25 individuals and count classes (26–50, 51–100, and >100) were assigned where the number of individuals exceeded 25.

Tier 2 Plant Species Post-fire Monitoring Results

Paired *t*-tests restrict us to using data from only those macroplots that were surveyed both before and after the fire (24 plots total) yet were more powerful than 2-sample *t*-tests in detecting differences in monitoring data collected before and after the fire (CEMML 2003b). Paired *t*-tests indicate statistically significant decreases ($\alpha \geq 0.1$) between pre- and post-fire mean abundance using one-tailed tests for *S. lanceolata*, *S. angustifolia*, and when all species were combined (Table 11). Differences in pre-fire and post-fire mean abundance for *F. hawaiiensis* and *H. haplostachya* were not statistically significant.

Table 11. Paired *t*-Test for all burn severity classes. Statistically significant values (α ≥ 0.1) are listed in bold

Species	Number of Plots Sampled	Pre-fire Mean	Post-fire Mean	*p* (*T*≤*t*) One-tail
Festuca hawaiiensis	2	23.00	16.50	0.39
Haplostachys haplostachya	5	403.00	185.80	0.11
Silene lanceolata	5	100.60	42.60	**0.05**
Stenogyne angustifolia	12	147.33	17.08	**0.06**
All species pooled	24	180.50	57.50	**0.01**

Monitoring Endangered Species Outplanted Within the Burned Area

We visited all outplanting locations after the fire to document potential impacts of fire to outplanted ESA-listed plants and their progeny. In December 2021 (pre-fire) and 2022 (post-fire) we monitored all outplants, recording the status of all tagged plants (originally planted 2004 to 2019). We included all unmarked adults and juveniles, assuming those plants germinated from seed produced by planted individuals.

Outplant Monitoring Results

Two outplanting areas are located within the fire footprint. *Silene lanceolata* declined by 27 individuals (26%) while S. *incompletum* declined by 5 individuals (30%). There was no net change from before to after the fire in the number of individuals in the outplanting areas for *H. haplostachya*, *K. coriacea*, or *Z. hawaiiense* (Table 12).

Table 12. Pre- and post-fire counts by life stage for outplants within the fire footprint

	Pre-fire (Dec. 2021)			Post-fire (Dec. 2022)				
Species	Total	Adults	Juveniles	Total	Adults	Juveniles	Total Change[a]	% Change
Haplostachys haplostachya	1	1	0	1	1	0	0	0
Kadua coriacea	1	1	0	1	1	0	0	0
Silene lanceolata	102	78	24	75	68	7	-27	-26%
Solanum incompletum	20	19	1	14	10	4	-6	-30%
Zanthoxylum hawaiiense	1	0	1	1	1	0	0	0

[a] Total change/percent change represents differences between pre- and post-fire abundances.

Discussion of Post-fire Impacts to TE Species

Of the Tier 1 management species, post-fire abundance was substantially lower for *P. sclerocarpa* and *Z. hawaiiense.* Of the Tier 2 management species, the lower post-fire mean abundances for *S.*

lanceolata and *S. angustifolia* were statistically significant and the difference in post-fire mean abundance for *H. haplostachya* was approaching statistical significance. Because the pre-fire data for *Silene hawaiiensis* was minimal, we were unable to compare pre- and post-fire mean abundance for this species using statistical *t*-tests. For the single monitoring plot where pre- and post-fire plants counts were available for *Silene hawaiiensis*, we observed an increase in individual plant counts from 9 to 19.

Following the fire, we observed recruitment of *H. haplostachya*, *Silene hawaiiensis*, *S. lanceolata,* and *S. angustifolia* within the burn area on PTA (Figure 16). Although some ESA-listed species can regenerate following fire, repeated burns likely affect their populations negatively and continue to degrade their habitats. The observed differences in post-fire abundances cannot be attributed solely to the Leilani Fire because there was a 2-to-5-year gap in time between pre- and post-fire monitoring efforts. During this time interval other factors, such as drought, rainfall, and natural mortality and recruitment, also likely contributed to the observed differences in abundance.

Figure 16. *Stenogyne angustifolia* resprouting from an underground stolon in an area that was severely burned in the Leilani Fire

2.2.7 Plant Species at Risk (SAR) Monitoring—*Exocarpos gaudichaudii*

Introduction

In addition to ESA-listed plant species, many other uncommon native Hawaiian plants can be found at PTA. Some of these plant species have limited state-wide distributions and low or declining populations and are considered Species at Risk (SAR). Monitoring actions for SAR met SOO Task 3.2.5 and INRMP objectives.

Of the 34 plant species that meet the DoD criteria to be classified as a SAR, *Exocarpos gaudichaudii* is by far the rarest (see Section 1.5.3 for a discussion on how SAR are determined). Besides the approximately 40 individuals currently extant at PTA, fewer than 150 individuals remain on Oʻahu, Molokaʻi, and Maui combined. One other small population exists at Hawaiʻi Volcanoes National Park on Hawaiʻi Island, but its status is unknown. Despite having no federally protected status, given these low population numbers, this plant species is assumed to be at risk of extinction.

Methods

Between February and June 2023, we monitored plants last visited in 2020 and collected fruit with assistance from State of Hawai'i Division of Forestry and Wildlife, Plant Extinction Prevention Program staff. We navigated to known *E. gaudichaudii* locations using previous GPS coordinates. We then tagged the plants with unique numbers and updated the plant's status and tag information in the Species at Risk 2020 database. Nylon mesh fruit collection bags were attached to ripening (green) fruits, which were extracted from the plants 2 to 3 months later (Figure 17).

Results and Discussion

In June 2023, 46 fruits were collected from 12 individuals—an average of 3.8 fruits per individual, ranging from 1 to 16 fruits per individual. Half of the seeds collected were sent to Lyon Arboretum (University of Hawai'i at Mānoa) for long-term storage and the other half were sent to Volcano Rare Plant Facility (University of Hawai'i, College of Tropical Agriculture and Human Resources) for propagation. Mesh bags were placed on 75 to 100 unripe fruits (on 10 individuals) to help protect them from rodent predation and to facilitate fruit collection during subsequent visits (Figure 17).

Of the 65 *E. gaudichaudii* identified during the 2011 to 2015 installation-wide surveys, 24 have since perished, with 8 dying sometime between 2020 and 2023. Many extant individuals exhibit symptoms of old (senescent) age, having a small number of younger shoots sprouting from large tree trunks, with many thick dead branches persisting. We observed 1 juvenile plant near an older tree, suggesting some regeneration is occurring, but motion-sensing camera footage suggests that rodents are eating the seeds (Figure 18). Many fruits have apparent gnaw marks and fruit collection bags have been chewed open as well. We plan to prioritize fruit collection for storage and propagation to manage this species over the next several years.

Figure 17. Nylon mesh fruit collection bag with ripe *Exocarpos gaudichaudii* fruits

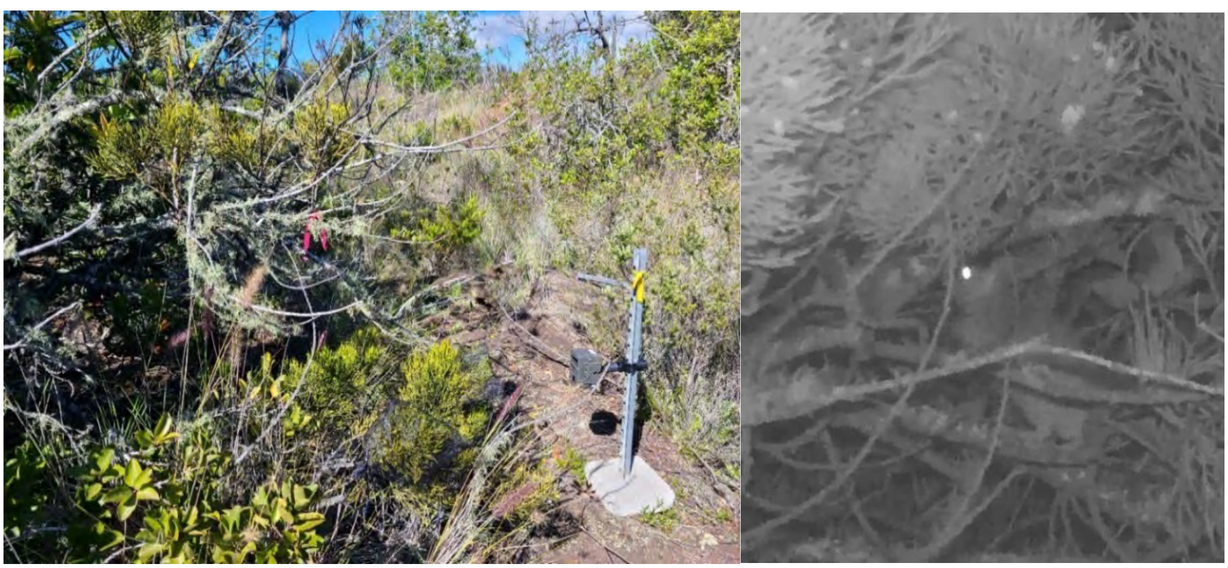


Figure 18. Motion sensing camera captured a rat predating on *Exocarpos gaudichaudii* fruits

2.2.8 Plant Surveys and Monitoring Discussion

Plant monitoring is an important aspect of the Army's Natural Resources Program. Information derived from monitoring informs progress towards INRMP objectives and compliance obligations and provides accurate information on the locations and status of ESA-listed species for installation planning.

Now that individual plants of the Tier 1 species are being tracked over time, we will gain important ecological information that should inform efforts to recover these species via management and outplanting. Although different monitoring methods were used in the past, new and old monitoring data for each species are presented in Section 2.5. After a second cycle using the individual plant-based monitoring protocol for Tier 1 species, we will begin to have multiple sets of data for comparison that were collected consistently and reliably.

Monitoring the Tier 2 species remains a challenge, due to their broad distribution across the landscape as well as the sheer number of occurrences at PTA. However, we improved our monitoring design and made progress toward providing annual estimates of abundance as well as regular census counts at PTA. Although the timeframe for collecting data for the Tier 2 species is longer, we are now on track to eventually compare changes in abundance over time for these species as well.

We plan to implement further threat and vegetation monitoring as resources allow. Understanding the presence and pattern of threats will help us establish meaningful management triggers and increase our management efficiency and effectiveness. Vegetation monitoring is important to understand community-level changes that occur following landscape-level management (e.g., ungulate removal) and disturbance events like wildland fire.

2.3 GENETIC CONSERVATION AND OUTPLANTING

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, 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 2020 PTA recovery permit (TE40123A-3) authorizes genetic conservation and outplanting 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 3.2.1.4, and 3.2.1.5 to: (1) collect and store propagules of ESA-listed plants and common native plants, (2) propagate common and rare plants for outplanting to improve habitats, and (3) increase the distribution and abundances of ESA-listed plants. To conserve and manage the ESA-listed plant genetic resources, 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.

We adopted new data management standards for the tracking and monitoring of plants in the Rare Plant Propagation Facility (RPPF), at outplanting sites, and for wild plants at PTA. Measures were taken to ensure improved tracking and monitoring and include the adoption of new naming conventions. For the new naming convention, we will assign a unique number to every Tier 1 plant (wild and/or outplant) plus every Tier 2 outplant (excluding Tier 2 legacy outplants where the original founders are difficult and/or impossible to correctly identify due to recruitment). Each plant will be tagged with a number (Plant or Founder ID) and an associated scannable bar code, thereby eliminating transcription errors. This naming convention will be applied throughout the Botanical Program to maintain consistency in the monitoring of natural and outplanted plants.

Our 5-year outplanting plan was approved in February 2023 per Army Regulation 200-1. This plan supports INRMP objectives and will support the draft Programmatic Biological Assessment. This outplanting plan provides a general blueprint for species outplanting and their locations through FY 2025.

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 RPPF.
- Maintain founders in the RPPF 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 plant species using demographic monitoring on an annual or other appropriate recurring cycle.
- Propagate common native species.
- For ESA-listed plant species directly affected 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

The genetic conservation strategy for the ESA-listed plants at PTA is generally described in the INRMP and the *Genetic Conservation and Outplanting Plan* (CEMML 2017). The 5-year outplanting plan details new (proposed) outplanting locations and which species will be planted at new and existing locations.

To implement genetic conservation actions, we assigned each of the ESA-listed plant species a genetic conservation implementation priority with 1 being high priority and 5 being low (Table 13). The implementation priority is based on the management tier level (Table 1) and previous outplanting efforts (e.g., the rarest plants with minimal previous outplanting efforts have the highest implementation priority rank). For species with high implementation priorities (1–3), for which even a single small-scale catastrophic event could impact the entire known population or a significant portion, we balance the importance of propagule banking (from both wild plants and living collections in the RPPF), augmentation of wild populations with plantings, establishment of new locations, and habitat improvement. For more abundant species with lower implementation priorities (4–5), we prioritize propagule banking over outplanting.

Table 13. 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 (E)	*Portulaca villosa* (E)
Portulaca sclerocarpa (E)	
Implementation Priority 3	
Neraudia ovata (E)	*Solanum incompletum* (E)
Schiedea hawaiiensis (E)	*Tetramolopium 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

From 2004 to 2019, we established 29 outplanting sites, both on and off PTA (Figure 19). During this period, we planted thousands of individuals of federally listed species and outplant monitoring has been ongoing since the early 2000s (CEMML 2019a and 2020b). In 2023 we renamed the sites established in 2019 to align with pre-existing numbering conventions for outplant sites. These sites were formerly named 2019-Temp 001–009; see Table 22 for a translation between the former and current names for these sites.

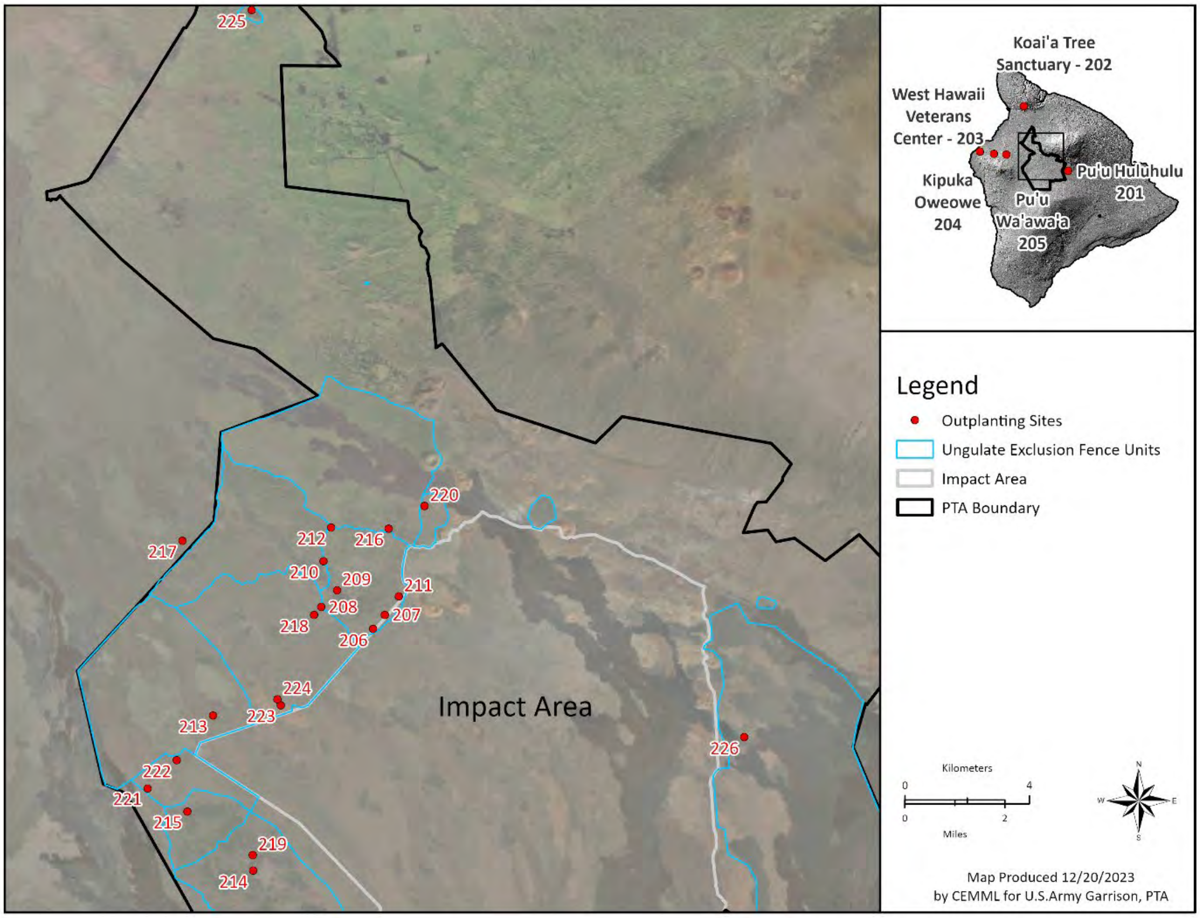


Figure 19. Location of outplanting sites on and off Pōhakuloa Training Area

Per the 2022 to 2025 outplanting plan, we will focus on outplanting sites on Army-controlled lands at PTA. With the goal of establishing self-sustaining populations of ESA-listed plant species at PTA, 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.

We plan to limit outplanting on non-Army controlled lands because there are administrative, regulatory, and spatial constraints to managing plants on lands not under Army authority. However, we plan to maintain the existing sites where plants remain and/or are self-sustaining and we aim to close out all outplanting projects on state lands by the end of 2023.

In addition, upon request we 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.

2.3.2 Genetic Conservation—Propagule Management

We implement several genetic conservation projects that meet SOO task 3.2.1.4 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 (e.g., 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 15 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 genetic resources. 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 and are currently exploring the feasibility of doing so at the Oʻahu Army Natural Resources Program (OANRP) facilities at Schofield Barracks.

We strive to ensure that the ex-situ collections remain viable by withdrawing and replacing seeds based on seed longevity 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.

<u>Propagule Collection Methods</u>

We systematically collect propagules to meet propagation and ex-situ storage needs in accordance with the conditions of the PTA Recovery Permit (TE40123A-3). 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 RPPF 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 RPPF to 1 generation removed from the wild 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, in the past we have used the USFWS source population areas as discrete collection units. However, these source population areas do not necessarily imply biological meaning or genetically distinct populations of rare plants within PTA. In 2023 we distinguished new collection units—all conspecific individuals that are greater than 1,000 meters apart. One or more individuals of a species found greater than 1,000 m from another individual or individuals of the same species were considered their own population and genetic resource collection unit. See Section 2.1 for further details and Sections 2.5 and 2.6 for maps of the populations delimited for each species.

Seed collection is prioritized by species abundance, level of natural recruitment, and current representation in storage. We aim to collect from at least 50 founders from each population, or from the total number of reproductively mature individuals in a population if it is comprised of less than 50 plants. We limit annual collections per conditions of the PTA Recovery Permit (TE40123A-3). We plan frequent, relatively small harvests over multiple years, as recommended in the peer-reviewed literature (Brown and Briggs 1991; Brown and Marshall 1995; Center for Plant Conservation (1991); Guerrant et al. 2004). In any given year, the plants from which seeds or cuttings 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. In addition, leaving sufficient material to maintain the natural seed bank is extremely important in sustaining in-situ population numbers and genetic variability.

For fruit/seed collection, we record the following information: species, location coordinates, date, collector, plant ID (if present), and quantity and type of material collected. We then assign a collection accession number associated with a plant ID (founder number) for Tier 1 species, or to the GPS location of collection (5.6 m radius circle) for Tier 2 species. If a collection is made from a plant in the RPPF or from an outplant in the field, propagation accession numbers are recorded, which link back to the associated collection accession information.

When collecting cuttings, we record the same information as we would for fruits/seeds and consolidate all cuttings taken on a given day from a single founder into a single collection accession. We immediately place the cuttings in moist peat and keep them cool and shaded until processing. Cuttings are prepared (within 24 hours) per propagation methods described below and survivorship is tracked and reported. Similar to fruit/seed collections, cuttings obtained from cultivated plants are associated with the source plant's original propagation accession number.

Propagule Storage Methods

We use propagule banks to store seeds and fruits over the short- and long-term. Propagules are collected and stored separately for each founder—one accession per species per collection event. We track the collection accessions by the source (e.g., natural population vs. cultivated plant) and by the type of propagule (e.g., seeds vs. fruits).

Fruit and seeds are processed as soon as possible following collection. Seeds are cleaned, counted, and dried. We reduce seed moisture (relative humidity) to less than 30% in drying chambers 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. We annually review the seed collection database to ensure adequate propagules and founders are represented and to refresh accessions as needed.

Propagule Collection and Storage Results

During the reporting period we collected propagules (seeds and cuttings) from 8 ESA-listed species. The 16 seeds of *Exocarpos menziesii* were transferred to the OANRP Seed Lab for germination trials. A total of 125 seeds from 5 *I. hosakae* founders were transferred to Lyon Arboretum for long term storage. All the remaining TE propagules were either stored or propagated at PTA (Table 14). In addition, 46 fruits were collected from the non-TE species *Exocarpos gaudichaudii* (see Section 2.2.3 for details).

Table 14. Summary record of propagule collections of plant species listed under the Endangered Species Act at Pōhakuloa Training Area, October 2021–September 2023

Species	Type Collected	Total No. Founders	Total Amount Collected	Disposition
Exocarpos menziesii	Seed	2	16	Propagation at OANRP
Isodendrion hosakae	Seed	16	631	Storage at PTA (5°C)
Lipochaeta venosa	Cutting	29	114	Propagation at PTA
Lipochaeta venosa	Seed	2	44	Storage at PTA (5°C)
Portulaca sclerocarpa	Seed	2	296	Storage at PTA (5°C)
Sicyos macrophyllus	Seed	1	837	Storage at PTA (5°C)
Solanum incompletum	Seed	1	8	Storage at PTA (5°C)
Stenogyne angustifolia	Cutting	1	6	Propagation at PTA
Zanthoxylum hawaiiense	Seed	1	24	Storage at PTA (5°C)

Propagule Collection and Storage Discussion

Collections made during the reporting period fulfilled a variety of purposes: (1) germination trials (*E. menziesii*); (2) increasing a particular founder's representation in our collection (*Portulaca sclerocarpa*, *Solanum incompletum* and *Zanthoxylum hawaiiense*); (3) increase total seed and founder representation in our collection (*Isodendrion hosakae* and *Sicyos macrophyllus*); and (4) cultivating living collections in the RPPF (*Lipochaeta venosa* and *Stenogyne angustifolia*).

The largest number of collections made, having the greatest impact on our ex-situ storage, was for *I. hosakae*. Our storage currently contains 728 seeds (representing 37 founders) collected from 2008 to 2022. In 2023 we added 506 seeds and 14 new founders to our collection. These collections partially offset the 633 seeds that were propagated in 2023, refreshing some of our oldest accessions.

Otherwise, propagule collections were somewhat limited in FY 2022 and FY 2023 due to the pressing need to reassess our existing collections and perform database maintenance and restructuring. We have been able to identify GPS source locations for 95% of our existing seed collections, culled from various legacy documents and sources. As a result, we are now able to more reliably associate collections with their population and individual of origin and can identify collections representing populations and individuals no longer extant. This information will guide future collections necessary to meet our ex-situ storage goals, as well as assist us in balancing founders in future outplanting populations derived from our collections.

We have identified the individuals and populations that are underrepresented in our collections and are continuing to focus on storing adequate representations of each. However, 58% of our ex-situ storage collection is over 10 years old. Since seed viability is known to decrease with age for many of our species, we are refreshing older collections while concurrently using them in seed germination/viability experiments.

After reconciling several different founder numbering systems, we can now more accurately count the number of propagules in storage at PTA by founder and type (Table 15). In addition, we continue to improve current information systems to improve tracking propagules from collection through storage and propagation to outplanting. A new database, built largely on lessons learned from older versions, is expected to be operational in the next fiscal year. We also completed a physical verification of the current inventory and noted storage conditions for each accession.

Table 15. Summary of propagules in ex-situ storage at Pōhakuloa Training Area as of 30 September 2023

Species	Source	Propagule Type	Number of Accessions	Number of Propagules	Total Number of Founders Represented
Asplenium peruvianum var. *insulare*	Wild	Blade	89	130	
	Greenhouse	Blade	94	610	67
Exocarpos menziesii	Wild	Seed	2	497	9
Festuca hawaiiensis	Wild	Seed	7	119	
	Greenhouse	Seed	1	198	
	Outplants	Seed	1	47	10
Haplostachys haplostachya	Wild	Fruit	756	12,032	
	Wild	Seed	96	41,684	
	Greenhouse	Fruit	102	30,354	
	Greenhouse	Seed	9	11,768	860
Isodendrion hosakae	Wild	Seed	62	1,193	51

Table 15. Summary of propagules in ex-situ storage at Pōhakuloa Training Area as of 30 September 2023, (cont.)

Species	Source	Propagule Type	Number of Accessions	Number of Propagules	Total Number of Founders Represented
Kadua coriacea	Wild	Seed	576	132,264	143
Neraudia ovata	Wild	Fruit	93	5,960	
	Greenhouse	Fruit	129	333,469	47
Portulaca sclerocarpa	Wild	Fruit	183	641	
	Wild	Seed	67	34,991	
	Greenhouse	Fruit	11	8,715	99
Portulaca villosa	Wild	Seed	5	22,911	
	Wild	Fruit	4	7	8
Schiedea hawaiiensis	Greenhouse	Seed	6	394,341	4
Sicyos macrophyllus	Wild	Seed	6	837	
	Greenhouse	Fruit	1	200	1
Silene hawaiiensis	Wild	Seed	97	11,425	
	Greenhouse	Seed	3	28,520	97
Silene lanceolata	Wild	Seed	323	478,946	
	Greenhouse	Seed	7	1,043,321	
	Outplants	Seed	3	26,430	307
Solanum incompletum	Wild	Fruit	93	2,505	
	Wild	Seed	15	2,862	
	Greenhouse	Fruit	46	8,879	
	Greenhouse	Seed	5	3,046	
	Outplants	Fruit	1	21	48
Spermolepis hawaiiensis	Wild	Seed	36	3,146	
	Greenhouse	Seed	28	542,196	
	Outplants	Seed	2	5,039	35
Stenogyne angustifolia	Wild	Seed	55	2,175	
	Greenhouse	Seed	18	8,640	
	Outplants	Seed	1	119	53
Tetramolopium arenarium	Wild	Seed	734	108,242	
	Greenhouse	Seed	10	4,822	
	Outplants	Seed	5	8,318	607
Tetramolopium stemmermanniae	Wild	Seed	192	27,583	
	Greenhouse	Seed	3	169,497	
	Outplants	Seed	4	65,838	172
Vigna o-wahuensis	Wild	Seed	104	3,395	
	Greenhouse	Seed	15	32,279	120
Zanthoxylum hawaiiense	Wild	Seed	367	6,270	278

In 2024, we plan to refine our collection goals for each population, refine the process to track progress toward stated targets, continue to evaluate the viability of the older accessions, and determine which collections need to be refreshed. We expect that collection volume will increase in future years now that our seed banking protocols and data structures have been reorientated. We will continue to work closely with the US Army Garrison-Hawaiʻi Natural Resources Program on Oʻahu to assist us in testing seed viability and dormancy here at PTA, and to curate a second ex-situ storage collection at their facility.

2.3.3 Propagation

We implement several projects that meet SOO task 3.2.1.5 and address INRMP objectives and regulatory mandates to increase the distribution and abundance for ESA-listed plant species by establishing new populations or augmenting populations of wild individuals. In addition, we propagate and outplant common native species to improve degraded habitat for ESA-listed plant species.

Propagation Strategy and Methods

For propagation, we withdraw a predetermined number of seeds from the appropriate seed accession or use seeds taken directly from wild plants that have not been stored. Information about the seed accession, the withdrawal, and germination is tracked to establish the provenance of the propagules and the resultant outplants. We track and report propagation and outplanting efforts via a propagation accession number that links to the original collection accession numbers in our database.

Pretreatments may include scarification, soaking, application of gibberellic acid in various concentrations, etc. Depending on specific species' needs, we sow seeds in a variety of sterile media such as agar, wet sand, paper towels, and various combinations of perlite, vermiculite, cinder and peat or coconut coir. After use, media is discarded and not re-used.

Sown seed trays are kept under various environmental conditions, depending on the species' needs.

Seedlings are transplanted into progressively larger pots as they grow to avoid bound roots. We are developing a better tracking system to monitor seedling survivorship and facilitate germination trials.

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 2or 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 cuttings to new pots with a soil mixture. These re-potted cuttings are moved to less-frequent watering regimes as they become more established.

Currently seedlings and cuttings are given an RPPF accession number only once they are large enough to be transferred to 4-inch pots. Most plants are outplanted from 4-inch pots.

In the next fiscal year, we will begin to use our seed germination chamber. This chamber will allow for finer control of environmental conditions and hopefully increase germination success. With the ability to control environmental parameters more accurately during germination, we hope to develop replicable germination protocols for each species, especially for species with low or inconsistent germination success. From past work, species with low seed germination success include: (1) *Haplostachys haplostachya,* (2) *Lipochaeta venosa,* (3) *Neraudia ovata,* (4) *Stenogyne angustifolia*, and (5) *Zanthoxylum hawaiiense*. With the germination chamber, we aim to improve our understanding of dormancy-breaking requirements for these hard-to-germinate species by experimenting using cold scarification. The chamber will also allow us to replicate protocols developed at OANRP's seed lab for conducting germination trials at PTA on our aging collections.

Data collected for propagation include species, founder, date seed/cutting collected, date planted, media used, number of seeds used, treatments used to promote germination, and the date and number of seeds germinated. After receiving training at OANRP's seed lab, in the coming year we hope to set up experiments to compare germination trials and seed treatments systematically and quantitatively. With the currently available germination trial data, we can make qualitative assessments about which treatments warrant further investigation under more controlled and scientific methods.

Propagation Results

Viability testing trials for 6 ESA-listed plant species were initiated at OANRP's seed lab in 2023 using PTA-sourced seed. These trials were set up as part of training received by PTA personnel at OANRP; all resultant plants are being transferred back to PTA for outplanting. The number of seeds and the age of collections tested are listed in Table 16. Germination success for seed accessions sown of *Isodendrion hosakae*, *Lipochaeta venosa*, and *Vigna o-wahuensis* is discussed in Section 2.5.

Table 16. Germination trials for species listed under the Endangered Species Act at Pōhakuloa Training Area, conducted at the US Army Garrison-Hawaiʻi Natural Resources Program on Oʻahu

Species	No. of Accessions Sown	Total No. Seeds Sown for all Accessions	Age of Collections (years)	Average % Germination Rate
Isodendrion hosakae	69	633	4–14	69
Exocarpos menziesii	2	16	0	trial incomplete
Lipochaeta venosa	11	323	4–15	2
Neraudia ovata	4	401	5–18	trial incomplete
Solanum incompletum	5	500	5–22	trial incomplete
Vigna o-wahuensis	10	459	8–14	92

We propagated 2 ESA-listed plant species from seed (Table 17) and 2 ESA-listed plant species from wild-collected cuttings (

Table 18) at PTA's RPPF. Germination rates for seed accessions sown are discussed in the Species Summaries Section 2.5. For propagation performed at PTA, we did not record germination success for *Vigna o-wahuensis* because similarly aged seed accessions sown in trials at OANRP achieved an average 92% germination rate.

Table 17. Seed propagation for plant species listed under the Endangered Species Act at Pōhakuloa Training Area, October 2021–September 2023

Species	No. Accessions Sown	Total No. Seeds Sown for all Accessions	Age of Collections (years)
Kadua coriacea	50	1,330	10–20
Vigna o-wahuensis	7	202	3–12

Table 18. Propagation success for cuttings collected from wild plant species listed under the Endangered Species Act at Pōhakuloa Training Area, October 2021–September 2023

Species	No. Cuttings Collected	No. Founders Collected	No. Cuttings Accessioned	No. Founders Accessioned
Lipochaeta venosa	124	31	34	20
Stenogyne angustifolia	6	1	3	1

We successfully propagated relatively small amounts of cuttings of *Stenogyne angustifolia* to maintain living collections of this species for demonstration purposes. Wild seed collections of *Lipochaeta venosa* have proven to be difficult to accomplish (many of the achenes appear inviable on wild plants). Therefore, we aim to maintain more than 30 founders of this species in living collections at the RPPF, to facilitate cross pollination of flowers for seed production (storage) and propagation of cuttings (outplanting

We also propagated several common native species from seed for use in outplanting to support habitat improvement for *Vigna o-wahuensis* at Puʻu Nohona O Hae (Table 19).

Table 19. Summary of seed propagation for common native Hawaiian plant species, October 2021–September 2023

Species	Approximate No. of Seeds Sown	Type of Collection	Location collected
Argemone glauca	50	bulk	Saddle Road near Puʻu Nohona O Hae
Bidens menziesii	50	bulk	Puʻu Nohona O Hae (ASR 48)
Leptecophylla tameiameiae	250	bulk	Puʻu Pāpapa
Osteomeles anthyllidifolia	700	bulk	Puʻu Pāpapa
Sophora chrysophylla	300	bulk	Nohona O Hae (ASR 48) and Pāpapa
Wikstroemia pulcherrima	100	bulk	Nohona O Hae (ASR 48) and Pāpapa

Discussion for Propagation

Although we have made substantial progress with propagating several ESA-listed plant species, benefitting from the accumulated knowledge and expertise of past horticulturalists at PTA, there is still more to learn to be able to propagate all species reliably and consistently. We will also continue to propagate our oldest seed accessions in germination trials to quantify seed viability reductions over time.

Our success at rooting cuttings of *Lipochaeta venosa* appeared to be as high as 47% at the time of transplanting (2 months post-collection), which is similar to success PTA horticulturalists have had in the past. However, by the time they were accessioned into the RPPF 3 months later, only 27% still survived. The transplants appeared highly susceptible to rot, and probably received too much water (every 24 hours) accompanied by too much sunlight when they were at such a vulnerable stage. In the future, the cuttings will be transplanted first into smaller pots (when possible, given the size of the root system) and watered with a weak vitamin-based fertilizer whenever the pots are dry. We will try keeping the rooted cuttings shaded for a longer period, provided they can still dry out between waterings.

In keeping with our intention to cooperate with outside agencies in the propagation of ESA-listed species, we have received USFWS and US Army Garrison, Pōhakuloa Training Area approval to transfer seeds and plants of *H. haplostachya*, *I. hosakae, N. ovata*, *P. sclerocarpa*, *S. incompletum*, *S. lanceolata*, *S. angustifolia*, and *Z. hawaiiense* to the State of Hawaii Department of Land and Natural Resources, Division of Forestry and Wildlife. We transferred 45 *P. sclerocarpa* plants from PTA's RPPF in FY 2023, with more seed transfers of additional species planned in the coming years.

In addition to the propagation of seeds during this reporting period mentioned above, we maintain ESA-listed plants in the RPPF that were propagated and accessioned in previous years (Table 20). Note that 34 of the 35 *Lipochaeta venosa* and 3 of the 3 *Stenogyne angustifolia* accessioned into the current inventory were germinated/rooted during FY 2023.

Table 20. Rare Plant Propagation Facility inventory of plants listed under the Endangered Species Act accessioned as of 30 September 2023

Species	Total No. of Founders Represented	Total No. of Plant Accessions
Exocarpos menziesii	4	15
Festuca hawaiiensis	1	1
Haplostachys haplostachya	1	1
Isodendrion hosakae	19	60
Kadua coriacea	9	67
Lipochaeta venosa	21	35
Neraudia ovata	3	7
Portulaca villosa	3	34
Schiedea hawaiiensis	1	1
Sicyos macrophylla	1	5
Silene hawaiiensis	1	11
Silene lanceolata	1	1
Solanum incompletum	4	4
Stenogyne angustifolia	1	3
Tetramolopium arenarium	1	1
Vigna o-wahuensis	17	235
Zanthoxylum hawaiiense	2	7

2.3.4 Outplanting

Outplanting Strategy and Methods

The outplanting strategy is generally described in the INRMP and the *Genetic Conservation and Outplanting Plan* (CEMML 2017).

To initiate an outplanting site, we evaluate the management needs of the selected site (weed control, habitat improvement, and ESA-listed species outplanting) and develop a site-specific plan and 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—outplant the propagated plants from Phase 2; and Phase 4—outplant 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 consider future climate projections when selecting species.

We inspect all plants before transporting them to the field and outplant only healthy specimens. We typically outplant to take advantage of fall and winter weather conditions (e.g., greater likelihood of rain). We select appropriate 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 planting holes and to guide soil amendments and watering. We follow the Hawaiʻi Rare Plant Restoration Group (HRPRG) guidelines for phytosanitation to reduce the possibility of introducing pests to the outplanting site. Each outplant is tagged at its base. Outplants are watered weekly for a period of 4 to 6 weeks. We inspect plants weekly and manage emerging problems as appropriate.

Outplanting Results

In March 2023 we planted 114 *Solanum incompletum* at site 209 and 24 *Vigna o-wahuensis* at site 225. The *S. incompletum* were growing in 1-gallon containers and 106 of 111 plants were associated with founder information (seed sourced from 16 wild ASR 24 founders); the 5 others had a founder labeled as *unknown*. The *V. o-wahuensis* were also growing in 1-gallon containers, mostly greenhouse volunteers with no known founder information. Six of the 24 plants had founder information associated with them and the seed was originally sourced from 3 wild Puʻu Nohona O Hae founders; 1 located in ASR 48 and 2 located in ASR 45.

In addition, we planted 120 individuals of *Metrosideros polymorpha* and 23 individuals of *Pittosporum terminaliodes* (both non-ESA species; founder information unknown) in an area of Kīpuka Kālawamauna West Fence Unit that was severely affected by the 2022 Leilani Fire.

Outplant Monitoring

Federal and state permits require annual monitoring for outplanted individuals, regardless of the assigned management tier. From 2004 to 2019, we established 29 outplanting sites, both on and off PTA (Figure 19). During this period, we planted thousands of federally listed individuals and outplant monitoring has occurred since the early 2000s (CEMML 2019a and 2020b).

However, for legacy outplanting sites (established between 2004 to 2014), annual monitoring was not designed to track individual plants over time. Monitoring was conducted intermittently and determining if remaining plants are the original outplants or individuals that germinated from seed on site (recruitment) is difficult. Therefore, we do not attempt to calculate outplant survivorship for the plants remaining at these legacy outplanting sites, but instead report the 2022–2023 outplant monitoring results as the number of each species present by life stage (adults, juveniles, and seedlings) at each outplanting site at PTA. These numbers are compared with the numbers obtained at these outplanting sites using a similar monitoring protocol during the previous 3 years.

For plantings after 2014 (ASRs 221–226), we tagged all outplants with a unique RPPF accession number. In 2023 we augmented site 209 (established prior to 2014) with additional plantings. Apart from the 2023 planting at ASR 225, no additional planting has occurred at ASRs 221–226 following 2019. For plants at these sites, which were tagged and tracked appropriately, we can reliably calculate annual survivorship and present the 2023 monitoring results separately for these sites. We can also identify which plants are the original outplants, and which are recruits (seedlings originating from an outplant).

Methods

From December 2022 to June 2023, we monitored federally listed species at 12 of the 20 legacy outplanting sites, sites that were established at PTA prior to 2014. Monitoring efforts since 2019 have consistently reported no plants found at sites 202, 208, 210, 212, and 216–218; these sites were not checked during this report period.

At sites planted before 2014, we navigated to historically known Tier 1 species plant locations and counted individuals by life stage (seedling, juvenile, adult). At Tier 2 plant locations we counted individuals by life stage up to 25 and assigned count classes when the number of individuals exceeded 25 (25–50, 51–100, and >100). Similarly, for seedlings of both Tier 1 and Tier 2 species, we counted all individuals up to 25 and assigned count classes when the number of individuals exceeded 25. When calculating the total number of individuals by life stage at a site, count classes are converted to the minimum value for the class (25, 51, or 101). All juvenile and adult individuals of Tier 1 species were given a tag and an identification number. At legacy sites we can't distinguish recruits from outplants, but with future outplantings when we are more certain of a plant's origin, we will quantify recruitment and track the number of generations that become established.

For sites established for Tier 1 species in 2019, we collected the same data and used similar count methods for all life stages, as described above. We also counted (and tagged) all previously untagged adults and juveniles when found and assumed that these plants germinated from seed produced by the planted individuals (i.e., recruits). Outplantings in March 2023 were not scheduled for monitoring in FY 2023.

Results

Monitoring data were collected consistently between 2019 and 2023 and the percent change in numbers of adults and juveniles is presented in Table 21. Percent change for each species by outplanting site is presented in the species summaries (Sections 2.5 and 2.6). While a few species showed increases at some sites, most species declined at most sites. In several instances, outplanted individuals were reported missing and then found again in subsequent years, which accounts for some of the positive changes in the number of outplants between years. In other instances, recruitment is occurring, which increases the numbers.

Table 21. Monitoring results from 2019 to 2023 at legacy outplanting sites (established between 2004–2014). Annual counts are total number of adults plus juveniles (including recruits) observed per year; number of seedlings reported in parentheses

Site No	Species	Total Planted[a]	Nov 2019	Nov 2020	Dec 2021	Feb 2022–March 2023	% Change 2019–2022
201	*Asplenium peruvianum* var. *insulare*	7	0	0	1	1	+100%
	Isodendrion hosakae	3	0	0	0	1	+100%
	Lipochaeta venosa	2	0	5	0	3	1.5
	Neraudia ovata	114	3	4	3	3	0%
	Schiedea hawaiiensis	259	12	13	11	14	+17%
	Silene lanceolata	51	29	4	29	13	-55%
	Solanum incompletum	455	62	45	43	56	-10%
	Stenogyne angustifolia	121	21	80	21	71	2.4
	Zanthoxylum hawaiiense	2	0	0	0	0	0%
203	*Isodendrion hosakae*	4	0	1	0	0	0%
204	*Neraudia ovata*	42	2	4	1	1	-50%
	Silene lanceolata	199	1	0	0	0	-100%
	Solanum incompletum	225	7	10	7	7	0%
205	*Isodendrion hosakae*	44	15	13	19	7	-53%
	Kadua coriacea	316	16	7	4	3	-81%
	Lipochaeta venosa	234	104	33	15	11	-90%
	Neraudia ovata	132	15	13 (4)	11	10	-33%
	Schiedea hawaiiensis	374	4	1	0	0	-100%
	Silene lanceolata	340	27	2	0	0	-100%
	Solanum incompletum	406	18	9	1	1	-94%
	Stenogyne angustifolia	78	103	9	3	3	-97%
	Vigna o-wahuensis	47	2	2	0	0	-100%
	Zanthoxylum hawaiiense	22	10	12	11	7	-30%
206	*Neraudia ovata*	4	1	1	1	1	0%
	Schiedea hawaiiensis	24	31	26	8	9	-71%
207	*Schiedea hawaiiensis*	5	5	4	0	0	-100%
209	*Solanum incompletum*	40	27	29 (1)	19	14	-48%
211	*Haplostachys haplostachya*	32	1	1	1	1	0%
	Kadua coriacea	20	1	1	1	1	0%
	Silene lanceolata	59	409	210	102	75	-82%
	Zanthoxylum hawaiiense	2	1	1	1	1	0%
213	*Neraudia ovata*	54	56	58	59 (2)	50	-7%
	Schiedea hawaiiensis	14	1	0	8	5	+500%
	Silene lanceolata	3	6	22	13	10	+67%
	Solanum incompletum	21	25	23	24	24	-4%
	Zanthoxylum hawaiiense	4	2	2	2	1	0%

Table 21. Monitoring results from 2019 to 2023 at legacy outplanting sites (established between 2004–2014). Annual counts are total number of adults plus juveniles (including recruits) observed per year; number of seedlings reported in parentheses (cont.)

Site No	Species	Total Planted[a]	Nov 2019	Nov 2020	Dec 2021	Feb 2022–March 2023	% Change 2019–2022
214	*Festuca hawaiiensis*	7	86	40	40	3	-97%
	Haplostachys haplostachya	95	2	3	1	0	-100%
	Isodendrion hosakae	7	3	4	4	4	+33%
	Schiedea hawaiiensis	69	25	12	23	3 (26)	+12%
	Silene hawaiiensis	10	6	6	3	4	-33%
	Silene lanceolata	75	637	462	243	235 (7)	-63%
	Solanum incompletum	170	320	271	297 (12)	462 (378)	+44%
	Spermolepis hawaiiensis	21	2	0	0	0	0%
	Stenogyne angustifolia	30	83	85	75	83	0%
	Tetramolopium stemmermanniae	139	—	278	207 (72)	263 (146)	-5%
215	*Neraudia ovata*	12	1	1	1	1	0%
219	*Asplenium peruvianum* var. *insulare*	23	4	72	4	2	-50%
	Haplostachys haplostachya	18	9	8	6	6	-33%
	Schiedea hawaiiensis	5	3	11 (14)	85 (80)	69	+2000%
	Solanum incompletum	4	4	16	36	28 (9)	+75%
220	*Silene lanceolata*	24	0	38	29 (1)	27 (7)	27.0
	Solanum incompletum	3	2	2	0	0	-100%
	Zanthoxylum hawaiiense	3	1	1	1	1	0%

[a] The data source for total planted is CEMML 2015. This is a cumulative total of all plants planted at that site between the years 2004 and 2014.

We report results separately for the sites established in 2019 because the monitoring was designed to track annual and overall survivorship (Table 22). This is possible because all individuals planted were tagged and no additional planting has occurred at these sites. No recruitment or seedlings were observed at any of these sites. Overall survivorship varied among species and sites. Net survivorship for each species by outplanting site is presented in the species summaries (Sections 2.5 and 2.6).

Table 22. Annual monitoring results for plant species listed under the Endangered Species Act outplanted at Pōhakuloa Training Area, March–April 2019. Counts are total number of adults plus juveniles (including recruits) observed; number of seedlings reported in parentheses

New Site Name	Old Site Name	Species	Total Planted	Nov 2019	Mar 2020	Dec 2021	August 2022 to August 2023	Survivorship[a]
221	Temp 2019-001	*Kadua coriacea*	18	6	6	4	2	11%
222	Temp 2019-002	*Kadua coriacea*	20	14	10	6	2	10%
223	Temp 2019-003	*Kadua coriacea*	21	11	11	9	9	43%
223	Temp 2019-003	*Portulaca sclerocarpa*	18	12	9	3	3 (2)	17%
224	Temp 2019-004	*Kadua coriacea*	24	24	24	15	14	58%
225	Temp 2019-005	*Lipochaeta venosa*	16	13	14	4	1	6%
225	Temp 2019-005	*Vigna o-wahuensis*	11	2	0	1	0	0%
None	Temp 2019-006	*Kadua coriacea*	4	1	0	0	0	0%
None	Temp 2019-007	*Kadua coriacea*	9	3	3	0	0	0%
None	Temp 2019-008	*Kadua coriacea*	7	3	2	0	0	0%
226	Temp 2019-009	*Kadua coriacea*	4	3	3	3	1	25%
226	Temp 2019-009	*Neraudia ovata*	9	4	3	3	3	33%
226	Temp 2019-009	*Schiedea hawaiiensis*	2	1	2	1	1	50%

[a] The percent survivorship value is calculated by dividing the number of plants remaining in 2022-2023 by the initial number of plants planted in March/April 2019 for each species at each site and does not include recruits.

Outplanting Discussion

For outplantings that occurred prior to 2014, monitoring efforts did not always track individual plants. As a result, in many cases we cannot positively identify whether any original outplants remain. However, we can evaluate the net change between the total number of each species planted at the site and the number of each outplanted species remaining at the sites (outplants and recruits).

For most species, especially the Tier 1 species, the number of individuals remaining at the sites is a small fraction of what was planted (Table 21 and Table 22). A few exceptions exist, the most notable being the relative success of *S. incompletum.* Most plantings of this species have maintained or increased themselves by recruitment—as much as a 2-to-8-fold increase in numbers has occurred at ASRs 214 and 219. Some of this apparent increase may be a result of vertical growth originating from roots (suckers), but this can't be proven without causing the plants substantial harm. Either way, the original outplants are thriving, even if not reproducing to the extent suggested by the monitoring data.

Tetramolopium stemmermanniae has also been successful at establishing itself at ASR 214—the number of plants has almost doubled from the time they were planted 10 to 20 years ago through the most recent monitoring completed in 2022.

Schiedea hawaiiensis has been known to produce similar increases via recruitment (as is currently occurring at ASRs 214 and 219) only to later crash in numbers (as was observed in the past at ASRs 206 and 207). We do not know the cause of the decline, but many threats to these plants exist at PTA including rodents, introduced insects, game birds, and drought. We will continue to monitor these outplants and to control threats at all locations.

Another example of our success has been with *S. lanceolata*; however, this Tier 2 species is also doing well across its naturally occurring distribution at PTA and future outplanting will likely be unnecessary to maintain or increase the abundance of this species. Evidence of recruitment for *Silene lanceolata* is not surprising, as this species readily reproduces in open areas when conditions are favorable (CEMML 2015). The exception to our success with this species has been at ASR 204—which receives considerably less rainfall and is at a much lower elevation than the other sites, as well as the sites of wild occurrences of this species on Hawaiʻi Island.

For the plants planted in March/April 2019, we can more closely track individuals. Over the course of 4 years, all species have declined at all sites. Survivorship for each species between the sites was variable. For example, *K. coriacea* declined by more than 50% within 6 months of planting at 4 of 8 sites. However, monitoring conducted between 2022 and 2023 showed that *K. coriacea* survivorship is ≥ 25% at only 3 of 8 sites (Table 22).

We continued to see challenges with planting *P. sclerocarpa, Lipochaeta venosa* and *V. o-wahuensis*, although the sample size (i.e., total number of plants outplanted) is low. *P. sclerocarpa* showed a steady decline in each monitoring period with an overall survivorship of 9% (March 2019 through December 2022). In past planting efforts, we did not successfully establish *P. sclerocarpa* at any of our outplanting sites (CEMML 2016), possibly due to taproots being damaged during transplanting. Within 6 months after planting, only 2 of 11 *V. o-wahuensis* plants remained, before they disappeared completely the following spring (2020). In 2021, a single *V. o-wahuensis* was located but this plant was believed to be a recruit. A similar pattern occurred with the *Lipochaeta venosa* plantings at that site. Historically, we have had little success with these 2 species persisting at outplanting sites, but this is probably correlated with the low numbers of outplants and the ephemeral nature of these species in their naturally occurring habitat. Future plantings will concentrate much larger numbers of individuals in each site, more closely resembling the density we see in the wild population during a particularly wet season. Because these species are capable of flowering and setting seed within their first year, we hope to quickly build up a large seed bank for future recruitment on site.

2.3.5 Genetic Conservation and Outplanting Discussion

Ex-situ storage of propagules is an effective and efficient means to safeguard the genetic resources 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 wild populations or 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 some seeds that are freeze sensitive have been stored in the freezer for over 10 years. In addition, many of these collections in storage are over 10 years old and the viability of the seed is likely decreasing. In 2019, we implemented new procedures for seed processing and now all seeds are removed from the fruit, dried to less than 30% moisture, and sealed in foil packets prior to storage. We will partner with the USAG, Hawaiʻi (USAG-HI) NRP on Oʻahu for storage of future collections in -50°C freezers under optimal long-term conditions, fulfilling a requirement to establish backup collections of seeds off site.

In FY 2024 we will begin using our seed germination chamber, for which our staff received training at the OANRP Seed lab during FY 2023. With the growth chamber, we will be able to control environmental parameters more accurately during germination and hopefully develop replicable germination protocols for each species, especially for those with low or inconsistent germination success. From past work, species with low seed germination success include: (1) *Haplostachys haplostachya,* (2) *Lipochaeta venosa,* (3) *Neraudia ovata,* (4) *Stenogyne angustifolia*, and (5) *Zanthoxylum hawaiiense*. With the germination chamber, we aim to improve our understanding of dormancy-breaking requirements for these hard-to-germinate species. In FY 2024, we plan to conduct germination trials on fresh wild-collected seed of *Haplostachys haplostachya* to determine if temperature scarification influences seed germination. The use of this chamber will also facilitate our replication of germination trial protocols developed at the OANRP Seed lab, and we plan on systematically testing the viability of our oldest accessions concurrent with the process of producing plants for outplanting.

Per the priorities laid out in the *Genetic Conservation and Outplanting Plan* (CEMML 2017), our focus for 2024 to 2025 will be on establishing new populations in KMA for *I. hosakae*, *L. venosa*, and *V. o-wahuensis.* Propagation of these species in the RPPF is currently underway, timed for outplanting during the rainy seasons of 2024 and 2025. In addition, *Sicyos macrophyllus* seedlings currently in the RPPF will be used to augment the wild population at ASR 251. We will translocate *I. hosakae*, *L. venosa*, and *V. o-wahuensis* between Puʻu Pāpapa and Puʻu Nohona O Hae (and between ASRs on Nohona O Hae) if that species was not known to previously occur in the immediate vicinity. Since these 3 species have shown the potential to produce many recruits, being able to track different genetic lineages of outplantings over time may not be possible. This translocation strategy will ensure we will be able to positively identify wild vs. outplanted individuals in the future and is necessary to maintain the integrity of the limited genetic resources available for these species. We will continue to plant common native species to restore habitats at KMA sites, particularly at ASR 45 on Nohona O Hae, which is degraded habitat dominated by fountain grass.

The numbers of wild individuals per population for *I. hosakae*, *L. venosa*, and *V. o-wahuensis* (Implementation Priority 1 species; Table 13) are often above USFWS recovery targets. On the other hand, the numbers of wild individuals per population for Implementation Priorities 2–3 species like *Kadua coriacea*, *Neraudia ovata*, and *Solanum incompletum* are much lower. Therefore, we plan on augmenting existing wild populations of these species, as outlined in the Outplanting plan. We plan on augmenting wild populations of *K. coriacea* in discrete areas (separate from wild plants) not currently occupied, mixing propagules of various founders from the population endemic to that area. The *K. coriacea* seeds have already germinated and are slated for planting in FY 2024. We plan on propagating the other 2 species early in FY 2024, with planting scheduled for FY 2025.

Currently, we are in the process of closing out the outplanting projects at Puʻu Waʻawaʻa and Puʻu Huluhulu. To minimize the future management burden to our state partners, we are allowing the sites to return to a similar composition as the communities surrounding the sites. We submitted reports detailing the planting history and remaining plants for Puʻu Waʻawaʻa and Puʻu Huluhulu and will meet with our state partners on-site in FY 2024 to discuss an acceptable exit strategy.

2.4 PUʻU NOHONA O HAE RESTORATION PROJECT

2.4.1 Introduction

Vigna o-wahuensis is an extremely rare federally endangered plant species that occurs at Puʻu Nohona O Hae, an ungulate-free fenced unit in the Keʻāmuku Maneuver Area (KMA) at PTA. Unknown factors are driving an apparent reduction in the distribution of this species. Because of the highly ephemeral nature of *V. o-wahuensis*, definitively documenting declines in abundance is extremely difficult.

Puʻu Nohona O Hae harbors the largest of the 5 remaining *V. o-wahuensis* populations in the State of Hawai'i, distributed across approximately 8.1 ha on the Puʻu. However, the habitat on the Puʻu has continued to decline as invasive grasses, especially *Cenchrus setaceus*, continue to degrade the native *Dodonaea viscosa* shrubland alliance. The *V. o-wahuensis* population on the Puʻu has fluctuated greatly in numbers of individuals since the Army began tracking the population in 2001, ranging from 0 to 490 individuals. Statewide, only 10 to 12 other individuals exist of this species. We are aiming to maintain at least 75 mature individuals within the Puʻu Nohona O Hae population by improving the native shrubland habitat. Monitoring efforts throughout our management project will address how changes in community structure may affect *V. o-wahuensis* survival and persistence.

We will eventually manage 3 ha total, but started with a single ha in 2022 and 2023, which is referred to as site 1. The management objectives for the project are as follows:

(1) Maintain restoration site at less than 20% combined cover of non-native, invasive species.
(2) Increase native plant species richness by 5 to 10 species at the site through natural regeneration and by outplanting.
(3) Achieve and maintain a minimum of 80% native shrubland cover and have each structural layer dominated by native species.
(4) Maintain the population of *V. o-wahuensis* within the restoration site above 75 mature individuals during the annual spring census.

(5) Establish at least 25 juvenile or adult individuals of each of the following TE species: *Isodendrion hosakae, Kadua coriacea, Portulaca sclerocarpa, Lipochaeta venosa,* and *Sicyos macrophyllus.*

2.4.2 Restoration Site Monitoring

To assess progress towards meeting project management objectives 1 through 3, vegetation within restoration sites will be monitored annually using plots systematically and randomly placed within each 1 ha site. Each site contains 40 monitoring plots, each 10 m x 25 m (Figure 20). Monitoring plots shaded in green represent a ~32% systematic random sample (n=13). Dotted lines bisecting the monitoring units are the transect segments used for point intercept data collection. The baseline (pre-management) monitoring data were collected in these plots in October 2022. Data to assess management objectives 4 and 5 will be collected annually during Individual plant-based monitoring (see Section 2.2.3).

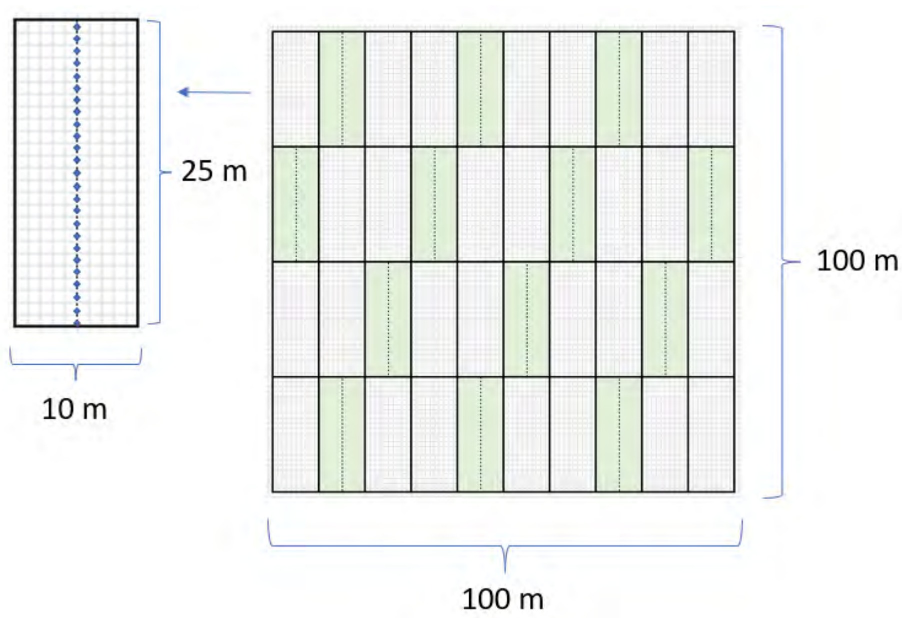


Figure 20. Vegetation monitoring units shaded in green with monitoring transects shown as a dotted line

2.4.3 Restoration Site Management

<u>Invasive Plant Removal</u>

In November 2022, we started to manage the first of 3 planned hectares at Nohona O Hae (i.e., site 1). We started a phased approach to remove non-native plants by avoiding areas where *V. o-wahuensis* was germinating from the seedbank, and where older plants were thoroughly entangled with *C. setaceus*.

V. o-wahuensis plants were located and flagged prior to invasive plant removal. Within 1 m of *V. o-wahuensis* plants, *C. setaceus* was hand cut to approximately 0.3 to 0.6 m high, with the grass left taller the closer it was to a flagged plant. In cases where *V. o-wahuensis* was climbing on grass, the grass was not cut. Outside of the 1 m safeguard, non-native plant species were cut with brush cutters to a height between 10 and 20 cm.

We applied herbicide to regrowth of non-native species approximately 3 to 4 weeks after cutting as follows: (1) applied herbicide (glyphosate in a 1.5 to 2% concentration) to non-native species within 1 m of *V. o-wahuensis* using hand-held pump sprayers or other approved method (e.g., sponges) to avoid herbicide drift, (2) apply herbicide to grass >1 m from *V. o-wahuensis* with backpack sprayers. After the initial spraying, glyphosate herbicide was applied to regrowth once a month (January through June 2023). We also used triclopyr (100% concentration) with a cut drip application to *Melilotus alba* that had heavily invaded the site following removal of the *C. setaceus*.

Native plant augmentation

A large proportion of the site was relatively sparse shrubland at the outset of the project, and we wanted to avoid erosion and exposure issues that might stem from reducing vegetation cover too rapidly. In December 2022, we began to augment the native plant community in site 1 with native species known to occur on a similar aspect of nearby Puʻu Pāpapa, as well as the northern gulch of Puʻu Nohona O Hae, using plants (seeds) sourced from those 2 areas (*Osteomeles anthyllidifolia*, *Santalum paniculatum*, *Sophora chrysophylla*, and *Wikstroemia pulcherrima*). *Erythrina sandwicensis* was sourced from a tree that once occurred on the highway near Nohona O Hae, well above the drier lowland habitat it usually inhabits. *Euphorbia multiformis* was also planted, using seeds sourced from the closest known population in lower Kīpuka Kālawamauna. A total of 80 individuals of these 6 species were outplanted in 2022, with 300 to 400 more individuals of 4 of these same species (plus the addition of *Leptecophylla tameiameiae*) planned for outplanting in 2024 to 2025.

2.4.4 Point intercept (Canopy Cover) and Species Richness Estimations

Monitoring Methods

Data was collected from the base of the transect line (northeast) to the end of the line (southwest). Photographs of plots were taken, with the bottom of the base transect stake in the bottom center of the photo, and the camera held at approximately 1.5 m off the ground. At each 1 m interval along the transect, starting at 0.5 m and ending at 24.5 m, an intercept pole was held level and perpendicular to the horizon against the transect line, with the bottom of the pole touching the ground. We recorded each species that contacted the intercept pole between 0–0.5 m, 0.5 m–1 m, and 1–2 m. Other species found within the plot (5 m on either side of the transect) that were not observed during the transect survey were recorded. This process was repeated for all 13 monitoring plots.

Results

Baseline monitoring data was collected in 2022 before weed management commenced and approximately 1 year later in 2023. Point intercept data was used to estimate the percent cover of native vs. non-native species within each canopy layer (0–0.5 m and 0.5–1.0 m). Non-native species far outnumbered native species in 2022, with a large reduction in 2023 (Figure 21). We recorded intercepts for individual species by strata in both 2021 and 2023 and estimated the canopy cover for each species (Figure 22 and Figure 23).

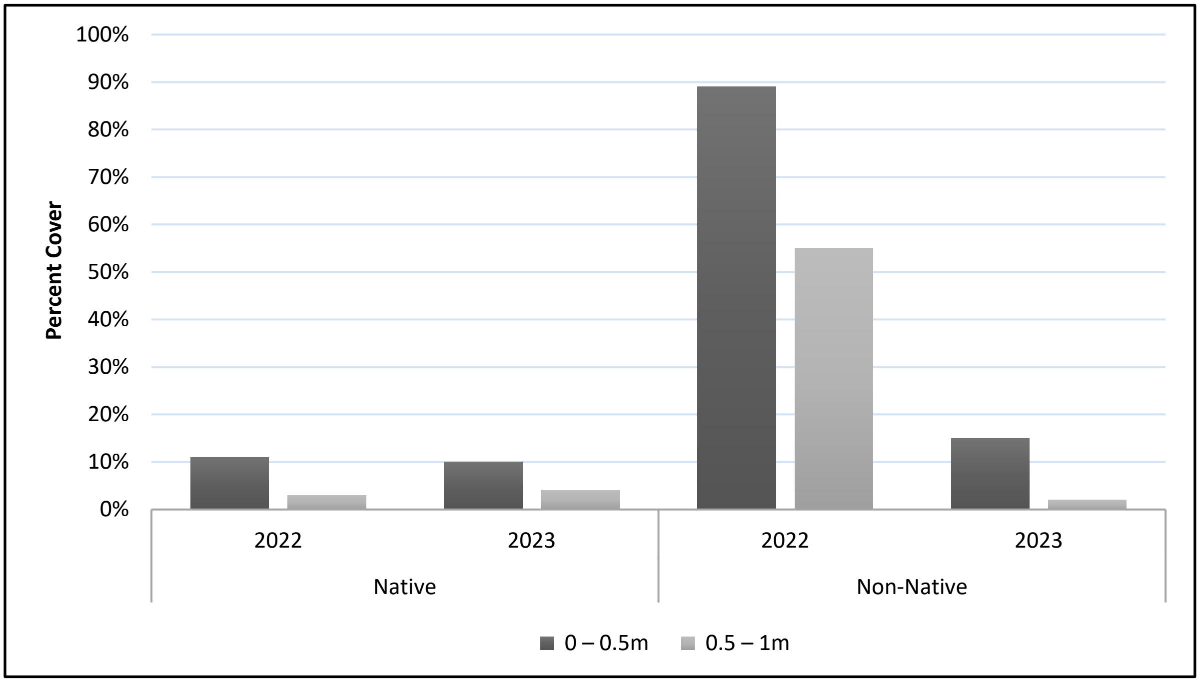


Figure 21. Canopy cover of non-native and native plant species by layer at Pu'u Nohona O Hae restoration site 1 (n=13) in 2022

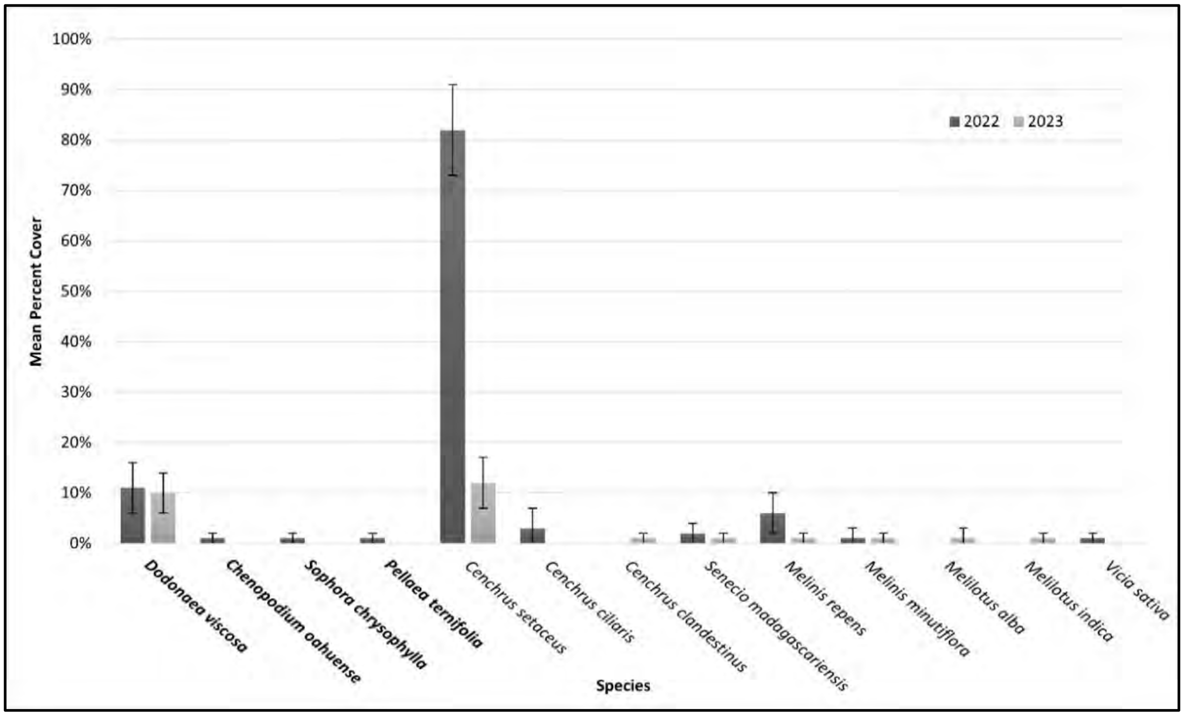


Figure 22. Mean percent canopy cover by species at 0–0.5 m and 90% confidence intervals (whiskers) averaged over 13 monitoring plots in site 1. Native species are in bold

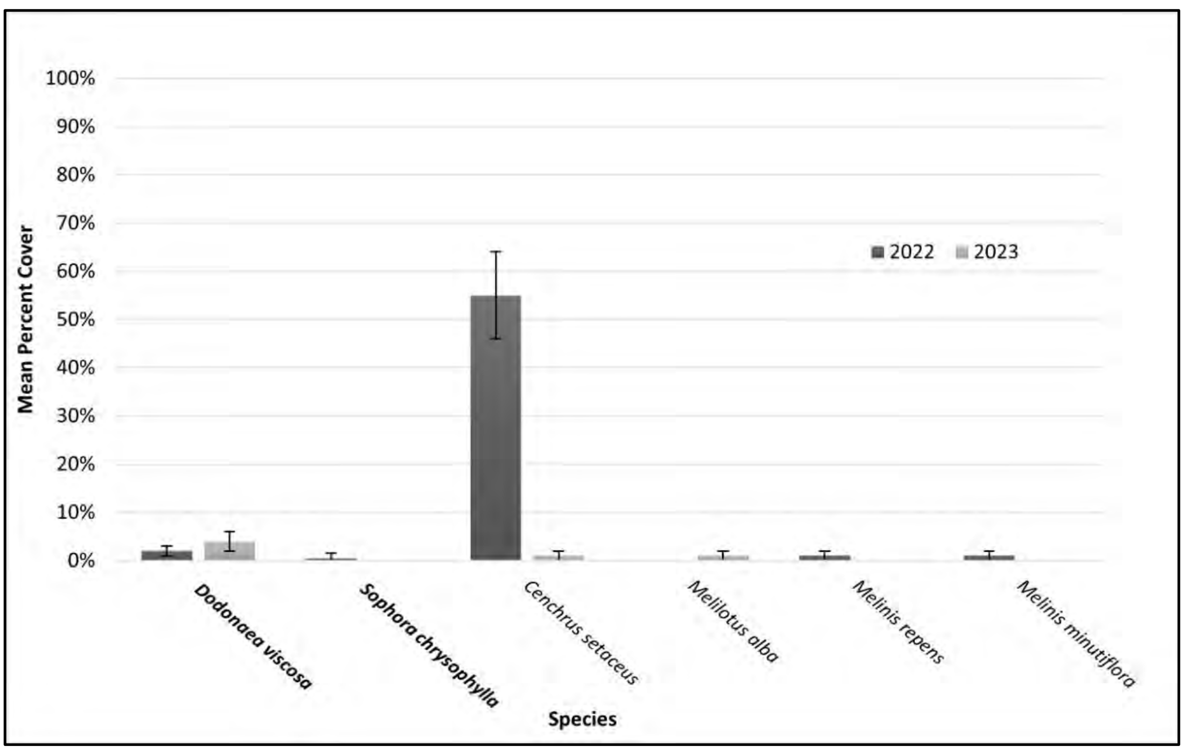


Figure 23. Mean percent canopy cover by species at 0.5–1.0 m and 90% confidence intervals (whiskers) averaged over 13 monitoring plots in site 1. Native species are in bold

We documented all native plant species within site #1 in 2022 and 2023, noting if a species occurred within a monitoring plot or larger 1 ha site (Table 23). Only half of the native species that occurred within the hectare were found growing within monitoring plots. *Carex wahuensis* and *Pellaea ternifolia* were not found in 2023, while 3 other native species, *Erythrina sandwicensis*, *Euphorbia multiformis*, and *Santalum paniculatum*, were first recorded in 2023.

Table 23. Native species richness for site 1

	Inside Plot		Outside Plot	
Native Species	**2022**	**2023**	**2022**	**2023**
Bidens menziesii	—	—	X	X
Carex wahuensis	—	—	X	—
Chenopodium oahuense	X	X	X	X
Dodonaea viscosa	X	X	X	—
Erythrina sandwicensis	—	—	—	X
Euphorbia multiformis	—	—	—	X
Ipomea indica	X	X	X	X
Osteomeles anthyllidifolia	—	—	X	X
Pellaea ternifolia	X	—	X	—
Santalum paniculatum	—	—	—	X
Sida fallax	X	X	X	X
Sophora chrysophylla	X	X	X	X
Vigna o-wahuensis	—	X	X	X
Waltheria indica	—	—	X	X
Wikstroemia pulcherrima	—	—	X	X

Photo Point Comparisons: Baseline (2022) vs. Year 1 (2023)

Figure 24. Transect 1; 24 October 2022 (left) and Transect 1; 25 September 2023 (right)

Figure 25. Transect 2; 24 October 2022 (left) and Transect 1; 25 September 2023 (right)

Figure 26. Transect 3; 24 October 2022 (left) and Transect 1; 25 September 2023 (right)

Figure 27. Transect 4; 24 October 2022 (left) and Transect 1; 25 September 2023 (right)

Figure 28. Transect 5; 24 October 2022 (left) and Transect 1; 25 September 2023 (right)

Figure 29. Transect 6; 24 October 2022 (left) and Transect 1; 25 September 2023 (right)

Figure 30. Transect 7; 24 October 2022 (left) and Transect 1; 25 September 2023 (right)

Figure 31. Transect 8; 24 October 2022 (left) and Transect 1; 25 September 2023 (right)


Figure 32. Transect 9; 24 October 2022 (left) and Transect 1; 25 September 2023 (right)


Figure 33. Transect 10; 24 October 2022 (left) and Transect 1; 25 September 2023 (right)

Figure 34. Transect 11; 24 October 2022 (left) and Transect 1; 25 September 2023 (right)

Figure 35. Transect 12; 24 October 2022 (left) and Transect 1; 25 September 2023 (right)


Figure 36. Transect 13; 24 October 2022 (left) and Transect 1; 25 September 2023 (right)

__Discussion__

Prior to removing non-native plant species, the restoration site was largely dominated by non-native species, with *C. setaceus* being the most prevalent species overall. Over the following year (through September 2023), we continued to remove non-native plants as *V. o-wahuensis* receded during the summer dry season, leaving 5 to 10 scattered patches of *V. o-wahuensis* entangled with *C. setaceus* (Figure 37). Native shrub cover increased over the course of the year, starting 2 to 3 months after the non-native species were removed (Figure 38). Non-native species percent canopy cover dropped dramatically, from 91% to 15%, between 2022 and 2023 and we achieved the objective to keep non-native plant cover below 20% within the site. However, non-native species still comprise the greatest proportion of the remaining the canopy cover within the plots, by 4% in the 0–0.5 m layer and 1% in the 0.5–1.0 m layer (Figure 21). As management continues and the existing vegetation passively recovers from years of invasive grass competition, we anticipate that the canopy will become native dominated. Native species richness increased by 1 species in 2023, but this is entirely due to outplanting additional native species within in the site. We hope additional native species will recruit from the seedbank within the site.

In the next fiscal year, we plan to compare 2022 and 2024 monitoring data for *V. o-wahuensis* across the population at Puʻu Nohona O Hae. We will use *V. o-wahuensis* individuals outside the managed ha as a control to assess differences between managed vs. un-managed areas. We plan to increase the monitoring frequency of the *V. o-wahuensis* individuals within the hectare to observe transition between life stages and confirm in-situ reproduction. We plan to assess whether our management is having a positive or negative effect, before proceeding with managing and monitoring transects in a second hectare in fall 2024.

Figure 37. ***Vigna o-wahuensis*** **entwined with** ***Cenchrus setaceus***

Figure 38. The area to the left is 2 months after non-native species removal; the area to the right is 11 months after non-native species removal

2.5 ESA-Listed Plant Species Summaries for Management Tier 1

We present the species summaries arranged by management tiers (Table 1) and then alphabetically by species. The genetic conservation implementation rank 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 conservation measures.

As mentioned above in the chapter introduction, we adopted the Hawaii and Pacific Plants Recovery Coordinating Committee (HPPRCC 2011) definition of a population—a group of conspecific individuals that are in close spatial proximity to each other (i.e., less than 1,000 m apart). In 2023, we used GIS to compile all Tier 1 plant locations observed between 2011 and 2023 to delineate groupings of conspecifics greater than 1,000 m apart for each federally listed species at PTA, including wild, outplanted, and mixed groupings. These maps for each species are in the following sections. The first set of population maps is strictly based on the 1,000 m separation criteria, which may create artificial populations for some species, and we plan to refine the maps over the next few years. However, these first maps are the foundation to help align management with recovery needs for each species and are a framework to report progress toward the recovery goals for each species.

For each Tier 1 species, we summarize count data from 2 monitoring periods—2019 to 2020 and 2023. Count data collected between 2019 and 2020 was collected quarterly using one monitoring protocol and monitoring data was collected once in 2023 using a different monitoring protocol. To make the data comparable between the 2 monitoring periods, we provide the mean number of plants counted between 2019 and 2020, with confidence intervals, by life stage. Also, during monitoring between 2019 and 2020, individual plants were not tagged. Therefore, during monitoring in 2023, it was sometimes difficult to discern vegetative adults from juveniles. To be conservative in reporting the number of mature (i.e., adult) plants in each population, we tagged and classified all vegetative plants as juveniles. However, this may have skewed the numbers of adults and juveniles between the 2 datasets.

To evaluate outplanting efforts conducted between 2004 and 2014, we provide the total number of each species planted at each site. This number reflects the general level of effort for a given species but does not account for survivorship/mortality over the period. All outplanting sites were monitored in 2014 after the final plantings at each site. The 2014 monitoring data most accurately reports the number of original outplants remaining and the number of plants that recruited on site from seed. During subsequent monitoring we were unable to distinguish the original outplants from recruits due to plant tags missing and/or not originally attached to base of plant. Therefore, we report the cumulative number of all adults and juveniles present for each species (i.e., original outplants plus recruits). To evaluate outplant performance, we report the percent change between the total number of adults and juveniles present in 2014 compared to 2022 to 2023.

2.5.1 Status of ESA-Listed Populations at PTA per the USFWS Species Recovery Criteria

The USFWS is working to update recovery criteria for ESA-listed plants in Hawaiʻi per 2011 guidelines issued by the Hawaiʻi and Pacific Rare Plant Coordinating Committee (HPRCC). The HPRCC guidelines established a new initial recovery stage—Preventing Extinction Stage—and criteria. Now the Interim Stabilization Stage is now the second stage of recovery. The criteria for the Preventing Extinction and Interim Stabilization stages are based on life history characteristics and these characteristics are the basis for determining the number of individuals and populations needed over specific timeframes to meet each stage. Below we discuss the status of ESA-listed populations at PTA in relation to the USFWS recovery criteria. Evaluating progress toward these criteria can help identify information gaps, management efficacy, and management needs to maintain or restore populations to continue working toward recovery.

2.5.2 *Isodendrion hosakae* (Endangered)

We tagged and monitored all known *I. hosakae,* a Tier 1 species, using the individual plant-based monitoring protocol between the months of May and October 2022. We postponed monitoring the wild population in FY 2023 to reevaluate the optimal season for monitoring, and shifted monitoring from the dry season, July to September, to the wet season, January to March. For genetic conservation, *I. hosakae* is an implementation priority 1 (high; Table 13). We collected propagules for storage and propagation to establish new populations at PTA and on State land.

Plant Monitoring

As of 2022, a total of 50 adults, 197 juveniles and at least 69 seedlings of *I. hosakae* are at PTA (Table 24). Two populations exist—a single wild population and a single outplanting site (Figure 39).

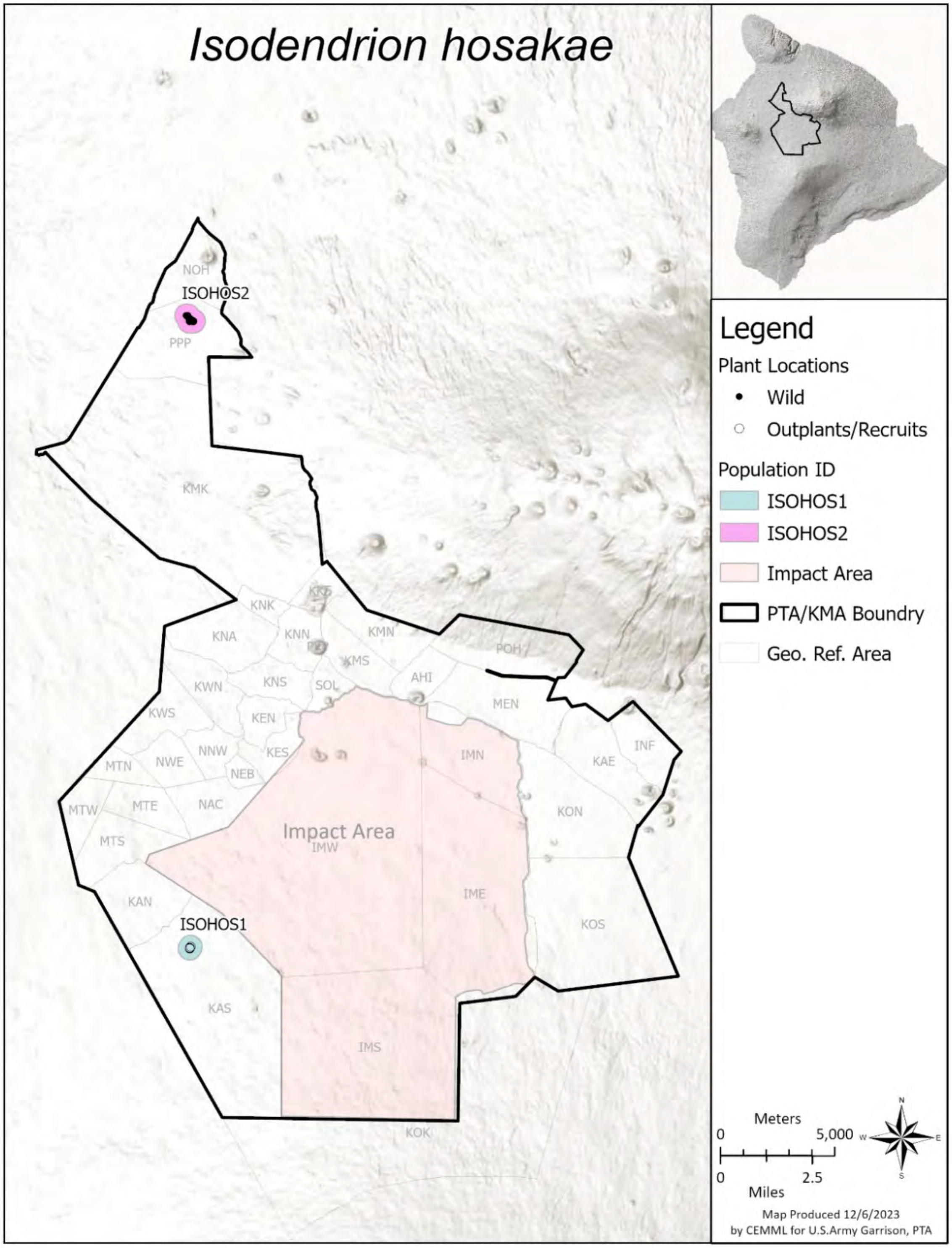


Figure 39. Current known distribution of Isodendrion *hosakae* individuals and populations at PTA[a]

[a]Data used to produce map were obtained from: (1) rare plant survey data collected between 2011 to 2021 plus monitoring of these locations conducted in 2022 to 2023; and (2) live plant locations collected during outplant monitoring in 2022.

Each adult or juvenile plant was scored based on its assigned vigor class (Healthy=5; Moderate=3; Poor=1) to arrive at an average health index for each population. Both populations were on average observed to be in healthy condition (Table 24).

Table 24. Average plant health index in *Isodendrion hosakae* populations

			Plant Health[a]			
Population	Monitoring Period	# of Plants	Healthy (5)	Moderate (3)	Poor (1)	Average Health Index
ISOHOS1	May 2022	4	100%	0%	0%	5.0
ISOHOS2	Aug–Oct 2022	242	94%	5%	1%	4.9

[a]Healthy = foliage that appears green and vigorous, with less than 10% dead leaves or defoliation; Moderate = leaves on plants may have some chlorosis, with 10–50% of the leaves dead or defoliated; Poor = mostly dead or chlorotic leaves, with greater than 50% dead leaves or defoliation.

We collected data for reproductive structures observed (Table 25). While not a complete phenological dataset, this data documents the reproductive health and status of a given population during the period monitored. The data collected in 2022 corroborate the previous consensus that June to August is the optimal time of year for fruit collection, although no data were collected for relative ripeness of fruits present (CEMML 2015).

Table 25. Presence of reproductive structures in *Isodendrion hosakae* populations

		Reproductive Structures Present			
Population	Monitoring Period	# of Plants	Fruits	Flowers	Flower Buds
ISOHOS1	May 2022	4	0%	75%	75%
ISOHOS2	Aug–Oct 2022	46	72%	2%	76%

Juveniles and seedlings dominate the current wild population structure of this species, as was the case during the previous monitoring period. Fourteen fewer adults were observed in 2022 than 3 years prior (Figure 40). Some of this attrition is real, as plants have vanished from a small number of locations on the Puʻu. However, this discrepancy may also be due to differences in methods used to distinguish life stages. In the current monitoring protocol, we categorize all vegetative plants as juveniles until evidence of current or past reproduction is present. We may have inadvertently counted some vegetative adults as juveniles, but with consistent annual monitoring this mis-categorization will correct itself. The wide confidence intervals for juveniles and seedlings in the 2020 dataset was likely caused by high variability in observed numbers due to the gradual decline of recent seedling flushes (CEMML 2022a).

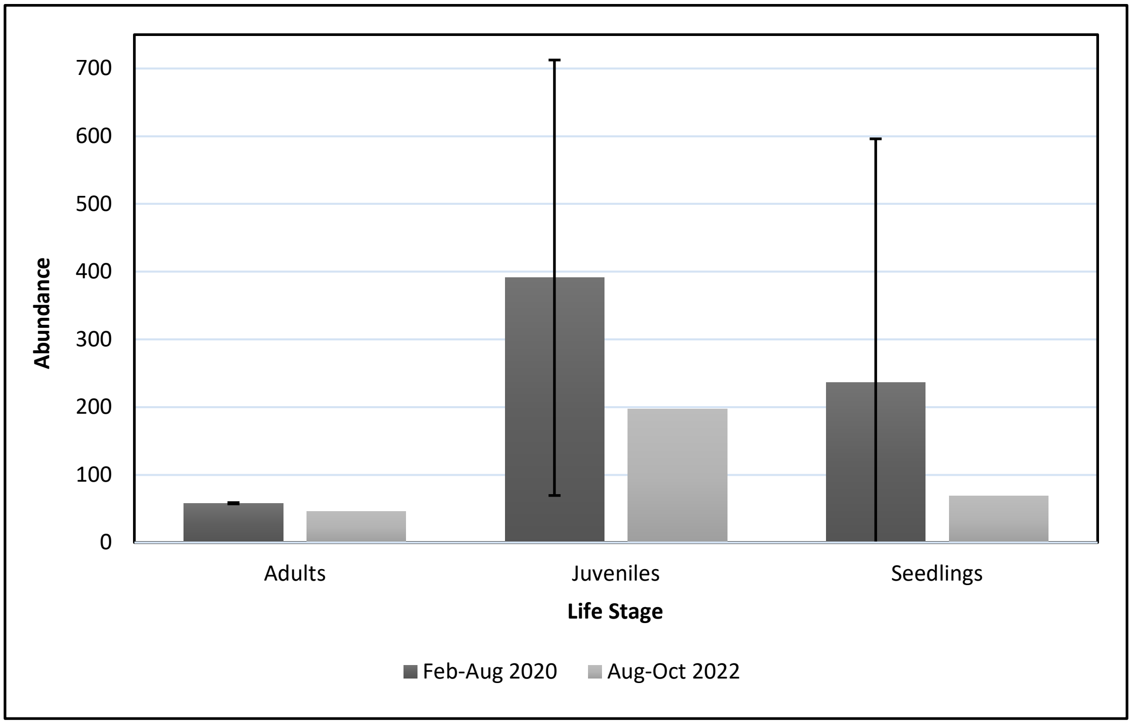


Figure 40. Monitoring data for wild *Isodendrion hosakae* individuals from February to August 2020 compared with August to October 2022. Mean abundance and 90% confidence intervals (whiskers) are derived from 3 monitoring quarters in 2019; monitoring data from 2022 to 2023 were collected once.

For combined *I. hosakae* locations, 38% of weed percent cover and 66% of fine fuels percent cover estimations exceeded our 20% cover management thresholds (Figure 41 and Figure 42). This was expected as weed control was suspended or reduced for 10% of the *I. hosakae* locations to reduce erosion. We plan to re-evaluate weed control efforts in 2024.

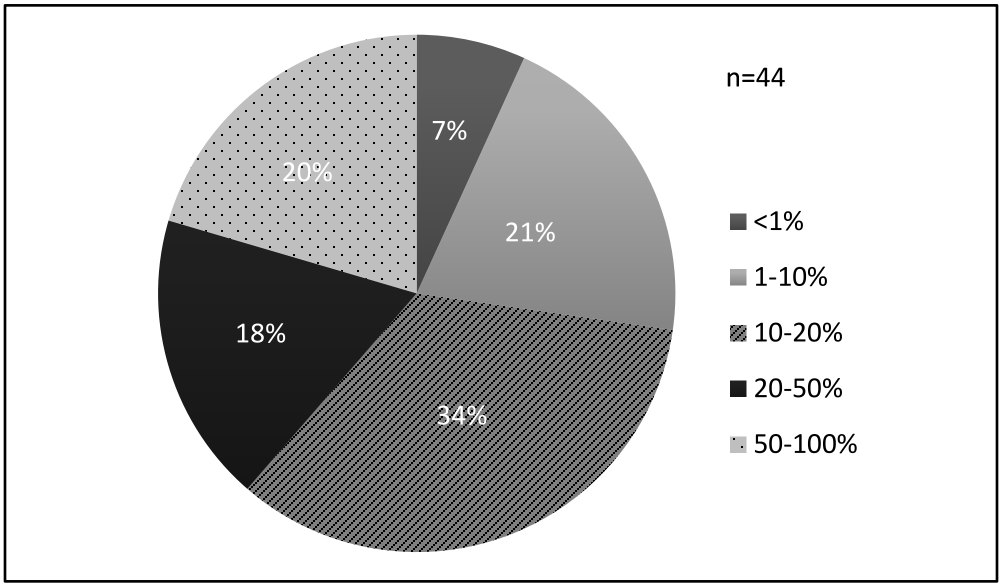


Figure 41. Overall proportion of weed percent cover classes reported for *Isodendrion hosakae* plant locations

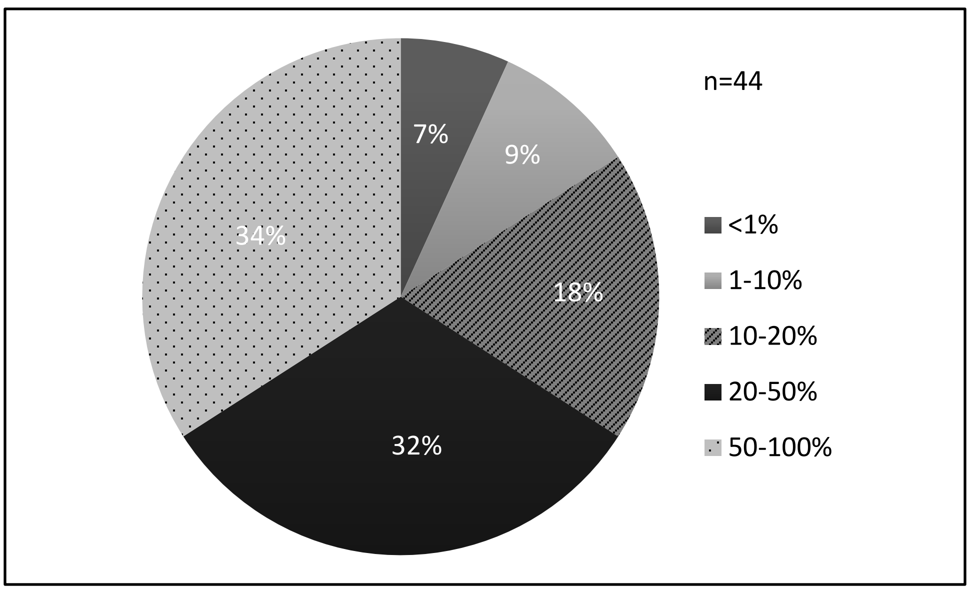


Figure 42. Overall proportion of fine fuels percent cover classes reported for *Isodendrion hosakae* plant locations

<u>Genetic Conservation</u>

Propagule Collection and Propagation

We collected 506 seeds from 16 wild founders at Puʻu Pāpapa in 2023 (Table 26). An additional 125 seeds from 5 of the same founders were collected and transferred to Lyon Arboretum. See Section 2.3.2 for a complete summary of ex-situ storage status for *I. hosakae* (Table 15).

Table 26. Propagule collections for *Isodendrion hosakae* in 2023. Seeds collected were dried to 28% relative humidity and stored at 5° C

Plant ID[a]	Date of Collection	Type of Propagule	Amount Collected	Population	UTM X	UTM Y
1263	15 May 23	Seed	4	ISOHOS2	218436	2202093
1671	04 Aug 23	Seed	13	ISOHOS2	218336	2202136
1583	04 Aug 23	Seed	6	ISOHOS2	218209	2202251
1628	04 Aug 23	Seed	44	ISOHOS2	218337	2202135
1635	04 Aug 23	Seed	109	ISOHOS2	218336	2202136
1265	04 Aug 23	Seed	31	ISOHOS2	218210	2202254
1263	04 Aug 23	Seed	14	ISOHOS2	218436	2202093
1479	04 Aug 23	Seed	24	ISOHOS2	218195	2202279
1429	04 Aug 23	Seed	65	ISOHOS2	218337	2202136
1573	04 Aug 23	Seed	71	ISOHOS2	218393	2202078
1273	04 Aug 23	Seed	36	ISOHOS2	218210	2202252
1527	04 Aug 23	Seed	33	ISOHOS2	218330	2202139
1172	04 Aug 23	Seed	80	ISOHOS2	218153	2202307
1269	04 Aug 23	Seed	34	ISOHOS2	218206	2202253
1267	04 Aug 23	Seed	8	ISOHOS2	218211	2202255
1264	04 Aug 23	Seed	14	ISOHOS2	218211	2202255
1661	04 Aug 23	Seed	10	ISOHOS2	218295	2202045

[a] Plant IDs refer to the number printed on tags of wild individuals collected.

Viability testing trials for *I. hosakae* were initiated at OANRP's seed lab in FY 2023 using PTA-sourced seed. These trials were set up as part of training received by PTA personnel at OANRP; all resultant plants were transferred back to PTA for outplanting. We sowed 632 seeds from multiple accessions of varying age (Table 27). Germination rates were generally high for all age ranges tested (Table 27).

Table 27. Germination trials for *Isodendrion hosakae* conducted in 2023 at the US Army Garrison-Hawaiʻi Natural Resources Program on Oʻahu

Age of Seed (years)	Number of Accessions	Number of Seeds Sown	Number of Seeds Germinated	Average % Germination Rate
14	30	267	187	70
12	5	23	19	82
11	2	11	4	36
				Av. Germ. Rate 11–14 years = 70%
10	12	72	31	43
8	6	27	20	74
6	2	17	17	100
				Av. Germ. Rate 6–10 years = 59%
5	3	64	36	56
4	8	116	89	76
1	1	35	33	94
				Av. Germ. Rate 1–5 years = 73%

From previous propagation efforts, 60 *I. hosakae* representing 19 founders were accessioned to the RPPF as of 30 September 2023 (Table 20).

Outplanting and Monitoring

We did not outplant *I. hosakae* during the reporting period. Between 2004 and 2014, we planted a combined total of 58 *I. hosakae* at 4 sites. At last monitoring in 2022, adults and/or juveniles were present at 2 sites off PTA (ASRs 201 and 205) and 1 site on PTA (ASR 214). However, all sites showed a decrease in the number of individuals present between 2014 and 2022 (Table 28).

Table 28. Monitoring results from May–December 2022 for *Isodendrion hosakae* outplanted 2004–2014

Location	ASR	Total Outplanted 2004–2014	Total Present 2014		Total Present 2022		% Change 2014–2022
			Adult	Juvenile	Adult	Juvenile	
Off PTA	201	3	0	2	0	1	-50%
	203	4	3	1	0	0	-100%
	205	44	13	33	7	0	-85%
On PTA	214	7	5	1	4	0	-33%

ASR, Area of Species Recovery. ASRs numbered in the 200s refer to outplanting sites that may be located within or adjacent to ASR established for wild populations.

Note: The data source for planting activity between 2004 to 2014 and 2014 monitoring data is CEMML 2015.

Discussion

Our efforts to monitor and conserve genetic resources for *I. hosakae* address SOO tasks 3.2.1.2, 3.2.1.4, and 3.2.1.5, 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—its only known current location. The distribution of *I. hosakae* has contracted since 1982 when it was reported from 3 cinder cones in South Kohala (Cuddihy et al. 1984). Two of these cinder cones, Puʻu Pāpapa and Puʻu Nohona O Hae, were purchased by the Army in 2006 as part of the KMA. In addition to range contraction, the population of *I. hosakae* has declined from 870 individuals in 2002 to 243 individuals in 2022 (a 72% reduction). Over the last 41 years, the *I. hosakae* population has experienced large fluctuations in the number of plants present, with the lowest estimation between 25 and 50 plants in 1988 (USFWS 1994). In 2017, the population was 46 adult and juvenile individuals and by 2022 the number of *I. hosakae* increased by more than 5-fold. With such large swings in population numbers, it is difficult to determine the overall health and viability of this population. However, the population distribution across Puʻu Pāpapa appears to be shrinking, and the overall trend over the last 40 years appears to be declining. This trend in abundance may be a natural response of this species to changing environmental conditions. Future outplanting strategies will seek to address these issues, with similarly aged substrates (11,000 to 64,000 years) at higher elevations and higher moisture regimes perhaps providing a safer refuge for this species.

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). Our individual plant-based monitoring is designed to directly track transition from one life stage to another, and we expect to be able to answer these questions over the next several years. Nothing is known about which *I. hosakae* age distributions support healthy and resilient populations. We do not know which, if any, of the life stages is most vulnerable and/or may regulate population sustainability. Understanding 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.

Because of the relatively low number of adults and limited distribution of *I. hosakae*, we recommend establishing new populations (of at least 50 mature individuals) on Puʻu Nohona O Hae, within the *Sicyos macrophyllus* fence unit in the KMA, and off-PTA on State land in less fire-prone areas.

We continue to make progress with genetic conservation of *I. hosakae*. In 2023 we added 14 new founders to our collection and refreshed a total of 506 of the 632 seeds sown. Sixty percent of the seeds sown were selected from our oldest accessions (>10 years old). Germinating these older seeds is critical to conserving *I. hosakae* genetic resources because some of the founders are no longer extant in the wild population, as was the case for 8 accessions representing 5 founders that were sown in 2023. Germination trials resulted in a 73% average germination rate within the first 5 years, which dropped to 59% for seed aged 5 to 10 years and 70% for seed aged 10 to 14 years (Table 27). These results indicate that seed viability for this species remains relatively high and stable within the first 14 years of storage at 5°C.

Previous efforts to propagate and outplant *I. hosakae* have been minimal. Not much is known about the former range of *I. hosakae,* and this lack of information has limited modeled projections of suitable habitat (Price et al. 2012). Based on assumptions of climate change, the projections of Fortini et al. (2013) show the suitable range for this species migrating approximately 400 m upslope. At ASR 214, about 700 m higher in elevation than the wild population, *I. hosakae* survived moderately well—these few individuals are the largest and healthiest outplants that have established to date. The highest number of *I. hosakae* persisted at ASR 205, which is about 200 m higher in elevation than the wild population. Outplanting *I. hosakae* is a high priority due to the limited abundance and distribution of this species as well as its vulnerability to wildland fire. In the coming year we plan on establishing 2 new populations, 1 of which lies within the migration zone for this species (Fortini et al. 2013). We will continue to monitor the success of plantings to help better understand this species' habitat requirements and to guide site selection for additional plants currently in propagation. We also recommend monitoring environmental conditions on site after planting events to guide post-planting care (i.e., watering) protocols.

Status of Isodendrion hosakae *Populations at PTA per the USFWS Species Recovery Criteria*

In the 5-year review for *I. hosakae* published in 2020, the USFWS established a new recovery stage—Preventing Extinction Stage—with updated criteria. The Preventing Extinction stage for *I. hosakae* requires 50 mature individuals in each of 3 populations, with at least 50 individuals (or the total number if less than 50) represented from each wild population in ex-situ storage. We continue to make progress towards the Preventing Extinction Stage for the 2 populations at PTA (Table 29). Through management, we strive to advance the species toward the next stage of recovery—Interim Stabilization. However, for *I. hosakae* to reach both the Preventing Extinction and Interim Stabilization stages, a third population must be established and maintained (at PTA or elsewhere) to meet the criteria. Through continued monitoring, we plan to document natural reproduction and assess population trends.

Table 29. Progress towards USFWS Preventing Extinction stage of recovery for *Isodendrion hosakae* at PTA

Population	# Adults Wild (OP)	# Juveniles Wild (OP)	# Founders Ex-situ Storage	Fenced	Invasive Plant Control	Natural Reproduction	Number Increasing
ISOHOS1	(4)	(0)	NA	Yes	Yes	ND	ND
ISOHOS2	46	197	51	Yes	Yes	ND	ND

NA, Not applicable; ND, No Data

Progress toward Compliance with Endangered Species Act Biological Opinion Conservation Measures

To offset the effects of military activities on *I. hosakae*, the 2003 BO conservation measures include fuels management to reduce fire risk, fencing and ungulate control to reduce browsing 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 (Sections 3.4 and 4.3). In addition, we actively conserve *I. hosakae* genetic resources; the ex-situ storage currently contains 1,193 seeds representing 51 founders in the wild population. To date, we have planted a combined total of 58 *I. hosakae* at 4 outplanting sites both on and off PTA; only 12 of these plants currently survive. 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 2.2 ha for *I. hosakae* (Section 3.2, Table 101). Between 2016 and 2019, we documented in-situ reproduction at 1 of 36 (3%) monitoring plots in the wild population of *I. hosakae*. Using our new individual plant-based monitoring protocol will allow us to document in-situ reproduction much more effectively; we expect to observe much more reproduction moving forward. Although we monitor *I. hosakae* annually to assess population patterns, we are unable to attribute changes in numbers to effects of 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 2.7).

2.5.3 *Kadua coriacea* (Endangered)

As a Tier 1 species, we tagged and monitored all known *K. coriacea* using the individual plant-based monitoring protocol between the months of January 2022 and February 2023. For genetic conservation, *K. coriacea* is an implementation priority 2 (moderately high; Table 13). In 2024 we plan to resume collecting propagules to refresh old accessions in storage, as well as to provide representation of individuals currently missing from our collection. We also plan to augment existing populations and establish new populations with outplants in 2023 to 2024.

<u>Plant Monitoring</u>

According to the latest monitoring, a total of 146 adults and 25 juveniles of *K. coriacea* exist at PTA. The distribution for *K. coriacea*, including the outplanting sites at PTA where this species currently persists, is shown in Figure 43. This map also includes the populations designated for this species, which consist of individuals that are in close spatial proximity to each other (i.e., less than 1,000 meters apart).

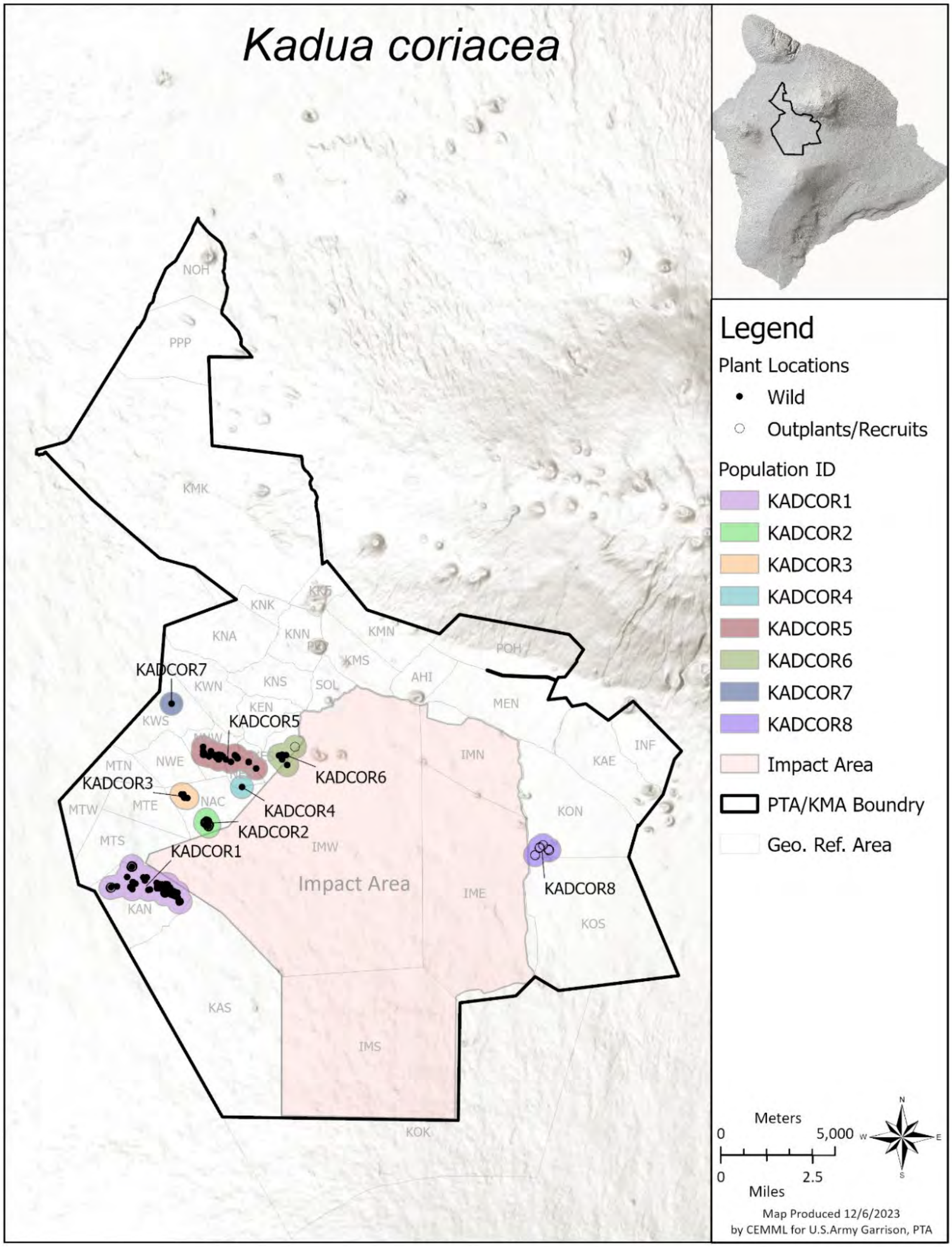


Figure 43. Current known distribution of *Kadua coriacea* individuals and populations at PTA[a]

[a]Data used to produce map were obtained from: (1) rare plant survey data collected between 2011 to 2021 plus monitoring of these locations conducted in 2022 to 2023; and (2) live plant locations collected during outplant monitoring in 2022.

Each adult or juvenile plant was scored based on its assigned vigor class (Healthy=5; Moderate=3; Poor=1) to arrive at an average health index for each population. Most populations were on average observed to be in poor or moderate condition (Table 30).

Table 30. Average plant health index in *Kadua coriacea* populations

			Plant Health[a]			
Population	**Monitoring Period**	**# of Plants**	**Healthy (5)**	**Moderate (3)**	**Poor (1)**	**Average Health Index**
KADCOR1	Jan–Nov 2022	86	34%	57%	9%	3.5
KADCOR2	Aug–Sep 2022	31	29%	35%	35%	2.8
KADCOR3	Jan 2022	7	14%	57%	29%	2.7
KADCOR4	Sept 2022	1	0%	100%	0%	3.0
KADCOR5	Sept 2022	36	33%	39%	28%	3.1
KADCOR6	Sep–Nov 2022	5	20%	40%	40%	2.6
KADCOR7	Oct 2022	1	0%	100%	0%	3.0
KADCOR8	Feb 2023	1	100%	0%	0%	5.0

[a]Healthy = foliage that appears green and vigorous, with less than 10% dead leaves or defoliation; Moderate = leaves on plants may have some chlorosis, with 10–50% of the leaves dead or defoliated; Poor = mostly dead or chlorotic leaves, with greater than 50% dead leaves or defoliation.

While not a complete phenological dataset, we are documenting the reproductive structures presents in a given population during the period monitored (Table 31). In future years, we plan on making the monitoring periods for a given population much shorter; thus, data on the presence of reproductive structures for this species will become more informative.

Table 31. Presence of reproductive structures in *Kadua coriacea* populations

		Reproductive Structures Present			
Population	**Monitoring Period**	**# of Plants**	**Fruits**	**Flowers**	**Flower Buds**
KADCOR1	Jan–Nov 2022	83	61%	27%	33%
KADCOR2	Aug–Sept 2022	14	71%	43%	36%
KADCOR3	Jan 2022	6	67%	33%	33%
KADCOR4	Sept 2022	1	100%	0%	100%
KADCOR5	Sept 2022	35	37%	14%	20%
KADCOR6	Sept–Nov 2022	5	50%	50%	25%
KADCOR7	Oct 2022	1	100%	0%	0%
KADCOR8	Feb 2023	1	100%	100%	100%

For wild plants, the population structure is dominated by adults, with many of these individuals found over 15 years ago (Figure 44). Mortality is occurring, with 5 individuals confirmed dead in the past 3 years. The differences in the number of juveniles between monitoring from 2019 to 2020 (4) and 2022 to 2023 (7) is likely due to differences in methods used to distinguish life stages (see the introduction to Section 2.5). Historically, limited recruitment has occurred. Rodents or game birds may be consuming propagules, seedlings, and juveniles, since ungulates are no longer a threat. Further investigations into factors affecting recruitment are warranted, since seeds readily germinate in the greenhouse, and maintain a 60% viability after 20 years of storage under optimal conditions (Table 32).

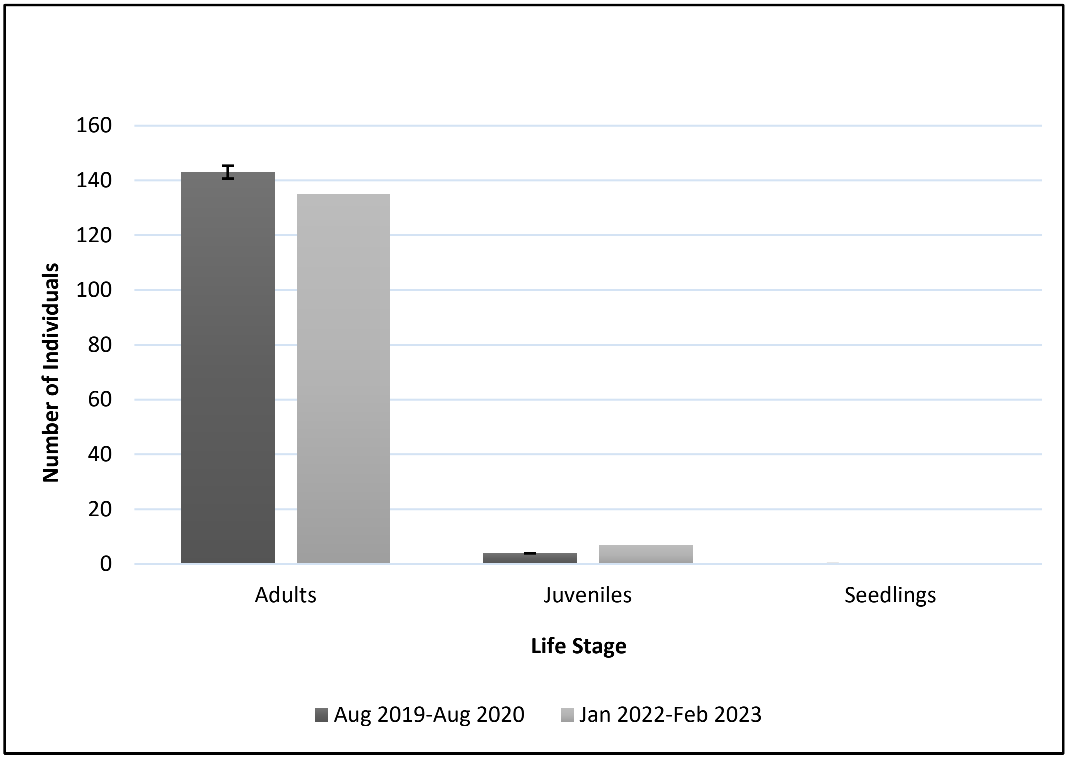


Figure 44. Monitoring data for wild *Kadua coriacea* individuals from 2019 to 2020 compared with 2022 to 2023. Mean abundance and 90% confidence intervals (error bars) are derived from 4 quarterly monitoring datasets collected in 2019 to 2020; monitoring census data from 2022 to 2023 is a single dataset

For combined *K. coriacea* locations, less than 1% of weed percent cover and fine fuels percent cover estimations exceeded our 20% cover management thresholds (Figure 45 and Figure 46).

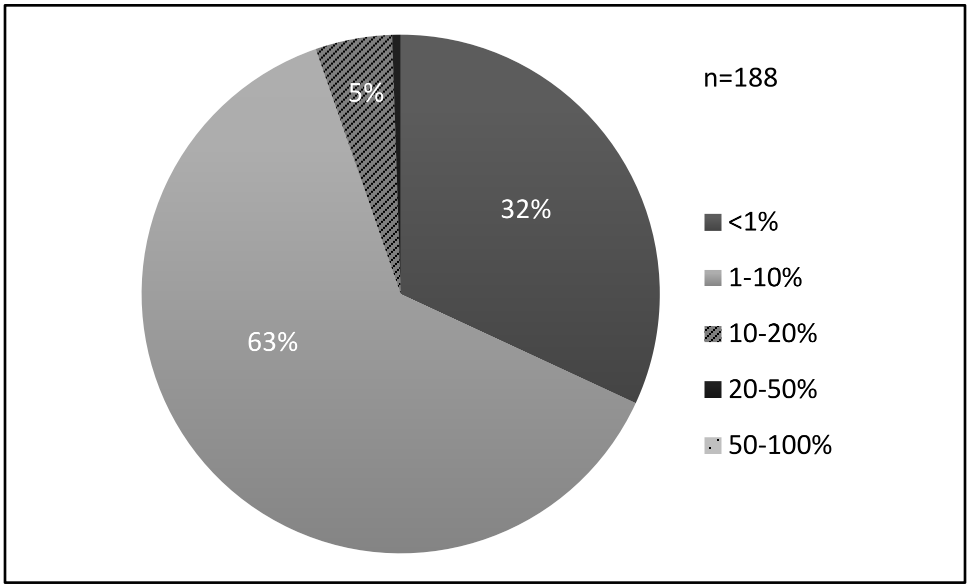


Figure 45. Overall proportion of weed percent cover classes reported for *Kadua coriacea* plant locations

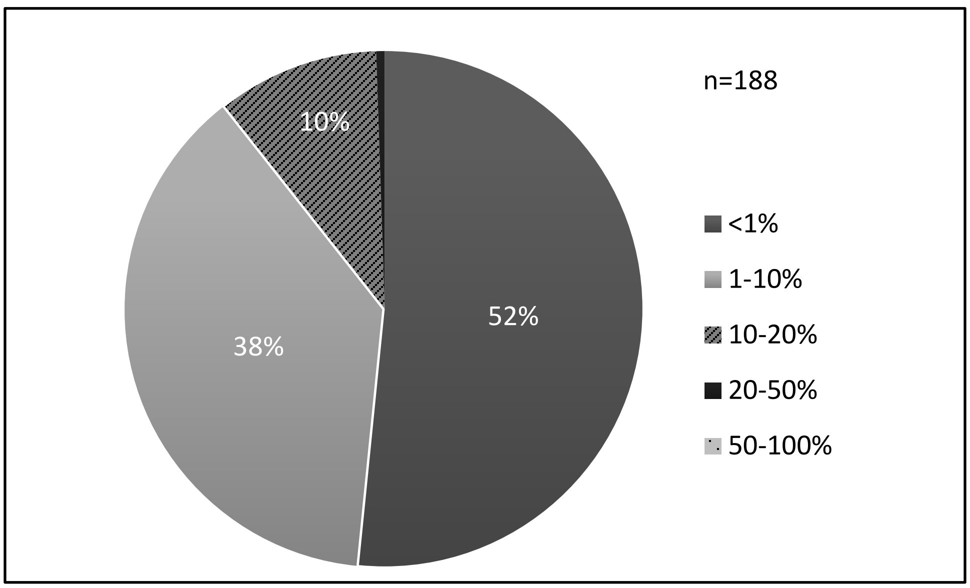


Figure 46. Overall proportion of fine fuels percent cover classes reported for *Kadua coriacea* plant locations

<u>Genetic Conservation</u>

Propagule Collection and Propagation

No propagule collection occurred during the reporting period. Please refer to Table 15 for a complete summary of ex-situ storage status for *K. coriacea.*

Viability testing trials for *K. coriacea* were conducted in FY 2023 using the oldest seeds from several targeted founders—individuals whose populations will be augmented per the approved 2022 to 2025 Outplanting Plan. We sowed 1,350 seeds from multiple accessions of various ages (Table 32). Germination rates were similar across all tested ages (Table 32).

Table 32. Germination trials for *Kadua coriacea* conducted at PTA in FY 2023

Age of Seed (years)	Number of Accessions	Number of Seeds Sown	Number of Seeds Germinated	Average % Germination Rate
20	2	50	39	78
18	2	50	24	48
				Av. Germ. Rate 18–20 years = 63%
15	6	186	107	58
14	15	434	233	54
12	11	275	170	62
10	13	335	223	67
				Av. Germ. Rate 10–15 years = 60%

From previous propagation efforts, there were 67 *K. coriacea* representing 9 founders accessioned to the RPPF as of 30 September 2023 (Table 20).

Outplanting and Monitoring

We did not outplant *K. coriacea* during this reporting period. Between 2004 and 2014, we planted a combined total of 583 *K. coriacea* at 7 sites. At last monitoring in 2022, adults were present at 1 site off PTA (205) and 1 site on PTA (211). However, all sites showed a decrease in the number of individuals present between 2014 and 2022 (Table 33); there were 4 fewer plants since monitoring in 2020 (CEMML 2022a).

Table 33. Monitoring results from September–December 2022 for *Kadua coriacea* outplanted 2004–2014

Location	ASR	Total Outplanted 2004–2014	Total Present 2014		Total Present 2022		% Change 2014–2022
			Adult	Juvenile	Adult	Juvenile	
Off PTA	201	75	0	0	0	0	0%
	202	63	0	0	0	0	0%
	203	19	5	11	0	0	-100%
	204	85	2	0	0	0	-100%
	<u>205</u>	316	72	70	3	0	-98%
On PTA	208	5	0	0	0	0	0%
	211	20	3	0	1	0	-67%

Note: The data source for planting activity between 2004 to 2014 and 2014 monitoring data is CEMML 2015. An underlined ASR number denotes juvenile/adult recruits were present in 2014.

In March/April 2019, we planted 107 *K. coriacea* at 8 sites on PTA (Table 34). As of last monitoring in 2022 to 2023, a total of 37 plants remained across 5 of the sites.

Table 34. Monitoring results from November 2022–June 2023 for *Kadua coriacea* outplanted in 2019

		Total Present 2022–2023			
ASR	Total Outplanted 2019	Adult	Juvenile	No. of Distinct Founders Represented	Survivorship
221	18	1	0	1	5%
222	20	0	2	1	5%
223	21	4	5	1	5%
224	24	5	9	3	12%
226	4	1	0	1	25%

Since monitoring in December 2020, 30 more outplants have perished (CEMML 2022a). Plants were lost from all sites where plants were present at last monitoring. This species continues to persist best at ASRs 223 and 224. These 2 ASRs are in close proximity (within 20–50 m) to a wild population on the exact same substrate as the wild plants.

<u>Discussion</u>

Our efforts to monitor and conserve genetic resources for *K. coriacea* address SOO tasks 3.2.1.2, 3.2.1.4, and 3.2.1.5, as well as several INRMP objectives and conservation measures from the 2003 and 2013 BO.

The natural distribution of *K. coriacea* is found in the *Metrosideros* woodlands on the west side of the installation (Figure 43). 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.

Nothing is known about which *K. coriacea* 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. Understanding 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. Now that we are monitoring individual plants of various life stages consistently from year to year, we anticipate having the data to help answer these questions.

We continue to progress with genetic conservation of *K. coriacea*, and after a recent re-evaluation of our collection we can target certain individuals and populations in need of ex-situ representation. In 2023, we tested the viability of some of our oldest collections (10 to 20 years old) via germination trials. Germinating these older seeds is critical to conserving *K. coriacea* genetic resources because some of the founders are no longer extant in the wild population. Germination trials resulted in a 60%

germination rate for seeds aged 10 to 15 years, which rose to 63% for seed aged 18 to 20 years (Table 32), demonstrating that seed viability for this species remains relatively high and stable within 10 to 20 years of storage at 5C. From previous propagation efforts, 67 *K. coriacea* represented 9 founders accessioned to the RPPF as of 30 September 2023 (Table 20). We are developing planting strategies and plan to continue investigating outplant performance and planting site characteristics to maximize the successful establishment of new self-sustaining groupings. Moving forward, we intend to test 2 hypotheses: (1) increasing size and age of outplant specimens will increase survivorship overall; and (2) choosing and preparing planting microsites more closely resembling those occupied by wild individuals will increase survivorship overall. In FY 2024, we will experiment with planting larger plants in 1-gallon containers side by side with smaller plants in 4-inch containers. In FY 2025 we will plant younger plants (18 months old) in microsites more like those occupied by wild individuals (i.e., filling cracks in raised pahoehoe with soil and leaf litter for planting) side by side with plants placed in soil pockets typically found in low-lying areas, as was done in the past.

Previous outplanting efforts conducted between 2004 to 2014 for *K. coriacea* have not been successful. The only recruitment observed has been a single juvenile at ASR 205 in 2014 (Table 33). At PTA, *K. coriacea* can live for over 20 years, so natural lifespan is likely not the cause of the observed attrition. Except for ASR 201, all outplanting sites were within the species potential geographic range (Price et al. 2012). The lack of success with previous outplanting efforts is concerning, considering that the wild population is dominated by older individuals and very little natural recruitment has been observed. We recommend further outplanting efforts for this species and monitoring designed to better understand habitat conditions that will support outplant persistence.

Forty-two of the *K. coriacea* planted in 2019 had perished 6 months after planting (61% of total; Table 22). These plantings remained relatively stable for the first 2 years, before experiencing a large decline over the past 2 years—currently 25% of the original plants survive. In comparison, only 0.06% of plants from 2004 to 2014 survive. Most outplantings (2004 to 2019) occurred within the species' potential geographic range (Price et al. 2012). We recommend continuing to monitor all outplants, especially at the 2019 sites, to better understand habitat characteristics that may influence persistence over time. As we continue to work with outplanting *K. coriacea,* closely monitoring environmental conditions after planting will assist planning supplemental watering. This care should take place more often and for a longer period than in past efforts to evaluate the effect on initial survivorship.

Status of Kadua coriacea *Populations at PTA per the USFWS Species Recovery Criteria*

In the 5-Year Review for *K. coriacea* published in 2020, the USFWS established a new recovery stage—Preventing Extinction Stage—with updated criteria. The Preventing Extinction stage for *K. coriacea* requires 50 mature individuals in each of 3 populations, with at least 50 individuals (or the total number if less than 50) represented from each wild population in ex-situ storage. We continue to make progress towards the Preventing Extinction Stage for the 8 populations at PTA (Table 35). Through management, we strive to advance the species toward the next stage of recovery—Interim Stabilization. However, for *K. coriacea* to reach both the Preventing Extinction and Interim

Stabilization stages, a third population must be established and maintained (on Oʻahu or Maui) to meet the criteria. Through continued monitoring, we plan to document natural reproduction and assess population trends.

Table 35. Progress towards USFWS Preventing Extinction stage of recovery for *Kadua coriacea* at PTA

Population	# Adults Wild (OP)	# Juveniles Wild (OP)	# Founders Ex-situ Storage	Fenced	Invasive Plant Control	Natural Reproduction	Number Increasing
KADCOR1	83	2	89	Yes	Yes	ND	ND
KADCOR2	5 (9)	3 (14)	6	Yes	Yes	ND	ND
KADCOR3	6	1	5	Yes	Yes	ND	ND
KADCOR4	1	0	0	Yes	Yes	ND	ND
KADCOR5	35	1	39	Yes	Yes	ND	ND
KADCOR6	4 (1)	0	6	Yes	Yes	ND	ND
KADCOR7	1	0	0	Yes	No	ND	ND
KADCOR8	(1)	0	NA	Yes	No	ND	ND

ND, No Data

Progress toward compliance with Endangered Species Act Biological Opinion Conservation Measures

To offset effects of military activities on *K. coriacea*, the 2003 BO conservation measures include fuels management to reduce fire risk, fencing and ungulate control to reduce browsing 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 browsing for all known individuals at PTA (Sections 3.4 and 4.3). In addition, we actively conserve *K. coriacea* genetic resources; the ex-situ storage contains 132,264 seeds representing 143 founders from the wild population. To date, we have outplanted a combined total of 690 individuals at 15 sites, both on and off PTA; only 31 of these plants currently survive. We control invasive plants around all known wild locations of *K. coriacea* in an area of approximately 30 ha (Section 3.2, Table 101). We have observed only minimal in-situ reproduction in the wild populations of *K. coriacea*. The new individual plant-based monitoring protocol will allow us to document in-situ reproduction much more effectively when it occurs. We monitor *K. coriacea* annually to assess population patterns but are not able to attribute changes in numbers to effects of training or management.

For a discussion about 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 2.7).

2.5.4 *Lipochaeta venosa* (Endangered)

We tagged and monitored all known *L. venosa,* a Tier 1 species, using the individual plant-based monitoring protocol in the months of October and November 2022. We postponed monitoring the wild population in FY 2023 to reevaluate the optimal season for monitoring and shifted monitoring to the dry season, July to September, from the wet season, January to March. For genetic conservation, *L. venosa* is an implementation priority 1 (high; Table 13). In 2023 we collected propagules for propagation to establish an ex-situ living collection for seed production.

Plant Monitoring

According to the latest monitoring, a total of 54 adults, 297 juveniles and at least 490 seedlings of *L. venosa* exist at PTA in 2 populations—a wild population and an outplanted population (Figure 47).

Each adult or juvenile plant was scored based on its assigned vigor class (Healthy=5; Moderate=3; Poor=1) to arrive at an average health index for each population. Both populations were on average observed to be in healthy condition (Table 36).

Table 36. Average plant health index in *Lipochaeta venosa* populations

			Plant Health[a]			
Population	Monitoring Period	# of Plants	Healthy (5)	Moderate (3)	Poor (1)	Average Health Index
LIPVEN1	Nov 2022	1	100%	0%	0%	5.0
LIPVEN2	Oct 2022	350	89%	9%	2%	4.7

[a]Healthy = foliage that appears green and vigorous, with less than 10% dead leaves or defoliation; Moderate = leaves on plants may have some chlorosis, with 10–50% of the leaves dead or defoliated; Poor = mostly dead or chlorotic leaves, with greater than 50% dead leaves or defoliation.

While not a complete phenological dataset, we are documenting the reproductive structures present in each population during the period monitored (Table 37). We documented 48% of plants with fruits; however, we are not certain these fruits were viable —we did not take data on apparent fruit ripeness at time of observation.

Table 37. Presence of reproductive structures in *Lipochaeta venosa* populations

		Reproductive Structures Present			
Population	Monitoring Period	# of Plants	Fruits	Flowers	Flower Buds
LIPVEN1	Nov 2022	0	0%	0%	0%
LIPVEN2	Oct 2022	54	48%	19%	4%

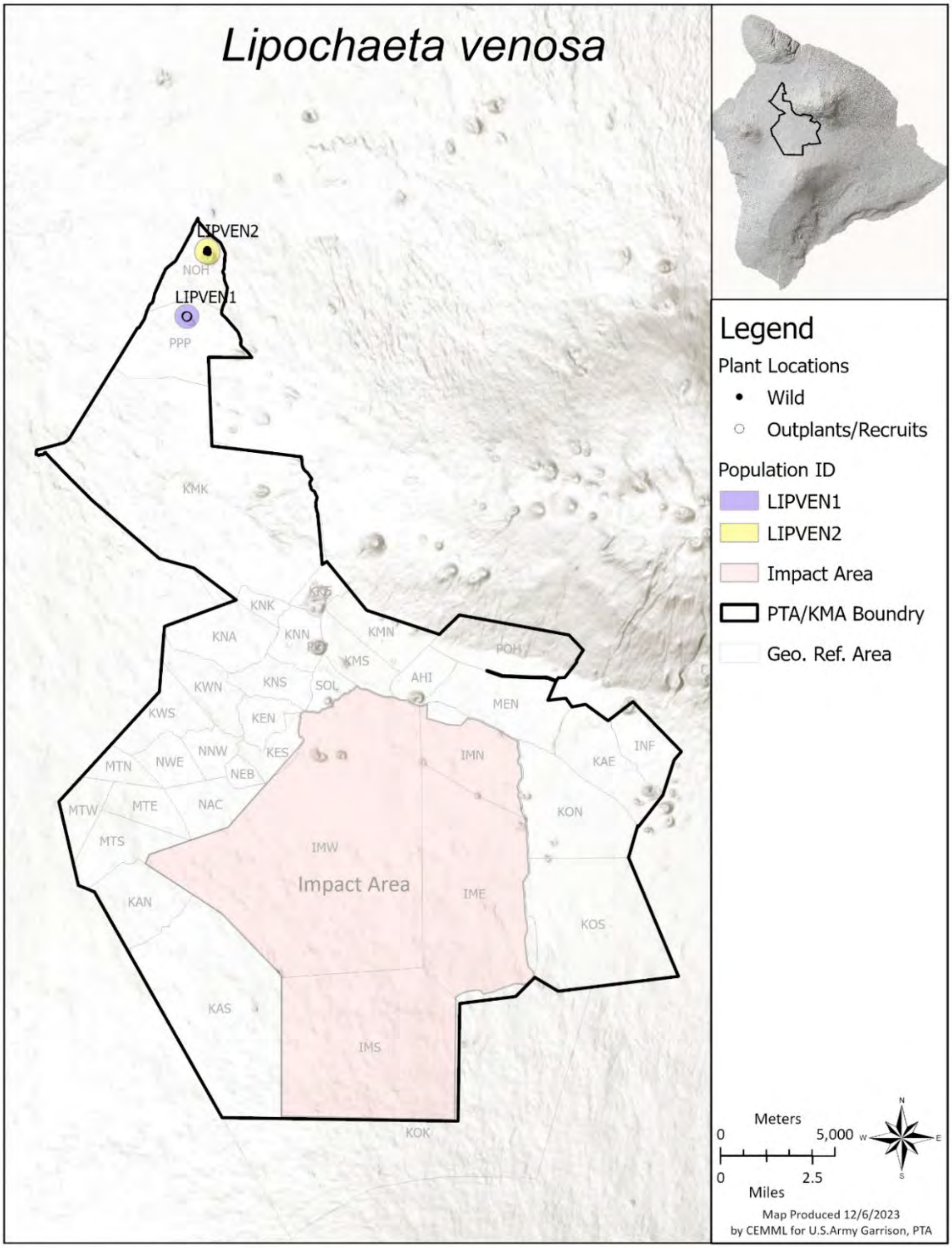


Figure 47. Current known distribution of *Lipochaeta venosa* individuals and populations at PTA[a]

[a]Data used to produce map were obtained from: (1) rare plant survey data collected between 2011 to 2021 plus monitoring of these locations conducted in 2022 to 2023; and (2) live plant locations collected during outplant monitoring in 2022.

The population structure of this species in the wild has shifted dramatically over the past 2–3 years. The number of adults dropped by 32% and the number of juveniles and seedlings rose by 95% and 99% respectively in October and November 2022 (Figure 48). The Keʻāmuku weather station (located 2.2 km and 140 m upslope from the plant population) measured 17.5 cm of rain during the months of August to October 2022. Between August 2019 and August 2020, the previous monitoring period, juvenile and seedling presence was much less and a total of 162.6 cm of rain fell, evenly distributed throughout the year. Unfortunately, the Keʻāmuku weather station was offline from September 2020 to August 2022, so we have no way of documenting a relative increase or decrease in rainfall between the 2 periods. Yet the substantial amount of rain in 2019 to 2020 suggests that rainfall is not the sole factor in shifting population dynamics.

The differences in the number of juveniles between the 2 monitoring periods was not likely influenced by differences in monitoring methods used. This species is a short-lived, semi-woody herb; thus, life stages are easy to differentiate. For combined *L. venosa* locations, 100% of weed percent cover and fine fuels percent cover estimations were below our 20% cover management thresholds (Figure 49 and Figure 50).

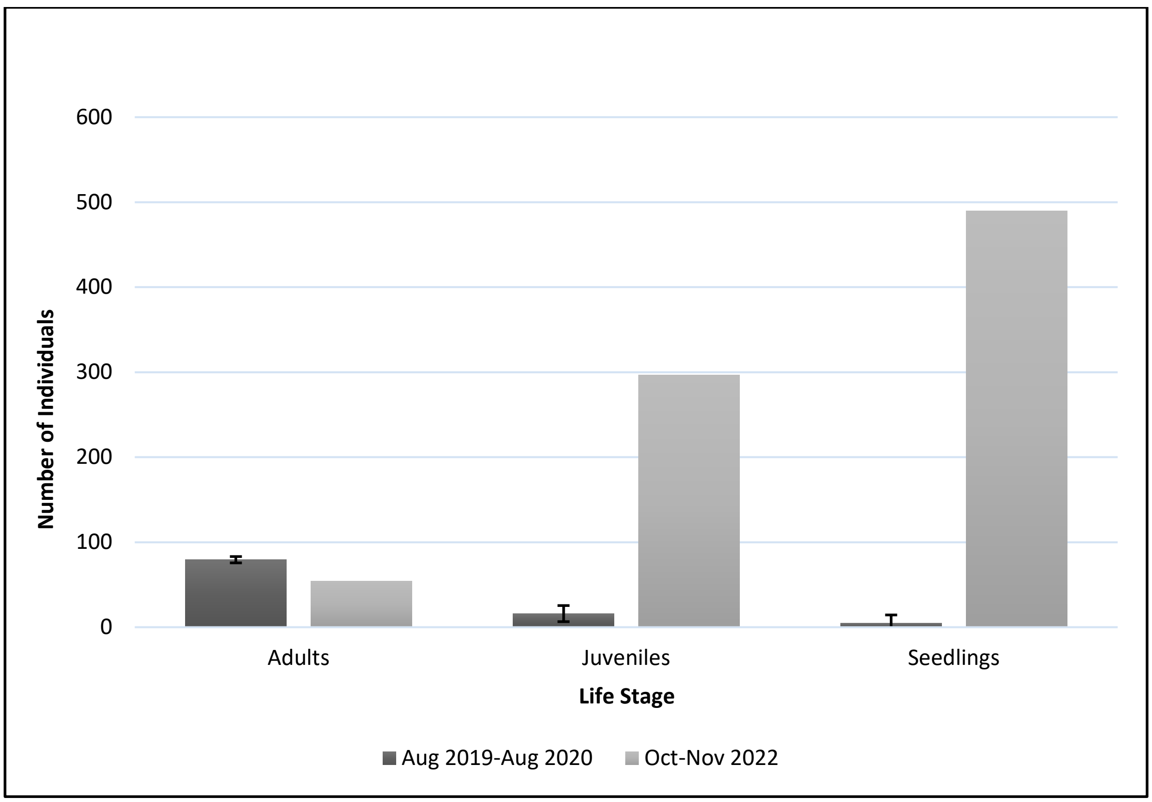


Figure 48. Monitoring data for wild *Lipochaeta venosa* individuals from 2019 to 2020 compared with 2022. Mean abundance and 90% confidence intervals (error bars) are derived from 5 quarterly monitoring datasets collected in 2019 to 2020; monitoring census data from 2022 are a single dataset

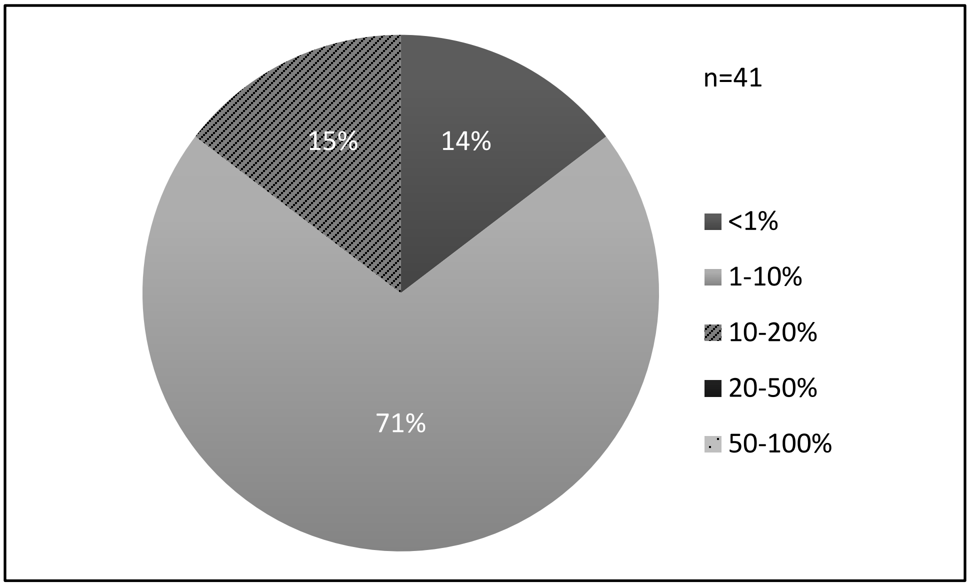


Figure 49. Overall proportion of weed percent cover classes reported for *Lipochaeta venosa* plant locations

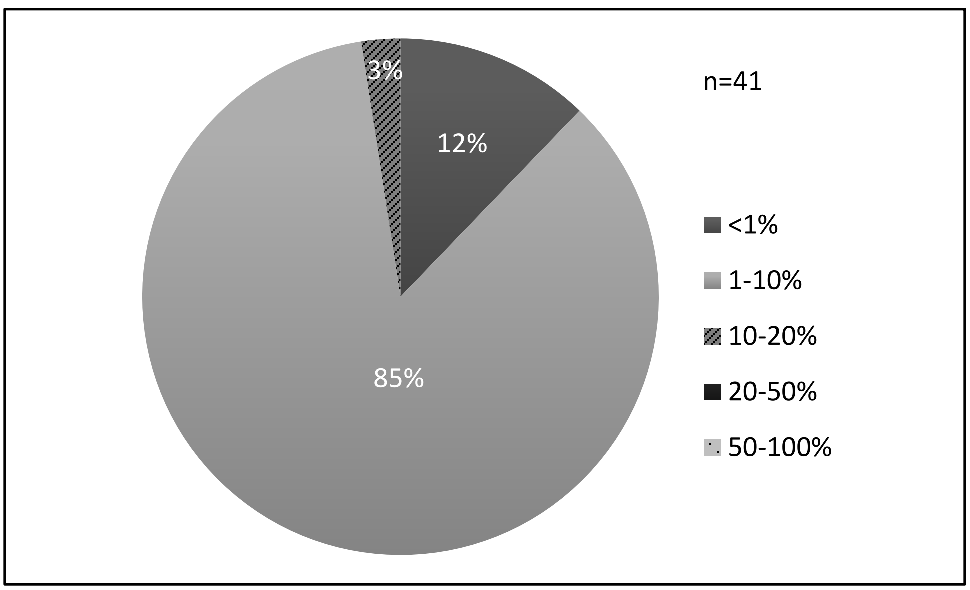


Figure 50. Overall proportion of fine fuels percent cover classes reported for *Lipochaeta venosa* plant locations

<u>Genetic Conservation</u>

Propagule Collection and Propagation

We collected 44 seeds from 2 wild founders and 158 cuttings from 29 wild founders at Puʻu Nohona O Hae in 2023 (Table 38). 5 of these cuttings were deposited at the Lyon Arboretum Micropropagation facility on Oʻahu. Following attrition, a total of 20 founders were accessioned as permanent living collections.

Table 38. Propagule collections for *Lipochaeta venosa* in 2023. Seeds collected were dried to 28% relative humidity and stored at 5° C. Vegetative propagules stored as permanent living collections in RPPF

Plant ID[a]	Date of Collection	Type of Propagule	Amount Collected	Population	UTM X	UTM Y
1830	14 Apr 23	Cutting	3	LIPVEN2	219027	2205093
2075	14 Apr 23	Cutting	5	LIPVEN2	219020	2205100
1871	14 Apr 23	Cutting	3	LIPVEN2	219076	2205161
2469	14 Apr 23	Cutting	4	LIPVEN2	219019	2205099
2347	14 Apr 23	Cutting	4	LIPVEN2	219086	2205180
2061	14 Apr 23	Cutting	4	LIPVEN2	219086	2205194
2220	14 Apr 23	Cutting	4	LIPVEN2	219076	2205152
2399	14 Apr 23	Cutting	4	LIPVEN2	219076	2205194
1699	14 Apr 23	Cutting	5	LIPVEN2	219085	2205191
2077	14 Apr 23	Cutting	2	LIPVEN2	219058	2205134
2318	14 Apr 23	Cutting	6	LIPVEN2	219125	2205065
2278	14 Apr 23	Cutting	4	LIPVEN2	219072	2205160
2454	14 Apr 23	Cutting	5	LIPVEN2	219078	2205209
2241	14 Apr 23	Cutting	4	LIPVEN2	219088	2205188
2462	14 Apr 23	Cutting	4	LIPVEN2	219015	2205106
2394	14 Apr 23	Cutting	5	LIPVEN2	219075	2205147
2407	14 Apr 23	Cutting	4	LIPVEN2	219068	2205131
2119	14 Apr 23	Cutting	4	LIPVEN2	219086	2205194
2400	14 Apr 23	Cutting	5	LIPVEN2	219087	2205193
2477	14 Apr 23	Cutting	3	LIPVEN2	219123	2205066
1940	15 May 23	Seed	8	LIPVEN2	219088	2205189
2308	15 May 23	Cutting	3	LIPVEN2	219020	2205098
2426	15 May 23	Cutting	3	LIPVEN2	219081	2205189
2080	16 May 23	Cutting	5	LIPVEN2	219048	2205177
2258	16 May 23	Cutting	2	LIPVEN2	219072	2205160
2071	16 May 23	Cutting	3	LIPVEN2	219076	2205171
2284	16 May 23	Cutting	4	LIPVEN2	219047	2205175
1906	16 May 23	Cutting	3	LIPVEN2	219079	2205157
2414	23 May 23	Cutting	4	LIPVEN2	219043	2205178
2094[b]	17 Jul 23	Cutting	5	LIPVEN2	219086	2205189
2318	17 Jul 23	Seed	36	LIPVEN2	219125	2205065

[a] Plant IDs refer to the number printed on tags of wild individuals collected.

[b] Cuttings collected from *Lipochaeta venosa* 2094 were put into long-term storage at the Lyon Arboretum Micropropagation Facility (University of Hawaiʻi at Mānoa).

Viability testing trials for *L. venosa* were conducted at OANRP's seed lab in FY 2023 using the entire existing seed collection (341 seeds) as many were aging and seed germination had never been successfully achieved. The number of seeds and the age of collections tested are listed in Table 39, along with the average percent germination. Overall germination rate for *L. venosa* was 2% (Table 16). All resultant plants are being transferred back to PTA for inclusion in the living collection.

Table 39. Germination trials for *Lipochaeta venosa* conducted at the US Army Garrison-Hawaiʻi Natural Resources Program on Oʻahu

Age of Seed (years)	Number of Accessions	Number of Seeds Sown	Number of Seeds Germinated	Average Germination Rate
15	1	5	0	0%
14	3	54	3	0.1%
				Av. Germ. Rate 14–15 years = 5%
7	3	4	1	25%
4	4	278	4	1%

Outplanting and Monitoring

We did not outplant *L. venosa* during this reporting period. Between 2004 and 2014, we planted a combined total of 265 *L. venosa* at 4 sites. At last monitoring in 2022, adults were present at 2 sites off PTA (201 and 205). While the number of individuals at 1 site has increased from 2 to 3 plants, the other site has seen a 95% reduction since outplanting occurred (Table 40).

Table 40. Monitoring results from October–December 2022 for *Lipochaeta venosa* outplanted 2004–2014.

Location	ASR	Total Outplanted 2004–2014	Total Present 2014		Total Present 2022		% Change 2014–2022
			Adult	Juvenile	Adult	Juvenile	
Off PTA	<u>201</u>	2	1	0	3	0	+200%
	203	28	0	0	0	0	-100%
	<u>205</u>	234	176	5	11	0	-95%
On PTA	214	1	0	0	0	0	-100%

ASR, Area of Species Recovery. ASRs numbered in the 200s refer to outplanting sites, which may be located within or adjacent to ASR established for wild populations.

Note: The data source for planting activity between 2004 and 2014 and 2014 monitoring data is CEMML 2015. An underlined ASR number denotes juvenile/adult recruits were present in 2014.

In 2019, we planted 16 *L. venosa,* representing 6 wild founders, on Puʻu Pāpapa in the Keʻāmuku Maneuver Area (ASR 225). Although historically known from Puʻu Pāpapa, *L. venosa* 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 December 2022 there was 1 juvenile *L. venosa* remaining at ASR 225, presumably a recruit. The survivorship for *L. venosa* at this site was 88% 20 months after planting in 2019.

<u>Discussion</u>

Our efforts to monitor and conserve genetic resources for *L. venosa* address SOO tasks 3.2.1.2, 3.2.1.4, and 3.2.1.5, 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, the total number of adult and juvenile *L. venosa* on Puʻu Nohona O Hae decreased by 72% (currently 351; Table 41); distribution has contracted from 225 ha to 0.5 ha (99%).

The plants known from PTA are likely a large proportion of the statewide population and are the only natural plants that occur on public lands and are actively managed with public funds. The limited distribution and low population number make managing threats to this species extremely important to prevent extinction.

In response to the decline, in 2016 we 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 to FY 2019 (CEMML 2019b).

Nothing is known about which *L. venosa* 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 sustainability. Understanding 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. Now that we are monitoring individual plants of various life stages consistently from year to year, we will amass data to help answer these questions.

We continue to progress with genetic conservation of *L. venosa*; however, many of the accessions we attempted to germinate in 2023 had no viable seed (Table 39); overall germination rate for *L. venosa* was 2% (Table 16). Based on these results, plus previous attempts at propagating this species (CEMML 2022a), we need to refine seed collection protocols to ensure viable propagules are put into storage. We worked with a Plant Extinction Prevention Program employee during the past year to learn proper identification of ripe (filled) achenes in the wild population. No filled achenes were observed in the wild population during peak flowering season between May and June. Per a recommendation from PEPP, we attempted to hand-pollinate several wild plants to increase seed set. In addition, to facilitate seed collection/production, we successfully cultivated 34 individuals, representing 20 wild founders, to maintain as a living collection in the Rare Plant Propagation Facility (RPPF). In the coming year, we plan to germinate seed from all wild plants that were hand pollinated (crosses) in 2023 and will begin to systematically cross individuals in the RPPF. The goal is to not only produce seed for storage, but also to vegetatively propagate individuals from these living collections for use in outplanting efforts.

Our success at rooting cuttings of *L. venosa* in 2023 appeared to be as high as 47% at the time of transplanting (2 months post-collection), which is similar to the success PTA horticulturalists have had in the past (CEMML 2015). However, 3 months later when the cuttings were accessioned into the RPPF, only 27% survived. The transplants appeared highly susceptible to rot, and probably received too much water (every 24 hours) accompanied by too much sunlight while they were vulnerable. In the future, the cuttings will be transplanted first into smaller pots, when their roots have developed sufficiently, and watered with a weak vitamin-based fertilizer whenever the pots are dry. We will try keeping the rooted cuttings shaded for a longer period, provided they can dry out between watering.

We have documented *L. venosa* recruitment at 3 sites in the past; however, the level of recruitment has never been high enough to offset losses. In addition, we were sometimes unable to determine if the plants were genetic clones of the original outplants, or if some of the plants germinated from seed. ASR 201 is outside the potential geographic range of *L. venosa* (Price et al. 2012) and above the suitable migration zone (Fortini et al 2013), so we are tracking performance of this species at ASR 201 to learn more about its adaptability to higher elevation and moisture regimes. Although *L. venosa* appears to be doing well at ASR 201 (Table 40 repots a +200% change between 2014 and 2022), the number of plants present at ASR 201 in 2022 had only increased by 1 compared to the total number of plants planted between 2004 and 2014. The *L. venosa* planted at ASRs 205 and 225 are both within the historic and possible range (Price et al. 2012), and the toleration zone (Fortini et al. 2013). We will continue to monitor all outplants to help better understand habitat characteristics that may influence persistence over time.

Lipochaeta venosa is a high priority for outplanting due to its limited numbers, restricted distribution, and extreme vulnerability to wildland fire. We plan to implement planting projects over the next 5 years to establish new populations of this species within the KMA, once enough outplants can be propagated. In the short term, establishing a robust collection in PTA's ex-situ storage (seeds and living collections) will take precedence, including up to 10 wild founders represented in micropropagation at Lyon Arboretum.

Status of Lipochaeta venosa *Populations at PTA per the USFWS Species Recovery Criteria*

In the 5-Year Review for *L. venosa* published in 2020, the USFWS established a new recovery stage—Preventing Extinction Stage with updated criteria. The Preventing Extinction stage for *L. venosa* requires 50 mature individuals in each of 6 populations, with at least 50 individuals (or the total number if less than 50) represented from each wild population in ex-situ storage. We continue to make progress towards the Preventing Extinction Stage for the 2 populations at PTA (Table 41). Through management, we strive to advance the species toward the next stage of recovery—Interim Stabilization. However, for *L. venosa* to reach both the Preventing Extinction and Interim Stabilization stages, a third population must be established and maintained (at PTA or elsewhere) to meet the criteria. Through continued monitoring, we plan to document natural reproduction and assess population trends.

Table 41. Progress towards USFWS Preventing Extinction stage of recovery for *Lipochaeta venosa* at PTA

Population	# Adults Wild (OP)	# Juvenile: Wild (OP)	# Founders Ex-situ Storage	Fenced	Invasive Plant Control	Natural Reproduction	Number Increasing
LIPVEN1	(0)	(1)	NA	Yes	Yes	ND	ND
LIPVEN2	54	297	20	Yes	Yes	ND	ND

ND, No Data

Progress toward Compliance with Endangered Species Act Biological Opinion Conservation Measures

To offset effects of military activities on *L. venosa,* the 2003 BO conservation measures include fuels management to reduce fire risk, fencing and ungulate control to reduce browsing 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 (Sections 3.4 and 4.3). In addition, we actively conserve *L. venosa* genetic resources; the RPPF currently holds 34 individuals representing 20 wild founders. One of these founders is also represented at Lyon Arboretum and we have plans to deliver material representing up to 9 more founders in the coming year. In 2019, we planted 16 *L. venosa* on Puʻu Pāpapa, representing 6 founders. In addition, prior to 2019, we outplanted a combined total of 265 individuals at 4 sites. We continue weed management at Puʻu Nohona O Hae across 1.7 ha of habitat (Section 3.2, Table 101). Between 2016 and 2019, we documented in-situ reproduction at 1 of 36 (3%) monitoring plots in the wild *L. venosa* population. Using our new individual plant-based monitoring protocol will allow us to document in-situ reproduction much more effectively; we expect to observe much more reproduction moving forward. Although we monitor *L. venosa* annually to assess population patterns, we are unable to attribute changes in numbers to effects of 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 2.7).

2.5.5 *Neraudia ovata* (Endangered)

We tagged and monitored all known *N. ovata*, a Tier 1 species, using the individual plant-based monitoring protocol between the months of January 2022 and February 2023. For genetic conservation, *N. ovata* is an implementation priority 3 (moderate; Table 13). In 2024 we plan to resume collection of propagules to refresh old accessions in storage, as well as to represent individuals currently missing from the collection. We also plan to augment existing populations and establish new populations with outplants in 2024 to 2025.

Plant Surveys and Monitoring

According to the latest monitoring, a total of 93 adults and 15 juveniles of *N. ovata* exist at PTA in 4 populations—1 wild and 3 outplanted (Figure 51).

Each adult or juvenile plant was scored for vigor (Healthy=5; Moderate=3; Poor=1) to arrive at an average health index for each population. The wild population (NEROVA2) was on average moderate to healthy (3.5), while the small outplanted populations, for which we have data available, were healthy (Table 42).

Table 42. Average plant health index in *Neraudia ovata* population

			Plant Health[a]			
Population	Monitoring Period	# of Plants	Healthy (5)	Moderate (3)	Poor (1)	Average Health Index
NEROVA1	Jan 2022	ND				
NEROVA2	Sept 2022	53	45%	34%	21%	3.5
NEROVA3	Nov 2022	ND				
NEROVA4	Sept 2022	1	100%	0%	0%	5.0
NEROVA5	Feb 2023	3	100%	0%	0%	5.0

ND, No Data

[a]Healthy = foliage that appears green and vigorous, with less than 10% dead leaves or defoliation; Moderate = leaves on plants may have some chlorosis, with 10–50% of the leaves dead or defoliated; Poor = mostly dead or chlorotic leaves, with greater than 50% dead leaves or defoliation.

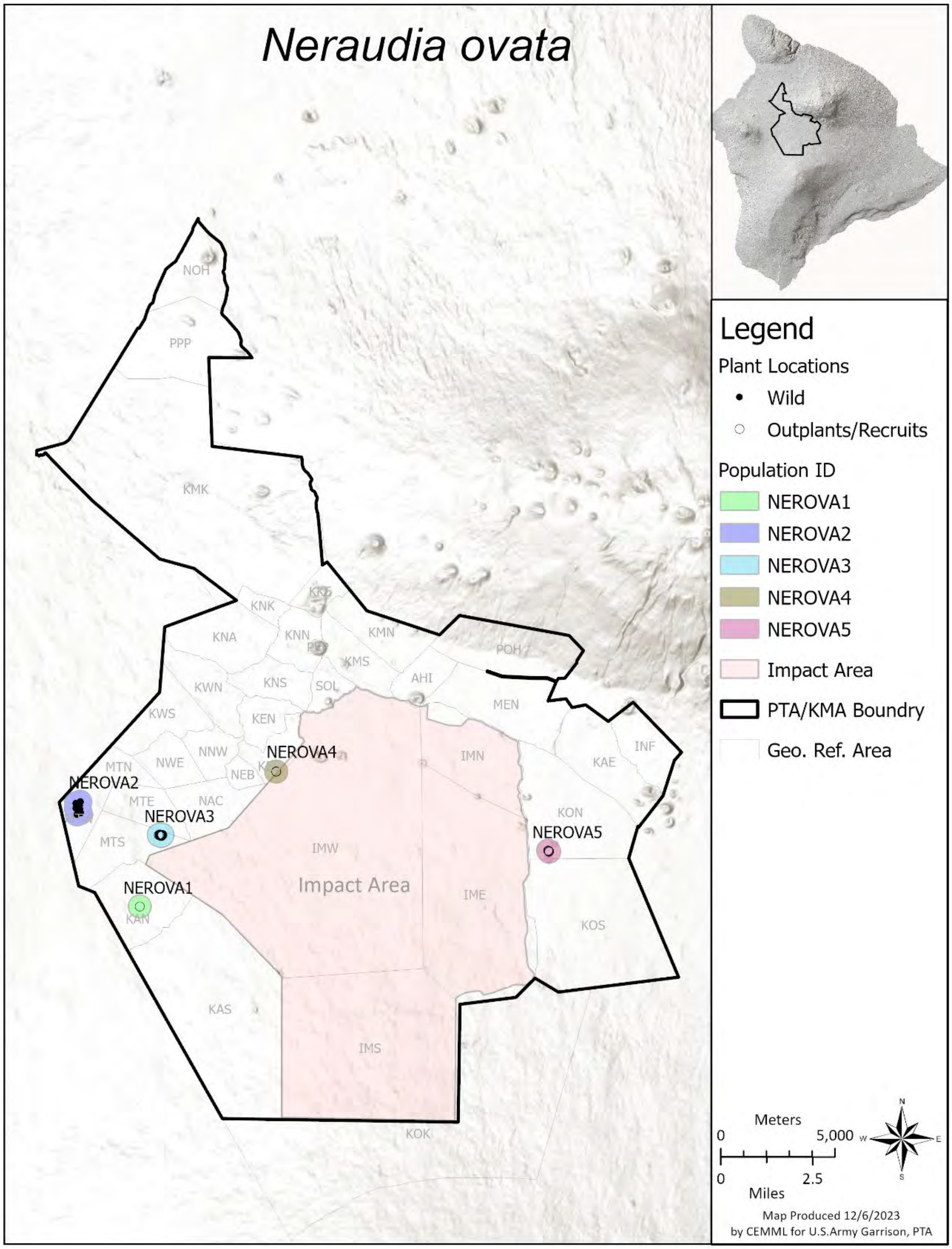


Figure 51. Current known distribution of *Neraudia ovata* individuals and populations at PTA[a]

[a]Data used to produce map were obtained from: (1) rare plant survey data collected between 2011 to 2021 plus monitoring of these locations conducted in 2022 to 2023; and (2) live plant locations collected during outplant monitoring in 2022.

We are documenting the reproductive structures present in a given population during the period monitored, although this is not a complete phenological dataset (Table 43). The data collected in 2022 and 2023 confirm that fruit can be collected year round, although we did not take data on fruit ripeness (CEMML 2015).

Table 43. Presence of reproductive structures in *Neraudia ovata* populations

		Reproductive Structures Present			
Population	**Monitoring Period**	**# of Plants**	**Fruits**	**Flowers**	**Flower Buds**
NEROVA1	Jan 2022	ND			
NEROVA2	Sept 2022	38	63%	21%	24%
NEROVA3	Nov 2022	ND			
NEROVA4	Sept 2022	ND			
NEROVA5	Feb 2023	3	75%	0%	0%

ND, No Data

The population structure of this species in the wild is dominated by adults, with many of these individuals found almost 20 years ago (Figure 52). Mortality of this extremely rare species has occurred, with 4 individuals dying in the past 2 years. The differences in the number of juveniles between the 2 monitoring periods (9 in 2019 to 2020 and 15 in 2022 to 2023) may be due to differences in methods used to distinguish life stages. In the current protocol, until evidence of current or past reproduction is presenting on these 6 individuals, we will continue to categorize them as juvenile. With previous protocols used to monitor plants, prior knowledge was sometimes used to determine the life stage of an individual, or else overall plant size was used as a surrogate for determining life stage. *N. ovata* is a long-lived perennial and stability in the adult life stage, with occasional gains and losses in the seedling and juvenile life stages, is consistent with expected life history characteristics. Limited recruitment has occurred since ungulates were removed from the fence units. Rodents or game birds may be consuming propagules, seedlings, and juveniles. At PTA, rodents are known to break branches and stems and to strip bark. Outplanting sites at lower elevation (off-PTA) experienced high levels of seedling/juvenile recruitment in the past, most perishing soon after (CEMML 2015).

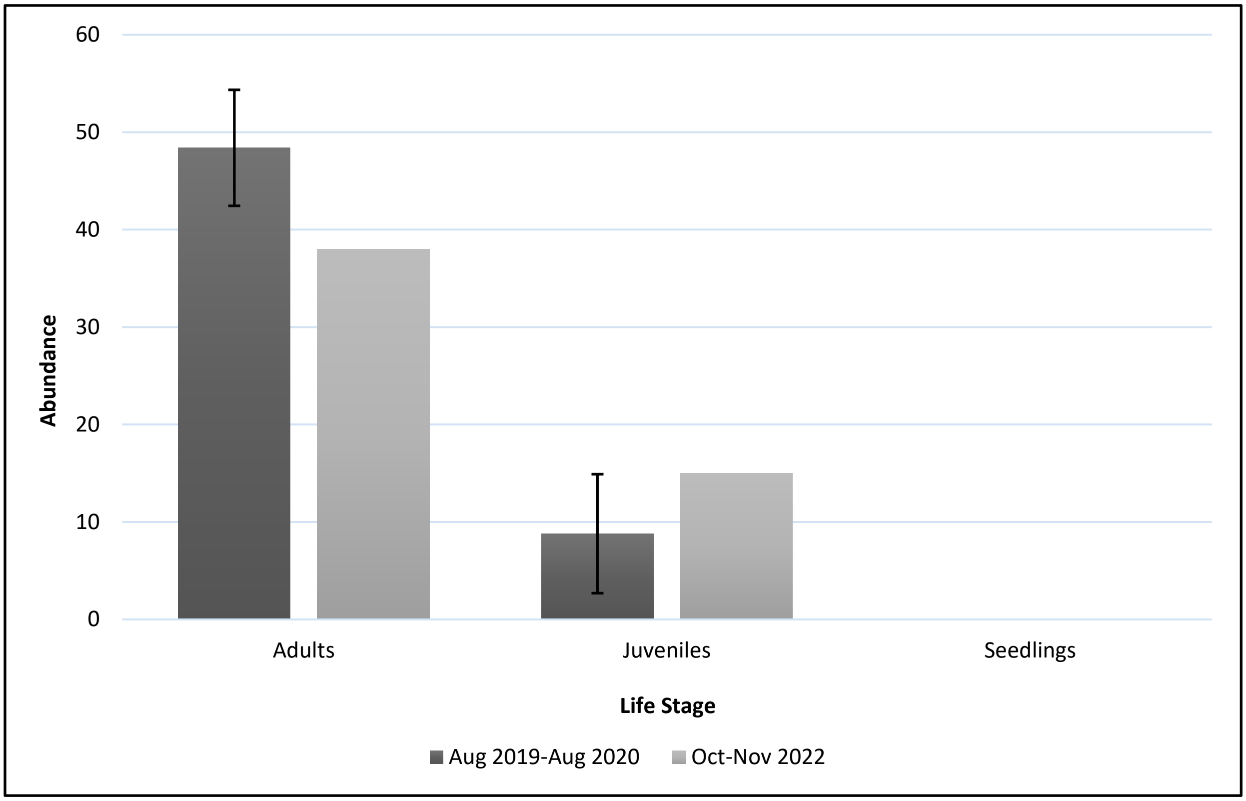


Figure 52. Monitoring data for wild *Neraudia ovata* individuals from 2019 to 2020 compared with 2022. Mean abundance and 90% confidence intervals (error bars) are derived from 5 quarterly monitoring datasets collected in 2019 to 2020; monitoring census data from 2022 are a single dataset

For combined *N. ovata* locations, only 2% of weed percent cover estimations exceeded our 20% cover management thresholds and 100% of fine fuels percent cover estimations were below our 20% cover management thresholds (Figure 53 and Figure 54).

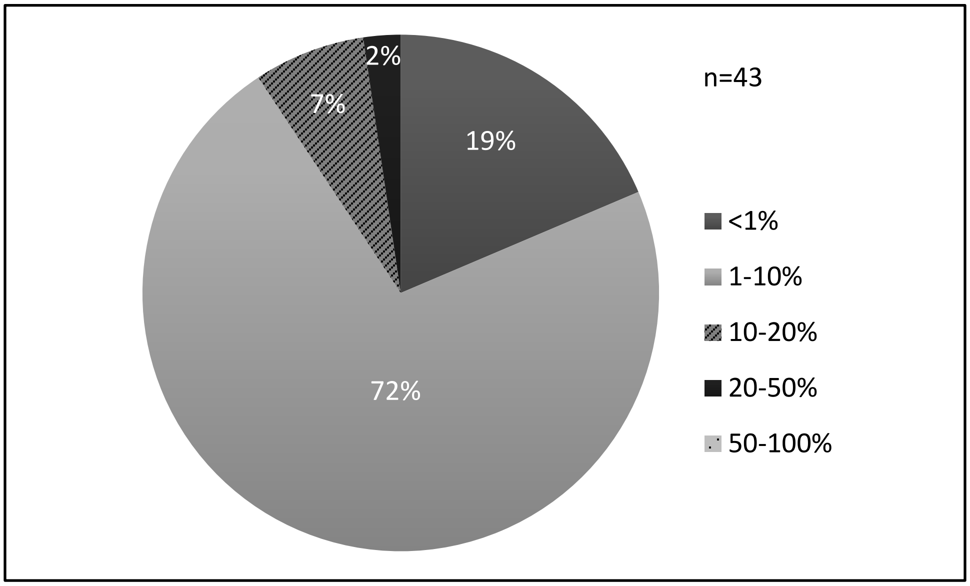


Figure 53. Overall proportion of weed percent cover classes reported for *Neraudia ovata* plant locations

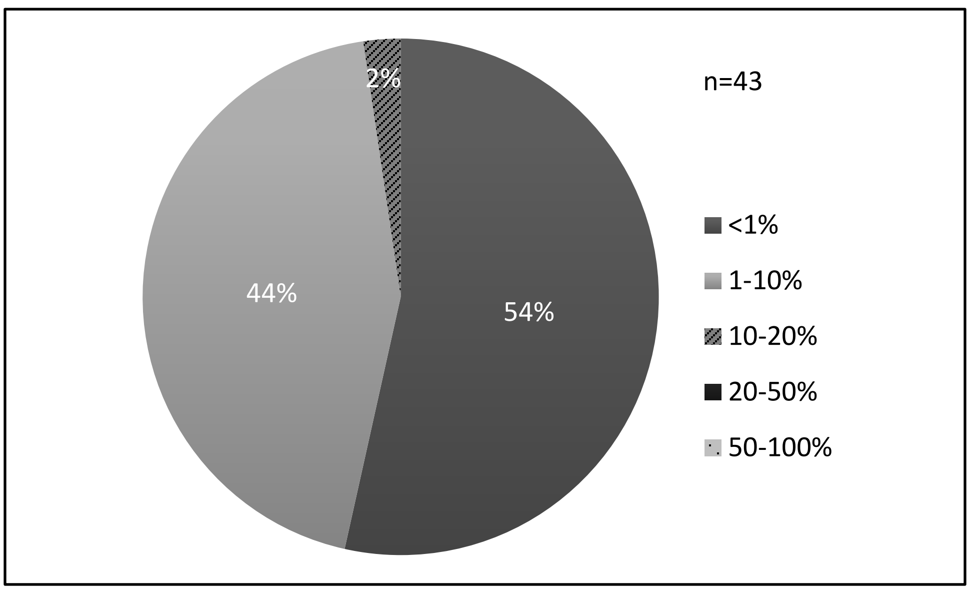


Figure 54. Overall proportion of fine fuels percent cover classes reported for *Neraudia ovata* plant locations

Genetic Conservation

Propagule Collection and Propagation

No propagule collection occurred during the reporting period. Please refer to Table 15 for a complete summary of ex-situ storage status for *N. ovata.*

Preliminary viability testing trials for *N. ovata* were conducted at OANRP's seed lab in FY 2023 using a small subset of accessions collected 5 to 18 years prior. They sowed 392 seeds from 4 accessions of varying age (Table 44); the average percent germination has yet to be calculated because the trial is not yet complete. This species is known to germinate slowly (sporadically germinating over a 24-month period); expected completion date March 2025. All resultant plants are being transferred back to PTA for outplanting.

Table 44. Germination trials for *Neraudia ovata* conducted in 2023 at the US Army Garrison-Hawaiʻi Natural Resources Program on Oʻahu

Age of Seed (years)	Number of Accessions	Number of Seeds Sown	Number of Seeds Germinated (as of 9-30-23)
18	1	102	0
10	1	109	0
5	1	95	1
5	1	86	0

From previous propagation efforts, 7 *N. ovata* clones of 3 deceased wild founders were accessioned to the RPPF as of 30 September 2023 (Table 20).

Outplanting and Monitoring

We did not outplant *N. ovata* during this reporting period. Between 2004 and 2014, we planted a combined total of 419 *N. ovata* at 10 sites. At last monitoring in 2022, adults were present at 3 ASR off PTA (201, 204, 205) and 3 ASR on PTA (206, 213, 215). However, all sites showed a decrease in the number of individuals present between 2014 and 2022 (Table 45); there were 13 fewer plants since monitoring in 2020 (CEMML 2022a).

Table 45. Monitoring results from January 2022–February 2023 for *Neraudia ovata* outplanted 2004–2014

Location	ASR	Total Outplanted 2004–2014	Total Present 2014		Total Present 2022–2023		% Change 2014–2022/2023
			Adult	Juvenile	Adult	Juvenile	
Off PTA	201	117	63	0	3	0	-97%
	202	16	0	0	0	0	0%
	<u>203</u>	31	39	86	0	0	-100%
	<u>204</u>	42	2	270	1	0	-99%
	<u>205</u>	132	50	10	10	0	-83%
On PTA	<u>206</u>	4	2	1	1	0	-67%
	211	3	0	0	0	0	0%
	213	54	52	0	50	0	-4%
	215	12	1	0	1	0	0%
	217	8	0	0	0	0	0%

ASR, Area of Species Recovery. ASRs numbered in the 200s refer to outplanting sites, which may be located within or adjacent to ASR established for wild populations.
Note: The data source for planting activity between 2004 and 2014 and 2014 monitoring data is CEMML 2015. A bold site number denotes seedlings and underline denotes juvenile/adult recruits were present in 2014.

In 2019, we outplanted 9 *N. ovata*, representing 5 founders, at ASR 226. The 9 plants were propagated from cuttings from founders established in the RPPF. As of February 2023, 3 healthy adult plants remained at the site (Population NEROVA5; Table 42).

<u>Discussion</u>

Our efforts to monitor and conserve genetic resources for *N. ovata* address SOO tasks 3.2.1.2, 3.2.1.4, and 3.2.1.5, as well as several INRMP objectives and conservation measures from the 2003 and 2013 BO.

N. ovata occurs as solitary individuals or small isolated groups within the single wild population at PTA, NEROVA5 (Figure 51). Extensive management at the wild population has included small- and large-scale fencing to protect the plants from ungulate browse, invasive plant control, and rodent management (which was conducted for a short period in 2011 but subsequently discontinued). *N. ovata* recruits from the seed bank in an episodic manner, in both wild and outplanted populations, with recruitment events occurring during favorable environmental conditions. Nothing is known about which *N. ovata* 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 sustainability. Understanding 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. Now that we are monitoring individual plants of various life stages consistently from year to year, we will amass data that will help to answer these questions.

We continue to make progress with genetic conservation of *N. ovata*, and through a recent re-evaluation of our collection we have been able to target certain individuals and populations in need of ex-situ representation. The germination trials started in 2023 will test the viability of some of our oldest collections (10 to 18 years old). More extensive testing of a greater number of accessions will be initiated in FY 2024. Germinating these older seeds is critical to conserving *N. ovata* genetic resources because some of the founders are no longer extant in the wild population. Another issue is that our entire collection of this species was dried and stored as whole fruits, which is known to lead to a reduction in seed viability over time (Center for Plant Conservation 2019).

The number of *N. ovata* outplanted between 2004 and 2014 have declined. *N. ovata* is a relatively long-lived species, so natural attrition due to age is not likely to be driving the observed declines. In 2014, high levels of recruitment were present at ASRs 203 and 204, but *N. ovata* failed to establish a self-sustaining population at ASR 203 and showed a sharp decline in numbers at site 204 (Table 45). We have documented excellent survivorship at ASR 213, above the potential geographic range of *N. ovata* (Price et al. 2012) yet within the suitable migration zone of Fortini et al. (2013). The outplants at Temp 2019-009 (PTA population NEROVA5) are also doing well in an area above the potential geographic range of *N. ovata* (Price et al. 2012) and above the suitable migration zone of Fortini et al (2013). In monitoring the sites on PTA, we hope to learn more about the adaptability of this species to higher elevation and moisture regimes. As we continue to work with outplanting *N. ovata,* closely monitoring environmental conditions after planting events will assist planning supplemental watering. Because our best long-term successes have taken place in higher elevation areas that receive more consistent moisture, this care should take place more often and for a longer period of time than what was tried in the past, to see if this has any positive effect on initial survivorship.

Status of Neraudia ovata *Populations at PTA per the USFWS Species Recovery Criteria*

In the 5-Year Review for *N. ovata* published in 2020, the USFWS established a new recovery stage—Preventing Extinction Stage—with updated criteria. The Preventing Extinction stage for *N. ovata* requires 100 mature individuals in each of 3 populations, with at least 50 individuals (or the total number if less than 50) represented from each wild population in ex-situ storage. We continue to make progress towards the Preventing Extinction Stage for the 5 populations at PTA (Table 46). Through management, we strive to advance the species toward the next stage of recovery—Interim Stabilization. Through continued monitoring, we plan to document natural reproduction and assess population trends.

Table 46. Progress towards USFWS Preventing Extinction stage of recovery for *Neraudia ovata* at PTA

Population	# Adults Wild (OP)	# Juveniles Wild (OP)	# Founders Ex-situ Storage	Fenced	Invasive Plant Control	Natural Reproduction	Number Increasing
NEROVA1	(1)	0	NA	Yes	No	ND	ND
NEROVA2	38	15	50	Yes	Yes	ND	ND
NEROVA3	(50)	0	NA	Yes	Yes	ND	ND
NEROVA4	(1)	0	NA	Yes	Yes	ND	ND
NEROVA5	(3)	0	NA	Yes	No	ND	ND

ND, No Data

Progress toward Compliance with Endangered Species Act Biological Opinion Conservation Measures

To offset effects of military activities on *N. ovata,* the 2003 BO conservation measures include fuels management to reduce fire risk, fencing and ungulate control to reduce browsing 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 (Sections 3.4 and 4.3). In addition, we actively conserve *N. ovata* genetic resources; the ex-situ storage contains 5,960 seeds collected from the wild population and 333,469 seeds collected from clones of wild plants grown in the RPPF as living collections, representing 50 wild founders total. To date, we have outplanted a combined total of 428 individuals at 11 sites and *N. ovata* has persisted at 7 of these sites with 65 total individuals remaining. We continue invasive plant management in the wild population at ASR 24 across about 8.7 ha (Section 3.2, Table 101). Between 2016 and 2019, we observed in-situ reproduction in 1 of 19 (5%) monitoring plots in the wild *N. ovata* population. Using our new individual plant-based monitoring protocol will allow us to document in-situ reproduction much more effectively; we expect to observe more reproduction moving forward. Although we monitor *N. ovata* annually to assess population patterns, we are unable to attribute changes in numbers to effects of 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 2.7).

2.5.6 *Portulaca sclerocarpa* (Endangered)

As a Tier 1 species, we tagged and monitored all known *P. sclerocarpa* using the individual plant-based monitoring protocol between the months of January through December 2022. For genetic conservation, *P. sclerocarpa* is an implementation priority 2 (moderately high; Table 13). In 2023 we made a small collection of seeds from 2 individuals that were not well represented in ex-situ storage.

In 2024 we plan to resume collection of propagules for refreshing old accessions in storage, as well as to provide additional representation of individuals currently missing from our collection. We have plans to assist in the establishment of new populations of this species in 2024 and 2025 on adjacent State land.

Plant Surveys and Monitoring

According to the latest monitoring, a total of 135 adults, 36 juveniles, and at least 47 seedlings of *P. sclerocarpa* exist at PTA in 13 populations—12 wild and 1 outplanted (Figure 55).

Each adult or juvenile plant was scored for vigor (Healthy=5; Moderate=3; Poor=1) to arrive at an average health index for each population. With one exception (PORSCL9), all the populations were on average moderate to healthy (Table 47).

Table 47. Average plant health index in *Portulaca sclerocarpa* populations

		Plant Health[a]				
Population	**Monitoring Period**	**# of Plants**	**Healthy (5)**	**Moderate (3)**	**Poor (1)**	**Average Health Index**
PORSCL1	Apr 2022	1	100%	0%	0%	5.0
PORSCL2	Jan–Oct 2022	5	60%	40%	0%	4.2
PORSCL3	Jan–Apr 2022	14	29%	57%	14%	3.3
PORSCL4	Sept 2022	1	100%	0%	0%	5.0
PORSCL5	Sept 2022	1	100%	0%	0%	5.0
PORSCL6	Aug 2022	3	33%	33%	33%	3.0
PORSCL7	Apr 2022	3	33%	33%	33%	3.0
PORSCL8	Sept 2022	20	75%	25%	0%	4.5
PORSCL9	Sept 2022	1	0%	0%	100%	1.0
PORSCL10	Sept 2022	1	100%	0%	0%	5.0
PORSCL11	Sept 2022	29	86%	10%	4%	4.7
PORSCL12	Aug–Dec 2022	89	45%	35%	20%	3.5
PORSCL13	Oct 2022	3	67%	0%	33%	3.7

[a]Healthy = foliage that appears green and vigorous, with less than 10% dead leaves or defoliation; Moderate = leaves on plants may have some chlorosis, with 10–50% of the leaves dead or defoliated; Poor = mostly dead or chlorotic leaves, with greater than 50% dead leaves or defoliation.

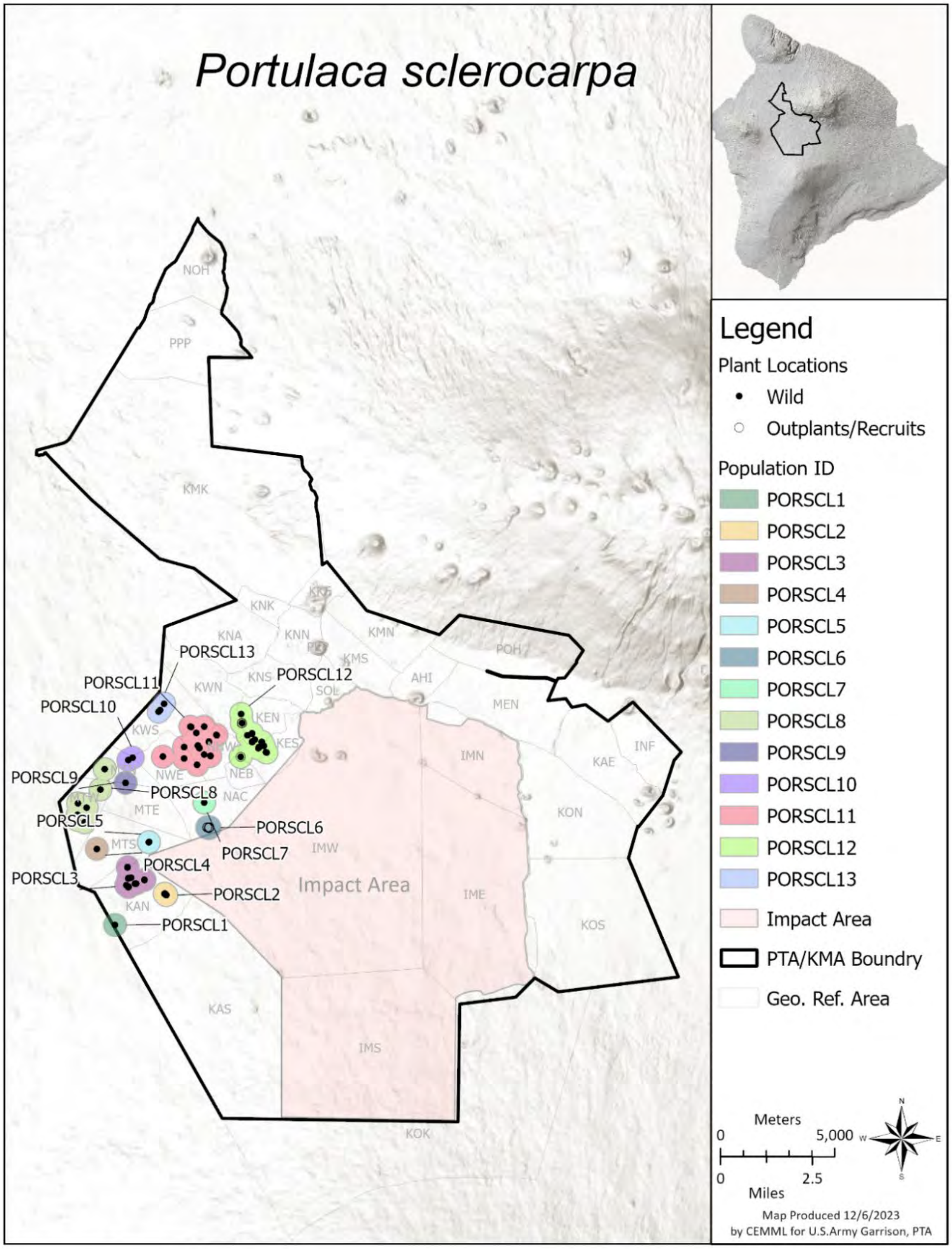


Figure 55. Current known distribution of *Portulaca sclerocarpa* individuals and populations at PTA[a]

[a]Data used to produce map were obtained from: (1) rare plant survey data collected between 2011 to 2021 plus monitoring of these locations conducted in 2022 to 2023; and (2) live plant locations collected during outplant monitoring in 2022.

While not a complete phenological dataset, we are documenting the reproductive structures present in each population during the period monitored (Table 48). Data collected in 2022 confirms fruit can be collected year-round, although we did not take data on fruit ripeness (CEMML 2015).

Table 48. Presence of reproductive structures in *Portulaca sclerocarpa* populations

			Reproductive Structures Present		
Population	**Monitoring Period**	**# of Plants**	**Fruits**	**Flowers**	**Flower Buds**
PORSCL1	Apr 2022	1	100%	0%	0%
PORSCL2	Jan–Oct 2022	5	40%	0%	60%
PORSCL3	Jan–Apr 2022	13	62%	15%	38%
PORSCL4	Sept 2022	1	100%	0%	0%
PORSCL5	Sept 2022	0	0%	0%	0%
PORSCL6	Aug 2022	2	100%	0%	0%
PORSCL7	Apr 2022	3	67%	0%	0%
PORSCL8	Sept 2022	17	35%	0%	12%
PORSCL9	Sept 2022	1	100%	0%	0%
PORSCL10	Sept 2022	1	100%	0%	0%
PORSCL11	Sept 2022	20	80%	0%	15%
PORSCL12	Aug–Dec 2022	69	23%	1%	10%
PORSCL13	Oct 2022	2	0%	0%	50%

The population structure of this species in the wild is currently dominated by adults (63% of total), slightly higher than was estimated during the previous monitoring when they accounted for only 50% of the total (Figure 56). Mortality has occurred, with 65 individuals dying (mostly juveniles) in the past 2 to 3 years. However, the previous monitoring data is averaged over 5 observations and the numbers of juveniles and seedlings varied widely (note the broad range of the error bars in Figure 56). Periodic recruitment has occurred since ungulates were removed from the fence units, yet favorable environmental conditions have encouraged higher numbers of plants in the past (CEMML 2022a). Rodents or game birds may be consuming propagules, seedlings, and juveniles. Rodents break stems and cache and crack seed capsules both in the RPPF and the field (CEMML 2015).

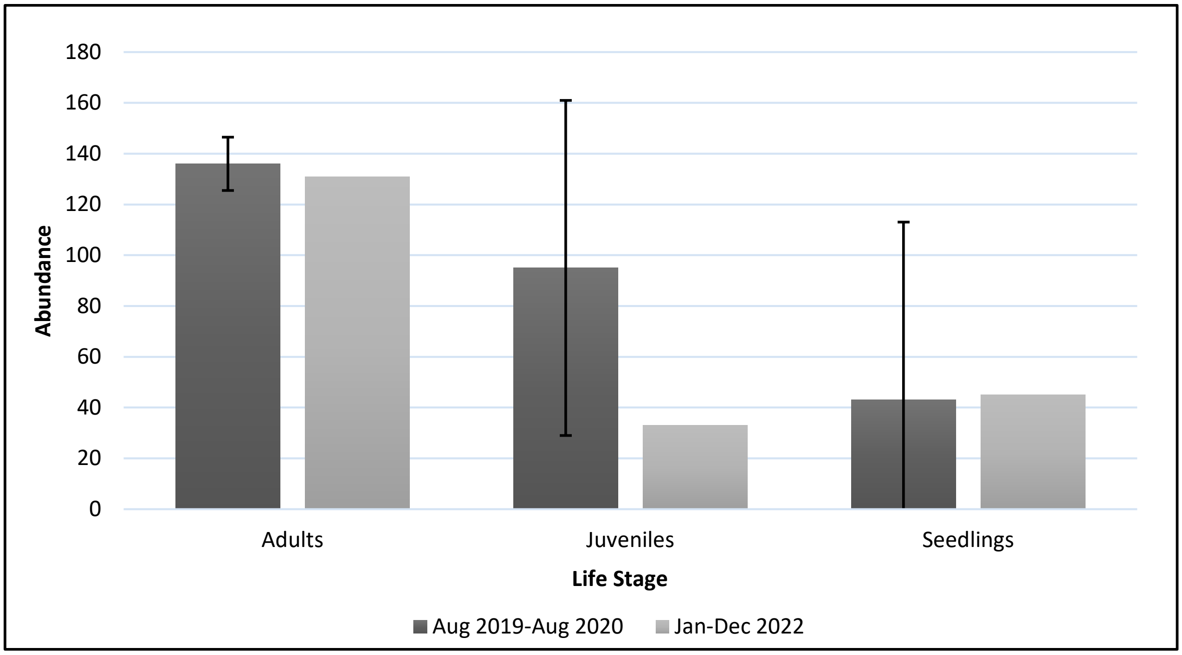


Figure 56. Monitoring data for wild *Portulaca sclerocarpa* individuals from 2019 to 2020 compared with 2022. Mean abundance and 90% confidence intervals (error bars) are derived from 5 quarterly monitoring datasets collected in 2019 to 2020; monitoring census data from 2022 are a single dataset

For combined *P. sclerocarpa* locations, 24% of weed percent cover and 37% of fine fuels percent cover estimations exceeded our 20% cover management thresholds (Figure 57 and Figure 58). This is not surprising since many locations have not been prioritized for weed management because *P. sclerocarpa* was once more abundant and not considered a top priority species. Further, many locations are remote with only a few individuals, making weed management challenging for this species.

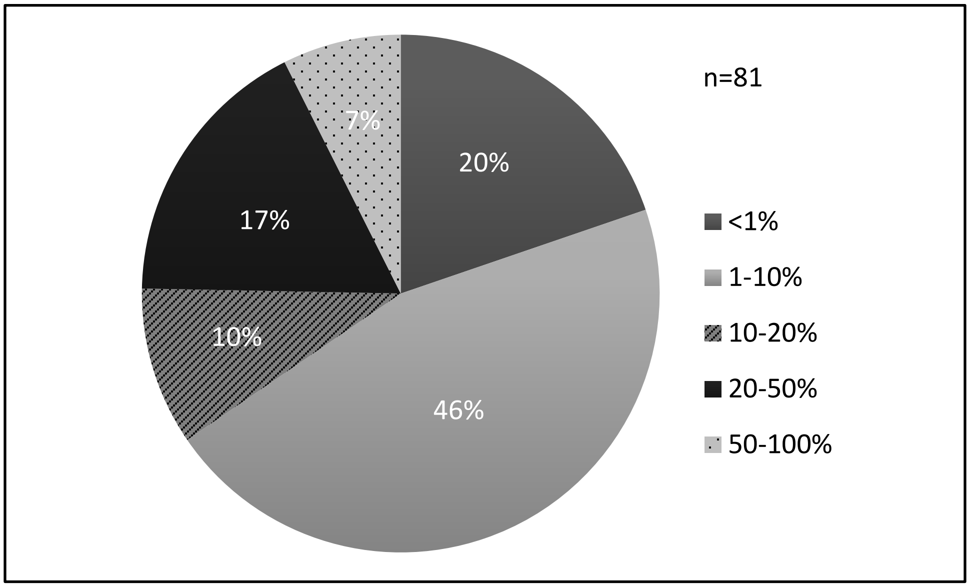


Figure 57. Overall proportion of weed percent cover classes reported for *Portulaca sclerocarpa* plant locations

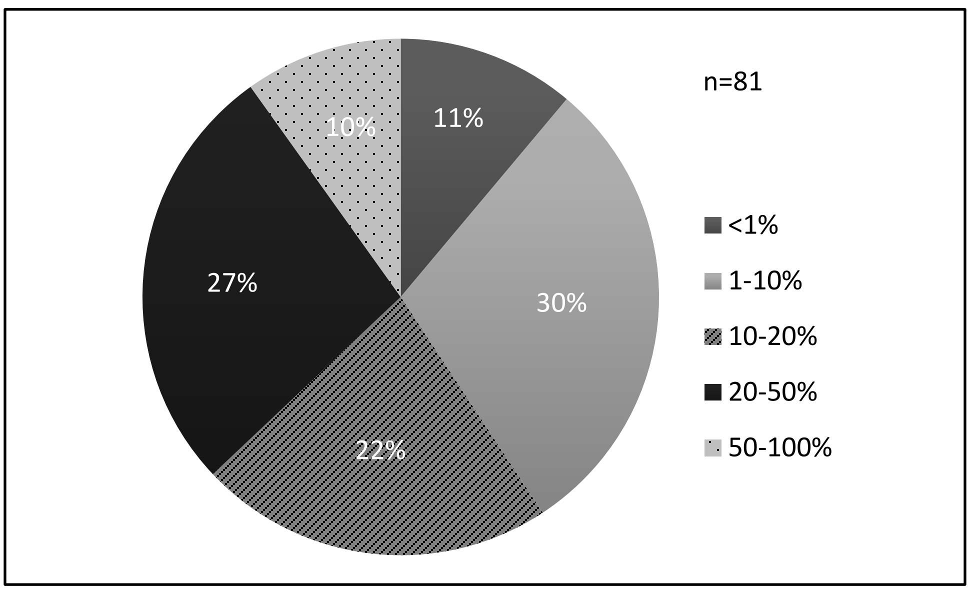


Figure 58. Overall proportion of fine fuels percent cover classes reported for *Portulaca sclerocarpa* plant locations

Genetic Conservation

Propagule Collection and Propagation

We collected 6 capsules from 2 individuals in 2023, which amounted to 296 seeds entering ex-situ storage (Table 49). Please refer to Table 15 for a complete summary of ex-situ storage status for *P. sclerocarpa.*

Table 49. Propagule collections for *Portulaca sclerocarpa* in 2023. Seeds collected were dried to 28% relative humidity and stored at 5° C

Plant ID[a]	Date of Collection	Type of Propagule	Amount Collected	Population	UTM X	UTM Y
1704	07 Mar 23	Seed	214	PORSCL11	218365	2184318
1755	28 Jul 23	Seed	82	PORSCL10	215801	2182979

[a] Plant IDs refer to the number printed on tags of wild individuals collected.

No propagation occurred during this reporting period, and no plants currently exist in the RPPF. A total of 45 plants from previous propagation efforts (representing at least 7 wild founders) were transferred to the custody of the State of Hawaii in 2023, for use in their outplanting efforts on adjacent state land.

Outplanting and Monitoring

We did not outplant *P. sclerocarpa* during this reporting period. Between 2004 and 2014, we planted a combined total of 271 *P. sclerocarpa* at 10 sites. At last monitoring in 2022, no outplanted plants remained at any of the sites (Table 50). Due to the lack of success at any site, we plan to continue to investigate planting site characteristics and other ecological requirements to maximize our chances of success. Belfield et al. (2011) reported similar difficulties with this species and the closely related *Portulaca villosa* at Hawaii Volcanoes National Park.

Table 50. Monitoring results from January–December 2022 for *Portulaca sclerocarpa* outplanted 2004–2014

Location	ASR	Total Outplanted 2004–2014	Total Present 2014		Total Present 2022		% Change 2014–2022
			Adult	Juvenile	Adult	Juvenile	
Off PTA	201	117	0	**0**	0	0	-100%
	202	16	0	**0**	0	0	-100%
	203	31	0	0	0	0	-100%
	204	42	0	0	0	0	-100%
	<u>205</u>	132	10	1	0	0	-100%
On PTA	206	4	0	0	0	0	-100%
	208	3	0	0	0	0	-100%
	210	54	0	0	0	0	-100%
	213	12	2	0	0	0	-100%
	214	8	6	0	0	0	-100%

ASR, Area of Species Recovery. ASRs numbered in the 200s refer to outplanting sites that may be located within or adjacent to ASR established for wild populations.
Note: The data source for planting activity between 2004 and 2014 and 2014 monitoring data is CEMML 2015. An underlined site number denotes juvenile/adult recruits were present in 2014.

In 2019, we outplanted 18 *P. sclerocarpa*, representing 2 founders, at ASR 223. In August 2022, there were 3 *P. sclerocarpa* remaining at ASR 223 (17% survivorship) plus 2 new seedlings. Based on previous failures we are encouraged by any survivorship at all 4 years after planting, and the recruitment of seedlings is also promising. Although predation of seeds, leaves and stems was an issue at several of the sites established previously, the common pattern was overall low vigor, minimal reproduction and decline within 1 to 3 years (CEMML 2015).

An additional outplanting occurred in the KKE fence unit in 2019 as part of ESTCP Project RC-201203. An unknown number of individuals were planted at this site—only 2 adults and 2 juveniles remain. These outplants surviving on site 4 years after planting are also a notable success.

<u>Discussion</u>

Our efforts to monitor and conserve genetic resources for *P. sclerocarpa* address SOO tasks 3.2.1.2, 3.2.1.4, and 3.2.1.5, 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 3; Table 101; Table 102). Hence, most plants receive no weed management, unless benefiting from co-occurrence with another managed species. Due to a decline in the *P. sclerocarpa* population at Hawaiʻi Volcanoes National Park (currently estimated at

160 individuals), the population at PTA now represents a large proportion of the state-wide population (USFWS 2018).

Although the quarterly monitoring in 2019 and 2020 was 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 which *P. sclerocarpa* 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 sustainability. Understanding 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. Now that we are monitoring individual plants of various life stages consistently from year to year, we will amass data that will help to answer these questions.

P. sclerocarpa is one of several federally listed species affected by the 2022 Leilani fire. Post-fire monitoring showed that the abundance of wild *P. sclerocarpa* declined by 85 individuals (48%) within the burn area (Table 10). Within the No/Low burn severity class, *P. sclerocarpa* abundance had the greatest decline, suggesting this species is either particularly sensitive to fire even at low severity or that factors other than fire may have influenced the decline. Over the same time period, the wild population outside the burn area declined by 13%. Most wild *P. sclerocarpa* locations outside the burn area are located on rocky substrate in ʻōhiʻa (*Metrosideros polymorpha*) forests, while most locations within the burn area were in shrublands with more developed soils and a higher density of invasive grasses. Dissimilarity in microclimates/conditions may underlie some of the differences in pre- and post-fire abundance we found between plants inside and outside the burn area. Multiple factors likely contributed to the observed decline in *P. sclerocarpa* abundance inside and outside the burn area. The fire certainly affected this species, but it is difficult to quantify the magnitude of the effect.

Although fire is a threat to the species (Shaw 1995), *P. sclerocarpa* is one of the few Tier 1 plants not protected by WCB. How fire affects *P. sclerocarpa* is not well understood. Whether individuals can resprout or if the seedbank can tolerate fire remains unknown. We plan to continue to monitor *P. sclerocarpa* locations where plants were lost on an annual basis to assess their status and to better understand longer-term impacts of fire to this species.

We continue to progress with genetic conservation for *P. sclerocarpa.* Many of the accessions in storage are from plants growing in the RPPF. Past efforts to propagate seed were variable and ranged from 0 to 100% germination success. We need to know more about seed characteristics prior to collecting capsules 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.

Genetic Study for Portulaca Species

In 2020, we coordinated a genetic study of *P. sclerocarpa* and *P. villosa* with several state and federal organizations. There has long been confusion between these 2 species as the characteristics used to identify them have significant overlap. Typically, *P. sclerocarpa* inhabits higher elevations consistent with habitats at PTA. Although *P. villosa* typically inhabits lower elevations, plants identified as *P. villosa* were recorded from PTA in 1997 (Shaw 1997). During plant surveys between 2011 and 2015, PTA staff recorded 2 locations of *P. villosa*. Because *P. villosa* was listed by the USFWS as endangered in 2016, confirming that both species are present at PTA will inform ESA consultation documents.

Status of Portulaca sclerocarpa *Populations at PTA per the USFWS Species Recovery Criteria*

In the 5-Year Review for *P. sclerocarpa* published in 2020, the USFWS amended the recovery criteria and established a new recovery stage—Preventing Extinction Stage—with updated criteria. The Preventing Extinction stage for *P. sclerocarpa* requires 50 mature individuals in each of 3 populations, with at least 50 individuals (or the total number if less than 50) represented from each wild population in ex-situ storage. We continue to make progress towards the Preventing Extinction Stage for the 13 populations at PTA (Table 51). Through management, we strive to advance the species toward the next stage of recovery—Interim Stabilization. Through continued monitoring, we plan to document natural reproduction and assess population trends.

Table 51. Progress towards USFWS Preventing Extinction stage of recovery for *Portulaca sclerocarpa* at PTA

Population	# Adults Wild (OP)	# Juveniles Wild (OP)	# Founders *Ex-situ* Storage	Fenced	Invasive Plant Control	Natural Reproduction	Number Increasing
PORSCL1	1	0	0	Yes	No	ND	ND
PORSCL2	5	0	4	Yes	No	ND	ND
PORSCL3	13	1	14	Yes	No	ND	ND
PORSCL4	1	0	3	Yes	No	ND	ND
PORSCL5	0	1	9	Yes	No	ND	ND
PORSCL6	(2)	(1)	NA	Yes	No	ND	ND
PORSCL7	3	0	3	Yes	No	ND	ND
PORSCL8	17	3	19	Yes	Yes	ND	ND
PORSCL9	1	0	1	Yes	No	ND	ND
PORSCL10	1	0	1	Yes	No	ND	ND
PORSCL11	20	9	16	Yes	No	ND	ND
PORSCL12	67(2)	18(2)	25	Yes	Yes	ND	ND
PORSCL13	2	1	2	Yes	No	ND	ND

ND, No Data

Progress toward Compliance with Endangered Species Act Biological Opinion Conservation Measures

To offset effects of military activities on *P. sclerocarpa,* the 2003 BO conservation measures include fuels management to reduce fire risk and fencing and ungulate control to reduce browsing 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 (Sections 3.4 and 4.3). Although not specifically mentioned in the 2003 BO, as part of the INRMP objectives we actively conserve *P. sclerocarpa* genetic resources; the ex-situ collection contains 641 fruit and 34,991 seeds collected from wild founders and 8,715 fruits collected from founders in the RPPF, representing 97 wild founders total. To date, we have outplanted a combined total of 289 individuals at 11 sites and *P. sclerocarpa* has persisted at only 1 of these sites. In addition, per INRMP objectives, *P. sclerocarpa* (co-occurring with *S. lanceolata*) receives the benefits of weed management in ASR 44 across about 2.4 ha and at ASR 24 (co-occurring with *N. ovata* and *S. incompletum*) across about 4 ha (Section 3.2, Table 101). Using our new individual plant-based monitoring protocol will allow us to document in-situ reproduction much more effectively; we expect to observe and document reproduction moving forward. Although we monitor *P. sclerocarpa* annually to assess population patterns, we are unable to attribute changes in numbers to effects of 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 2.7).

2.5.7 *Portulaca villosa* (Endangered)

We tagged and monitored all known *P. villosa*, a Tier 1 species, using the individual plant-based monitoring protocol in the month of December 2022. For genetic conservation, *P. villosa* is an implementation priority 2 (moderately high; Table 13). No collections were made in 2023; a complete representation of the single existing population is currently held in our collection.

Plant Surveys and Monitoring

According to the latest monitoring, a total of 7 adults and 1 seedling of *P. villosa* occur at 2 distinct locations at PTA. These 2 locations comprise the single wild population at PTA (Figure 59).

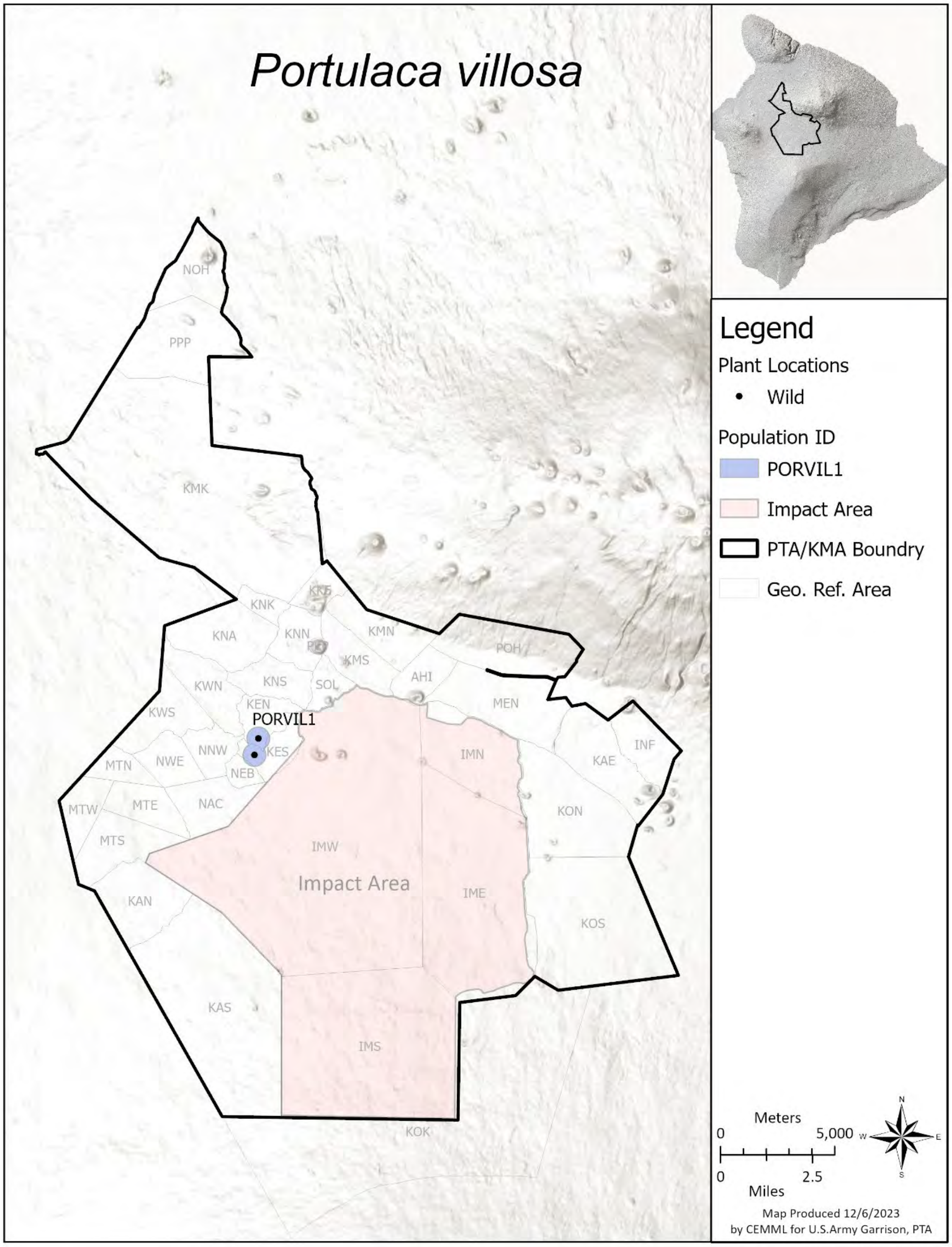


Figure 59. Current known distribution of *Portulaca villosa* individuals and populations at PTA[a]

[a]Data used to produce map were obtained from rare plant survey data collected between 2011 to 2021 plus monitoring of these locations conducted in 2022 to 2023.

We are documenting the reproductive structures present in a given population during the period monitored, although this is not a complete phenological dataset (Table 52).

Table 52. Presence of reproductive structures in the *Portulaca villosa* population

Population	Monitoring Period	Reproductive Structures Present			
		# of Plants	Fruits	Flowers	Flower Buds
PORVIL1	Dec 2022	7	100%	0%	0%

The population structure of this species in the wild is currently dominated by adults (100% of total; Figure 60). Mortality has occurred, with 5 individuals (3 juveniles, 2 seedlings) dying in the past 2–3 years. However, the previous monitoring data is averaged over 5 observations and the numbers of juveniles and seedlings varied from 1 to 3 individuals in each life stage (Figure 60). Rodents or game birds may be consuming propagules, seedlings, and juveniles. Rodents may also break stems and depredate seeds, similar to effects documented for *P. sclerocarpa* (CEMML 2015).

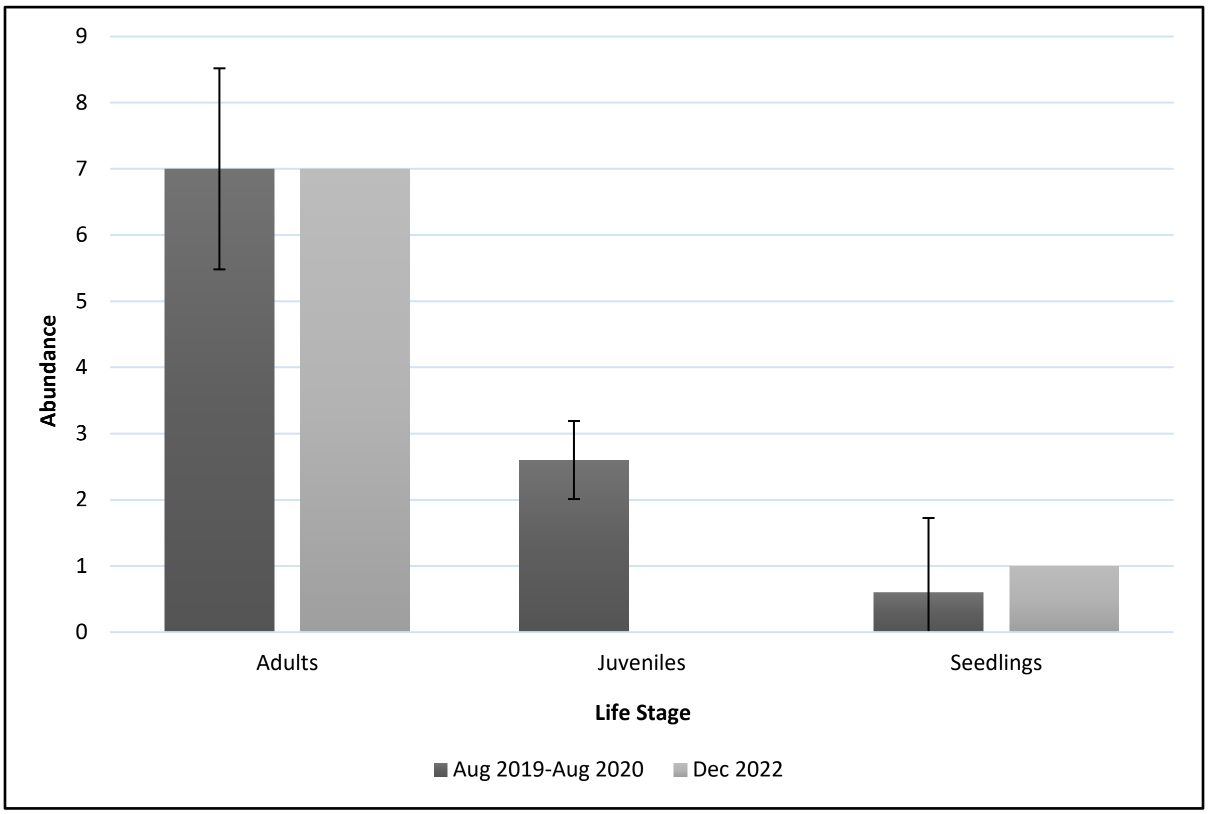


Figure 60. Monitoring data for wild *Portulaca villosa* individuals from 2019 to 2020 compared with 2022. Mean abundance and 90% confidence intervals (error bars) are derived from 5 quarterly monitoring datasets collected in 2019 to 2020; monitoring census data from 2022 are a single dataset

For combined *P. vilosa* plant locations, 100% of weed percent cover and fine fuels percent cover estimations were below our 20% cover management thresholds (Figure 61 and Figure 62).

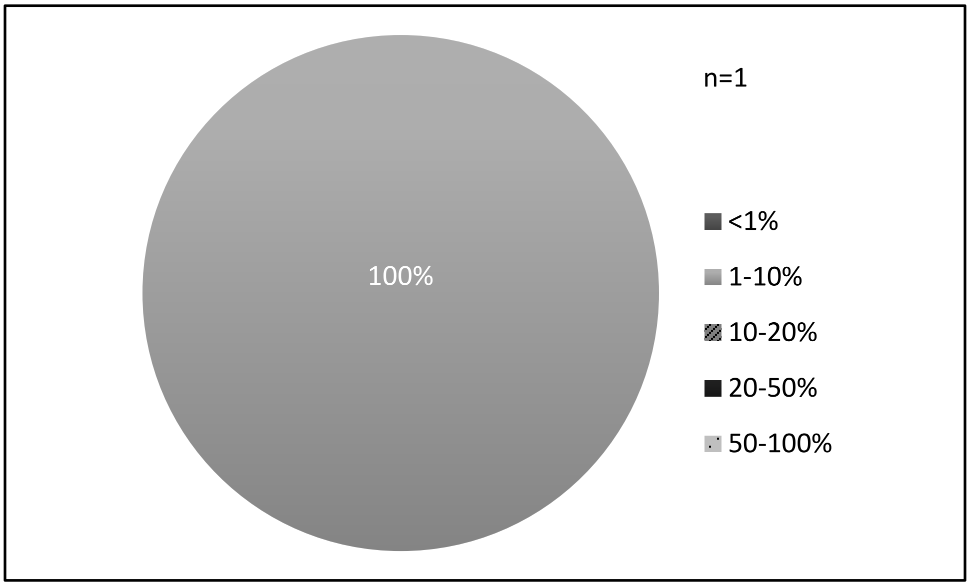


Figure 61. Overall proportion of weed percent cover classes reported for *Portulaca vilosa* plant locations

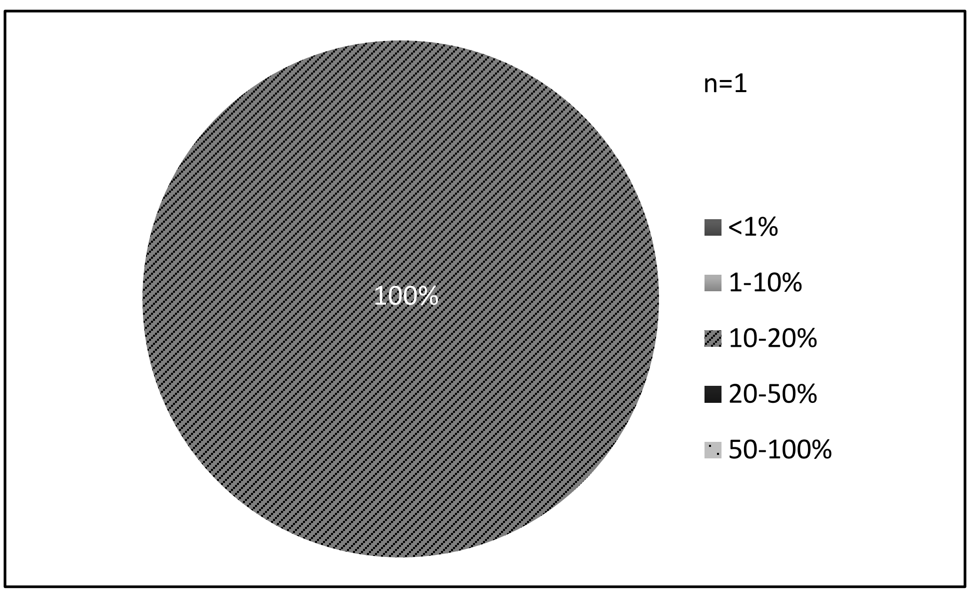


Figure 62. Overall proportion of fine fuels percent cover classes reported for *Portulaca vilosa* plant locations

Genetic Conservation

Propagule Collection and Propagation

No propagule collection or propagation occurred during the reporting period. Please refer to Table 15 for a complete summary of ex-situ storage status for *P. villosa.* From previous propagation efforts, 34 *P. villosa* representing 3 founders were accessioned to the RPPF as of 30 September 2023 (Table 20).

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 monitor and conserve genetic resources for *P. villosa* address SOO tasks 3.2.1.2, 3.2.1.4, and 3.2.1.5, as well as several INRMP objectives.

At PTA, the plants believed to be *P. villosa* occur in 2 small clusters within the Kīpuka Kālawamauna East Fence Unit, less than 1 kilometer apart (Figure 59). Although quarterly monitoring in 2019 and 2020 was not designed to 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 which *P. villosa* age distributions support healthy and resilient populations. We also know little about the ecological requirements of *P. villosa* at the high elevations of PTA. Understanding these life history attributes is important for designing management actions to maximize the likelihood that *P. villosa* will persist and potentially increase, especially with changing climate conditions. Now that we are monitoring individual plants of various life stages consistently from year to year, we will amass data that will help to answer these questions.

We are developing planting strategies for the 34 *P. villosa* accessioned to the RPPF. We plan to continue investigating outplant performance and planting site characteristics to maximize the successful establishment of new self-sustaining groups.

Genetic Study for Portulaca Species

See the discussion in Section 2.5.6 for details regarding the genetic study of *Portulaca* specimens.

Status of Portulaca villosa *Populations at PTA per the USFWS Species Recovery Criteria*

In the 5-Year Review for *P. villosa* published in 2021, the USFWS amended the recovery criteria and established a new recovery stage—Preventing Extinction Stage—with updated criteria. The Preventing Extinction stage for *P. villosa* requires 50 mature individuals in each of 3 populations, with at least 50 individuals (or the total number if less than 50) represented from each wild population in ex-situ storage. We continue to make progress towards the Preventing Extinction Stage for the single population at PTA (Table 53). Through management, we strive to advance the species toward the next stage of recovery—Interim Stabilization. However, advancing to the next stage will be dependent upon a third population being maintained to recovery criteria on at least one other Hawaiian Island. Through continued monitoring, we plan to document natural reproduction and assess population trends.

Table 53. Progress towards USFWS Preventing Extinction stage of recovery for *Portulaca villosa* at PTA

Population	# Adults Wild (OP)	# Juveniles Wild (OP)	# Founders Ex-situ Storage	Fenced	Invasive Plant Control	Natural Reproduction	Number Increasing
PORVIL1	7	0	8	Yes	No	ND	ND

ND, No Data

Progress toward INRMP Objectives

We are preparing to initiate a formal consultation with the USFWS under the ESA to analyze the potential effects of military activities on *P. villosa*[11]. 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 genetic resources 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 (Sections 3.4 and 4.3). We actively conserve *P. villosa* genetic resources and have 4,833 seeds representing 8 wild founders in ex-situ storage. Currently, we have not implemented weed control for this species. Between 2016 and 2019, we observed in-situ reproduction in 1 of 2 (50%) monitoring plots for *P. villosa.* Using our new individual plant-based monitoring protocol will allow us to document in-situ reproduction much more effectively; we expect to observe and document reproduction moving forward. Although we monitor *P. villosa* annually to assess population patterns, we are unable to attribute changes in numbers to effects of 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 2.7).

2.5.8 *Schiedea hawaiiensis* (Endangered)

We tagged and monitored all known *Schiedea hawaiiensis*, a Tier 1 species, using the individual plant-based monitoring protocol from May 2022 through March 2023. For genetic conservation, *Schiedea hawaiiensis* is an implementation priority 3 (moderate; Table 13). We plan to collect propagules from

[11] The text reflects the status of the PBA during the report period (01 October 2021 through 30 September 2023). Since, the Army has worked to develop additional wildland fire planning and preparedness documents to support the PBA preparation process and the fire model used for the effects analysis was updated with data from wildland fires that occurred in 2021 and 2022.

wild individuals for refreshing those already in storage and to outplant judiciously to establish new populations in the coming years, once implementation priority 1 and 2 species have been addressed in a similar manner.

Plant Surveys and Monitoring

According to the latest monitoring, a total of 37 adults, 54 juveniles, and at least 26 seedlings of *Schiedea hawaiiensis* occur at PTA, in 2 wild and 2 outplanted populations (Figure 63).

Each adult or juvenile plant was scored for vigor (Healthy=5; Moderate=3; Poor=1) to arrive at an average health index for each population. All the populations were on average moderate to healthy (Table 54).

Table 54. Average plant health index in *Schiedea hawaiiensis* populations

		Plant Health[a]				
Population	Monitoring Period	# of Plants	Healthy (5)	Moderate (3)	Poor (1)	Average Health Index
SCHHAW1	May 2022	3	100%	0%	0%	5.0
SCHHAW2	Sept 2022	4	50%	50%	0%	4.0
SCHHAW3	Sept 2022	2	0%	100%	0%	3.0
SCHHAW4	Mar 2023	1	100%	0%	0%	5.0

[a]Healthy = foliage that appears green and vigorous, with less than 10% dead leaves or defoliation; Moderate = leaves on plants may have some chlorosis, with 10–50% of the leaves dead or defoliated; Poor = mostly dead or chlorotic leaves, with greater than 50% dead leaves or defoliation.

We are documenting the reproductive structures present in a given population during the period monitored, although this is not a complete phenological dataset (Table 55). Data collected in 2022 confirm that fruit can be collected from February through May, although we did not take data on fruit ripeness (CEMML 2015).

Table 55. Presence of reproductive structures in *Schiedea hawaiiensis* populations

			Reproductive Structures Present		
Population	Monitoring Period	# of Plants	Fruits	Flowers	Flower Buds
SCHHAW1	May 2022	1	100%	100%	100%
SCHHAW2	Sept 2022	3	33%	33%	33%
SCHHAW3	Sept 2022	2	0%	100%	0%
SCHHAW4	Mar 2023	1	100%	100%	100%

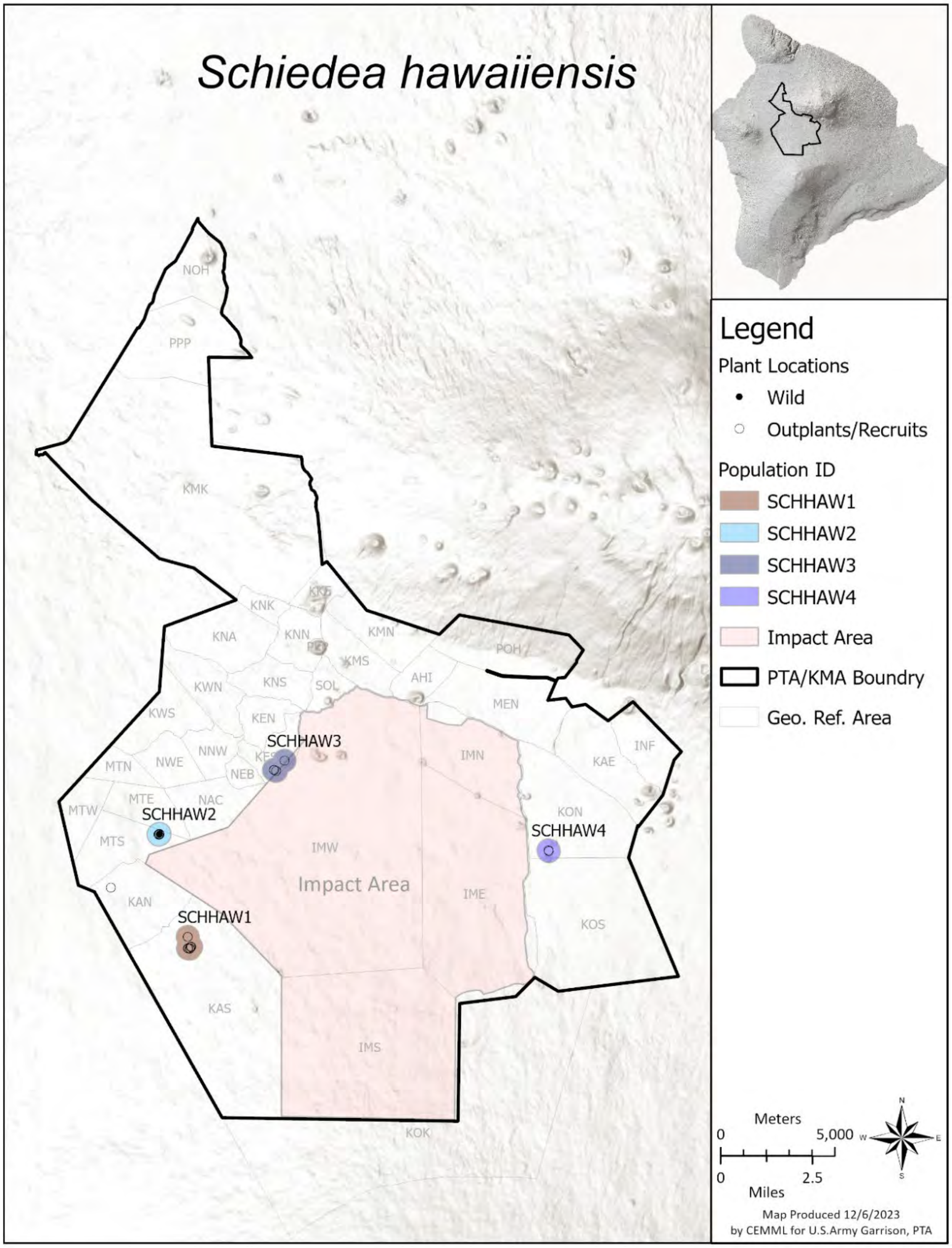


Figure 63. Current known distribution of Schiedea hawaiiensis individuals and populations at PTA

[a]Data used to produce map were obtained from: (1) rare plant survey data collected between 2011 to 2021 plus monitoring of these locations conducted in 2022 to 2023; and (2) live plant locations collected during outplant monitoring in 2022.

The population structure of this species in the wild is currently dominated by adults, whereas previously it was dominated by juveniles (Figure 64). Mortality has occurred, with 10 individuals dying (mostly juveniles) in the past 2 to 3 years. However, the previous monitoring data is averaged over 5 observations and the numbers of juveniles and seedlings varied widely (note the broad range of the error bars in Figure 64). Overall, the number of adults did not change much over the 4-year period when we monitored the wild population quarterly. The number of juveniles was more variable, and seedlings were generally absent or very sparse (CEMML 2022a). In the past, we have documented game birds damaging inflorescences and other plant parts. We are investigating how game birds may be limiting recruitment and causing damage to adult plants. We have installed netting to reduce game bird access to plants and are monitoring to assess the need for additional management. We have also documented rodents climbing on plant stems, presumably to reach and eat the leaves.

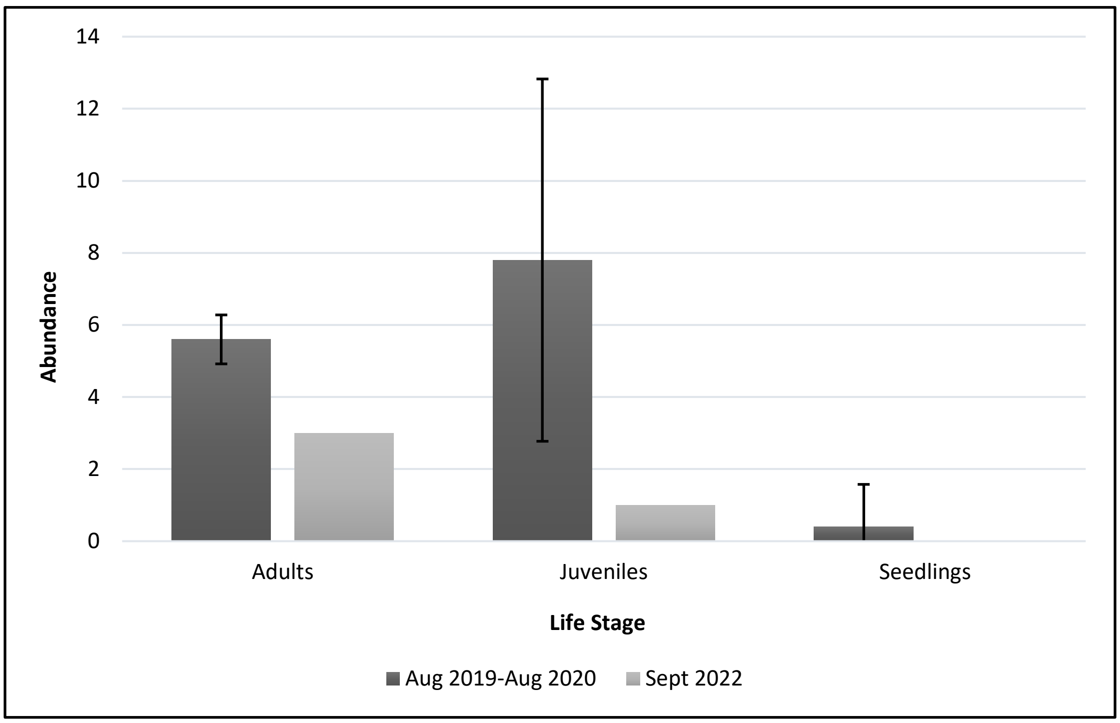


Figure 64. Monitoring data for wild *Schiedea hawaiiensis* individuals from 2019 to 2020 compared with 2022. Mean abundance and 90% confidence intervals (error bars) are derived from 5 quarterly monitoring datasets collected in 2019 to 2020; monitoring census data from 2022 are a single dataset

For combined *Schiedea hawaiiensis* locations, 100% of weed percent cover and fine fuels percent cover estimations were below our 20% cover management thresholds (Figure 65 and Figure 66).

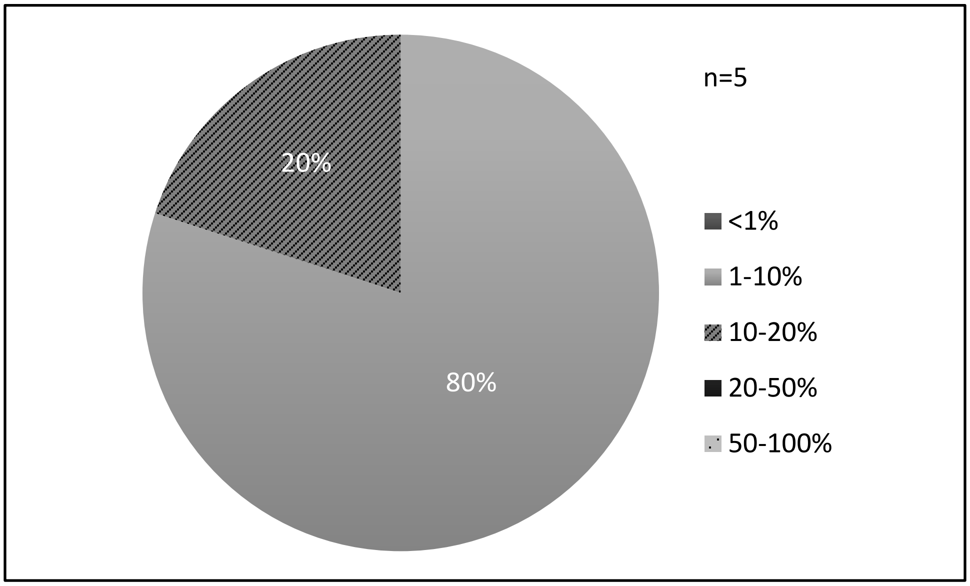


Figure 65. Overall proportion of weed percent cover classes reported for *Schiedea hawaiiensis* plant locations

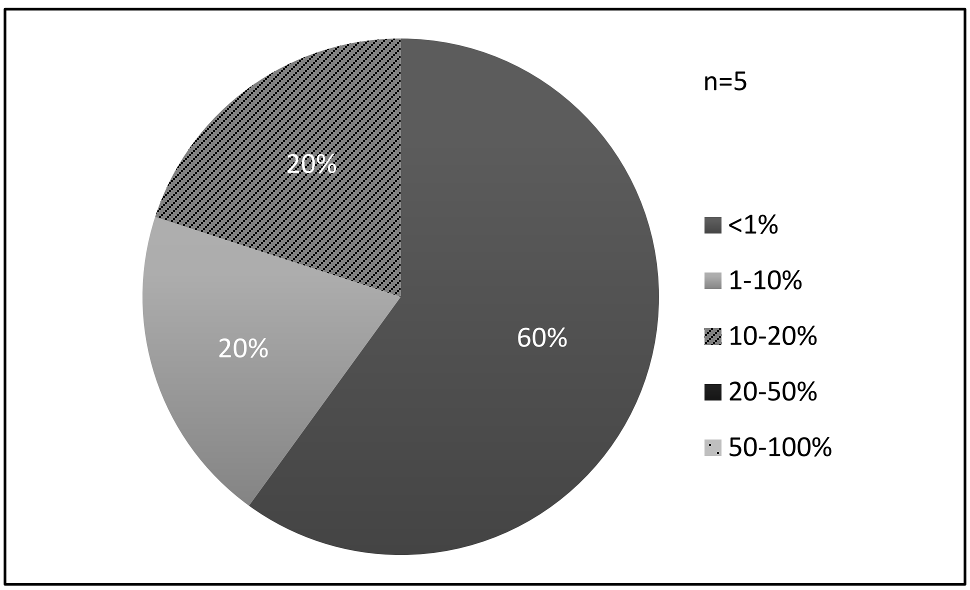


Figure 66. Overall proportion of fine fuels percent cover classes reported for *Schiedea hawaiiensis* plant locations

<u>Genetic Conservation</u>

Propagule Collection and Propagation

No propagule collection or propagation occurred during the reporting period. Please refer to Table 15 for a complete summary of ex-situ storage status for *Schiedea hawaiiensis.* Refreshing old collections and collecting more seed from the wild population will be a priority in the coming years. From previous propagation efforts, a single *Schiedea hawaiiensis* was accessioned to the RPPF as of 30 September 2023 (Table 20).

Outplanting and Monitoring

We did not outplant *Schiedea hawaiiensis* during the reporting period. In previous years we outplanted a combined total of 994 *Schiedea hawaiiensis* at 9 sites (Table 56). At last monitoring in 2022 and 2023, adults and juveniles were present at 1 site off PTA (ASR 201) and 4 sites on PTA (ASRs 206, 213, 214 and 219). All but 2 sites showed a decrease in the number of individuals present between 2014 and 2022/2023 (Table 56); there were 2 fewer adults but 40 additional juveniles and 21 additional seedlings since monitoring in 2020 (CEMML 2022a).

Table 56. Monitoring results from May 2022–March 2023 for *Schiedea hawaiiensis* outplanted 2004–2014

Location	ASR	Total Outplanted 2004–2014	Total Present 2014		Total Present 2022–2023		% Change 2014–2022/2023	Seedlings 2022/2023
			Adult	Juvenile	Adult	Juvenile		
Off PTA	**201**	259	71	150	8	6	-94%	0
	202	40	0	0	0	0	0%	0
	204	204	0	45	0	0	-100%	0
	205	374	59	1	0	0	-100%	0
On PTA	**206**	24	15	30	9	0	-80%	0
	207	5	1	33	0	0	-100%	0
	213	14	8	0	8	1	+12%	0
	214	69	76	150	1	2	-99%	25
	219	5	5	0	18	51	+1280%	0

ASR, Area of Species Recovery. ASRs numbered in the 200s refer to outplanting sites, which may be located within or adjacent to ASR established for wild populations.
Note: The data source for planting activity between 2004 and 2014 and 2014 monitoring data is CEMML 2015. Sites listed in bold denotes seedlings and underline denotes juvenile/adult recruits were present in 2014.

In 2019, we outplanted 2 individuals of *Schiedea hawaiiensis* at ASR 226. By March 2023, only a single outplant had survived (50% survivorship). 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.

Discussion

Our efforts to monitor and conserve genetic resources for *Schiedea hawaiiensis* address SOO tasks 3.2.1.2, 3.2.1.4, and 3.2.1.5, as well as several INRMP objectives.

Schiedea hawaiiensis has the most restricted distribution of any ESA-listed plant species at PTA. The single wild occurrence covers approximately 1 m^2 (SCHHAW2; Figure 63).

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 do not know if *Schiedea hawaiiensis* is capable of vegetative reproduction (i.e., clones), and if it is, how this relates to seed germination and healthy population structure. 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. Understanding 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. Now that we are monitoring individual plants of various life stages consistently from year to year, we will amass data that will help to answer these questions.

We continue to investigate wildlife threats to *Schiedea hawaiiensis*. Deployment of A24 traps appears to effectively reduce observed damage from rodent browse. We continue to monitor the plants for interactions with game birds. We continue to monitor the impact of leafcutter bees on *Schiedea hawaiiensis*. Based on the biology of leafcutter bees and the current level of observed damage to *Schiedea hawaiiensis,* we do not plan to control the bees. If the level of damage increases and threatens the survival of the plants, we can investigate control options.

The number of *Schiedea hawaiiensis* adults and juveniles (combined) present at most outplanting sites declined between 2014 and 2022/2023 (Table 56). After almost 20 years, the once prolific *Schiedea hawaiiensis* at ASRs 206 and 207 has declined to only 9 adult plants in total (zero juveniles or seedlings). However, at ASR 219, *Schiedea hawaiiensis* adults and juveniles (combined) increased in number by 138%. Because the natural population of *Schiedea hawaiiensis* is limited to 1 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.

Status of Schiedea hawaiiensis *Populations at PTA per the USFWS Species Recovery Criteria*

In the 5-Year Review for *Schiedea hawaiiensis* published in 2020, the USFWS established a new recovery stage—Preventing Extinction Stage —with updated criteria. The Preventing Extinction stage for *Schiedea hawaiiensis* requires 50 mature individuals in each of 3 populations, with at least 50 individuals (or the total number if less than 50) represented from each wild population in ex-situ storage. We continue to make progress towards the Preventing Extinction Stage for the 4 populations at PTA (Table 57). Through management, we strive to advance the species toward the next stage of recovery—Interim Stabilization. Through continued monitoring, we plan to document natural reproduction and assess population trends.

Table 57. Progress towards USFWS Preventing Extinction stage of recovery for *Schiedea hawaiiensis* at PTA

Population	# Adults Wild (OP)	# Juveniles Wild (OP)	# Founders Ex-situ Storage	Fenced	Invasive Plant Control	Natural Reproduction	Number Increasing
SCHHAW1	(19)	(53)	NA	Yes	Yes	ND	ND
SCHHAW2	3 (5)	1	4	Yes	Yes	ND	ND
SCHHAW3	(9)	0	NA	Yes	Yes	ND	ND
SCHHAW4	1	0	NA	Yes	No	ND	ND

ND, No Data

Progress toward INRMP Objectives

The USFWS listed *Schiedea hawaiiensis* as endangered under the ESA in 2013. We have not initiated a formal consultation with the USFWS to analyze the potential effects of military activities on *Schiedea hawaiiensis*[12]. 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 genetic resources 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 (Sections 3.4 and 4.3). We actively conserve *Schiedea hawaiiensis* genetic resources; the ex-situ collection contains 315 seeds from the wild population and 394,326 seeds from individuals grown in the RPPF, representing 4 wild founders total. To date, we have outplanted a combined total of 996 *Schiedea hawaiiensis* at 9 sites, with plants persisting at 6 of those sites with a total of 105 individuals remaining. We control invasive plants at the wild and outplanted population across a combined total of about 1.4 ha (Section 3.2, Table 101). Between 2016 and 2019, we observed in-situ reproduction in 1 of 2 (50%) monitoring plots for *Schiedea hawaiiensis.* Using our new individual plant-based monitoring protocol will allow us to document in-situ reproduction much more effectively; we expect to observe and document reproduction moving forward. Although we monitor *Schiedea*

[12] The text reflects the status of the PBA during the report period (01 October 2021 through 30 September 2023). Since, the Army has worked to develop additional wildland fire planning and preparedness documents to support the PBA preparation process and the fire model used for the effects analysis was updated with data from wildland fires that occurred in 2021 and 2022. Also, the PBA was updated to include the formal designation of critical habitat for *Schiedea hawaiiensis* in March 2024 (Fed. Reg., vol 89, No. 49, pp. 17902–17981).

hawaiiensis annually to assess population patterns, we are unable to attribute changes in numbers to effects of 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 2.7).

2.5.9 *Sicyos macrophyllus* (Endangered)

We tagged and monitored all known *S. macrophyllus*, a Tier 1 species, using the individual plant-based monitoring protocol in January 2022. For genetic conservation, *S. macrophyllus* is an implementation priority 1 (high; Table 13). We plan to collect additional propagules from wild individuals and to outplant judiciously to establish new populations in the coming years.

Plant Surveys and Monitoring

According to the latest monitoring, a total of 4 adults, 1 juvenile, and at least 26 seedlings of *S. macrophyllus* occur at PTA in a single wild population (Figure 67).

Each adult or juvenile plant was scored for vigor (Healthy=5; Moderate=3; Poor=1) to arrive at an average health index for each population. All the individuals in the population were healthy (Table 58).

Table 58. Average plant health index in the *Sicyos macrophyllus* population

		Plant Health[a]				
Population	Monitoring Period	# of Plants	Healthy (5)	Moderate (3)	Poor (1)	Average Health Index
SICMAC1	Jan 2022	5	100%	0%	0%	5.0

[a]Healthy = foliage that appears green and vigorous, with less than 10% dead leaves or defoliation; Moderate = leaves on plants may have some chlorosis, with 10–50% of the leaves dead or defoliated; Poor = mostly dead or chlorotic leaves, with greater than 50% dead leaves or defoliation.

We are documenting the reproductive structures present in a given population during the period monitored, although this is not a complete phenological dataset (Table 59).

Table 59. Presence of reproductive structures in the *Sicyos macrophyllus* population

		Reproductive Structures Present			
Population	Monitoring Period	# of Plants	Fruits	Flowers	Flower Buds
SICMAC1	Jan 2022	4	100%	100%	100%

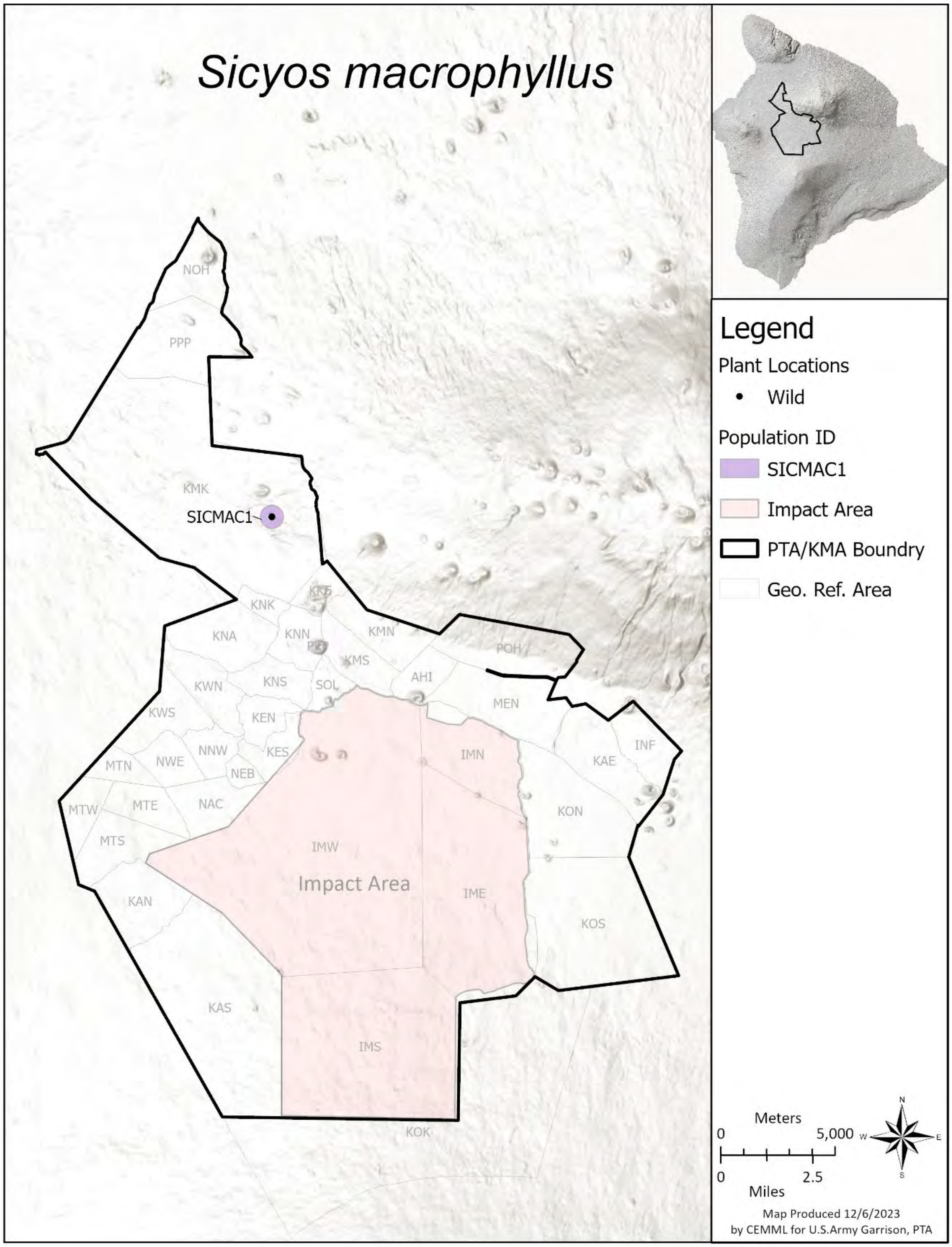


Figure 67. Current known distribution of *Sicyos macrophyllus* individuals and populations at PTA[a]

[a]Data used to produce map were obtained from rare plant survey data collected between 2011 to 2021 plus monitoring of these locations conducted in 2022 to 2023.

After the only known *S. macrophyllus* plant at PTA died in 2017, we suspended habitat management at the site. Between 2017 and 2020, grass grew thickly within the fence unit, possibly curtailing recruitment. To create more optimal conditions for recruitment, we applied herbicide to the grass within the fence unit in March/April 2020. This management, coupled with favorable environmental conditions, likely supported germination from the seed bank in early 2021. By December 2021, there were 4 mature individuals and 1 seedling (CEMML 2022a). This number increased in January 2022 when at least 26 new seedlings were observed, and the seedling from the previous year had transitioned into a juvenile.

For combined *S. macrophyllus* locations, 100% of weed percent cover and fine fuels percent cover estimations were below our 20% cover management thresholds (Figure 68 and Figure 69).

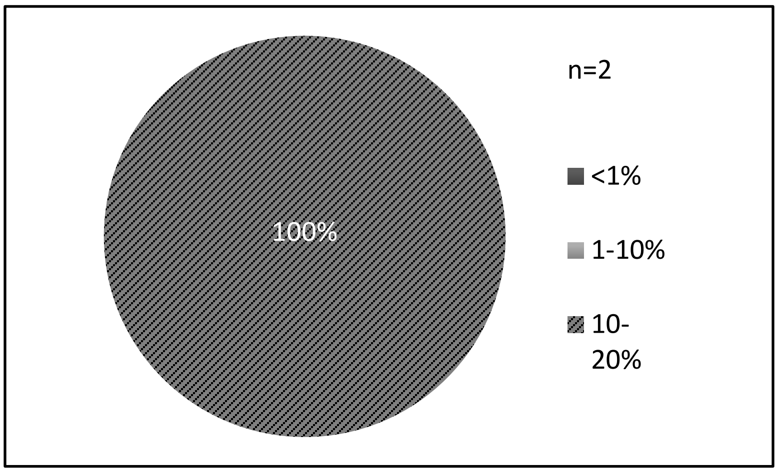


Figure 68. Overall proportion of weed percent cover classes reported for *Sicyos macrophyllus* plant locations

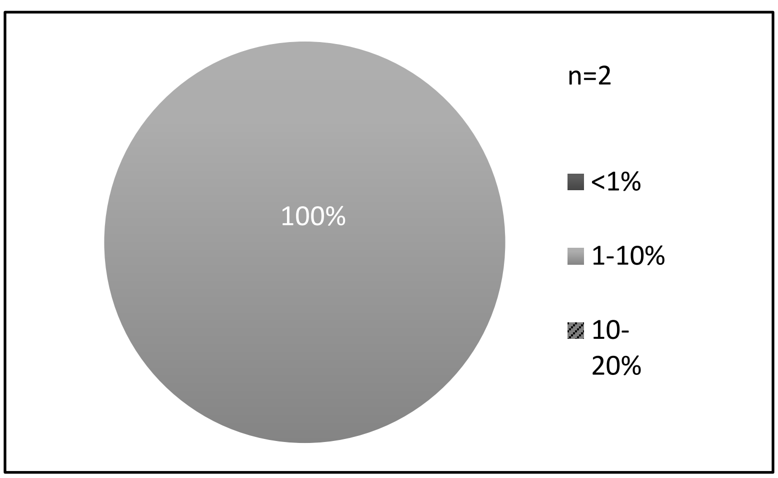


Figure 69. Overall proportion of fine fuels percent cover classes reported for *Sicyos macrophyllus* plant locations

Genetic Conservation

Propagule Collection and Propagation

We collected 837 seeds from 1 or more individuals in December 2021. Because the plants were entwined, it was difficult to distinguish individual plants. Therefore, we cannot be certain if the seeds were collected from 1 or more plants that occupy the site. Refreshing older collections will be a priority in the coming years. Please refer to Table 15 for a complete summary of ex-situ storage status for *S. macrophyllus.* From germination trials conducted at OANRP, 5 *S. macrophyllus* were accessioned to the RPPF as of 30 September 2023 (Table 20). No propagation occurred during this reporting period.

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 monitor and conserve genetic resources for *S. macrophyllus* address SOO tasks 3.2.1.2, 3.2.1.4, and 3.2.1.5, as well as several INRMP objectives.

The *S. macrophyllus* plants occur in a highly degraded gulch in KMA (Figure 67). The original plant location was discovered in 1981 (Cuddihy et al. 1982) and then re-located in 2015. We constructed a small fence (~0.5 ha) around the plant in 2016. After the plant died in 2017, we suspended vegetation control within the fence. The grass formed a dense mat that likely impeded natural regeneration at the site. Because seeds are believed to be relatively short-lived, we implemented grass control in March/April 2020. Removing the grass, coupled with favorable environmental conditions, likely contributed to the germination and recruitment from the seed bank in early 2021. The seeds that germinated from the seed bank were about 4 years old. We worked with seed researchers at OANRP to investigate germination requirements, seed viability, and outplanting techniques. In the coming year, we will outplant 5 individuals that resulted from the OANRP germination trials in a discrete location inside the wild *Sicyos* fence unit. In the future, additional seeds will be collected from individuals extant on State land, and propagated at PTA, to mix a wider variety of founders at a separate location in the KMA.

Status of Sicyos macrophyllus *Populations at PTA per the USFWS Species Recovery Criteria*

In the 5-Year Review for *S. macrophyllus* (2021), the USFWS amended the recovery criteria and established a new recovery stage—Preventing Extinction Stage—with updated criteria. The Preventing Extinction stage for *S. macrophyllus* requires 50 mature individuals in each of 3 populations, with at least 50 individuals (or the total number if less than 50) represented from each wild population in ex-situ storage. We continue to make progress towards the Preventing Extinction Stage for the 4 populations at PTA (Table 60). Through management, we strive to advance the species toward the next stage of recovery—Interim Stabilization. Through continued monitoring, we plan to document natural reproduction and assess population trends.

Table 60. Progress towards USFWS Preventing Extinction stage of recovery for *Sicyos macrophyllus* at PTA

Population	# Adults: Wild (OP)	# Juveniles: Wild (OP)	# Founders Ex-situ Storage	Fenced	Invasive Plant Control	Natural Reproduction	Number Increasing
SICMAC1	5	0	1	Yes	No	ND	ND

ND, No Data

Progress toward INRMP Objectives

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 of military activities on *S. macrophyllus*[13]*.* Therefore, we implement management for this species under INRMP objectives. We constructed a fence to prevent ungulate browsing at the only known location of *S. macrophyllus.* Vegetation is managed within the fence in <0.1 ha (Section 3.2, Table 101). We actively conserve *S. macrophyllus* genetic resources; the ex-situ collection contains 837 seeds from the wild population and 200 fruits from a cultivated individual. Although we monitor *S. macrophyllus* annually to assess population patterns, we are unable to attribute changes in numbers to effects of 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 2.7).

2.5.10 *Solanum incompletum* (Endangered)

We tagged and monitored all known *S. incompletum*, a Tier 1 species, using the individual plant-based monitoring protocol between the months of April 2022 and February 2023. For genetic conservation, *S. incompletum* is an implementation priority 3 (moderate; Table 13). In 2023, we collected a few seeds from an individual that was not well represented in ex-situ storage. In 2024, we plan to resume collection of propagules to refresh old accessions in storage, as well as to represent additional individuals missing from our collection. We outplanted individuals in 2023, and we plan to germinate additional seeds in 2024 for future outplanting.

<u>Plant Surveys and Monitoring</u>

[13] The text reflects the status of the PBA during the report period (01 October 2021 through 30 September 2023). Since, the Army has worked to develop additional wildland fire planning and preparedness documents to support the PBA preparation process and the fire model used for the effects analysis was updated with data from wildland fires that occurred in 2021 and 2022.

According to the latest monitoring, a total of 199 adults, 329 juveniles, and at least 387 seedlings of *S. incompletum* occur at PTA. This number does not include the cohort of individuals we outplanted in 2023. At PTA 7 populations exist—4 wild and 3 outplanted (Figure 70).

Each adult or juvenile plant was scored for vigor (Healthy=5; Moderate=3; Poor=1) to arrive at an average health index for each population. The 2 largest wild populations (SOLINC3 and SOLINC7) were on average moderate to healthy (3.5 and 3.7 respectively), while the third wild population (SOLINC5) was in moderate to poor condition (Table 61).

Table 61. Average plant health index in *Solanum incompletum* populations

		Plant Health[a]				
Population	**Monitoring Period**	**# of Plants**	**Healthy (5)**	**Moderate (3)**	**Poor (1)**	**Average Health Index**
SOLINC1	May 2022	488	91%	8%	1%	4.8
SOLINC2	Nov 2022	ND				
SOLINC3	Sept 2022	63	51%	24%	25%	3.5
SOLINC4	Sept 2022	ND				
SOLINC5	Sept 2022	2	0%	50%	50%	2.0
SOLINC6	Jan 2022	14	50%	36%	14%	3.7
SOLINC7	Apr 2022–Feb 2023	6	50%	33%	17%	3.7

ND, No Data

[a]Healthy = foliage that appears green and vigorous, with less than 10% dead leaves or defoliation; Moderate = leaves on plants may have some chlorosis, with 10–50% of the leaves dead or defoliated; Poor = mostly dead or chlorotic leaves, with greater than 50% dead leaves or defoliation.

We are documenting the reproductive structures present in a given population during the period monitored, although this is not a complete phenological dataset (Table 62). Data collected in 2022 and 2023 confirm that fruit can be collected year round, although we did not take data on fruit ripeness (CEMML 2015).

Table 62. Presence of reproductive structures in *Solanum incompletum* populations

		Reproductive Structures Present			
Population	**Monitoring Period**	**# of Plants**	**Fruits**	**Flowers**	**Flower Buds**
SOLINC1	May 2022	165	30%	68%	67%
SOLINC2	Nov 2022	ND			
SOLINC3	Sept 2022	47	67%	27%	29%
SOLINC4	Sept 2022	ND			
SOLINC5	Sept 2022	2	50%	100%	50%
SOLINC6	Jan 2022	10	30%	40%	40%
SOLINC7	Apr 2022–Feb 2023	5	0%	80%	60%

NA, Not applicable; ND, No Data

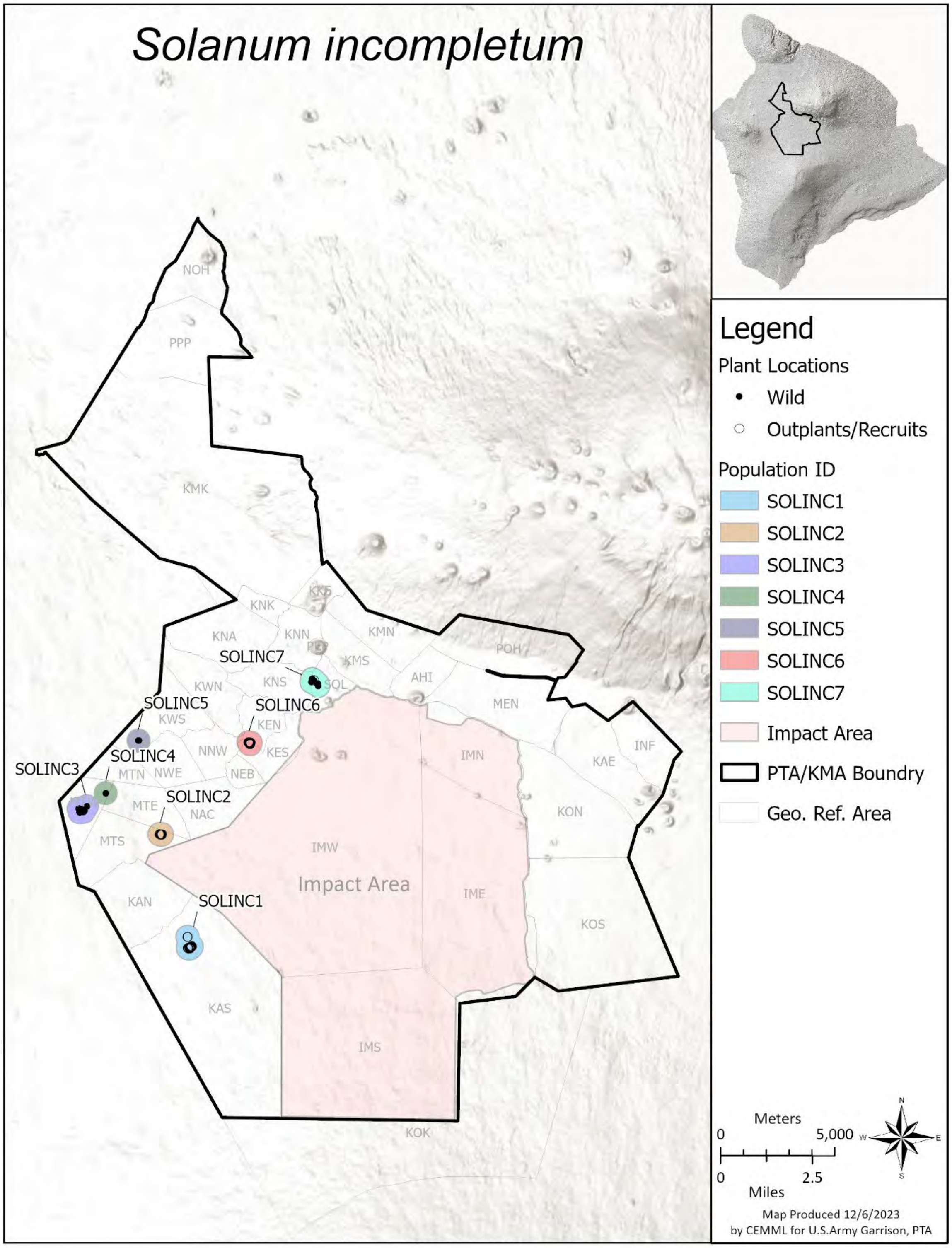


Figure 70. Current known distribution of *Solanum incompletum* individuals and populations at PTA[a]

[a]Data used to produce map were obtained from: (1) rare plant survey data collected between 2011 to 2021 plus monitoring of these locations conducted in 2022 to 2023; and (2) live plant locations collected during outplant monitoring in 2022.

The population structure of this species in the wild is somewhat evenly distributed among the different life stages at present when compared with monitoring between 2019 and 2020 when the population was observed to be 85% adults (Figure 71). The total number of plants has increased by 25 seedlings, while the proportion of adults and juveniles has shifted, implying an increasing number of juveniles. *S. incompletum* is a long-lived perennial and stability in the adult life stage, with occasional gains and losses in the seedling and juvenile life stage, is consistent with expected life history characteristics. Contrary to what the data suggest, it is not likely that we lost 25 adults in the last 2 or 3 years.

The difference in the number of adults between monitoring periods 2019 to 2020 and 2022 to 2023 is likely due to differences in methods used to distinguish life stages (see the introduction to Section 2.5). *S. incompletum* presents additional challenges for monitoring because some individuals produce clones. The original stems can die and leave the remaining clonal stems, which can appear to represent juveniles or seedlings. A genetic study, within and among plant locations, may be useful to understand genetic diversity and the species' life history and reproductive strategies.

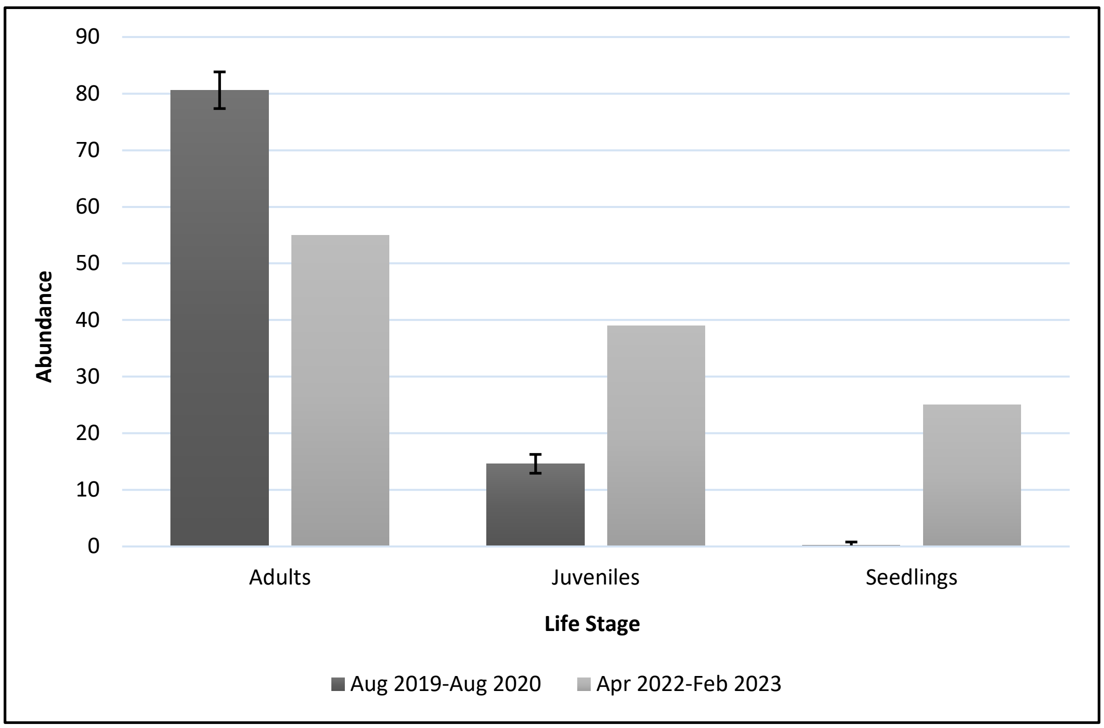


Figure 71. Monitoring data for wild *Solanum incompletum* individuals from 2019 to 2020 compared with 2022. Mean abundance and 90% confidence intervals (error bars) are derived from 5 quarterly monitoring datasets collected in 2019 to 2020; monitoring census data from 2022 to 2023 are a single dataset

For combined *S. incompletum* locations, 100% of weed percent cover estimations were below our 20% cover management thresholds and only 2% of fine fuels percent cover estimations exceeded our 20% cover management thresholds (Figure 72 and Figure 73).

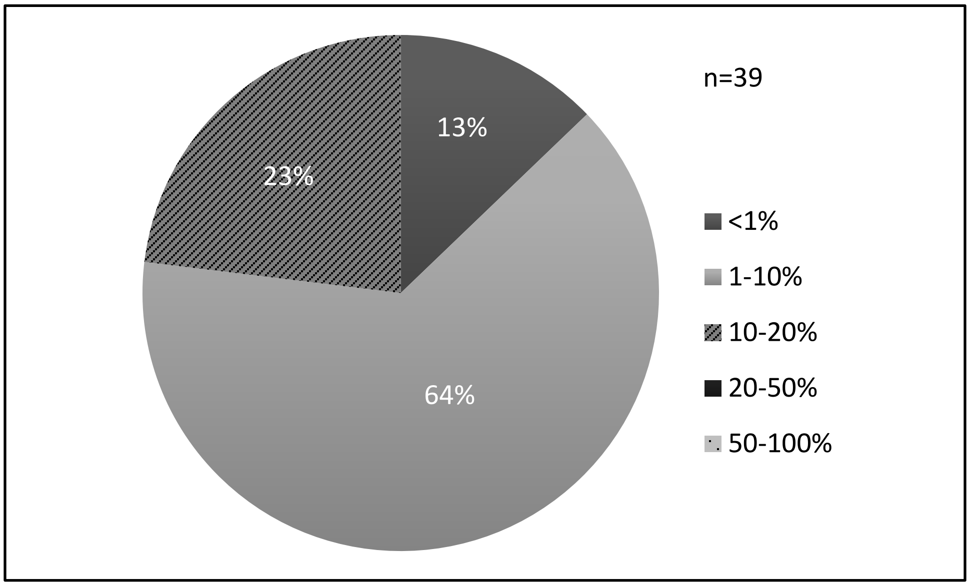


Figure 72. Overall proportion of weed percent cover classes reported for *Solanum incompletum* plant locations

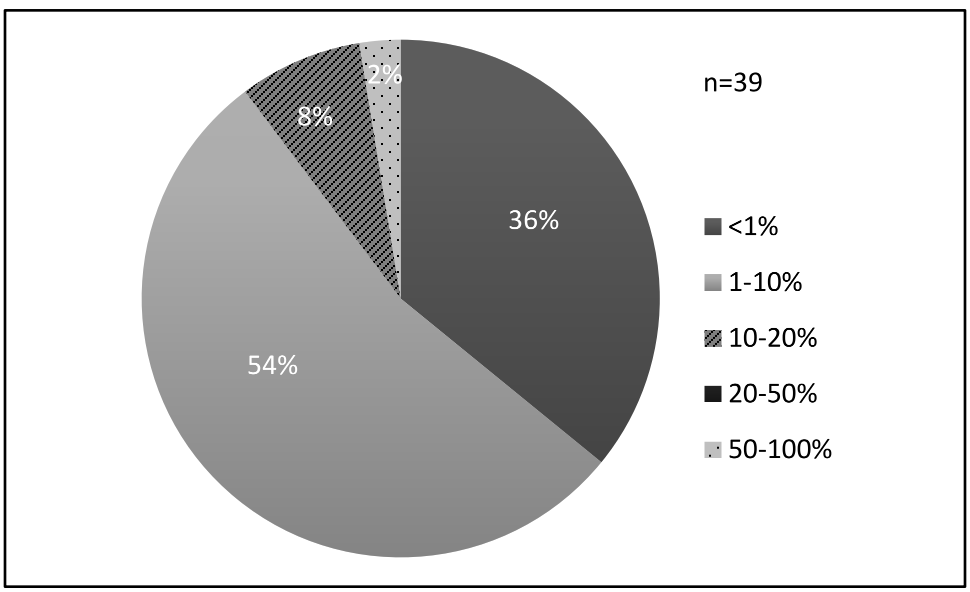


Figure 73. Overall proportion of fine fuels percent cover classes reported for *Solanum incompletum* plant locations

Genetic Conservation

Propagule Collection and Propagation

We collected 2 fruits from 1 individual in 2023, which amounted to 8 seeds entering ex-situ storage (Table 63). Please refer to Table 15 for a complete summary of ex-situ storage status for *S. incompletum.*

Table 63. Propagule collections for *Solanum incompletum* in 2023. Seeds collected were dried to 28% relative humidity and stored at 5° C

Plant ID[a]	Date of Collection	Type of Propagule	Amount Collected	Population	UTM X	UTM Y
1784	28 Jul 23	Seed	8	SOLINC5	216060	2183700

[a] Plant ID refers to the number printed on tags of wild individual collected.

Preliminary viability trials for *S. incompletum* were conducted at OANRP's seed lab in FY 2023 using a small subset of accessions collected 5 to 22 years prior. OANRP staff sowed 435 seeds from 3 accessions of varying age (Table 64); the average percent germination has yet to be calculated because the trials are not yet complete. This species is known to germinate slowly (sporadically germinating over a 24-month period); the expected completion date is March 2025. All resultant plants will be transferred back to PTA for outplanting.

Table 64. Germination trials for *Solanum incompletum* conducted in 2023 at the US Army Garrison-Hawai'i Natural Resources Program on O'ahu

Age of Seed (years)	Number of Accessions	Number of Seeds Sown	Number of Seeds Germinated (as of 9-30-23)
22	1	10	0
10	1	100	1
5	4	325	9

From previous propagation efforts, there were 4 *S. incompletum* individuals, a mixture of clones and seedlings, representing 4 founders (2 are deceased in the wild) accessioned to the RPPF as of 30 September 2023 (Table 20).

Outplanting and Monitoring

In March 2023 we planted 114 *S. incompletum* at ASR 209. The *S. incompletum* were growing in 1-gallon containers and 106 of 111 plants were associated with founder information (seed sourced from 16 wild ASR 24 founders), the 5 others had their founder labeled as unknown. The outplants plants have yet to be monitored for calculating survivorship.

In previous years we planted a combined total of 1,427 *S. incompletum* at 11 sites (Table 65). *S. incompletum* was historically known from ASR 201 (Puʻu Huluhulu) and our outplantings have persisted there quite well, albeit with a slow decline over time. Recruitment has occurred at several sites. At some sites (ASRs 213, 214, 219 and 220) the number of adults and juveniles (combined) present increased between 2014 and 2022. ASR 209 saw the largest decrease since monitoring in 2020 after remaining stable for the first 6 years. The largest increase since monitoring in 2020 occurred at ASR 214, which increased by 192 juveniles and 378 seedlings in the last 2 years (CEMML 2022a).

Table 65. Monitoring results from January–December 2022 for *Solanum incompletum* outplanted 2004–2014

Location	ASR	Total Outplanted 2004–2014	Total Present 2014		Total Present 2022		% Change 2014–2022	Seedlings[a] 2022
			Adult	Juvenile	Adult	Juvenile		
Off PTA	**<u>201</u>**	455	182	47	34	22	-76%	0
	202	78	0	0	0	0	0%	0
	203	11	4	0	0	0	-100%	0
	<u>204</u>	225	7	2	0	7	-22%	0
	<u>205</u>	406	134	42	1	0	-99%	0
On PTA	**209**	40	29	6	10	4	-60%	1
	211	14	1	0	0	0	-100%	0
	213	21	15	6	24	0	+14%	0
	<u>214</u>	170	168	83	161	301	+84%	378
	219	4	4	0	4	24	+600%	9
	220	3	3	0	4	1	+67%	0

ASR, Area of Species Recovery. ASRs numbered in the 200s refer to outplanting sites, which may be located within or adjacent to ASR established for wild populations.

Note: The data source for planting activity between 2004 to 2014 and 2014 monitoring data is CEMML 2015. ASR listed in bold denotes seedlings and underline denotes juvenile/adult recruits were present in 2014.

[a] We counted all seedlings up to 25 and assigned count classes when the number of seedlings exceeded 25 (25–50, 51–100, and >100). When a count class was assigned, we used the minimum count for that class.

Discussion

Our efforts to monitor and conserve genetic resources for *S. incompletum* address SOO tasks 3.2.1.2, 3.2.1.4, and 3.2.1.5, 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. Wild populations of *S. incompletum* contain adults and juveniles with periodic flushes of seedlings around both wild and outplanted individuals. However, we do not know which, if any, of the life stages is most vulnerable and/or may regulate population dynamics. Understanding 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. Now that we are monitoring individual plants of various life stages consistently from year to year, we will amass data that will help to answer these questions.

Unfortunately, 3 out of 4 wild populations have been declining in recent years. The single individual comprising SOLINC4 is now dead, the larger of the 2 individuals comprising SOLINC5 is currently in poor health, and 5 of the 11 individuals comprising SOLINC7 died in the last 2 years. As per the 2003 BO conservation measures, 1 of the individuals at SOLINC7 received supplemental watering and shade protection in August 2023 when it appeared to be water stressed (Figure 74 and Figure 75).

Figure 74. Shade structure constructed in August 2023 around a water-stressed *Solanum incompletum* (left) compared to a healthy *Solanum incompletum* individual (right)

Figure 75. Close-up photograph of water-stressed *Solanum incompletum*

We continue to make progress with genetic conservation for *S. incompletum.* Many of the accessions in storage are more than 10 years old and we have begun to assess these collections to determine the rate of viability decay over time, a process that will take 2 to 3 years to complete. Another issue is the large proportion of our collections that were dried and stored as whole fruits, which is known to reduce seed viability over time (Center for Plant Conservation 2019). Important *S. incompletum* accessions represent 28 individuals that are dead in the wild and include over 400 fruits from a Kīpuka Kālawamauna population that has been completely extirpated. These 28 individuals will be prioritized for propagation in the coming years.

We outplanted over 1,000 *S. incompletum* individuals between 2004 and 2014. Plants are doing especially well at ASRs 214 and 219 with an increase of 84% to 600% in the number of adults and juveniles present. Some of the apparent increase in the number of juveniles and seedlings may be a result of vertical growth originating from roots (suckers), but this can't be proven without causing the plants substantial harm. Either way, the plants at these sites are thriving, even if not reproducing from seed to the extent suggested by the monitoring data. Despite the success of *S. incompletum* at some sites, we still know relatively little about the habitat preferences of this species.

Status of Solanum Incompletum *Populations at PTA per the USFWS Species Recovery Criteria*

In the 5-Year Review for *S. incompletum* published in 2020, the USFWS amended the recovery criteria and established a new recovery stage—Preventing Extinction Stage—with updated criteria. The Preventing Extinction stage for *S. incompletum* requires 50 mature individuals in each of 3 populations, with at least 50 individuals (or the total number if less than 50) represented from each wild population in ex-situ storage. We continue to make progress towards the Preventing Extinction Stage for the 7 populations at PTA (Table 66). Through management, we strive to advance the species toward the next stage of recovery—Interim Stabilization. However, to meet the Interim Stabilization stage, another population must be established and maintained to meet the criteria on Lānaʻi, or Maui. Through continued monitoring, we plan to document natural reproduction and assess population trends.

Table 66. Progress towards USFWS Preventing Extinction stage of recovery for *Solanum incompletum* at PTA

Population	# Adults Wild (OP)	# Juveniles Wild (OP)	# Founders Ex-situ Storage	Fenced	Invasive Plant Control	Natural Reproduction	Number Increasing
SOLINC1	(165)	(325)	NA	Yes	Yes	ND	ND
SOLINC2	(24)		NA	Yes	Yes	ND	ND
SOLINC3	48	38	33	Yes	Yes	ND	ND
SOLINC4	0	0	0	Yes	No	ND	ND
SOLINC5	2	0	1	Yes	Yes	ND	ND
SOLINC6	(10)	(4)	NA	Yes	Yes	ND	ND
SOLINC7	5	1	13	Yes	Yes	ND	ND

ND, No Data

Progress toward Compliance with Endangered Species Act Biological Opinion Conservation Measures

To offset effects of military activities on *S. incompletum,* the 2003 BO conservation measures include fuels management to reduce fire risk, fencing and ungulate control to reduce browsing 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 (Sections 3.4 and 4.3). We actively conserve *S. incompletum* genetic resources; the ex-situ collection contains 2,505 fruit and 2,862 seeds from the wild populations and another 8,900 fruit and 3,046 seed from individuals grown in the RPPF or from individuals outplanted. To date, we have outplanted 1,541 individuals at 11 sites, with plants persisting at 8 of those sites, for a current total of 597 individuals, many of them presumed recruits. We manage invasive plants for all wild and outplanted populations, with all areas totaling over 11 ha for *S. incompletum* (Section 3.2, Table 101). Between 2016 and 2019, we observed in-situ reproduction in 1 of 20 (5%) monitoring plots for *S. incompletum.* Using our new individual plant-based monitoring protocol will allow us to document in-situ reproduction much more effectively; we expect to observe and document reproduction moving forward. Although we monitor *S. incompletum* annually to assess population patterns, we are unable to attribute changes in numbers to effects of 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 2.7).

2.5.11 *Tetramolopium arenarium* (Endangered)

We tagged and monitored all known *T. arenarium,* a Tier 1 species, using the individual plant-based monitoring protocol between September and October 2022. For genetic conservation, *T. arenarium* is an implementation priority 3 (moderate; Table 13). In 2024, we plan to resume collecting propagules to refresh old accessions in storage and plan to germinate these older seeds for future outplanting.

Plant Surveys and Monitoring

According to the latest monitoring, a total of 77 adults, 17 juveniles and 37 seedlings of *T. arenarium* occur at PTA, in a single wild population (Figure 76).

Each adult or juvenile plant was scored for vigor (Healthy=5; Moderate=3; Poor=1) to arrive at an average health index for each population. Individuals in the population were on average poor (Table 67).

Table 67. Average plant health index in the *Tetramolopium arenarium* population

		Plant Health[a]				
Population	Monitoring Period	# of Plants	Healthy (5)	Moderate (3)	Poor (1)	Average Health Index
TETARE1	Sept–Oct 2022	94	7%	50%	43%	2.3

[a]Healthy = foliage that appears green and vigorous, with less than 10% dead leaves or defoliation; Moderate = leaves on plants may have some chlorosis, with 10–50% of the leaves dead or defoliated; Poor = mostly dead or chlorotic leaves, with greater than 50% dead leaves or defoliation.

We are documenting the reproductive structures present in a given population during the period monitored, although this is not a complete phenological dataset (Table 68).

Table 68. Presence of reproductive structures in the *Tetramolopium arenarium* population

		Reproductive Structures Present			
Population	Monitoring Period	# of Plants	Fruits	Flowers	Flower Buds
TETARE1	Sept–Oct 2022	77	32%	45%	13%

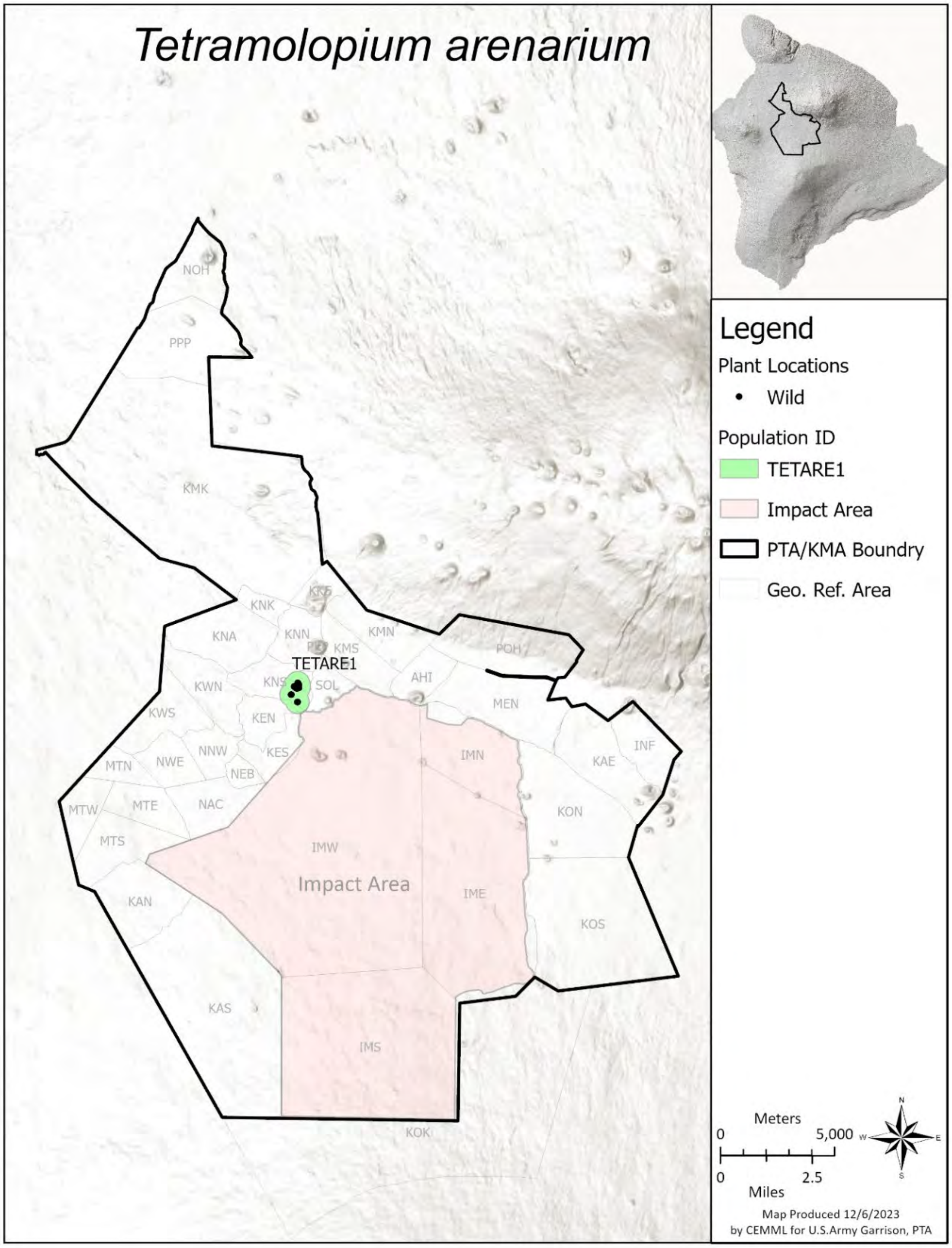


Figure 76. Current known distribution of *Tetramolopium arenarium* individuals and populations at PTA[a]

[a]Data used to produce map were obtained from rare plant survey data collected between 2011 to 2021 plus monitoring of these locations conducted in 2022 to 2023.

The population structure of this species in the wild is dominated by adults (59%), with juveniles and seedlings comprising 13% and 28%, respectively (Figure 77). *T. arenarium* is believed to be a relatively short-lived species that relies on high reproductive output and quick seedling establishment to sustain persistent populations over time (Laven et al. 1991). There were 268 fewer adults and juveniles combined in 2022 compared to 2019 to 2020; the number of individuals hasn't been this low since early 2016. In late 2016 a flush of 684 seedlings was reported, and the population has been on a slow decline ever since (CEMML 2022a). However, population numbers have declined more quickly over the last 3 years and seedling germination and establishment have not occurred in sufficiently high numbers to offset this trend.

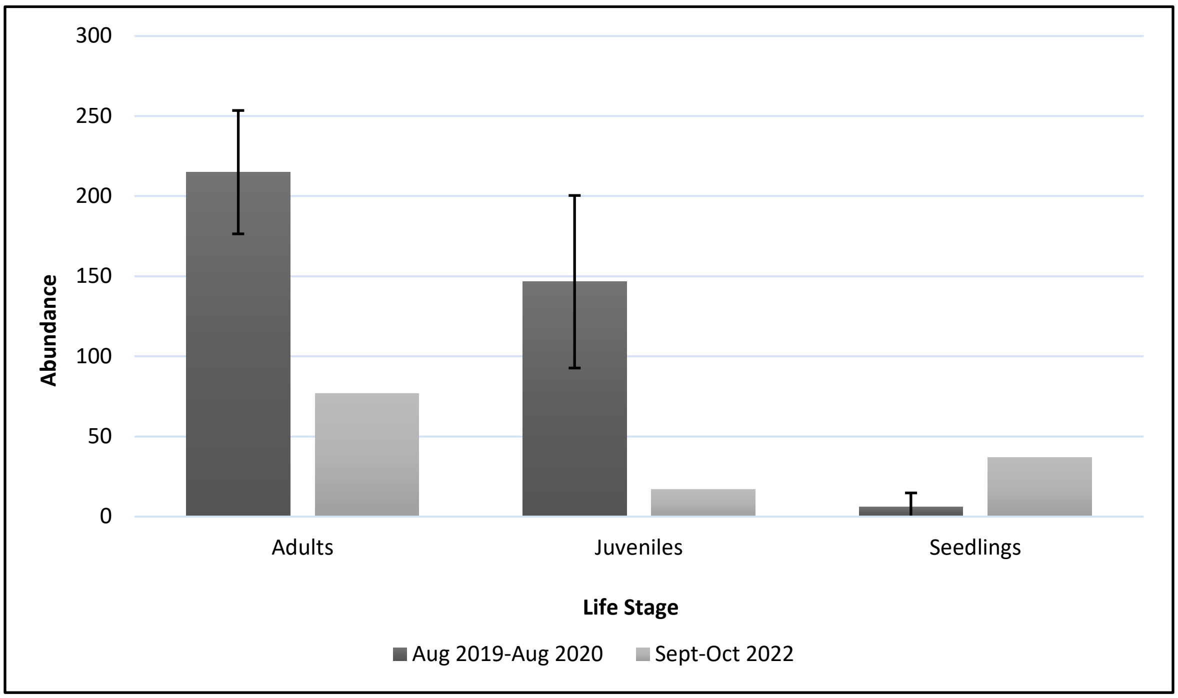


Figure 77. Monitoring data for wild *Tetramolopium arenarium* individuals from 2019 to 2020 compared with 2022. Mean abundance and 90% confidence intervals (error bars) are derived from 5 quarterly monitoring datasets collected in 2019 to 2020; monitoring census data from 2022 are a single dataset

For combined *T. arenarium* locations, 100% of weed percent cover and fine fuels percent cover estimations were below our 20% cover management thresholds (Figure 78 and Figure 79).

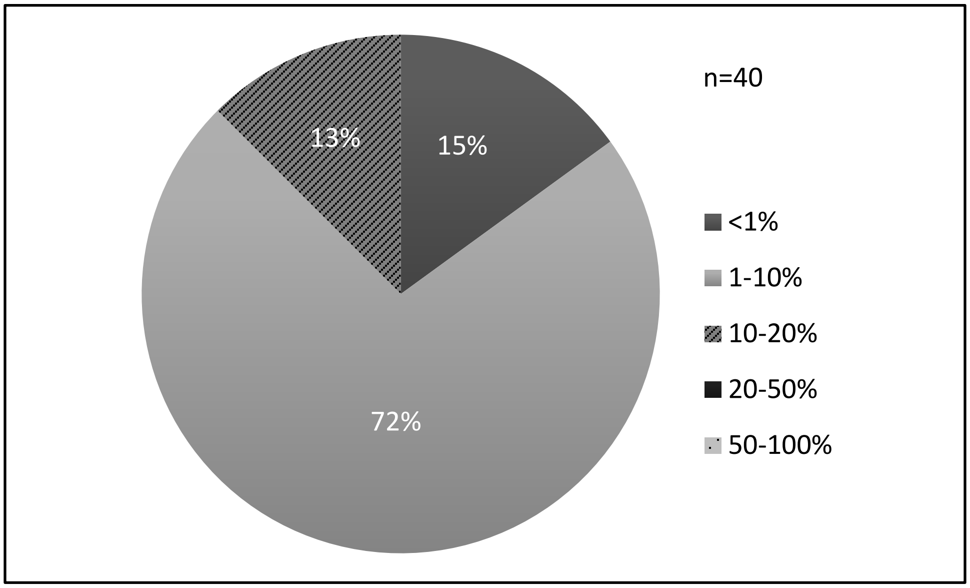


Figure 78. Overall proportion of weed percent cover classes reported for *Tetramolopium arenarium* plant locations

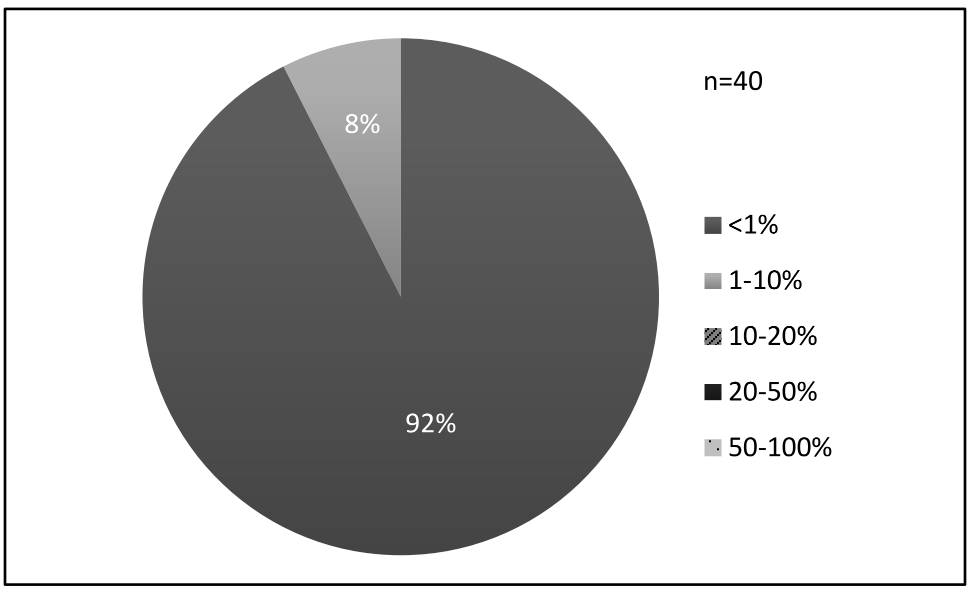


Figure 79. Overall proportion of fine fuels percent cover classes reported for *Tetramolopium arenarium* plant locations

__**Genetic Conservation**__

Propagule Collection and Propagation

No propagule collection or propagation occurred during the reporting period. Please refer to Table 15 for a complete summary of ex-situ storage status for *T. arenarium.* From previous propagation efforts, 1 *T. arenarium* representing 1 deceased founder was accessioned to the RPPF as of 30 September 2023 (Table 20).

Outplanting and Monitoring

We did not outplant *T. arenarium* during the reporting period. In previous years we planted a combined total of 510 *T. arenarium* individuals at 6 sites (Table 69). No individuals remained at any site as of December 2022. Because the plants are relatively short-lived, we do not expect any of the original outplants to be living. Although we have documented recruitment at some sites in the past, self-recruiting populations are not present at any site.

Table 69. Monitoring results from December 2022 for *Tetramolopium arenarium* outplanted 2004–2014

Location	ASR	Total Outplanted 2004–2014	Total Present 2014		Total Present 2022		% Change 2014–2020	Seedlings 2022
			Adult	Juvenile	Adult	Juvenile		
Off PTA	201	32	0	0	0	0	-100%	0
	204	18	0	0	0	0	-100%	0
	<u>205</u>	231	382	721	0	0	-100%	0
On PTA	210	96	0	0	0	0	-100%	0
	211	48	0	0	0	0	-100%	0
	216	85	5	0	0	0	-100%	0

ASR, Area of Species Recovery. ASRs numbered in the 200s refer to outplanting sites, which may be located within or adjacent to ASR established for wild populations.
Note: The data source for planting activity between 2004 to 2014 and 2014 monitoring data is CEMML 2015. Sites listed in bold denotes seedlings and underline denotes juvenile/adult recruits were present in 2014.

Discussion

Our efforts to monitor and conserve genetic resources for *T. arenarium* address SOO tasks 3.2.1.2, 3.2.1.4, and 3.2.1.5, as well as several INRMP objectives and conservation measures from the 2003 and 2013 BO.

At PTA, *T. arenarium* naturally occurs in the *Dodonaea* shrubland. It currently occurs in a single cluster distributed over fewer than 8 ha within the Kīpuka Kālawamauna North Fence Unit in ASR 8. *Tetramolopium arenarium* can fluctuate in numbers, sometimes dramatically, especially in the seedling life stage. We documented a large decline in adults and juveniles in late 2016. In early 2017 we recorded high numbers of seedlings, and a large proportion of these transitioned into the juvenile and adult life stages in subsequent census periods (CEMML 2022a). 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). Laven et al. (1991) suggest that episodic recruitment during favorable environmental conditions may be one possible life history strategy for *T. arenarium* to sustain populations. Laven et al. (1991) suggest 2 other life history strategies that may help sustain *T. arenarium*—r strategy life history characteristics (i.e., rapid establishment vs. long-lived) and/or colonization of disturbed sites. In addition, *T. arenarium* is not a strong competitor (Aplet and Laven 1993). Low competitive ability and germination delay 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* 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*. Aslan et al. (2019) documented several native and non-native insects visiting *T. arenarium* flowers and likely providing pollinator services. The most frequent visitor to the flowers was a native Cambrid moth (*Otonecine* sp.). Other visitors included the non-native honeybee (*Apis mellifera*), hover flies (*Syrphid* spp.), unspecified moths, unspecified wasps, and a keyhole wasp (*Pachodynerus nasidens*).

In addition, monitoring data suggest that invasive invertebrates may influence mortality in *T. arenarium.* Between 2007 and 2009, scales and/or aphids were documented on 22% to 27% of all tagged *T. arenarium* adults. Monitoring data from 2007 to 2009 suggest that plants infested with scales had a higher mortality rate. 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.

We continue to make progress with genetic conservation of *T. arenarium*. Many of the accessions in storage are aging. We do not know how aging affects the viability of the seed.

Previous outplanting efforts for *T. arenarium* were unsuccessful over the long term. Data from the 2014 monitoring show that outplants failed to establish at most sites but were present at ASRs 205 and 216; impressive recruitment from the 2006 to 2013 plantings was documented in 2014 at ASR 205. However, as of December 2022 *T. arenarium* is not present at any site. This lack of success suggests that these sites were a poor fit for this species. We are developing planting strategies and plan to continue investigating outplant performance and planting site characteristics to better understand factors that will support self-sustaining populations.

Status of Tetramolopium arenarium *Populations at PTA per the USFWS Species Recovery Criteria*

In the 5-Year Review for *T. arenarium* published in 2020, the USFWS amended the recovery criteria and established a new recovery stage—Preventing Extinction Stage—with updated criteria. The Preventing Extinction stage for *T. arenarium* requires 50 mature individuals in each of 3 populations, with at least 50 individuals (or the total number if less than 50) represented from each wild population in ex-situ storage. We continue to make progress towards the Preventing Extinction Stage for the single populations at PTA (Table 70). Through management, we strive to advance the species toward the next stage of recovery—Interim Stabilization. Through continued monitoring, we plan to document natural reproduction and assess population trends.

Table 70. Progress towards USFWS Preventing Extinction stage of recovery for *Tetramolopium arenarium* at PTA

Population	# Adults Wild (OP)	# Juveniles Wild (OP)	# Founders Ex-situ Storage	Fenced	Invasive Plant Control	Natural Reproduction	Number Increasing
TETARE1	77	17	607	Yes	Yes	ND	ND

ND, No Data

Progress toward Compliance with Endangered Species Act Biological Opinion Conservation Measures

To offset effects of military activities on *T. arenarium,* the 2003 BO conservation measures include fuels management to reduce fire risk, fencing and ungulate control to reduce browsing 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*, we implement landscape-level projects to reduce fire risk and ungulate browse for all known individuals at PTA (Sections 3.4 and 4.3). In addition, we actively conserve *T. arenarium* genetic resources; the ex-situ collection contains 108,242 seeds from the wild population and another 13,140 seeds from individuals grown in the RPPF or from individuals outplanted. To date, we have outplanted a combined total of 510 individuals at 6 sites, but *T. arenarium* has not persisted at any. We manage weeds in several buffers within ASR 8 totaling about 11.7 ha for the wild *T. arenarium* population (Section 3.2, Table 101). Between 2016 and 2019, we observed in-situ reproduction in 5 of 27 (19%) monitoring plots for *T. arenarium.* Using our new individual plant-based monitoring protocol will allow us to document in-situ reproduction much more effectively; we expect to observe and document more reproduction moving forward. Although we monitor *T. arenarium* annually to assess population patterns, we are unable to attribute changes in numbers to effects of 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 2.7).

2.5.12 *Tetramolopium stemmermanniae* (Not ESA-listed)

As a Tier 1 species, we tagged and monitored all known *T. stemmermanniae* using the individual plant-based monitoring protocol between the months of April through October 2022. For genetic conservation, *T. stemmermanniae* is a priority, but was not included in the *Genetic Conservation and Outplanting Plan* (CEMML 2017) because it is not ESA-listed. In 2024, we plan to resume collecting propagules to refresh old accessions in storage, as well as to provide additional representation of individuals currently missing from our collection. We also plan to outplant to augment the existing population and to establish new populations.

Plant Surveys and Monitoring

According to the latest monitoring, a total of 129 adults, 216 juveniles, and at least 188 seedlings of *T. stemmermanniae* occur at PTA. Six populations exist—5 wild and 1 outplanted (Figure 80).

Each adult or juvenile plant was scored for vigor (Healthy=5; Moderate=3; Poor=1) to arrive at an average health index for each population. All the populations were on average moderate to healthy (Table 71).

Table 71. Average plant health index in *Tetramolopium stemmermanniae* populations

		Plant Health[a]				
Population	Monitoring Period	# of Plants	Healthy (5)	Moderate (3)	Poor (1)	Average Health Index
TETSTE1	Oct 2022	5	60%	0%	40%	3.4
TETSTE2	May 2022	263	70%	29%	1%	4.4
TETSTE3	Apr–May 2022	72	79%	13%	8%	4.4
TETSTE4	Apr 2022	1	0%	100%	0%	3.0
TETSTE5	Sept 2022	2	50%	50%	0%	4.0
TETSTE6	Sept 2022	2	100%	0%	0%	5.0

[a]Healthy = foliage that appears green and vigorous, with less than 10% dead leaves or defoliation; Moderate = leaves on plants may have some chlorosis, with 10–50% of the leaves dead or defoliated; Poor = mostly dead or chlorotic leaves, with greater than 50% dead leaves or defoliation.

We are documenting the reproductive structures present in a given population during the period monitored, although this is not a complete phenological dataset (Table 72). Data collected in 2022 support May as the end of the optimal season for fruit collection (CEMML 2015), as only 25% of plants were reproductive at that time.

Table 72. Presence of reproductive structures in *Tetramolopium stemmermanniae* populations

		Reproductive Structures Present			
Population	Monitoring Period	# of Plants	Fruits	Flowers	Flower Buds
TETSTE1	Oct 2022	3	0%	33%	33%
TETSTE2	May 2022	78	23%	26%	21%
TETSTE3	Apr–May 2022	46	20%	28%	20%
TETSTE4	Apr 2022	0	0%	0%	0%
TETSTE5	Sept 2022	2	50%	100%	100%
TETSTE6	Sept 2022	0	0%	0%	0%

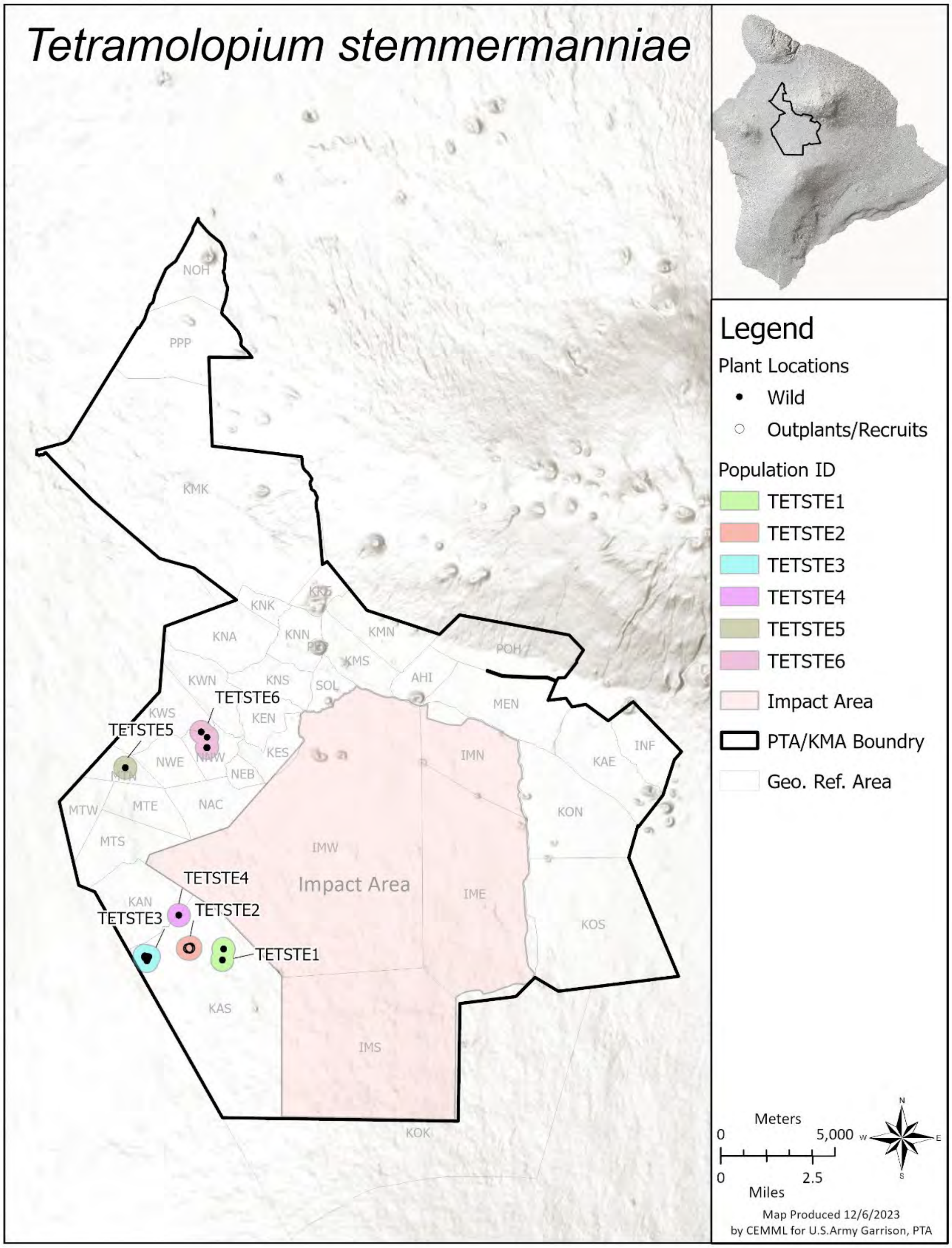


Figure 80. Current known distribution of *Tetramolopium stemmermanniae* individuals and populations at PTA[a]

[a]Data used to produce map were obtained from: (1) rare plant survey data collected between 2011 to 2021 plus monitoring of these locations conducted in 2022 to 2023; and (2) live plant locations collected during outplant monitoring in 2022.

The population structure of this species in the wild is somewhat evenly distributed among the different life stages at present, with 24% more adults than juveniles. The numbers of adults and juveniles were stable and proportional to one another throughout 2019 to 2020, as opposed to the wide range in the numbers of seedlings observed over the 5 monitoring periods (Figure 81). However, the total number of adults and juveniles combined decreased by 48% from 2019 to 2020 monitoring to the 2022 monitoring.

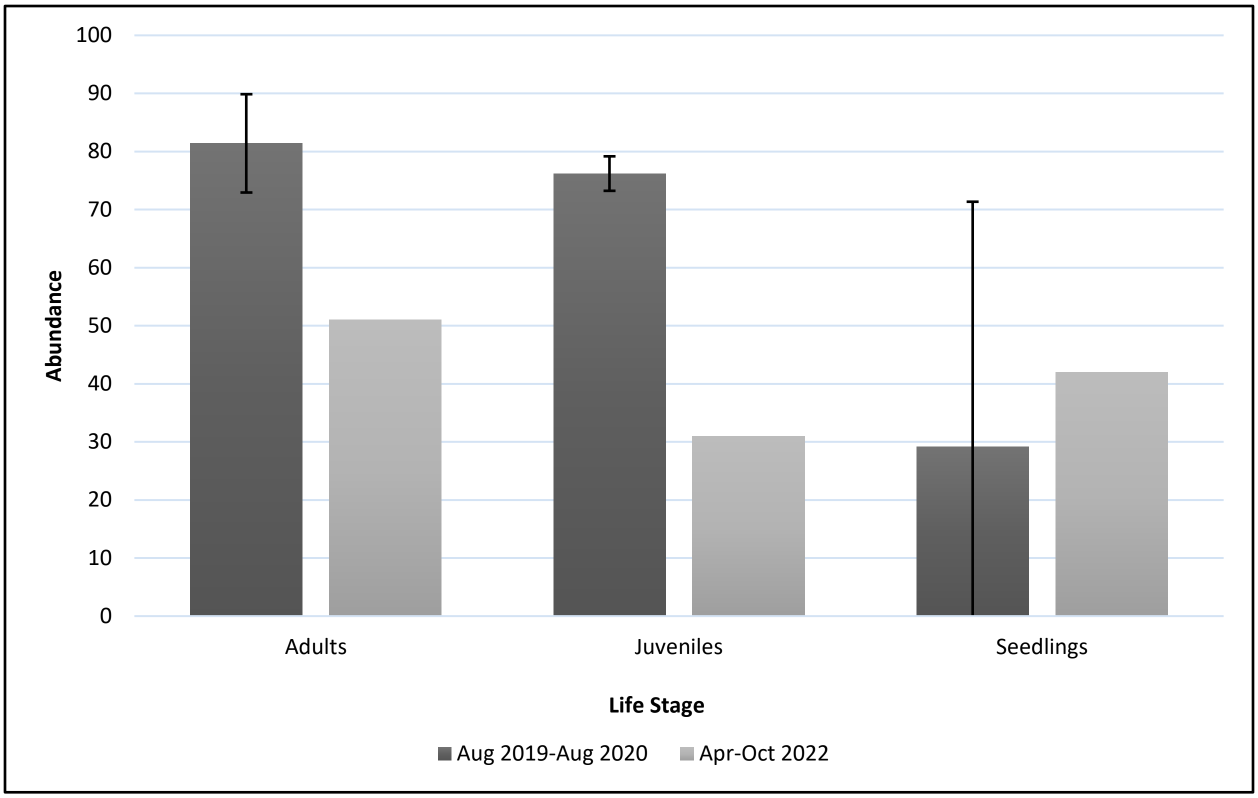


Figure 81. Monitoring data for wild *Tetramolopium stemmermanniae* individuals from 2019 to 2020 compared with 2022. Mean abundance and 90% confidence intervals (error bars) are derived from 5 quarterly monitoring datasets collected in 2019 to 2020; monitoring census data from 2022 are a single dataset

For combined *T. stemmermanniae* locations, 3% of weed percent cover and 7% of fine fuels percent cover estimations exceeded our 20% cover management thresholds (Figure 82 and Figure 83).

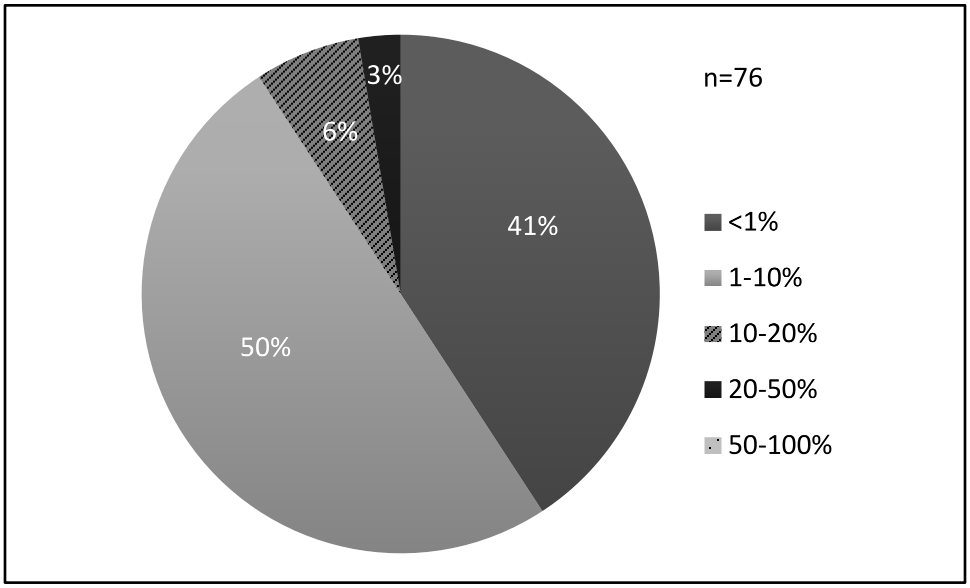


Figure 82. Overall proportion of weed percent cover classes reported for *Tetramolopium stemmermanniae* plant locations

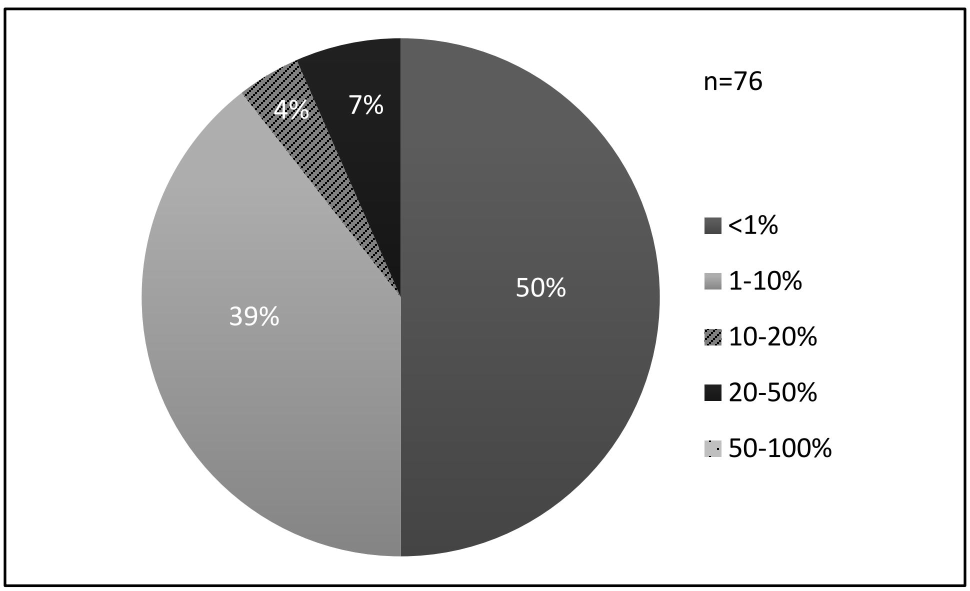


Figure 83. Overall proportion of fine fuels percent cover classes reported for *Tetramolopium stemmermanniae* plant locations

Genetic Conservation

Propagule Collection and Propagation

No propagule collection or propagation occurred during the reporting period. Please refer to Table 15 for a complete summary of ex-situ storage status for *T. stemmermanniae.*

Outplanting and Monitoring

We did not outplant *T. stemmermanniae* during the reporting period. In previous years we planted a combined total of 357 *T. stemmermanniae* individuals at 4 sites (Table 73). *T. stemmermanniae* established well at ASR 214, and plants have been self-sustaining. Recruitment occurs annually and the occupied area continues to expand, especially in areas where grass is managed. However, the total number of juvenile and adult plants has declined by 42% since monitoring in 2020.

Table 73. Monitoring results from May–December 2022 for *Tetramolopium stemmermanniae* outplanted 2004–2014

Location	ASR	Total Outplanted 2004–2014	Total Present 2014		Total Present 2022		% Change 2014–2020	Seedlings 2022
			Adult	Juvenile	Adult	Juvenile		
Off PTA	**201**	83	1	0	0	0	0%	0
	202	69	0	0	0	0	0%	0
On PTA	**209**	66	1	0	0	0	0%	0
	214	139	197	1,500	78	185	-85%	146

ASR, Area of Species Recovery. ASRs numbered in the 200s refer to outplanting sites, which may be located within or adjacent to ASR established for wild populations.
Note: The data source for planting activity between 2004 to 2014 and 2014 monitoring data is CEMML 2015. ASR listed in bold denotes seedlings and underline denotes juvenile/adult recruits were present in 2014.

Discussion

Our efforts to monitor and conserve genetic resources for *T. stemmermanniae* address SOO tasks 3.2.1.2, 3.2.1.4, and 3.2.1.5, as well as several INRMP objectives and conservation measures from the 2003 and 2013 BO.

At PTA, *Tetramolopium stemmermanniae* naturally occurs in the *Metrosideros polymorpha* Woodland alliance and the *Myoporum sandwicense—Sophora chrysophylla* Shrubland alliance. This plant is only known from PTA, and due to its apparent rarity, we manage this species similarly to other Tier 1 ESA-listed plant species.

Little is known about the life history characteristics of this species, but it likely shares some characteristics with other congeners. *T. stemmermanniae* likely has some life history characteristics in common with early successional species (r strategists) and with *T. arenarium*. Based on lessons learned with *T. arenarium*, we plan to investigate monitoring and management approaches suited for early successional species. However, we recommend basic research into life history characteristics to support science-based management of this species. Understanding these attributes is important for designing management actions to maximize the likelihood that *T. stemmermanniae* will persist and potentially increase, especially with changing climate conditions.

Since its discovery at PTA in the early 1990s, *T. stemmermanniae* had not been scientifically recognized as a species. In the 1997 publication *Rare Plants of Pōhakuloa Training Area*, Shaw uses the specific epithet *T. diersingii*, but this publication did not meet scientific requirements for naming a new species. Results from a 2015 collaborative study with Dr. Clifford Morden of the University of Hawaiʻi confirmed that *T. stemmermanniae* is genetically distinct from other species of *Tetramolopium* found at PTA (Morden and Yorkston 2015). In 2023, a species description was finally published, more than 25 years after its initial discovery (Evans et al. 2023).

We continue to make progress toward genetic conservation targets for *T. stemmermanniae*. However, many of these accessions in storage are older and we do not know how aging affects the viability of the seed. During the FY 2017 to FY 2019 reporting period, we had low germination success with accessions collected in 2018. We recommend using the new germination chamber to better understand germination requirements under controlled conditions.

The *T. stemmermanniae* outplanted between 2004 and 2014 showed poor establishment at most sites, except at ASR 214. At the lower elevation ASRs, 201 and 204, no recruitment was observed. Although recruitment was observed at ASR 209, plants failed to persist to 2022. Plants initially established well at ASR 214 but after 2014, the numbers of adults and juveniles declined sharply. In contrast to the very poor performance at other sites, *T. stemmermanniae* appears to be doing well at ASR 214. Similar to its close relative *T. arenarium*, we suspect that *T. stemmermanniae* may rely on large recruitment events to ensure adequate adults exist to sustain the population (Laven et al. 1991). Because *T. stemmermanniae* is limited in number and distribution, we recommend this species be assigned a genetic conservation rank of Implementation Priority 1 and that outplanting be a high priority for this species. We know little about the life-history of this species, which will make selecting good outplanting sites challenging. We recommend including *T. stemmermanniae* in all future outplanting plans.

Progress toward Compliance with INRMP Objectives

Because *Tetramolopium stemmermanniae* is a newly described and unlisted species, we implement management for *T. stemmermanniae* under INRMP objectives that minimize threats to Hawaiian plants from wildfire and invasive species.

To manage threats for *T. stemmermanniae*, we implement landscape-level projects to reduce fire risk and browse from ungulates for all known individuals at PTA (Sections 3.4 and 4.3). We actively conserve *T. stemmermanniae* genetic resources; the ex-situ collection contains 27,583 seeds from the natural population and 235,335 seeds from individuals grown in the RPPF or from outplanted individuals, representing a total of 172 wild founders. To date, we have outplanted a combined total of 357 *Tetramolopium* at 4 sites. We control weeds in ASR 28 for the wild population of *T. stemmermanniae*, for a total area of 0.9 ha (Section 3.2, Table 101). Between 2016 and 2019, we observed in-situ reproduction in 8 of 64 (13%) monitoring plots for *T. stemmermanniae.* Using our new individual plant-based monitoring protocol will allow us to document in-situ reproduction much more effectively; we expect to observe and document more reproduction moving forward. Although we monitor *T. stemmermanniae* annually to assess population patterns, we are unable to attribute changes in numbers to effects of 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 2.7).

2.5.13 *Vigna o-wahuensis* (Endangered)

We tagged and monitored all known *V. o-wahuensis*, a Tier 1 species, using the individual plant-based monitoring protocol between the months of October and November 2022. For genetic conservation, *V. o-wahuensis* is an implementation priority 1 (high; Table 13). In 2024, we plan to resume collecting propagules to refresh old accessions in storage, as well as to provide additional representation of subpopulations currently lacking in our collection. We outplanted individuals in 2023, and we germinated seeds for additional outplanting in 2024 as well.

Plant Surveys and Monitoring

According to the latest monitoring, a total of 13 adults, 137 juveniles, and at least 168 seedlings of *V. o-wahuensis* exist at PTA. This number does not include the cohort of individuals we outplanted in 2023. At PTA there are 2 populations—1 wild and 1 outplanted (Figure 84).

Each adult or juvenile plant was scored for vigor (Healthy=5; Moderate=3; Poor=1) to arrive at an average health index for each population. The wild population (VIGOWA 2) was on average healthy (Table 74).

Table 74. Average plant health index in *Vigna o-wahuensis* populations

			Plant Health[a]			
Population	Monitoring Period	# of Plants	Healthy (5)	Moderate (3)	Poor (1)	Average Health Index
VIGOWA1	Nov 2022	ND				
VIGOWA2	Oct –Nov 2022	150	97%	3%	0%	4.9

NA, Not applicable; ND, No Data
[a]Healthy = foliage that appears green and vigorous, with less than 10% dead leaves or defoliation; Moderate = leaves on plants may have some chlorosis, with 10-50% of the leaves dead or defoliated; Poor = mostly dead or chlorotic leaves, with greater than 50% dead leaves or defoliation.

We are documenting the reproductive structures present in a given population during the period monitored, although this is not a complete phenological dataset (Table 75).

Table 75. Presence of reproductive structures in *Vigna o-wahuensis* populations

		Reproductive Structures Present			
Population	Monitoring Period	# of Plants	Fruits	Flowers	Flower Buds
VIGOWA1	Nov 2022	ND			
VIGOWA2	Oct –Nov 2022	10	0%	0%	100%

ND= No Data

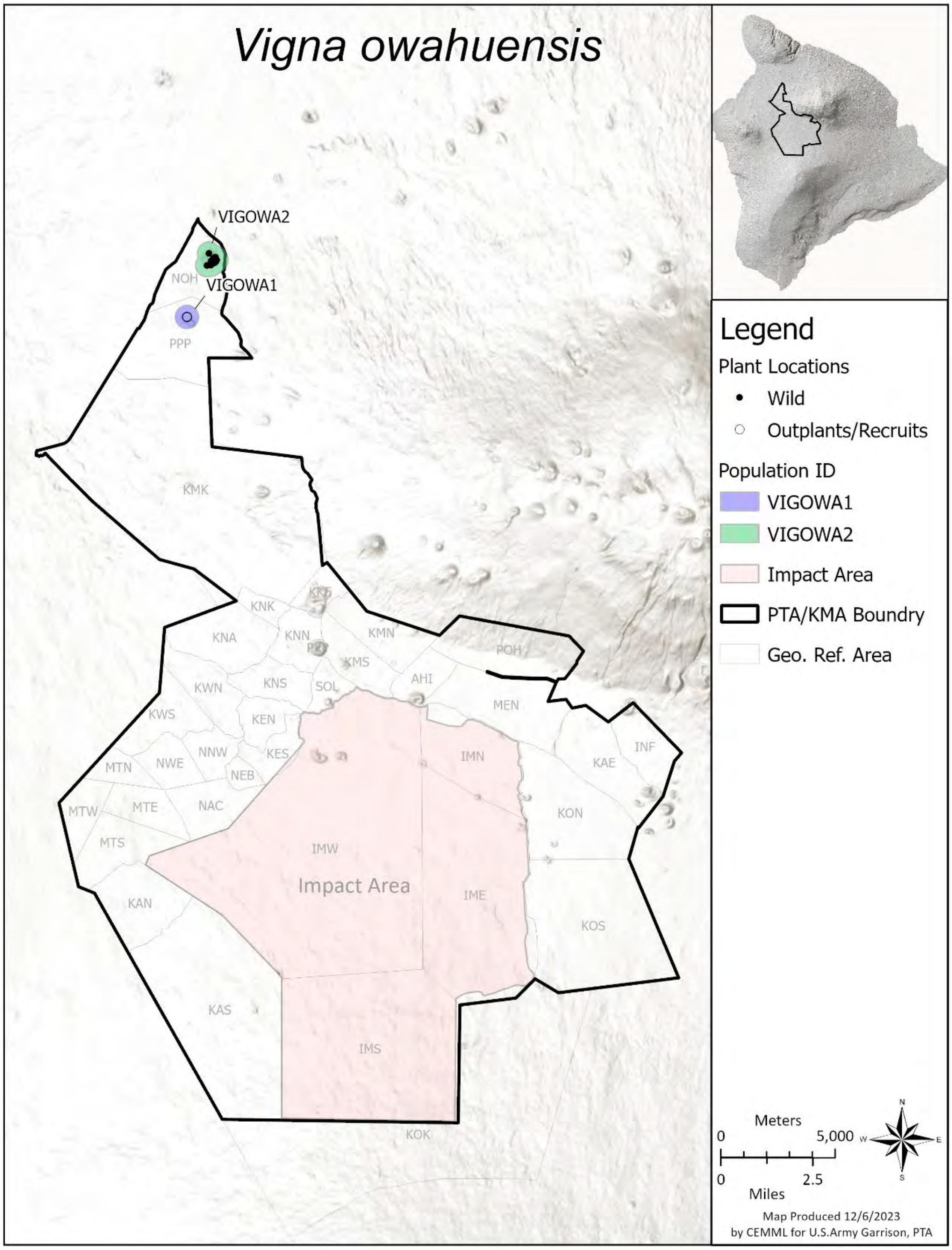


Figure 84. Current known distribution of *Vigna o-wahuensis* individuals and populations at PTA[a]

[a]Data used to produce map were obtained from: (1) rare plant survey data collected between 2011 to 2021 plus monitoring of these locations conducted in 2022 to 2023; and (2) live plant locations collected during outplant monitoring in 2022.

Of the 150 adult and juvenile plants observed in October and November 2022, only 9% were adults. Seedlings represented more than 50% of the total number of plants observed, much higher than during previous monitoring in 2019 to 2020 (Figure 85). The plant seems to have been responding to favorable early-winter conditions in 2022 and recovering from a period of relative dormancy. *V. o-wahuensis* is known to be an ephemeral species and may not be present for extended periods of time at a particular location. It also appears to be seasonally transient in the wide range of adult and juvenile plants observed during 2019 to 2020 quarterly monitoring (as indicated by the wide confidence intervals; Figure 85). The species is currently found in highly degraded habitat dominated by *C. setaceus* yet is nonetheless able to maintain a substantial seedbank. Habitat characteristics that allow *V. o-wahuensis* to persist are not well understood. Future management and monitoring efforts will address how changes in community structure may affect *V. o-wahuensis* survival and persistence.

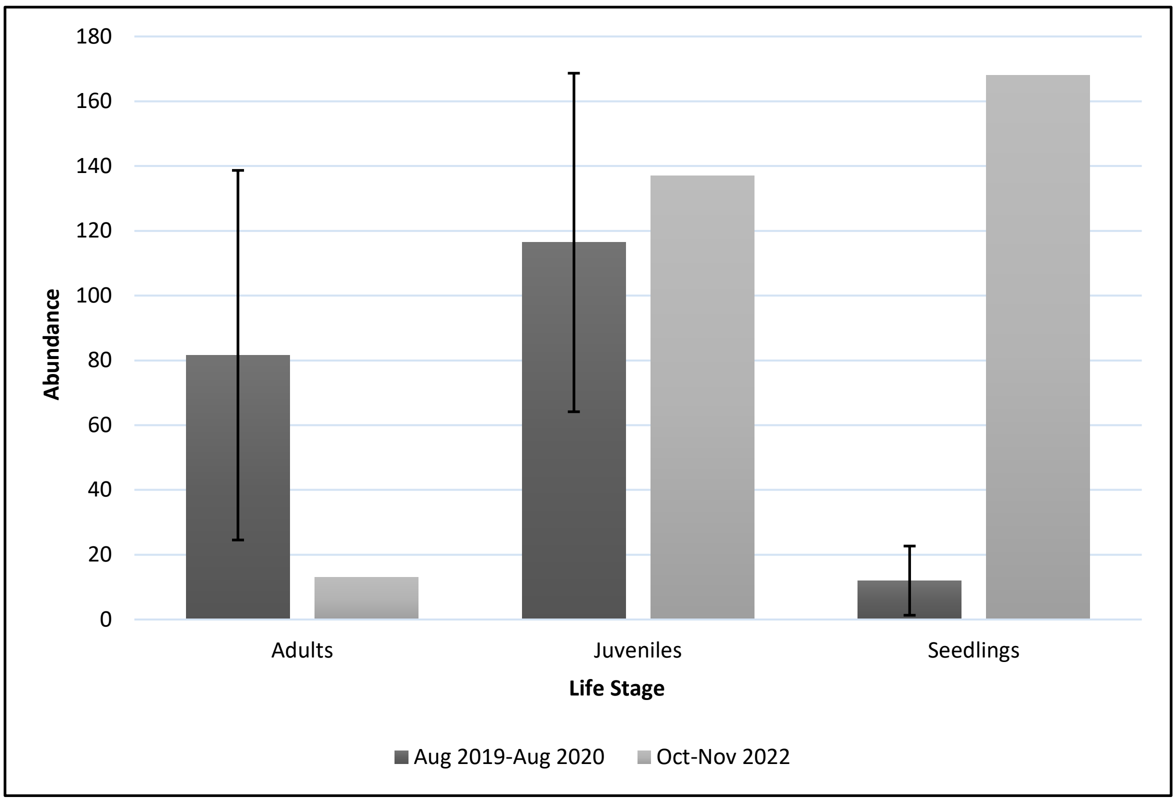


Figure 85. Monitoring data for wild *Vigna o-wahuensis* individuals from 2019 to 2020 compared with 2022. Mean abundance and 90% confidence intervals are derived from 5 quarterly monitoring datasets collected in 2019 to 2020; monitoring census data from 2022 are a single dataset

For combined *V. o-wahuensis* locations, 100% of weed percent cover and fine fuels percent cover estimations exceeded our 20% cover management thresholds (Figure 86 and Figure 87). However, 94% of percent cover estimations fell within the habitat restoration site, where weed control management began shortly after monitoring. The remaining 6% were collected for isolated individuals that receive no management at this time.

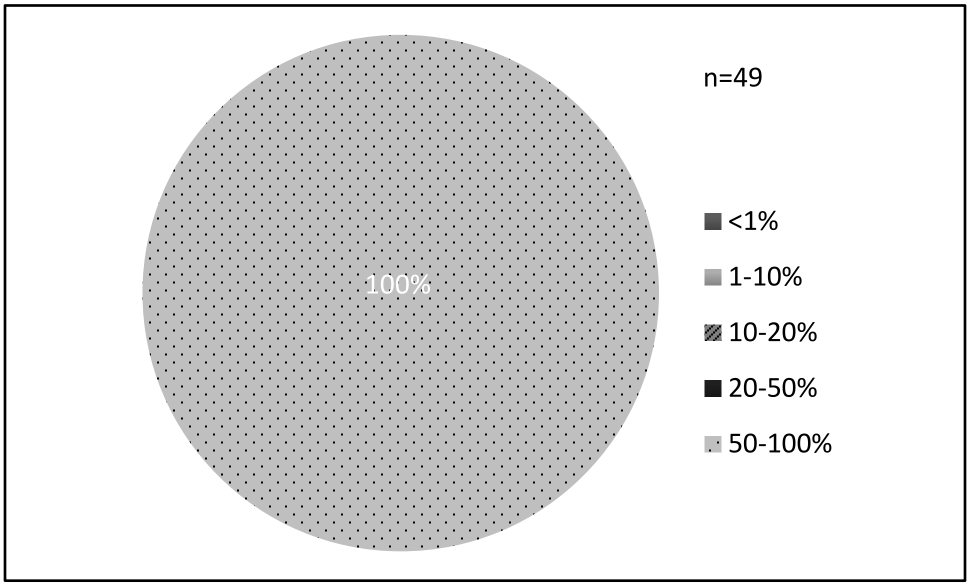


Figure 86. Overall proportion of weed percent cover classes reported for *Vigna o-wahuensis* plant locations

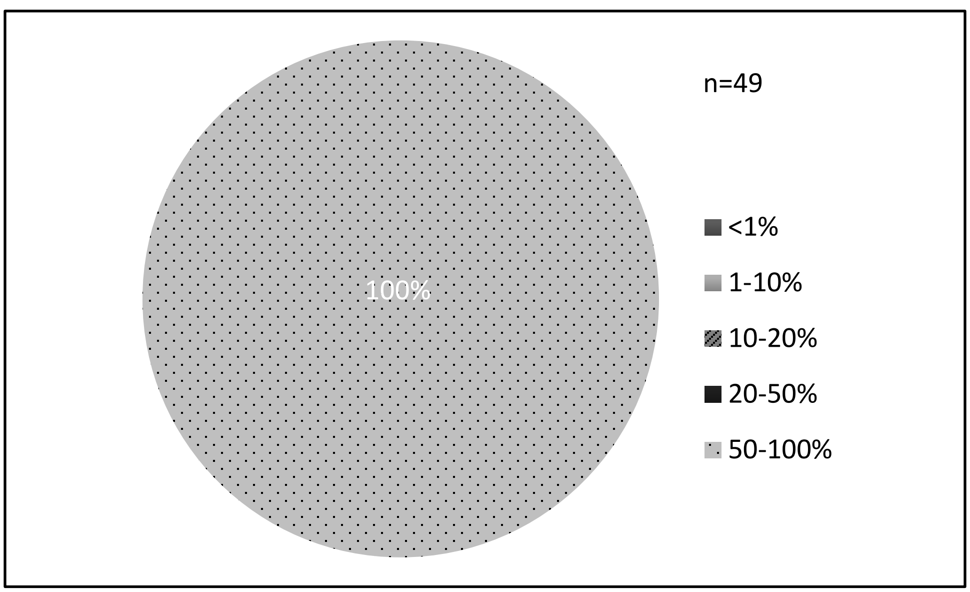


Figure 87. Overall proportion of fine fuels percent cover classes reported for *Vigna o-wahuensis* plant locations

Genetic Conservation

Propagule Collection and Propagation

No propagule collection occurred over the reporting period. Please refer to Table 15 for a complete summary of ex-situ storage status for *V. o-wahuensis.*

Viability testing trials for *V. o-wahuensis* were initiated at OANRP's seed lab in FY 2023 using PTA-sourced seed. These trials were set up as part of training received by PTA personnel at OANRP; all resultant plants were transferred back to PTA for outplanting in 2024. Two accessions, each over 10 years old, were tested and the germination rate of each accession was over 90% (Table 76).

Table 76. Germination trials for *Vigna o-wahuensis* conducted in 2023 at the US Army Garrison-Hawai'i Natural Resources Program on O'ahu

Age of Seed (years)	Number of Accessions	Number of Seeds Sown	Number of Seeds Germinated	Average Germination Rate
14	5	82	81	99%
10	5	377	342	91%

From germination trials conducted at OANRP seed lab in 2023, 235 *V. o-wahuensis* representing 17 founders were accessioned to the RPPF as of 30 September 2023 (Table 20).The 45% loss that occurred between the time they germinated and the time they were accessioned was due to fungal infection of seedlings while in the growth chamber at OANRP.

Following the conclusion of the germination trials, we sowed at the RPPF an additional 7 accessions (202 seeds) representing 7 more founders to produce a more diverse and balanced mix of individuals for outplanting in 2024. Additional seedlings (and founders) from the PTA sowings in 2023 have sprouted but have yet to be accessioned.

Outplanting and Monitoring

From 2003 through 2014, we planted a combined total of 85 *V. o-wahuensis* at 7 ASR (Table 77). In addition, we broadcasted seed at 4 ASR. As of December 2022, all of these outplants were dead.

Table 77. Monitoring results from December 2022 for *Vigna o-wahuensis* outplanted 2004–2014

Location	ASR	Total Outplanted 2004–2014	Total Present 2014		Total Present 2020		% Change 2014–2020	Seedlings 2020
			Adult	Juvenile	Adult	Juvenile		
Off PTA	201+	7	0	0	0	0	0%	0
	202	7	0	0	0	0	0%	0
	203+	11	0	0	0	0	0%	0
	<u>204+</u>	0	0	1	0	0	-100%	0
	<u>205+</u>	47	4	16	0	0	-100%	0
On PTA	214	2	1	0	0	0	-100%	0
	216	11	0	0	0	0	0%	0

ASR, Area of Species Recovery. ASRs numbered in the 200s refer to outplanting sites, which may be located within or adjacent to ASR established for wild populations.

Note: The data source for planting activity between 2004 and 2014 and 2014 monitoring data is CEMML 2015. Underlined ASR denotes juvenile/adult recruits were present in 2014. A + symbol indicates that seeds were broadcast at the site.

In 2019, we planted 11 *V. o-wahuensis,* representing a single founder, on Puʻu Pāpapa in the Keʻāmuku Maneuver Area (ASR 225). In 2023 we planted an additional 24 individuals at this site, representing a single (unknown) founder. In 2002, Arnett (2002) found 3 *V. o-wahuensis* plants on Puʻu Pāpapa. Reintroduction of *V. o-wahuensis* to Puʻu Pāpapa was established as a goal in the *Genetic Conservation and Outplanting Plan* (CEMML 2017). In December 2022, none of the 2019 outplants (or their recruits) remained, but we are hopeful that the plants planted in 2023 and the much larger plantings planned for 2024 will establish a self-sustaining population.

<u>Discussion</u>

Our efforts to monitor and conserve genetic resources for *V. o-wahuensis* address SOO tasks 3.2.1.2, 3.2.1.4, and 3.2.1.5, 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. Quarterly monitoring from 2019 to 2020 shows that the abundance of *V. o-wahuensis* fluctuates over time. *V. o-wahuensis* may rely on episodic recruitment during favorable environmental conditions to sustain the population. As is true for many species at PTA, we know very little about the life history characteristics of *V. o-wahuensis*. Understanding 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 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. After completing germination trials, we now know that viability has the potential to remain relatively high after 10 to 14 years of storage (92% average). We will continue to test the viability of our oldest accessions to support these initial findings.

Outplanted *V. o-wahuensis* outplants have low survivorship, although the number of attempted outplants is relatively low (85) and data suggest that individual plants are ephemeral in their natural habitat. Future plantings in 2024 and 2025 will concentrate much larger numbers of individuals in each site, more closely resembling wild population densities at the beginning of a particularly wet season. Because this species is capable of flowering and setting seed within its first year, we hope to quickly build up a large seed bank for future recruitment on site.

Status of Vigna o-wahuensis *Populations at PTA per the USFWS Species Recovery Criteria*

In the 5-Year Review for *V. o-wahuensis* published in 2020, the USFWS amended the recovery criteria and established a new recovery stage—Preventing Extinction Stage—with updated criteria. The Preventing Extinction stage for *V. o-wahuensis* requires 50 mature individuals in each of 3 populations, with at least 50 individuals (or the total number if less than 50) represented from each wild population in ex-situ storage. We continue to make progress towards the Preventing Extinction Stage for the single populations at PTA (Table 78). Through management, we strive to advance the species toward the next stage of recovery—Interim Stabilization. However, to meet the Interim Stabilization stage, another population must be established and maintained to meet the criteria on Molokaʻi or Maui. Through continued monitoring, we plan to document natural reproduction and assess population trends.

Table 78. Progress towards USFWS Preventing Extinction stage of recovery for *Vigna o-wahuensis* at PTA

Population	# Adults Wild (OP)	# Juveniles Wild (OP)	# Founders Ex-situ Storage	Fenced	Invasive Plant Control	Natural Reproduction	Number Increasing
VIGOWA2	13	137	120	Yes	Yes	ND	ND

ND, No Data

Progress toward Compliance with Endangered Species Act Biological Opinion Conservation Measures

To offset effects of military activities on *V. o-wahuensis,* the 2003 BO conservation measures include fuels management to reduce fire risk, fencing and ungulate control to reduce browsing 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 browsing for all known individuals at PTA (Sections 3.4 and 4.3). In addition, we actively conserve *V. o-wahuensis* genetic resources; the ex-situ storage contains 3,395 seeds from the wild population and 32,279 seeds from individuals grown in the RPPF. To date, we have outplanted 109 individuals at 6 sites; no outplants remain at the sites as of December 2021 (not including the cohort planted in 2023 that has yet to be monitored). We control weeds in ASR 45 for the wild population of *V. o-wahuensis*, for a total area of 1 ha (Section 3.2, Table 101). Between 2016 and 2019, we observed in-situ reproduction in 18 of 46 (39%) monitoring plots for *V. o-wahuensis.* Using our new individual plant-based monitoring protocol will allow us to document in-situ reproduction much more effectively; we expect to observe and document more reproduction moving forward. Although we monitor *V. o-wahuensis* annually to assess population patterns, we are unable to attribute changes in numbers to effects of 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 2.7).

2.5.14 *Zanthoxylum hawaiiense* (Endangered)

We monitored all known plants of *Z. hawaiiense*, a Tier 1 species, in FY 2020, with the next monitoring scheduled for FY 2024. We intend to monitor this long-lived species on a 3-year cycle. For genetic conservation, *Z. hawaiiense* is an implementation priority 4 (low; Table 13). We plan to collect propagules for storage with little to no outplanting.

Plant Surveys and Monitoring

To update the distribution and abundance of *Z. hawaiiense,* in March 2020 we revisited 575 previously documented locations and counted all individuals present. We recorded the GPS coordinates for each individual adult/juvenile found so that each location represents a single adult or juvenile. When present, seedlings were counted in a 5 m radius circle around each adult or juvenile plant location. *Z. hawaiiense* adults and juveniles were tagged with a preprinted metal tag attached with copper wire around the base of the tree.

We found 498 living trees (Figure 88). Of the 498 living trees observed, 208 were female, 4 were male, and the sex of the remaining 286 trees could not be determined.

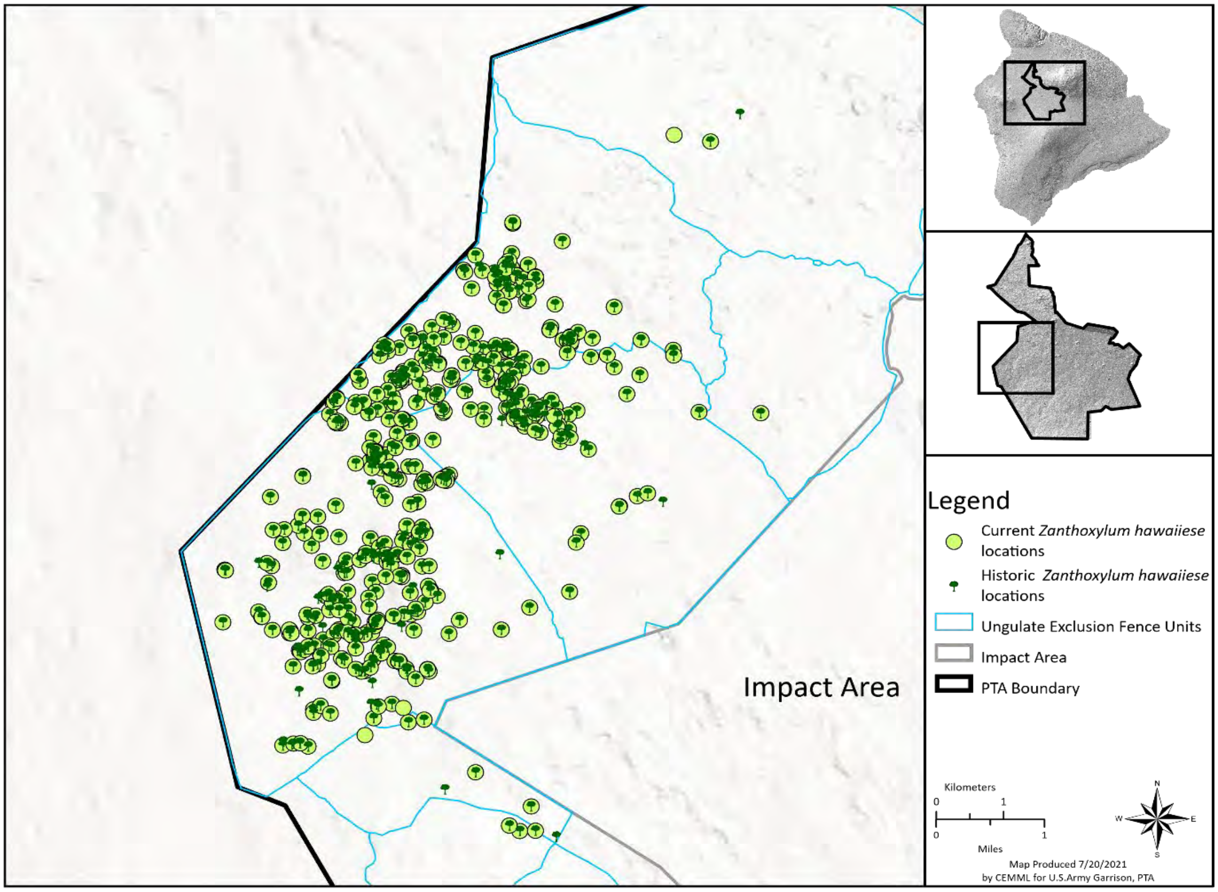


Figure 88. Historic and current locations of *Zanthoxylum hawaiiense* monitored April–September 2020

Most trees were categorized as healthy (n= 384, >90% green foliage), but a few were categorized as moderate (n= 89, 50–90% green foliage) or poor (n=19, <50% green foliage). Yellowing or chlorotic leaves could be the result of site-specific nutrient deficiencies, or perhaps responses to drought conditions. In December 2020, a fruiting tree was incidentally discovered in TA 22, bringing the known number of trees to 493 (209 females). In addition, a cumulative total of 140 seedlings (young trees less than 0.5 m tall) were recorded at 43 plant locations.

See Section 2.2.3 for results of additional monitoring of this species in 2023 as part of the Leilani post-fire assessment. At PTA there are 5 populations—3 wild and 2 outplanted (Figure 89).

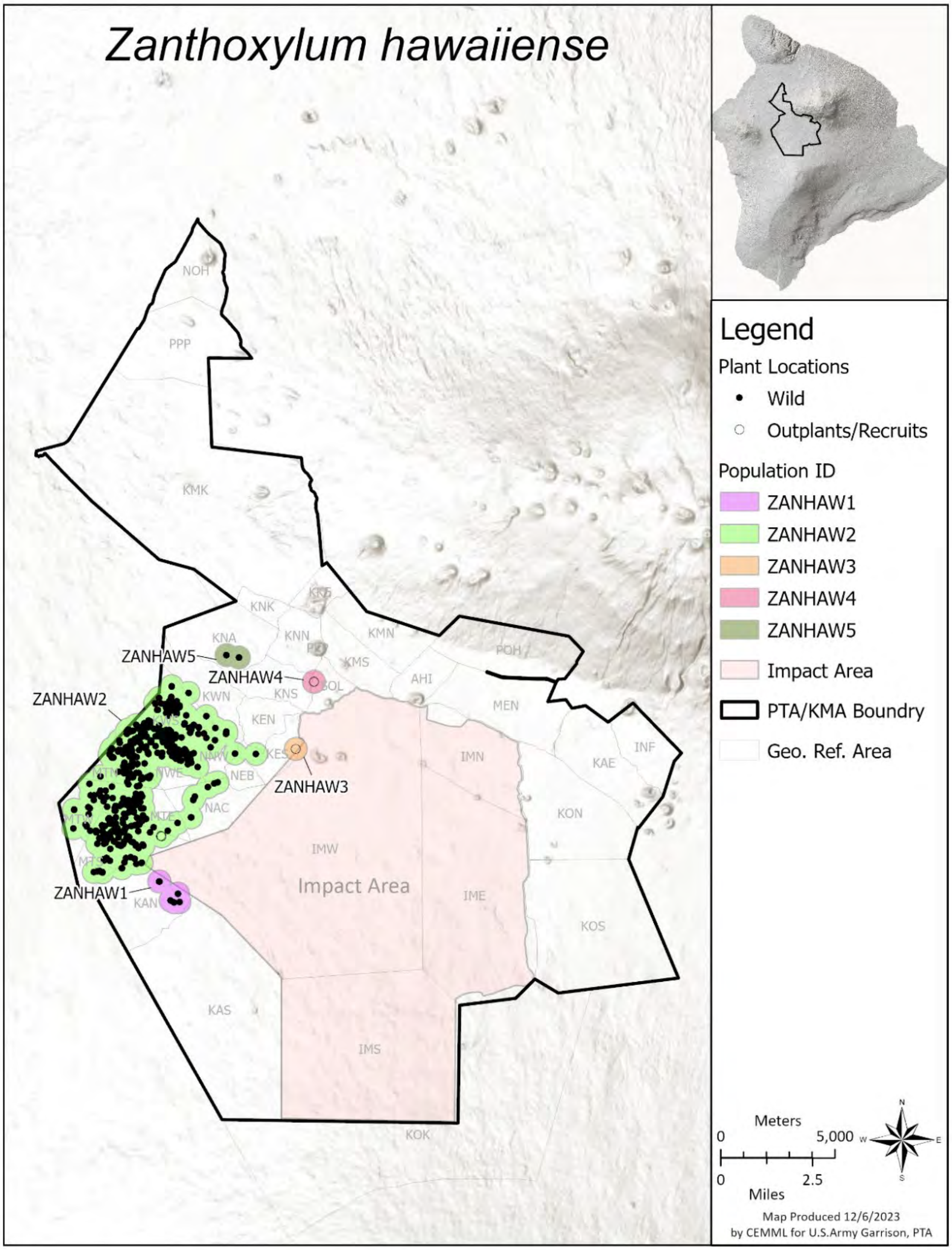


Figure 89. Current known distribution of *Zanthoxylum hawaiiense* individuals and populations at PTA[a]

[a]Data used to produce map were obtained from: (1) rare plant survey data collected between 2011 to 2020 and (2) live plant locations collected during outplant monitoring in 2022.

Genetic Conservation

Propagule Collection and Propagation

We collected 24 seeds from 1 individual in 2022 (Table 79). Please refer to Table 15 for a complete summary of ex-situ storage status for *Z. hawaiiense.* No propagation occurred during the reporting period.

Table 79. Propagule collections for *Zanthoxylum hawaiiense* in 2022. Seeds collected were dried to 28% relative humidity and stored at 5° C

Founder[a]	Date of Collection	Type of Propagule	Amount Collected	Population	UTM X	UTM Y
517-1682-030-001	2 Dec 22	Seed	24	ZANHAW2	216577	2182235

[a]Founder number listed in lieu of Plant ID as the tree has yet to be tagged.

Outplanting and Monitoring

We did not outplant *Z. hawaiiense* during the reporting period. In previous years we planted a combined total of 40 *Z. hawaiiense* individuals at 7 sites (Table 80). During the last monitoring of the outplanting sites in December 2020, we documented 11 *Z. hawaiiense* alive (3 juveniles and 8 adults).

Table 80. Monitoring results from April–November 2022 for *Zanthoxylum hawaiiense* outplanted 2004–2014

Location	ASR	Total Outplanted 2004–2014	Total Present 2014		Total Present 2022		% Change 2014–2022
			Adult	Juvenile	Adult	Juvenile	
Off PTA	201	2	0	1	1	0	0%
	203	2	0	0	0	0	0%
	205	22	8	11	6	1	-63%
On PTA	208	5	0	1	0	0	-100%
	211	2	0	1	1	0	0%
	213	4	0	0	1	1	+200%
	220	3	0	3	0	1	-67%

ASR, Area of Species Recovery. ASRs numbered in the 200s refer to outplanting sites, which may be located within or adjacent to ASR established for wild populations.
Note: The data source for planting activity between 2004 to 2014 and 2014 monitoring data is CEMML 2015.

Discussion

Our efforts to monitor and conserve genetic resources for *Z. hawaiiense* address SOO tasks 3.2.1.2, 3.2.1.4, and 3.2.1.5, 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. Scattered individuals also occur in the Kīpuka Kālawamauna North, Kīpuka Kālawamauna East, *Kadua coriacea*, and Kīpuka ʻAlalā North Fence Units.

As is true for many species at PTA, we know very little about the life history characteristics of *Z. hawaiiense*. Understanding 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 basic research into life history characteristics to support science-based management of this species.

Z. hawaiiense is one of several federally listed species affected by the 2022 Leilani fire. The abundance of *Z. hawaiiense* declined by 39 individuals following the fire (a 45% decrease in the burn area; Table 10). Most of the trees lost (95%) were located in Moderate and High burn severity classes. Within the burn area, no WCB were established specifically for *Z. hawaiiense,* and few trees occurred in WCB established for other species. This lack of grass/fuel control may have also contributed to the decline in abundance. The 1994 Kīpuka Kālawamauna fire "completely consumed…4 plants, and no resprouting was observed for any of the stumps. Also, [after a year] no seedlings of *Z. hawaiiense* [were] found in the area where the plants occurred prior to the fire" (Shaw 1995, p. 26). Fire appears to have a large effect on this species and was likely a substantial driver in the decline in abundance of *Z. hawaiiense*.

We continue to make progress with genetic conservation of *Z. hawaiiense*. Many of the accessions in storage are older and we do not know how aging affects seed viability. We had minimal success with seed germination and cutting establishment. 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. We are developing planting strategies and plan to continue investigating outplant performance and planting site characteristics in 2024 to maximize the successful establishment of new self-sustaining groupings.

Status of Zanthoxylum hawaiiense *Populations at PTA per the USFWS Species Recovery Criteria*

In the 5-Year Review for *Z. hawaiiense* published in 2021, the USFWS amended the recovery criteria and established a new recovery stage—Preventing Extinction Stage—with updated criteria. The Preventing Extinction stage for *Z. hawaiiense* requires 25 mature individuals in each of 3 populations, with at least 50 individuals (or the total number if less than 50) represented from each wild population in ex-situ storage. We continue to make progress towards the Preventing Extinction Stage for the single populations at PTA (Table 81). Through management, we strive to advance the species toward the next stage of recovery—Interim Stabilization. However, to meet the Interim Stabilization stage, another population must be established and maintained to meet the criteria on Kauaʻi, Molokaʻi, Lānaʻi, or Maui. Through continued monitoring, we plan to document natural reproduction and assess population trends.

Table 81. Progress towards USFWS Preventing Extinction stage of recovery for *Zanthoxylum hawaiiense* at PTA

Population	# Adults Wild (OP)	# Juveniles Wild (OP)	# Founders Ex-situ Storage	Fenced	Invasive Plant Control	Natural Reproduction	Number Increasing
ZANHAW1	4	1	2	Yes	No	ND	ND
ZANHAW2	309 (1)	119	262	Yes	No	ND	ND
ZANHAW3	(1)	0	NA	Yes	Yes	ND	ND
ZANHAW4	0	(1)	NA	Yes	Yes	ND	ND
ZANHAW5	2	0	1	Yes	No	ND	ND

ND, No Data

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 browsing 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 (Sections 3.4 and 4.3). In addition, we actively conserve *Z. hawaiiense* genetic resources; the ex-situ storage contains 6,270 seeds representing 278 wild founders. To date, we have outplanted a combined total of 40 individuals at 7 sites. Because *Z. hawaiiense* is a slow-growing tree, it has not yet established self-sustaining populations. Prior to 2021, *Z. hawaiiensis* was classes in a lower priority management tier and thus we have not implemented weed management specifically for *Z. hawaiiense*. In addition, *Z. hawaiiensis* are widely distributed in small clusters across thousands of acres making weed management for this species impractical across the entire distribution. Future weed management will need to be targeted to trees in higher fire risk areas. However, this species benefits from invasive plant management where it occurs in weed control buffers that were implemented for other species. In 2021, we noted recruitment at 43 plant locations for a cumulative total of 140 seedlings (i.e., young trees less than 0.5 m tall). Using our new individual plant-based monitoring protocol will allow us to document in-situ reproduction much more effectively; we expect to observe and document more reproduction moving forward. Although we monitor *Z. hawaiiense* every 3 years to assess population patterns, we are unable to attribute changes in numbers to effects of 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 2.7).

2.6 ESA-Listed Plant Species Summaries for Management Tier 2 Species

We present the species summaries arranged by management Tiers (Table 1) and then alphabetically by species. We present Tier 2 species together as these species receive similar management. We delineate the distributions and estimate abundances for these species via plant survey data. These surveys were completed twice (2011 to 2015 and 2017 to 2020) within the ungulate exclusion fence units. We used plant survey data from 2011 through 2021, locations of incidental plant finds, and 2022 to 2023 monitoring data to update the plant distribution maps. For *Spermolepis hawaiiensis*, we continue to report count class data collected between 2011 and 2015. 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 conservation measures.

To evaluate outplanting efforts conducted between 2004 and 2014, we provide the total number of each species planted at each site. This number reflects the general level of effort for a given species but does not account for survivorship/mortality over the period. All outplanting sites were monitored in 2014 after the final plantings at each site. The 2014 monitoring data accurately reports number of original outplants remaining and the number of plants that recruited on site from seed. Since we cannot reliably distinguish the original outplants from recruits we report the cumulative number of all adults and juveniles present for each species (i.e., original outplants plus recruits). To evaluate outplant performance, we report the percent change between the total number of adults and juveniles present in 2014 compared to 2022.

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

As a Tier 2 species, we survey and monitor a portion of the known *A. peruvianum* var. *insulare* population at PTA each year to refresh the distribution and abundance estimates. The aim is to survey the entire population at PTA over a 3-year period. For genetic conservation, *A. peruvianum* var. *insulare* is an implementation priority 4 (low; Table 13). We plan to collect propagules for storage with little to no outplanting.

<u>Plant Surveys and Monitoring</u>

Based on previous monitoring of known locations from July to September 2020, we estimated there were 217 adults, 497 juveniles and 192 gametophytes of wild *A. peruvianum* var. *insulare* within the fence units at PTA (CEMML 2022a). We also counted 13 adults and 53 juveniles at 2 wild locations outside the fence units (Table 3). Before monitoring in 2020, the species was categorized as a Tier 1 species (< 500 individuals); it has since been reclassified as a Tier 2 species. Using the Tier 2 (location-based) monitoring protocol during the current reporting period in Regions 3 and 4, we estimated 19 *A. peruvianum* var. *insulare* (90% CI: 0–46) within Region 4 (Table 6). The distribution for *A. peruvianum* var. *insulare*, including outplanting sites, is shown in Figure 90.

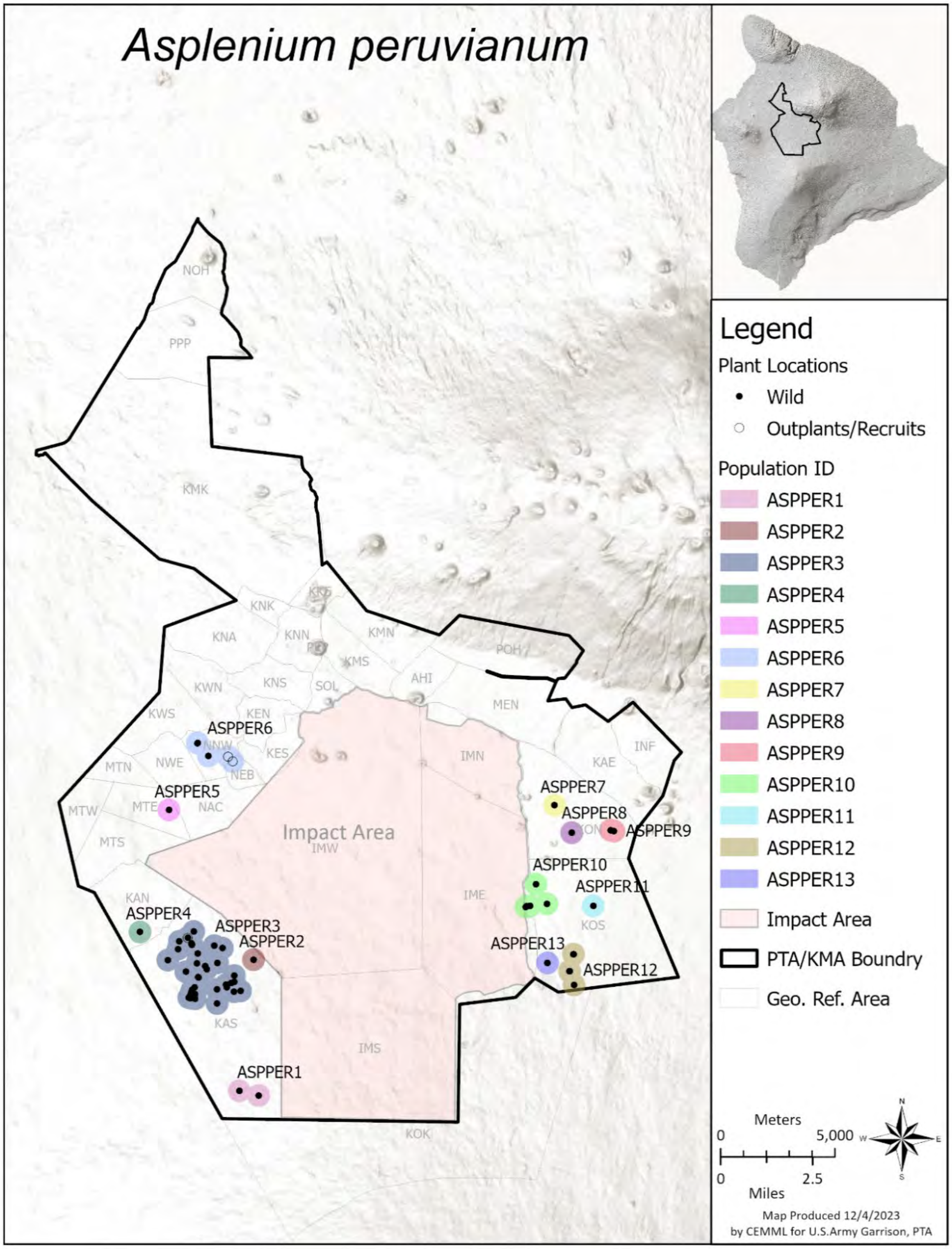


Figure 90. Current known distribution of *Asplenium peruvianum* var. *insulare*[a]

[a] The distribution is derived from a compilation of plant survey data (2011 to 2021), monitoring data, and incidental rare plant finds.

Genetic Conservation

Propagule Collection and Propagation

No propagule collections or propagation occurred during the reporting period for *A. peruvianum* var. *insulare.* Refer to Table 15 for a complete summary of ex-situ storage status for *A. peruvianum* var. *insulare*. There are no *A. peruvianum* var. *insulare* accessioned in the RPPF.

Outplanting and Monitoring

We did not outplant *A*. *peruvianum* var. *insulare* during the reporting period.

In previous years we planted a combined total of 48 *A*. *peruvianum* var. *insulare* at 3 sites. At last monitoring in 2022, there were 2 adults at ASR 219, and a single adult at ASR 201 (Table 82).

Table 82. Monitoring results from December 2022 for *Asplenium peruvianum* var. *insulare* outplanted 2004–2014

Location	ASR	Total Outplanted 2004–2014	Total Present 2014		Total Present 2022		% Change 2014–2022
			Adult	Juvenile	Adult	Juvenile	
Off PTA	201	10	1	0	1	0	0%
On PTA	218	15[a]	29	0	0	0	-100%
	219	23[a]	9[b]	0	2	0	-91%[b]

Note: The data source for planting activity between 2004 to 2014 and 2014 monitoring data is CEMML 2015.

[a] During FY 2106 to FY 2017, 15 *Asplenium peruvianum* var. *insulare* were transplanted from ASR 218 to ASR 219 increasing the total planted at ASR 219 from 8 to 23.

[b] In 2014, there were 8 ferns present. However, to account for the addition of 15 in FY 2016, we used the number of ferns remaining at the FY 2016 monitoring to calculate the % change.

Discussion

Our efforts to monitor and conserve genetic resources for *A*. *peruvianum* var. *insulare* address SOO tasks 3.2.1.2, 3.2.1.4, and 3.2.1.5, 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 Kīpuka ʻAlalā South Fence Unit. *A. peruvianum* var. *insulare* is currently found predominantly outside of the ASRs designated for the species. 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 (CEMML 2022a). Gametophytes were present each census period. Although our monitoring was not designed to track transition from one life stage to another, patterns in the quarterly count numbers suggest that transition from gametophyte and juvenile life stages supported gains in the adult life stage (CEMML 2022a). Little is 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.

Because *A. peruvianum* var. *insulare* is an implementation priority 4 (low) for genetic conservation, propagule collection and storage are our primary conservation actions. The ex-situ storage contains 130 blades (each with multiple fertile sori attached) from wild founders and 610 blades from plants in the RPPF, representing 66 wild founders total. Because we have not worked extensively with *A. peruvianum* var. *insulare* in past years, there is still much to learn about germination requirements and seedling establishment and care.

Status of Asplenium peruvianum *var.* insulare *Populations at PTA per the USFWS Species Recovery Criteria*

In the 5-year review for *A. peruvianum* var. *insulare* published in 2020, the USFWS established a new recovery stage—Preventing Extinction Stage—with updated criteria. The Preventing Extinction stage of recovery for *A. peruvianum* var. *insulare* require 100 mature individuals in each of 3 populations, with at least 50 individuals (or the total number if less than 50) represented from each wild population in ex-situ storage. We continue to make progress towards the Preventing Extinction Stage for the 13 populations at PTA (Table 83). Advancing to the next recovery stage, Interim Stabilization, requires maintenance of a population on Maui that meets the criteria. At PTA, documenting the presence of natural reproduction and trends in abundance over time will require several additional monitoring cycles.

Table 83. Progress towards USFWS Preventing Extinction stage of recovery for *A. peruvianum* var. *insulare* at PTA; population census data collected 2019–2020

Population	# Adults Wild	# Juveniles Wild	# Founders Ex-situ Storage	Fenced	Invasive Plant Control	Natural Reproduction	Number Increasing
ASPPER1	8	50	0	No	No	ND	ND
ASPPER2	1	3	0	Yes	No	ND	ND
ASPPER3	184	354	62	Yes	No	ND	ND
ASPPER4	2	2	0	Yes	No	ND	ND
ASPPER5	0	3	0	Yes	No	ND	ND
ASPPER6	1	1	2	Yes	No	ND	ND
ASPPER7	0	0	1	Yes	No	ND	ND
ASPPER8	0	0	0	Yes	No	ND	ND
ASPPER9	0	1	0	Yes	No	ND	ND
ASPPER10	13	101	0	Yes	No	ND	ND
ASPPER11	0	0	1	Yes	No	ND	ND
ASPPER12	28	47	0	Yes	No	ND	ND
ASPPER13	4	4	0	No	No	ND	ND

ND, No Data

Progress toward Compliance with Endangered Species Act Biological Opinion Conservation Measures

To offset effects of military activities on *A*. *peruvianum* var. *insulare*, the 2003 and 2013 BO conservation measures include fuels management to reduce fire risk, fencing and ungulate control to reduce browsing 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 most known *A*. *peruvianum* var. *insulare* individuals at PTA (Sections 3.4 and 4.3). We actively conserve *A*. *peruvianum* var. *insulare* genetic resources; the propagule bank contains 130 blades from the wild population and 610 blades from individuals grown in the RPPF, representing 66 wild founders total. To date, we have outplanted a combined total of 48 ferns at 3 sites (ASRs 201, 218, and 219). Propagation requirements and locating suitable outplanting sites remain limiting factors for this species. Other than outplanting sites with ASRs, we have not implemented weed control buffers specifically for wild *A*. *peruvianum* var. *insulare;* however, weeds are managed in 0.1 ha for an outplanted population at ASR 219 (Section 3.2, Table 101). Between 2016 and 2019, we documented in-situ reproduction at 13 of the 43 (30%) quarterly monitoring plots. Although we monitor a portion of the distribution of *A*. *peruvianum* var. *insulare* annually to estimate abundance, we are unable to attribute changes in numbers to effects of 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 2.7).

2.6.2 *Exocarpos menziesii* (Endangered)

We survey and monitor a portion of the known *E. menziesii* population, a Tier 2 species, at PTA each year to refresh the distribution and abundance estimates. The aim is to survey the entire population at PTA over a 3-year period. For genetic conservation, *E. menziesii* is an implementation priority 5 (low; Table 13). We plan to collect propagules for storage with little to no outplanting.

<u>Plant Surveys and Monitoring</u>

Based on previous survey work from 2019 to 2020, we estimate 1,875 (90% CI: 1,458–2,292) juvenile and adult individuals of *E. menziesii* within fence units (Table 8) and 3,674 (90% CI: 2,940–4,410) outside the fence unit in TA 23 (Table 4). The distribution for *E. menziesii* is shown in Figure 91. Using data collected during the reporting period, we estimate there are currently 612 *E. menziesii* (90% CI: 413–811) within Region 4 (Table 6).

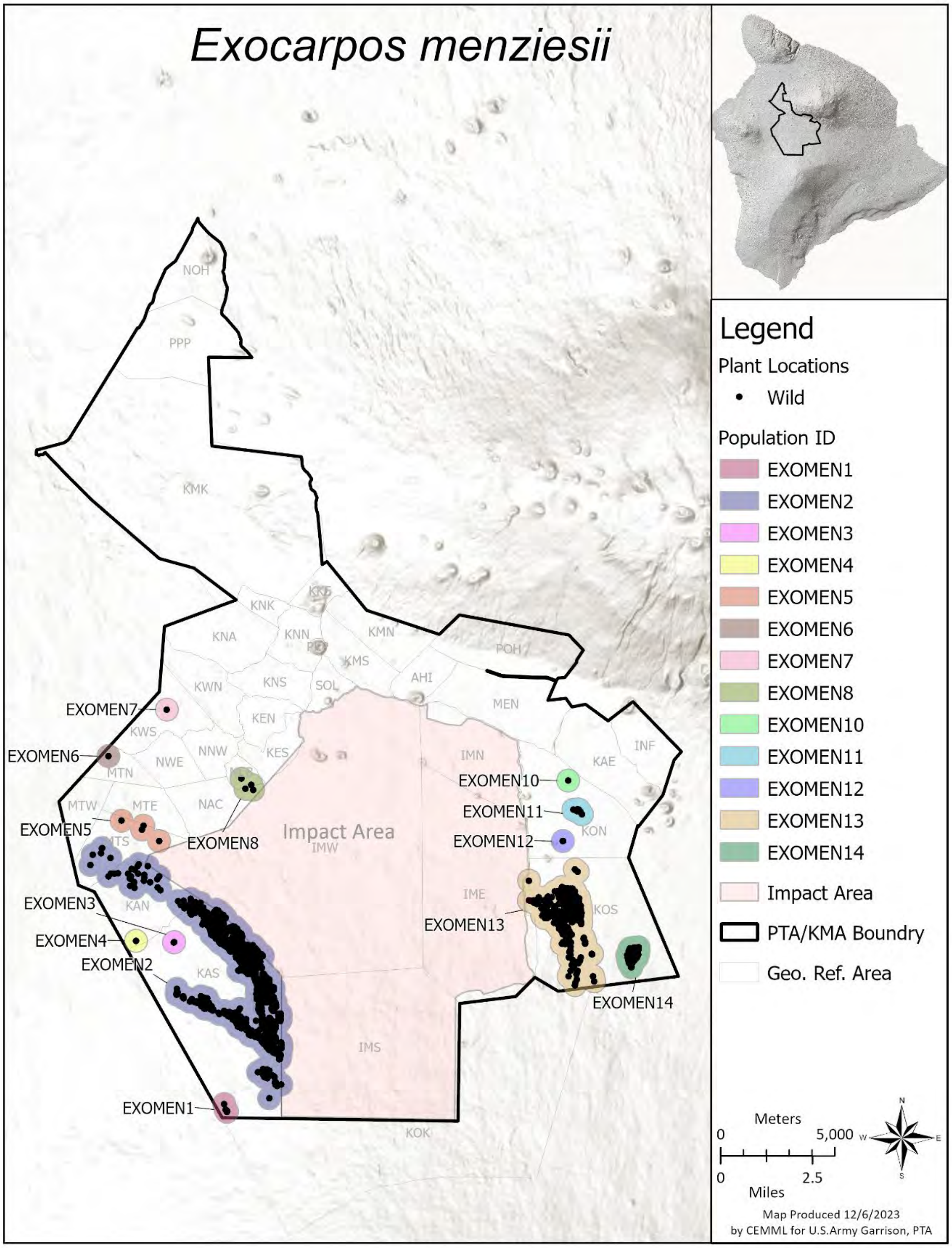


Figure 91. Current known distribution of *Exocarpos menziesii*[a]

[a] The distribution is derived from a compilation of plant survey data (2011 to 2021), monitoring data, and incidental rare plant finds.

The 2022 Mauna Loa eruption mostly inundated barren lava flows except for 2 kīpuka that were last surveyed in 2014; at that time there were 257 *E. menziesii* plants in the affected kīpuka (Figure 92). During post-eruption surveys in March 2023, we found 15 *E. menziesii* individuals remaining. We assume the lava flow affected the other 242 individuals. However, due to the 9-year gap since the last survey, the actual number of individuals present immediately preceding the lava inundation is unknown; therefore, an accurate estimate of the number of individuals lost to the lava is not possible. Although the plants in this kīpuka represent only a fraction of the overall plants at PTA, they were relatively isolated from other groups; therefore, collecting propagules from the remaining plants to conserve this genetic resource is recommended.

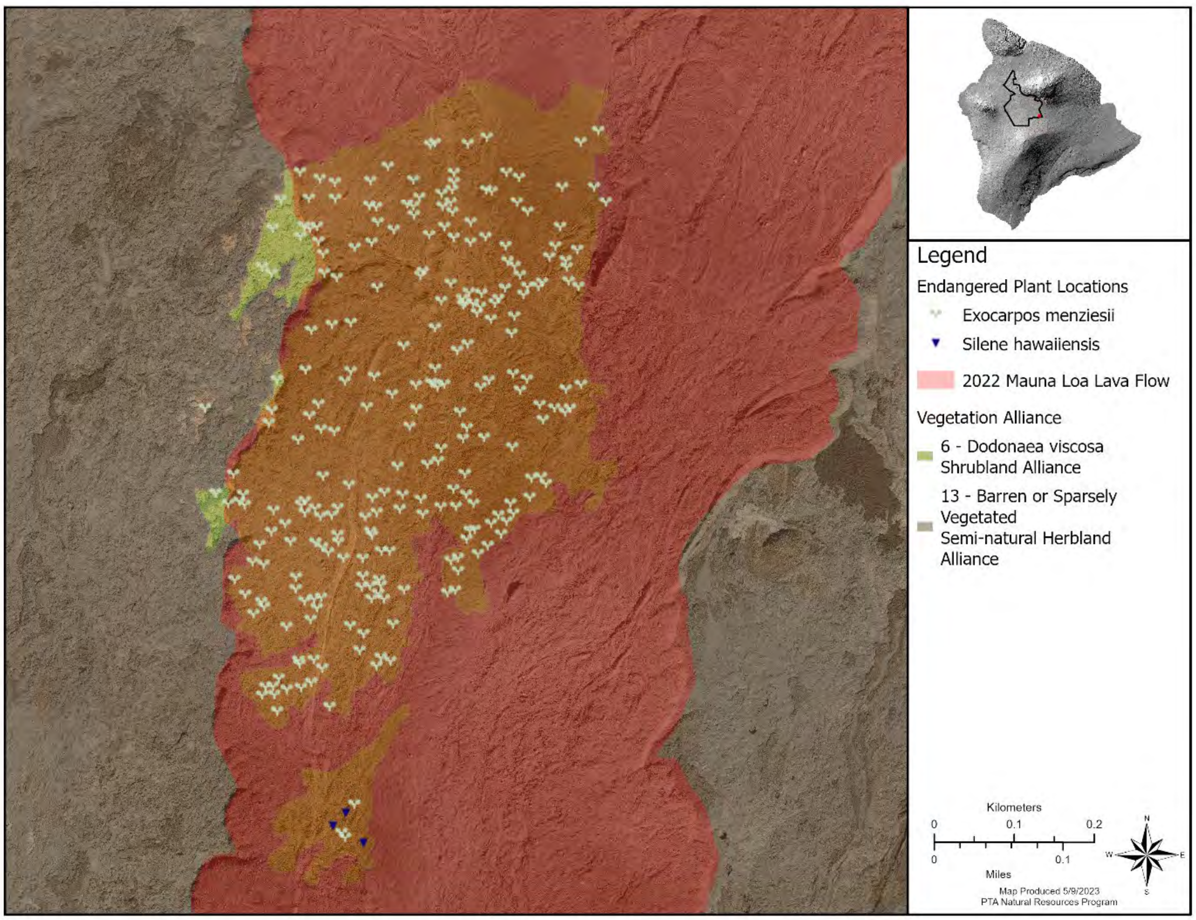


Figure 92. *Exocarpos menziesii* locations covered by the 2022 Mauna Loa lava flow at Pōhakuloa Training Area

Genetic Conservation

Propagule Collection and Propagation

During this reporting period, we collected propagules from 2 *E. menziesii* individuals (Table 84). These 16 seeds were propagated at the OANRP seed lab—no germination has yet been reported. Refer to Table 15 for a complete summary of ex-situ storage status for *E. menziesii.* There are currently 15 accessions representing 4 wild founders in the RPPF (Table 20).

Table 84. Propagule collections for *Exocarpos menziesii* in 2023

Species	Plant ID	Date of Collection	Type of Propagule	Amount Collected	Population	UTM X	UTM Y
Exocarpos menziesii	NA	06 Mar 23	Seed	8	EXOMEN14	237459	2174314
Exocarpos menziesii	NA	06 Mar 23	Seed	8	EXOMEN14	237579	2174526

Outplanting and Monitoring

No outplanting or monitoring of outplants occurred during the reporting period.

Discussion

Our efforts to monitor and conserve genetic resources for *E. menziesii* address SOO tasks 3.2.1.2, 3.2.1.4, and 3.2.1.5, as well as several INRMP objectives.

At PTA, *E. menziesii* naturally occurs primarily in sparse *Metrosideros* treeland and *Dodonaea* shrubland habitat types. 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.*

Since the listing of *E. menziesii* in 2016, we have not investigated additional 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 that many fruits and seeds under the adult shrubs had been eaten, likely by rodents. Rodents have been observed eating fruits of its congener, *E. gaudichaudii* (Figure 18). However, we have observed substantial fruit set over several years, so it is unclear how much rodent predation is affecting natural recruitment.

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, this species is ranked as Tier 2 due to its relatively high numbers. However, now is the time to evaluate threats to the plants and investigate factors affecting recruitment 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. The ex-situ storage contains 497 seeds representing 9 wild founders, and the RPPF currently holds 15 individuals representing 4 wild founders. 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.

Status of Exocarpos menziesii *Populations at PTA per the USFWS Species Recovery Criteria*

In 2022, the USFWS established recovery criteria for *E. menziesii*. Recovery stages include the Preventing Extinction stage, which requires 25 mature individuals in each of 3 populations, with at least 50 individuals (or the total number if less than 50) represented from each wild population in ex-situ storage. We continue to make progress toward recovery criteria and there are 13 populations at PTA (Table 85). During surveys at PTA, the life stage of individuals were not recorded so we currently lack knowledge of the number of mature plants (i.e., adults) present (CEMML 2014, CEMML 2022a). Future monitoring will include counts by life stage and more information about natural recruitment will be available.

Table 85. Progress towards USFWS Preventing Extinction stage of recovery for *Exocarpos menziesii* at PTA

Population	[a]Approximate # Individuals	# Founders Ex-situ Storage	Fenced	Invasive Plant Control	Natural Reproduction	Number Increasing
EXOMEN1	11	0	No	No	ND	ND
EXOMEN2	3657	9	Partial	No	ND	ND
EXOMEN3	2	0	Yes	No	ND	ND
EXOMEN4	1	0	Yes	No	ND	ND
EXOMEN5	4	0	Yes	No	ND	ND
EXOMEN6	1	0	Yes	No	ND	ND
EXOMEN7	1	0	Yes	No	ND	ND
EXOMEN8	4	0	Yes	No	ND	ND
EXOMEN9	1	0	Yes	No	ND	ND
EXOMEN10	12	0	Yes	No	ND	ND
EXOMEN11	1	0	Yes	No	ND	ND
EXOMEN12	542	0	Yes	No	ND	ND
EXOMEN13	15	0	No	No	ND	ND

ND, No Data

[a]Count classes were used to estimate the number of plants at each 5.6 m radius location where more than 10 plants were observed. This is a sum of minimum counts, representing the lowest count value for the count class (11–50, 51–100, >100) recorded for each location where plants were observed.

Progress toward INRMP Objectives

We are preparing to initiate a formal consultation with the USFWS under the ESA to analyze the potential effects of military activities on *E. menziesii*[14]. 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 genetic resources 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 (Sections 3.4 and 4.3). We actively conserve *E. menziesii* genetic resources; the ex-situ collection contains 497 seeds from a single wild population, representing 9 wild founders. We have not implemented weed control for this species. Although we monitor a portion of the distribution of *E. menziesii* annually to estimate abundance, we are unable to attribute changes in numbers to effects of 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 2.7).

2.6.3 *Festuca hawaiiensis* (Endangered)

We survey and monitor a portion of the known *F. hawaiiensis* population, a Tier 2 species, at PTA each year to refresh the distribution and abundance estimates. The aim is to survey the entire population at PTA over a 3-year period. For genetic conservation, *F. hawaiiensis* is an implementation priority 5 (low; Table 13). We plan to collect propagules for storage with little to no outplanting.

<u>Plant Surveys and Monitoring</u>

Based on previous survey work from 2019 to 2020, we estimate 11,699 (90% CI: 8,365–15,033) wild juvenile and adult individuals of *F. hawaiiensis* within fence units (Table 8), while 8 wild individuals (7 adults and 1 juvenile) were documented outside the fences (Table 3). Using data collected during the reporting period, we estimate there are currently 159 wild *F. hawaiiensis* (90% CI: 39–279) within Region 3 (Table 6). The distribution for *F. hawaiiensis*, including outplanting sites, is shown in Figure 93.

[14] The text reflects the status of the PBA during the report period (01 October 2021 through 30 September 2023). Since, the Army has worked to develop additional wildland fire planning and preparedness documents to support the PBA preparation process and the fire model used for the effects analysis was updated with data from wildland fires that occurred in 2021 and 2022.

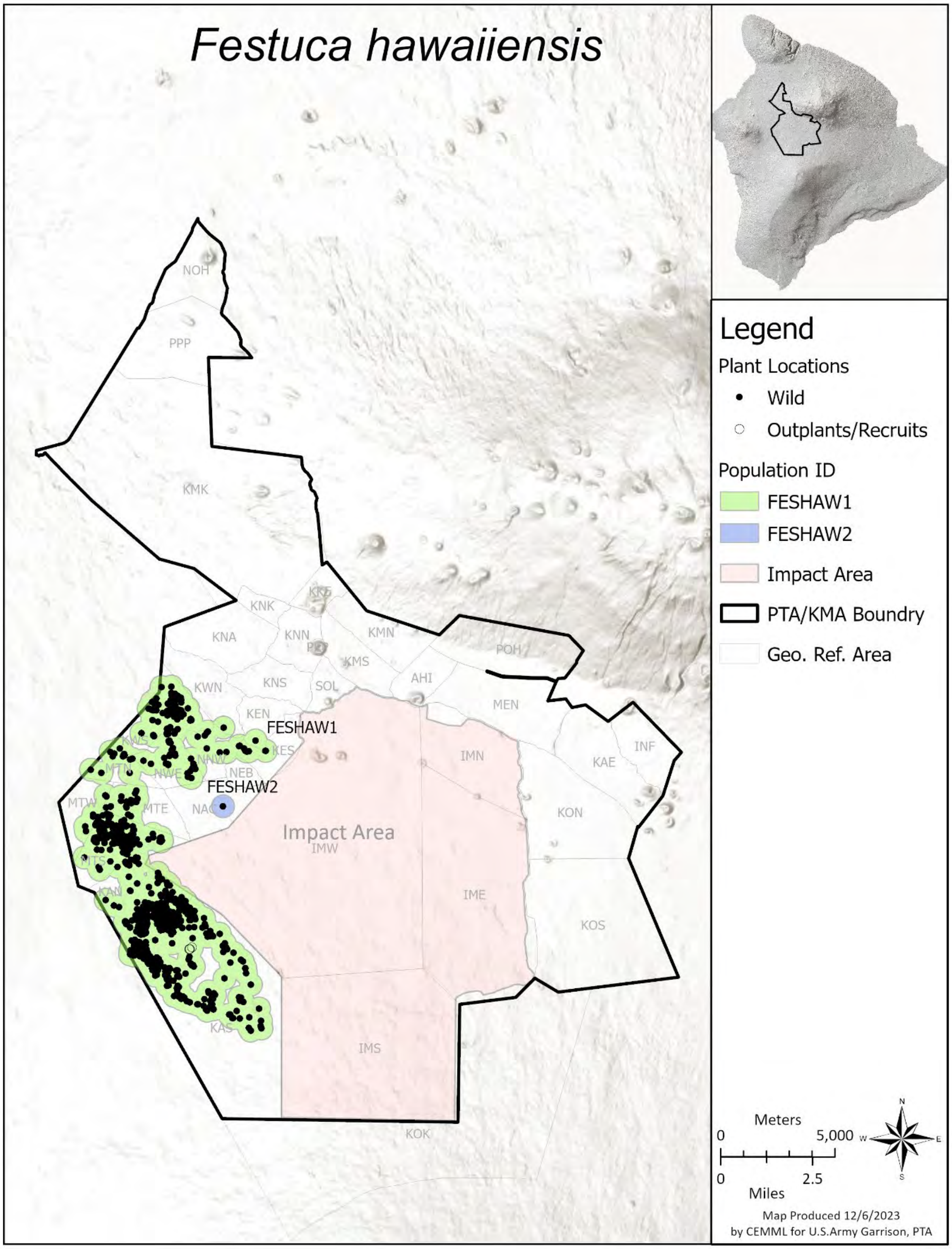


Figure 93. Current known distribution of Festuca hawaiiensis[a]

[a] The distribution is derived from a compilation of plant survey data (2011 to 2021), monitoring data, and incidental rare plant finds.

Genetic Conservation

Propagule Collection and Propagation

During this reporting period, we did not collect propagules or propagate *F. hawaiiensis.* Refer to Table 15 for a complete summary of ex-situ storage status for *F. hawaiiensis.* There is currently 1 accession of *F. hawaiiensis* in the RPPF (Table 20).

Outplanting and Monitoring

During the reporting period, we did not outplant *F. hawaiiensis.* In previous years, we planted a total of 11 *F. hawaiiensis* individuals at 2 sites (Table 86). *F. hawaiiensis* did not establish at ASR 201. In 2016 at ASR 214, we did not find *F. hawaiiensis*, but 36 adults and 6 juveniles were reported in 2020 and 3 adults were reported in December 2022. We assume the plants found at the site in 2020 and 2022 were offspring of the plants planted between 2004 and 2014. Although the number of plants present from 2014 to 2022 has decreased by 95%, we are encouraged by the persistence of *F. hawaiiensis* at this site. Because *F. hawaiiensis* is relatively abundant at PTA, and numbers appear to be increasing following the removal of feral ungulates from the fences, additional outplanting is not a priority for this species.

Table 86. Monitoring results from December 2022 for *Festuca hawaiiensis* outplanted 2004–2014

Location	Site	Total Outplanted 2004–2014	Total Present 2014 Adult	Total Present 2014 Juvenile	Total Present 2022 Adult	Total Present 2022 Juvenile	% Change 2014–022
Off PTA	201	4	63	0	0	0	0%
On PTA	<u>214</u>	7	15	40	3	0	-95%

Note: The data source for planting activity between 2004 to 2014 and 2014 monitoring data is CEMML 2015. An underlined site number denotes juvenile/adult recruits were present in 2014.

Discussion

Our efforts to monitor and conserve genetic resources for *F. hawaiiensis* address SOO tasks 3.2.1.2, 3.2.1.4, and 3.2.1.5, 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. There are also 8 individuals outside the fence units in TA 23.

F. hawaiiensis is one of several federally listed species affected by the 2022 Leilani fire. The estimated post-fire abundance of *F. hawaiiensis* in the burn area is 76 (90% CI: 0–172) wild individuals (CEMML 2023f). Data analysis indicates that the difference in pre- and post-fire abundance of *F. hawaiiensis* in the plots sampled was not statistically significant (Table 11). How fire affects *F. hawaiiensis* is not well known. Shaw (1995) lists *F. hawaiiensis* as a species affected by the 1994 Kīpuka Kālawamauna fire but does not assess fire-related impacts on the species or recovery. Although we know little about species-specific sensitivities to fire, repeated fires degrade habitat by increasing competition from invasive grasses like *C. setaceus.*

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 RPPF.

Previous outplanting efforts for *F. hawaiiensis* were minimal. At ASR 201, a lower elevation site, *F. hawaiiensis* failed to persist from 2014 to 2020. The initial outplants performed well and increased to 64 plants at ASR 201 by 2014. By 2016, there were no *F. hawaiiensis* remaining at ASR 201. We do not know the natural lifespan of *F. hawaiiensis* but apparently the level of recruitment was insufficient to offset losses of individuals at this site. In contrast, *F. hawaiiensis* has persisted at ASR 214. We continue to learn more about the life history of *F. hawaiiensis* and plan to use this information to improve management and outplanting plans.

Currently *F. hawaiiensis* is a low priority for outplanting due to its relatively high abundance and wide distribution. However, we know relatively little about the ecology of *F. hawaiiensis.* The genus *Festuca* uses a photosynthetic pathway way called C3. Grass species that use C3 photosynthesis typically grow better in cooler climates and require more precipitation than grasses that use a different photosynthesis pathway called C4 (Edwards and Still 2008). We recommend evaluating the projected habitat climate envelopes projected at PTA for *F. hawaiiensis* to evaluate how habitats for *F. hawaiiensis* are expected to shift at PTA and in the region. We recommend incorporating previous work regarding distribution of C3 vs. C4 grasses in Hawaiʻi into management planning (Rundel 1980).

Status of Festuca hawaiiensis *Populations at PTA per the USFWS Species Recovery Criteria*

In 2022, the USFWS established recovery criteria for *F. hawaiiensis*. Recovery stages include the Preventing Extinction stage, which requires 100 mature individuals in each of 3 populations, with at least 50 individuals (or the total number if less than 50) represented from each wild population in ex-situ storage. We continue to progress toward recovery criteria for the 2 populations at PTA (Table 87). Advancing to the next stage of recovery, Interim Stabilization, depends on maintaining a population on Maui to meet recovery criteria. During surveys at PTA, we did not record the life stage of individuals, so we currently lack the number of mature plants (i.e., adults) present (CEMML 2014, CEMML 2022a). Future monitoring will include counting individuals by life stages to calculate future population trends.

Table 87. Progress towards USFWS Preventing Extinction stage of recovery for *Festuca hawaiiensis* at PTA

Population	[a]Approximate # Individuals	# Founders Ex-situ Storage	Fenced	Invasive Plant Control	Natural Reproduction	Number Increasing
FESHAW1	5,640	10	Yes	No	ND	ND
FESHAW2	1	0	Yes	No	ND	ND

ND, No Data

[a]Count classes were used to estimate the number of plants at each 5.6 m radius location where more than 10 plants were observed. This is a sum of minimum counts, representing the lowest count value for the count class (11–50, 51–100, >100) recorded for each location where plants were observed.

Progress toward INRMP Objectives

We are preparing to initiate a formal consultation with the USFWS under the ESA to analyze the potential effects of military activities on *F. hawaiiensis*[15]. 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 genetic resources of *F. hawaiiensis*.

To manage threats proactively for *F. hawaiiensis*, we implement landscape-level projects to reduce fire risk and ungulate browsing for all known individuals at PTA (Sections 3.4 and 4.3). We actively conserve *F. hawaiiensis* genetic resources; the ex-situ collection contains 184 seeds from the wild population and 245 seeds from individuals grown in the RPPF or from individuals outplanted, representing 10 wild individuals total. We have not implemented weed control for this species. Although we monitor a portion of the distribution of *F. hawaiiensis* annually to estimate abundance, we are unable to attribute changes in numbers to effects of 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 2.7).

[15] The text reflects the status of the PBA during the report period (01 October 2021 through 30 September 2023). Since, the Army has worked to develop additional wildland fire planning and preparedness documents to support the PBA preparation process and the fire model used for the effects analysis was updated with data from wildland fires that occurred in 2021 and 2022.

2.6.4 *Haplostachys haplostachya* (Endangered)

As a Tier 2 species, we survey and monitor a portion of the known *H. haplostachya* population at PTA each year to refresh the distribution and abundance estimates. We aim to survey the entire population at PTA every 3 years. For genetic conservation, *H. haplostachya* is an implementation priority 5 (low; Table 13). We plan to collect propagules for storage with little to no outplanting.

<u>Plant Surveys and Monitoring</u>

Based on surveys conducted from 2022 to 2023, we estimate there are approximately 19,132 (90% CI: 4,518–13,746) adult and juvenile plants at PTA. Using different monitoring methods, we estimate there are an additional 4,954 (90% CI: 3,943–5,965) adult and juvenile plants on Puʻu Kapele (Table 6). The sum of the 2 abundance estimates is 14,086 (90% CI: 8,461–13,746) plants. The distribution for *H. haplostachya*, including the outplanting sites at PTA where this species currently persists, is shown in Figure 94.

Abundance Estimate Comparisons

We attempted to compare abundance estimates for *H. haplostachya* with data derived from 3 monitoring efforts—Installation Wide Survey 1 and 2 methods and location-based monitoring method for Tier 2 species. For IWS 1 (2011 to 2015), count classes were used to estimate the number of plants at each 5.6 m radius location and all individuals present, including seedlings, were combined into the final count number for each location (CEMML 2014). For IWS 2 (2017 to 2020), individuals were counted up to 10 plants for each location (5.6 m radius circle) and, if more than 10 plants were present, count classes were used to estimate the number for all life stages combined (including seedlings, CEMML 2022a). See Section 2.2.3 for the location-based monitoring methods for Tier 2 species.

To compare previous population estimates for *H. haplostachya* occurring both on and off Puʻu Kapele we added seedling counts to our most recent abundance estimates (based on the location-based monitoring protocol), to be consistent with how these estimates were produced in the past. The abundance estimates for *H. haplostachya* at PTA (excluding Puʻu Kapele) are similar for the 2 most recent monitoring periods, which are both well above the 2012 estimate, whereas the abundance estimate on Puʻu Kapele has dropped substantially since the previous survey was conducted (Table 88).

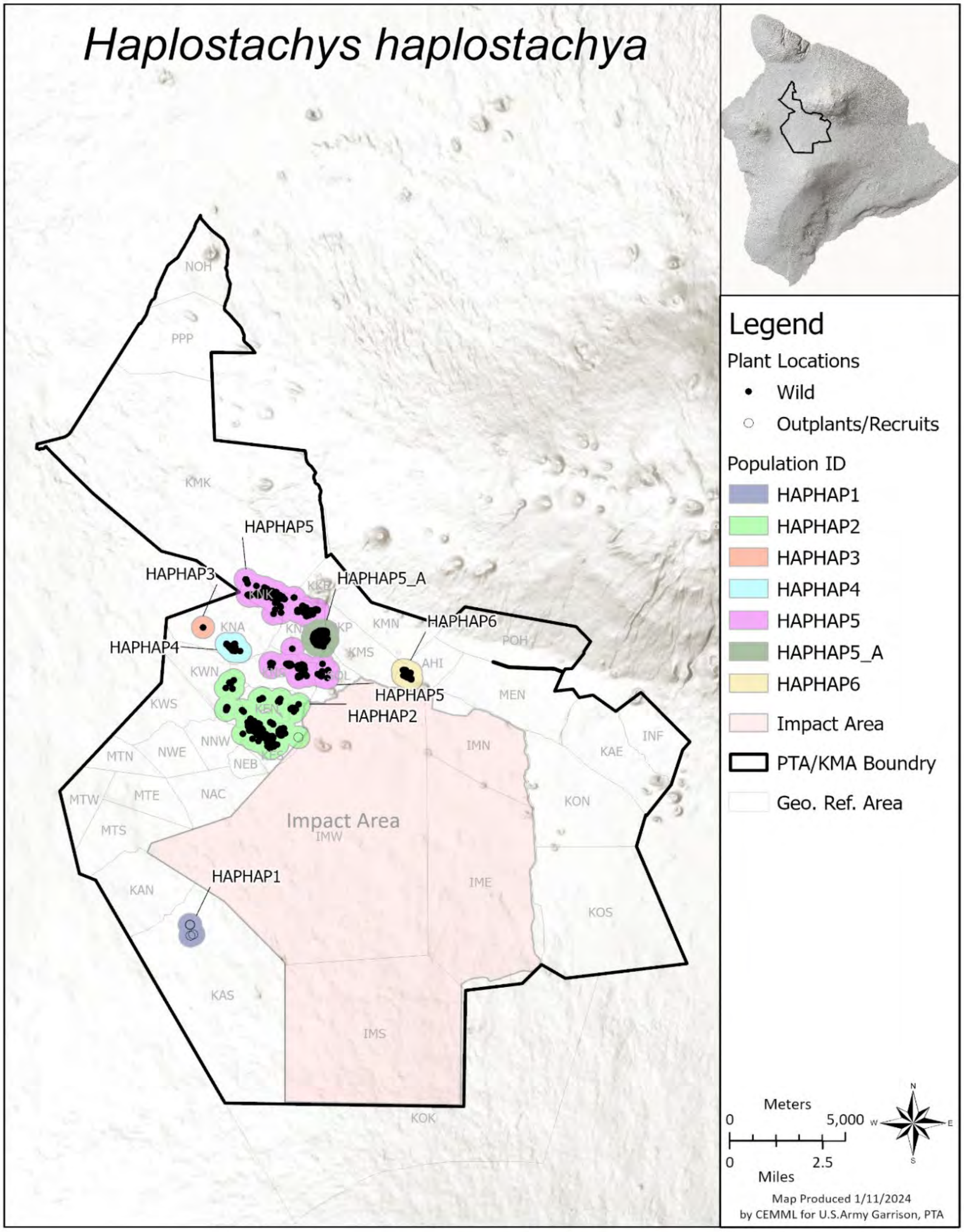


Figure 94. Current known distribution of *Haplostachys haplostachya*[a]

[a] The distribution is derived from a compilation of plant survey data (2011 to 2021), monitoring data, and incidental rare plant finds.

Table 88. Estimated abundance of adult, juvenile, and seedlings (combined) for *Haplostachys haplostachya* compared between regions and monitoring periods

Region	Monitoring Protocol	Monitoring Period	Number of Plots Sampled[a]	Estimated Abundance	Lower Limit 90% CI	Upper Limit 90% CI
3–4	Location-based	2022–2023	54	19,252	6,884	31,619
3–4	IWS2	2019–2020	52	17,215	9,223	25,206
3–4	IWS1	2012	NA[b]	12,609[c]	—	—
Puʻu Kapele	Location-based	2022–2023	54[d]	5,002	3,984	6,020
Puʻu Kapele	IWS1	2012	NA	11,661	—	—

CI, Confidence Interval; IWS, Installation Wide Survey. Refer to CEMML 2014 and CEMML 2022a for IWS survey methods and Section 2.2.3 for location-based monitoring method for Tier 2 species.

[a]The number of plots refers to the number of 100 m x 250 m macroplots sampled, each consisting of ten 10 m transects.

[b]The 2012 Survey was a census count of the population (not an estimate/sample of plots requiring confidence intervals).

[c] This is a sum of minimum counts, representing the lowest count value for the count class (11–50, 51–100, >100) recorded for each location (5.6 m radius) where plants were observed.

[d]The number of plots on Puʻu Kapele refers to the number of 4 m x 250 m belt transects sampled.

Genetic Conservation

Propagule Collection and Propagation

During this reporting period, we did not collect propagules or propagate *H. haplostachya.* Refer to Table 15 for a complete summary of ex-situ storage status for *H. haplostachya.* There is currently 1 accession of *H. haplostachya* in the RPPF (Table 20).

Outplanting and Monitoring

During the reporting period we did not outplant *H. haplostachya.* In previous years, we planted a total of 531 *H. haplostachya* individuals at 8 sites (Table 89). During monitoring in December 2022, *H. haplostachya* outplants persisted at only 2 sites.

Table 89. Monitoring results from December 2022 for *Haplostachys haplostachya* outplanted 2004–2014

Location	ASR	Total Outplanted 2004–2014	Total Present 2014		Total Present 2022		% Change 2014–2022
			Adult	Juvenile	Adult	Juvenile	
Off PTA	201	51	7	0	0	0	-100%
	203	69	0	0	0	0	0%
	<u>204</u>	8	0	1	0	0	-100%
	<u>205</u>	251	57	1	0	0	-100%
On PTA	**<u>210</u>**	10	0	9	0	0	-100%
	211	32	1	0	1	0	0%
	<u>214</u>	95	68	1	0	0	-100%
	219	18	16	0	6	0	-62%

Note: The data source for planting activity between 2004 to 2014 and 2014 monitoring data is CEMML 2015. Sites listed in bold denotes seedlings and underline denotes juvenile/adult recruits were present in 2014.

<u>Discussion</u>

Our efforts to monitor and conserve genetic resources for *H. haplostachya* address 3.2.1.2, 3.2.1.4, and 3.2.1.5, 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.

Although *H. haplostachya* was one of the first endangered plants documented at PTA in the late 1970s, 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). However, Aslan et al. (2019) found that no native insects visited *H. haplostachya* and the most frequent visitor to *H. haplostachya* flowers was a keyhole wasp (*Pachodynerus nasidens*). 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 observe seedlings in the natural populations, sometimes in very high numbers. Genetic variation among individuals was shown to be higher in larger groups of plants (Morden and Loeffler 1999). It's possible that smaller groups, with less genetic variation, are more vulnerable to changes in environmental conditions. We plan to incorporate this information into plans for germplasm collections and potential augmentation of small natural populations. We recommend basic research into life history characteristics to support science-based management of this species. Understanding 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.

When Puʻu Kapele is excluded, the total number of adults, juveniles, and seedlings of *H. haplostachya* increased by 34% over the last 10 years (Table 88). Seedlings comprised 52% of the total number of plants (outside of Kapele) in 2022 to 2023, a presumed flush in response to the 2022 Leilani fire. Another large fire occurred in the same area before monitoring took place in 2019, whereas the 2012 data was not collected in the immediate aftermath of a fire. We didn't distinguish life stages in 2019 to 2020 or 2012 so we don't know the relative proportion of seedlings in the abundance estimates from those earlier periods. The flush of seedlings that occurs after a fire potentially explains why the estimate for 2019 to 2020 is almost as high as the estimate from 2022 to 2023, while the number from 2012 was 34% less.

On the other hand, the total number of adults, juveniles, and seedlings of *H. haplostachya* decreased by 57% over the last 10 years on Puʻu Kapele. There has not been a recent fire on this Puʻu, which might be why seedling numbers comprised less than 1% of the data collected between 2022 and 2023. The apparent reduction of this species on Puʻu Kapele (as opposed to the rest of PTA) is concerning. *Cenchrus setaceus* has encroached on the Puʻu over the past 10 years and weed control is challenging due to the threat of erosion on the steep slopes. Invasive grasses are deleterious to seedling regeneration and make finding them much more difficult. Immediately after a fire, seedlings have an open habitat to take advantage of, and are easily observed and counted during monitoring.

We should also consider the full extent of the 90% confidence interval when comparing actual counts and estimates from a sample, as the confidence intervals for the sampling estimates outside of Puʻu Kapele from 2019 to 2020 and 2022 to 2023 encompass the census number from 2012. The wide confidence intervals for the 2019 to 2020 and 2022 to 2023 abundance estimates, are likely due to the high level of variance driven in part by sporadically distributed large clusters of seedlings. Clustering of plants drives large between-plot variance and increases the confidence interval surrounding the overall estimate.

H. haplostachya is one of several federally listed species affected by the 2022 Leilani fire. The estimated post-fire abundance of *H. haplostachya* in the burn area is 6,028 (90% CI: 1337–10,718) wild individuals (CEMML 2023f). We also recorded a minimum count of 3,241 wild seedlings proximate to wild plants. The result of the paired t-test ($\alpha \geq 0.1$, $p = 0.11$) suggest the decline in post-fire abundance in the plots sampled is approaching significance (Table 11).

Haplostachys haplostachya can resprout or recruit from the seedbank in areas where the fire intensity was low. For example, Shaw (1995) found that following the 1994 Kīpuka Kālawamauna fire:

> In lightly burned areas or when the plants were only scorched by the heat, individuals resprouted from the root crown as soon as sufficient precipitation occurred. *Haplostachys* individuals were killed in slightly or moderately burned areas. Seedlings, however, were observed in the vicinity of known populations several months after the fire. The substantial precipitation that occurred 2 months following the fire seemed to enhance resprouting as well as seed germination.

A post-fire assessment completed in August 2018 found varying degrees of fire-related impacts to *H. haplostachya* and also recorded post-fire recovery, including germination of plants from the seedbank. About 1 year after the 2018 fire, *H. haplostachya* abundance had increased by a factor of 8 over pre-fire abundance (CEMML 2020a). Substantial precipitation fell in the burn area between October and December 2022, and large numbers of seedlings (3,241) were observed between December 2022 and January 2023, mostly in areas of No/Low to Moderate burn severity.

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 genetic resources. We have partnered with OANRP to leverage their expertise to establish reliable germination procedures. Per their recommendations, we plan to use cold stratification in our germination chamber. We have had minimal success in outplanting *H. haplostachya* and 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.

We continue to monitor outplantings conducted between 2004 and 2014 (Table 89). Overall, sites have sharply decreased in the number of adults and juveniles present since the last planting in 2014. Because we know little about the average life span of *H. Haplostachya,* it is difficult to know if the observed declines are due to site conditions or natural attrition due to age. Survivorship for the first 3 years following planting was high with a sharp decline in numbers in subsequent years (CEMML 2016), suggesting that the natural life cycle may be driving declines after the third year. However, recruitment of new individuals has not been adequate to replace lost individuals. Again, it is difficult to know if site conditions or factors influencing seed set and germination (or interactions between these and other unknown factors) are limiting recruitment at the sites.

Although outplanting is not a high priority for this relatively abundant species, we committed per the 2003 BO to conserve and outplant the genetic material collected from a population of *H. haplostachya* population that was affected by construction of the Battle Area Complex (BAX) in TA 7 (see CEMML 2016 for history about the *H. haplostachya* population at the BAX). Per the 2003 BO, we are working toward replacing the number of individuals affected by the construction. Although the location of the *H. haplostachya* within the BAX was not directly affected by construction, the plants are located within the range footprint and within 120 m of a range road. The location is unfenced and exposed to feral ungulates and was last monitored in 2013.

Currently, there are 13,577 seeds from the BAX population in storage; however, we have limited success in germinating *H. haplostachya* seeds, and the viability of this collection is likely decreasing with time. From 2006 to 2013, seedlings were collected from the BAX population and transplanted to outplanting sites, primarily ASRs 213 and 214. Similar to other outplanting sites, the *H. haplostachya* individuals have declined since 2014 and recruitment has been observed only at ASR 214.

To continue to work toward the 2003 BO conservation measures, we need to improve our ability to germinate *H. haplostachya* seeds. Further, we need to have a better understanding of some of the factors that are influencing persistence and establishment of recruits from seed at outplanting sites . We recommend, where possible, collaborating with other scientists, researchers, and students to address some of these research needs. We recommend continuing with small-scale outplantings of this species and to document, via good monitoring designs, outplant performance to develop procedures aimed at improving establishment of self-sustaining populations.

Status of Haplostachys haplostachya *Populations at PTA per the USFWS Species Recovery Criteria*

In 2022, the USFWS established recovery criteria for *H. haplostachya*. Recovery stages include the Preventing Extinction stage, which requires 50 mature individuals in each of 6 populations, with at least 50 individuals (or the total number if less than 50) represented from each wild population in ex-situ storage. We continue to manage the 6 *H. haplostachya* populations at PTA and progress toward recovery criteria (Table 90). Advancing to the next stage of recovery, Interim Stabilization, depends upon maintaining a population on Kauaʻi or Maui that meet recovery criteria. At PTA, we did not record the life stage of individuals during surveys, so we currently lack the number of mature plants (i.e., adults) present (CEMML 2014 and CEMML 2022a). Future monitoring will include counts of individuals by life stage. In the future we will be able to update this table with counts for the various life stages and document natural reproduction. Future data will be used to calculate population trends.

Table 90. Progress towards USFWS Preventing Extinction stage of recovery for *Haplostachys. haplostachya* at PTA; population census data collected in 2012

Population	[a]Approximate # Individuals Wild (OP)	# Founders Ex-situ Storage	Fenced	Invasive Plant Control	Natural Reproduction	Number Increasing
HAPHAP1	0 (6)	NA	Yes	Yes	ND	ND
HAPHAP2	7,903	349	Yes	Partial	ND	ND
HAPHAP3	1	0	Yes	No	ND	ND
HAPHAP4	72	0	Yes	No	ND	ND
HAPHAP5	5,869	208	Yes	No	ND	ND
HAPHAP5A	11,661	164	Yes	No	ND	ND
HAPHAP6	1,65	139	Yes	Partial	ND	ND

NA, Not applicable; ND, No Data

[a]Count classes were used to estimate the number of plants at each 5.6 m radius location where more than 10 plants were observed. This is a sum of minimum counts, representing the lowest count value for the count class (11–50, 51–100, >100) recorded for each location where plants were observed.

Progress toward Compliance with Endangered Species Act Biological Opinion Conservation Measures

To offset effects of military activities on *H. haplostachya,* the 2003 BO conservation measures include fuels management to reduce fire risk, fencing and ungulate control to reduce browsing 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 browsing for all known individuals at PTA (Sections 3.4 and 4.3). In addition, we actively conserve *H. haplostachya* genetic resources; the ex-situ collection contains 41,684 seeds and 12,032 fruits from the wild population and 11,768 seeds and 30,354 fruits from individuals grown in the RPPF or individuals outplanted, representing 860 wild founders total. To date, we have outplanted 534 individuals at 8 sites and outplants have shown low success. We managed invasive plants across about 1.6 ha specifically for wild *H. haplostachya* in ASR 4 (Section 3.2, Table 101). This species also co-occurs in several other ASR (e.g., ASRs 18, 16, 44) and likely receives some benefit from weed management in these areas. In 2022 monitoring, we recorded a minimum count of 3,354 seedlings of *H. haplostachya*. Although we monitor a portion of the distribution of *H. haplostachya* annually to estimate abundance, we are unable to attribute changes in numbers to effects of 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 2.7).

2.6.5 *Silene hawaiiensis* (Threatened)

As a Tier 2 species, we survey and monitor a portion of the known *Silene hawaiiensis* population at PTA each year to refresh the distribution and abundance estimates. The aim is to survey the entire population at PTA over a 3-year period. For genetic conservation, *Silene hawaiiensis* is an implementation priority 5 (low; Table 13). We plan to collect propagules for storage with little to no outplanting.

Plant Surveys and Monitoring

Based on previous survey work from 2019 to 2020, we estimate 7,479 (90% CI: 5,552–9,406) wild juvenile and adult *Silene hawaiiensis* within fence units (Table 8). We also counted 78 wild adults and 9 wild juveniles outside the fence units (Table 3). The distribution for *Silene hawaiiensis*, including the outplanting site at PTA where this species currently persists, is shown in Figure 95.

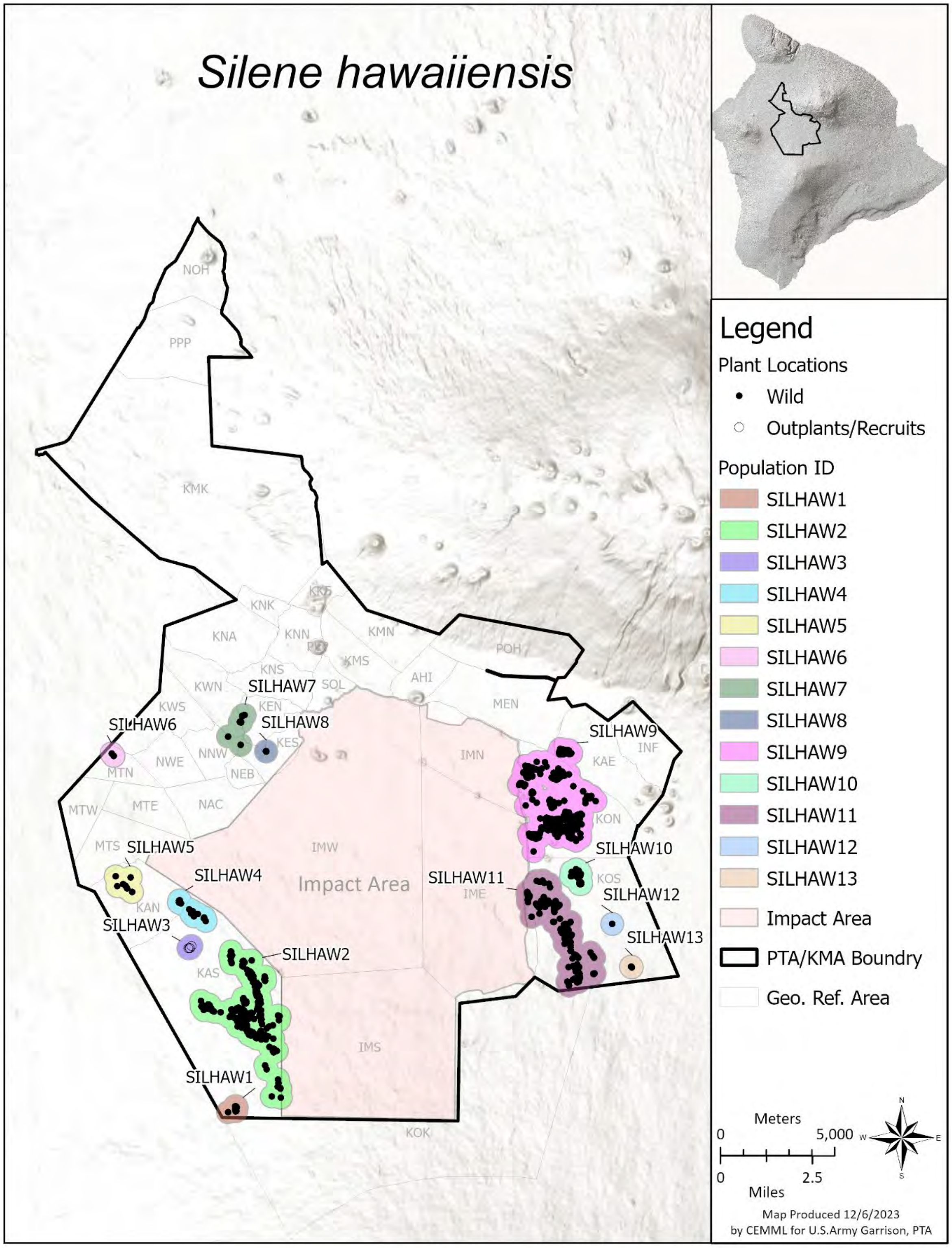


Figure 95. Current known distribution of *Silene hawaiiensis*[a]

[a] The distribution is derived from a compilation of plant survey data (2011 to 2021), monitoring data, and incidental rare plant finds.

Genetic Conservation

Propagule Collection and Propagation

During this reporting period, we did not collect propagules or propagate *Silene hawaiiensis.* Refer to Table 15 for a complete summary of ex-situ storage status for *Silene hawaiiensis.* There are currently 11 individuals, representing 1 founder, in the RPPF (Table 20).

Outplanting and Monitoring

During the reporting period, we did not outplant *Silene hawaiiensis.* In previous years, we planted a total of 83 *Silene hawaiiensis* individuals at 5 sites (Table 91). As of December 2022, outplants persist only at ASR 214.

Table 91. Monitoring results from December 2022 for *Silene hawaiiensis* outplanted 2004–2014

			Total Present 2014		Total Present 2022		
Location	ASR	Total Outplanted 2004–2014	Adult	Juvenile	Adult	Juvenile	% Change 2014–2022
Off PTA	**201**	31	14	3	0	0	-100%
	203	18	0	0	0	0	-100%
	205	22	8	1	0	0	-100%
On PTA	**214**	10	6	3	0	4	-33%
	219	2	1	1	0	0	-100%

Note: The data source for planting activity between 2004 to 2014 and 2014 monitoring data is CEMML 2015. Sites listed in bold denotes seedlings and underline denotes juvenile/adult recruits were present in 2014.

Discussion

Our efforts to monitor and conserve genetic resources for *Silene hawaiiensis* address SOO tasks 3.2.1.2, 3.2.1.4, and 3.2.1.5, 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 Puʻu Koli Fence Units. 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 the Impact Area. From 2021 to 2022, we documented 87 wild individuals in TA 23 outside the fence unit.

Pratt et al. (2012) studied *Silene hawaiiensis* within Hawaiʻi Volcanoes National Park and found flowers present year-round with a peak 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 been.

We assume that many of *Silene hawaiiensis'* traits documented at Hawaiʻi Volcanoes National Park will be similar to plants at PTA, but the information from the park should be used to guide local investigations as there may be seasonal shifts in phenology due climate and environmental differences.

Between 2007 and 2010, we monitored *Silene hawaiiensis* outplants at 5 sites and collected demographic information (CEMML 2010). Although we did not observe seedlings at any of the sites, 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.

Silene hawaiiensis is one of several federally listed species affected by the 2022 Leilani fire. The estimated post-fire abundance for *Silene hawaiiensis* in the burn area is 48 (90% CI: 0–126) wild individuals (CEMML 2023f). We also recorded 3 seedlings proximate to wild plants. All occurrences were in areas of No/Low burn severity. Because *Silene hawaiiensis* was present in only 1 macroplot surveyed before and after the fire, we could not use t-tests to evaluate differences in pre- and post-fire abundance. This species can regenerate from a large fleshy taproot (Shaw 1997) and therefore, could be resilient to a low-intensity fire.

We continue to make progress with genetic conservation of *Silene hawaiiensis.* We successfully germinated seed greater than 20 years old. However, at most outplanting sites, *Silene hawaiiensis* has not persisted to 2022, except for ASR 214 where *Silene hawaiiensis* persisted in moderate numbers. Even at this location, though, recruitment is not sufficient to offset individual losses. We are unsure why plants are not persisting at most planting sites or why recruitment is too low to sustain the numbers at ASR 214. 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 23 *Silene hawaiiensis* accessioned to the RPPF.

Status of Silene hawaiiensis *Populations at PTA per the USFWS Species Recovery Criteria*

In the 5-Year Review for *Silene hawaiiensis* published in 2020, the USFWS established a new stage of recovery—Preventing Extinction—with criteria. The Preventing Extinction stage of recovery for *Silene hawaiiensis* require 50 mature individuals in each of 3 populations, with at least 50 individuals (or the total number if less than 50) represented from each wild population in ex-situ storage. We continue to manage the 13 populations of *Silene hawaiiensis* at PTA and are progressing toward recovery criteria (Table 92). To better understand needs to advance to the next recovery stage—Interim Stabilization—we need to know the number of mature plants at PTA. During earlier surveys, we did not record the life stage of individuals, so we currently lack the number of mature plants (i.e., adults) present at PTA (CEMML 2014, CEMML 2022a). Future monitoring will include individual counts by life stage and this data will be used to evaluate natural reproduction and to calculate population trends.

Table 92. Progress towards USFWS Preventing Extinction stage of recovery for *Silene hawaiiensis* at PTA; population census data collected 2011–2015

Population	[a]Approximate # Individuals Wild (OP)	# Founders Ex-situ Storage	Fenced	Invasive Plant Control	Natural Reproduction	Number Increasing
SILHAW1	16	0	No	No	ND	ND
SILHAW2	1877	77	Yes	No	ND	ND
SILHAW3	(4)	NA	Yes	Yes	ND	ND
SILHAW4	60	0	Yes	No	ND	ND
SILHAW5	14	2	Yes	No	ND	ND
SILHAW6	19	0	Yes	No	ND	ND
SILHAW7	40	16	Yes	Partial	ND	ND
SILHAW8	7	2	Yes	No	ND	ND
SILHAW9	2688	0	Yes	Partial	ND	ND
SILHAW10	125	0	Yes	No	ND	ND
SILHAW11	362	0	Yes	No	ND	ND
SILHAW12	1	0	Yes	No	ND	ND
SILHAW13	3	0	Yes	No	ND	ND

ND, No Data

[a]Count classes were used to estimate the number of plants at each 5.6 m radius location where more than 10 plants were observed. This is a sum of minimum counts, representing the lowest count value for the count class (11–50, 51–100, >100) recorded for each location where plants were observed.

Progress toward Compliance with Endangered Species Act Biological Opinion Conservation Measures

To offset effects of military activities on *Silene hawaiiensis,* the 2003 BO conservation measures include fuels management to reduce fire risk, fencing and ungulate control to reduce browsing 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 browsing for all known individuals at PTA (Sections 3.4 and 4.3). In addition, we actively conserve *Silene hawaiiensis* genetic resources; the ex-situ collection contains 11,425 seeds from the wild population and 28,520 seeds from individuals grown in the RPPF, representing 97 wild founders total. To date, we have outplanted 83 individuals at 5 sites; however, we have not observed enough reproduction to consider *Silene hawaiiensis* self-sustaining at any of the sites. We managed invasive plants for wild *Silene hawaiiensis* in ASR 3 in about 9.6 ha and in ASR 19 in about 1.1 ha (Section 3.2, Table 101). 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 *Silene hawaiiensis* for in-situ reproduction annually, previous monitoring of *Silene hawaiiensis* outplants at 5 sites documented increases in plants (presumably from seedlings that germinated between monitoring periods). Although we monitor a portion of the distribution of *Silene* *hawaiiensis* annually to estimate abundance, we are unable to attribute changes in numbers to effects of 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 2.7).

2.6.6 *Silene lanceolata* (Endangered)

We survey and monitor a portion of the known *S. lanceolata* population, a Tier 2 species, at PTA each year to refresh the distribution and abundance estimates. The aim is to survey the entire population at PTA over a 3-year period. For genetic conservation, *S. lanceolata* is an implementation priority 5 (low; Table 13). We plan to collect propagules for storage with little to no outplanting.

Plant Surveys and Monitoring

Based on survey work from 2019 to 2020, we estimate 10,326 (90% CI: 6,972–13,679) wild juvenile and adult *S. lanceolata* within fence units at PTA (Table 8). The distribution for *S. lanceolata*, including the outplanting sites at PTA where this species currently persists, is shown in Figure 96. Using data collected during the reporting period, we estimate 3,145 wild *S. lanceolata* (90% CI: 1,500–4,790) occur within Regions 3 and 4 (Table 6).

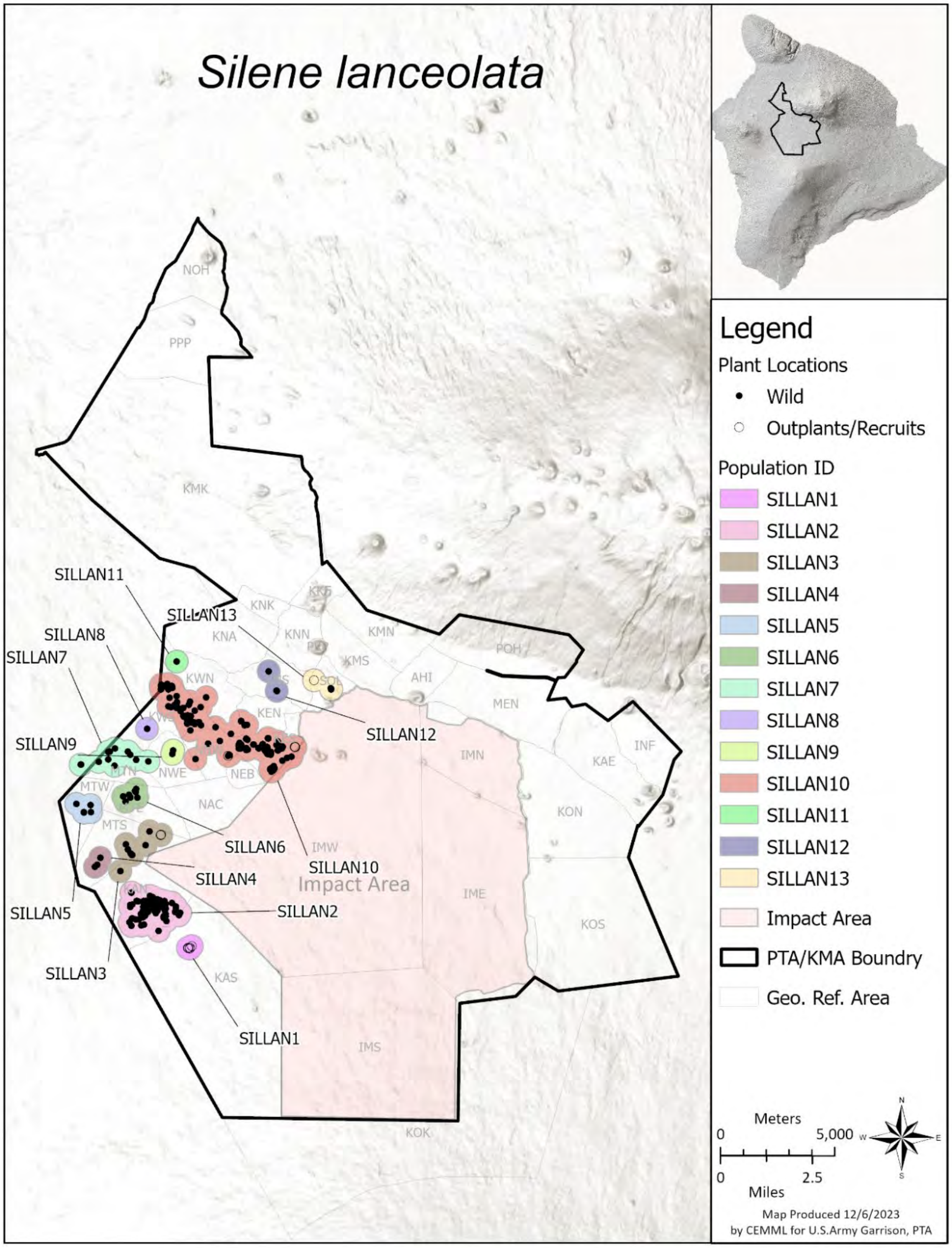


Figure 96. Current known distribution of *Silene lanceolata*[a]

[a] The distribution is derived from a compilation of plant survey data (2011 to 2021), monitoring data, and incidental rare plant finds.

Genetic Conservation

Propagule Collection and Propagation

During this reporting period, we did not collect propagules or propagate *S. lanceolata.* Refer to Table 15 for a complete summary of ex-situ storage status for *S. lanceolata.* There is currently 1 accession in the RPPF (Table 20).

Outplanting and Monitoring

During this reporting period, we did not outplant *S. lanceolata.* In previous years, we planted a total of 917 *S. lanceolata* individuals at 10 sites (Table 93). The number of *S. lanceolata* adults and juveniles present increased at ASRs 211, 213, and 214 between the time of planting and 2022. At all other sites, the number of adults and juveniles present declined between 2014 and 2022.

Table 93. Monitoring results from December 2022 for *Silene lanceolata* outplanted 2004–2014

Location	ASR	Total Outplanted 2004–2014	Total Present 2014		Total Present 2022		% Change 2014–2022	Seedlings 2022
			Adult	Juvenile	Adult	Juvenile		
Off PTA	**201**	51	10	13	2	11	-44%	0
	202	27	0	0	0	0	0%	0
	203	12	0	0	0	0	0%	0
	204	199	10	60	0	0	-100%	0
	205	340	502	600	0	0	-100%	0
On PTA	210	125	8	28	0	0	-100%	0
	211	59	25	86	68	7	-33%	0
	212	26	1	14	0	0	-100%	0
	213	3	3	0	10	0	+333%	0
	214	75	802	1,600	104	131	-90%	7

Note: The data source for planting activity between 2004 to 2014 and 2014 monitoring data is CEMML 2015. Sites listed in bold denotes seedlings and underline denotes juvenile/adult recruits were present in 2014.

Discussion

Our efforts to monitor and conserve genetic resources for *S. lanceolata* address SOO tasks 3.2.1.2, 3.2.1.4, and 3.2.1.5, 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.

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 basic research into life history characteristics to support science-based management of this species. Understanding 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.

S. lanceolata is one of several federally listed species affected by the 2022 Leilani fire. The estimated post-fire abundance of *S. lanceolata* within the burn area is 1,456 (90% CI: 638–2,275) wild individuals (CEMML 2023f). We also recorded a minimum count of 114 seedlings proximate to wild plants. Results from the paired t-test showed significant decline in the plots sampled between pre- and post-fire abundance ($\alpha \geq 0.1$, $p = 0.05$; Table 11).

A considerable proportion of the installation-wide *S. lanceolata* population was located within the burn area prior to the fire. Although we cannot quantify the magnitude of the decline in *S. lanceolata* abundance within the burn area, we assume the decrease was substantial for the installation-wide population and should be considered in future post-fire restoration efforts. Shaw (1995) found that following the 1994 Kīpuka Kālawamauna fire, heat-scorched *S. lanceolata* resprouted, but recruitment from the seedbank following the fire was not detected. We recorded live plants on macroplots in Moderate/High burn severity classes. Although we did not attempt to document the origin of the plants encountered, some plants likely survived the fire while others likely recruited following the fire.

We continue to make progress with genetic conservation of *S. lanceolata*. Many of the accessions in storage are older and we do not know how aging affects the viability of the seed. Typically, we have good success propagating *S. lanceolata*, so it is a lower priority for germination and dormancy research.

Previous outplanting efforts for *S. lanceolata* have been successful at a few locations but outplants have not persisted at most locations (Table 93). At ASRs 204 and 205, the initial performance of the outplants was extremely promising with strong recruitment; however, by 2022 there were no plants present. For ASR 205, the decline may be due in part to a gap in habitat management between 2017 and 2019 that allowed invasive grasses to overrun many of the planting areas. This may have increased competition with the invasive plants and reduced the available germination sites. At ASR 214, initial recruitment was also high, but since 2014 the number of adults and juveniles present has declined sharply, suggesting that recruitment was insufficient to replace losses. Although the losses at ASR 214 have been high, we are encouraged by the large number of adults and juveniles still present, suggesting a self-sustaining population has been established. Additionally, the number of *S. lanceolata* adults and juveniles present increased at ASRs 211 and 213. Initially, relatively few plants were planted at ASR 213, suggesting that site conditions were favorable to establishment and recruitment.

Because the wild *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.

Status of Silene hawaiiensis *Populations at PTA per the USFWS Species Recovery Criteria*

In the 5-Year Review for *Silene hawaiiensis* published in 2021, the USFWS established a new stage of recovery—Preventing Extinction—with criteria. The Preventing Extinction stage recovery for *S. lanceolata* requires 50 mature individuals in each of 3 populations, with at least 50 individuals (or the total number if less than 50) represented from each wild population in ex-situ storage. We continue to manage the 13 populations of *S. lanceolata* and progress toward recovery criteria (Table 94). Advancing to the next stage of recovery—Interim Stabilization—depends upon maintaining a population on Oʻahu, Molokaʻi, or Lānaʻi that also meets the recovery criteria. At PTA during surveys, we did not record the life stage of individuals, so we currently lack the number of mature plants (i.e., adults) present (CEMML 2014, CEMML 2022a). Future monitoring will include counts of individuals by life stage to document natural reproduction and to calculate future population trends.

Table 94. Progress towards USFWS Preventing Extinction stage of recovery for *Silene lanceolata* at PTA; population census data collected 2011–2015

Population	[a]Approximate # Individuals Wild (OP)	# Founders Ex-situ Storage	Fenced	Invasive Plant Control	Natural Reproduction	Number Increasing
SILLAN1	0 (235)	NA	Yes	Yes	ND	ND
SILLAN2	4,996	1	Yes	Partial	ND	ND
SILLAN3	279 (24)	4	Yes	Partial	ND	ND
SILLAN4	31	0	Yes	No	ND	ND
SILLAN5	266	3	Yes	No	ND	ND
SILLAN6	73	0	Yes	No	ND	ND
SILLAN7	115	0	Yes	No	ND	ND
SILLAN8	3	0	Yes	No	ND	ND
SILLAN9	27	0	Yes	No	ND	ND
SILLAN10	3,406 (75)	299	Yes	Partial	ND	ND
SILLAN11	1	0	Yes	No	ND	ND
SILLAN12	31	0	Yes	Partial	ND	ND
SILLAN13	21 (27)	0	Yes	Partial	ND	ND

ND, No Data
[a]Count classes were used to estimate the number of plants at each 5.6 m radius location where more than 10 plants were observed. This is a sum of minimum counts, representing the lowest count value for the count class (11–50, 51–100, >100) recorded for each location where plants were observed.

Progress toward Compliance with Endangered Species Act Biological Opinion Conservation Measures

To offset effects of military activities on *S. lanceolata,* the 2003 BO conservation measures include fuels management to reduce fire risk, fencing and ungulate control to reduce browsing 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 (Sections 3.4 and 4.3). In addition, we actively conserve *S. lanceolata* genetic resources; the propagule bank contains 478,946 seeds from the wild population and 1,069,751 seeds from individuals grown in the RPPF or from individuals outplanted, representing 307 wild founders total. To date, we have outplanted 917 individuals at 10 sites and *S. lanceolata* has increased in number at 3 of the sites. We manage weeds in 10 ASRs where *S. lanceolata* occurs alone or with 1 or more Tier 1 plant species. Within these 10 ASRs, we manage weeds in about 30 ha for *S. lanceolata* and other Tier 1 plants co-located in the control buffers (Section 3.2, Table 101). 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, a minimum of 220 seedlings were recorded in Regions 3 and 4 during monitoring from 2022 to 2023. In 2008 and 2009, we noted *S. lanceolata* seedlings in all 10 ASRs monitored but none in 2007 or 2010, suggesting that in-situ reproduction is not constant but occurs when environmental conditions are favorable. Although we monitor a portion of the distribution of *S. lanceolata* annually to estimate abundance, we are unable to attribute changes in numbers to effects of 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 2.7).

2.6.7 *Spermolepis hawaiiensis* (Endangered)

As a Tier 2 species, our goal is to survey and monitor a portion of the known *Spermolepis hawaiiensis* population at PTA each year to refresh the distribution and abundance estimates. The aim is to survey the entire population at PTA over a 3-year period. For genetic conservation, *Spermolepis hawaiiensis* is an implementation priority 5 (low; Table 13). We plan to collect propagules for storage with little to no outplanting. The distribution for *Spermolepis hawaiiensis*, including outplanting sites, is shown in Figure 97.

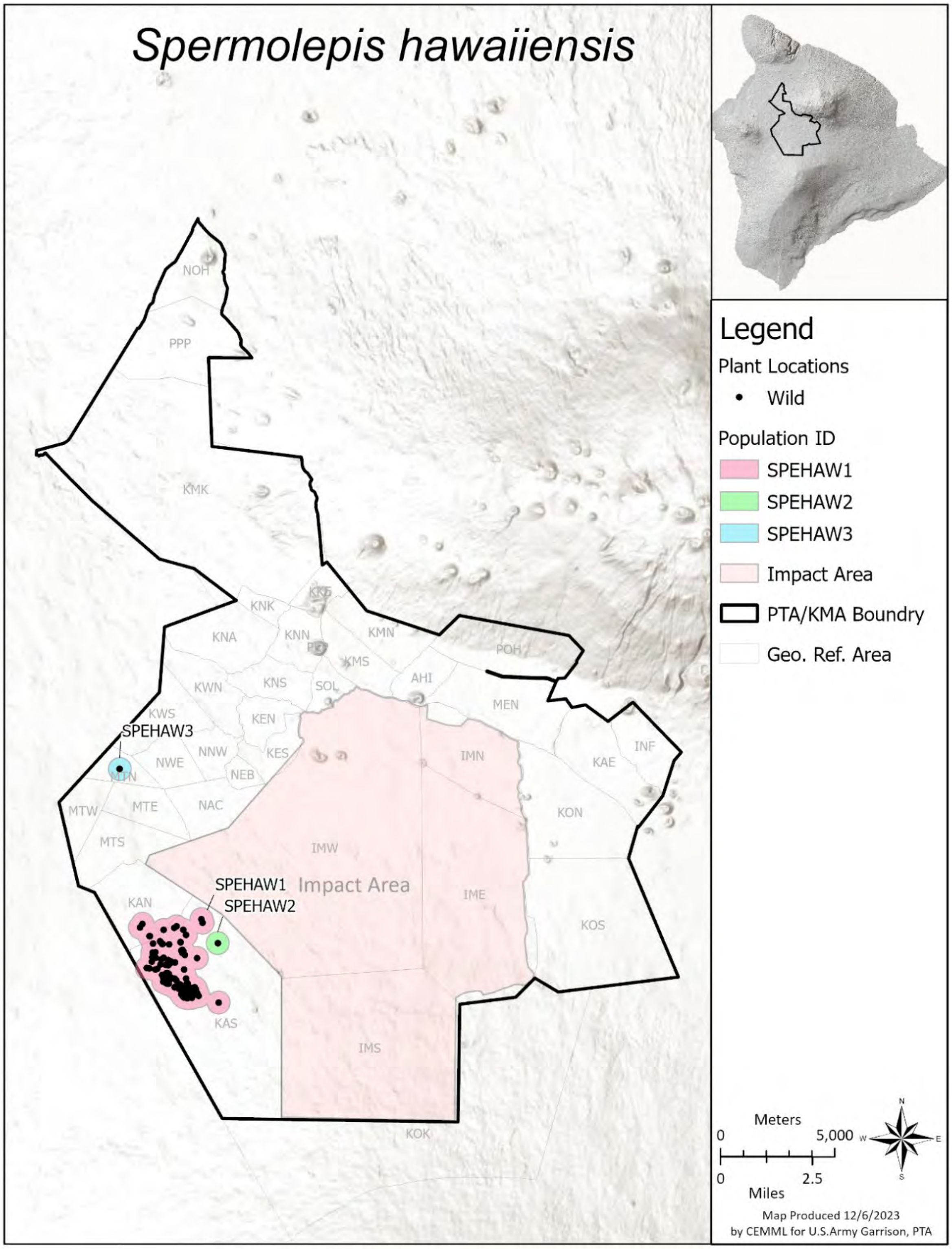


Figure 97. Current known distribution of *Spermolepis hawaiiensis*[a]

[a] The distribution is derived from a compilation of plant survey data (2011 to 2021), monitoring data, and incidental rare plant finds.

Plant Survey and Monitoring

Spermolepis hawaiiensis was not included in survey efforts from 2022 to 2023 because the sampling design was not well suited to reliably detect this species. Because *Spermolepis hawaiiensis* is an annual and its presence is highly dependent on precipitation, surveys and monitoring should be conducted at the same time each year to help minimize interannual variation and to improve the detectability of the species. Until a new monitoring approach is developed for *Spermolepis hawaiiensis,* we will continue to report the minimum number of plants at PTA. To generate this estimate, we used the lower boundary of each count class collected between 2011 and 2015 during rare plant surveys to quantify the minimum number of individuals for descriptive purposes only. For *Spermolepis hawaiiensis*, there were 372 plant locations representing at least 595 plants.

Genetic Conservation

Propagule Collection and Propagation

During this reporting period, we did not collect propagules or propagate *Spermolepis hawaiiensis.* Refer to Table 15 for a complete summary of ex-situ storage status for *Spermolepis hawaiiensis.* There are no accessions of *Spermolepis hawaiiensis* in the RPPF.

Outplanting and Monitoring

During this reporting period, we did not outplant *Spermolepis hawaiiensis.* In previous years, we planted a total of 49 *Spermolepis hawaiiensis* individuals at 5 sites and broadcasted seed at 2 sites (Table 95). *Spermolepis hawaiiensis* no longer remains at any outplanting site. Due to the lack of plants at the sites, we assume that seed banks failed to establish.

Table 95. Monitoring results from December 2022 for *Spermolepis hawaiiensis* outplanted 2004–2014

			Total Present 2022		
Location	**ASR**	**Total Outplanted 2004–2014**	**Adult**	**Juvenile**	**Seedlings**
Off PTA	<u>201</u>	1	0	0	0
	203	8	0	0	0
	204	0+	0	0	0
	<u>205</u>	3+	0	0	0
On PTA	<u>214</u>	21	0	0	0
	216	16	0	0	0

Note: The data source for planting activity between 2004 to 2014 is CEMML. The number of *Spermolepis hawaiiensis* present was not reported for the 2014 monitoring, but recruitment was noted (indicated by an underlined site number).
+ Broadcast seed

Discussion

Our efforts to monitor and conserve genetic resources for *Spermolepis hawaiiensis* address SOO tasks 3.2.1.2, 3.2.1.4, and 3.2.1.5, 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. *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 basic research into life history characteristics to support science-based management of this species.

Previous outplanting and seeding efforts for *Spermolepis hawaiiensis* have failed to establish self-sustaining populations, despite the evidence of some recruitment at ASRs 201, 205, and 214 in 2014. Since *Spermolepis hawaiiensis* is an annual, we do not expect that any of the original outplants remain at any of the sites. We anticipated that a seed bank would establish at these sites and new generations would emerge each year when conditions were favorable, but this did not happen. *Spermolepis hawaiiensis* seeds in the RPPF spread to other pots and readily germinate. We recommend continuing to experiment with broadcast seeding into different habitats at outplanting sites.

Status of Spermolepis hawaiiensis *Populations at PTA per the USFWS Species Recovery Criteria*

In the 5-Year review for *Spermolepis hawaiiensis* published in 2021, the USFWS established a new recovery stage—Preventing Extinction—with criteria. The Preventing Extinction state of recovery requires 50 mature individuals in each of 3 populations, with at least 50 individuals (or the total number if less than 50) represented from each wild population in ex-situ storage. We continue to manage the 3 *Spermolepis hawaiiensis* populations at PTA (Table 96). Advancing to the next recovery stage—Interim Stabilization—depends upon maintaining a population on Kauaʻi, Oʻahu, Molokaʻi, Lānaʻi, or Maui that meets recovery criteria. At PTA, we did not record the life stage of individuals counted, so we currently lack the number of mature plants (i.e., adults) present (CEMML 2014, CEMML 2022a) Future monitoring will count individuals by life stage and data will document natural reproduction and be used to calculate population trends.

Table 96. Progress towards USFWS Preventing Extinction stage of recovery for *Spermolepis hawaiiensis* at PTA

Population	[a]Approximate # Individuals	# Founders Ex-situ Storage	Fenced	Invasive Plant Control	Natural Reproduction	Number Increasing
SPEHAW1	595	35	Yes	No	ND	ND
SPEHAW2	1	0	Yes	No	ND	ND
SPEHAW3	1	0	Yes	No	ND	ND

ND, No Data

[a]Count classes were used to estimate the number of plants at each 5.6 m radius location where more than 10 plants were observed. This is a sum of minimum counts, representing the lowest count value for the count class (11–50, 51–100, >100) recorded for each location where plants were observed.

Progress toward Compliance with Endangered Species Act Biological Opinion Conservation Measures

To offset effects of military activities on *Spermolepis hawaiiensis,* the 2003 BO conservation measures include fuels management to reduce fire risk and fencing and ungulate control to reduce browsing pressure.

To address these conservation measures for *Spermolepis hawaiiensis*, we implement landscape-level projects to reduce fire risk and ungulate browsing for all known individuals at PTA (Sections 3.4 and 4.3). In addition, we actively conserve *Spermolepis hawaiiensis* genetic resources; the ex-situ collection contains 3,146 seeds from the wild population and 547,235 seeds from individuals grown in the RPPF or from individuals outplanted, representing 35 wild individuals total. We have direct seeded *Spermolepis hawaiiensis* at 2 outplanting sites. The outplanted *Spermolepis hawaiiensis* did not successfully establish self-sustaining populations at either site.

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 2.7).

2.6.8 *Stenogyne angustifolia* (Endangered)

We survey and monitor a portion of the known *S. angustifolia* population, a Tier 2 species, at PTA each year to refresh the distribution and abundance estimates. The aim is to survey the entire population at PTA over a 3-year period. For genetic conservation, *S. angustifolia* is an implementation priority 5 (low; Table 13). We plan to collect propagules for storage with little to no outplanting.

Plant Surveys and Monitoring

Based on previous survey work from 2019 to 2020, we estimate 12,038 (90% CI: 6,684–17,392) wild juvenile and adult *S. angustifolia* within fence units at PTA (Figure 98). The distribution for *S. angustifolia*, including the outplanting site at PTA where this species currently persists, is shown in Figure 98. Using data collected during the reporting period, we estimate there are currently 2,727 *S. angustifolia* (90% CI: 1,641–3,814) within Regions 3 and 4 (Table 6).

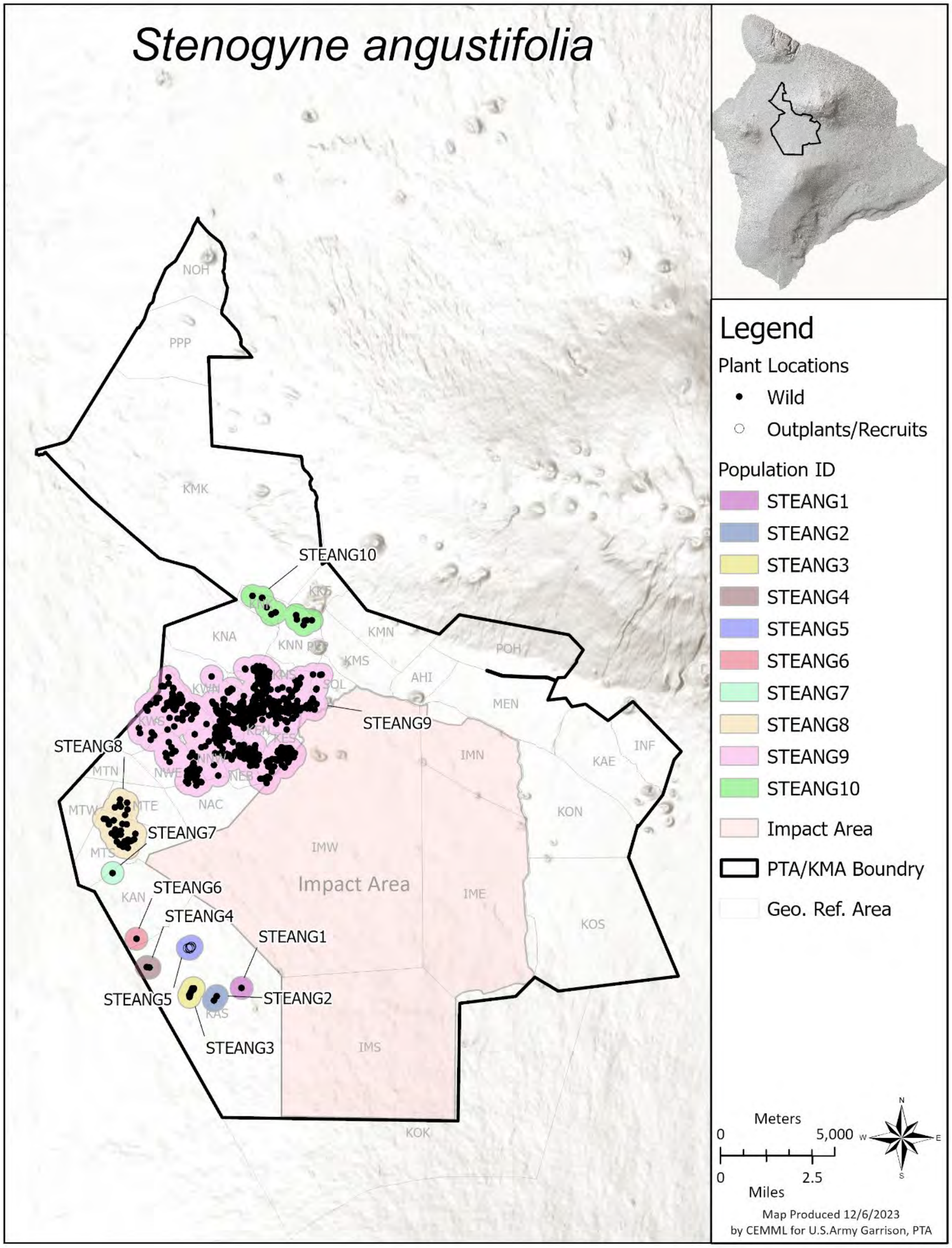


Figure 98. Current known distribution of *Stenogyne angustifolia*[a]

[a] The distribution is derived from a compilation of plant survey data (2011 to 2021), monitoring data, and incidental rare plant finds.

Genetic Conservation

Propagule Collection and Propagation

We collected 6 cuttings from 1 individual during the reporting period Table 97. Three of the 6 cuttings collected successfully rooted (

Table 18) and are being held as living collections in the RPPF (Table 20). Refer to Table 15 for a complete summary of ex-situ storage status for *S. angustifolia*.

Table 97. Propagule collections for *Stenogyne angustifolia* in 2023

Species	Collection Date	Type of Propagule	Amount Collected	Population	UTM X	UTM Y
Stenogyne angustifolia	18 Apr 23	Cutting	6	STEANG9	220524	2184554

Outplanting and Monitoring

During this reporting period, we did not outplant *S. angustifolia.* In previous years, we planted a total 246 *S. angustifolia* individuals at 6 sites (Table 98). Because *S. angustifolia* grows in mat-like clusters, it can be challenging identifying each individual during monitoring. As of December 2022, *S. angustifolia* remained at ASR 205, but had decreased substantially in the number of adults and juveniles present. However, ASR 205 showed a 15% increase and at ASR 214 the number of *S. angustifolia* adults and juveniles increased by 208%. From past plantings at ASR 205, 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 98. Monitoring results from December 2022 for *Stenogyne angustifolia* outplanted 2004–2014

Location	Site	Total Outplanted 2004–2014	Total Present 2014		Total Present 2022		% Change 2014–2022
			Adult	Juvenile[a]	Adult	Juvenile	
Off PTA	201	121	62	0	11	60	+15%
	203	8	0	0	0	0	0%
	204	8	0	0	0	0	0%
	205	78	48	0	2	1	-94%
On PTA	214	30	27	0	65	18	+208%
	219	1	1	0	0	0	-100%

Note: The data source for planting activity between 2004 to 2014 and 2014 monitoring data is CEMML 2015. Sites listed in bold denotes seedlings and underline denotes juvenile/adult recruits were present in 2014.

[a] In 2014, recruitment was noted for all sites (except site 203), but it was determined to be clonal and was not quantified.

Discussion

Our efforts to monitor and conserve genetic resources for *S. angustifolia* address SOO tasks 3.2.1.2, 3.2.1.4, and 3.2.1.5, 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. It is also scattered in the Mixed Tree Fence Unit and an isolated location in the Kīpuka ʻAlalā North Fence Unit.

We know relatively little about life history characteristics and population dynamics of *S. angustifolia*. Little is known about native pollinators for *S. angustifolia.* In addition, researchers concluded that ants, Argentine (*Linepithema humile*) in particular, are a threat to *S. angustifolia* (Dr. Christina Liang, Forest Ecologist, US Forest Service, personal communication, May 2018). We recommend basic research into life history characteristics to support science-based management of this species. Understanding 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.

S. angustifolia is one of several federally listed species affected by the 2022 Leilani fire. The estimated post-fire abundance of *S. angustifolia* in the burn area is 1,168 (90% CI: 875–1,731) wild individuals (CEMML 2023f). We also recorded a minimum count of 89 seedlings proximate to wild plants. Results from the paired t-test showed significant decline between pre- and post-fire abundance in the plots sampled ($\alpha \geq 0.1$, $p = 0.06$; Table 11).

Much of the installation-wide *S. angustifolia* population was located within the burn area prior to the fire. Although we cannot quantify the magnitude of the decline in *S. angustifolia* abundance within the burn area, we assume the decrease was substantial to the installation-wide population and should be considered in future post-fire restoration efforts. However, the magnitude of change in abundance cannot be inferred from the t-test results and because the sample size for the paired plots was relatively low ($n = 12$), how well these plots represent the whole population within the burn area is unknown.

Within the burn area, vegetation was not controlled specifically for *S. angustifolia,* but this species co-occurs with other species for which vegetation control was established. Shaw (1995) found that *S. angustifolia* resprouted from rhizomes regardless of fire intensity following the 1994 Kīpuka Kālawamauna fire. Approximately 1 year after a fire in 2018 that partially or completely burned 36% of all known *S. angustifolia* locations at PTA, post-fire monitoring indicated that *S. angustifolia* abundance more than doubled pre-fire abundance estimates (CEMML 2020a). Although *S. angustifolia* appears to be moderately resilient to fire impacts, repeated burns continue to alter the vegetation community and promote more fire-prone landscapes. The fire certainly affected this species, but it is difficult to quantify the magnitude of the effect or its long-term impacts.

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 genetic resources. We have partnered with the OANRP to leverage their expertise to establish reliable germination procedures. Per their recommendations we will experiment with cold stratification in our germination chamber. Although outplanting is a low priority for *S. angustifolia* due to its relative abundance and good distribution, we recommend continuing to experiment with planting locations and selectively planting this species to increase the community structure of outplanting sites.

Status of Stenogyne angustifolia *Populations at PTA per the USFWS Species Recovery Criteria*

In 2022, the USFWS established recovery criteria for *S. angustifolia*. Recovery stages include the Preventing Extinction stage, which requires 50 mature individuals in each of 6 populations, with at least 50 individuals (or the total number if less than 50) represented from each wild population in ex-situ storage. We continue to manage the 11 *S. angustifolia* populations at PTA and are evaluating next steps to work toward recovery criteria (Table 99) At PTA, we did not count individuals by life stage, so we currently lack the number of mature plants (i.e., adults) present (CEMML 2014, CEMML 2022a). Future monitoring will include counts of individuals by life stage and data will document natural reproduction and be used to calculate population trends.

Table 99. Progress towards USFWS Preventing Extinction stage of recovery for *Stenogyne angustifolia* at PTA; population census data collected 2011–2015

Population	[a]Approximate # Individuals Wild (OP)	# Founders Ex-situ Storage	Fenced	Invasive Plant Control	Natural Reproduction	Number Increasing
STEANG1	4	0	Yes	No	ND	ND
STEANG2	14	0	Yes	No	ND	ND
STEANG3	208	0	Yes	No	ND	ND
STEANG4	16	0	Yes	No	ND	ND
STEANG5	0 (57)	NA	Yes	Yes	ND	ND
STEANG6	6	0	Yes	No	ND	ND
STEANG7	1	0	Yes	No	ND	ND
STEANG8	69	0	Yes	No	ND	ND
STEANG9	5,816	53	Yes	Partial	ND	ND
STEANG10	18	0	Yes	Yes	ND	ND
STEANG11	5	0	Yes	Yes	ND	ND

ND, No Data

[a]Count classes were used to estimate the number of plants at each 5.6 m radius location where more than 10 plants were observed. This is a sum of minimum counts, representing the lowest count value for the count class (11–50, 51–100, >100) recorded for each location where plants were observed.

Progress toward Compliance with Endangered Species Act Biological Opinion Conservation Measures

To offset effects of military activities on *S. angustifolia,* the 2003 BO conservation measures include fuels management to reduce fire risk, fencing and ungulate control to reduce browsing 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 browsing for all known individuals at PTA (Sections 3.4 and 4.3). In addition, we actively conserve *S. angustifolia* genetic resources; the ex-situ collection contains 2,175 seeds from the wild population and 8,759 seeds from individuals grown in the RPPF or from individuals outplanted, representing 53 wild founders total. To date, we have outplanted 246 individuals at 6 sites and they have persisted at a few sites, mostly in low numbers. 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 *S. angustifolia* for in-situ reproduction annually, we have observed seedlings—most recently in the area burned by the 2022 Leilani fire. Although we monitor a portion of the distribution of *S. angustifolia* annually to estimate abundance, we are unable to attribute changes in numbers to effects of 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 2.7).

2.7 Overall Summary Discussion for the Botanical Program

Implementation of a Botanical Program is an essential component of the Army's NRP 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 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 pollination of 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 high population numbers of ESA-listed plants reduce the risk that military operations at PTA will affect 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 minimize the potential that these species will require ESA listing in the future. Also, effective implementation of the INRMP to protect plant habitats at the landscape level demonstrates that the Army's NRP is 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[16] 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 Tier 1 plants. *Portulaca villosa, Sicyos macrophyllus,* and *Tetramolopium stemmermanniae* were not included in the 2003 BO, but we report in-situ reproduction for these species as well (Table 100). In addition, there are 5 ESA-listed plants that were included in the 2003 BO but are not Tier 1 species. We discuss reproduction for the Tier 2 species in the Species Summaries (see Sections 2.5 and 2.6).

Most Tier 1 species are reproducing in the field at most of the monitoring plots (Table 100). 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 *K. coriacea.* 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 this species. In addition, reproduction for *Isodendrion hosakae*

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

was limited to a single monitoring plot during this time period. Although data show that most Tier 1 plants are reproducing naturally, and are receiving conservation benefits from our management, our recently-implemented individual-based monitoring methods will allow us to accurately track how this reproduction contributes to population structure over time.

Table 100. Tier Species 1 monitoring plots with documented in-situ recruitment at least once between 2016–2019 during quarterly monitoring

Species	No. of Plots	No. of Plots w/ reproduction[a]	Percent of plots w/ reproduction[a]
Asplenium peruvianum var. *insulare*	43	13	30%
Isodendrion hosakae	36	1	3%
Kadua coriacea	124	0	0%
Lipochaeta venosa	17	3	18%
Neraudia ovata	19	1	5%
Portulaca sclerocarpa	41	7	17%
Portulaca villosa	2	1	50%
Sicyos macrophyllus	1	0	0%
Schiedea hawaiiensis	2	1	50%
Solanum incompletum	20	1	5%
Tetramolopium arenarium	27	5	19%
Tetramolopium stemmermanniae	64	8	13%
Vigna o-wahuensis	46	18	39%
Zanthoxylum hawaiiense	493[b]	--	--

[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.
[b] For *Zanthoxylum hawaiiense,* data were taken at each plant location instead at plots.

As a learning organization, we have many challenges ahead of us. 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 re-examine many of our approaches. To maximize our effectiveness at integrating management at both ecosystem and localized scales, we need to re-examine 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 ongoing management of ESA-listed plants. In addition, our recently-implemented Tier 1 and Tier 2 species monitoring protocols will estimate population 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 3.2.4.1 through 3.2.4.3 and task 3.2.5.3 to comply with INRMP objectives (Sikes Act Improvement Act), ESA consultation requirements, regulatory outcomes from NEPA documents, and the IWFMP (USAG-PTA 2021).

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[17]. 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*[18]. Without an ESA consultation, these species lack formal conservation measures. We also manage the undescribed species *Tetramolopium stemmermanniae* due to its rarity and limited distribution even though this plant is not ESA-listed.

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 3.2.4.1 and 3.2.5.3 and projects implemented under Fuels Management Section address SOO tasks 3.2.4.2 and 3.2.4.3. SOO task 3.2.4.4 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 H.

[17] *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*, *V. o-wahuensis*, and *Z. hawaiiense.*

[18] The text reflects the status of the PBA during the report period (01 October 2021 through 30 September 2023). Since, the Army has worked to develop additional wildland fire planning and preparedness documents to support the PBA preparation process and the fire model used for the effects analysis was updated with data from wildland fires that occurred in 2021 and 2022.

This report summarizes project methods and general results for each IPP section and documents our progress with SOO tasks.

3.2 VEGETATION CONTROL IN AREAS OF SPECIES RECOVERY AND OUTPLANTING SITES

3.2.1 Introduction

Projects implemented under the Vegetation Control Section address SOO tasks 3.2.4.1 and 3.2.5.3 and conversation measures from the 2003 BO for 13 plant species. 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 conservation project at Hakalau Forest National Wildlife Refuge (HFNWR) by mowing and cutting grass in Army-managed areas frequented by geese. This project addresses SOO task 3.2.2.2 (see Wildlife Program Section 4.2.3 for project details).

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.

Background

The 2003 BO specifically addresses weed control for 13 of the ESA-listed plants at PTA (*P. sclerocarpa* and *Spermolepis hawaiiensis* were not addressed). In addition, plant species listed under the ESA in 2013 and 2016 currently have no regulatory requirements for weed control (*E. menziesii, F. hawaiiensis, P. villosa,* and *S. macrophyllus*). Beginning in 2001 (RCUH 2002), we focused efforts on the rarest plants (categorized as priority species 1[19]) at the greatest risk from competition from invasive plants and/or fire. In 2005 (CEMML 2005), we prioritized 7 of the 9 species addressed in the 2003 BO for weed management and aimed to implement weed control for the remaining 4 species addressed in the 2003 BO in subsequent years. By 2011 at PTA, we implemented weed control for most of the populations for *K. coriacea, N. ovata, Schiedea hawaiiensis* (not listed as endangered in 2011)*, S. incompletum,* and *T. arenarium,* about half the *S. lanceolata* distribution, and a few select groupings of *H. haplostachya* and *Silene hawaiiensis.* Due to a lack of capacity and funding, as of 2023 we have not implemented weed control across most of the populations for *A. peruvianum* var. *insulare, E. menziesii, F. hawaiiensis, H. haplostachya, P. sclerocarpa,* and *P. villosa*. Weed control from *Sicyos macrophyllus* is primarily around the plants and does not extend out to the full 25 m.

3.2.2 Weed Control in Delineated Areas of Species Recovery and Outplanting Sites

Weed control in ASRs meets SOO tasks 3.2.4.1 and 3.2.5.3. To accomplish these tasks for ESA-listed plant species, we focus invasive plant management in a series of WCBs within ASRs (Figure 3). 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. 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. WCBs may periodically be adjusted, suspended, or decommissioned as plant locations, conditions, or program resources change.

Prior to the FY 2018–2019 biennial report, we reported on ASRs and outplanting sites (OPs) separately. ASRs are areas where wild ESA-listed plant species occur. Outplanting sites are areas where ESA-listed plant species are planted to increase their distributions and abundances (see Section 2.3). ASRs are assigned a 1 or 2 digit number (e.g., ASR 1, ASR 24), while outplanting sites are assigned a 200-series number. Three outplanting sites were implemented within existing ASRs and assigned a 200-series number (OPs 213, 218, and 220). We control weeds in these 3 OPs and their respective ASRs at the same time and track management per the ASR number only. Thus, weed control in ASRs and OPs are reported together in Table 101 and the 3 OPs referenced above are shown next to the ASR they are located within (e.g., 11/218). More detailed information about the OPs and their focal species can be found in Section 2.3.

To control weeds over time, we repeat weed control treatments within WCBs. The frequency of weed control in an 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

[19] *Isodendrion hosakae, Kadua coriacea, Lipochaeta venosa, Neraudia ovata, Schiedea hawaiiensis* (listed as endangered in 2013), *Solanum incompletum, Tetramolopium arenarium, Tetramolopium stemmermanniae* (formerly species 1, which is not listed as endangered), and *Vigna o-wahuensis,*

time. We schedule each actively managed ASR, ranging from quarterly to every 2 years depending on site characteristics and historical management data, to assess it for percent weed cover 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 Section 3.3 (IPSM) of this report.

We prioritize ASRs for weed control using several criteria: (1) management tier of ESA-listed plant species (see Section 2.3), (2) ESA-listed plant species abundance, (3) level of threats present, (4) site access, (5) recovery potential, and (6) 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*. ASRs we have managed for several years also tend to need less weed control over time as the seed bank is depleted and native plant cover increases. 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 88.4 ha of WCBs within ASRs and OPs (Table 101). All actively managed ASRs and OPs received weed control during the reporting period for the primary species *Sicyos macrophyllus* except ASR 49*.* The frequency of weed control efforts varied across ASRs and OPs. We decreased the WCB area in 8 ASRs and 2 OPs, increased it in 3 ASRs and 1 OP, and implemented a new WCB in ASR 45 in support of the *Vigna o-wahuensis* Habitat Restoration

Project at Puʻu Nohona o Hae (see Section 2.4). The largest reduction (3.8 ha) was in ASR 3 where we previously managed the entire *Silene hawaiiensis* fence unit, including areas over 25 m from ESA-listed plant locations. We decreased the WCB to include only the pahoehoe flow where the ESA-listed plants are located. Our continued maintenance of the larger area had no obvious benefits to the ESA-listed plants in the remainder of the ASRs and took many needed resources away from other priorities while we struggled with staff reductions and vacancies. We decreased the WCB area in 2 ASRs affected by the Lailani fire (ASRs 13 and 19). We suspended management of 1 WCB in ASR 13 that the fire burned, destroying the ESA-listed plants. The fire also burned through a WCB in ASR 19, but the focal and some non-focal ESA-listed plants survived. When we re-delineated and re-flagged the buffer, the WCB was reduced by 0.1 ha after we located the plants and adjusted the managed area. The Leilani fire also burned the edges of OP 209 WCB. The WCB area was reduced by 0.4 ha when we reflagged and retracked it for the GIS. The WCB area decreased in ASRs 16, 25, and 40 by 0.5 ha overall due to human error and/or GPS accuracy issues when we replaced old worn-out boundary flagging and retracked the area. We reduced the WCB area in ASR 44 by 0.6 ha and OP 211 by 0.5 ha for safety of field staff due to the hazardous terrain on the outer edge, which offered little benefit to the ESA-listed plants. We increased the WCB area in 3 ASRs (24, 29, and 41) and 1 OP (206) by 1.6 ha overall to ensure 25 m distance criteria from ESA-listed plants was met.

There are 26 ASRs in which we either do not control weeds or we only control weeds for selected ESA-listed plant species (Table 102). 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 101. Weed control in areas of species recovery and outplanting sites, FY 2022–FY 2023

ASR/OP	Primary Species	WCB Hectares	WC Frequency
3	*Silene hawaiiensis*	9.6	4
4	*Haplostachys haplostachya*	1.6	2
8	*Tetramolopium arenarium*	11.7	3
11/218	*Kadua coriacea/ Silene lanceolata*	4.9	1
12	*Silene lanceolata*	1.3	3
13	*Silene lanceolata*	4.6	4
16	*Silene lanceolata*	2.6	5
18	*Kadua coriacea/ Silene lanceolata*	3.4	3
19	*Silene hawaiiensis*	1.1	1
20	*Silene lanceolata*	0.8	3
21	*Kadua coriacea*	1.0	1
22	*Kadua coriacea*	0.6	1
24	*Neraudia ovata/ Solanum incompletum/ Silene lanceolata*	8.7	4
25	*Silene lanceolata*	1.2	4
28	*Tetramolopium stemmermanniae*[a]	0.9	2
29	*Kadua coriacea*	2.0	2
30	*Kadua coriacea*	18.2	1
40/220	*Solanum incompletum*	1.4	2
41/213	*Schiedea hawaiiensis*	1.2	2
44	*Silene lanceolata/ Portulaca sclerocarpa*	2.4	3
45	*Vigna o-wahuensis*	1.0	6
46	*Isodendrion hosakae*	2.2	7
47	*Solanum incompletum*	0.3	3
48	*Lipochaeta venosa*	1.7	4
49	*Sicyos macrophyllus*	<0.1	0
201	Several ESA-listed plant species (Off PTA)	0.6	2
205	Several ESA-listed plant species (Off PTA)	0.4	3
206	*Schiedea hawaiiensis/Neraudia ovata*	0.4	2
207	*Schiedea hawaiiensis*	0.2	2
209	*Solanum incompletum*	1.2	2
211	*Silene lanceolata*	0.7	5
214	Several ESA-listed plant species	0.4	3
219	*Asplenium peruvianum var. insulare/Solanum incompletum*	0.1	4
	Total	**88.4**	

ASR, area of species recovery; WCB, weed control buffer; WC, weed control; OP, outplanting site
[a] *Tetramolopium stemmermanniae* is not an ESA-listed plant. However, this recently described species is managed due to its rarity.

Table 102. 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*	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
31	*Silene lanceolata*	Suspended	Management challenges, benefits unclear
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

ASR, Area of Species Recovery

3.2.3 Hakalau Forest National Wildlife Refuge Hawaiian Goose Habitat Management

Habitat management at HFNWR meets SOO tasks 3.2.2.2 and conservation measures of the 2013 BO. We control vegetation (e.g., cutting and mowing grass, and selectively applying herbicide 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 conducted habitat management actions between October 2021 and March 2023 (see Section 4.2.3 for project details).

Over the course of 5 site visits, we maintained approximately 1.2 ha of habitat for the Hawaiian Goose by mowing and weed-whacking grass in the Pua ʻĀkala management 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 for established WCBs. All but 1 ASR on the schedule received weed control during the reporting period. We also implemented a new WCB in ASR 45 in support of the *Vigna o-wahuensis* habitat restoration project at Puʻu Nohona o Hae in the KMA (see Section 2.4). Our implementation of this WCB resulted in a substantial reduction of non-native plant cover within the first year, from 91% to 15%. By controlling vegetation in WCBs, with the objective of reducing threats from invasive plants to ESA-listed plants and their habitats, we are achieving our goals as described. Our vegetation control actions at HFNWR also likely benefit 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 plan to develop 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.

In the FY 2018–2019 Biennial Report, we documented that 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 2020a). This fire was caused by an inadvertent discharge of flares from a US Marine Corps aircraft during aerial live-fire training. Our post-fire assessment showed that the fire burned right up to the edge of 4 WCBs and then stopped. Additionally, our analysis of burn severity after the Leilani Fire in Training Area 22 during July and August of 2022 indicates that management in WCBs where *C. setaceus* was removed (i.e., fine fuels removal) resulted in less burned vegetation and thus lower impacts to ESA-listed plants and their habitat (CEMML 2023f). This underscores our conclusion that removal and control of weeds, particularly *C. setaceus*, within WCBs is a crucial factor in preventing fire impacts to ESA-listed plant species in the WCBs.

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. We are now noticing that less effort is required to control *S. madagascariensis* as well, particularly in WCBs where native shrub cover has increased, but also in WCBs with more open cover. We speculate that our consistent control of *S. madagascariensis* before it goes to seed is reducing the seed bank, while increased native shrub cover may be preventing germination of persistent seed banks in some areas. We believe all these factors are contributing to our success in maintaining WCBs with less effort and less herbicide application.

Invasive species management can promote recovery of native species and ecosystem function, but invasive species removal programs can sometimes lead to unintended consequences such as invasion by another exotic species (Zavaleta et al. 2001; Prior et al. 2018). In areas with rocky substrates at PTA, we generally see successful control of *C. setaceus* with minimal increases in cover of other invasive plant species. However, sometimes the removal of *C. setaceus* creates open areas that can lead to increases in cover of other invasive plant species. This happens more frequently in areas with more soil, especially in areas that have been invaded for many years (e.g., the KMA). In these systems, we have observed increases, sometime large, in the invasive plant cover (e.g., *Glycine wightii*). However, these changes in observed cover are likely also influenced by the removal of non-native ungulates, which eat certain invasive plants such as *G. wightii,* from the fence units where these weed control buffers are located. Invasive species management can have cascading effects across management areas and trophic levels, some beneficial and some unintended (Zavaleta et al. 2001; Prior et al. 2018). We recommend that future plans for invasive species control, especially in areas where they have been established for many decades, consider the full suite of species present to design a multi-species approach for invasive species management. This will minimize the potential for replacing one invasive species with another (Zavaleta et al. 2001).

3.3 INVASIVE PLANT SURVEY AND MONITORING

3.3.1 Introduction

Our goal 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 3.2.4.1 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 prioritizing 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. We have 42 species designated as secondary target weeds and assess them for prioritization by management tier based on several factors (Table 103). One recently detected species, *Cucumis dipsaceus* (hedgehog cucumber), is a proposed target weed we are assessing for possible addition to the list and is shown under Tier 1 in the table. The assessment process we use to prioritize secondary target weeds for control is outlined in Appendix A of this report. Four of the species are listed on the United States Department of Agriculture's Hawaiʻi State Noxious Weed List.

We continued drafting a technical report documenting each species' invasiveness, biology, and distribution. The primary purpose of this report is to document, summarize, and analyze the known distribution of secondary target weed species at PTA. This consolidated information will support revision of monitoring and control protocols, the development of a refined decision support tool/system, the evaluation and update of actively managed ASRs, and prioritization of target species, locations, and sites for management. It also identifies data gaps and related database needs.

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, potential impacts on high-quality habitats and ESA-listed species, and alteration of the landscape and/or ecosystem. Each of these projects is discussed in more detail below.

Table 103. Secondary target weeds of Pōhakuloa Training Area listed alphabetically by management tier

Species	Weed Risk Assessment Score[a]	Effect on System Score[a]	Weediness Score[a]	Feasibility of Control Score[a]
Management Tier 1[a]				
Ambrosia artemisiifolia	28	7	A	10
Cucumis dipsaceus[b]	11	6	B	10
Emex spinosa[c]	12	6	B	10
Eschscholzia californica	14	3	B	10
Foeniculum vulgare	19	6	A	10
Lantana camara	32	9	A	10
Parthenium hysterophorus	18	8	A	10
Paspalum dilatatum	12	6	B	10
Pluchea carolinensis	16	7	B	10
Prosopis pallida	20	6	A	10
Psidium guajava	21	8	A	10
Ricinus communis	21	6	A	10
Schedonorus arundinacea	17	9	A	10
Sphagneticola trilobata	13	9	B	10
Management Tier 2[a]				
Cupressus spp.	12	3	C	10
Grevillea robusta	8	6	C	10
Heteromeles arbutifolia	9	3	C	10
Macrotyloma axillare	10	6	C	10
Melinis minutiflora	18	8	A	6
Nicotiana tabacum	9	3	C	10
Rhamnus californica	5	3	C	10
Rubus rosifolius	10	3	C	10
Sambucus nigra ssp. canadensis	9	6	C	10
Schinus molle	10	6	C	10
Tribulus terrestris	11	5	C	10
Trifolium pratense	13	2	C	10
Management Tier 3[a]				
Acacia mearnsii[c]	15	9	B	7
Datura stramonium	5	1	D	10
Leucaena leucocephala	15	8	B	7
Lophospermum erubescens	10	9	B	7

Table103. Secondary target weeds of Pōhakuloa Training Area listed alphabetically by management tier (cont.)

Species	Weed Risk Assessment Score[a]	Effect on System Score[a]	Weediness Score[a]	Feasibility of Control Score[a]
Portulaca pilosa	23	3	A	6
Rubus niveus[c]	23	9	A	6
Management Tier 4[a]				
Centaurea melitensis	21	7	A	5
Cirsium vulgare	18.5	5	B	5
Delairea odorata	14	9	B	5
Gomphocarpus physocarpus	23	9	A	5
Kalanchoe delagoensis	19	8	A	5
Neonotonia wightii	16	6	B	5
Nicotiana glauca	17	9	A	5
Olea europaea	3	9	C	5
Passiflora tarminiana[c]	24	6	A	5
Piptatherum miliaceum	7	5	C	5
Salsola tragus	18.5	9	A	5

[a] The target weed assessment process, including assessment scores and management tiers, are described in Appendix G.
[b] *Cucumis dipsaceus* is a proposed target weed being assessed for possible addition to the secondary target weed list.
[c] Indicates species is on the United States Department of Agriculture's Hawaiʻi State Noxious Weed List.

3.3.2 Roadside Surveys

Methods

We use roadside weed survey methods similar to those of other early detection programs in Hawaiʻi. Two people, driving 5 mph, scan each side of the road for incipient and secondary target weeds. We focus efforts to 3 m on each side of the road, although weeds at greater distances will occasionally be observed and recorded.

We survey approximately 314 km of roads at PTA annually for early detection and control of incipient and secondary target weeds. For scheduling purposes, and to account for changes in phenology and seasonality of plant species that may affect detection, we survey roads in 1 of 4 annual Survey Areas (Survey Areas 2–5, Figure 99) on a rotating basis each quarter. We survey select roads in the KMA once each year (Figure 100). We may truncate, reschedule, or cancel surveys during periods when drought or other events have reduced any reasonable likelihood of weed germination, identification, or detection.

We survey the approximately 5 km perimeter of BAAF (Survey Area 1,Figure 99) quarterly and all earth works construction sites quarterly during construction and for 6 months after construction ends. Thereafter, we typically survey construction sites annually.

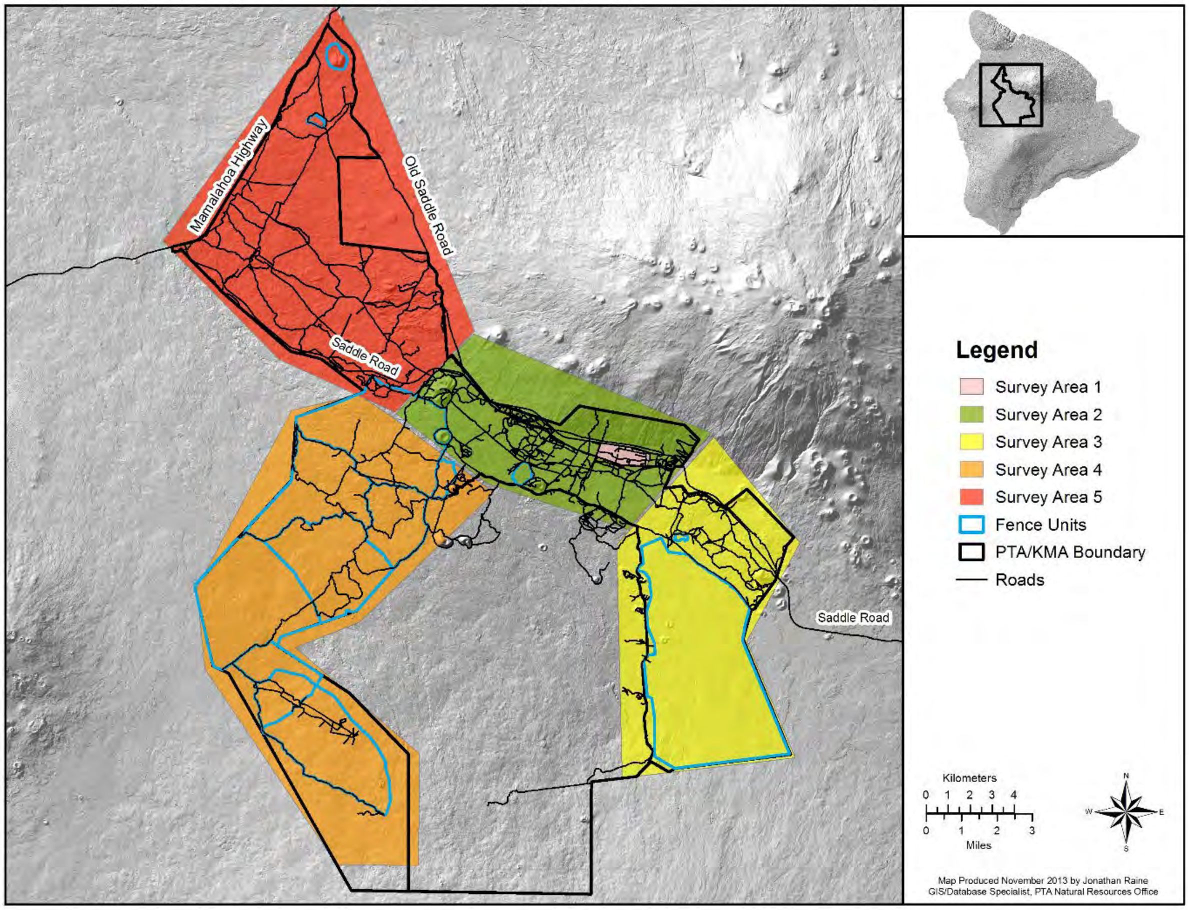


Figure 99. Invasive plant survey areas at Pōhakuloa Training Area

Results

We completed all roadside surveys as scheduled (Table 4). We surveyed BAAF every quarter during the reporting period and earth-moving construction sites quarterly during construction (if access was available) and for 6 months following completion.

We controlled secondary target weeds when found, unless in areas of known infestation (e.g., *Passiflora tarminiana* (banana poka) in Kīpuka ʻAlalā). We did not find any incipient weeds in Survey Areas 1 through 4, but we found 1 incipient weed species, *Cucumis dipsaceus,* in Survey Area 5. We controlled the 1 *C. dipsaceus* plant we found along Kālawamauna North Trail in April 2023. The Kālawamauna North Trail is part of the KMA Road Capping Completion construction project. *C. dipsaceus* has a Hawaiʻi Pacific Weed Risk Assessment (HPWRA) score of 11, which puts it in the high-risk category (Chimera 2023). The species has become invasive in many regions of the world where it has spread or was introduced, including in the Hawaiian Islands (Dube 2017). It is an annual climbing herb that can smother other plants and is a host for zucchini yellow mosaic virus (Dube 2017), which can possibly affect the endangered *S. macrophyllus*. We are evaluating adding this species to our secondary target weed list.

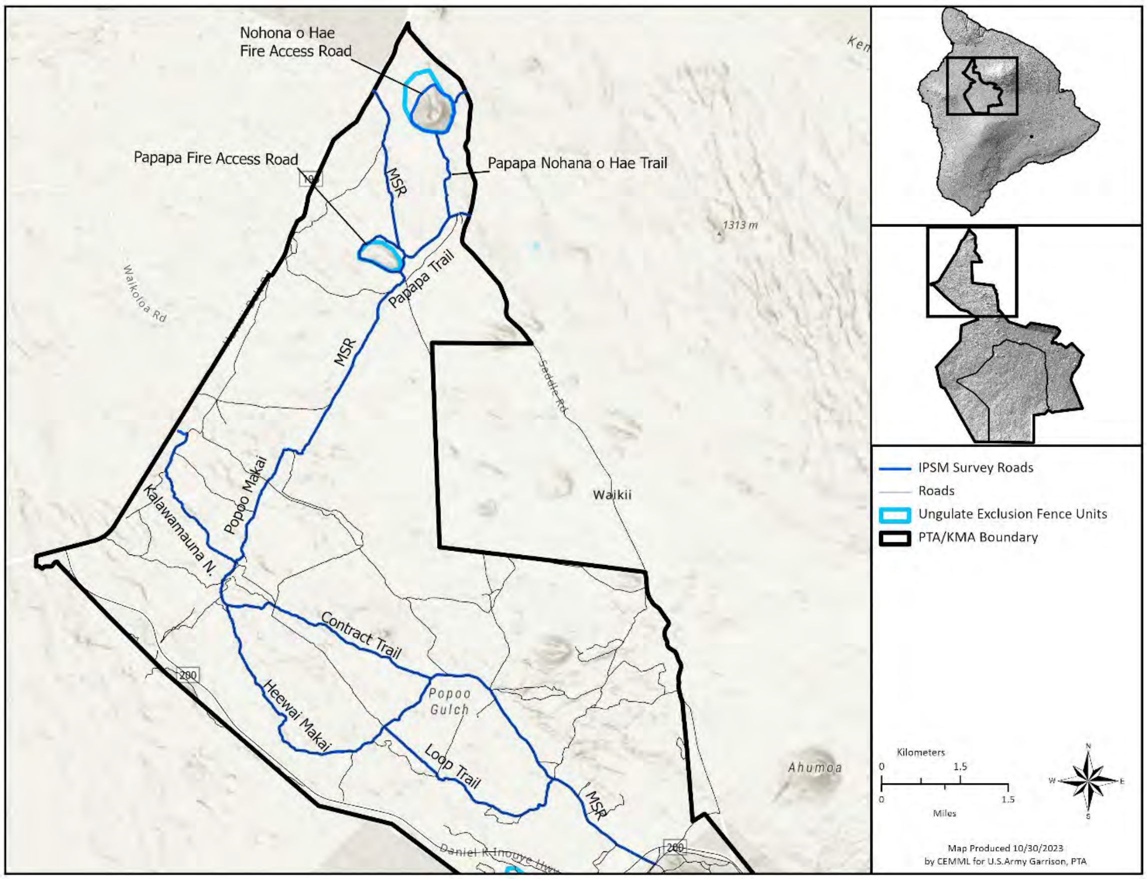


Figure 100. Invasive plant survey and monitoring roads in the Keʻāmuku Maneuver Area

In the previous reporting period, we found approximately 10 locations of the vine *Macrotyloma axillare* (perennial horse gram) along Heʻewai Makai Trail in the KMA. We targeted it for control due to its apparently limited distribution and several invasive characteristics including a smothering or climbing growth habit, drought resistance, broad climate and soil tolerance, and its ability to invade open forests and woodlands. Originally thought to be limited to a few roadside locations, we now know that the infestation stretches along approximately 2.6 km of roadside and extends outward into the grasslands for an unknown distance (at least 50 m in some areas). We suspect that *M. axillare* might be fairly widespread in the KMA and went undetected until it was found in 2021, but a full survey of the areas is needed to determine the full extent of the infestation. The species can be difficult to distinguish from *Neonotonia wightii* from a distance and is therefore difficult to see during roadside surveys. Although previously undocumented on Hawaiʻi Island, and undocumented in the state until 2003, Staples et al. (2003) state that "It is possible that *M. axillare* is more widespread in the Hawaiian Islands than the single voucher specimen indicates; this species is used as a forage and fodder crop, and it may have been planted for similar purposes in the islands." Due to the extent of the infestation and the degraded nature of the area, we have decided to suspend management of *M. axillare* in the KMA. We will control this species if found within ungulate exclusion fence units at PTA.

Table 104. Quarterly and annual surveys completed FY 2022–FY 2023

Survey Description	Survey Area	General Area(s)	Survey Units	Survey Frequency[a]
Quarterly BAAF Survey	1	BAAF	5.0 km	8
Annual Roadside Surveys	2	TA 5–16, cantonment	106.0 km	2
	3	TA 1–4, 21	61.0 km	2
	4	TA 17–20, 22–23	102.0 km	2
	5	KMA	45.0 km	2
Quarterly Construction Site Surveys	1	BAAF perimeter	3.3 km	8
	2	FIP	0.7 km	8
	5	KMARC 2021	13.3 km	2
	3	Range 1 KD	1.0 ha	6

BAAF, Bradshaw Army Airfield; FIP, Facilities Improvement Plan; KMARC, KMA Road Capping Completion; TA, Training Area; KD, Known Distance

[a] Survey frequency refers to the number of times each general area was surveyed between the beginning of FY 2022 and the end of FY 2023. 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 2022 and FY 2023.

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. 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 (1) the size of the population, (2) recommendations from local experts and published literature, (3) the herbicides and application tools currently stocked by the program, and (4) safety to human health and the environment. Methods include hand pulling and various herbicide application techniques (e.g., spraying, cut/drip, drill-squirt, etc.).

After initial control efforts are completed, we monitor documented secondary target weed locations to control any regeneration from the existing seedbank, as well as monitor efficacy of new control methods or herbicides used. We schedule monitoring and control operations based on the reproductive period for the species whenever possible to prevent the plant(s) from entering another reproductive cycle.

In general, secondary target weed species present in low numbers at PTA are treated installation-wide. 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.

Nicotiana glauca (tree tobacco), a food source and non-native host plant for larvae of the endangered *Manduca blackburni* (Blackburn's sphinx moth, BSM), is only controlled when found above the upper elevation limit of the known BSM range (1,524 m) or when young plants (<1 m height) are found on fuel breaks at any elevation. To minimize potential affects to BSM from *N. glauca* control at PTA, we follow USFWS guidance (Tim Langer, USFWS, personal communication, 29 Jan 2014) when controlling *N. glauca.*

We recorded and treated new locations of secondary target weeds when found, and monitored and treated existing locations when time and resources permitted (Table 5). These data include locations within site-specific survey grids (see Section 0) and in outlying areas across the installation.

Table 105. Results of installation-wide monitoring and control, FY 2022–FY 2023

Secondary Target Weeds	Known Locations	New Locations	Locations Treated at Least Once[a]	
Acacia mearnsii	34	0	0	
Ambrosia artemisiifolia	42	0	6	
			6	6
Centaurea melitensis	139	8	9	
Cirsium vulgare	169	3	4	
Cucumis dipsaceus	1	1	1	
Cupressus species	3	0	0	
Datura stramonium	28	3	3	
Delairea odorata	234	3	8	
Emex spinosa	109	2	3	
Eschscholzia californica	8	0	0	
Foeniculum vulgare	27	4	5	
Gomphocarpus physocarpus	287	24	35	
Grevillea robusta	76	3	5	
Heteromeles arbutifolia	2	0	0	
Kalanchoe delagoensis	59	4	13	
Lantana camara	15	1	2	
Leucaena leucocephala	123	2	3	
Lophospermum erubescens[b]	351	21	155	

Table 105. Results of installation-wide monitoring and control, FY 2022–FY 2023 (cont.)

Secondary Target Weeds	Known Locations	New Locations	Locations Treated at Least Once[a]
Macrotyloma axillare[c]	10	250	260
Melinis minutiflora	72	13	42
Neonotonia wightii	3	0	1
Nicotiana glauca[d]	1678	966	1028
Nicotiana tabacum	14	0	0
Olea europaea	8	0	2
Parthenium hysterophorus	57	1	5
Paspalum dilatatum	3	0	0
Passiflora tarminiana[b]	2295	9	40
Piptatherum miliaceum	267	0	0
Pluchea carolinensis	33	1	1
Portulaca pilosa	16	0	3
Prosopis pallida	6	0	0
Psidium guajava	2	0	0
Rhamnus californica	29	0	2
Ricinus communis	29	3	3
Rubus niveus[b]	1446	153	903
Rubus rosifolius	4	2	2
Salsola tragus	150	10	10
Sambucus nigra ssp. *canadensis*	44	0	2
Schedonorus arundinaceus	28	0	0
Schinus molle	1	0	0
Sphagneticola trilobata	1	0	0
Tribulus terrestris	28	4	5
Trifolium pratense	1	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 106) and in outlying areas across the installation.
[c] Number of locations (along 2.6 km stretch of Heʻewai Makai Trail in the KMA) are estimated for this species.
[d] Number of locations within the Infantry Platoon Battle Area (an approximately 7.4 ha infestation) are estimated for this species.

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 receive control only in delineated areas that contain or are near ASRs and/or high-quality or TES habitat. Each year these taxa expand in distribution at PTA. Due to limited personnel resources, our goal with these taxa is not necessarily eradication but rather to reduce the density and/or contain the population, thus controlling spread into TES habitat.

We survey for 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. We aim to survey most if not all grids at least once per year and to monitor and control locations within these grids 1 to 2 times per year, depending on species biology and available time and resources. When staff resources are limited, we may monitor locations within grids in lieu of surveying.

To determine the efficacy of our survey, monitoring, and control efforts, we compiled data from repeat visits to site-specific survey grids. Specifically, we looked at the change in (1) the number of live plant locations, (2) the number of live individuals, and (3) the number of locations with reproductive individuals over the reporting period (Table 106).

Currently, there are survey grids in Kīpuka ʻAlalā in TA 23 for *Passiflora tarminiana* (Figure 101), *Rubus niveus* (Mysore raspberry; Figure 102), and *Lophospermum erubescens* (roving sailor; Figure 103). There are also survey grids for *P. tarminiana* and *L. erubescens* in TA 22 (Figure 101 and Figure 103, respectively). Kīpuka ʻAlalā is a resource-rich area, providing habitat for several forest birds and the Hawaiian hoary bat (*Aeorestes semotus*), and hosting wild 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 fungal disease Rapid ʻŌhiʻa Death (see Section 3.3.5 for more details).

We must weigh many factors when deciding which secondary target species to focus our limited resources on for site-specific survey and control operations. We focus our efforts on the 3 species noted above because they are considered ecosystem changers and we have invested consistent management effort in containing the spread of these species over several years. There are other secondary target species for which we don’t apply the same effort due to (1) our limited resources, (2) their widespread distribution across the installation, (3) remoteness of locations, and (4) feasibility of control.

<u>Passiflora tarminiana</u>

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. We focused our efforts this reporting period on controlling locations of *P. tarminiana* in TA 22, where this vine has begun establishing itself in recent years. We continued monitoring and control efforts in 2 grids in TA 22 (Pastar 22A and Pastar 22B, Figure 101). We did not have the resources to continue survey, monitoring, and control efforts in Kipuka ʻAlalā (Pastar NKA, Figure 101), where *P. tarminiana* is present in great densities. For an infestation as large as the one in Kipuka Alalā, biocontrol is likely the only efficient control strategy.

Table 106. Results of site-specific survey, monitoring, and control, FY 2022–FY 2023

				No. Live Locations			No. Live Individuals			No. Reproductive Locations		
Species[a]	Grid	Hectares Surveyed	Visit Frequency[b]	Start	End	% Change	Start	End	% Change	Start	End	% Change
Lophospermum erubescens	Loperu01A	19.5	4	15	16	7	65	50	-23	2	5	150
	Loperu01C	4.6	2	1	1	0	1	2	100	1	1	0
	Loperu01D	1.0	1	0	0	N/A	0	0	N/A	0	0	N/A
	Loperu01E	1.9	3	1	2	100	8	13	63	0	0	N/A
	Loperu02	4.4	3	15	8	-47	27	53	96	3	1	-100
	Loperu03	1.5	3	2	3	50	5	9	80	0	1	N/A
	Loperu04	2.6	3	4	3	-25	12	4	-67	0	0	N/A
	Loperu05	3.4	4	2	1	-50	6	3	-50	1	0	-100
	Loperu06	14.1	4	23	23	0	121	77	-36	4	1	-75
	Loperu07	1.7	1	0	0	N/A	0	0	N/A	0	0	N/A
	Loperu08	2.3	4	3	2	-33	14	7	-50	4	0	-100
	Loperu09	1.7	3	1	1	0	15	50	233	0	0	N/A
	Loperu11	2.1	3	1	4	300	2	8	300	0	0	N/A
Passiflora tarminiana	Pastar22A	19.0	3	0	1	N/A	0	1	N/A	0	0	N/A
	Pastar22B	32.2	3	24	17	-29	122	72	-41	7	9	29
Rubus niveus	Rubniv01	59.2	2	166	305	84	474	1767	273	21	99	371
	Rubniv02	41.6	3	170	282	66	488	1082	122	5	47	840
	Rubniv03B	12.2	4	32	1	-97	61	1	-98	7	1	-86

a Lophospermum erubescens, Passiflora tarminiana, and Rubus niveus are managed installation wide. Note that plant locations presented in Table 6 are a subset of those presented in Table 105.
[b] Visit frequency includes both survey and monitoring efforts. Both types of visits include control.

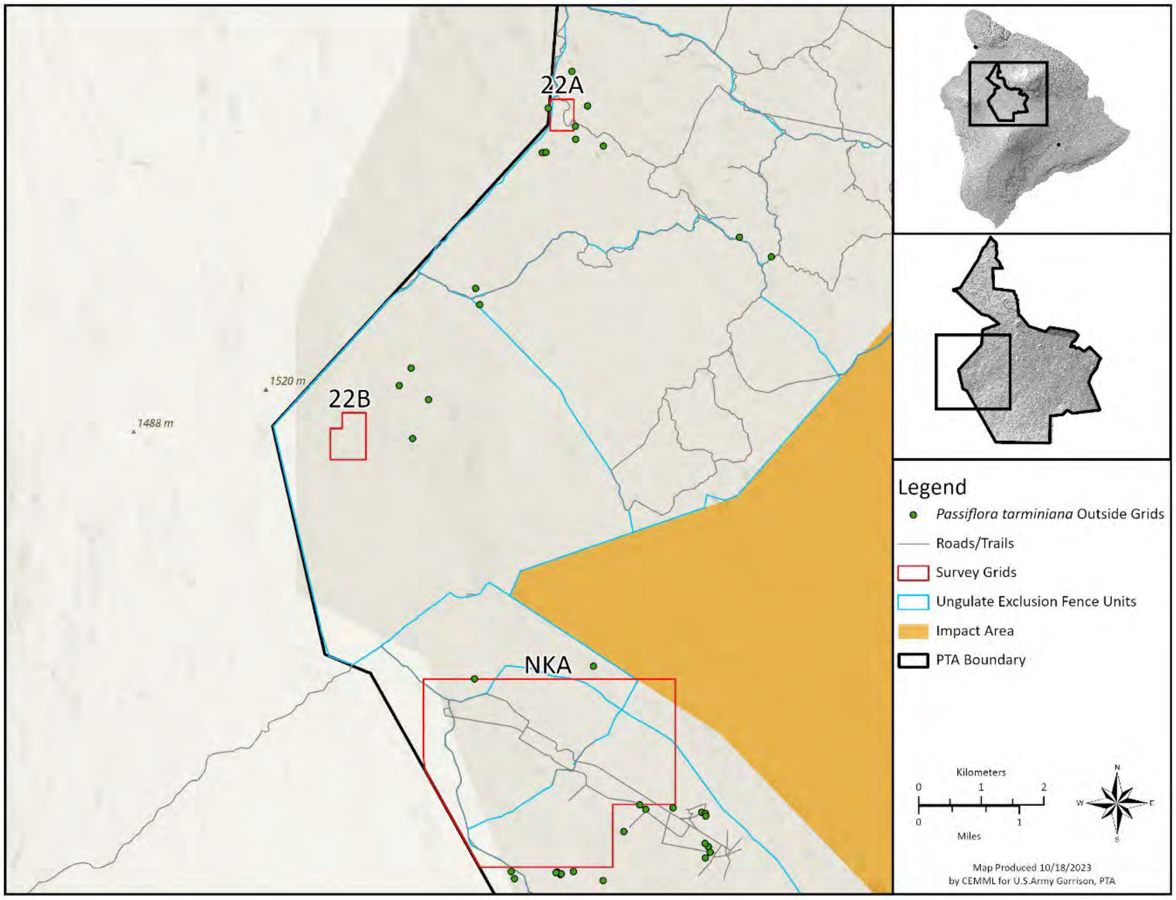


Figure 101. *Passiflora tarminiana* site-specific survey grids and known locations outside grids at Pōhakuloa Training Area

We monitored plant locations within grids Pastar 22A and Pastar 22B 3 times each (Table 106). In grid Pastar 22A, although we saw an increase of 1 live plant location and an increase of 1 living individual, *P. tarminiana* numbers remain low within the grid and no reproductive individuals were present at the end of the reporting period. In fact, over the course of the reporting period, only 1 reproductive individual was found—after an 8-month interval since the previous monitoring effort—and this individual had not yet produced fruit. In grid Pastar 22B, we saw a decrease in both the number of live locations and the number of living individuals, although the number of locations with reproductive individuals increased. Despite the slight increase over this reporting period, the number of locations with reproductive individuals in grid Pastar 22B is still less than half the number we found when we started regular control efforts in FY 2021, down from 23 to 9.

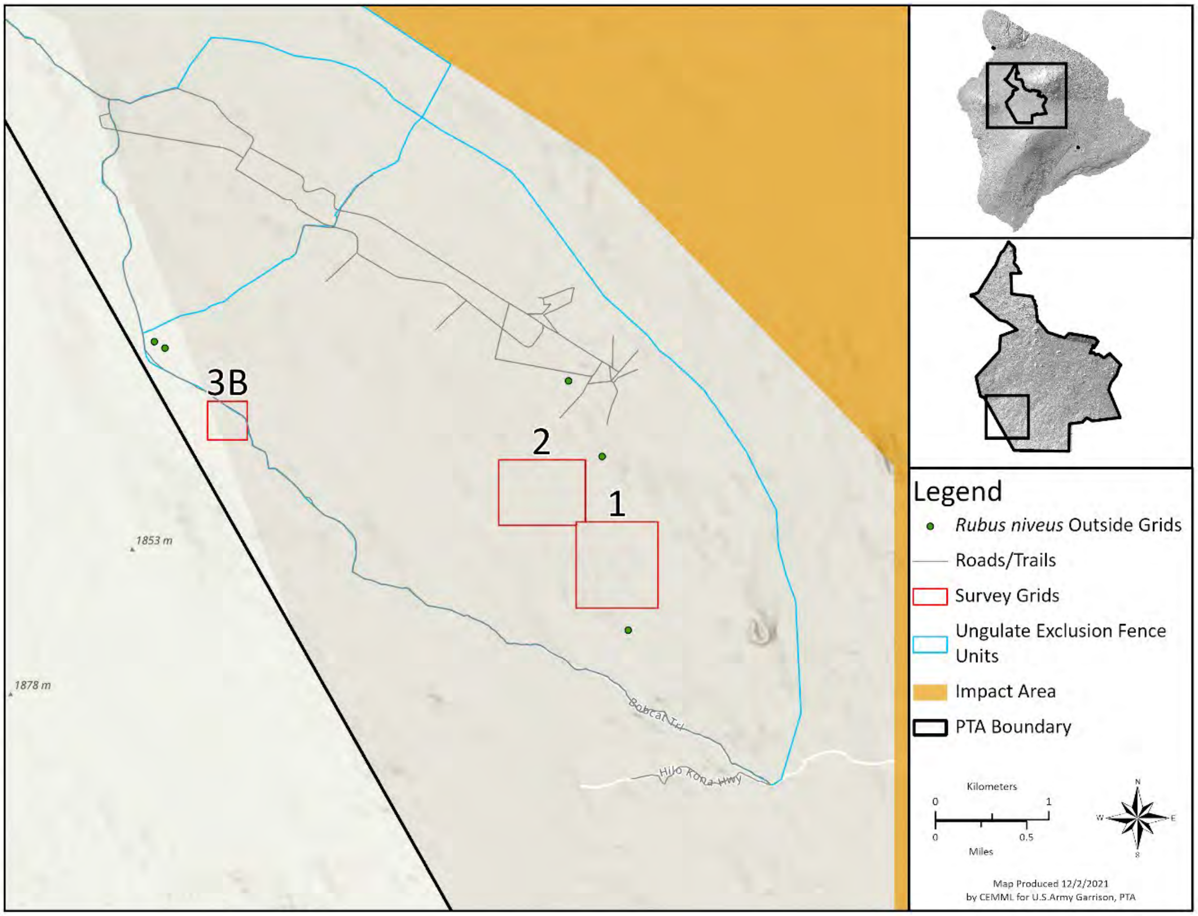


Figure 102. *Rubus niveus* site-specific survey grids and known locations outside grids at Pōhakuloa Training Area

Rubus niveus

R. niveus is an invasive shrub that forms dense, impenetrable thickets due to its arching and intertwining stems. It displaces native vegetation, impedes regeneration of native shrubs and trees, and impacts wildlife habitats (Weber 2003). All infestations for *R. niveus* are in Kīpuka ʻAlalā (Figure 102), with no individuals documented in other areas of the installation.

Grids Rubniv 1 and Rubniv 2 pose challenges for management. Their remoteness and size mean that many staff hours are required to manage *R. niveus* within these grids even minimally (i.e., only monitoring known locations). Combined with recent reductions in staff and the need to prioritize multiple projects, these challenges have made it difficult to survey or monitor these grids more than once a year.

Over the 2-year period, we surveyed grid Rubniv 1 once, and monitored plant locations within the grid once (Table 106). We did not survey grid Rubniv 2, although we did monitor plant locations within the grid 3 times. We saw sizable increases in both grids in all 3 metrics: (1) number of live locations, (2) individuals, and (3) reproductive locations.

Grid Rubniv 3B is smaller and easier to access than the other 2 *R. niveus* grids. Monitoring within this grid can be completed by a single person. We surveyed the grid once and monitored plant locations within the grid 3 times (Table 106). We saw considerable decreases in the number of live plant locations, the number of individuals, and the number of locations with reproductive individuals.

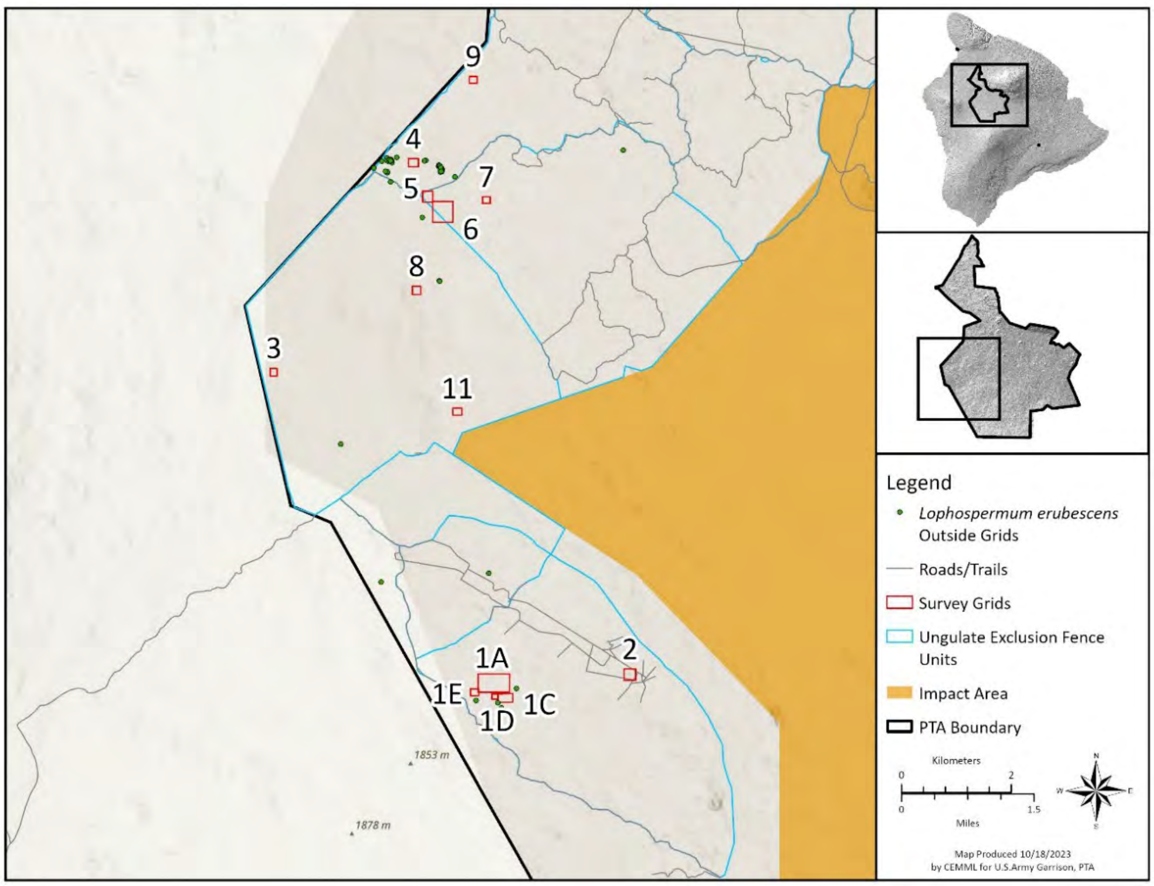


Figure 103. *Lophospermum erubescens* site-specific survey grids and known locations outside grids at Pōhakuloa Training Area

Lophospermum erubescens

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 Hawaiʻi, and control of this species was a key objective during this reporting period. There are 13 active grids for *L. erubescens* at PTA (Figure 103). We visited each of these grids at least once, with most being visited 3-4 times—including survey and control efforts and monitoring and control efforts (Table 106). The grids that we visited only once were either more remote or did not have plants in them for over a year. We expanded 1 grid (Loperu 1C) from 1.8 ha to 4.6 ha in February 2023 because we found additional plant locations outside the original grid.

The number of live plant locations decreased in 4 of the 13 *L. erubescens* grids, did not change in 5 grids, and increased in 4 grids (Table 106). The number of individuals decreased in 5 of the grids visited, did not change in 2 grids, and increased in 6 grids. The number of plant locations with reproductive individuals decreased in 4 of the grids, increased in 2 grids, did not change in 1 grid. In 6 grids, plants were never present. Overall, we have maintained low numbers of *L. erubescens* in most if not all grids, and any increases for all 3 metrics were minimal.

Results of control efforts for 2 of the more densely populated grids are displayed graphically below (Figure 104 and Figure 105).

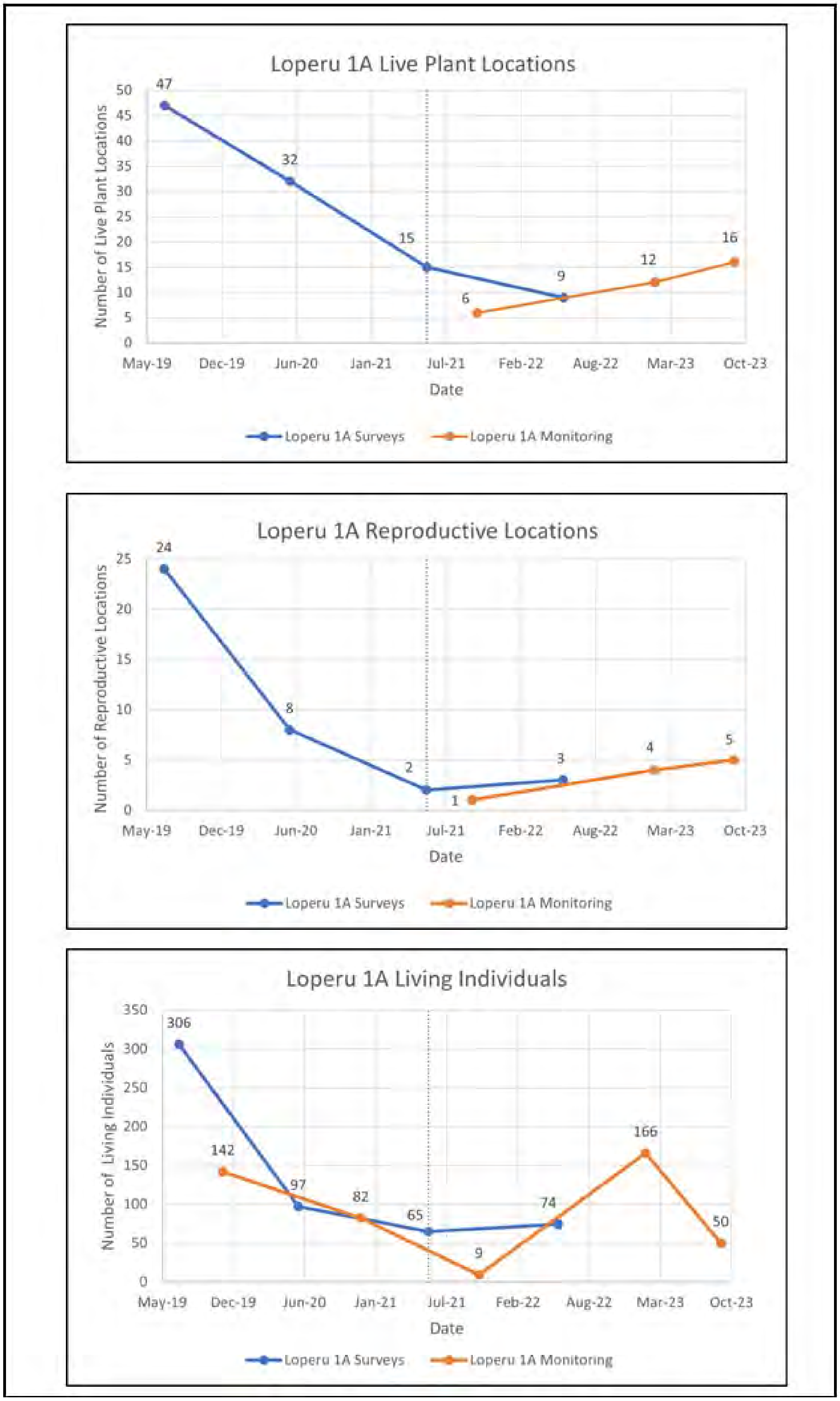


Figure 104. Graphs showing changes in number of live plant locations, reproductive locations, and live individuals in the *Lophospermum erubescens* (Loperu) 1A site-specific survey grid at Pōhakuloa Training Area. Dashed vertical lines represent the date the grid was expanded

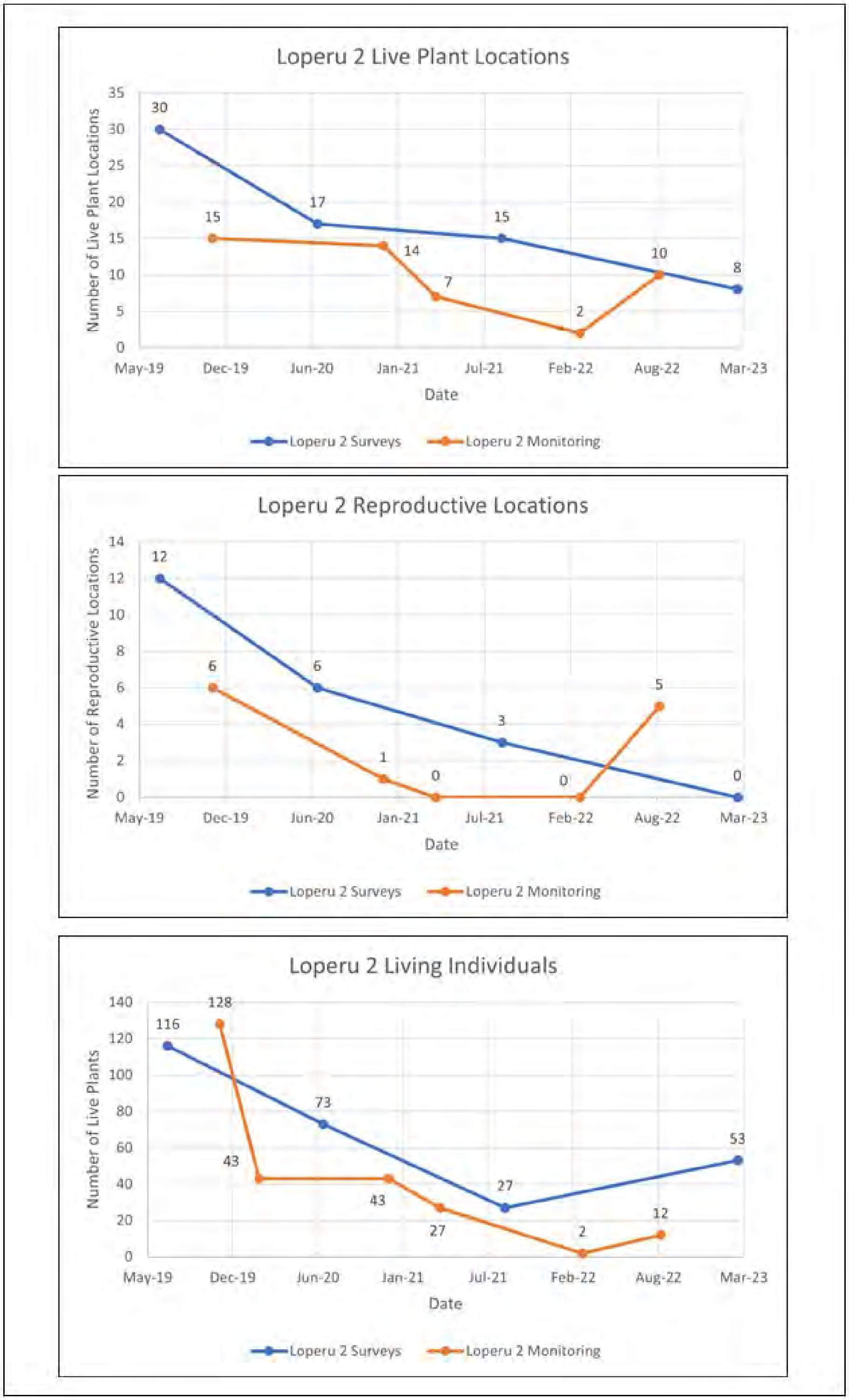


Figure 105. Graphs showing changes in number of live plant locations, reproductive locations, and live individuals in the *Lophospermum erubescens* (Loperu) 2 site-specific survey grid at Pōhakuloa Training Area

3.3.5 Rapid ʻŌhiʻa Death Survey, Monitoring, and Sampling

Rapid ʻŌhiʻa Death (ROD) is a new fungal disease that attacks and kills ʻōhiʻa (*M. polymorpha*), the most abundant native tree and important keystone species in the state of Hawaiʻi. Two 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, affecting a tree more slowly and requiring several infections to kill a tree.

Because PTA harbors approximately 5% (approximately 11,480 ha) of the total distribution of ʻōhiʻa forests on Hawaiʻi 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 are needed 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. Using State of Hawaiʻi Department of Land and Natural Resources guidance, Big Island Invasive Species Committee and CEMML NRP personnel conducted aerial surveys of PTA ʻōhiʻa forests via helicopter in December 2021 and January 2023. No trees suspected of having ROD were observed. 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. We satisfied our requirements for quarterly surveys at BAAF and implemented roadside surveys per the schedule. 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. Preventing the establishment of new invasive species typically requires less time, effort, and funding than responding to and managing infestations of new invasive species.

Compared to the last reporting period, we spent almost twice as much effort monitoring and controlling target weeds outside of survey grids. We do not focus these efforts on large dense infestations in disturbed areas. In places where we focus our efforts, we continue to see progress in reducing plant numbers and/or locations. We are working toward prioritizing species by location depending on their localized infestation.

Our data show that we continue to make progress in reducing plant abundance and distribution in most if not all site-specific survey grids we visited regularly. During the prior reporting period (FY 2020 to 2021), we increased regular survey, monitoring, and control efforts following a period of negligible effort due to staff vacancies and other project priorities. Our data showed dramatic decreases in plant abundance and distribution during that time. Our data for FY 2022 to 2023 do not show the same dramatic decreases. However, we believe better indicators of success at this time are low levels of both live and reproductive target weed locations.

Although we saw notable decreases in both live locations and individuals in Pastar 22B (-29% and -49%, respectively), reproductive locations increased, but only minimally (from 7 to 9). While the data trends for our 3 metrics in the 13 grids for *L. erubescens* are more variable, the numbers are relatively low and any increases we observed are minimal for all 3 metrics. Further, increases in individuals tended to be young seedlings. Anecdotally, it seems that after approximately 4 years of repeat control efforts, longer intervals between visits may be sufficient to maintain *L. erubescens* grids. Initially, it appeared necessary to visit grids every 4 months to maintain adequate control; more recently, grids seem manageable if visited every 6 months. We anticipated that this would be the case, with target weed locations and grids requiring less effort over time when consistent management is applied over several years. More concerning is the sizable increases in all 3 metrics within the remote grids for *R. niveus* (Rubniv 1 and Rubniv 2) where numbers are staggering. Although the number of reproductive locations in both grids are still much lower than they were when we started regular control efforts during FY 2020 to 2021—the number of reproductive locations in Rubniv 1 decreased by 2.5-fold and the number of reproductive locations in Rubniv 2 decreased by 4.4-fold—we will continue to see increases in plant locations and individuals until the seed bank is exhausted. This underscores the need for more frequent visits to these grids to maintain progress we made but will require more staff and resources.

Due to recent staff shortages, we decreased our efforts in site-specific survey grids by almost half. Despite this, we were successful at maintaining low numbers of secondary target weeds in most grids, although we lacked the resources to provide optimal control in the larger, more remote grids, particularly Rubniv 1 and Rubniv 2. However, to maintain and increase current control for these highly invasive plants, increased capacity, staffing, and funding is required.

Addressing aggressive secondary target weeds (e.g., *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 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.

We continued drafting a technical report detailing the (1) status, (2) locations, (3) habitat, and (4) biology of each secondary target weed species at PTA. We formed a project team and have worked towards the goal of re-evaluating 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. We began revising the IPSM protocol to clarify these methods and strategies. We plan to continue re-evaluating our methods and overall approach in the next year, and to continue to reassess our data collection and analyses to improve our ability to quantify our control efforts and make valid comparisons to evaluate control methods and management strategies over time.

3.4 FUELS MANAGEMENT

3.4.1 Introduction

Fuels management meets SOO tasks 3.2.4.2 and 3.2.4.3 and addresses INRMP objectives and conservation measures in the 2003 and 2013 BOs. Our mission is to implement the Army's Integrated Wildland Fire Management Plan (IWFMP) 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 IWFMP (USAG-PTA 2021).

We create and maintain firebreaks, fuel breaks, and fuel monitoring corridors (FMC) identified in the IWFMP aimed at protecting ESA-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 2003a, USFWS 2013a).

Currently, the Fuel Break System consists of 14 fuel breaks totaling approximately 61.5 km (Figure 106). 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-PTA 2021) dictate that fuel breaks be maintained at less than 20% crown cover via ocular estimation, with 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.

Together, the Fuel Break System and FMCs protect valuable natural resources, including TES habitat and ESA-listed plants, from wildland fires on the installation. Fuel breaks are designed to help firefighters conduct firefighting 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 Kālawamauna Endangered Plants Habitat (KKEPH), divides the area into discrete cells (Figure 106). The idea is that a single catastrophic fire event will not destroy all individuals of a species that are located in more than 1 cell and gives firefighters several lines of defense for backburning operations. FMCs, described in Section 1.4.3 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. Most FMCs are located around the border of the Impact Area, so they generally 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.

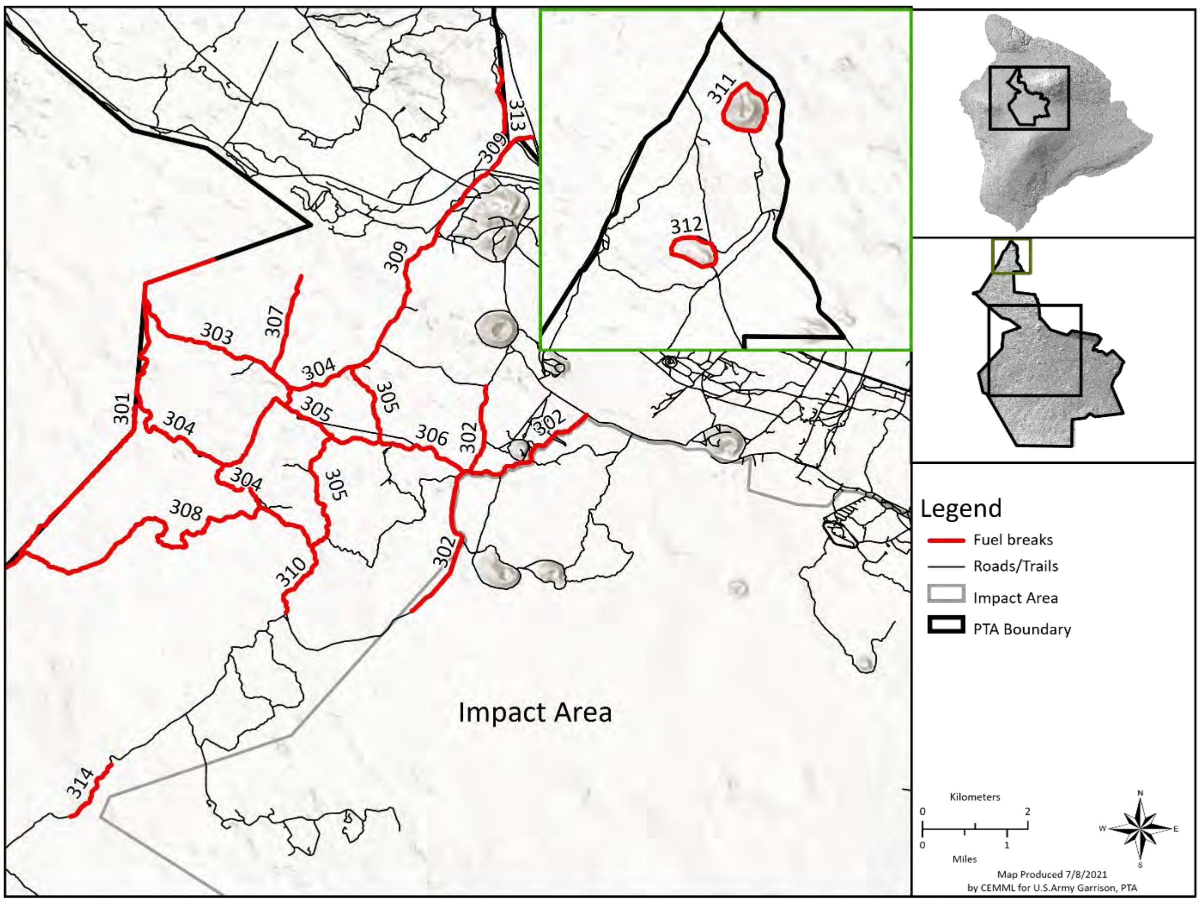


Figure 106. Fuel Break System at Pōhakuloa Training Area

3.4.2 Maintenance of Fuel Breaks

We have fully implemented all fuel breaks and are currently maintaining fuels (Table 107). 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.

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 107). The gap shown for the ʻAlalā FMC at the westernmost extent of the Impact Area (Figure 107) is where FB 314 is located (Figure 106).

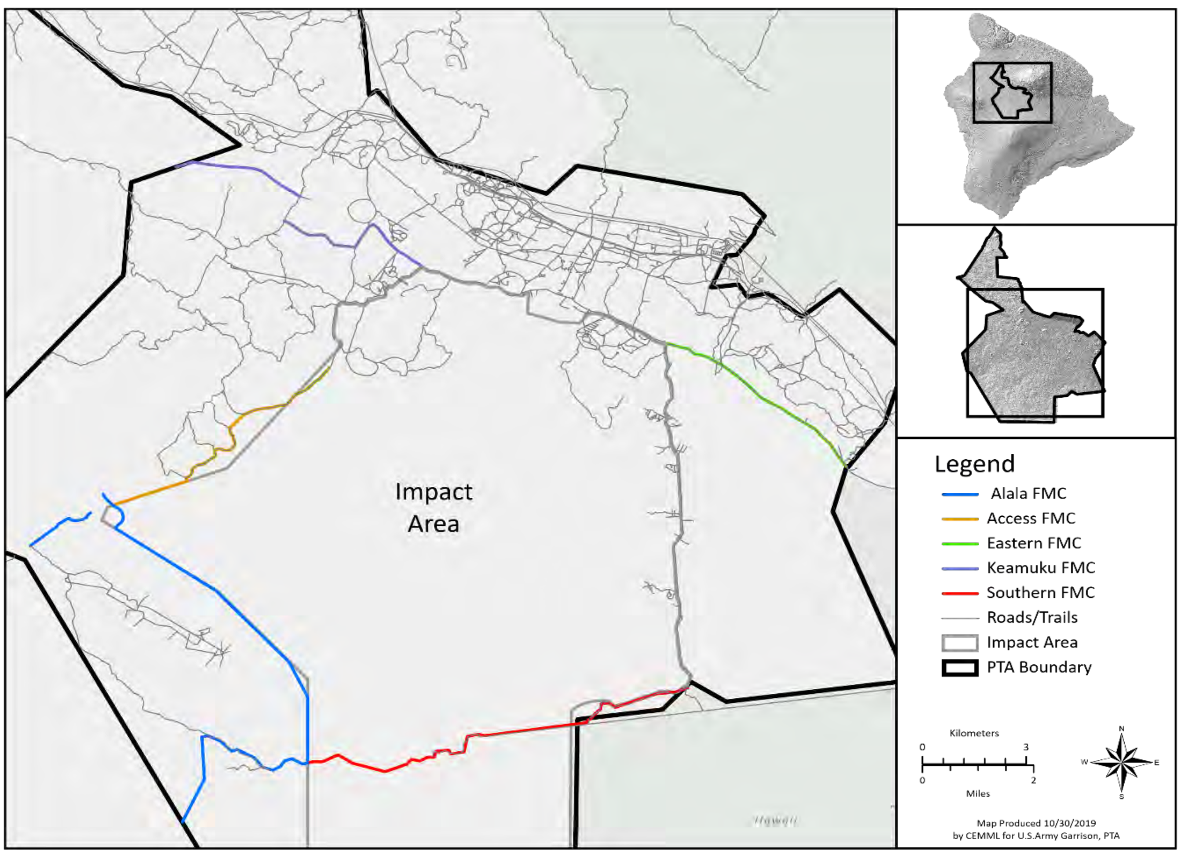


Figure 107. Fuel monitoring corridors at Pōhakuloa Training Area

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. Because 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 (1) review of imagery, (2) plotting a course, and (3) flying over the FMCs via helicopter to make ocular estimates of fuels cover to determine if they are contiguous. FMCs are described in more detail in the current IWFMP (USAG-PTA 2021).

We monitored the FMCs in calendar year 2020. Results and subsequent actions of that effort were detailed in an MFR to the Army. Based on results of the assessment, no management of surface fuels is required at this time. However, we identified 2 areas where invasive grasses may need management in the future, or implementation of a fuel break/firebreak combination. One area is within the Keʻāmuku FMC and the other is within the Access FMC. We plan to monitor the FMCs again in CY 2025.

Table 107. Assessment and maintenance effort for fuel breaks, FY 2022–FY 2023

Fuel Break (FB)	Length (m)	Action	Frequency
301A	4,457	Assess FB	2
		Shrub/limb	2
		Spray	4
301B	2,380	Assess FB	7
		Spray	7
301C	1,687	Assess FB	5
		Spray	7
302A	2,858	Assess FB	3
		Spray	4
302B	1,946	Assess FB	6
		Shrub/limb	1
		Spray	7
302C	3,223	Assess FB	3
		Spray	6
303	3,564	Assess FB	7
		Spray	9
304A	2,015	Assess FB	5
		Spray	9
304B	1,440	Assess FB	4
		Spray	6
304C	3,192	Assess FB	6
		Spray	7
304D	2,248	Assess FB	4
		Spray	5
305A	1,768	Assess FB	5
		Spray	6

Table 107. Assessment and maintenance effort for fuel breaks, FY 2022–FY 2023 (cont.)

Fuel Break (FB)	Length (m)	Action	Frequency
305B	2,186	Assess FB	6
		Shrub/limb	1
		Spray	10
305C	2,586	Assess FB	8
		Shrub/limb	1
		Spray	9
306	1,899	Assess FB	8
		Shrub/limb	1
		Spray	9
307	2,007	Assess FB	7
		Spray	8
308	5,929	Assess FB	4
		Shrub/limb	1
		Spray	3
309A	3,041	Assess FB	7
		Spray	8
309B	1,055	Assess FB	2
		Spray	4
309C	1,627	Assess FB	2
		Spray	3
310	2,212	Assess FB	7
		Shrub/limb	1
		Spray	4
311	2,719	Assess FB	7
		Mow	4
		Spray	8
		Weed whack	8
312	2,337	Assess FB	7
		Mow	3
		Weed whack	5
313	1,761	Assess FB	6
		Mow	2
		Weed whack	2
314	1,434	Assess FB	7
		Spray	7
Total	**61,570**		

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-PTA 2021). The USAG-PTA IWFMP (2021) was finalized in January 2022 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 July and August 2022, the Leilani wildland fire occurred in Training Area 22 at PTA (CEMML 2023f). The fire affected about 2,126 ha of threatened and endangered species habitat at the installation. Although firefighters presumably used fuel breaks/firebreaks to battle the fire, it is unclear how well the breaks functioned because the fire spread rapidly in extremely high wind conditions. However, as mentioned in Section 3.2.4, several actively managed WCBs may have played a role in preventing losses to ESA-listed plants located within them because fine fuels, specifically fountain grass (*Cenchrus setaceus*), were maintained to less than 20% cover. Our analyses of burn severity in the fire footprint indicate that management in WCBs (e.g., fuels removal) resulted in less burned vegetation and therefore lesser impacts to ESA-listed plants and their habitat (CEMML 2023f). Refer to Section 8.0 for more details about the Leilani Fire and the assessment of impacts to federally listed species at PTA.

Continued support for fuels control on the Fuel Break System helps to reduce losses of ESA-listed plants. Loss of ESA-listed plants due to wildland fire can require 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. Fuels 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 for the Invasive Plants Program

At PTA, management of invasive plant species is essential to help conserve native habitats that support TES and species at risk[20]. 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 vegetation control within ASRs, at HFNWR, and along the Fuel Break System.

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. 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

[20] 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).

addition, our observations from past years 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.

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 (Boice et al. 2010). Likewise, control of secondary target weeds at newly found satellite locations, especially in high quality or TES habitat, is more cost effective and creates fewer 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 to prevent impacts to TES and high-value resources. Results from our data of site-specific survey grids indicate that maintaining efforts in survey, monitoring, and control are having the desired effect of decreasing secondary target weed species metrics in several grids. However, when we are unable to apply consistent and sustained management due to lack of resources, increases in these metrics occur and we lose momentum in our progress. In addition, the Army partners with the State of Hawaiʻi to manage invasive species and fuels on State lands adjacent to PTA via the Department of Defense Readiness and Environmental Integration Program (REPI). See Section 7.6.3 for information regarding REPI projects.

Our fuels management actions contributed to a positive outcome for ESA-listed plants during several wildfires in past years. Although we do not know specifically how well these fuel breaks functioned during the Leilani fire in July and August of 2022, we assume they were critical for firefighters in responding to and battling the intense fire. Continued maintenance of the 61.5 km of conservation fuel breaks is crucial to mitigate impacts to TES from future wildland fires at PTA and is essential to the PTA Fire Department in fire suppression and containment efforts, underscoring 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 2024. 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 presence and assess the distribution of ESA-listed animals to inform species management, guide military training and range development, and report status. In addition, we manage introduced and invasive animals to reduce negative impacts on TES and their habitats.

To manage wildlife resources at PTA, we implement SOO tasks 3.2.2.1 through 3.2.2.5 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 hoary bat (*Aeorestes semotus*), Band-rumped Storm Petrel (*Hydrobates castro)*, Hawaiian Petrel (*Pterodroma sandwichensis*), anthricinan yellow-faced bee (*Hylaeus anthracinus*), and Blackburn's sphinx moth (*Manduca blackburni*). Since 2006, 12 additional bird species protected under the MBTA have been observed at PTA (USAG-PTA2020).

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 hoary bat, and 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 December 2019, USFWS finalized a ruling to downlist the Hawaiian Goose from endangered to threatened with a Section 4(d) rule (USFWS 2019). Despite the downlisting, all previous measures, conditions, and terms from previous consultation documents remain unchanged.

In January 2020, the USFWS finalized a ruling to remove the Hawaiian Hawk (*Buteo solitarius*) from the federal list of endangered and threatened wildlife (USFWS 2020b). Monitoring and management for the Hawaiian Hawk will be implemented under the INRMP and in accordance with the Migratory Bird Treaty Act. In 2016, we determined that Hawaiian Petrels do not use land-based habitat at PTA; rather, they fly over the installation (CEMML 2016). Therefore, we will continue to record Hawaiian Petrel sightings at the installation.

In May 2020, the Army completed an informal consultation with USFWS for predator control at a Band-rumped Storm Petrel colony during the breeding season at PTA. The Army received concurrence from USFWS with the determination that the Army's proposed actions (nest survey with detector dogs and predator management) may affect, but is not likely to adversely affect, the Band-rumped Storm Petrel (USFWS 2020a). In December 2020, the Band-rumped Storm-Petrel was added to the federal recovery permit (TE40123A-3).

In December 2021, the Army was provided a signature of approval copy for the state permit, Protected Wildlife Permit, for the purpose of scientific collecting (WL21-15) that authorizes us to complete our field work at PTA for the Band-rump Storm Petrel project.

In April 2019 and April 2022, the Army received approval for 2 federal permits (Regional Migratory Bird Permit Office), scientific collecting with import /export permit, MB95880B-0 and MB95880B that authorize collecting Band-rump Storm Petrel carcasses or salvage materials in the field.

On 15 October 2021, 16 September 2022, and 19 September 2023, the Army received 3 federal permits, Special Use Permits (SUP) 12516-21020-G, 12516-22023-R, and 12516-23020-R that authorizes conservation activities for the Hawaiian Goose at HFNWR.

We have not consulted with the USFWS under section 7(a)(2) of the ESA for Band-rumped Storm Petrel, anthricinan yellow-faced bee, or Blackburn's sphinx moth. Without an ESA consultation, these species lack formal conservation measures[21]. The Army is in the process of preparing a Programmatic Biological Assessment to consult with the USFWS under section 7(a)(2) of the ESA for listed animal species that occur at or around PTA, as well as the 20 species of listed plants. Reporting requirements for anthricinan yellow-faced bee and Blackburn's sphinx moth will be addressed in future reports.

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 3.2.2.1 and 3.2.2.2 and projects implemented under the Wildlife Threats Management Section address SOO tasks 3.2.2.3, 3.2.2.4, and 3.2.2.5. For a list of drivers for each of the projects and sections in the Wildlife Program, please refer to Appendix C.

[21] The text reflects the status of the PBA during the report period (01 October 2021 through 30 September 2023). Since, the Army has worked to develop additional wildland fire planning and preparedness documents to support the PBA preparation process and the fire model used for the effects analysis was updated with data from wildland fires that occurred in 2021 and 2022.

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 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 Hawaiian Petrel presence and habitat use at PTA.
- Monitor Band-rumped Storm Petrels and manage conditions to promote nesting success.
- Monitor Palila (*Loxioides bailleui*) presence and habitat use at PTA.
- Monitor avian species listed under the MBTA presence and habitat use at PTA.
- Monitor 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.
- Educate military unit leaders (e.g., Commanders, Officers in Charge, Range Safety Officers, and Non-commissioned Officers) to avoid and minimize take and negative impacts to ESA-listed species.

4.2.2 Hawaiian Goose Management at Pōhakuloa Training Area

We manage for Hawaiian Geese at PTA to meet SOO tasks 3.2.2.1 and 3.2.2.2 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 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).

Hawaiian Goose Monitoring

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, contractors, 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 historical, 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 108).

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. Systematic surveys were conducted year-round, 1 day per week. 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.

Systematic Monitoring Results

From FY 2022 to FY 2023, in the core management areas, we recorded a total of 17 goose observations during 8 of 407 surveys (Table 108). Geese were observed only at Forward Operating Base (FOB) Warrior Search Area and BAAF. From the leg-band information, we confirmed that 5 individuals with unique leg bands visited these areas.

Table 108. Hawaiian Goose systematic monitoring data and leg-band information in core monitoring areas, FY 2022–FY 2023, at Pōhakuloa Training Area

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	83	0	0	0	0	0
FOB Warrior Search Area	109	6	14	3	4	6
Bradshaw Army Airfield	104	2	3	2	0	1
Training Areas 6 and 7	111	0	0	0	0	0

FOB, Forward Operating Base

[a] Total goose observations include 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.

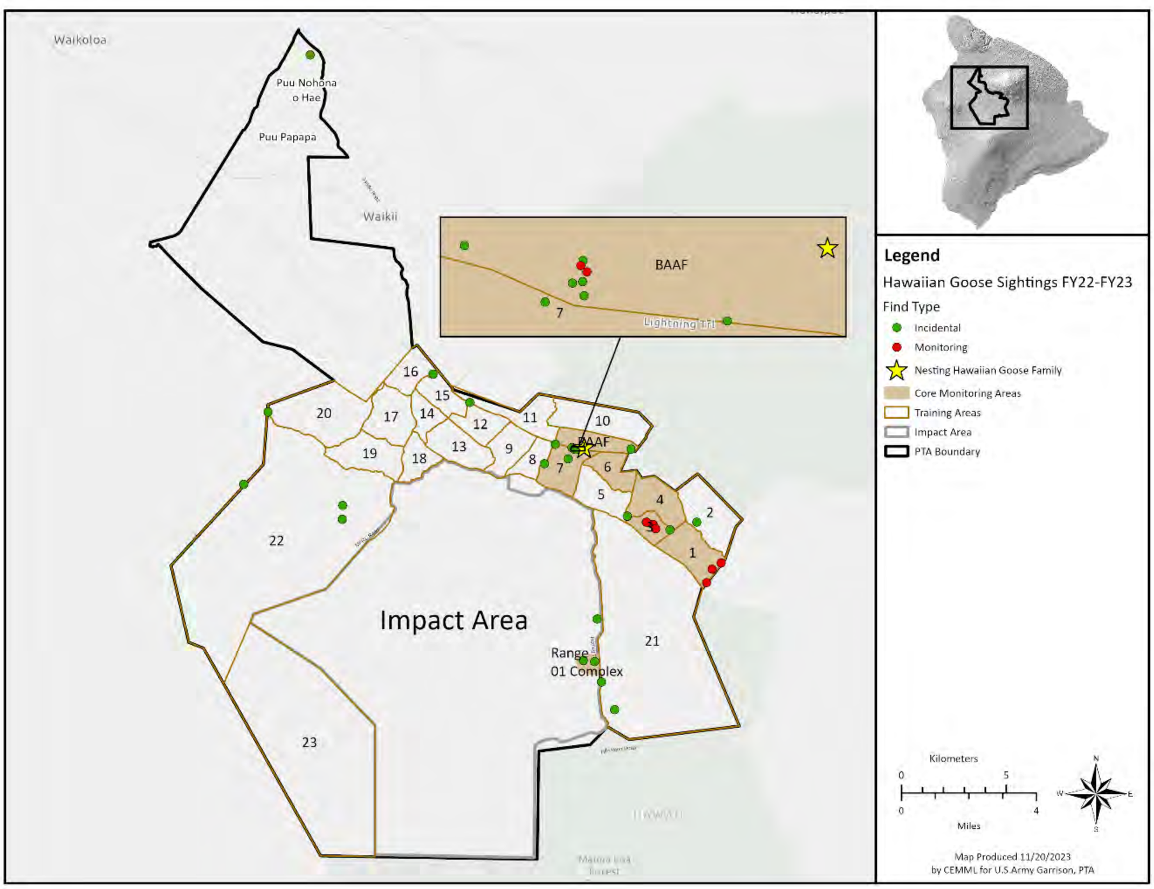


Figure 108. Hawaiian Goose sightings, FY 2022–FY 2023, in core and non-core monitoring areas at Pōhakuloa Training Area

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.

Systematic Monitoring Results

From FY 2022 to FY 2023, in the core management areas, we recorded a total of 17 goose observations during 8 of 407 surveys (Table 109). Geese were observed only at FOB Warrior Search Area and BAAF. From the leg-band information, we confirmed that 5 individuals with unique leg bands visited these areas.

Table 109. Hawaiian Goose systematic monitoring data and leg-band information in core monitoring areas, FY 2022–FY 2023, at Pōhakuloa Training Area

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	83	0	0	0	0	0
FOB Warrior Search Area	109	6	14	3	4	6
Bradshaw Army Airfield	104	2	3	2	0	1
Training Areas 6 and 7	111	0	0	0	0	0

FOB, Forward Operating Base

[a] Total goose observations include 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.

Incidental Sightings Methods

We received and managed incidental goose reports from CEMML staff, military units, contractors, and other PTA personnel. 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. We managed incidental sightings to help track the distribution of goose activity patterns at PTA and to determine if systematic monitoring of new areas was warranted.

Incidental Sighting Results

In the core monitoring areas, we observed a total of 37 geese (all observations pooled including repeat visits) from 16 incidental sighting events (Table 110). From the 37 observations, we identified 12 individual geese by their unique leg bands. One goose lacked a leg band and we were unable to determine the presence of leg bands for the other 22 observations; therefore, we cannot determine the number of individual birds these observations represent.

In non-core monitoring areas, we observed a total of 28 geese (all observations pooled including repeat visits) from 10 incidental sighting events. From the 28 observations, we identified 1 individual goose by its unique leg bands, but we were unable to determine the presence of leg bands for the other 27 observations; therefore, we cannot determine the number of individual birds these observations represent.

Table 110. Hawaiian Goose incidental sightings by location and leg-band information in core and non-core areas, FY 2022–FY 2023, at Pōhakuloa Training Area

Survey Area	Incidental Sighting Events	Total Goose Observations[a]	With Bands	W/out Bands	Band not Identified
Core Areas					
Range 1 Complex	3	13	2	0	11
FOB Warrior Search Area	4	8	3	0	5
Bradshaw Army Airfield	3	6	3[c]	0	1
Training Areas 6 and 7	6	10	4	1	5
Non-Core Areas	10	28	1	0	27

FOB, Forward Operating Base

[a] Total goose observations included repeat visits of geese with leg-bands and repeat visits of birds without bands or when the bands could not be identified.

[b] Repeated observations of unique leg band goose. Three total geese were observed at FOB, but 1 goose was previously seen before in another 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.

Targeted Monitoring Results

On 27 March 2023, 2 banded geese (Grey/Black A97 and Green/White KZP) were observed molting at BAAF. Between March 27 to April 24, the geese were monitored and predator control was implemented.

On 21 April 2023, another banded goose (Grey/Black A98) and 3 goslings were observed with the other 2 banded geese. On April 24, we assisted State of Hawaiʻi Department of Forestry and Wildlife (DOFAW) personnel in the capture and translocation of the goose family (Grey/Black A97 and A98 and 3 gosling) away from BAAF. These geese were safely captured with long-handled nets and caged in a large plastic animal carrier. Green/White KZP was not captured; it remained at BAAF and was last seen on 17 July 2023. For more information regarding the goslings' discovery and the capture and translocation of the goose family, please refer to Appendix E. The nest was also discovered and contained several eggshell fragments and 1 unhatched egg (Figure 108).

Other Survey Efforts

We did not detect geese at PTA during the statewide annual Hawaiian Goose surveys. Surveys occurred 28 July 2022 and 24 August 2023. These surveys are coordinated by DOFAW, and we have participated since 2016.

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 (e.g., 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 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 manage potential disruptions to military activities more efficiently.

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 and across years.

To review activity patterns for FY 2019 through FY 2023, goose observations recorded during systematic surveys were pooled for all core monitoring areas by year 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 (Table 111). Over the past 5 years, goose observations have either declined or remain similar throughout the years during systematic and incidental sightings. Correspondingly, there were fewer interrupted training events and requests for support due to geese on the ranges. Moreover, geese did not need to be hazed from live-fire ranges over the reporting period.

Table 111. Total number of goose observations per survey effort in core monitoring areas, FY 2019–FY 2023, at Pōhakuloa Training Area

	Systematic Sightings					Incidental Sightings				
	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023
Total goose observations	20	17	4	2	15	30	25	4	12	25
Number of Surveys/Reports	140	145	191	198	193	9	10	3	4	12
Mean # Geese/Survey	0.14	.011	0.02	0.01	0.07	—	—	—	—	—

The reasons for the decline in goose observations between FY 2021 and 2022 or the higher number of goose observations in FY 2019, 2020, and 2023 at PTA are unknown. Movement and patterns of presence during flocking season (May to August) are not well understood, but are likely influenced by environmental conditions, especially water availability (Leopold and Hess 2017). In recent years, we have not observed standing water at the Range 1 Complex as was noted in past years with high goose visitations. Although we cannot definitively attribute habitat management actions at the Range 1 Complex to the reduction in goose observations, we believe the reduction in their preferred fodder grass, hairy wallaby oatgrass (*Rytidosperma pilosum*), has lessened the attractiveness of the range to geese (see the next section for details about habitat management).

Monitoring helps us to better manage potential conflicts between geese and military activities in a timely and efficient manner and minimize training disruptions. Because Hawaiian Geese are highly mobile, we recommend continuing monitoring to identify new areas of use and shifts in patterns of presence or activity (i.e., increase 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 training.

Management Activities at Pōhakuloa Training Area

We manage goose 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 sightings and our efforts to brief personnel below.

Actions to Manage Hawaiian Goose Molting and Breeding Activity

As stated above on 27 March 2023, 2 geese, Grey/Black A97 and Green/White KZP, were observed molting at BAAF. On 21 April 2023, a family of geese (Grey/Black A98, A97 and 3 goslings) and Green/White KZP were observed at BAAF. On April 24, we assisted DOFAW personnel to capture and translocate the family away from BAAF.

To protect the breeding geese from predators, between March and April 2023, we deployed 5 live traps spaced approximately 200 m apart and equipped each trap with a Skyhawk™ electronic sensor The traps captured 4 mongooses and 1 feral cat. Two non-target game birds (Erckel’s Spur Fowl, *Pternistis erckelii*) were captured and safely released.

Actions to Minimize Conflicts between Training and Hawaiian Geese

The 2013 BO requires the Army to manage 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 sources for the Hawaiian Goose, primarily *R. 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 designated area at the complex where Hawaiian Geese often feed and loaf (Figure 109).

Hawaiian Goose habitat enhancement occurs within the Wildlife Enhancement Area (WEA) fence unit proximate to the Range 1 Complex (Figure 109). Habitat enhancement includes promoting habitat and food availability by selectively cutting and applying herbicide to unwanted weed species such as fire weed (*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.

We selectively applied 147 gallons of herbicide (1.5% Roundup PowerMax herbicide with active ingredient [A.I.] glyphosate) and 0.22% Oust XP per gallon (A.I. sulfometuron-methyl) to approximately 13 ha in the Range 1 Complex footprint. Post-treatment evaluations indicate that Roundup PowerMax was effective in controlling *R. pilosum*. In addition, to control fireweed and fountain grass and support the growth of *R. pilosum*, we selectively applied 21 gallons of herbicide (1.0% Garlon 4 Ultra [A.I. triclopyr]) to approximately 7 ha in the WEA (Figure 109).

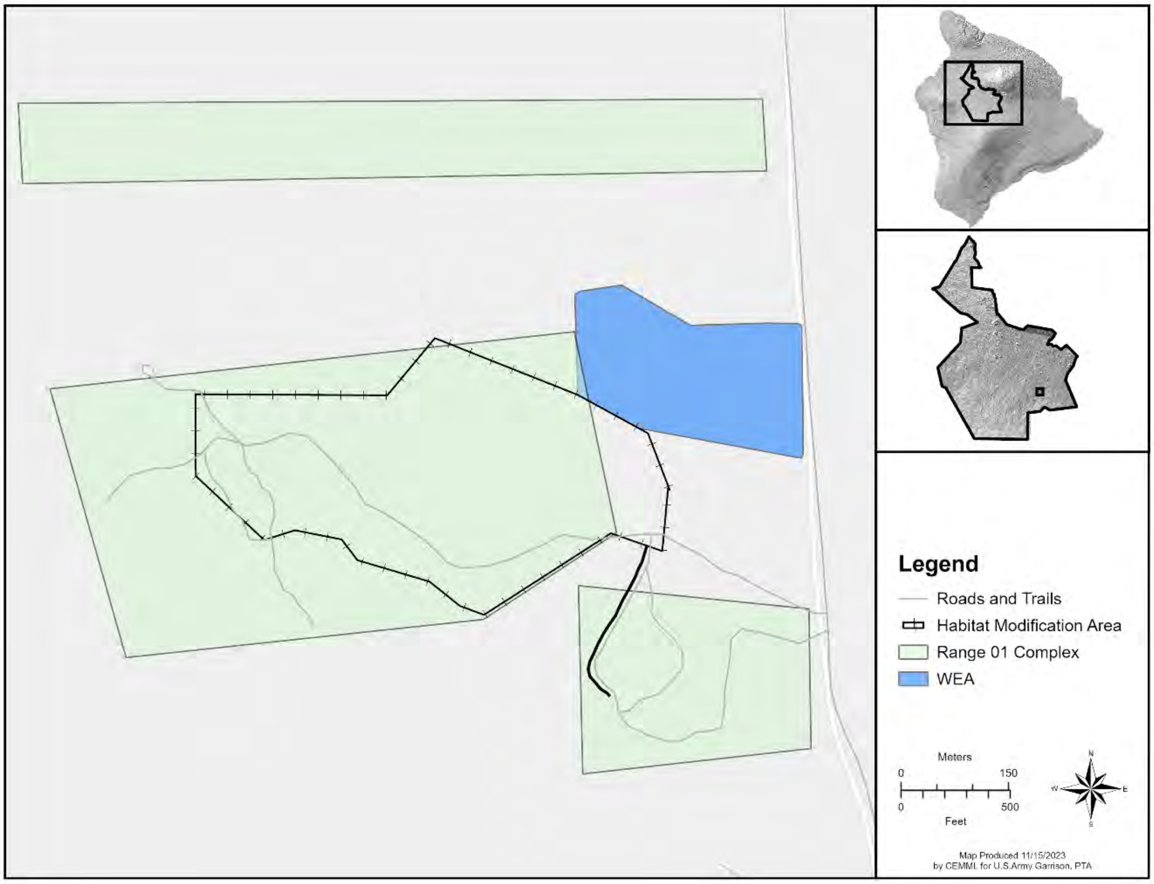


Figure 109. Hawaiian Goose habitat modification area and the Wildlife Enhancement Area at the Range 1 Complex, Pōhakuloa Training Area

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. In FY 2022 and FY 2023, 9 uniquely banded geese were observed incidentally or during systematic surveys at PTA: 1 (11%) came from the HFNWR population, 2 (22%) from unknown origins, and 6 (67%) from the Puʻu ʻŌʻō Ranch population (translocated from Kauaʻi). Since 2009, most banded geese sighted at PTA have come from HFNWR, but in 2011, DOFAW translocated several hundred Hawaiian Geese from Kauaʻi to Puʻu ʻŌʻō Ranch (approximately 18 km southeast of PTA). Since this translocation, geese from the Puʻu ʻŌʻō Ranch have been sighted more frequently at PTA, and they are the only group that has successfully nested more than 3 times at PTA since 2014. The pair that breed at BAAF in 2023 (G/BA97 and A98) was translocated from Kauaʻi. We are uncertain what influences geese to visit and use PTA. Although our monitoring results do not estimate numbers of geese using PTA, we have made fewer detections per survey effort over the past 5 years (Table 111).

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.

PTA and military personnel continue to report incidental sightings of geese. Sightings occur at a low frequency 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 minimize training disruptions. Because Hawaiian Geese are highly mobile, we will continue to monitor and 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.

In FY 2024, we will continue systematic monitoring for geese in high-use areas, manage incidental sighting reports, and, when necessary, act to reduce potential conflicts between military activities and the geese, especially during breeding and molting when geese are more vulnerable.

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 18 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.

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 110). Within the Pua ʻĀkala management area, we manage habitat only within the footprint of the proposed predator-proof fence (Pua ʻĀkala habitat enhancement in Figure 110).

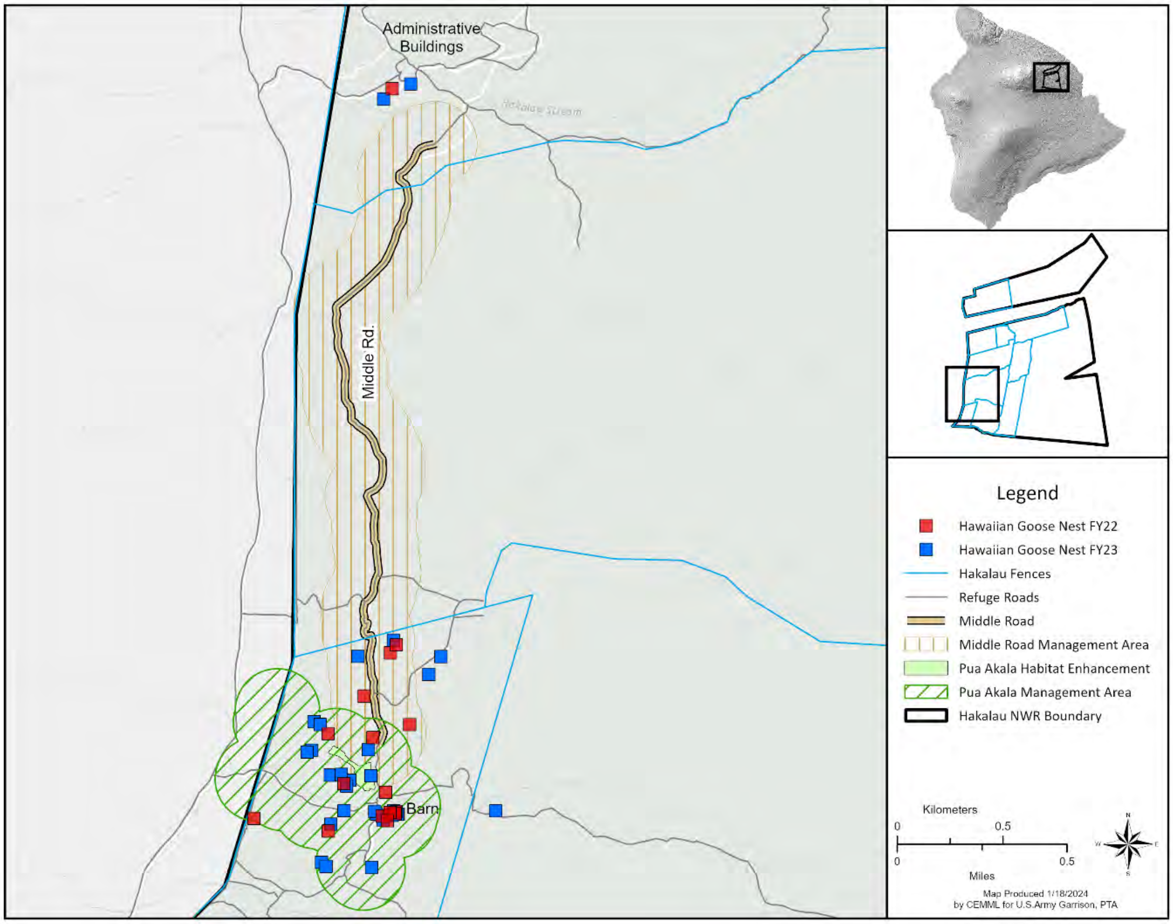


Figure 110. Army-supported management areas, FY 2022–FY 2023, and Hawaiian Goose nest locations (48 nests) at Hakalau Forest National Wildlife Refuge

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 2021/2022 and the 2022/2023 Hawaiian Goose breeding seasons (CEMML 2022a; CEMML 2023a). In this biennial report, we summarize major highlights from each technical report.

Habitat Management

We enhance habitat within the Pua ʻĀkala management area by cutting grass and removing invasive plant species to create goose foraging grounds (Figure 110). Inadequate nutritional quality at high elevation sites is a limiting factor for Hawaiian Goose reproduction and gosling survival (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 are increased when habitat is managed in this way.

In FY 2022 and FY 2023, we cut ~1.2 ha of kikuyu grass (*Cenchrus clandestinus*) within the Pua ʻĀkala management area 6 times, using weed whackers and a large deck mower. We also spot-sprayed blackberry (*Rubus discolor*), bull thistle (*Cirsium vulgare*), and gorse (*Ulex europaeus*). Six small wooden shelters were placed around the mowed area to provide additional protection for geese.

Hawaiian Goose Monitoring

In FY 2022 and FY 2023, we monitored geese inside the Army-managed areas at HFNWR during the breeding season from October to April (FY 2022) and October to June (FY 2023; Figure 110). 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 geese 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 us determine the number of goslings that are supported to fledging through our management efforts. Fledglings consistently observed in management areas, whether they hatched from a nest within or 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.

Over the report period, we observed cumulative totals of 179 geese with unique leg bands and 7 fledglings identified by 1 or 2 banded parents (Table 112). Multiple unbanded geese were observed each year in the Army-managed areas. Compared to previous years, we sighted more geese in Army-managed areas in 2021 to 2022 (Table 112). Since we began managing the habitat at HFNWR in 2017, geese have been observed regularly using the Army-managed areas.

Table 112. Hawaiian Goose sightings from Army-managed areas during breeding seasons (September–April), 2017–2023, at Hakalau Forest National Wildlife Refuge

Breeding Season	Banded Adults	Unbanded Adults[a]	Unbanded Fledglings[a]
2017–2018[b]	68	5	5
2018–2019	67	6	16
2019–2020[b]	54	8	12
2020–2021	88	17	18
2021–2022[b]	100	5	3
2022–2023[b]	79	9	4

[a] Unbanded adults and juveniles that were identifiable by 1 or more banded partner/parent.
[b] Monitoring began in October these years due to various delays.

In FY 2022, 4 Hawaiian Goose gosling carcasses were discovered within the Pua ʻĀkala management area. The cause of each death is unknown. On 16 February 2022, an injured gosling was discovered within Pua ʻĀkala management area. The cause of injury was unknown, with no direct evidence indicating that management activities resulted in the injury. In coordination with the HFNWR staff and the Hawaii Wildlife Center, we captured the injured gosling and transferred it to the Hawaiʻi Wildlife Center. Unfortunately, due to the severity of the injury, the gosling was euthanized at the Hawaiʻi Wildlife Center. For more information regarding the incidental sightings, please refer to Appendix E.

In FY 2023, 3 Hawaiian Goose carcasses were discovered within the Pua ʻĀkala management area. The cause of each death is unknown. However, on 28 December 2022, we observed 2 feral dogs inside the Pua ʻĀkala management area, which was the same day 2 of the 3 carcasses were found. We reported the feral dog sighting to HFNWR staff the same day. After each carcass was discovered, we notified HFNWR staff, and they removed the carcasses. For more information regarding the incidental sightings, please refer to Appendix E.

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 16 nests in Army-managed areas between October 2021 and April 2022, and 32 nests between October 2022 and June 2023, for a total of 48 nests over the report period (Figure 110).

To count fledglings toward our fledging production goals, we established 3 criteria:

(1) Fledglings that hatched from nests within management areas are counted if they are banded, seen flying, or seen alive after 10 weeks since hatching.
(2) Fledglings that hatched from unknown locations that are found utilizing the Army-supported management areas are counted if they appear at least 10 weeks of age.
(3) During the leg banding process, any fledglings near or within the Army-supported management areas that were considered at least 10 weeks of age or older were captured and banded.

Using these criteria, we counted a total of 14 fledglings produced over the report period: 10 between October 2021 and April 2022, and 4 between October 2022 and June 2023. The 2-year average fledgling production for the report period is 7 fledglings per year, which falls short of our annual goal of supporting 26 goslings to fledging. We discuss the overall 6-year progress toward the goal of producing 26 fledglings on average annually below.

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 111).

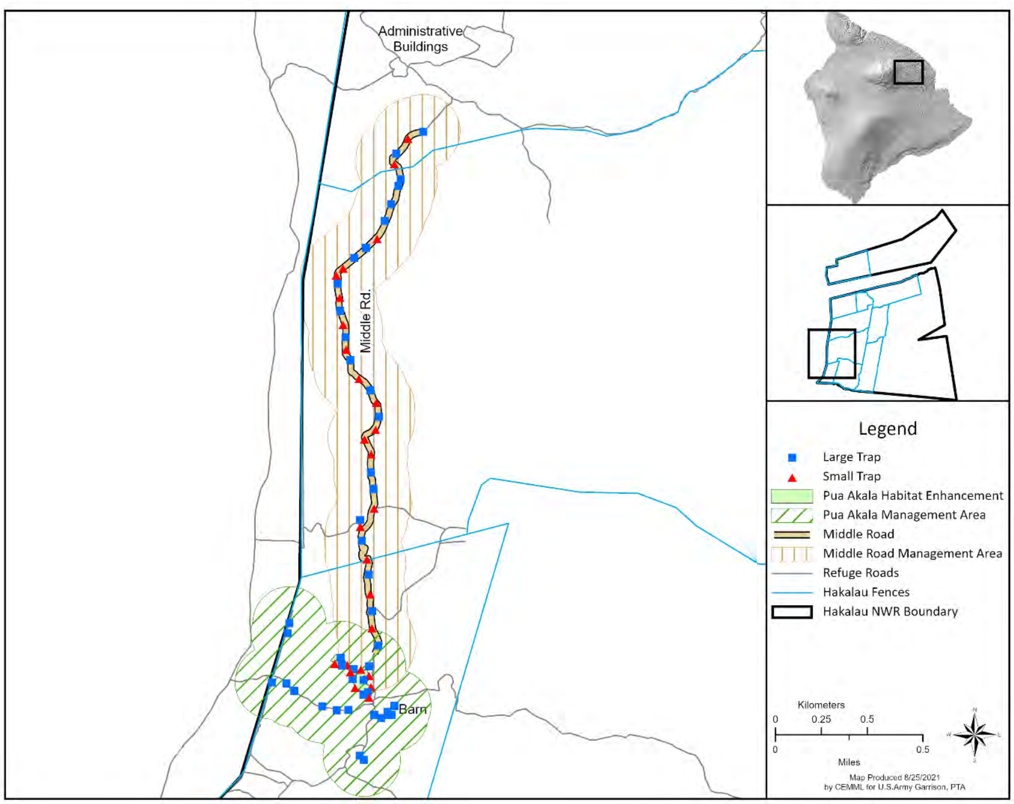


Figure 111. Predator trap layout during FY 2022–FY 2023 Hawaiian Goose breeding season at Hakalau Forest National Wildlife Refuge

Live Trapping Results

From October 2021 to April 2022 (FY 2022), we deployed 71 live traps and removed 28 predators (3 feral cats, 23 mongooses, and 2 rats). No geese or non-targets were captured during the trapping period.

From October 2022 to June 2023 (FY 2023), we deployed 71 traps and removed 8 predators (8 mongooses) (Table 113). No geese were captured, but 2 non-native game birds, Erckel's Spur Fowl (*Pternistis erckelii*), were captured and safely released during the trapping period.

Table 113. Predators captured in live traps during FY 2022–FY 2023 Hawaiian Goose breeding season on Army-managed areas at Hakalau Forest National Wildlife Refuge

Breeding Season	Traps Deployed	Total Captures	Cats	Mongoose	Rats
FY 2022	71	28	3	23	2
FY 2023	71	8	0	8	0

Lethal Trapping Results

From October 2021 to April 2022 (FY 2022), we deployed up to 4 A24 traps, spaced approximately 25 m away from each Hawaiian Goose nest. We removed at least 40 predators (1 mongooses, 3 rats, and 36 mice). No geese or non-targets were captured during the trapping period.

In FY 2023, we deployed up to 4 A24 traps, spaced approximately 25 m away from each Hawaiian Goose nest. We removed at least 48 predators (1 rat and 47 mice). No geese or non-targets were captured during the trapping period.

<u>Discussion for Hawaiian Goose Management at Hakalau Forest National Wildlife Refuge</u>

Our management activities at HFNWR continue to support Hawaiian Goose conservation in Hawaiʻi and mitigate goose impacts from military training activities. During the reporting period, management within the Army-managed areas, Pua ʻĀkala, Middle Road, and the administration building area, contributed to the successful fledging of 14 geese—10 goslings in FY 2022 and 4 goslings in FY 2023. Compared to the previous 6-year period, fewer goslings fledged in FY 2022 and FY 2023 (Table 114).

Table 114. Cumulative Hawaiian Goose nests and fledglings on Army-managed areas during breeding seasons (September to April), 2017–2023, at Hakalau Forest National Wildlife Refuge

Breeding Season	Total Nests	Total Fledglings	% Fledgling Production Goal
2017–2018[a]	6	7	27%
2018–2019	13	20	77%
2019–2020	12	12	46%
2020–2021	18	18	69%
2021–2022	16	10	39%
2022–2023	32	4	15%
6-year Mean	16	12	46%

[a] Sightings for the 2017/2018 breeding season began in October.

In FY 2022, we were unable to search and trap in the middle and upper areas of the Middle Road management area during the peak nesting period (October to mid-January) due to road repairs and closures. This limited access and trapping effort may have influenced the low number of fledglings counted this year (Table 114). In FY 2023, road repairs were completed, and we once again monitored nests and trapped in the Middle Road Management area.

Despite FY 2023 having the highest number of nests monitored, number of eggs laid, number of eggs hatched, and number of goslings seen, only 4 goslings (4%) survived to fledge. The 2 feral dogs observed on 28 December 2022 are a likely cause of the low gosling survivorship. For more information regarding the incidental sightings, please refer to Appendix E. Prior to sighting the dogs, we observed, via camera or in person, 32 goslings with their parents. By 5 January 2023, we observed these same parents with zero goslings. In addition, throughout the breeding season, we observed Hawaiian Hawks perched or circling in the sky above where the goslings' families were located. Although we did not witness hawks depredating goslings, hawks may have captured and consumed goslings, contributing to the lower survivorship this breeding season.

Since FY 2018, management activities in the Army-managed areas have supported goslings to fledgling age across 6 breeding seasons (Table 114). On average, these efforts have supported about 12 fledglings per year, which is short of the target in the 2013 BO of producing an average of 26 fledglings per year by year 10 of the project. The BO target is predicated on the construction of a predator-proof fence and the translocation of families with goslings into the predator-proof fence. Without this influx of breeding potential into the predator-proof fence within the Army-managed areas, it will likely take many years before the existing breeding population in the Army-managed areas increases in number sufficiently to support an average production of 26 goslings per year, even with the relatively high survival rate for nests and goslings within the Army-managed areas.

To sustain high fledgling success and to achieve the annual requirement of 26 fledglings, we recommend continuing management activities in the 2023 to 2024 breeding season. In addition, we recommend continuing negotiations with HFNWR staff to construct the predator-proof fence and/or translocating some family groups with young goslings from the HFNWR Administrative site to encourage future nesting in the Army-managed areas. Also, we recommend working with HFNWR staff to identify additional areas where unmanaged geese may benefit from Army management.

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 3.2.2.1 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 was to determine occupancy and seasonal activity patterns throughout the installation between 2014 and 2023. The project aimed to identify habitat association based on 5 vegetation classes, and bat prevalence in potential treeland roosting habitats more generally. Between 2014 and 2017, we collected occupancy data quarterly based on reproductive cycles as described by Menard (2001).

The transition between the end of lactation (August) and the beginning of mating/fledging (September) appears to be significant at PTA and may be a cause of interannual variation in bat prevalence. Mean activity across PTA has also been consistently highest during September. The activity dataset now spans June 2014 to August 2021, which helps clarify our assumptions about seasonal activity patterns. In FY 2022, due to staff shortage and equipment malfunctions, we did not collect seasonal bat activity data. In FY 2023, starting in May 2023, we resumed collecting seasonal bat activity data.

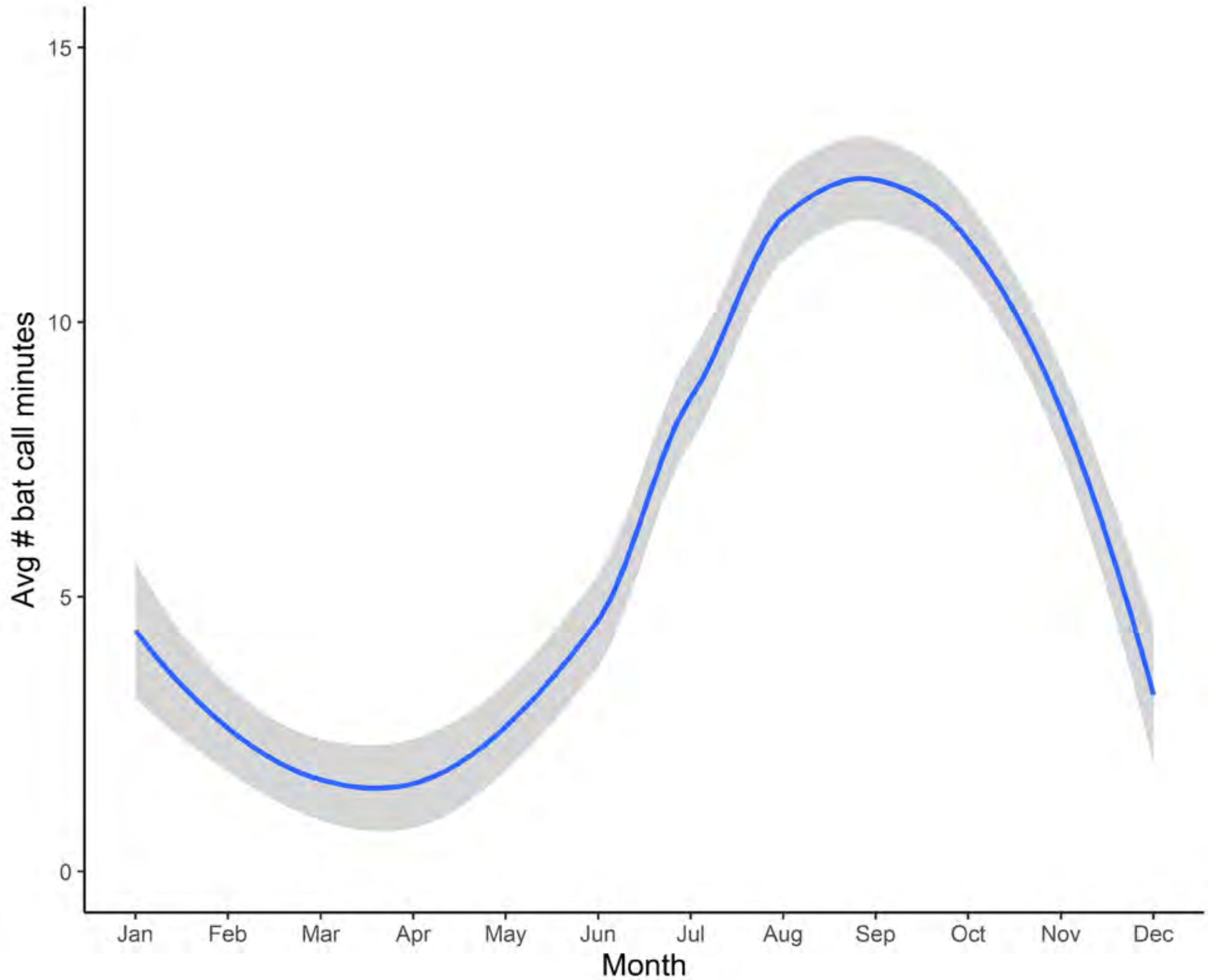
Due to staff shortage and equipment malfunctions, we did not collect occupancy data during the peak of activity in FY 2022. We resumed occupancy data collection in FY 2023 for 9 weeks starting in September when activity rates are high, rather than centering data collection across the 4 months when adults mate and juveniles fledge (September to December). We limited the sampling period to the peak of activity because it increases the probability of detecting bats, reduces variability in the sample due to the changing energetic costs to bats throughout the year, and allows us to strengthen our assumptions about baseline occupancy, despite the 2-year pause in presence/absence data collection.

We have not completed any additional data analysis since the previous Biennial Report. Refer to the pervious Biennial Report for study methods and an expanded discussion on results (CEMML 2022a). We aim to complete a technical report for both the activity study and the occupancy study in early 2024. Key findings from each study are presented below.

Activity Study Key Findings

(1) From 2014 to 2021, mean bat activity calls were highest during mating and fledging September to December, followed by lactation June to August, and finally by pre-pregnancy and pregnancy (January to mid-June) (Figure 112).
(2) Other than time-of-year effects, activity was not strongly correlated with other modeled covariates, such as weather or vegetation type, including treeland.
(3) Bats were present at PTA year-round.

Figure 112. Mean nightly bat call minutes by month July 2014–August 2021[a]



[a] Monthly means of bat call minutes pooled by location and year from July 2014 through August 2021. Trend line uses LOESS (locally estimated scatterplot smoothing). Smooth curve and the shaded area represents the 95% confidence intervals.

Occupancy Results For Peak Activity Season: September to December

Data collection for 2 additional years during the season with peak activity (September to December), improved the standard error from model parameter estimators.

For data collected during the peak seasons (September to December) from 2014 to 2017 and 2019 to 2022, the mean probability of detection was 0.50 and the mean arrival (colonization) probability was 0.79.

Discussion for Hawaiian Hoary Bat Survey, Monitoring, and Management

Acoustic activity analyses and occupancy modeling show that bats are present across the installation throughout the year and that activity peaks during the autumn months. The analyses complement each other by emphasizing time-of-year effects on bat prevalence. 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). Similar to trends in bat prevalence in other studies (Gorresen et al. 2013, Gorresen et al. 2015), bat activity peaked at PTA between the end of the lactation cycle (August) and the beginning of the fledging cycle (September). Researchers speculate this uptick in activity is driven by newly volant pups beginning to forage with their mothers after being weaned (Gorresen et al. 2013, Gorresen et al. 2015).

Bat breeding biology at PTA is not well known. We are uncertain if females raise young at PTA or if they return to the area once the pups can fly. If females are present at PTA with non-volant pups in summer months, they may be at higher risk from fire, military training, or construction during this period. Despite the uncertainties, the increase in activity from August to September appears to be significant and may be a cause of interannual variation in bat prevalence.

The activity and occupancy analysis results show 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 feed, roost, or traverse the installation in ways that may not be adequately modeled with the variables collected. The 2014 to 2021 activity dataset shows consistent peaks during September, although the magnitude varies from year to year. Additionally, although previous studies on Hawaiʻi Island show that bats migrate to interior highlands (between 1,000 and 3,000 m elevation) during the winter months (Menard 2001; Gorresen et al. 2013; Bonaccorso et al. 2015), PTA does not appear to experience any increase in occupancy or activity. Our highest survey location is 2,030 m. Most likely the increase in activity occurs in areas with a higher number of *Peridroma* moths in caves between 2,000 and 3,600 m (Bonaccorso et al. 2015). While certain survey areas may provide more reliable foraging opportunities, foraging conditions at PTA do not appear to attract bats as part of the altitudinal migration. We recommend investigating the insect prey availability at PTA to better understand bat habitat preference.

Further analysis is required to determine the statistical power necessary to detect a specific trend in either direction (increasing or decreasing) over a given number of years. The number of sites and the duration of the study as well as the power to detect the trend are all factors for designing occupancy studies. Trend test power will be higher for longer monitoring periods even if annual sample sizes or annual trend magnitudes are smaller (WEST 2015). Although the PTA take statement for bats is not currently linked to a specific decline in occupancy, statistical power and bias have long-term implications for triggering management actions as a result of a percentage decrease in occupancy. The parameters used for these simulations are not the same as those from our pilot data but may still serve as a general guide for long-term monitoring efforts and consultation with USFWS.

In FY 2024, we will continue to monitor bats and improve knowledge of seasonal activity and occupancy estimates at PTA to help evaluate the impact of potential hazards to bats such as fire, military training, or construction. In addition, in FY 2024 we plan to complete 2 technical reports and a conservation plan. These documents will help manage the Hawaiian hoary bat and its associated habitats at PTA, minimize long-term constraints to military training, and satisfy requirements to develop and coordinate such a plan with agency partners.

Hawaiian Hoary Bat Management

We delivered 18 briefs over the reporting period to military unit leaders about their responsibilities to protect bats at PTA. All military personnel trained at PTA were instructed to report any vehicle or aircraft bat strikes. No bats strikes were reported during the reporting period.

In addition, we briefed PTA directorates at least annually and provided briefs as necessary when new employees were hired. We also advised construction contractors and military units regarding tree removal or trimming to avoid impacts during bat birthing and pup rearing season, 01 June through 15 September. No trees taller than 5 m were trimmed or removed any year between 01 June through 15 September. For trees shorter than 5 m, we inspected the trees for bats before approving any action. No bats were observed during the inspections.

Incidental Take

The Army must document and report all incidental take of Hawaiian hoary bats due to military activities, including quarterly inspections of all barbed-wire security fences for entangled Hawaiian hoary bats. No take due to military training activities was reported and no Hawaiian hoary bat entanglements were discovered at PTA over the reporting period.

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 the amount of treeland habitat destroyed outside the Impact Area annually as a proxy for incidental indirect take of bats. 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.

Wildland Fires from FY 2022 to FY 2023

Training Area 21

On 20 May 2022, at approximately 1405 hours, a wildland fire ignited near Range 10 in Training Area 21 at PTA. Post-fire inspection did not reveal clear evidence of a cause, such as a lightning strike or human action. The fire burned approximately 11 ha of vegetation considered potential available treeland habitat for roosting of Hawaiian hoary bats. The fire resulted in indirect incidental take of Hawaiian hoary bats, consuming 23% of the allowable loss of 48 ha per year. No bat carcasses were reported in the burned area.

Leilani in Training Area 22

In July and August 2022, wildland fire burned near Puʻu Leilani in Training Area 22 at PTA. The fire burned approximately 1,216 ha of vegetation considered potential available treeland habitat for roosting of Hawaiian hoary bats. The Leilani Fire is the single largest fire so far to affect available treeland roosting habitat for Hawaiian hoary bats at PTA. The Leilani Fire surpassed the annual and cumulative allowances, 48 ha and 1,345 ha, respectively, for authorized incidental take of potential available treeland roosting habitat outside the Impact Area (USFWS 2003a). No bat carcasses were reported in the burned area.

Keʻāmuku Maneuver Area Complex Fire

On 12 February 2023, at approximately 1520 hours, wildland fires ignited at KMA. Post-fire inspection revealed that the 2 fires were started by lightning strikes. The fire burned approximately 97 ha of vegetation considered potential available treeland habitat for roosting of Hawaiian hoary bats. The cause of the KMA Complex Fire was natural and not related to military training activity; therefore, no indirect incidental take occurred because of Army activities. No bat carcasses were reported from the burn area during operations or other field assessments and direct impacts to Hawaiian hoary bats are assumed to be negligible.

Refer to Section 8.0 of this report for additional information regarding the wildland fires.

4.2.5 Seabird Management

In 2015, we discovered an active Band-rumped Storm Petrel (BSTP, *Hydrobates castro*) burrow at PTA, which was the first confirmed location of an active breeding burrow for BSTP in Hawaiʻi. In 2016, the BSTP was listed as endangered under the ESA. Since 2015, we have continued to monitor and study the extent of BSTP activity (breeding and non-breeding) at PTA. To date, we have documented via video 5 active nests and have gained a better understanding of the BSTP breeding season for PTA and Hawaiʻi Island. At PTA, BSTP arrive in late May, likely lay eggs during July, and with a 42-day incubation, young likely hatch 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 the following:

(1) Geographic extent of the BSTP colony, to better analyze potential effects to the birds from military activities
(2) 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) Impact of predators on BSTP, to minimize depredation

In May 2020, the Army completed an informal consultation with USFWS for predator control within the BSTP colony at PTA during the breeding season (i.e., when BSTP are present). The Army received concurrence from USFWS with the determination that the Army's proposed actions (nest survey with detector dogs and predator management) may affect, but are not likely to adversely affect, the BSTP (USFWS 2020a).

In December 2020, the Army received the amended recovery permit (TE40123A-3) to authorize the management activities described in the PTA *Band-rumped Storm Petrel* (*Hydrobates castro*) *Management Plan*, which was submitted to the USFWS with the amendment request (CEMML 2020b). Two additional permits are required to manage BSTP at PTA. The USFWS Migratory Birds Program issued USAG-PTA a Scientific Collection Permit (Number MB95880B) to authorize salvage, transport, and possession of BSTP, which is protected under the Migratory Bird Treaty Act. The State of Hawaiʻi Board of Land and Natural Resources, Division of Forestry and Wildlife (DOFAW) issued USAG-PTA a Protected Wildlife Permit (Number WL19-42) to authorize salvage, transport, and collection of up to 25 BSTP specimens per year. To comply with reporting requirements for permit WL19-42, in January 2023 we submitted to DOFAW 2 technical reports, *2022 Annual Report for Pōhakuloa Training Area, Hawaiʻi Island, Hawaiʻi, US Fish and Wildlife Service Recovery Permit TE40123A-3 and State of Hawaiʻi Natural Area Reserve, Rare Plant and Native Invertebrate Research Permit 12942 and State of Hawaiʻi Protected Wildlife Permit WL21-15* (CEMML 2023b).

Nine years after the discovery of the first BSTP burrow at PTA, delineating the geographic extent of the colony for non-breeding and breeding BSTP activities remains challenging. To better understand the extent of the BSTP colony, breeding phenology, and pertinent behavioral characteristics, we deploy acoustic monitoring devices to record BSTP calls, survey for potential BSTP nests with a detector dog, monitor potential nests via camera surveillance, and control predators through trapping efforts.

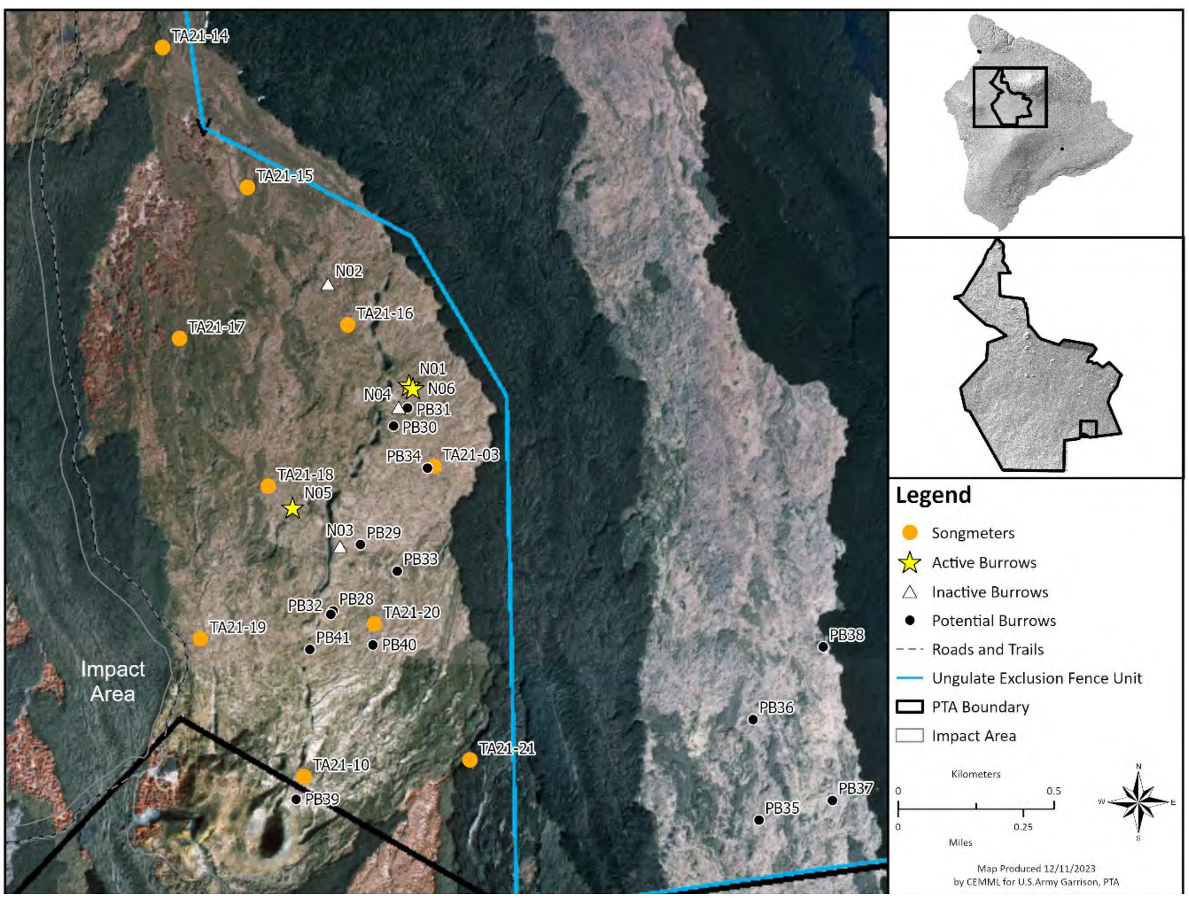
In this biennial report, we summarize highlights from the FY 2022 and FY 2023 BSTP breeding seasons. Because the BSTP chicks fledge between October and November, we reported fledging events that occurred between October and November in 2021 and 2022. Any fledging that occurs between October and November 2023 will be reported in subsequent fiscal year reports.

In addition, the Army is preparing a Programmatic Biological Assessment for formal consultation with the USFWS under Section 7(a)(2) of the ESA for the BSTP, and other species protected under the ESA at PTA[22].

Determining the Geographic Extent of the Known Colony

Acoustic Monitoring Methods

To continue the acoustic monitoring that was started in 2022, we deployed Song Meter 4 (SM) bioacoustics recorders (Wildlife Acoustics, Inc.) at 10 sites within the BSTP colony from 23 May 2023 through 30 November 2023. Each monitoring site was uniquely numbered with the training area number (21) followed by a 2-digit number (Figure 113). The same monitoring sites, recording schedules, and equipment settings used in 2022 were replicated in 2023. Each SM was programmed to record audio for 90 minutes per night The SMs recorded audio for 1 minute of every 5-minute interval for 5 hours after sunset (60 minutes of recording) and 1 minute of every 10-minute interval



[22] The text reflects the status of the PBA during the report period (01 October 2021 through 30 September 2023). Since, the Army has worked to develop additional wildland fire planning and preparedness documents to support the PBA preparation process and the fire model used for the effects analysis was updated with data from wildland fires that occurred in 2021 and 2022.

for 5 hours before sunrise (30 minutes of recording). At the end of each month, SM batteries were changed, and SD memory cards were collected and replaced.

Figure 113. Song Meter and burrow locations monitored in FY 2022–FY 2023 in the Band-rumped Storm Petrel Colony

All SMs were secured to a portable steel and aluminum frame at a height of 1.4 m from the ground. The left microphone faced the prevailing wind direction to ensure minimal noise interference for the right microphone. The Song Meter Configuration Utility from Wildlife Acoustics was used to configure settings for each SM.

Conservation Metrics, Inc. (CMI, Santa Cruz, CA) was contracted to store and analyze PTA SM acoustic data. CMI uses neural network classifiers to identify vocalizations for BSTP and summarize nightly, seasonal, and geographical patterns of BSTP calls at each site. The 2023 acoustic data will be submitted to CMI for analysis by January 2024, with a final report expected by April 2024.

On 1 May 2023, we received CMI's report for acoustic data collected between 23 May and 29 November during the 2022 BSTP breeding season (CMI 2023). We present highlights from the report.

Acoustic Monitoring Results

CMI analyzed the audio recordings for the 2022 BSTP breeding season with custom detection and classification software that uses a speech recognition classification tool called Deep Neural Networks (Deng et al. 2013). CMI creates a Deep Neural Network classification model and uses cross-validation datasets containing positive vocalizations of the target species, including recordings collected from PTA in 2015 and negative sounds, to train the model to find target species calls within audio recordings.

During the 2022 BSTP breeding season, a total of 2,850 hours of audio recordings were collected over the course of 1,910 recording nights. The SM devices detected BSTP calls at all 10 survey locations over the course of the monitoring period. The first detection of the season was on 27 May at Site TA21-14 and the last detection was on 28 November at Site TA21-10 (Table 115). Sites TA21-10, TA21-03, and TA21-20 had the highest mean call rates among all sites, at 0.26 (standard deviation [SD]±0.52) calls per minute, 0.25 (SD±0.46) calls per minute, and 0.24 (SD±0.34) calls per minute, respectively (Table 115). The percentage of nights (n=119) BSTP calls were detected at the sites ranged from 35% to 77%. Six of the 10 sites had over 50% of the nights with a BSTP call detected.

Table 115. Mean Band-rumped Storm Petrel calls per minute and the percentage of nights that calls were detected at survey site. Call rates were calculated using the diel period 100–300 minutes after sunset from 30 May–25 September 2022; 119 nights were monitored at each location

Survey Site	Mean Calls per Minute (±SD)	% of Nights with Calls Detected
TA21-10	0.26 (±0.52)	54
TA21-03	0.25 (±0.46)	71
TA21-20	0.24 (±0.34)	77
TA21-21	0.19 (±0.31)	67
TA21-19	0.16 (±0.33)	61
TA21-18	0.14 (±0.23)	64
TA21-16	0.11 (±0.31)	43
TA21-15	0.06 (±0.16)	34
TA21-17	0.05 (±0.11)	37
TA21-14	0.04 (±0.07)	40

A diel[23] peak period of 100 to 300 minutes after sunset was selected to calculate daily call rates. BSTP calls show a peak about 200 minutes after sunset (2120 h) with a gradual decrease after the peak (Figure 114). The calls-per-minute patterns showed a relationship between call rates and the lunar period. BSTP call rates were more prevalent closer to the new moon (Figure 115).

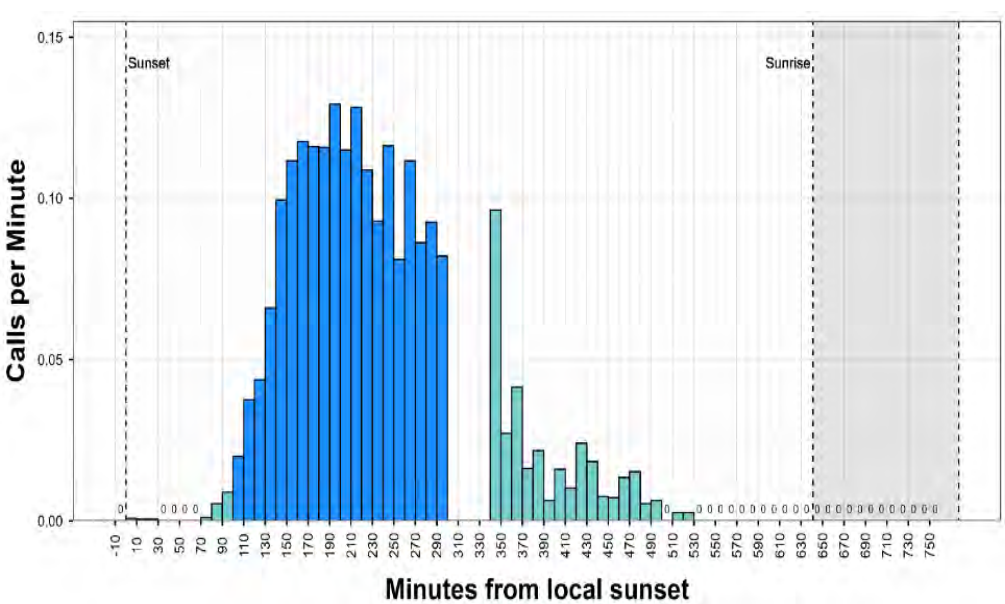


Figure 114. Band-rumped Storm Petrel mean calls per minute for all survey sites during the 2022 breeding season (May–November) at Pōhakuloa Training Area. Dark blue bars indicate the diel period 100–300 minutes after sunset used for daily call rate calculations

[23] Diel refers to a 24-hour period, especially a regular daily cycle, as of the physiology or behavior of an organism.

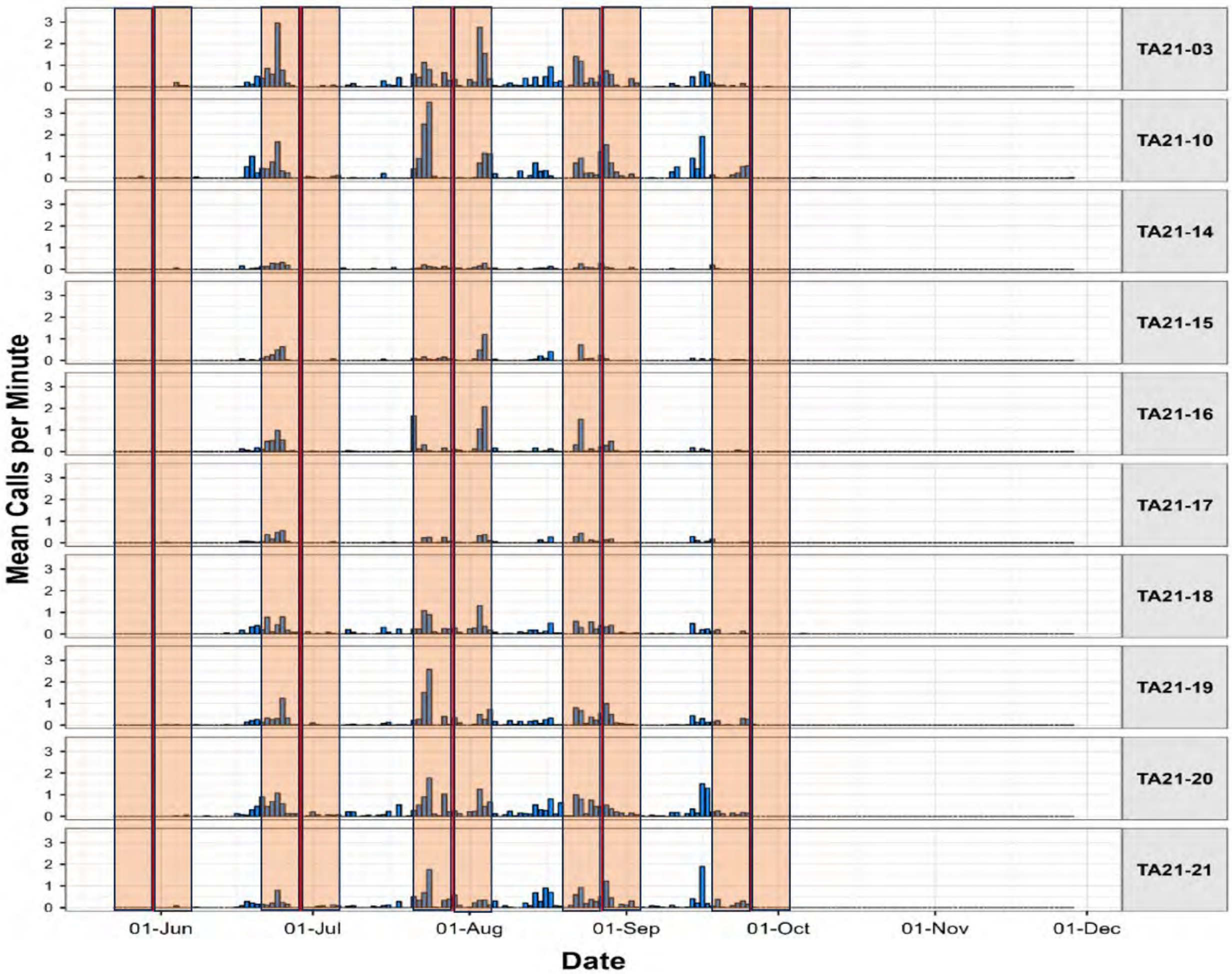


Figure 115. Band-rumped Storm Petrel mean calls per minute by survey site during the 2022 breeding season (May–November) at Pōhakuloa Training Area. The red line represents new moon lunar period and the orange fill represents the dark period after sunset until moonrise between the third quarter moon and the waxing crescent moon

Surveys with Search Dog Methods

Due to the cryptic burrowing habits of BSTP, we used 2 trained detector dogs (Slater and Ikaika) and their handler to locate BSTP burrows. Slater (McNab breed) and Ikaika (Labrador breed) were chosen because of their ability to work at high elevations, their demonstrated ability to leave the target species unharmed, and their previous success detecting BSTP and Hawaiian Petrel (*Pterodroma sandwichensis*). Slater's first year working at PTA was FY 2022; Ikaika's was FY 2023. A total of 10 burrow surveys were conducted in the mornings and afternoons (0700 to 1400) between August and September 2022 (5 surveys) and June and September 2023 (5 surveys) (Figure 116). For most searches, Slater and Ikaika were off leash but within sight of the handler. When a more thorough search was required, the handler placed a leash on the dogs and guided them. We also visited each known burrow, including active and potential burrows, from previous years to monitor for fresh scent.

An Astro Garmin 320 GPS device was used to record Slater's and Ikaika's search tracks. 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 burrow was found. A point was deemed a potential burrow (PB) when the dog's behavior (i.e., pointing) indicated the presence of a specific target. A point was deemed an area of significant interest when the dogs showed keen interest in the area but could not pinpoint a specific location. A 50 m buffer surrounding a potential burrow was intensively searched for other openings to ensure the safe deployment of predator traps. Each active or potential burrow was uniquely marked (aluminum tag with engraved numbering or flagging on a rock) and its location recorded. The tags were placed at least 0.6 m from the burrow entrance. Only 2 observers worked at a potential or active burrow at any given time to minimize burrow disturbance.

Burrow Survey with Search Dog Results

During FY 2022, we conducted 5 searches with Slater, covering a total of 38 km (Figure 116). Each search lasted about 6.5 hours. A total of 13 burrows were discovered by Slater. Five were previously known burrows—2 active (N01 and N05), 3 inactive (N02, N03, and N04), and 1 was a potential burrow from 2021 (PB24) (Figure 113 and Figure 116). Seven were new potential burrows found in 2022 (PB25 [renamed N06], PB26–PB31) (Figure 113 and Figure 116). PB25 was later reclassified as an active burrow (N06) when BSTP activity was detected by camera. Adult BSTP activity was detected by camera at the following burrows: N01 on 19 May, N05 on 27 May, and N06 on 11 August 2022. No BSTP carcasses or evidence of BSTP depredation were discovered during any of the searches.

During FY 2023, we conducted 5 searches (3 with Slater and 2 with Ikaika) covering a total of 25 km (Figure 116). Each search lasted about 6.5 h. A total of 19 burrows were discovered by both dogs. Nine were previously known burrows—3 active (N01, N05, N06), 2 inactive (N03, N04), and 4 potential burrows from 2022 (PB28, PB29, PB30, PB31) (Figure 113 and Figure 116). Ten were new potential burrows found in 2023 (PB32–PB41) (Figure 113 and Figure 116). Adult BSTP activity was detected by the camera at the following burrows: N01 on 6 June, N05 on 29 May, and N06 on 5 June 2023. No BSTP carcasses or evidence of BSTP depredation were discovered during any of the dog searches.

On 28 September 2023 during a burrow survey with the dogs, we discovered a broken eggshell fragment (1 cm x 1 cm) at the cavity entrance of N01. The eggshell fragment was collected and cataloged for future possible BSTP scent training.

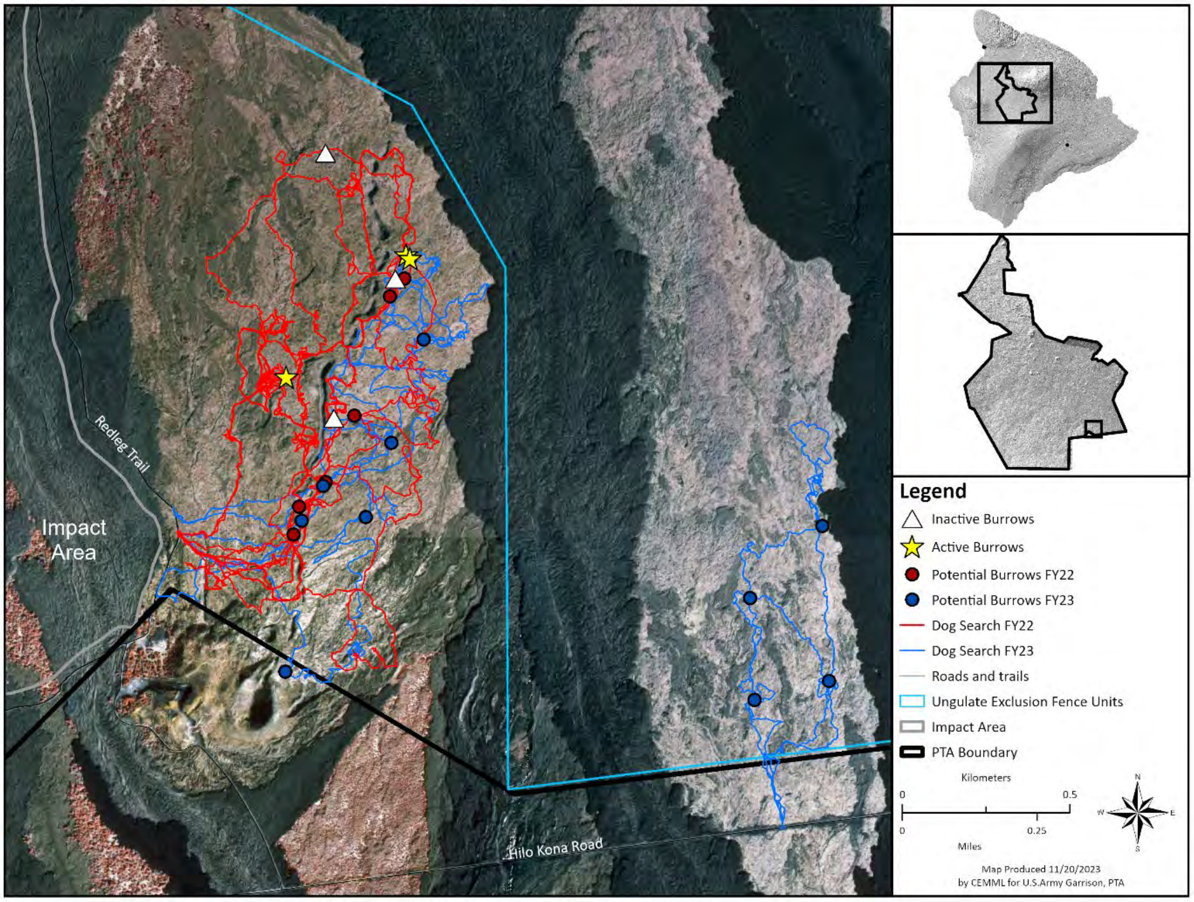


Figure 116. Dog search tracks (63 km) for Band-rumped Storm Petrel nests, FY 2022–FY 2023, in Training Area 21 at Pōhakuloa Training Area

Table 116. Dog search survey scent detection and video surveillance results, 2021–2023, in Band-rumped Storm Petrel breeding season

Active or Potential Burrow ID	Dog Search Year	Scent Detected[a] (Yes/No)	Camera Surveillance BSTP Detection (Yes/No)
N01	2021	Yes	Yes (Adult and Chick)
	2022	Yes	Yes (Adult)
	2023	Yes	Yes (Adult)
N02[b]	2022	Yes	No
	2023	—	No
N03	2022	No	No
	2023	No	No
N04	2022	No	No

Table 116. Dog search survey scent detection and video surveillance results, 2021–2023, in Band-rumped Storm Petrel breeding season (cont.)

Active or Potential Burrow ID	Dog Search Year	Scent Detected[a] (Yes/No)	Camera Surveillance BSTP Detection (Yes/No)
	2023	No	No
N05	2021	Yes	Yes (Adult and Chick)
	2022	Yes	Yes (Adult and Chick)
	2023	Yes	Yes (Adult)
N06/PB25	2022	Yes	Yes (Adult)
	2023	Yes	Yes (Adult)
PB24	2022	Yes	No
PB26	2022	Yes	No
PB27	2022	Yes	No
PB28	2022	Yes	No
	2023	Yes	No
PB29	2022	Yes	No
	2023	Yes	No
PB30	2022	Yes	No
	2023	Yes	No
PB31[c]	2022	Yes	No
	2023	No	—
PB32	2023	Yes	No
PB33	2023	Yes	No
PB34	2023	Yes	No
PB35	2023	Yes	No
PB36	2023	Yes	No
PB37	2023	Yes	No
PB38	2023	Yes	No
PB39	2023	Yes	No
PB40	2023	Yes	No
PB41	2023	Yes	No

The 2021 BSTP breeding season, only contains information if a BSTP chick was detected between October and November 2021.

[a] Band-rumped Storm Petrel scent or potential scent detected by detector dog.

[b] No dog search occurred at N02 in 2023, but the burrow was monitored by a camera.

[c] A camera was not deployed to monitor PB31 because no BSTP scent was detected by the search dog in 2023 and no BSTP activity was detected by a camera in 2022.

Characterizing BSTP Behavior

Burrow Monitoring Methods

BSTP breeding biology in Hawaiʻi is poorly understood. At PTA, individuals nest in natural cavities (i.e., burrows). Based on previous recorded call activity, BSTP return annually to PTA in late May for the breeding season and depart by mid-November (Galase 2019). The species is highly faithful to nesting sites, typically returning to the same colony and burrow each year (Slotterback 2002).

Each year after conducting burrow surveys with a detector dog, any location where the dog showed interest that was deemed an active or potential burrow was monitored with a time-lapse surveillance camera (Reconyx XP-9 Ultrafire™ professional covert camera traps or Browning Dark Ops HD Pro®). Most of the cameras were mounted on a camera bracket and secured to a 2 m t-post embedded in a portable cement base; some were positioned on the ground. Each camera was at least 5 m away from the burrow entrance, pointed directly at the entrance.

Active Burrows

Each camera at an active burrow was set to take a photograph every 15 seconds between 1800 h and 0600 h for a total of approximately 2,880 photographs per monitoring night, and to trigger 5 photos if motion was detected.

Inactive or Potential Burrows

Most of the inactive and potential burrow cameras were set to take a photo every 15 seconds between 2100 h and 0200 h and to trigger 5 photos if motion was detected. A few of the cameras were set with only motion sensor activated within a 24 h period. Before arming a camera, a walk test was performed to ensure that the camera would take a picture when something moved in front of the burrow's opening.

We used 64 GB SD cards to record photographs. Cards were switched out each visit, approximately weekly, lithium batteries were replaced as needed, and solar panels were installed on the cameras to ensure continuous coverage over the season. The photographs were reviewed in the office to assess BSTP activity and presence/absence of predators at the burrows. BSTP activity captured in photographic sequences was categorized into 10 behaviors:

(1) **Arrival**—BSTP on the exterior of the burrow opening, initial image of a BSTP with its head facing the entry of the burrow cavity or landing outside of burrow cavity.

(2) **Departure**—BSTP exiting the burrow cavity, outside of burrow facing away from the burrow cavity entry or showing signs of wing fluttering at the edge of the photograph frame before the BSTP disappears.

(3) **Burrow Maintenance**—BSTP using its beak to manipulate debris (e.g., vegetation, rocks, or soil) from the burrow entrance.

(4) **Locomotion**—BSTP changing body posture and locations around the burrow.

(5) **Preening**—BSTP using its beak to position feathers.

(6) **Resting**—BSTP belly region flat on the ground (no feet observed) and body posture not moving from its initial location.

(7) **Standing**—BSTP standing with its belly above the ground and feet can be seen.

(8) **Wing exercise**—BSTP moving its wings (e.g., chick energetically flapped its wings practicing for flight).

(9) **Territorial**—BSTP moving towards other birds or predators.

(10) **Unknown**—BSTP behaviors that could not be classified due to poor image quality, inability to clearly see the bird's full body, or photo taken within the burrow cavity.

Based on the presence/absence of BSTP photographed by the cameras, each burrow was assigned a final status based on the descriptions below:

(1) **Active Burrow**—

- (a) **Active breeding**—adults regularly are detected arriving and departing from the burrow throughout the breeding season.
  - (i) **Successful**—evidence of a chick fledging, to include when a chick or down feathers are observed outside the burrow and no depredation is observed.
  - (ii) **Unknown**—no chick or down was observed, or depredation was not detected.
  - (iii) **Failed**—depredation was detected.
- (b) **Prospecting—**adults not regularly detected arriving and departing from the burrow throughout the breeding season.

(2) **Inactive Burrow**—a previously active burrow with no activity in the current breeding season.

(3) **Potential Burrow**—a burrow identified by the detector dog with possible BSTP scent, but no BSTP activity detected by the cameras.

Photos were processed with Timelapse Image Analyzer (Greenberg Consulting Inc. 2021) and the files were organized by collection date and by burrow site. We developed a custom data entry interface for Timelapse Image Analyzer Template to document the following: personnel performing the analysis, date and time of the photo, presence of adult BSTP, presence of BSTP chicks, BSTP behavior, presence and species of predators, and data quality control (QC) information (e.g., QC, QC Date and QC observer). This information is exported from Image Analyzer and saved as .csv files viewable with Microsoft Excel.

Burrow Monitoring Results

In FY 2022, we deployed cameras at 13 burrows from May through November and detected BSTP activity at 3 burrows (N01, N05, and N06); 1 chick was detected in N05 (Table 117). Burrows N01, N05, and N06 each had an extra camera deployed to monitor additional burrow cavity openings or to monitor an active burrow opening from a different angle.

In FY 2023, we deployed cameras at 19 burrows from May through September and detected BSTP activity at 3 burrows (N01, N05, and N06) (Table 117). Burrows N01, N05, and N06 each had an extra camera deployed to monitor additional burrow cavity openings or to monitor an active burrow opening from a different angle.

Table 117. Band-rumped Storm Petrel active/inactive and potential burrow monitoring results via camera surveillance, 2021–2023

Burrow ID	Burrow Status	Adult Detected (Yes/No)	Chick Detected (Yes/No)	Fledging Detected (Yes/No)	Depredation Detected (Yes/No)
N01	Active Breeding–Success[a]	Yes	Yes[a]	Yes	No
N02	Inactive	No	No	No	No
N03	Inactive	No	No	No	No
N04	Inactive	No	No	No	No
N05	Active Breeding–Success[b]	Yes	Yes[b]	Yes	No
N06/PB25	Active Breeding–Unknown	Yes[c]	No	No	No
PB24	Inactive	No	No	No	No
PB26	Inactive	No	No	No	No
PB27	Inactive	No	No	No	No
PB28	Inactive	No	No	No	No
PB29	Inactive	No	No	No	No
PB30	Inactive	No	No	No	No
PB31[d]	Inactive	No	No	No	No
PB32	Inactive	No	No	No	No
PB33	Inactive	No	No	No	No
PB34	Inactive	No	No	No	No
PB35	Inactive	No	No	No	No
PB36	Inactive	No	No	No	No
PB37	Inactive	No	No	No	No
PB38	Inactive	No	No	No	No
PB39	Inactive	No	No	No	No
PB40	Inactive	No	No	No	No
PB41	Inactive	No	No	No	No

[a] BSTP chick was detected at N01 in 2021, but not in 2022 or 2023.
[b] BSTP chick was detected at N05 in 2021 and FY 2022, but not in 2023.
[c] Adult BSTP was detected at N06 in 2022 and 2023, but the burrow was not discovered in 2021.
[d] In FY 2023, no camera was deployed to monitor PB31 because no BSTP scent was detected by the detector dog in 2023 and no BSTP activity was detected by a camera in 2022.

No BSTP depredation was detected at any of the burrows, although multiple black rats and mice were seen entering and exiting the burrow cavities. A more detailed monitoring summary for each burrow is provided below.

Burrow N01 (Active)

In FY 2022, a BSTP chick was detected on 03 November 2021, and it was last detected on 10 November 2021. The camera did not detect the fledging event. We assume the bird took flight after the last detection. Also, during FY 2022 we placed a camera at N01 on 19 May and observed the first adult entering the burrow on 11 June. A second camera was placed on 2 November to monitor the burrow entrance from a different angle. The last BSTP adult visit was detected 12 September. A total of 556,625 photographs was recorded from 19 May to 11 November 2022. During the monitoring period, black rats were detected on 1 day and mice on 13 days. No depredation of BSTP was detected.

In 2023, we placed a camera at N01 on 22 May and observed the first adult entering the burrow on 6 June. The last BSTP adult visit was detected on 26 September. A total of 287,047 photographs was recorded from 22 May to 30 September 2023. During the monitoring period, no black rats were detected, and mice were detected on 8 days. No depredation of BSTP was detected.

Burrow N02 (Inactive)

In FY 2022, we placed a camera at N02 on 23 May and no BSTP activity was detected during the breeding season. This burrow was inactive in 2022. However, late in the season the detector dog indicated a possible BSTP scent at a crevice less than 5 m away from the camera. We relocated the camera to monitor the burrow, but we did not detect BSTP. A total of 109,729 photographs was recorded from 23 May to 31 October 2022. During the monitoring period, black rats were detected on 7 days, mice on 2 days, and 1 cat on 1 day.

In FY 2023, we placed a camera at N02 on 22 May and no BSTP activity was detected during the breeding season. This burrow was inactive in 2023. A total of 374,056 photographs was recorded between 22 May and 30 September 2023. During the monitoring period, black rats were detected on 31 days and mice on 5 days.

Burrow N03 (Inactive)

In FY 2022, we placed a camera at N03 on 23 May and no BSTP activity was detected during this breeding season. This burrow was inactive in 2022. A total of 73,498 photographs was recorded from 23 May to 29 September 2022. During the monitoring period, no black rats were detected, and mice were detected on 8 days.

In FY 2023, we placed a camera at N03 on 30 May and no BSTP activity was detected during this breeding season. This burrow was inactive in 2023. A total of 9,589 photographs was recorded from 30 May to 30 September 2023. During the monitoring period, black rats were detected on 4 days, and no mice were detected.

Burrow N04 (Inactive)

In FY 2022, we placed a camera on N04 on 23 May and no BSTP activity was detected during this breeding season. This burrow was inactive in 2022. A total of 100,826 photographs was recorded from 23 May to 28 September 2022. During the monitoring period, a black rat was detected on 1 day and a mouse on 1 day.

In FY 2023, we placed a camera on N04 on 30 May and no BSTP activity was detected during this breeding season. This burrow was inactive in 2023. A total of 189 photographs was recorded from 30 May to 29 September 2023. During the monitoring period, a black rat was detected on 1 day, but no mice were detected.

Burrow N05 (Active)

In FY 2022, a BSTP chick was detected on 20 October 2021, and it was last detected on 24 October 2021. The cameras did not detect the fledging event. We assume the bird took flight after the last detection. Also in FY 2022, we placed 2 cameras at N05 on 19 May to monitor the 2 different cavity openings the pair used in 2021. The first detection of the adult BSTP entering the burrow was on 27 May. The last adult visit was detected on 9 November.

A BSTP chick was detected on 6 November using a third cavity in the vicinity of N05. A third camera was deployed on 8 November to cover this cavity, but based on data from the other 2 cameras, the chick had likely already departed the area. The chick was last detected on 7 November. We assume the bird took flight after the last detection. A total of 1,032,462 photographs was recorded from 19 May to 17 November 2022. During the monitoring period, a black rat was detected on 1 day and no mice were detected. No depredation of BSTP was detected.

In FY 2023, we placed 2 cameras at N05 on 22 May and observed an adult BSTP entering the burrow on 29 May. The last BSTP adult visit was detected on 25 September. No BSTP chick or fledgling was detected in 2023 and the active breeding activity fate is unknown. A total of 634,451 photographs was recorded between 22 May and 27 September 2023. During the monitoring period, black rats were detected on 7 days and mice were detected on 6 days. No depredation of BSTP was detected.

Burrow N06/PB25 (Active)

In FY 2022, we placed a camera on N06 on 08 August and observed an adult entering the burrow on 11 August. The last BSTP adult visit was detected on 3 November. A second camera was deployed on 4 November. No BSTP chick or fledgling was detected in 2022 and we assume the nest failed. A total of 319,726 photographs was recorded. During the monitoring period, no black rats were detected, and mice were detected on 3 days. No depredation of BSTP was detected.

In FY 2023, we placed a camera on N06 on 22 May and observed an adult entering the burrow on 5 June. The last BSTP adult visit was detected on 27 September. No BSTP chick or fledgling was detected in 2023 and the active breeding activity fate is unknown. A total of 370,146 photographs was recorded between 22 May and 30 September 2023. During the monitoring period, black rats were detected on 5 days and mice were detected on 4 days. No depredation of BSTP was detected.

PB26 (Inactive)

In FY 2022, we placed a camera on PB26 on 23 August and no BSTP activity was detected during this breeding season. This burrow was inactive in 2022. A total of 23,442 photographs was recorded from 23 August to 9 September 2022. During the monitoring period, no black rats or mice were detected.

In FY 2023, no camera was deployed to monitor the burrow.

PB27 (Inactive)

In FY 2022, we placed a camera on PB27 on 23 August and no BSTP activity was detected during this breeding season. This burrow was inactive in 2022. A total of 13,284 photographs was recorded from 23–28 August 2022. During the monitoring period, no black rats or mice were detected.

In FY 2023, no camera was deployed to monitor the burrow.

PB28 (Inactive)

In FY 2022, we placed a camera on PB28 on 23 August and no BSTP activity was detected during this breeding season. This burrow was inactive in 2022. A total of 165,839 photographs was recorded from 23 August to 7 September 2022. During the monitoring period, no black rats or mice were detected.

In FY 2023, we placed a camera on PB28 on 22 May and no BSTP activity was detected during this breeding season. This burrow was inactive in 2023. A total of 22,479 photographs was recorded from 22 May to 30 September 2023. During the monitoring period, black rats were detected 2 days and no mice were detected.

PB29 (Inactive)

In FY 2022, we placed a camera on PB29 on 7 September and no BSTP activity was detected during this breeding season. This burrow was inactive in 2022. A total of 149,116 photographs was recorded from 7 September to 31 October 2022. During the monitoring period, no black rats or mice were detected.

In FY 2023, we placed a camera on PB29 on 22 May and no BSTP activity was detected during this breeding season. This burrow was inactive in 2023. A total of 41,515 photographs was recorded from 22 May to 30 September 2023. During the monitoring period, a black rat was detected on 1 day and no mice were detected.

PB30 (Inactive)

In FY 2022, we placed a camera on PB30 on 8 September and no BSTP activity was detected during this breeding season. This burrow was inactive in 2022. A total of 294,969 photographs was recorded from 8 September to 3 November 2022. During the monitoring period, no black rats or mice were detected.

In FY 2023, we placed a camera on PB30 on 15 June and no BSTP activity was detected during this breeding season. This burrow was inactive in 2023. A total of 25,492 photographs was recorded from 15 June to 30 September 2023. During the monitoring period, black rats were detected on 3 days and no mice were detected.

PB31 (Inactive)

In FY 2022, we placed a camera on PB31 on 29 September and no BSTP activity was detected during this breeding season. This burrow was inactive in 2022. A total of 99,667 photographs was recorded from 29 September to 2 November 2022. During the monitoring period, no black rats or mice were detected.

In FY 2023, no camera was deployed to monitor PB31 because no BSTP scent was detected during the search dog in 2023 and no BSTP activity was detected by a camera in 2022.

PB32 (Inactive)

In FY 2023, we placed a camera on PB32 on 15 June and no BSTP activity was detected during this breeding season. This burrow was inactive in 2023. A total of 179 photographs was recorded from 15 June to 17 July 2023. During the monitoring period, no black rats or mice were detected.

PB33 (Inactive)

In FY 2023, we placed a camera on PB33 on 15 June and no BSTP activity was detected during this breeding season. This burrow was inactive in 2023. A total of 22,879 photographs was recorded from 15 June to 27 September 2023. During the monitoring period, no black rats or mice were detected.

PB34 (Inactive)

In FY 2023, we placed a camera on PB34 on 15 June and no BSTP activity was detected during this breeding season. This burrow was inactive in 2023. A total of 29,194 photographs was recorded from 15 June to 30 September 2023. During the monitoring period, black rats were detected on 18 days and mice were detected on 6 days.

PB35 (Inactive)

In FY 2023, we placed a camera on PB35 on 10 August and no BSTP activity was detected during this breeding season. This burrow was inactive in 2023. A total of 10,241 photographs was recorded from 10 August to 30 September 2023. During the monitoring period, black rats were detected 9 days and no mice were detected.

PB36 (Inactive)

In FY 2023, we placed a camera on PB36 on 10 August and no BSTP activity was detected during this breeding season. This burrow was inactive in 2023. A total of 11,209 photographs was recorded from 10 August to 30 September 2023. During the monitoring period, black rats were detected 21 days and no mice were detected.

PB37 (Inactive)

In FY 2023, we placed a camera on PB37 on 10 August and no BSTP activity was detected during this breeding season. This burrow was inactive in 2023. A total of 9,927 photographs was recorded from 10 August to 26 September 2023. During the monitoring period, black rats were detected 10 days and no mice were detected.

PB38 (Inactive)

In FY 2023, we placed a camera on PB38 on 14 August and no BSTP activity was detected during this breeding season. This burrow was inactive in 2023. A total of 943 photographs was recorded from 14 August to 25 September 2023. During the monitoring period, a black rat was detected on 1 day and no mice were detected.

PB39 (Inactive)

In FY 2023, we placed a camera on PB39 on 7 September and no BSTP activity was detected during this breeding season. This burrow was inactive in 2023. A total of 1,192 photographs was recorded from 7 September to 30 September 2023. During the monitoring period, no black rats or mice were detected.

PB40 (Inactive)

In FY 2023, we placed a camera on PB40 on 7 September and no BSTP activity was detected during this breeding season. This burrow was inactive in 2023. A total of 13,798 photographs was recorded from 7 September to 30 September 2023. During the monitoring period, no black rats or mice were detected.

PB41 (Inactive)

In FY 2023, we placed a camera on PB41 on 2 October and no BSTP activity was detected during this breeding season, but detailed camera data results will be reported in FY 2024.

Predator Control Management

Live and Lethal Trapping

We implement cat, mongoose, and rodent control in TA 21 within what we believe to be the extent of the BSTP breeding colony, now designated as ASR 501 (Figure 117). A combination of live and lethal traps was used to remove small mammals. In FY 2022, 6 rodent treatment sites (RTS; RTS01–RTS06) were managed and in FY 2023, 3 RTSs (RST01, RTS02, RTS03) were managed (Figure 117). In FY 2023, the predator control activities reported below occurred from 1 October to 28 November 2022 and 31 January to 30 September 2023. Predator control activities were discontinued from 29 November 2022 to 30 January 2023 due to the Mauna Loa eruption. On 31 January 2023, we redeployed 41 live traps to the colony. We adjusted the size and configuration of 3 rodent treatment sites that protect active and inactive burrows and redeployed 74 lethal traps to the RTSs on 1 February 2023.

Live Trapping

We deployed up to 41 Tomahawk® (30" x 10" x 12") live traps spaced 200 m apart across the known breeding area (Figure 117). Live traps were monitored daily using SkyHawk® (PICA Production Development) sensors, an electronic cellular connectivity device that alerts the user when a trap has been triggered (trap door closes or trap vibrates). These sensors eliminated the need to physically check traps every 24 hours, which is a Colorado State University Animal Care and Use Committee requirement. All the live traps were baited monthly with a can of sardines (Beach Cliff brand sardines in soybean oil) with scent holes punctured in the top. All live traps with SkyHawk sensors were set and open 7 days per week.

Lethal Trapping

To protect nesting BSTP from rodents, in FY 2022 we managed 6 RTSs and in FY 2023 we managed 3 RTSs that encompassed all potential, inactive, and active burrows (Figure 117). In each RTS, we deployed 16 A24 traps spaced about 50 m apart in a 150 m x 150 m grid centered on the burrow(s) being protected (small adjustments in the spacing were made due to the terrain). When burrows were proximate, RTS grids overlapped to create larger grids. All A24 traps were placed at least 50 m away from burrow openings to minimize potential BSTP interactions with the traps. Every 3 months, the Goodnature® chocolate formula bait lure and CO_2 canister were replaced. Also, for each RTS, up to 4 snap traps (Kress™ Snap-E traps) were deployed inside protective boxes and set at least 2 m from the burrow openings. We rebaited snap traps every 2 weeks with the Goodnature® chocolate formula bait lures. While maintaining the snap traps, we also removed any carcasses from around the A24 traps every 2 weeks.

In addition, 5 to 8 surveillance cameras (Browning Dark Ops HD Pro®) were deployed to monitor 8 randomly selected A24 traps for non-target take and scavengers. Several native birds that may be attracted to the A24 traps occur in TA 21, including the Hawaiian Goose, the Hawaiian Short-eared

Owl (*Asio flammeus sandwichensis*), and the ʻŌmaʻo (*Myadestes obscurus*). In addition, the Barn Owl (*Tyto alba*), a documented BSTP predator, has been observed in TA 21.

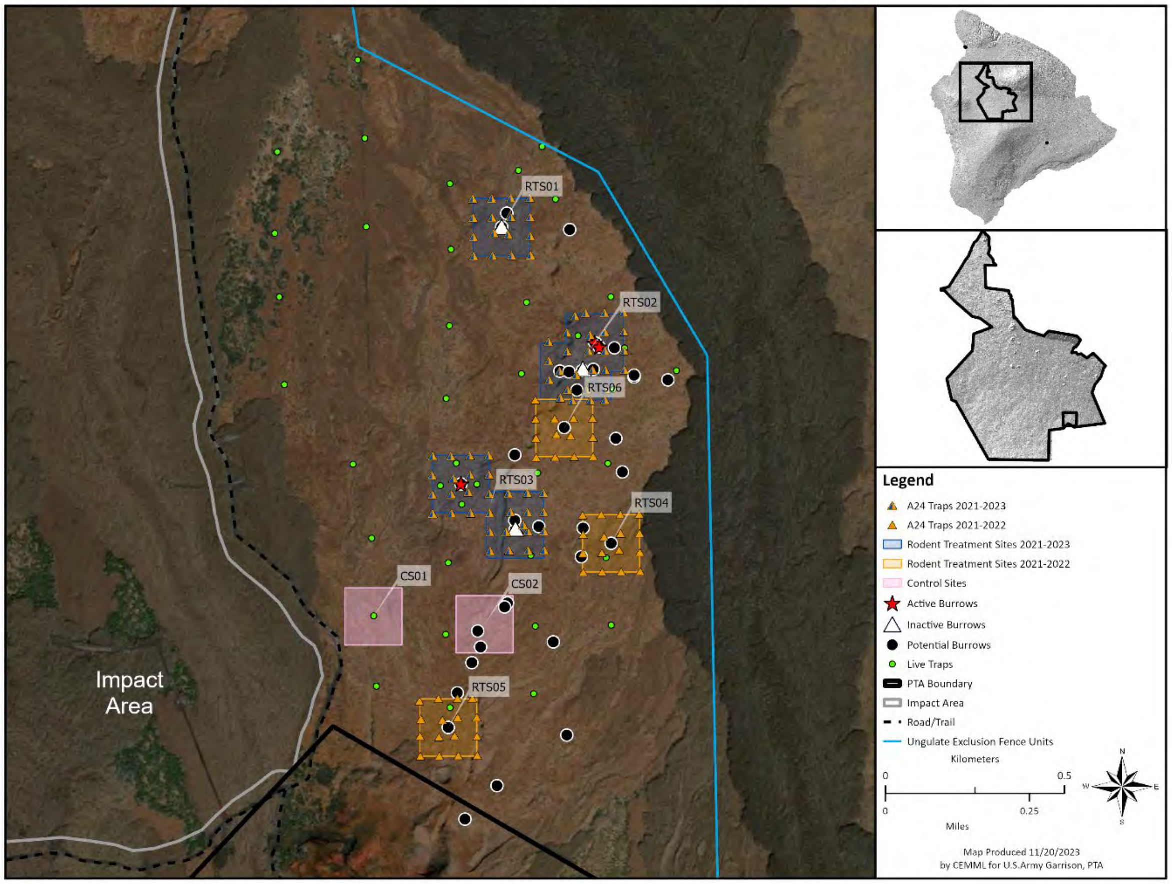


Figure 117. Predator trap layout, FY 2022–FY 2023, in the Band-rumped Storm Petrel colony in Training Area 21 at Pōhakuloa Training Area

<u>Live and Lethal Trapping Results</u>

Live Traps

In FY 2022, we monitored 40 live traps, and removed 3 feral cats (Table 118). In FY 2023, we deployed 41 live traps and removed 1 mongoose and 2 black rats (Table 118). In addition, in FY 2022, 3 non-native game birds, 1 Chukar (*Alectoris chukar*) and 2 Erckel's Spur Fowl (*Pternistis erckelii*), were captured in the live traps and released unharmed and no non-targets were captured in FY 2023. No native or endangered animals were captured in live traps during the reporting period.

Table 118. Predators captured in live traps around the petrel breeding colony site (ASR 501) at Pōhakuloa Training Area, FY 2022–FY 2023

Breeding Season	Traps Deployed	Total Captures	Cats	Mongoose	Rats
FY 2022[a]	40	3	3	0	0
FY 2023[b]	41	3	0	1	2

ASR, Area of Species Recovery
[a] Live trapping occurred October 2021–September 2022.
[b] Live trapping occurred October 2022–November 2022 and February–September 2023.

Lethal Traps

In FY 2022, we monitored 122 A24 traps and 32 snap traps and removed 96 rodent carcasses (37 black rats and 59 mice) (Table 119). In FY 2023, we also monitored 122 A24 traps and 32 snap traps and removed 145 rodent carcasses (83 black rats and 62 mice) (Table 119). In FY 2023, we had the first non-target animal killed by the A24 traps. We collected 2 non-target juvenile Chukar carcasses from A24 traps. In previous years we have detected many adult Chukars interacting with the A24 traps, but we have never detected a kill. In addition, our cameras did detect juvenile Chukars interacting with the A24 trap, but the carcasses discovered at A24 traps were not monitored by a camera. Because carcasses may be on the ground for up to 2 weeks, some carcasses may be scavenged before we find them. 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. No native or endangered animal carcasses were discovered in the A24 traps.

Table 119. Total number of A24 traps and snap traps deployed and the total number of rodents collected and removed from each rodent treatment site at ASR 501, FY 2022–FY 2023[a]

Rodent Treatment Site	A24 Traps		Snap Traps		Black Rats Removed		Mice Removed	
	FY 2022	FY 2023	FY 2022	FY 2023	FY 2022	FY 2023	FY 2022	FY 2023
RTS01	16	16	2	2	11	31	19	24
RTS02	27	27	18	18	4	17	9	16
RTS03	31	31	10	10	8	29	11	22
RTS04	16	16	0	0	5	2	9	0
RTS05	16	16	0	0	8	4	4	0
RTS06	16	16	2	2	1	0	7	0
Total	**122**	**122**	**32**	**32**	**37**	**83**	**59**	**62**

[a] FY 2023 lethal trapping occurred between October 2022 – November 2022 (RTS 01-RTS06) and February 2023 – September 2023 (RTS01-RTS03).

No native or endangered birds (BSTP, Hawaiian Goose, Hawaiian Short-eared owl, and ʻŌmaʻo) were detected at the 9 monitored A24 traps. In addition, no Barn Owls were detected at the A24 traps. The cameras detected 4 other birds: Chukar, Skylark (*Alauda arvensis,* non-native), House finch (*Haemorhous mexicanus*, non-native) and Pacific Golden Plover (*Pluvialis fulva,* indigenous). Most birds in the photographs did not appear to interact with the trap, but Chukar showed mild interest in the Goodnature® chocolate lure bait when placed outside the trap and juvenile Chukars were photographed entering the traps.

Tracking Tunnels

We used tracking tunnels to monitor changes in rodent activity in response to trap deployment, because tracking tunnels indicate the relative abundance of the rodent population. We also established 2 tracking tunnel grids in areas where no traps were deployed (termed Control Sites) to monitor baseline rodent activity outside treatment areas. Tracking tunnels were spaced 25 m apart within the RTS or Control Site (CS). All tracking tunnels were deployed for 3 consecutive nights and ink-tracked papers collected after the third night.

Tracking tunnels consist of tracking paper with an inked area and bait placed inside a weather-resistant tunnel. As a rodent investigates the bait inside the tunnel, the ink is transferred onto the foot of the animal, resulting in a footprint left on the un-inked portion of the tracking paper, which can be identified to species. Tracking tunnels are 35.5 x 11.3 x 13.5 cm (length x width x height) and made of Polytag® weather-resistant material (Cole Graphic Solutions all-terrain printing®). Tracking papers are 35 x 11 cm (length x width), constructed from all-weather paper (Rite in the Rain paper, JL Darling LLC®). A 15 x 8 cm (length x width) area in the center of the tracking paper is inked (tracking ink, Pest Control Research LP, New Zealand). The tracking paper is inserted, and the tunnel is baited with Goodnature® chocolate formula lure.

On 26 May 2020, prior to trapping, we deployed 152 tracking tunnels within 5 RTS and 2 CS and on November 2021, 1 additional RTS (RTS06) was added. Following trapping, in FY 2022 and on November 2022 we deployed 168 tracking tunnels and for FY 2023, we deployed 120 tracking tunnels at the same sites quarterly (Figure 118).

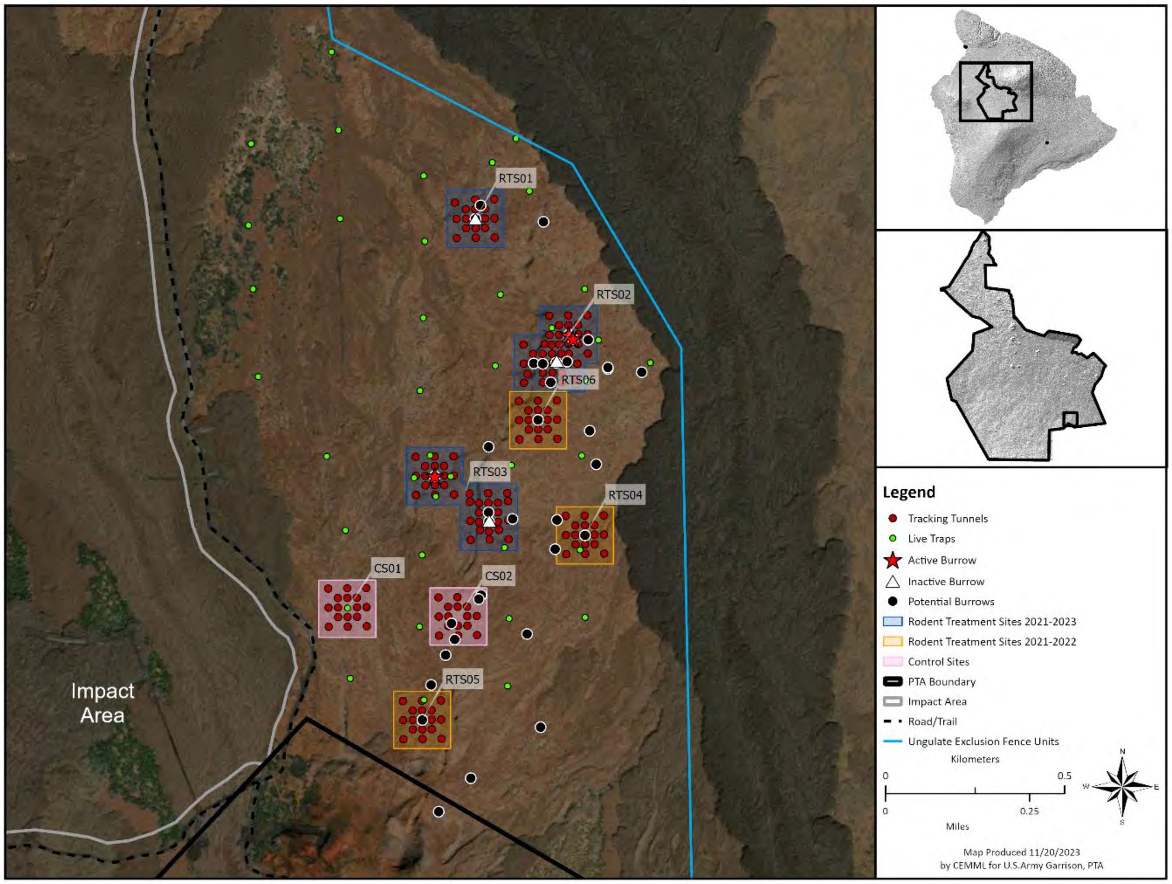


Figure 118. Tracking tunnel layout, FY 2022–FY 2023, in the Band-rumped Storm petrel colony in Training Area 21 at Pōhakuloa Training Area[a]

<u>Tracking Tunnel Results</u>

Tracking tunnel results show that rodent activity (i.e., percent of tunnels with rodent tracks relative to total tunnels set) varied among all the RTS and CS (Table 69). Overall, rat activity decreased in each RTS following trapping. Since February 2021, black rat activity for all RTS has been below 11% (range 0 to 11%). However, black rat activity was 0% in each CS between May and August 2021, which suggests that rat activity was low overall during this period independent of our trapping efforts.

Mouse activity did not show a clear pattern between pre- and post-trapping efforts in the RTS (Table 69). In addition, mouse activity was also highly variable in the CS. However, in general, when black rat activity decreased, mouse activity increased. A similar pattern has been noted for other rodent control efforts at PTA in TA 22 (USAG-PTA NRP unpublished data) and TA 23 (RCUH 1998).

Table 120. Tracking tunnel results, which indicate rodent activity in the rodent treatment sites and control site, in ASR 501 from May 2020 and November 2021 to August 2023

Site ID	Species	May 2020[a]	Nov 2021	Feb 2022	May 2022	Aug 2022	Nov 2022	Feb 2023	May 2023	Aug 2023
CS01	Black Rat	**38%**	0%	0%	0%	0%	0%	19%	69%	88%
	Mouse	**50%**	81%	0%	0%	6%	38%	0%	0%	0%
CS02	Black Rat	**44%**	0%	0%	0%	6%	0%	19%	75%	0%
	Mouse	**6%**	63%	6%	0%	6%	0%	0%	0%	0%
RTS01	Black Rat	**31%**	0%	0%	0%	0%	44%	0%	0%	6%
	Mouse	**69%**	56%	13%	0%	0%	0%	38%	6%	0%
RTS02	Black Rat	**17%**	0%	0%	0%	0%	0%	0%	11%	0%
	Mouse	**6%**	0%	0%	0%	3%	3%	0%	0%	25%
RTS03	Black Rat	**44%**	11%	0%	0%	0%	0%	0%	17%	0%
	Mouse	**36%**	0%	0%	0%	0%	6%	8%	22%	53%
RTS04[b]	Black Rat	**44%**	6%	0%	0%	0%	0%	–	–	–
	Mouse	**44%**	0%	0%	0%	0%	13%	–	–	–
RTS05[b]	Black Rat	**69%**	0%	0%	0%	0%	0%	–	–	–
	Mouse	**25%**	0%	6%	0%	6%	0%	–	–	–
RTS06[b]	Black Rat	**–**	0%	0%	0%	0%	0%	–	–	–
	Mouse	**–**	0%	0%	0%	0%	0%	–	–	–

CS, Control Site (no rodent trapping), RTS, Rodent Treatment Site (rodent trapping).

[a] Data reported for May 2020 are the percent of tracking tunnels with rodent activity by species before rodent trapping commenced in the rodent treatment sites (RTS). Data reported to the right of the vertical solid line are post-rodent trapping in the RTS. Trapping at RTS06 initiated after May 2020 and therefore did not have pre-rodent trapping data.

[b] Trapping and tracking tunnels discontinued at RTS04, RTS05, and RTS06 after November 2022.

Seabird Discussion

Survey and Monitoring Activities

Since the first BSTP active burrow (N01) was discovered in 2015, we have successfully confirmed 5 additional active burrows (N02, N03, N04, N05, and N06). However, N02 has been inactive since 2018, N03 inactive since 2019, and N04 inactive since 2020 (Table 121).

Table 121. Camera monitoring results for active Band-rumped Storm Petrel burrows, 2015–2023

Burrow ID	Years Video Monitored	Years BSTP Activity Confirmed	Years BSTP Chick Activity Confirmed
N01	2015–2023	2015, 2017–2023	2018, 2021
N02	2017–2023	2017[a]	—
N03	2017–2023	2018	—
N04	2018–2023	2018, 2019	—
N05	2018–2023	2019–2023	2019, 2020[b], 2021, 2022
N06	2022–2023	2022–2023	—

[a] **Camera footage documented a feral cat depredating an adult BSTP at the burrow.**

[b] **No BSTP chick was detected by the surveillance camera, but 1 down feather was found, suggesting a possible fledge event.**

In FY 2022 and FY 2023, out of 3 active burrows (N01, N05, and N06), N02 was the only successful burrow where a chick was detected. No fledging event was detected by the camera, but numerous wing exercises behaviors were recorded that suggest the chick might have fledged.

The use of multiple cavities to access burrows may explain past difficulties with detecting chick activity at N05 and N06 despite documenting adult activity. Monitoring multiple cavities is costly and time consuming, and we find assigning the right number of cameras to the right locations for optimal detection challenging.

Finding and confirming new active nests has also been challenging, and despite our efforts we still do not know the extent of the area that BSTP use for breeding at PTA. With only 6 active nests documented within the past 9 years, our understanding of breeding activity and behavior remains rudimentary.

In addition to breeding activity, BSTP call activity from previous years suggests that many non-breeding BSTP are visiting the colony and using the airspace above the known burrows. Because non-breeders are the most frequent callers at a colony (Buxton and Jones 2012) and breeding birds tend to be silent (Simons 1985), we assume the colony has a substantial non-breeding component. However, we have little information about the non-breeding component of the colony at PTA. With the acoustic monitoring results from 2022, we have gained more information about nightly colony attendance patterns of non-breeders. BSTP calls show a peak about 200 minutes (2120 h) after sunset with a gradual decrease after the peak, and there appears to be a strong relationship between call rates and a new moon cycle.

Since 2022, we have monitored active burrows N01, N05, and N06 intensively with cameras. We pooled the BSTP behaviors—arrival, departure, burrow maintenance, and wing exercise—to better understand how their detections compare across the breeding season. All burrow camera monitoring methods and camera views were identical. We describe the most frequently observed behaviors for periods throughout the breeding season, based on 2022 and 2023 data (Figure 119). From late May to early June, BSTP adults primarily arrive at the burrows (Figure 119). Between mid-June and the end of June, birds engage in burrow maintenance. From late June to mid-August, birds arrive and depart with a low frequency (likely the egg incubation period). From late August to late September, the frequency of arrivals and departures increases greatly (likely parents are feeding the chick) and we also observed the pairs maintaining the burrow with moderate frequency. Throughout October, adults arrive and depart less and less frequently until such activity ends in early November. Finally, in late October to early November, the BSTP chicks begin to emerge from the burrow and exercise their wings. By mid-November, the chicks fledge.

Next year we plan to use this new information about likely breeding stages to guide field operations including dog searches, night vision surveys, and camera monitoring.

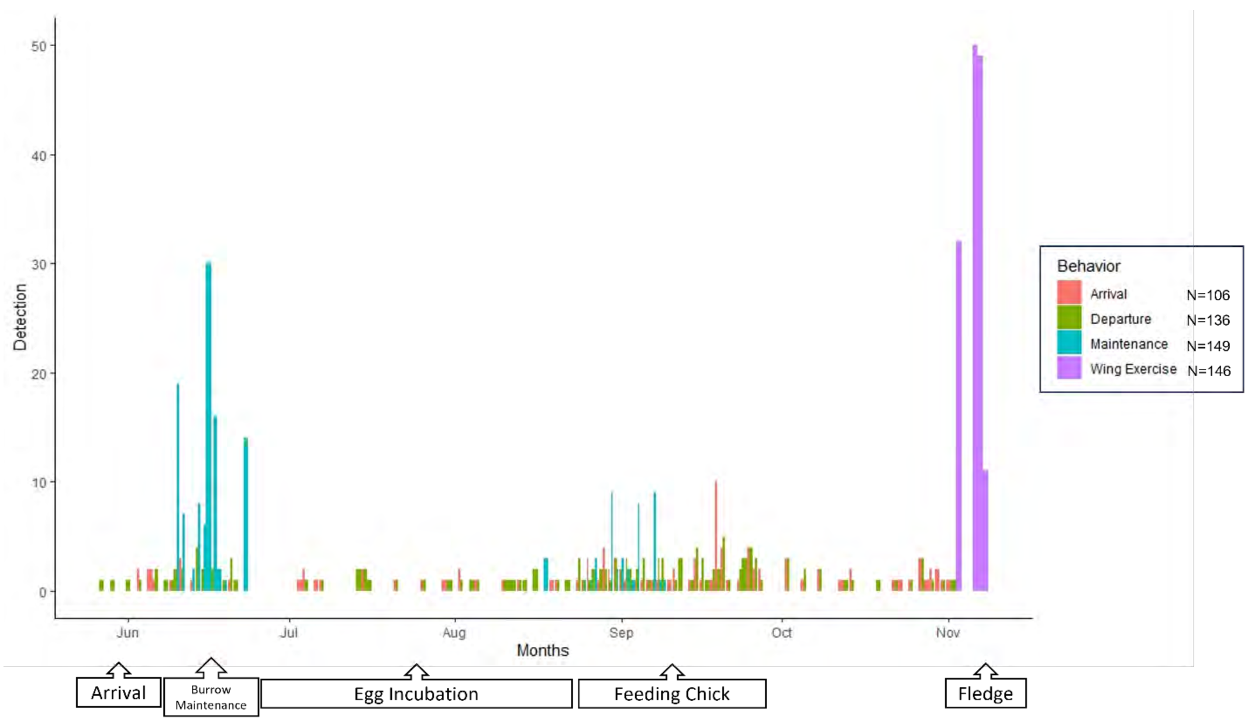


Figure 119. Band-rump Storm Petrel behaviors, 2022–2023 breeding season

Predator Control Activities

Trapping for cats year-round has increased the number of captures outside the breeding season, which helps keep predator presence low prior to the arrival of breeding birds. Year-round trapping also likely contributed to low levels of black rat activity within the RTS. Between 2015 and 2017, predator control efforts were minimal and confined to a few weeks prior to the birds arriving in late May. Between 2015 and 2017, we discovered evidence of BSTP depredation (e.g., feathers, wings, bones) during dog searches. In 2017, a feral cat was documented depredating an adult BSTP at its burrow. However, with increased predator control efforts since 2018, we have not discovered evidence of additional BSTP depredation during dog surveys or via camera surveillance.

In addition, maintaining the A24 traps year-round in the RTSs likely contributed to low black rat and mouse activity levels. In FY 2022, black rat activity across the RTSs ranged from 0% to 11% and mouse activity levels ranged from 0% to 56% (Table 120). In FY 2023, black rat activity across the RTSs ranged from 0% to 44% and mouse activity levels ranged from 0% to 53% (Table 120). The cause of the rodent activity increase is not known. However, in past years, trapping efforts have helped keep black rat and mice activity below 20% in all RTSs. Based on information from other rodent control efforts in Hawaiʻi, keeping black rat activity below 20% likely confers a positive conservation benefit to focal species (Shiels et al. 2019) such as the BSTP. Because predation has a large impact on BSTP populations (Slotterback 2002), reducing predation on adults, chicks, and eggs is a top priority.

The presence of predators within the colony appears to have increased in FY 2023 compared to FY 2022. There was an increase in rodents captured in A24 traps from FY 2022 to FY 2023 (Table 122). There were almost 3 times as many black rats collected in FY 2023 (77) compared to FY 2022 (23) and below twice as many mice collected in 2023 (62) compared to FY 2022 (39). The tracking tunnel data in the 2 CSs also had a larger range of black rat activity in FY 2023 (0% to 88%) than in 2022 (0% to 6%) (Table 123). In addition, in past years in all burrows monitored by camera, predator detections were infrequent.

Table 122. Lethal trapping results, FY 2022–FY 2023, in the Band-rumped Storm Petrel colony

Breeding Season	Rodent Treatment Site	A24 Traps	Snap Traps	Black Rats Removed	Mice Removed
FY 2022	RTS01	16	2	11	19
	RTS02	27	18	4	9
	RTS03	31	10	8	11
	Total	**74**	**30**	**23**	**39**
FY 2023	RTS01	16	2	31	24
	RTS02	27	18	17	16
	RTS03	31	10	29	22
	Total	**74**	**30**	**77**	**62**

RTS–Rodent Treatment Site

Table 123. Tracking tunnel results, FY 2022–FY 2023, as percent of tunnels with activity by rodent species at the control management sites in the Band-rumped Storm Petrel colony.

Breeding Season	Site	Species	May 2020[a]	Nov 2021	Feb 2022	May 2022	Aug 2022
FY 2022	CS01	Black Rat	**38%**	0%	0%	0%	0%
		Mouse	**50%**	81%	0%	0%	6%
	CS02	Black Rat	**44%**	0%	0%	0%	6%
		Mouse	**6%**	63%	6%	0%	6%
				Nov	**Feb**	**May**	**Aug 2023**
FY 2023	CS01	Black Rat	**38%**	0%	19%	69%	88%
		Mouse	**50%**	38%	0%	0%	0%
	CS02	Black Rat	**44%**	0%	19%	75%	0%
		Mouse	**6%**	0%	0%	0%	0%

CS, Control Site (no rodent trapping), RTS, Rodent Treatment Site (rodent trapping).

[a] Data reported for May 2020 are the percentages of tracking tunnels with rodent activity by species before trapping began in the rodent treatment sites (RTS).

Despite the increase of rodents, no BSTP depredation was detected this year. Continuing trapping efforts across the seabird colony are reducing predators, likely benefiting BSTP survivorship and nest success.

4.2.6 Avian Monitoring

We have monitored birds annually at PTA since 1998. 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.

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.

Methods

Fifteen monitoring transects ranging between 2 to 3.5 km in length cover 3 study areas: TA 1 through 4 (4 transects), TA 22 (4 transects), and TA 23 (7 transects). From 14 to 24 monitoring stations are spaced every 150 m along each transect (Figure 120). Transect and station spacing were selected to minimize the likelihood of counting the same bird at 2 or more stations and were 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 on selected days from December through early January. 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. Detection frequency (mean number of bird calls detected per station) is estimated through a ratio of the total number of bird detections, by species, to the total number of monitoring stations.

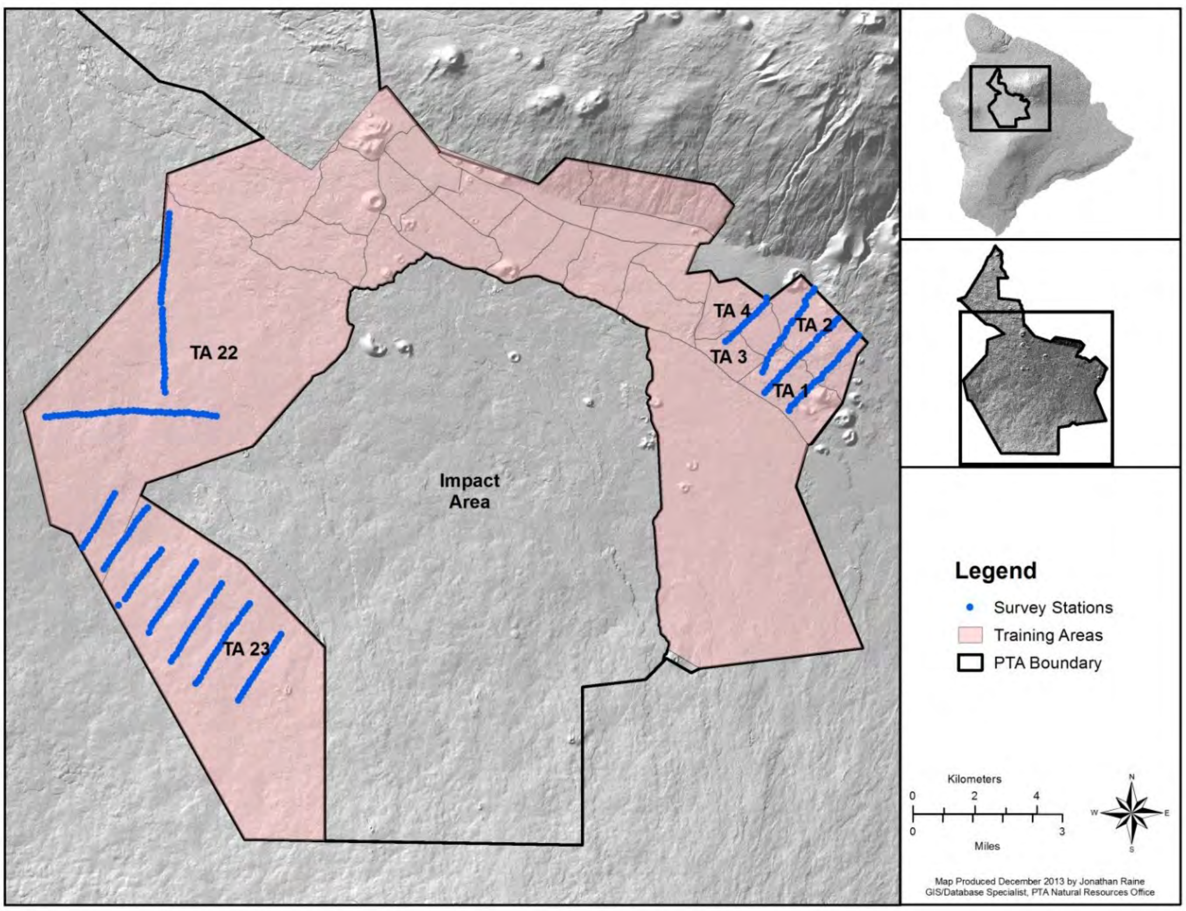


Figure 120. Avian monitoring transects at Pōhakuloa Training Area

Results

Birds detected in FY 2022 and FY 2023 are summarized in Table 124. Of the 28 birds detected, 5 were native species, 17 were non-native non-game species, 5 were non-native game species, and 1, Pacific Golden Plover, is indigenous (Table 124). Twelve 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*), Erckel's Spur Fowl (*Pternistis erckelii),* Yellow Fronted Canary (*Serinus mozambicus*), House Finch (*Haemorhous mexicanus*), Sky Lark (*Alauda arvensis*), and African Silverbill (*Lonchura cantans*).

We did not detect the endangered Palila (*Loxioides bailleui*) during the reporting period.

Table 124. Avian monitoring species counts and bird per station mean results, FY 2022–FY 2023

		FY 2022		FY 2023	
Common Name	**Species**	**Species counted**	**Mean birds/ station**	**Species counted**	**Mean birds/ station**
African Silverbill[c]	*Euodice cantans*	129	0.45	49	0.17
‘Apapane[ab]	*Himatione sanguinea*	24	0.08	15	0.05
Barn Owl[ac]	*Tyto alba*	1	0	0	0
Black Francolin[d]	*Francolinus francolinus*	19	0.07	19	0.07
California Quail[d]	*Callipepla californica*	19	0.07	5	0.02
Chinese Hwamei[c]	*Garrulax canorus*	5	0.02	0	0
Chukar[d]	*Alectoris chukar*	4	0.01	6	0.02
Common Myna[c]	*Acridotheres tristis*	6	0.02	1	0
Erckel’s Spur Fowl[d]	*Pternistis erckelii*	188	0.66	165	0.58
Hawaiian ‘Amakihi[ab]	*Chlorodrepanis virens*	1157	4.06	774	2.71
Hawaiian Hawk[ab]	*Buteo solitarius*	2	0.01	1	0
Hawaiian Short-eared Owl[ab]	*Asio flammeus*	4	0.01	0	0
House Finch[ac]	*Haemorhous mexicanus*	80	0.28	117	0.41
Japanese Bush-Warbler[c]	*Cettia diphone*	0	0	2	0.01
Warbling White-eye[c]	*Zosterops japonicus*	422	1.48	346	1.21
Kalij Pheasant[d]	*Lophura leucomelanos*	3	0.01	5	0.02
Lavender Waxbill[c]	*Glaucestrilda caerulescens*	3	0.01	9	0.03
Mourning Dove[ac]	*Zenaida macroura*	1	0	0	0
Northern Cardinal[ac]	*Cardinalis cardinalis*	11	0.04	3	0.01
Northern Mockingbird[ac]	*Mimus polyglottos*	50	0.18	20	0.07
Nutmeg Mannikin[c]	*Lonchura punctulata*	18	0.06	0	0
‘Oma‘o[ab]	*Myadestes obscurus*	1	0	0	0
Pacific Golden Plover[a]	*Pluvialis fulva*	14	0.05	36	0.13
Rock Pigeon[c]	*Columba livia*	3	0.01	0	0

Table 124. Avian monitoring species counts and bird per station mean results, FY 2022–FY 2023 (cont.)

		FY 2022		FY 2023	
Common Name	Species	Species counted	Mean birds/ station	Species counted	Mean birds/ station
Saffron Finch[c]	*Sicalis flaveola*	15	0.05	0	0
Sky Lark[ac]	*Alauda arvensis*	95	0.33	61	0.21
Yellow Billed Cardinal[c]	*Paroaria capitata*	30	0.11	0	0
Yellow Fronted Canary[c]	*Serinus mozambicus*	119	0.42	164	0.57

FY 2022, total station monitored 285. FY 2023, total station monitored 286.
[a] Migratory Bird Treaty Act listed species
[b] Native species
[c] Non-native, non-game species
[d] Non-native, game species

Discussion of 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 12 native and non-native bird species protected under the MTBA (Table 124). Since 1998, Hawaiian Amakihi, Japanese White-eye, Yellow Fronted Canary, and House Finch have been the most frequently detected species, as reported in previous annual and biennial reports.

In FY 2023, we drafted a manuscript analyzing the bird monitoring dataset from 1998 through 2021. We modeled the data set using the program DISTANCE to estimate population densities and abundances. We plan to draft a detailed technical report in 2024.

Avian monitoring provides baseline information for bird species that meet the Department of Defense's definition of a species at risk (SAR). Currently at PTA, 6 native birds meet the SAR definition (Appendix C). 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 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, we plan to upload the monitoring into the national Avian Knowledge Network (AKN) per Department of Defense memorandum (2022, Department of Defense Avian Knowledge Network Program) endorsing the use of the AKN as a clearinghouse for bird monitoring data.

In addition, DISTANCE sampling techniques are not well suited for 2 SAR that occur at PTA: Pacific Golden Plover and Hawaiian Short-eared Owl. Another SAR, the Hawaiian Thrush, is known to occupy sub-alpine habitats on the installation that are not currently included in our annual monitoring.

Avian monitoring addresses several compliance issues simultaneously. Understanding population trends for SAR can aid in developing population change thresholds to trigger management actions that may help to minimize population declines and avert potential listing of these bird species as threatened or endangered. Managing species before they become listed under the ESA benefits the Army because it is likely to be more cost effective and can help 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.

4.2.7 Anthricinan Yellow-Faced Bee

Projects for the anthricinan yellow-faced bee comply with SOO section 3.2.2 and these projects satisfied INRMP stewardship objectives. The anthricinan yellow-faced bee was listed as endangered under the ESA in 2016. Because of its recent listing, we provided technical assistance to the Army to prepare a Biological Assessment that describes the status of the bee at PTA and evaluates the potential effects of military activities on the bee and its habitat.

A single anthricinan yellow-faced bee was collected at PTA in 2004, possibly a vagrant (USFWS 2013b, USFWS 2016). 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 the presence of a permanent breeding population at the installation is questionable (Magnacca and King 2013).

For this reporting period we did not conduct any *Hylaeus* surveys. No anthricinan yellow-faced bee sightings were reported during the reporting period.

4.2.8 Blackburn’s Sphinx Month

Projects for Blackburn’s sphinx moth (BSM, *Manduca blackburni*) comply with SOO section 3.2.2 and these projects satisfied INRMP stewardship objectives. BSM is listed as an endangered species under the ESA and was first found at PTA in 2019. Because BSM was recently discovered at PTA, we provided technical assistance to the Army to prepare a Biological Assessment that describes the status of the moth at PTA and evaluates the potential effects of military activities on the species and its habitat.

No BSM sightings were reported during the reporting period. In FY 2024, we plan to have NRP staff attend a BSM monitoring workshop sponsored by Hawaiʻi Department of Forestry and Wildlife staff working at Puʻu Waʻawaʻa.

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 between FY 2022 and FY 2023, which contributes to 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. This reporting period, we successfully detected 3 active burrows (N01, N05, and N06) and we were able to document BSTP breeding behaviors across the breeding season (Figure 119).

With the listing of the anthricinan yellow-faced bee and the 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 for 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. 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.

As we continue to manage wildlife, we recognize that along with our challenges, we can improve in some areas. Several projects lack detailed planning documents (e.g., protocols) to align project purpose, goals, and objectives with SOO tasks, INRMP objectives, and other compliance obligations. In addition, protocols help improve information flow from defined project intents and purposes, management actions, data collection and analysis, through reporting outcomes to support future management directions or efforts. In FY 2024, we plan to improve project planning, implementation, data management, and reporting via protocol development for select wildlife management projects.

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); 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 wildlife threats to TES and their habitats include feral goats (*Capra hircus*), feral sheep (hybrids of *Ovis aries*), black rats (*Rattus rattus*), mice (*Mus musculus*), mongoose (*Herpestes auropunctatus*), feral cats (*Felis catus*), feral 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, rodents, and invertebrates that threaten ESA-listed animal and plant species 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

Projects implemented for ungulate management address SOO task 3.2.2.5, INRMP objectives, and conservation measures identified in the 2003 BO. There are 15 ungulate exclusion fence units at PTA totaling 138 km in length that protect 15,092 ha of native habitat. In 2017, all 15 fence units were deemed 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.

<u>Ingress Monitoring Methods</u>

To monitor for ungulate ingress into the fence units, we conduct aerial surveys for ungulates, 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, and deploy radio-collared animals (i.e., Judas animals) inside fences if needed. 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 bedding sites) 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 3 Browning Dark Ops Pro HD surveillance cameras at selected gates (Figure 121). Camera locations were selected based on road traffic patterns, military and construction contractor use, sizes of fence units, and areas where ungulates have been sighted outside of the fence unit gates. These infrared-equipped cameras remain active 24 hours a day.

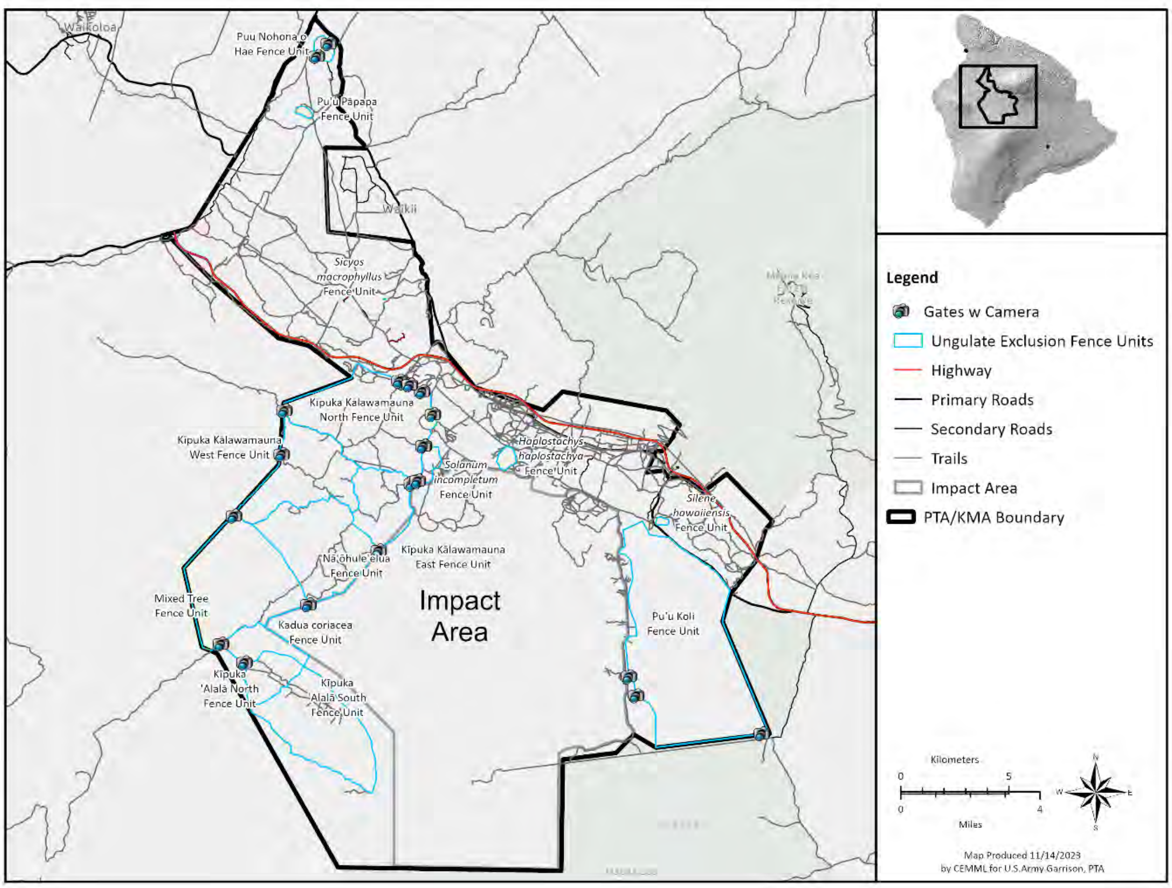


Figure 121. Ungulate exclusion fence units and surveillance camera locations at Pōhakuloa Training Area

We 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 Fence Maintenance 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 are reviewed monthly for organization and to guide management activities. For small fence units (<100 ha), we typically survey on foot since ungulates are easily tracked inside these units.

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.

Ungulate Removal Methods

We remove any ungulates confirmed within the exclusion fences, using several methods in conjunction. Methods include live trapping, drives, and shooting with or without aerial support.

To trap the animals, we may use corral traps (3 to 4 interlocked panels of 30 cm X 15 cm galvanized welded wire). Water, plant material, or salt blocks are used to lure ungulates into the trap. We monitor traps daily and 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 also 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

Aerial Survey Results

In FY 2022, HGM conducted aerial surveys over the ungulate exclusion fence units on 25 and 26 June 2022 for a total of 10 hours over the 2 days (Figure 122). In FY 2023, HGM conducted aerial surveys over the ungulate exclusion fence units on 5 and 6 May 2023 for a total of 8 hours over 2 days (Figure 122). During the FY 2022 survey, HGM removed 3 ungulates from the fence units (2 collared and 1 uncollared). During the FY 2023 survey, HGM did not detect ungulates inside the fence units.

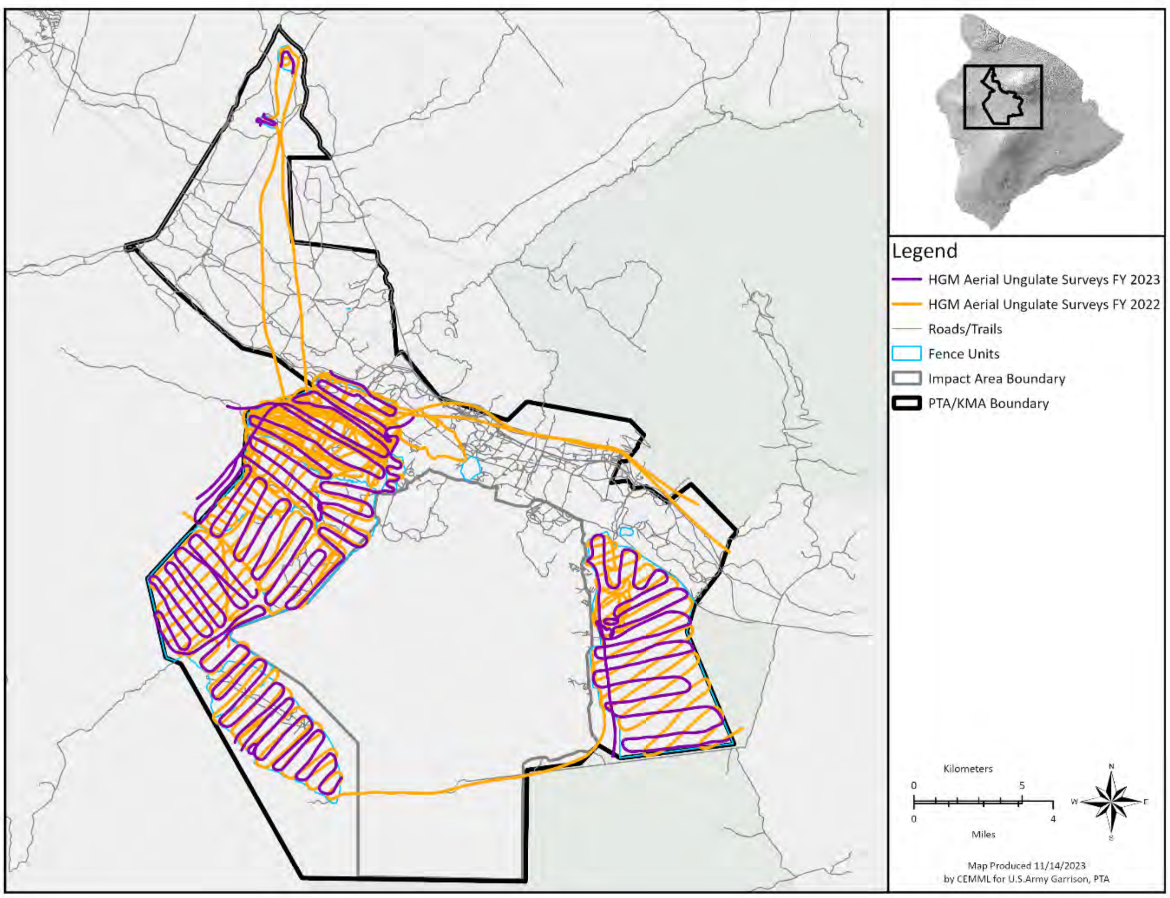


Figure 122. Hawai'i Game Management aerial survey transects conducted at Pōhakuloa Training Area, FY 2022–FY 2023

Incidental Reports and Camera Surveillance Monitoring and Ungulate Removal Results

We initiated ungulate monitoring to detect possible ungulate ingress into the exclusion fences based on 8 reports (5 incidental sightings and 3 camera detections). For 7 of the 8 reports, we confirmed ungulates in the fence units (Table 125). A total of 41 uncollared ungulates were detected and 40 were removed. We are continuing to monitor 1 sheep inside the Puʻu Koli Fence Unit. Actions taken over the report period are summarized for each fence unit below (Table 125 and Table 126).

Table 125. Ungulate ingress detections in the ungulate exclusion fence units at Pōhakuloa Training Area, FY 2022–FY 2023

			Initial Detection Method		Method to confirm detection		
Fence Unit	**Report Date**	**No. of Ungulates Detected**	**Incidental Sighting**	**Camera**	**Camera**	**No. Judas[d] Animals**	**No. of Ungulates Removed**
Puʻu Koli	July 2021[a]	6		X	X	1	6[bc]
Kīpuka Kālawamauna North	July[a] 2021	1		X	X	1	1[b]
Puʻu Nohona O Hae	Jan 2022	30	X		X		30
Puʻu Nohona O Hae	April 2022	1	X				1
Kīpuka Kālawamauna North	Aug 2022	1		X	X		1
Puʻu Koli	June 2023	1	X		X		1
Puʻu Koli	Sept 2023	1	X		X		0
Total		**41**				**2**	**40**

[a] The initial ingress event occurred in FY 2021, but the ungulates were removed in FY 2022.
[b] Collared ungulate removed from fence unit at the same time as the uncollared ungulates.
[c] Judas (collared ungulates) animals removed from the unit. Judas animals deployed and removed not included in the overall total ungulates detected and removed count.
[d] A camera detected 4 ungulates entering and 6 ungulates exiting the fence unit through an open gate.

Through our camera surveillance, we documented 65 times that vehicle gates into the ungulate exclusion fence unit were left open and unattended. Most of 776,962 photos recorded at the vehicle gates showed personnel entering and exiting the fence units. In addition, some photos detected mongoose, feral cats, feral dogs, game birds, and ungulates (outside of the fence unit).

Based on the camera surveillance and aerial survey data, we implemented removal operations as needed. We successfully removed 40 of the 41 remaining uncollared ungulates that we confirmed, via our monitoring efforts, inside the fence units (Table 126). During the reporting period, we conducted a total of 7 ungulate removal operations: 3 in the Puʻu Koli Fence Unit, 2 in the Puʻu Nohona O Hae Fence Unit, and 2 in the Kīpuka Kālawamauna North fence unit. In the Puʻu Koli Fence Unit and the Puʻu Nohona O Hae Fence Unit, our cameras detected 30 uncollared animals exiting through the same open gate they used to enter the unit.

Table 126. Number of ungulates removed per fence unit at Pōhakuloa Training Area, FY 2022–FY 2023

Fence Unit	Sighting Report Date	No. of Ungulates Detected	No. of Ungulates Removed	Date(s) Ungulate Removed	No. of Ungulates Removed per Removal Method			
					Live Trap	Exit[b] Through Gate	Drive	HGM
Puʻu Koli[a]	July 2021	6	6	Jun 2022		6		
Kīpuka Kālawamauna North[a]	July 2021	1	1	Jul 2022			1	
Puʻu Nohona O Hae	Jan 2022	30	30	Jan–Jun 2022		24	5	1
Puʻu Nohona O Hae	April 2022	1	1	Apr 2022			1	
Kīpuka Kālawamauna	August 2022	1	1	Mar 2023	1			
Puʻu Koli	June 2023	1	1	Aug 2023	1			
Puʻu Koli	Sept 2023	1	0	—				
Total		**41**	**40**		**2**	**30**	**7**	**1**

[a] Single Judas (collared ungulates) animals removed from the unit. Judas animals deployed and removed not included in the overall total ungulate counts.
[b] Uncollared ungulates were detected exiting the fence unit thru the open gate by surveillance camera.

Puʻu Koli Fence Unit

In July 2021, a vehicle gate was not locked properly, and a surveillance camera detected 4 sheep entering the Puʻu Koli fence unit. However, 6 sheep were later detected via camera exiting the gate. Because we were uncertain if additional ungulates entered but were not detected on the camera, in August 2021, we deployed additional cameras and placed a Judas ram inside the Puʻu Koli fence unit. Over the next 10 months, camera monitoring did not detect uncollared ungulates inside the fence unit. On 05 October 2021 and 16 March 2022, we tracked the collared ram to determine if it herded with other ungulates. During both surveys, we did not detect uncollared ungulates. Because our monitoring efforts provided no evidence of uncollared ungulates inside the Puʻu Koli fence unit, we returned the fence unit to ungulate-free status in June 2022. On 25 June 2022, HGM removed the collared ram from the fence unit.

On 21 June 2023, we received an incidental sighting report of a single sheep inside the Puʻu Koli fence unit. We deployed 3 surveillance cameras near the sighting area to search for additional ungulates. Cameras confirmed the presence of a single lamb inside the fence unit. On 17 July 2023, we deployed a corral trap near the original sighting area and on 01 August 2023, we captured and subsequently released the lamb outside the fence unit.

We detected a single sheep inside the Puʻu Koli fence unit on 27 September 2023. We plan to deploy several surveillance cameras and activate a corral trap near the sighting area in FY 2024. This is the only confirmed ungulate that remains inside any of the 15 ungulate exclusion fence units at PTA.

Kīpuka Kālawamauna North Fence Unit

In July 2021, a surveillance camera at a vehicle gate detected a young goat inside the fence unit. Photographs from all 7 cameras monitoring this fence unit provided no evidence of the goat entering through an open gate. We completed an inspection of the fence perimeter and found openings under the fence caused by substrate erosion, which were repaired. We added more cameras inside the fence unit, but the goat remained elusive and was rarely detected. On 22 March 2022, we deployed a Judas goat to aid the search. Over the next 3 months we monitored the collared goat, but it did not herd with the uncollared goat. On 26 June 2022, HGM removed the collared goat from the Kīpuka Kālawamauna North fence unit. On 6 July 2022, we located the uncollared goat and successfully drove it outside of the fence unit.

On 10 August 2022 during the Leilani wildland fire, a surveillance camera photographed a ram entering the Kīpuka Kālawamauna North fence unit via an open gate. Over the next 7 months, 6 different cameras documented the ram walking throughout the fence unit. In September 2022, we installed 2 corral traps inside the fence unit near the most recent camera sightings, but the ram was not captured. In January 2023, we spotted the ram while driving in the area and unsuccessfully attempted an ungulate drive. During the ungulate drive, we located a bedding spot and relocated a corral trap near that location. On 21 March 2023, we successfully trapped and removed the ram from the Kīpuka Kālawamauna North fence unit. This fence unit is considered ungulate-free.

Puʻu Nohona O Hae Fence Unit

A surveillance camera at the Puʻu Nohona O Hae fence unit recorded an open gate from 20 January 2022 to 31 January 2022. During this 12-day period, the camera documented 30 goats entering and 24 goats exiting the fence unit through the open gate (Figure 123). On 30 January 2022 and 1 February 2022, we organized 2 ungulate drives and removed 4 goats from the fence unit. Afterwards, a single goat remained inside the Puʻu Nohona O Hae fence unit. Over the next 3 months, we attempted 4 additional ungulate drives, but unlike most ungulates that run along the fence line and out a gate when herded, this goat ran towards the middle of the fence unit. We constructed a corral trap inside the fence unit in April 2023. On 02 May 2023, we found the goat with a newborn kid. We successfully removed the kid via ungulate drive, but again the adult goat fled the area. On 04 June 2023, the corral trap captured the goat. Unfortunately, the goat broke the trap door latch and escaped. On 26 June 2022, HGM removed the goat from the Puʻu Nohona O Hae fence unit.

Figure 123. Surveillance camera photograph of a single feral goat inside the Puʻu Nohona O Hae fence unit while approximately 40 feral goats are outside the fence unit

On 14 April 2022, during a fence inspection, we discovered a small piglet inside the Puʻu Nohona O Hae fence unit. We initiated an ungulate drive and removed the piglet from the fence unit. During the fence inspection, we discovered a large area where recent flooding moved large amounts of silt and dirt approximately 0.76 m high along 60 m of fence. We believe the dirt pile allowed the piglet to walk through the fence’s 15 cm x 15 cm spaced holes and enter the fence unit. We initiated fence repairs immediately to prevent additional ingress and completed the fence repairs on 28 April 2022. This fence unit is considered ungulate-free.

<u>Discussion for Ungulate Management</u>

We successfully removed 40 uncollared ungulates and 2 collared 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 impacts of ungulates on 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 plant species, 34 plant SAR, and 25 animal SAR.

The Puʻu Koli fence unit remains unsecure because 2 large sections were breached by the Mauna Loa lava flow in December 2022. We attribute both June 2023 and September 2023 ungulate ingress to these 2 fence breaches. Until the damaged sections are repaired, this fence unit remains highly vulnerable to additional ungulate ingress.

On 17 November 2022, the Army finalized a Memorandum of Understanding to allow specialists that work for Hawaii Game Management (HGM) to discharge firearms at PTA. Prior to this agreement, our ungulate control removal options were limited to corral trapping and ungulate drives. This agreement provides us another option to remove uncollared ungulates quickly and efficiently from the fence units.

4.3.2 Small Mammal Management

Projects implemented for small mammal management address SOO task 3.2.2.3, 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[24] is described as an ongoing conservation action 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 Tier 1 species annually and record any plant damage caused by rodents (see Section 2.2.3). If damage is detected, we control rodents to minimize rodent populations around the plants.

[24] *Neraudia ovata*, *Solanum incompletum*, and *Zanthoxylum hawaiiense.*

We continue to implement rodent control at ASR 41 to protect wild and outplanted *Schiedea hawaiiensis* and outplanted *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 predatory small mammals, 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 monitor changes in rodent activity in response to controls, as tracking tunnels present an index of the relative abundance of the rodent population.

Tracking tunnels consist of tracking paper with an inked area and bait placed inside a weather-resistant tunnel. As a rodent investigates the bait inside the tunnel, the ink is transferred onto the foot of the animal, resulting in a footprint left on the un-inked portion of the tracking paper, which can be identified to species. Tracking tunnels are 35.5 x 11.3 x 13.5 cm (length x width x height) and made of Polytag® weather-resistant material (Cole Graphic Solutions all-terrain printing®). Tracking papers are 35 x 11 cm (length x width), constructed from all-weather paper (Rite in the Rain paper, JL Darling LLC®). A 15 x 8 cm (length x width) area in the center of the tracking paper is inked (tracking ink, Pest Control Research LP, New Zealand). The tracking paper is inserted, and the tunnel is baited with Goodnature® chocolate formula lure. Tracking tunnels are deployed quarterly and left on site for 3 consecutive days.

We also use surveillance cameras, 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. For all cameras, we collect SD cards on a rotational basis and review photographs for rodent activity.

Control Methods

We used Little Giant® (91 x 29 x 34 cm) and larger Tomahawk® traps (76 x 25 x 30 cm) 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® trap (41 x 13 x 13 cm) 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 A24 self-resetting traps. The A24 traps were spaced between 25 m and 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. To decrease the chance for non-target captures, we placed the snap traps inside unbaited bait boxes. 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 *at ASR 41*

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 December 2021 to September 2023. The percent of boards tracked by black rats and mice ranged from 0% to 77% and 0% to 11%, respectively (Table 127). From December 2021 to September 2023, we maintained 16 A24 traps and observed evidence of kills at ASR41. The high percentage of rat and mouse activity in December 2021 was likely the result of not replacing the bait at 3-month intervals. We left the bait lures for a 6-month period as recommended by the vendor, starting in June 2021. When we checked the A24 traps after the 6-month period, we noticed many of the A24 traps had no bait and some CO_2 canisters were completely expended. Based on this outcome, we returned to bait replacements every 3 months and instituted monthly bait checks. After this adjustment, rodent activity levels returned to similar levels recorded prior to the 6-month bait test. Although we noticed an increase in rodent activity in September 2023, the data coincides with an installation-wide increase in rodent detections and compares with increased rodent captures at ASR 501.

Table 127. Tracking tunnel results as percent of tracking tunnels with activity (i.e., percent activity) by rodent species at Area of Species Recovery 41, FY 2022–FY 2023

Species	May 2017[a]	Dec 2021	Mar 2022	Jun 2022	Sep 2022	Dec 2022	Mar 2023	Jun 2023	Sep 2023
Black rat	77%	77%	0%	0%	11%	0%	0%	0%	44%
House mouse	0%	0%	0%	0%	11%	0%	0%	11%	11%

[a] Data reported for May 2020 is the percent of tracking tunnels with rodent activity by species before rodent trapping commenced in the rodent treatment sites. Data reported to the right of the vertical solid line are post rodent trapping.

Small Mammal Control to Protect the Band-rumped Storm Petrel

We implement cat, mongoose, and rodent control at the Band-rump Storm Petrel Colony (ASR 501) to decrease depredation pressure.

In FY 2022, using live traps, we removed 3 predators (3 feral cats) and in FY 2023, we removed 3 predators (1 mongoose and 2 rats).

In FY 2022, we removed 96 rodent carcasses (37 black rats and 59 mice) from the A24 traps and snap traps. In FY 2023, we removed 145 rodent carcasses (83 black rats and 62 mice) from the A24 traps and snap traps.

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 implement cat, mongoose, and rodent control at PTA and in the Army-managed areas at HFNWR, to increase nest success and gosling survivorship.

In FY 2022, we did not control predators at PTA for Hawaiian Geese because we did not observe any molting or breeding activity. In FY 2023, using live traps at PTA to protect molting and breeding Hawaiian Geese at BAAF, we removed 5 predators (4 mongooses and 1 feral cat).

Refer to Section 4.2.2 for a detailed description of the predator control at PTA for Hawaiian Goose management.

In FY 2022, using live traps at HFNWR to protect Hawaiian Geese, we removed 28 predators (3 feral cat, 23 mongooses, and 2 rats) and in FY 2023, we removed 8 predators (8 mongooses).

In FY 2022, using A24 traps at HFNWR to protect Hawaiian Geese, we removed 40 predators (3 rats, 36 mice, and 1 mongoose) and in FY 2023, we removed 48 predators (1 rat and 47 mice).

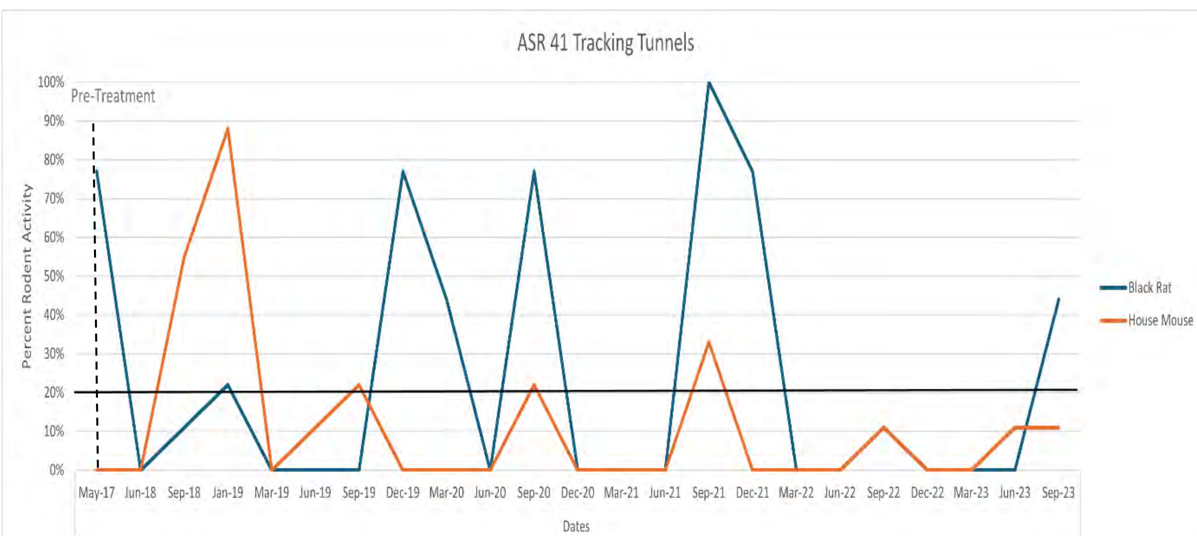
Refer to Section 4.2.3 for a detailed description of predator control at HFNWR for Hawaiian Goose management.

Discussion for Small Mammal Management

Since 2017, *Schiedea hawaiiensis* and *N. ovata* have been documented to have high levels of rodent damage (e.g., bite marks on leaves and stems, broken stems) at ASR 41. Following deployment of the A24 traps in May 2017, we recorded a large decrease overall in black rat activity at the site. In June 2021, we changed our bait replacement frequency from every 3 months to 6 months per recommendations of the A24 trap product label. After this change, rat activity levels increased during the next 6 months—on September 2021 rat activity was at 100% and in December 2021 rat activity was at 77%. This increase in rat activity and the observations of many of the A24 trap's bait lures found empty in December caused us to return to replacing bait lures every 3 months. Following the replacement of bait every 3 months, the tracking tunnel data showed a decrease of rat activity ranging from 0% to 11% for the next 15 months (March 2022 to June 2023). In September 2023, the rat activity level increased to 44%.

The natural breeding cycle of rodents at ASR41 is unknown but tracking tunnel data from ASR 41 over the past 6 years demonstrate an overall increase in rat activity annually from September to December. This matches research that found black rat densities are high from June through January in Hawaiian forests and are influenced by factors such as food availability and predator density (e.g., cats and mongoose) (Shiels et al. 2014). Mouse activity was generally low from 2021 through 2023, but our tracking tunnel data also indicated a small increase in mouse activity between September and December each year.

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. From 2017 to 2023, we deployed tracking tunnels 22 times. During this period, black rat activity was below or near 20% for 16 of the deployments (73%) and mouse activity was below or near 20% for 17 deployments (78%) (Figure 124). In addition, we recorded a decrease in rodent damage to *Schiedea hawaiiensis* and *N. ovata* plants during quarterly plant monitoring over the same time period.



The dotted line marks pre-treatment date May 2017 and the dark horizontal line marks 20% activity.

Figure 124. Tracking tunnel results as percent of tracking tunnels with activity by rodent species at Area of Species Recovery (ASR) 41, May 2017–September 2023

Adjusting A24 bait replacements to a quarterly schedule and initiating monthly trap tests returned activity levels comparable to those from 2017 to 2021. For FY 2024, we plan to test the new Goodnature® Meat Lovers bait lure in the A24 traps. Because tracking tunnels detect mongoose in the area and we are unclear how the mongoose presence affects rodent activity levels, we also plan to use ASR 41/213 to test the new Goodnature® A18 traps that are designed for trapping squirrels and mongoose.

Although it is difficult to make a direct connection between small mammal control activities and survivorship of ESA-listed plants, Hawaiian Geese, and Band-rumped Storm Petrels, we assume that the removal of predators benefits these species. For example, the removal of feral cats, mongooses, and numerous rodents is likely to have a positive effect by decreasing predator pressure on the Hawaiian Goose and the Band-rumped Storm Petrel during breeding season. In FY 2024, we plan to continue our year-round trapping efforts in the Band-rumped Storm Petrel colony (ASR 501).

Control of small mammals that depredate ESA-listed plants and animals is critical for minimizing the negative effects of these predators to the listed species and to maximize 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. 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 Invertebrate Management

We implement invertebrate control projects to meet SOO tasks 3.2.2.4, to address INRMP objectives and conservation measures from the 2003. The goals for invertebrate control are to detect and control invasive invertebrate species around ESA-listed and rare plants, and outplanting sites. Emergent invertebrate threats to the plants and their impacts are reported when detected during plant monitoring or when incidentally discovered. We evaluate the threat based on the invertebrate species, assess invertebrate control methods (e.g., pesticide, barriers, and traps), and implement selected methods. Plant health is re-evaluated after invertebrate control efforts. The 2003 BO identifies 2 invertebrate taxa to control: aphids and ants. Per 2003 BO conservation measures, we must reduce or eliminate aphids for *H. haplostachya* and prevent or reduce invasive ant introductions by individuals, plant materials, vehicles, machinery, and construction materials to new areas at PTA. Aphids damage plants and transmit numerous pathogenic viruses (Messing et al. 2007). The introduction and establishment of invasive ants pose a threat to Hawaiʻi's native biota through competition and predation. By controlling invertebrates that threaten the federally listed species at PTA, we minimize negative impacts to these protected species and work toward the overall goal of maximizing military training capacity at PTA.

To prevent introductions of invasive invertebrate species at PTA, vehicles, machinery, and construction materials must be carefully inspected and sanitized for invasive ants prior to arriving at PTA. Two invasive ants of concern are the Argentine ant (*Linepithema humile*), already established at PTA, and the little red fire ant (LFA, *Wasmannia auropunctata*), which is not established at PTA.

In FY 2020, we incidentally observed Argentine ants along with aphids and scale at ASR 40 on *S. incompletum* plants. Argentine ants have been established at ASR 40 for over a decade, but in 2019, several of the *S. incompletum* appeared unhealthy or died. Many factors may have contributed to the decline of these plants (e.g., drought, invertebrate infestations, and invasive plants). We removed aphids and scales with insecticidal soaps and applied insecticide to control invasive ants.

Invertebrate Management Methods at ASR 40

Ant Monitoring with Vials

We used a systematic design to investigate the presence of ants in ASR 40. We established 3 ant management sites: 1 control site (C01) and 2 ant treatment sites (ATS01 and ATS02). Each site consisted of a 75 m x 75 m grid (Figure 125). In the center of each treatment site (ATS01 and ATS02) there were a few *S. incompletum* plants. Within each ATS, we placed 16 baited vials spaced 25 m apart. Each vial was baited with a protein and a sugar source (peanut butter, Spam, or tuna; and jelly or jam) and placed in the shade and near potential forage areas where possible.

We left the vials in place for a minimum of 45 minutes before collection. When retrieving the vials, if no ants were present in the vial, we opportunistically searched the sample location. 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.

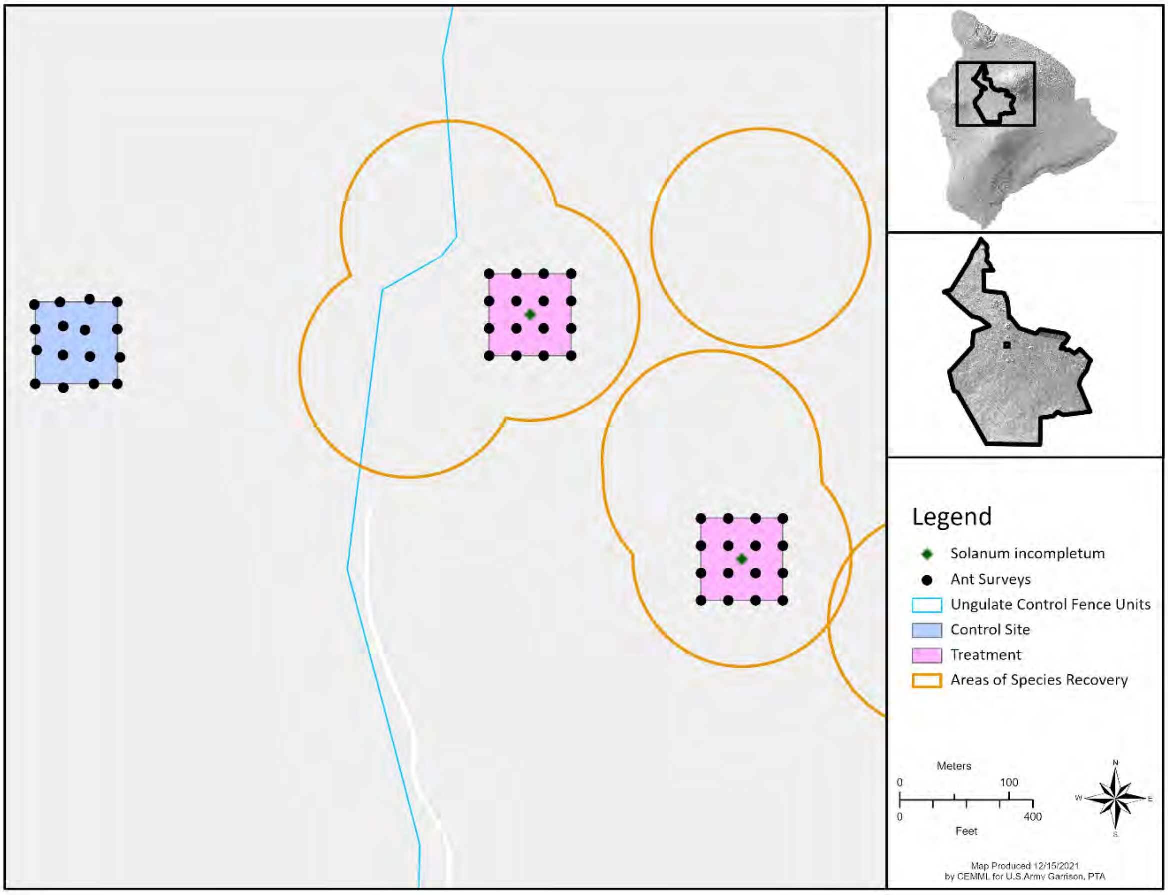


Figure 125. Ant management sites, FY 2022–FY 2023, in Area of Species Recovery 40 at Pōhakuloa Training Area

Invertebrate Infestation Monitoring

At each ATS, we opportunistically searched each *S. incompletum* plant for a total of 4 minutes per plant (Figure 126). Each plant was monitored from the lowest point of the plant touching the soil substrate to the tallest part of the plant. Each search was divided into 4 segments per plant so an observer would walk around the plant and record the number of invertebrates observed by species (e.g., aphid, ant, scale). Each segment of the plant was observed for 1 minute. There are no *S. incompletum* plants in the control site (CS01); therefore, we cannot compare infestation levels on *S. incompletum* in treated and untreated areas.

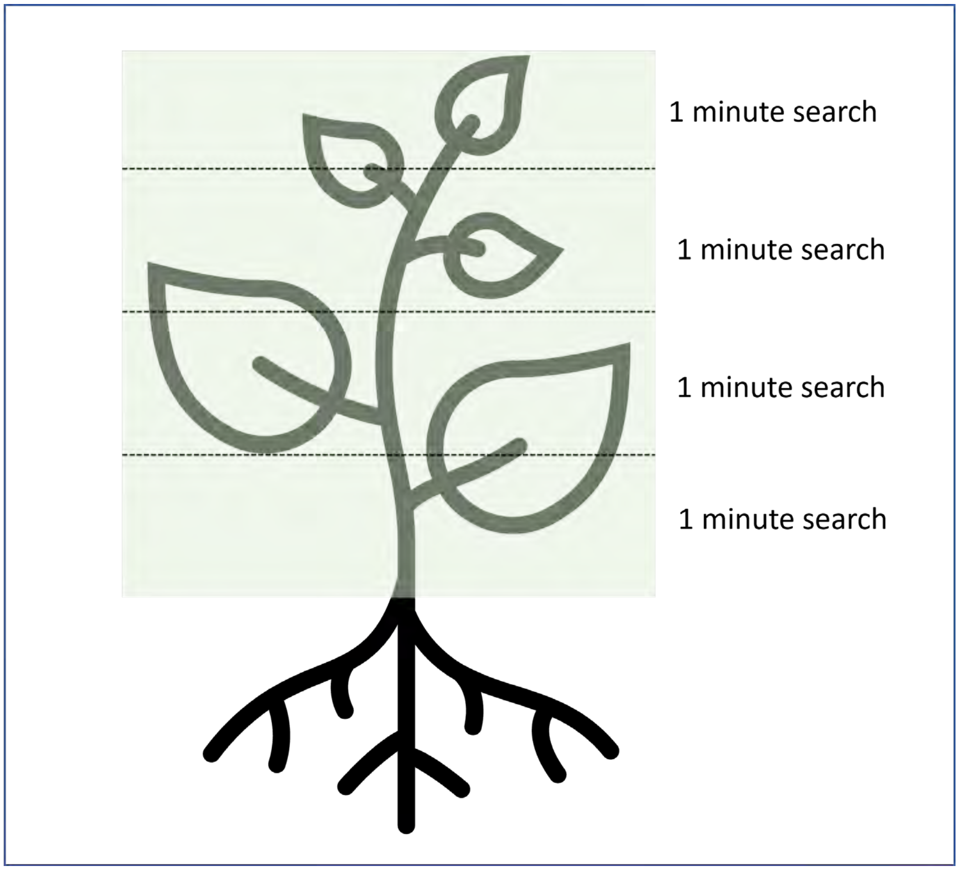


Figure 126. Invertebrate infestation monitoring design for visually counting the total number of invertebrates found on each plan during a 4-minute count

Ant Treatment

We applied Maxforce® Complete Granular Insect Bait (active ingredient Hydramethylnon 1%) using granular hand spreaders at each ATS. We applied approximately 0.94 kg of Maxforce across each ATS every quarter between January 2022 and July 2023. Applicators walked 5 m wide transects, applying an even distribution of insecticide at each location. CS01 is approximately 350 m from the outer treatment boundary from ATS01 and was not likely affected by the treatments (Figure 125).

Ant Vials Monitoring Results

In May 2021 (pre-treatment), and quarterly between January 2022 and July 2023 (post-treatment) we collected ant vials approximately 2 weeks after each insecticide application from the 3 ant management sites (16 vials C01, 16 vials ATS01 and 16 ATS02). The only ant species found in all 3 sites was Argentine ant. Ant presence was measured as the number of ants per collection vial. The average number of ants per vial in ATS01 and ATS02 remained lower than the May 2021 collection except for July 2022 (Table 128). The observed increase and decline in the number of ants at all 3 sites may have been caused by a natural cycle, but during the 7 post treatment collections, both ATS01 and ATS02 showed consistently lower ant totals than the control site.

Table 128. Mean number of ants per vial collected in the ant management areas in Area of Species Recovery 40 pre- and post-treatment

Site	May 2021 (± SE)	Feb 2022 (± SE)	Apr 2022 (± SE)	Jul 2022 (± SE)	Nov 2022 (± SE)	Jan 2023 (± SE)	Apr 2023 (± SE)	July 2023 (± SE)
CS01	60.3	10.7	50.8	213.3	10.1	44.1	32.3	60.6
	(24.9)	(6.4)	(16.3)	(52.3)	(4.2)	(15.6)	(15.3)	(27.3)
ATS01	14.4	0.1[b]	6.4	44.3	2.1	3.5[b]	3.0[b]	7.6
	(11.6)	(0.1)	(4.3)	(22.2)	(1.9)	(3.5)	(3.0)	(4.8)
ATS02	2.2	2.3	0.1[b]	33.3	0.1[b]	0.1[b]	0	0.1[b]
	(1.4)	(1.4)	(0.1)	(13.2)	(0.1)	(0.1)	(0)	(0.1)

CS, Control Site; ATS, Ant Treatment Site
[a] Data for 26 May 2021 was prior to treatment. Data right of the vertical line were taken post treatment.
[b] Mean ant count and SE value have similar numbers because only 1 of 16 ant vials contained ants during the sample collection.

Invertebrate Infestation Monitoring

During pre-treatment monitoring on 26 May 2021, at AST01 and AST02, respectively, we found 0 live aphids and 0 live scales on *S. incompletum* plants. During the post-treatment monitoring between January 2022 and July 2023, at AST01 and AST02, respectively, we found 1 live aphid and 6 live scales on *S. incompletum* plants (Table 129). Because no *S. incompletum* plants are established in CS01, we cannot compare the results in treatment vs. non-treatment areas.

Table 129. Number of living aphids and scales found in the ant management areas in Area of Species Recovery 40 pre- and post-treatment

Site	Pest	May 2021[a]	Feb 2022	Apr 2022	Jul 2022	Nov 2022	Jan 2023	Apr 2023	Jul 2023
ATS01	Aphid	0	0	0	0	0	0	0	0
	Scale	0	0	4	0	0	0	0	0
ATS02	Aphid	0	0	0	0	1	0	0	0
	Scale	0	0	0	0	0	0	0	2

ATS, Ant Treatment Site
[a] Data reported for 26 May 2021 are prior to treatment. Data right of the vertical line taken post treatment.

Discussion for Invertebrate Management

Results from the post-treatment showed a reduction of Argentine ant activity at all the ATS except in July 2022. Meanwhile, post-treatment ant activity in the CS remained generally the same for 3 of the 7 monitoring periods, significantly increased for 1 period, and declined for 3 of the 7 monitoring periods. The causes of the increases and declines in ant activity in the control site are unknown, but seasonal patterns and natural environmental cycles most likely contributed to some of the results. Although we cannot discern clear presence patterns for this control effort, early results indicate that the insecticide treatment reduced ant activity within the treatment areas.

Invertebrate infestation results were inconclusive, but from September to April 2022 we observed 4 living scales, in November 2022 we found 1 aphid, and in July 2023 we observed 2 living scales on the

S. incompletum plants. We are assuming a direct relationship between ants, aphids, and scales based on literature. However, we continue to learn how ant control affects the presence of aphids and scale. At this time, we do not have enough evidence to link a reduction in ants to a reduction in aphid and scale. Moreover, we need additional data to better evaluate the response of *S. incompletum* plants to the treatments applied in the ATS sites. We suspect these invertebrate infestations affect the plant's fitness and health and may influence survivorship. Work done by CEMML with *Tetramolopium arenarium,* another federally listed plant, in the same general area, showed that *T. arenarium* infested with aphids had lower survivorship than plants that were not infested (CEMML 2020a). In addition, the interaction between invertebrates and plants is complex. There is likely an interaction between plant health, environmental conditions, and invertebrate infestations. We recommend collaborating with external researchers to help better understand the mechanisms that influence infestations with the aim of identifying key factors that may be more cost-effective to manage compared to ant and invertebrate control.

In FY 2024, we plan to evaluate if ant treatment should continue at ASR 40, because between September 2021 and September 2023, 8 of the 10 *S. incompletum* we monitored at ASR40 died. There is likely an interaction between plant health, environmental conditions, and invertebrate infestations, but the reduction of Argentine ants, aphids, and scale did not make a noticeable impact to the decline of *S. incompletum* at this location. Environmental conditions (e.g., drought and invasive plants) are more likely contributing to the decline of the *S. incompletum* at ASR40.

We also plan to use a similar ant management design for other TES that are affected by invasive ants. In addition, we plan to develop a comprehensive ant management strategy that will be included in the management plans being developed for each ESA-listed plant species.

4.3.4 Early Detection and Control of Invasive Animal Species

We implement early detection and invasive species control projects to meet SOO tasks 3.2.2.3 and 3.2.2.4 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 BAAF environs; at construction and auxiliary sites; on plant or plant products brought to PTA; and on incoming machinery, vehicles, and construction equipment.

Early Detection Survey and Monitoring Methods

To fulfill conservation measures from the 2003 BO, we systematically survey and monitor 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. Baited 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; jelly or jam) and deployed at intervals between 5 m and 100 m, 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, and artificial 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.

All civilian, military, and 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 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 animals 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

Bradshaw Army Airfield

We inspected BAAF in 8 of 8 quarters. 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.

On 27 April 2023, we inspected for invasive invertebrates around a large dirt pile on BAAF scheduled for relocation to Range 20 for the Aha Alakai Survivability LPD project. We detected Argentine ants (*Linepithema humile*) at 9 of the 40 survey locations. On 08 May 2023, we selectively applied 4.0 pounds of insecticide (Maxforce Complete Granular Insect Bait®) around the dirt pile to minimize the risk of relocating Argentine ants to the new site.

Off-Site Quarries

On 13 January 2021 and 11 January 2022, we inspected off-site aggregate piles at the Edwin DeLuz Trucking and Gravel quarry for invertebrate invasive species. No newly introduced invasive animal species were detected during either survey.

Equipment and Materials

On 21 August 2021, while a PTA team member was inspecting a pull-along trailer that contained boxes of Red Cross supplies, he detected little fire ants (LFA) in the container. The trailer was approved to be parked inside the cantonment prior to inspection. Following the discovery of the LFA, the PTA team member notified our program on 24 August 2021. Per our recommendation, he sprayed the inside of the trailer with Ortho® Home Defense Insect Killer (A.I. Bifenthrin 0.05%).

On 28 October 2021, we deployed 6 baited vials inside the infested trailer, 6 vials in each of 4 other trailers that were brought to PTA at the same time, and 25 vials in a 33 m x 33 m area surrounding the 5 containers. During post-treatment monitoring of the interiors and area surrounding the trailers, no other LFA were detected in October 2021. After monitoring this site for 2 months, we determined that the area is LFA free, and no further treatments or monitoring were needed.

On 16 November 2021, we completed 1 invasive invertebrate inspection on incoming equipment and materials. No newly introduced invasive animal species were detected on the equipment.

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.

The early detection efforts in controlling LFA appear to have been successful. After 2 months of follow-up assessments with no LFA detections, we concluded that LFA was likely not established at PTA as a consequence of the trailer delivery. We also observed that the treatment reduced the abundance of Argentine ants. The drop in Argentine ant abundance suggests that treatment would most likely similarly control any remnant LFA colonies.

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. Preventing the establishment of new invasive species (e.g., LFA, two-lined spittlebug, coconut rhinoceros beetle, African killer bees, and rabbits) typically requires less time, effort, and funding than responding to already-established infestations.

4.3.5 Fence Maintenance

Fence maintenance meets SOO task 3.2.2.5 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 as 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 the status and condition at 22 gates. Refer to the Ungulate Control Management Section 4.3.1 for additional information about the surveillance camera and ungulate incursion events. 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

During FY 2022 to FY 2023, we repeatedly inspected the fence lines, covering a combined distance of approximately 962 km, and completed 58 major fence repairs (damage severe enough to possibly allow an ungulate breach). We removed 38 fallen trees from fence lines, fixed 19 locations damaged by erosion below the fence, and replaced 1 area of fence damaged by vehicle strike. In addition, 13 damaged gates were discovered and repaired. Gate repairs included replacing bent 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 316 hours clearing vegetation (approximately 302 hours applying herbicides, approximately 14 hours cutting brush) along the fence corridors. We applied 1,124 gallons of herbicides on invasive plants covering about 44.8 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.

We detected 1 occurrence of major gate damage via camera. The driver of a large military vehicle misjudged a narrow turn and destroyed a gate door, fence posts, and gate hardware. The gate and fence were repaired, and no ungulates were detected entering the fence unit through the damaged gate

Fence Maintenance Discussion

Maintaining fence and gate integrity are essential to prevent animals from accessing the habitats inside the fence units. Through these activities, we continue to meet INRMP objectives and conservation measures in BOs. We have successfully maintained the 15 ungulate exclusion fence units ungulate-free for the last 2 years. Our efforts to maintain the fences and minimize opportunities for incursions further efforts to increase the abundance and distribution of ESA-listed plant species and other plant SAR.

Over a mile of fence along the Puʻu Koli fence unit is missing because of the 2022 Mauna Loa lava flow. Until this section is replaced, this fence unit remains highly vulnerable to additional ungulate ingress. We will continue increased monitoring of the Puʻu Koli fences and remove any uncollared ungulates detected inside the fence unit.

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. 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 managed invasive ants to protect TES species. Through these efforts, we are progressing toward our goal of protecting and improving habitat for TES.

During the reporting period, operational goals were achieved for most projects in the Threat Management Section. Significant program achievements include removing predators year-round in the BSTP breeding colony (ASR 501), continuing to maintain an ungulate-free status in all ungulate exclusion fence units, and controlling invasive ants at PTA.

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 is more cost effective and results in less impact 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 2024. 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.

5.0 GAME MANAGEMENT PROGRAM

5.1 INTRODUCTION

To manage game resources at PTA, we implement SOO (optional) tasks to comply with INRMP objectives (Sikes Act Improvement Act), ESA consultation requirements, and regulatory outcomes from NEPA documents.

The Game Management Program manages introduced game mammals within designated hunting areas to reduce negative impacts to Palila Critical Habitat (TAs 1, 2, 3, 4, 10, and 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 USAG-PTA (Figure 127). 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.

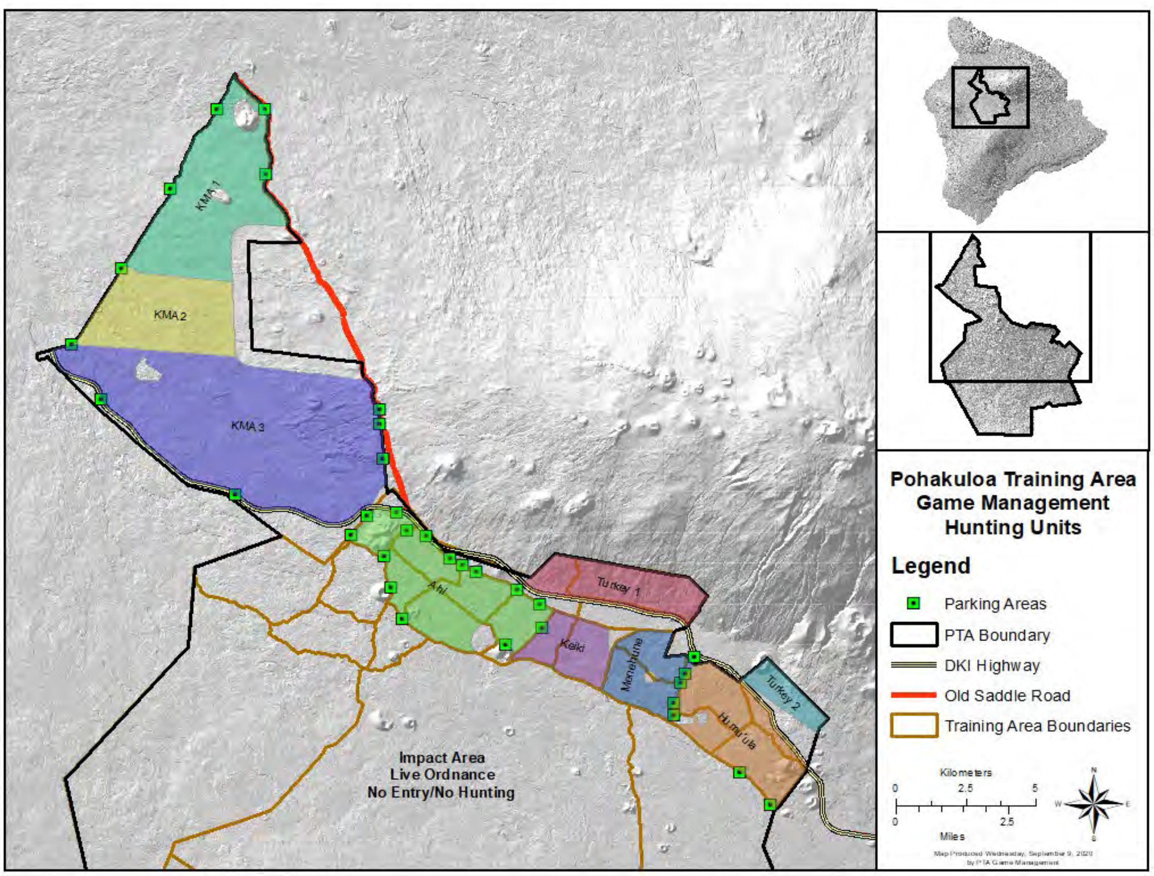


Figure 127. Public hunting unit and parking area locations at Pōhakuloa Training Area

All hunting activity at PTA is subordinate to military training. Based on the training schedule, 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 the troops.

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. Turkey 1 and Turkey 2 hunting units are also designated specifically for spring turkey season (Figure 127). Game mammal species available for archery hunting include hybrid mouflon-domesticated 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. Upland game birds may be hunted with shotguns at PTA. There are 12 species of game birds available to harvest (Table 130). Rifles, muzzleloaders, and handguns are not approved for use at PTA. Disabled hunters with valid medical documentation are permitted to use crossbows.

Table 130. Upland game bird species present at Pōhakuloa Training Area

Common Name	Species	Origin
Black Francolin	*Francolinus francolinus*	Introduced
California Quail	*Callipepla californica*	Introduced
Chestnut-bellied Sandgrouse	*Pterocles exustus*	Introduced
Chukar	*Alectoris chukar*	Introduced
Erckel's Spur Fowl	*Pternistis erckelii*	Introduced
Gray Francolin	*Ortygornis pondicerianus*	Introduced
Japanese Quail	*Coturnix japonica*	Introduced
Kalij Pheasant	*Lophura leucomelanos*	Introduced
Ring-necked Pheasant	*Phasianus colchicus*	Introduced
Spotted Dove	*Spilopelia chinensis*	Introduced
Wild Turkey	*Meleagris gallopavo*	Introduced
Zebra Dove	*Geopelia striata*	Introduced

To coordinate access to hunting, the Game Manager implements hunting policy, issues permits, establishes protocols to control hunting access, and identifies areas appropriate for public hunting activity each weekend. The policy is updated as needed, but not more often than 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 smartphone 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 effectiveness in enforcing USAG-PTA hunting regulations and facilitating hunter safety.

Nine types of hunting permits can be obtained through iSportsman. Paid permits include combo hunting permit (mammal and bird), $50.00; game mammal hunting permit, $30.00; and game bird hunting permit, $30.00. Free permits include youth bird permit, youth mammal permit, senior mammal permit, senior bird permit, hunter assistant permit, and a guest permit. All hunting permits are valid from 01 July through 30 June.

During the reporting period, a total of 820 permits were sold or distributed. A total of $19,855.00 was collected. Revenue from permit sales is used to support game management projects at PTA, such as construction of a game bird guzzler in 2019 (see Section 5.2 below).

Most of the funds collected from permit fees will be spent on a home range/space use study of Erckel's Spur Fowl, and to renew the iSportsman web service contract in FY 2024. These projects will be covered in future reports.

5.2 Field Operations

5.2.1 Game Management Facilities

A variety of facilities have been built or installed to support the Game Management Program: parking areas, fences, signs and check stations, and game bird guzzler units (water storage/delivery mechanisms). Regular maintenance of these facilities must occur to ensure their proper function and appearance for the hunting public. Vegetation control and maintenance of water storage/delivery systems are part of regular maintenance. Brush cutting and spot-spraying of 1.5% Roundup PowerMax herbicide (active ingredient glyphosate) were used to reduce fuel loads and to decrease the potential of fire in these parking areas.

In FY 2022, 1 day of vegetation control was needed to maintain the hunter parking areas at the KMA (1–3) hunting areas. In FY 2023, 5 days of vegetation control were needed to maintain the hunter parking areas at the KMA (1–3) and Ahi hunting areas.

5.2.2 Hunter Effort and Harvest

Game Mammal Harvest

During FY 2022 and FY 2023, 33 days were available for mammal hunting with a total of 1,851 check-ins. Hunters harvested 890 mammals (Table 131).

Table 131. Game mammals harvested in the public hunting units at Pōhakuloa Training Area, FY 2022–FY 2023

Game Mammal	Ahi	Humuʻula	KMA	Total
Feral pig	0	0	20	**20**
Wild sheep	198	318	222	**738**
Feral goat	24	57	51	**132**
Total	**222**	**375**	**293**	**890**

KMA, Keʻāmuku Maneuver Area

Game Bird Harvest

During FY 2022 and FY 2023, 11 days were open for upland game bird hunting and there were 314 hunter check-ins. Hunters harvested 335 game birds representing 7 game species (Table 132).

Table 132. Game birds harvested in the public hunting units Pōhakuloa Training Area, FY 2022–FY 2023

Game	Ahi	Humuʻula	KMA[a]	Total
Black Francolin	57	15	66	138
California Quail	10	69	12	91
Chestnut-bellied Sandgrouse	5	0	0	5
Chukar Partridge	44	53	0	97
Erckel's Spur Fowl	49	118	90	257
Gray Francolin	0	1	1	2
Japanese Quail	4	0	0	4
Ring-necked Pheasant	1	0	122	123
Spotted Dove	2	0	0	2
Wild Turkey	4	9	12	25
Total				**744**

KMA, Keʻāmuku Maneuver Area

[a] KMA 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 for game management decision making. Information about game distribution, abundance, and activity can help select areas to open for hunting and determine the amount of hunting pressure that 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 methods to estimate abundance of game species.

5.3.2 Mammals

We used game cameras to monitor ungulate population densities across the PTA hunting units. Based on previous work at PTA (CEMML 2022a), we continue to collect camera data to use within the space to event (STE) model and instantaneous sampling (IS) methods (Moeller et al. 2018; Moeller 2021). Briefly, the concept of the STE model is that if random areas of the landscape are observed at an instant in time, the total area observed before an animal is detected is a function of abundance. Data collection involves the sampling of the landscape in that the data collected are the amounts of space (i.e., areas) observed between animal detections. This is accomplished through the random deployment of time-lapse cameras that take photographs at pre-determined times. A sampling occasion is defined as a single instant in time; for each sampling occasion, an animal or animals are either detected or not detected at each camera, and the *space to detection* is calculated as the total area sampled before an animal is first observed. The IS estimator is a simplified STE model and can use the same set of photographs, except that the data recorded are the number of animals pictured instead of space to detection. It uses the counts of animals over many spatial and temporal replicates to calculate density as the mean count divided by the collective viewable area of cameras (see CEMML 2022a for a more in-depth discussion).

Despite efforts to maximize the number of hunts per year and implementing *ewe-only* hunts, the density of sheep continues to rise (Table 133). In FY 2021, 28 archery mammal hunts were held; however, 11 of those hunts took place in the KMA units where ungulate density is less of an issue. Only 3 hunts took place in the Humu’ula unit, where ungulate density is highest. Thirteen hunts took place in the Ahi unit.

Table 133. Annual abundance and density estimates and 90% confidence intervals of sheep in each hunting unit. Note that there was no estimate for KMA in 2021 due to fire. Estimation in Ahi started 2021

Unit	Area (km^2)	Year	Estimated Density of Sheep (per km^2)	Estimated # of Sheep	SE	Abundance Lower Confidence Limit (alpha = 0.1)	Abundance Upper Confidence Limit (alpha = 0.1)
Ahi	19.8	2021	26	513	67	415	635
		2022	91	1793	161	1547	2078
KMA	90.5	2019	8	747	117	579	965
		2020	10	916	113	749	1122
		2022	30	2668	374	2122	3356
Humu’ula	11.9	2019	28	327	46	262	415
		2020	40	476	56	393	576
		2021	99	1178	93	1031	1336
		2022	145	1732	243	1377	2179

At such high densities, ungulates inflict considerable harm on the environment, which we have observed and documented in various ways. Negative effects include, but are not limited to, severe over-browsing of vegetation, increased erosion, destruction of game bird and forest bird habitat, and increased collision risk for motorists. Ungulate density is highest in the Ahi and Humu’ula hunting units, which corresponds to the most observed environmental damage. For example, photographs taken in the Humu’ula unit at an ungulate monitoring site between 2019 and 2022 document the degradation of the habitat and ecosystem health; this degradation correlates to increased ungulate density each year. Similarly, photographs from the Ahi unit (2021 to 2022) show where the landscape has been almost completely denuded by ungulates. Some of the observed impacts on the habitat are undoubtedly from dry conditions. However, across the Daniel K. Inouye highway, where animal densities are very low, the vegetation is intact, including native trees and shrubs, lending credence that the high density of ungulates is driving the extreme environmental degradation. Moreover, within the Ahi unit inside a small ungulate-free fence, vegetation, including native shrubs, remains intact.

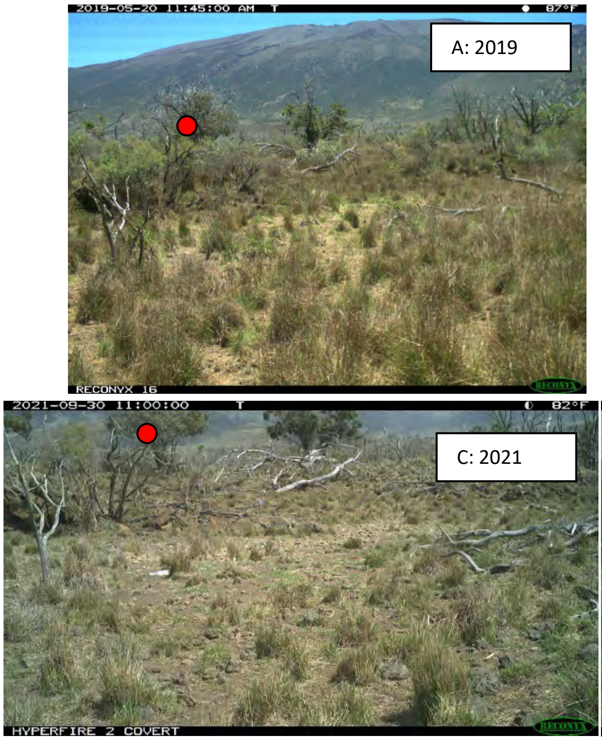


Figure 128. Progression of vegetation destruction in the Humu'ula hunting unit, 2019 to 2022. The red dot in all photographs is on the same tree for reference

Figure 129. Vegetation destruction in the Ahi hunting unit. The picture on the left was taken 29 June 2021, and the picture on the right was taken 28 September 2022. This portion of the hunting unit has been almost completely denuded of all vegetation

5.3.3 Game Birds

We continue to search for a method to accurately estimate game bird populations. Previous monitoring efforts did not produce an adequate sample size to estimate densities using Distance sampling. In FY 2022, we initiated a new method using N-mixture models. With this model class, all that is required to estimate density and abundance are counts of unmarked individuals that are replicated in 2 dimensions: there must be multiple sites and replicate observations for at least some of the sites. The data collection process involves driving linear transects along roads within hunting units and stopping at point count stations that are placed along the linear transects. Humu'ula was surveyed 19 to 23 September 2022, Ahi was surveyed 26 to 30 September 2022, and the KMA was surveyed 03 to 14 October 2022. Analyses were suspended with the departure of the Game Manager in March 2023. However, preliminary findings indicate adequate model fitting for Erckel's Spur Fowl and Ring-necked Pheasant (*Phasianus colchicus*).

Between January and May 2022, we capture Erckel's Spur Fowl and affixed GPS-GSM wildlife tracking devices (CCT®-ES420 telemetry device by Cellular Training Technologies) to 12 birds—6 in Humu'ula and 6 in KMA. The CCT® device transmitted position data for each bird at set intervals over a cellular network to a central database. Data through December 2022 were summarized, and the mean preliminary general home range estimate was 24.5 ha, with a mean core home range of 3.9 ha. The mean general and core home range for males were 25.0 ha and 4.2 ha, respectively, and for females 24.0 ha and 3.6 ha, respectively. However, the Game Manager departed PTA before the analysis was completed; therefore, the information provided here and the tables below are considered initial drafts.

Table 134. Mean general and core home range estimated for Erckel's Spur Fowl in 2 hunting units at Pōhakuloa Training Area

Date Captured	Bird_ID	Sex	Region	General home range (ha)	Core home range (ha)
2022-01-20	F-1	F	Humu'ula	29.9	4.8
2022-02-08	F-2	F	Humu'ula	24.3	3.4
2022-03-03	M-1	M	Humu'ula	14.1	2.3
2022-03-08	M-2	M	Humu'ula	60.5	12.3
2022-03-10	F-3	F	KMA	4.6	0.8
2022-03-16	M-3	M	KMA	27.6	3.6
2022-03-17	M-4	M	KMA	20.3	3.4
2022-03-29	M-5	M	KMA	13.1	1.7
2022-04-07	F-4	F	Humu'ula	15.6	1.6
2022-04-15	M-6	M	Humu'ula	14.6	1.9
2022-04-20	F-5	F	KMA	22.0	2.9
2022-04-21	F-6	F	KMA	31.0	4.8
2022-05-26	F-7	F	KMA	40.8	7.1
			Mean	**24.5**	**3.9**

Note: One female capture in KMA died (Bird_ID F-3) and a different bird was captured in KMA and the transmitted affixed.

5.4 OVERALL DISCUSSION FOR THE GAME MANAGEMENT PROGRAM

Public hunting at PTA provides the Army an opportunity for positive community engagement. It is the only recreational activity 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 the PTA hunting access policy and the implementation of iSportsman.

However, the increasingly high density of ungulates at PTA continues to cause environmental degradation. Part of the Humu'ula unit is within federally designated critical habitat for the Palila, an endangered bird, and ungulate impacts on the vegetation are readily apparent. We have also documented a decline in forest bird and game bird populations in the Humu'ula hunting unit and compelling evidence indicates ungulate over browsing is in part responsible (Figure 130). The upshot is that analysis of a 17-year bird point-count dataset showed negative population trends were more likely for birds in the ungulate-dense Humu'ula unit than in ungulate-free regions.

We recommend maximizing the number of hunts in the Humu'ula and Ahi units and to continue with *ewe-only* hunts. In addition, the State of Hawaii, DOFAW issued the Army a permit allowing increased take of animals over the stated limits in Hawaiʻi Revised Statues Title 13, Chapters 123 and 124. We also recommend exploring options to trap and relocate the overabundance of ungulates to other hunting regions, on or off PTA, to help reduce the number of animals and browsing pressure and to allow the vegetation to recover. We recommend using all the tools listed above to reduce ungulate populations quickly and maintain densities that allow the forest/vegetation community to sustain itself.

In FY 2024, we plan to hire a permanent hunting coordinator and continue to operate the PTA hunting program for the 2024/2025 hunting season.

Figure 130. Habitat degradation within federally designated critical habitat for the endangered Palila (*Loxioides bailleui*) in Training Area 1 in 2023. The high density of ungulates in the region, along with lower precipitation due to climate change and other invasive species impacts, has contributed to the drastic decline in vegetation.

6.0 ECOLOGICAL DATA PROGRAM

6.1 INTRODUCTION

The Ecological Data Program (EDP) implements SOO tasks 3.2.7.1 through 3.2.7.5 and supports planning, implementing, analyzing, and reporting work conducted by technical programs (Botanical, Invasive Plants, Wildlife, and Game Management). We provide centralized guidance and support for project design, geospatial and tabular data collection, data management, analysis, and project evaluation.

EDP guides and supports the technical programs so that data collection methods, data/GIS structures and management, analyses, and results reporting are tightly aligned with overarching programmatic goals and objectives as defined in the SOO. This function is essential for the efficient, cost-effective fulfillment of PTA NRP obligations and allows us to use all available knowledge and data to develop and implement natural resource management strategies. In addition, we develop, implement, and maintain all necessary information technology (IT) infrastructure to support all aspects of the project. We also help technical programs coordinate and incorporate research results from external agencies so the program can effectively fulfill goals and objectives.

We assist with project protocol development to ensure protocols efficiently address defined management and monitoring goals and objectives based on project purpose and intents. These efforts include data-driven assessments of management efficacy, strategy optimization, budget tracking, and accounting. While we have had our share of challenges, particularly in the form of limited program capacity, we continue to seek ways to be as effective as possible in fulfilling our larger organizational role.

6.2 CENTRALIZED DATA SUPPORT AND DATA MANAGEMENT SYSTEMS

The EDP supports centralized guidance for geospatial and tabular data collection, management, and analysis to technical programs, including building custom frameworks for project implementation. 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.

The EDP provides a variety of specialized support functions to technical programs ranging from guidance on project strategy and protocol development to the creation of mobile applications and operational databases to efficiently collect data in the field to support project goals. Functions also include data analysis and technical writing support. This helps ensure project strategies, goals, and methods for implementation, execution, and analysis are fully described, documented, and approved by senior CEMML and Army staff prior to project implementation.

Specific support functions we provided include the development and maintenance of data collection and management frameworks for seabird monitoring, Hawaiian Goose work at PTA and HFNWR, fence inspection and maintenance, game bird and ungulate surveys and monitoring, IPP weed and fuels control efforts, and all rare plant monitoring and survey work. Additionally, we also provided support as needed for the continued development of the Programmatic Biological Assessment (PBA), including data development, processing, curation, management, analysis, and distribution.

For most of the reporting period, we had a dedicated Technical Documentation Specialist on staff, and we were often called upon to develop technical documents to meet specific reporting and communications requirements (Table 135). For a comprehensive list of completed document deliverables produced by the NRP to support military initiatives and compliance-related regulatory obligations during the reporting period, please refer to Appendix F. Our Technical Documentation Specialist resigned in April 2022 and the position was not filled by the end of the reporting period.

Table 135. Highlights of technical writing support provided by Ecological Data Program

Document / Deliverable Title	Description	EDP Role	Status
Biennial Report FY 2022–2023	Two-year report for the PTA NRP. Report summarizes accomplishments, relevant biological/ecological trends	Document management, data/map/graphic creation, text development, edits, format, and final production	To be delivered to Army in FY 2024
Annual Compliance Report FY 2022	Report satisfies annual reporting requirements mandated in regulatory and guiding documents	Document management, primary author for Botanical Section, data and graphics support, final production	Delivered to USFWS and State in 2023
Recovery Permit TE40123A-2 Report 2021	Annual report required by conditions of the permit. Report covered genetic conservation actions for 20 T&E species	Data support and technical review	Delivered to USFWS in Feb. 2022
Recovery Permit TE40123A-3 Report 2022	Annual report required by conditions of the permit. Report covered genetic conservation actions for 20 T&E species	Data support and technical review	Delivered to USFWS in Jan 2023
Quarterly Performance Progress Reports	Report describing NRP activities and achievements submitted quarterly to meet the requirements of CEMML Cooperative Agreement	Complete section addressing EDP-specific SOO requirements	Delivered quarterly throughout the reporting period
Leilani (TA 22) Fire Technical Report and Assessment July 2022	Report describing impacts of the Leilani Fire (TA 22) as required by 2003 Biological Opinion	Document management, data/map/graphic creation, text development, edits, format, and final production	Delivered to Army May 2023

Table 135. Highlights of technical writing support provided by Ecological Data Program (cont.)

Document / Deliverable Title	Description	EDP Role	Status
KMA Complex Fire Technical Report and Assessment February 2023	Report describing impacts of the KMA Complex Fire as required by 2003 Biological Opinion	Document management, data/map/graphic creation, text development, edits, format, and final production	Delivered to Army July 2023
Treeland Roosting Habitat	Report summarizing results from analyzing land cover data to assess changes in the quality and availability of potential Hawaiian Hoary bat treeland roosting habitat at PTA	Primary author	Draft
Records of Environmental Consideration	We provided technical reviews, comments, and natural resources recommendations for proposed Army projects to support NEPA process	Data support and technical review	Discontinued
Information Papers	Series of papers prepared to brief PTA Command Team on important natural resources issues (e.g., external research, HFNWR, the NRP, outreach, PBA, publications, and presentations.	Primary author	Discontinued

6.3 ORGANIZATIONAL-LEVEL DATA SUPPORT

The primary focus of the EDP continues to be the development and improvement of mobile GIS tools to streamline the collection, organization, analysis, and overall use of geospatial data collected in the field to achieve programmatic goals and objectives as described in the SOO and other guiding documents. Our priority is to build frameworks to allow data to be collected efficiently with minimal issues with data quality and integrity. It is essential to incorporate QA/QC BMPs throughout the process. We help ensure that data being collected will allow for the measurable achievement of project goals and objectives.

We use several tools available within ESRI's ArcGIS mapping and analytics platform: (1) ArcGIS Pro, (2) ArcGIS Online, (3) ArcGIS Enterprise, and (4) Field Maps. Using those applications, we develop custom data collection, management, and analytical solutions for a range of projects, including BSTP burrow monitoring and predator trapping components of the seabird project, Hawaiian Goose work at PTA and Hakalau, ungulate fence inspection and maintenance, IPP and Invasive Plant Monitoring Sections (IPSM) weed control projects, Tier 1 and Tier 2 rare plant monitoring, and genetic conservation and outplanting efforts.

For non-spatial data, we use relational databases to manage complex datasets and develop specialized data queries to manage, filter, and extract data for analysis. The EDP uses our overlapping expertise in ecology, experimental design, data management, and programming to help technical programs collect and manage complex ecological data for all facets of work done at PTA. We work directly with technical program managers and project leads to develop data summaries and provide real-time access to data to streamline the process of interacting with and making use of data as needed to meet project management goals and objectives.

We also continued our work maintaining and managing the Management Actions Tracking System (MATS), a database that stores and organizes information on the effort expended toward the fulfillment of SOO tasks. This database tracks personnel hours and other costs to implement management actions. Management actions are linked to itemized statutory requirements so that all expenditures toward the fulfillment SOO tasks can be explicitly tracked and reported. This is an essential function for reporting, budgeting, accountability, and strategic planning. In the coming quarters, we will upgrade MATS to be more efficient and in line with administrative needs. This new system will take advantage of data already collected in project-specific mobile GIS applications and will be better integrated into program operations so that important real-time information is available to CEMML senior leadership and the PTA Army Biologist to allow for data-driven strategic and operational planning.

6.4 Botanical Program Support

The Botanical Program made significant overhauls to all core projects, including efforts within the GCOS and Rare Plant Survey and Monitoring sections of the program. For projects associated with GCOS goals, EDP participated in clearly defining goals and objectives and the specific system components necessary for the successful execution of work. Importantly, we helped outline conceptual frameworks for data collection and management structures integral to the proper functioning of each project component. We also overhauled a seed storage database that allows us to track accurate inventories of plant propagules, including their sources and fates. This database is an essential tool for reporting and compliance with our state and federal permit requirements.

We also played a key role in the design and development of plant monitoring protocols for Management Tier 1 and 2 species and outplants, which replace all previous plant monitoring projects within the Botanical Program. These efforts included writing detailed project protocols establishing (1) clear goals and measurable objectives, (2) clear SOPs for what and how data will be collected in the field, (3) designs for data collection and management systems within an ArcGIS online environment, (4) detailed guidance and schedules for QA/QC procedures both in the field and the office to ensure data quality and integrity, (5) methods for project progress tracking and management, (6) approaches for data extraction and analysis, and (7) designs for data products to be synthesized from project data for reporting and species management improvements.

Overall, we helped the Botanical Program develop projects and data collection and management strategies and systems to efficiently turn field-collected data into usable information and knowledge to meet reporting and management obligations.

6.5 Invasive Plants Program Support

We continued to provide support to the Invasive Plants Program by developing spatially explicit data collection and management approaches, primarily using ESRI's ArcGIS online framework, for both the Invasive Plant Survey and Monitoring and the Vegetation Control Sections. Efforts included the maintenance and management of geodatabases that house project-specific data to streamline data analysis and to create data products for planning, tracking, and reporting project success in quarterly progress reports and other documentation as needed.

For IPSM section projects, we developed data and map products to help plan and execute quarterly management actions to strategically survey, monitor, and control the presence of potentially high-impact invasive plant species. This work included the creation of survey grids and transects and management tools to visualize species presence across the landscape to prioritize control operations.

For Vegetation Control Section projects, our role was similar—providing data and map products to document locations of managed weed control buffers, fuel breaks and firebreaks, and vegetation monitoring corridors. These products were used to plan, implement, and report on management actions to achieve overall project goals and objectives.

6.6 Wildlife Program Support

We provided extensive support to nearly all projects within the Wildlife Program, including fence inspection and maintenance, predator and rodent trapping, Band-rumped Storm Petrel monitoring and management, Hawaiian hoary bat activity and occupancy studies, both onsite and offsite Hawaiian Goose projects, and PTA hunting and game management. For each project, we provided technical guidance and support for data collection, management, storage, and analysis. We also worked directly with project leaders to provide map and data products as needed for project planning, implementation, and reporting. Most projects are supported using spatially-explicit data management systems developed in ArcGIS online, with some auxiliary data management and analysis done in Microsoft Access.

We look forward to continuing our work with the Wildlife Program to further assess project needs and develop detailed project protocols based on those assessments. Our primary goal is to find opportunities for further streamlining workflows and integrating data management tools to ensure projects are implemented as efficiently and effectively as possible.

6.7 Support for Army Training Initiatives

The EDP continues to provide technical services to the Army for (1) initiatives to develop training capacity at PTA, (2) natural resources-related initiatives in cooperation with private, State, and Federal partners (e.g., grazing rights and upcoming ESA section 7 actions), and (3) technical support for state lease renewal proceedings. We also provided significant support to PTA command and the Department of Emergency Services, using imagery analysis and other mapping tools to aid wildland fire suppression efforts, ensuring Army Training can continue in safe, sustainable ways.

We supported Army range planners to help deconflict range development initiatives and natural resources considerations. For example, in cases where Records of Environmental Consideration must be completed, we provided data to map and analyze the locations of natural resources assets in proximity to planned operations.

We are fortunate to have on-staff experts in the fields of remote data acquisition and utilization. We leveraged our in-house capacity to access and use publicly available remotely sensed data including satellite imagery, LiDAR, and other multi-spectral datasets to effectively accomplish SOO tasks and to address emergent issues as needed (e.g., during wildland fire and volcanic eruption events).

We are regularly called upon to provide situational awareness support in the event of wildland fire. Using MODIS satellite VIIRS data and Sentinel-2 satellite imagery, we provided near real-time situational updates to front-line fire fighters and decision makers regarding the advancement of fire fronts and how they may impact natural, cultural, civilian, and DoD assets on the ground. The multispectral datasets allow us to produce visual band imagery in addition to vegetation indices, including differential Normalized Burn Ratio, Normalized Difference Vegetation Index, Near Infrared, and Visible Atmospherically Resistant Index—all used to better visualize and understand fire impacts to the landscape. We also use these data to delineate burn footprints and estimate area impacted to support planning field assessments of impacts to natural resources from the fire. We used these approaches to make real-time and after-event assessments of impacts from the Mauna Loa eruption in December 2022.

In August 2023, we began collaborating with the CEMML Environmental GIS Support lab to bring GIS data into compliance with federal Spatial Data Standards for Facilities, Infrastructure, and Environment (SDSFIE), as now required in the SOO. Ensuring data is SDSFIE compliant entails adding fields and metadata descriptions described in Army Quality Assurance Plans. This work will facilitate data sharing with Army GIS and other stakeholders. We currently have 3 datasets (Rare Flora, Hunting, and Firebreaks) updated to meet these standards. We have provided these data to the USAG-HI GIS Administrator for review and will use feedback to ensure the remaining data layers are SDSFIE compliant in FY 2024 (Table 136).

Table 136. GIS data layers for conversion to federal metadata standards (SDSFIE)

Data Layer	Description	Update Interval
Special Status Species Flora	Current best-known locations of all federally protected flora	Annual
Firebreaks	Current location of fuel/firebreaks	Annual
Habitat Protective Zone	Weed control areas for federally protected flora	Annual
Flora Planting	Locations of currently managed outplanting areas	Annual
Hunting Locations	Locations of areas available for hunting program	Annual
Habitat Protective Zone Fauna 1	Management areas for federally protected fauna	Annual
Habitat Protective Zone Fauna 2	Potential treeland roosting habitat as described in the Incidental Take Statement from the 2003 Biological Opinion	Annual
Nuisance Species Flora	Locations of weeds (including invasive and noninvasive species) that directly or indirectly cause harm to federally protected flora or fauna	Annual
Nuisance Species Fauna	Locations of insect or other animal pests (including invasive and noninvasive species) that directly or indirectly cause harm to federally protected flora or fauna	Annual
Special Status Species Fauna	Current and historical known locations of federally protected fauna	Annual
Wildland Fire	Cumulative historical locations of wildland fires	Annual

6.8 Overall Summary Discussion

The EDP is an essential component of the Army Natural Resources Program at PTA, supporting the efficient and effective accomplishment of programmatic goals and objectives. Beyond the important function of providing expertise in data collection, management, and analysis, we also help advise, guide, and support technical programs in the development of project protocols to ensure alignment between project goals and efforts expended.

We continue to provide high-end cartographic/GIS/spatial analysis support for all natural-resource-related elements of the Army mission at PTA. We provide map and graphics support for reports, regulatory consultations, wildland fire events and assessments, and other Army-initiated data calls. All projects described in this report requiring the use of spatially explicit data products (graphics, maps, spatial analysis) have been supported with assistance and expertise from the EDP. Spatial data are managed with the goal of easily sharing and collaborating with Army and conservation partners (e.g., using appropriate metadata and data transfer protocols). One major initiative recently reinvigorated toward this end is ensuring compliance with SDSFIE standards. Formatting our data this way is beneficial to the Army and to CEMML as it eliminates the need to compile data each time we receive a request.

We have also taken steps to transition to ArcGIS Enterprise as our primary system of GIS data management and dissemination. To date, we have configured our network systems to support the function of this server-based platform and have tested it by housing versions of our Botanical Program survey and monitoring data collection systems. With those efforts, we have proven the feasibility and effectiveness of operating within an Enterprise framework. However, our transition to an ArcGIS Enterprise-based setup is temporarily on hold due to several factors, primarily as a result of recent decreased program capacity and the need to bring all currently managed datasets into compliance with federal metadata standards. Moving forward, we will assess the best ways to convert fully to Enterprise. Future work will include curating and transitioning existing data and refining processes and systems to ensure maximum utility of the spatial data we collect and manage.

The EDP has an optimal, centralized vantage point within the organization to help plan projects and assist in developing protocols so the organization can use its limited resources to meet project goals and SOO objectives most efficiently. We continue to develop and implement digital data collection and management approaches used in all technical programs for field data collection efforts. New technologies continue to be assessed for use in optimizing field-to-office data flow with mobile device software, including next-generation field data collection applications from ESRI. In the future, we look forward to working with the Army to further improve our systems so they can better align with programmatic needs and ensure all project goals are achieved with the highest level of performance and efficiency.

AREA 2: TECHNICAL SUPPORT 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 training capacity initiatives, for cooperative initiatives with state and federal resource agencies, and for defense in litigation proceedings. We also review proposed military actions to assess potential effects to TES and other species of concern. Technical and administrative support are provided under CEMML's Statement of Objectives (SOO) tasks 3.2.8 and 3.2.9.

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 supporting military initiatives and compliance-related regulatory obligations during this reporting period, please refer to Appendix F.

7.1 INTEGRATED NATURAL RESOURCES MANAGEMENT PLAN

The PTA INRMP (USAG-PTA 2020) is the foundational document of the Army's Natural Resources Program at PTA and sets objectives for managing natural resources. 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.

During the reporting period, we assisted the Army Biologists with coordinating the annual INRMP partnership meetings between the Army, federal and state regulators/conservation partners, and relevant stakeholders in October 2021 and 2022. Due to the COVID-19 pandemic, we held hybrid meetings (i.e., in-person and virtual attendance) and facilitated discussions with regulatory partners regarding annual accomplishments toward INRMP goals, the review process, stakeholder responsibilities, and PTA NRP areas. We prepared a series of presentations on our annual accomplishments toward INRMP goals on the following topics: INRMP overview and status update, Botanical Program, Invasive Plants Program, Wildlife Program, Game Management, PBA update, and other INRMP projects (e.g., climate change, pest management, boundary issues/access process, law enforcement). After the presentations, managers were available to answer questions and facilitate discussion about NRP goals and how they relate to the military mission at PTA.

Per the Sikes Act Improvement Act (1997), the DoD requires INRMPs to be updated or revised every 5 years if substantial changes to the natural rescues or the program have occurred. Since the plan was last updated in 2020, several changes to the NRP have occurred that will require new and/or updated information in the next INRMP. During the report period, we developed information to meet DoD requirements to address climate-driven changes (DoDM 4715.03). We compiled climate change information specific to the PTA region, developed vulnerability assessments for native species and habitats at PTA, and recommended adaptation strategies to help mitigate projected climate-driven effects to species and their habitats. In addition, we provided recommendations and information to improve INRMP sections regarding public hunting and game management, agricultural lease programs, and inclusion of marine and coastal resources.

7.2 ENDANGERED SPECIES ACT AND NATIONAL ENVIRONMENTAL POLICY ACT

7.2.1 Programmatic Biological Assessment

The PBA is a comprehensive document that identifies and measures potential impacts to TES or critical habitat at PTA. 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 is mostly complete and is pending review and approval to submit to USFWS by internal Army authorities. During the reporting period, we coordinated with, met with, and provided natural resources information to USAG-PTA, US Army Garrison-Hawaiʻi, USFWS, Army Environmental Command/ Installation Management Command, and US Army Corps of Engineers, Engineer Research and Development Center, Construction Engineering Research Laboratory (USACERL). We participated in periodic conference calls and reviewed and commented on draft threats analysis methods.

7.2.2 Technical Reviews of USFWS and National Marine Fisheries Documents

During the reporting period, the USFWS requested review and comments for several draft documents and proposed rules. We provided technical support by monitoring the Federal Register for publication of documents pertaining to TES that occur at PTA. Under direction from the Army Biologists, we reviewed the draft documents and prepared responses.

In FY 2022 and FY 2023, we reviewed and commented on the following documents:

<u>Proposed rule for critical habitat designation for the green sea turtle (*Chelonia mydas*)</u>

On 30 September 2021, the USFWS and National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) contacted the Army to request data and information to prepare a proposed rule for green sea turtle (*Chelonia mydas*) critical habitat designations in the water and on land. We provided information regarding Army assets at Kawaihae harbor to the Natural Resources Program Manager for a joint response between USAG-HI and USAG-PTA, which was sent to USFWS on 22 November 2022. In this letter, the Army requested exemption from critical habitat designations, based on the INRMPs for Oahu and PTA.

However, for DoD-controlled areas to be excluded from critical habitat designation, the installation's INRMP must (1) provide a benefit to the species, (2) provide certainty that the agreed-to actions will be implemented, and (3) provide certainty that conservation efforts will be effective (DoDM 4715.03). The PTA INRMP 2019–2024 did not address green sea turtles or their water or land habitats at Kawaihae harbor. In our response letter to the USFWS (November 2022), we provided the following actions to be added to the PTA INRMP to address green sea turtles and land habitats at Kawaihae harbor:

- Brief all incoming units to report all basking turtle sightings.
- Conduct environmental awareness training for any Army use of GST habitat that includes implementing a 50-foot buffer if a turtle is observed.
- Erect signs to communicate the standard procedures if turtles and other protected wildlife are observed on the beach and how to report sightings.
- Ensure that any lighting on Army lands at Kawaihae Harbor is wildlife safe.

On 19 July 2023, when NFMS and USFWS published the proposed rule for green sea turtle critical habitat in the Federal Register (Fed. Reg. Vol. 88, No. 137, pp. 46376-46570), we had not updated the INRMP. Therefore, proposed critical habitat units at Kawaihae harbor included Army-controlled waters.

In response to the proposed critical habitat units at Kawaihae harbor, we assisted the US Army Environmental Command and the PTA Army Biologists to develop an INRMP addendum that describes the ongoing and planned conservation actions that benefit the green sea turtle and its water and land habitats at the harbor.

We continue to work with NFMS and USFWS to ensure the draft INRMP addendum meets the above criteria above to provide proactive, effective conservation of the green sea turtle and its water and land habitats, so that Army-controlled waters and lands at Kawaihae harbor will not require critical habitat designation. The draft INRMP addendum was submitted to USFWS in September 2023.

Proposed rule for critical habitat designation for Iʻiwi

On 6 October 2021, the USFWS contacted the Army to request data and information to prepare a proposed rule for Iʻiwi (*Drepanis coccinea*), an endangered native bird. On 21 December 2022, we responded via letter to assist the USFWS to gather the best scientific data available for Iʻiwi at PTA. Although Iʻiwi were last detected at PTA in 1995 (David 1995), the species is addressed in the PTA INRMP (2019). The plan describes implementation of several ecosystem-level management actions, including fencing, feral ungulate control, and wildland fire risk reduction, that benefit native dryland forest habitats historically used by Iʻiwi (Scott 1985).

On 27 April 2022, USFWS requested review and comments on the draft Incremental Effects Memorandum for the proposed rule to designate critical habitat for Iʻiwi. USFWS planned to use the information in the memo to conduct an economic analysis for the proposed designation. We assisted the Army Biologist to develop a response detailing the potential economic impacts to the Army if critical habitat were to be designated at PTA.

On 28 December 2022, USFWS published a proposed rule to designate critical habitat for Iʻiwi (Fed. Reg, Col 87, No. 248, pp. 79942-79975). Critical habitat was not proposed at PTA; therefore, an exemption was not requested, and the Army did not provide additional comments to USFWS.

However, critical habitat was proposed for lands that fall within the proposed action area in the draft PBA. These lands are occupied by Iʻiwi and the PBA addresses effects to the species from Army actions, but effects to the habitat are not addressed. Following publication of the final rule, the PBA will need to be updated to reflect new critical habitat units that fall within the action area.

Proposed rule for critical habitat designation for *Schiedea hawaiiensis*

On 3 November 2021, the USFWS contacted the Army to request data and information to prepare a proposed rule to designate critical habitat for 12 plant species on Hawaiʻi Island, including *Schiedea hawaiiensis*, an endangered plant species that occurs only on PTA. On 21 December 2022, we responded via letter to assist the USFWS to gather the best scientific data available for this species and to describe INRMP actions for ongoing ecosystem management of the dryland forests habitat where *Schiedea hawaiiensis* occurs at PTA.

On 29 March 2023, USFWS published the proposed rule to designate critical habitat, which included *Schiedea hawaiiensis* (Fed. Reg. Vol. 88, No. 60, pp. 18756-18821). Although the USFWS excluded lands at PTA from critical habitat designation, it designated only 1 unoccupied critical habitat unit for *Schiedea hawaiiensis* in Puʻu Anahulu, State land adjacent to the western PTA boundary. The Puʻu Anahulu region is within the proposed action area for the draft PBA. We assisted the Army Biologist with a response letter, sent to USFWS on 30 May 2023, to document likely additional administrative and operational burdens to the Army if this area becomes critical habitat. Currently, the draft PBA does not address potential effects of the Army's actions to habitat within the proposed unit. If the final rule includes the proposed unit, potential effects to habitat from the action will need to be analyzed and, if needed, new conservation actions to avoid, minimize, or offset impacts to the habitat will need to be developed.

Draft Recovery Plan for 50 Hawaiian archipelago species—March 2022

On 24 February 2022, USFWS published a notice (Fed. Reg., Vol 87, No. 37, pp. 10378–10381) that a new recovery plan for 50 Hawaiian archipelago species was available and requested comments by 25 April 2022. The plan updated recovery goals for 8 species that occur at PTA—6 plants (*E. menziesii, F. hawaiiensis, H. haplostachya, P. villosa, S. macrophyllus,* and *S. angustifolia*), 1 invertebrate (*Hylaeus anthracinus*), and 1 bird (*Hydrobates castro*). We reviewed the plan for these species and developed a comment matrix, which we delivered to USFWS on 20 April 2022.

In the draft recovery plan, USFWS identified *H. haplostachya* as reproducing primarily via vegetative reproduction. Based on this reproductive strategy, USFWS doubled the number of populations needed to meet progressive stages of recovery. Because we have no direct evidence of vegetative reproduction, and have observed reproduction from seeds, we requested that USFWS reconsider this designation in the recovery plan and to provide the source of its information (since *H. haplostachya* occurs mostly at PTA). USFWS published the approved plan in December 2022 and did not change the information regarding reproductive biology for *H. haplostachya* or the number of required populations to meet recovery stages nor did USFWS provide a justification for the information. We recommend following up with the USFWS to get source information regarding the reproductive biology of this species and/or conducting research to determine the primary mode of reproduction for this species.

Threatened and Endangered Species Recovery—5-year Review Document Reviews

On 23 March 2023, the USFWS published a notice (Fed. Reg., Vol 88, No. 56, pp. 17611-17614) to initiate a 5-year review of the recovery status of several threatened and endangered species and requested new information regarding these species. Fourteen of the species occur at PTA—13 plants (*A. peruvianum* var. *insulare, H. haplostachya, I. hosakae, K. coriacea, L. venosa, N. ovata, P. sclerocarpa, Schiedea hawaiiensis, Silene hawaiiensis, S. Incompletum, S. angustifolia, T. arenarium,* and *V. o-wahuensis*) and the Hawaiian hoary bat (*A. semotus*). We reviewed the previous 5-year review for these species and provided new information in a comment matrix, which we delivered to USFWS on 16 May 2023.

7.2.3 NEPA Support—Army Training Land Retention Environmental Impact Statement

During the report period, we provided technical support and information to the Army contractor writing the Army Training Land Retention Environmental Impact Statement (EIS). Specifically, we provided annual and biennial PTA NRP program reports and scientific studies completed at PTA including vegetation monitoring reports and data, invertebrate inventories, bird monitoring data, bat monitoring data and management plans, and GIS data layers. We reviewed versions of the draft EIS and provided comments and technical corrections. We participated in phone meetings and live-editing sessions to ensure technical corrections were accurate. As requested and directed, we will continue to engage with the Army Biologists and the Army contractor through the completion of the EIS.

7.2.4 NEPA Support—Records of Environmental Consideration

During the reporting period, we assisted the PTA Army Biologists with reviewing Records of Environmental Consideration (RECs) when requested. RECs are submitted with project documentation under 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 2022 and FY 2023, we reviewed and commented on the following RECs:

- (No Number) Roadside mowing along the Main Supply Route in the Keʻāmuku Maneuver Area
- 4777 BAAF Airfield Pads
- 4830 NRAO Portable Weather Station
- 4872 Keʻāmuku Maneuver Area Grazing Lease
- 4873 T-Storm Swarm Capability

- 5036 Remove and replace fencing
- 5059 Cooper Airstrip Extension

We provided technical support to the Army Biologists and PTA fire department personnel to develop a REC for roadside mowing in the KMA to reduce fuel loads.

7.3 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 a short description of each permit necessary to meet our SOO tasks and INRMP objectives.

7.3.1 Federal Permits Issued by the US Fish and Wildlife Service

Native Endangered & Threatened Species Recovery Endangered & Threatened Plants (TE40123A-3)

This permit is issued by the USFWS, Endangered Species Program to USAG-PTA under section 10(a)(1)(A) of the ESA to assist in the recovery of 20 threatened and endangered plants and 1 endangered animal 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. The permit establishes operational terms and conditions as well as data collection and reporting requirements. The USAG-PTA 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. Annual reports were submitted in January 2022 and January 2023 (see Appendix F for report summaries).

Federal Fish and Wildlife Permit—Scientific Collection with Import / Export (MB95880B)

This permit is issued to USAG-PTA 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 (*Hydrobates castro*). Normally, possession of remains of birds protected under MBTA is unlawful, but with the permit we can use these remains for scientific purposes. The USAG-PTA Commander is the permit holder and CEMML staff listed on the permit are authorized to perform the work. The permit was renewed in 2022 and expires 31 March 2025. Annual reports were submitted in January 2022 and January 2023 (see Appendix A for report summaries).

National Wildlife Refuge System Research and Monitoring Special Use Permits (121516-21020-G, 12516-22023-R, and 12516-23020-R)

The USFWS, National Wildlife Refuge System issues Special Use Permits annually to USAG-PTA to authorize management activities for the Hawaiian Goose (*Branta sandvicensis*) at Hakalau Forest

National Wildlife Refuge on Hawaiʻi Island. The permit specifies terms and conditions for working on refuge lands with the endangered goose. Three permits were issued over the report period: 121516-21020-G, 12516-22023-R, and 12516-23020-R. The USAG-PTA Deputy Garrison Commander is the current permit holder and CEMML staff listed on the permit are authorized to implement actions prescribed on the permit. Annual reports were submitted in July 2022 and July 2023 (see Appendix F for report summaries).

7.3.2 State of Hawaiʻi Permits issued by the Department of Land and Natural Resources, Division of Forestry and Wildlife under Hawaiʻi Revised Statues Title 12 and Hawaiʻi Administrative Rules Title 13

Permit for Threatened and Endangered Plant Species (I2942 and I5287)

This permit authorizes us to collect, possess, propagate, and outplant state-listed and ESA-listed threatened and endangered plant species on State lands. 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, and 2 permits were issued over the report period: I2942 and I5287. The USAG-PTA Commander is the current permit holder and CEMML staff listed on the permit are authorized to perform the work in accordance with the permit's terms and conditions. Annual reports were submitted in January 2022 and January 2023 (see Appendix F for report summaries).

Mauna Loa Forest Reserve Permit for Access and Research, Puʻu Huluhulu Native Plant Sanctuary

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. A permit was issued for 1 July 2022 to 1 July 2023, and 20 August 2023 through 20 August 2024. For this permit to be valid, we must also possess the following valid permits: (1) Federal Native Endangered & Threatened Species Recovery Endangered & Threatened Plants (TE40123A-3) and (2) State of Hawaiʻi Permit for Threatened and Endangered Plant Species (I2689). The USAG-PTA Commander as 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. Annual reports were submitted in January 2022 and January 2023 (see Appendix F for report summaries).

Hawaiʻi Experimental Tropical Forest Research Permit

This permit is jointly issued by the US Forest Service and the Hawaiʻi State Department of Land and Natural Resources, Division of Forestry and Wildlife. It is necessary to access outplanting sites on state land at Puʻu Waʻawaʻa. For this permit to be valid, we must also possess the following valid permits: (1) Federal Native Endangered & Threatened Species Recovery Endangered & Threatened Plants (TE40123A-3) and (2) State of Hawaiʻi Permit for Threatened and Endangered Plant Species (I2689). This permit is renewed annually, and 2 permits were issued over the report period: 30 November 2021 through 30 November 2022, and 22 December 2022 through 23 December 2023. The USAG-PTA Commander is the current permit holder and CEMML staff listed on the permit are authorized to perform management in accordance with permit terms and conditions. Annual reports were submitted in January 2022 and January 2023 (see Appendix F for report summaries).

Protected Wildlife Permit—Scientific Collection (WL19-42 and WL21-15)—Band-rumped Storm Petrel (*Hydrobates 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). The USAG-PTA Commander is the permit holder and CEMML staff are listed as the sub-permittees responsible for performing activities in accordance with permit terms and conditions. The permit is renewed every 2 years. Annual reports were submitted in January 2022 and January 2023 (see Appendix F for report summaries).

Protected Wildlife Permit—Scientific Collection (Upland Gamebirds: WL21-11)

This permit authorizes the capture of the game bird species Erckel's Spur Fowl (*Pternists erkelii*)[25] to better understand the role game birds play in exotic seed dispersal by examining their diet and movement patterns within PTA. To investigate the movements and home range size of Erckel's Spur Fowl, we were authorized to: (1) capture 10 Erckel's Spur Fowl via drop nets or Tomahawk trap, (2) band captured birds on the leg with a Darvic identification band, (3) attach a GPS transmitter, and (3) possess birds. During the report period, we amended permit WL21-11 to increase the allowable number of captured birds from 10 to 12. The permit expired 5 November 2023. Annual reports were submitted in January 2022 and January 2023 (see Appendix F for report summaries).

Wildlife Control Permit (WHI-PTA1)

This permit authorizes the Army to set the number of ungulates each hunter can harvest per hunt-day at PTA above the harvest-limit prescribed in State Regulations.

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 Biologists 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 FY 2021 and FY 2023 Annual Work Plans and budgets, including annual projected revenue and requested reimbursements.

[25] The common and scientific names have changed from Erckel's Francolin (*Francolinus erckelii*) to Erckel's Spur Fowl (*Pternists erckelii*) (Citation for the AOS / Birds of the Word).

For FY 2022, we purchased 12 GPS-enabled transmitters, including a monthly data subscription fee, to track a species of game bird, Erckel's Spur Fowl (*Pternistis erckelii*), to map home ranges. See Section 5.3.3 for a description of the project and plans to analyze the data. For FY 2023, we requested the purchase of 5 cameras to monitor sheep and goat populations. See Section 5.3.2 for information on how these support population monitoring. 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.

In 2016, the Army leased ~312 ha to Hoʻilina Ranch within a buffer surrounding the Waikiʻi Ranch community within the KMA (Lease No. DACA84-1-16-223). The lease was for a 5-year term with another 5-year option and expired on 7 June 2021. This lease was not properly embedded within the CRFCP program. Therefore, in 2021, the PTA Army Biologists worked with Army Environmental Command and the US Army Garrison Resources Management team (fiscal) to establish proper procedures to deposit lease revenue and to withdraw funds to reimburse approved expenditures for natural resources-related projects at the installation. In June 2021, the 5-year option for the lease was executed and the lease extended to Hoʻilina Ranch for another 5 years. The lease now expires 24 May 2026. The supplemental lease agreement added new actions to include mowing a 20-foot-wide strip of Army-owned land outside the leased premises to a height of no greater than 12 inches annually by 31 July each year to help reduce wildfire risk. During this lease negotiation, the Army Biologist set up procedures to collect lease fees within the CRFCP to benefit natural resources management and protection.

In 2022, to address heightened fire risk to the Waikiʻi Ranch community, the Army began working to lease an additional ~2,185 ha to lease for grazing. The PTA Army Biologists worked with internal Army directorates and the US Army Corps of Engineers to finalize the bid package (DACA84-9-22-0726). The Army is negotiating with a local ranch and the final lease agreement is expected in early 2024 with grazing operations beginning the same year.

During the reporting period, we provided assistance to the PTA Army Biologist by reviewing program requirements, assessing the current and proposed lease agreements, and providing technical and natural resources information about the area under the current grazing lease in the KMA.

7.5 Collaborations with Partner Agencies

We collaborated with several conservation organizations and working groups to participate in or host meetings to share program information, work strategies, and accomplishments and to keep abreast of current/emerging science and management practices employed by our colleagues. We also provided information on PTA natural resources, TES, and ecosystem management to local newspaper and magazine publications to promote public education and outreach.

7.5.1 Wildland Fire Management

Pacific Wildfire Exchange

Per the Army's directive, we coordinated with and provided natural resources information to the Pacific Wildfire Exchange to develop collaborative fire prevention and management strategies. Specifically, we provided comment and review for a 2023 publication *Wildfire's Impacts to Rare and Endangered Hawaiian Plants* (Pacific Fire Exchange 2023). In addition, we continued low-level engagement with Hawaiʻi Wildfire Management Organization over the report period.

7.5.2 Rapid ʻŌhiʻa Death Working Group

During the reporting period, we participated in meetings of the statewide and Hawaiʻi Island Rapid ʻŌhiʻa Death (ROD) Working Groups. The statewide 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 over 200 individuals representing state, county, federal, university, nonprofit organizations, local and private businesses, and private citizens. The Hawaiʻi Island group was formed later to focus discussions on island-specific issues and progress. The purpose of the groups 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 statewide ROD Working Group meetings are held monthly via conference phone with members calling in from around the state and the mainland. The Hawaiʻi Island ROD Working Group meets quarterly via video conference. Committees focusing on research, surveys, control, and outreach provide reports to keep interested parties current on the latest information.

The threats posed by ROD and associated monitoring and testing at PTA are described in Section 3.3.5.

7.5.3 Hawaiʻi Island Watershed Participation

During the reporting period, we participated in meetings of the Mauna Kea Watershed Alliance (MKWA). The MKWA partnership boundaries span over 2,023 km^2 across the upper elevation Mauna Kea landscape, with partnership lands representing around 2/3 of the total area. The alliance is composed of several landholders, including federal and state of Hawaiʻi agencies, land trusts, nonprofits, 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.

During the reporting period, CEMML staff assisted Mauna Kea Forest Restoration Project (MKFRP) staff with predator control in areas at PTA buffering Palila Critical Habitat. We coordinated access for MKFRP staff to control predators at PTA in 2022; however, MKFRP staff were unable to sustain trapping efforts in 2023.

7.5.4 Pacific Islands Climate Adaptation Science Center, Pacific Regional Invasive Species and Climate Change Management Network

During the reporting period, we attended several virtual presentations hosted by the Pacific Regional Invasive Species and Climate Change (RISCC) Management Network to learn more about the synergistic effects of climate change and invasive species. RISCC is a collaboration of entities from across the Pacific to help explore perspectives, identify research needs, and make accessible research related to the confluence of invasive species management and climate adaptation in the Pacific. RISCC hosts virtual presentations where experts present their research. RISCC also disseminates summaries of relevant research articles to help make the large body of climate change research more accessible.

7.5.5 Endangered Palila Management

Annual Statewide Palila Population Counts

During the reporting period, 1 or 2 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 through PTA. We ensured all survey participants accessing PTA received all required safety briefs from PTA Range Control. We have participated in this project since 1997.

7.5.6 Hawaiian Goose Management

Annual Statewide Hawaiian Goose Counts

During the reporting period, 1 CEMML staff participated in each annual statewide Hawaiian Goose Survey. We have participated in this project since 2016.

Banding of Hawaiian Geese at Hakalau Forest National Wildlife Refuge

On 9 February 2022, in conjunction with Mr. Raymond McGuire from the Division of Forestry and Wildlife we attempted to band fledgling geese at HFNWR. We were unable to find fledglings old enough to band, but we banded 7 adult geese.

On 2 March 2022, with McGuire's assistance, we successfully banded 6 fledglings. Of the 6 fledglings that were banded, 2 were from nests that we had monitored. No harm or injuries were observed during the banding process.

On 9 June 2023, in conjunction with Raymond McGuire as well as Eldridge Naboa of HFNWR staff, we attempted to band fledgling geese from late-season nests at HFNWR. We were unable to find or capture any fledglings or adults old enough to band. The lack of success was likely due to the time of year, as breeding season is typically finished before June and summer flocking is well underway.

Translocation of Hawaiian Geese from Bradshaw Army Airfield to Puʻu Oʻo on State lands

On 24 April 2023, we assisted State of Hawaiʻi Department of Forestry and Wildlife (DOFAW) personnel in the capture and translocation of a goose family (Grey/Black A97 and A98 and 3 goslings) away from BAAF to State lands. These geese were safely captured with long-handled nets and caged in a large plastic animal carrier. For more information regarding the goslings' discovery and the capture and translocation of the goose family, please refer to Section 4.2.2 and Appendix E.

7.5.7 Seabird Management

Nest surveys with Assistance from a Detector Dog

During the reporting period, 1 or 2 CEMML staff assisted State of Hawaiʻi, Department of Natural Resources-Division of Forestry and Wildlife staff to survey for seabirds (Hawaiian Petrel and Band-rump Storm Petrel) using a detector dog on Mauna Loa over 3 days. We helped place cameras once the dog indicated a potential burrow. We advised them about camera settings (e.g., sensor triggers, camera arm times, and timelapse settings) we used to successfully capture images of petrels.

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.

We provided coordination, support, and technical assistance for multiple research efforts with federal, state, and non-government organizations. Support and technical assistance included collaboration on and reviews of research proposals, coordinating letters of support to granting agencies, coordinating PTA Command Team approvals and access to PTA, assisting with on-site logistics, and reviewing and providing comments on draft manuscripts. During the reporting period, we provided support for the following external research efforts.

7.6.1 Strategic Environmental Research and Development Program

Title: Using Population and Fire Models to Predict Interacting Responses of Invasive and Threatened and Endangered Plant Responses to Invasive Foundation Species Controls.
Principal Investigator: Dr. Clare Aslan
Abstract: The research team will examine invasive plant control methods and their effects on interacting population trajectories of invasive and T&E plant species at the Department of Defense's

Pōhakuloa Training Area (PTA) on Hawaiʻi Island. Our aims are to identify (a) the impacts via competition and fire regime modification of 2 invasive foundation plant species on population trajectories of 6 T&E plant species, (b) the effect on those impacts of projected climate-change-driven drought, (c) the impact of invasive plant control methods on population demographics of the focal invasive plants, and (d) the impact of invasive plant control methods on focal T&E plant population trajectories. This work builds on our multiple previous years of field research on T&E plants at PTA.

Title: Next Generation Biosecurity Monitoring of Invasive Alien Arthropod Species
Principal Investigator: Mr. George Roderick
Abstract: The major pathways for the spread of invasive alien terrestrial species (IATS) that cause environmental and economic damage are transportation and shipment of goods. These pathways are directly relevant to movement of military vehicles and cargo during deployment and redeployment activities, with implications for readiness, public affairs, environmental health, and financial impact. This project will develop new technology to improve the efficacy of biosecurity efforts to control IATS found on military vehicles and cargo. The objectives are to: (1) use next-generation DNA approaches to identify IATS present in Pacific locations associated with DoD installations and training; (2) develop additional sources of environmental DNA (eDNA) that can be used for detecting IATS; (3) improve specificity and reduce time and costs associated with identification and classification of IATS; and (4) provide real-time information on IATS for managers and decision makers. We propose to develop a next-generation biosecurity monitoring system that uses standardized field monitoring coupled with next-generation DNA sequencing, integrated through a data science framework and associated analyses, to detect, classify, and provide information on IATS in locations associated with DoD activities. We will focus on DoD installations and training locations in the Pacific Islands, where the impact of IATS tends to be particularly acute; we will use locations in Hawaii, Guam, and Okinawa as prototypes. We will develop new sources of eDNA to detect IATS and use new data science tools to improve methods to identify and classify IATS. Finally, we will create user-friendly online materials and conduct workshops to transfer these techniques to managers, in a way that could be scaled to bases around the world.

7.6.2 Environmental Security Technology Certification Program

Title: Remote, Near-Real-Time, Autonomous Acoustic Monitoring of Military Lands for At-Risk Species

Principal Investigator: Mr. Patrick Wolff

Abstract: Endangered Species Act-mandated surveys and monitoring of threatened and endangered species (TES) can be costly and time-intensive, particularly for rare or cryptic species. Passive acoustic monitoring is often used to survey for acoustically active TES such as birds, bats and frogs; however, the data processing effort, technical expertise required, and associated delay in obtaining results are often prohibitive for installation managers and hamper their capacity for timely decision-making. Given limited resources, managers require cost-effective and time-saving solutions to meet the regulatory burden of TES monitoring and avoid training conflicts. The objective of this project is to

demonstrate a dynamic acoustic monitoring system that encompasses real-time and archival data collection, multi-species automated analysis and synthesis, and near-real-time reporting on the presence of federally listed species on military ranges. We will achieve this objective in a case study of bird species occurring at PTA, where conflict between TES and military training poses a threat to military readiness. Our acoustic monitoring system seamlessly records and classifies acoustic data from remote field locations, and then transmits the results to a web-based dashboard interface for near-real-time reporting. The system consists of 3 elements: (1) autonomous recording units; (2) an automated algorithm, BirdNET, for detecting and classifying focal species; and (3) a web-based dashboard for automated, near-real-time reporting and verification of species occurrences. This technology would enable land managers to autonomously monitor multiple areas of interest simultaneously from the convenience and safety of the office, while reducing on-the-ground species monitoring costs. The ability to react to the presence of TES quickly is particularly critical when such species are highly mobile (e.g., birds) and have the potential to conflict with military operations without warning.

7.6.3 Readiness and Environmental Protection Integration Program

<u>**FY 2021 Grant Award**</u>

Title: Increasing Military Installation Resilience and Mitigating Rare Plant Impacts in the Hawaiʻi U.S. Army Garrison
Award Type: REPI Challenge
Partner Agency: Department of Land and Natural Resources, Division of Forestry and Wildlife
Agency Point(s) of Contact: Ms. Emma Yuen and Ms. Edith Adkins
Project Description: This project will reduce fire risk, improve access, and improve endangered species populations that will help relieve anticipated environmental restrictions to live-fire and maneuver training, as well as use of advanced autonomous systems, including Shadow and other UAS units. These key capabilities support the National Defense Strategy at PTA. Management actions proposed include reducing wildfire risk through risk reduction planning and fuels management, as well as management of endangered and species at risk (SAR) plant species in nearby state-managed conservation units outside the installation boundaries. Fire planning and risk reduction implementation will reduce the fire risk to sensitive and important plant habitat within the PTA Action Area that occurs on adjacent state lands in Puʻu Anahulu. Puʻu Anahulu currently harbors 7 endangered plant species whose populations are at risk due to potential wildfire from training activities on PTA lands. In addition, the protection and management of SAR and endangered species on adjacent ecologically similar state land outside the PTA Action Area at Puʻu Waʻawaʻa will help stabilize and increase the statewide population for multiple species, thereby distributing the extinction risk to the species across non-federal managed lands. The project will improve habitat quality within the historical range of the species on state lands that currently occur solely or primarily at PTA. Habitat improvements will allow for establishment of new populations outside PTA in areas that are unaffected by training activities outside of the Action Area. PTA has 20 known endangered

and 28 SAR plant species. Of the endangered and SAR plant species present, 9 endangered and 15 SAR species occur at Puʻu Waʻawaʻa and Puʻu Anahulu (collectively known as Napuʻu). Napuʻu is within the documented range of an additional 11 PTA SAR and contains critical habitat for 2 of the 20 PTA endangered species. Creating new populations is a critical component of the actions identified by the USFWS for species recovery.

FY 2022 Grant Award

Title: Climate Resilience through Wildfire Prevention and Habitat Preservation for Palila and ʻAkēʻakē Protection Near Pōhakuloa Training Area, Hawaiʻi Island
Award Type: REPI Challenge
Partner Agency: Department of Land and Natural Resources, Division of Forestry and Wildlife
Agency Point(s) of Contact: Ms. Lanie Berry
Project Description: This project mitigates increased wildfire risk due to more frequent droughts due to climate change, which is a major and direct threat to the infrastructure of the U.S. Army's Pōhakuloa Training Area (PTA), the road corridors used to access the area, as well as the safety of the military and civilian personnel that serve the area. Additionally, the ignition of wildfires in PTA can lead to increased restrictions to training because of the presence of a listed endangered forest bird, the Palila (*Loxioides bailleui*), as well as the 'Akē'akē or Band-rumped Storm-petrel (*Hydrobates castro*), a seabird also listed as endangered. Palila Critical Habitat comprises ~24,356 ha around Mauna Kea, of which 2,064 ha occurs on PTA land and 22,292 ha on State land. This dry environment is extremely vulnerable to wildfire, which puts the endangered Palila at great risk of extinction if a major wildfire were to spread through the area. Establishment and maintenance of fuel breaks and fire breaks, control of fountain grass, and the repair of a water tank will aid in fire suppression efforts. In future years, the relining of a reservoir will further support fire suppression by providing a large water source. From 17 to 21 July 2021 a major wildland fire originating from Pōhakuloa Training Area burnt approximately 101 ha of Palila Critical Habitat just below the core nesting area. If this fire had not been extinguished, the Palila population would have been severely impacted. Palila currently only occupy the western portion of PCH, which is directly adjacent to PTA. The project is covered under the authority of 16 U.S.C. § 670c-1 and/or 10 U.S.C. § 2679. Building wildfire suppression capacity on adjacent lands will enhance the military mission. Coordination with USFWS is ongoing through consultation regarding ESA Section 7 compliance requirements for these activities.

FY 2023 Grant Awards

Title: Napuʻu Natural Resources Protection: Mitigating Rare Plant Impacts
Award Type: REPI Challenge
Partner Agency: Department of Land and Natural Resources, Division of Forestry and Wildlife
Agency Point(s) of Contact: Ms. Edith Adkins
Project Description: This project will protect and increase endangered species and species at-risk (SAR) plant populations through community outreach and small fence exclosures. Community outreach and education plays a critical role in maintaining the diverse landscapes found at Napuʻu

and volunteers contribute a significant amount of labor to help with management actions. Education leading to public support of conservation of natural resources is needed for long-term sustainability of these watersheds. The 4 proposed fences in this proposal are specifically targeted to protect 4 endangered species that are also found and intensively managed on PTA lands (*Silene lanceolata, Solanum incompletum, Stenogyne angustifolia*, and *Zanthoxylum hawaiiense*). Actions funded through this proposal would not only protect in-situ wild populations at Napuʻu, it would fund restoration efforts in other fenced units within the species' ranges to bolster population numbers.

Title: Napuʻu Wildfire Management
Award Type: Regular REPI
Partner Agency: Department of Land and Natural Resources, Division of Forestry and Wildlife
Agency Point(s) of Contact: Ms. Lanie Berry
Project Description: This project aims to improve public safety and endangered species protection by reducing fire risk and increasing firefighting capabilities through fire management planning and upgrading the existing fuel break network on public lands. These actions will greatly improve our ability to prevent and fight fires effectively and protect human communities and natural and cultural resources in West Hawaiʻi. Moreover, this project addresses endangered species impacts as well as improved installation resilience for reducing wildfire risk. State-managed lands in Napuʻu represent a remarkable diversity of historical, natural, cultural, and recreational resources, including archaeological and cultural sites, rare and uncommon ecosystems that are highly unique in their species composition, and hunting. Fire planning and risk reduction implementation will reduce the fire risk to sensitive and important plant habitat within the PTA Action Area that occurs on adjacent state lands. In addition, the protection of endangered species from fire on adjacent ecologically similar state land outside the PTA Action Area will help stabilize and increase the statewide population for multiple species, thereby distributing the extinction risk to the species across non-federal managed lands.

Title: Napuʻu and Mauna Kea Invasive Species Management
Award Type: Regular REPI
Partner Agency: Department of Land and Natural Resources, Division of Forestry and Wildlife
Agency Point(s) of Contact: Ms. Emma Yuen and Ms. Lanie Berry
Project Description: The project will address invasive species with 3 approaches: (1) planning and compliance for fencing of approximately 405 ha of montane dry forest in the Puʻu Anahulu GMA to exclude ungulates, (2) conducting resistance trials to determine genetic resistance of a native shrub (Naio) to the invasive naio thrips, and (3) planning and construction of a predator-proof fence on Mauna Kea in Palila Critical Habitat (PCH). Napuʻu provides habitat for endangered plants and species at risk that are also known at PTA. Fencing in this area will improve habitat quality within the historical range of the species on state lands that currently occur solely or primarily at PTA. Habitat improvements will allow for establishment of new populations outside PTA in areas that are unaffected by training activities outside of the Action Area. Naio thrips (*Klambothrips myopori*) are an invasive pest species that affect plants in the genus Myoporum, including the endemic naio

(*Myoporum sandwicensis*). Naio thrips causes severe leaf malformation, and high infestations result in dieback of plants. Occasional healthy plants are found on the landscape, but it is unclear whether their condition is due to genetic resistance or environmental conditions. This project will focus on resistance trials to determine if genetic resistance or tolerance to naio thrips can be found. The Palila (*Loxioides bailleui*) is an endangered honeycreeper bird with an estimated population of less than 700 individuals in 2021, its lowest number ever. It is restricted to the dry māmane-dominated forest on the western portion of PCH, directly adjacent to PTA. A predator-proof fence in optimal Palila breeding habitat would help recover the population by significantly increasing breeding success.

Title: Detection and Management of High-Impact Aquatic and Terrestrial Invasive Species in Hawaiʻi
Award Type: REPI Challenge
Partner Agency: Department of Land and Natural Resources, Division of Forestry and Wildlife
Agency Point(s) of Contact: Ms. Chelsea Arnott and Ms. Franny Brewer
Project Description: The U.S. Department of Navy 2015 Pacific Regional Biosecurity Plan for Micronesia and Hawaii states that "invasive species negatively affect most major concerns within the region such as climate change adaptation, human health, green economy development, natural resources conversation, economic stability and growth, and food security." The plan's goal focuses on coordination amongst multiple agencies and jurisdictions to improve biosecurity and manage the threat invasive species pose to the region. This proposal aligns with the Regional Biosecurity Plan's goal through prevention of new pest incursions and management of existing threats in Hawaii with the coordinated efforts of several partner agencies across the State dedicated to the detection and management of priority pests. Outlined in this proposal is a multifaceted approach to addressing invasive species across 26,256 ha of both aquatic and terrestrial ecosystems. This proposal includes projects that (1) increase early detection and rapid response capacity, (2) manage incipient populations of pests in priority watersheds and areas, and (3) implement landscape-level tools to manage widespread weeds. The following projects were selected as the best use of funds to make the biggest impact and aid in climate resiliency while safeguarding military installations and operations. Silk oak (*Grivellea robusta*), tree tobacco (*Nicotiana glauca*), black wattle (*Acacia mearnsii*), gorse (*Ulex europaeus*), and devil weed (*Chromolaena odorata*) are all prolific seeders that resprout rapidly after fire, forming monotypic stands that crowd out native species. Oily allergenic compounds in devil weed and silk oak also increase their fire fuel potential, and wildfire occurrence has increased in the leeward Kona/PTA area over the last decade. Gorse has been identified as one of 2 species that drove the fast spread and difficult control of a July 2021 fire that scorched 1,273 ha in KMA and over 16,997 ha overall—one of Hawaii's largest fires in recorded history.

Title: Palila Critical Habitat Protection on Department of Hawaiian Home Land Lands
Award Type: Regular REPI
Partner Agency: Department of Hawaiian Home Lands
Agency Point(s) of Contact: Mr. Joseph Kualiʻi Camera
Project Description: Project activities will include fence construction and maintenance/repair, feral ungulate control, fuels management, weed removal, and reforestation. Fence construction,

maintenance and repair will be conducted around 971 ha of PCH on DHHL lands (9 km length). Feral ungulate control will be implemented to remove sheep from the fenced area with approved methods, favoring non-lethal relocation of animals through ungulate drives to adjacent gorse-infested areas, where ungulates do not pose as much of a threat to natural resources. Fuels management and access improvements will be done within the on DHHL Aina Mauna lands to reduce the risk of damaging wildfires for DHHL and the adjacent Mauna Kea Forest Reserve and increase access for the project, reducing project costs and improving safety of first responders. Weed removal focused on gorse surveys and control will be conducted within and surrounding the project area. Control of invasive grasses within planned planting areas will be conducted for site preparation for potential outplanting. Common native species may be planted in remnant māmane forest to improve connectivity between remnant native forest patches and increase diversity in plant communities.

Title: Creating the first predator free colony of Band-rumped storm petrels on Lanai
Award Type: REPI Challenge
Partner Agency: National Fish and Wildlife Foundation
Agency Point(s) of Contact: Dr. Lindsay Young
Project Description: U.S. Army Garrison–Hawaiʻi, Pacific Missile Range Facility Barking Sands, and Marine Corps Base Hawaiʻi are working in close collaboration with the National Fish and Wildlife Foundation (NFWF) to protect and enhance native habitats that support conservation and climate resilience. NFWF is an independent 501(c)(3) non-profit that protects and restores imperiled species, promotes healthy oceans and estuaries, improves working landscapes for wildlife, advances sustainable fisheries, and conserves water for wildlife and people. The island of Lānaʻi, located in the Maui Nui complex, is home to numerous threatened, endangered, and at risk species, many of which are similar to those also found on DOD installations on other islands, such as Pōhakuloa Training Area (PTA) and Pacific Missile Range Facility (PMRF). This project will create a predator protected nesting area for endangered band-rumped storm petrels, restore rare native dry-forest habitat, establish a protected, artificial habitat for reintroducing endangered orange black Hawaiian damselflies, and preserve and restore native forest habitat critical for recharging the island's freshwater aquifer. This ground-breaking project will build the first landscape-scale fenced management area on Lana'i to cultivate at-risk native landscapes and species in a compatible environment free of non-native, damaging animals like feral pigs and deer. The shared benefit to all partners is large-scale habitat improvement on Lānaʻi, ultimately increasing numbers of at-risk species found primarily within critical DOD training areas, away from military operations.

7.6.4 Office of Local Defense Community Cooperation, Defense Community Infrastructure Pilot (DCIP) Program

FY 2022 Grant Award

Title: DOFAW West Warehouse to Support Firefighting and Conservation
Partner Agency: Department of Land and Natural Resources
Point of Contact: Ms. Emma Yuen
Project Description: This project will address one of PTA's largest threats, wildfire, by improving the incident command center at the Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife (DOFAW) West Hawaiʻi base yard. This facility, located in the nearest town of Waimea, is the main hub for multiple agencies treating wildfires across west Hawaiʻi. This project will help to prevent loss of property, threats to public safety, and loss of natural resources. The DLNR-DOFAW West Hawaiʻi base yard serves as the incident command center during wildfire emergencies. During these emergencies, dozens of fire personnel from multiple agencies are housed at this site. However, the base yard lacks both adequate storage capacity and sufficient covered spaces. As such, large quantities of materials cannot be stored or sheltered and are therefore exposed to the elements where they are also vulnerable to theft. A warehouse will enhance incident response by providing housing and meeting areas for incident command staff, allowing faster repair of firefighting vehicles, and protecting materials. This request seeks funding for the foundation, structural support, utilities, perimeter fence, and paving for a 60'x150' steel warehouse, as well as other base yard upgrades that increase response and storage capacity. Overall, this project will help provide a safer and more effective wildfire response. It will enhance military value at Pōhakuloa Training Area, installation resilience, and military family quality of life by mitigating fire risk and protecting watershed resources, thus protecting livelihoods and minimizing disruption to military training. This project improves the availability and condition of land and facilities by reducing damage from wildfire, which is a key threat to PTA.

FY 2023 Grant Award

Title: Waimea Nui Emergency Operations building
Grant Recipient: Department of Hawaiian Home Lands
Grant Award Year(s): FY 2023
Point of Contact: Ms. Lilliane Makaila
Project Description: This project is to construct a customized distributed Emergency Operations Center (EOC) and facility to house emergency firefighting equipment in Waimea. This project supports the Army's life-saving mission and readiness training by providing the infrastructure necessary to increase the capacity for Army personnel, first responders, and community members to maximize resources and coordination when responding to emergency situations, including wildfires, earthquakes, hurricanes, and volcanic eruptions. These real-life situations are important training opportunities, providing valuable experience and lessons learned that can be applied when responding to contingency situations around the globe. The development and design of a distributed

EOC that uses an operationally ready technology to provide an otherwise-nonexistent Common Operating Picture (COP) over 450 square miles of rugged, isolated terrain has a direct impact on joint warfighting, training, and readiness. The distributed EOC will enable a COP for first responders to effectively coordinate and use Army heavy equipment, vehicles, and aviation assets in and around PTA on Hawaiʻi Island and increase capacity to respond to life-threatening situations, including vehicle accidents, hunting accidents, altitude sickness, wildfires, hurricanes, lava flows, tsunamis, and earthquakes. The Army's ability to coordinate with civilian emergency response vehicles, equipment, and personnel utilizing a common operating picture with real-time data has the potential to diminish costs to the military by increasing the capabilities of civilian first responders and community members. This facility and the related capacities also provide the necessary tools to ensure the condition of the lands and training area facilities are better protected from natural hazards. Additionally, it improves installation resilience by better equipping PTA to manage wildfires and hurricanes, which have intensified due to climate change. This project prepares PTA and the neighboring community to minimize adverse impacts of extreme weather, geologic events, and other natural disasters on the installation and the critical infrastructure serving it and the surrounding area.

7.6.5 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 have 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.

7.6.6 University of Hawaiʻi at Mānoa

Title: Genetic Diversity among Populations of Endemic *Portulaca sclerocarpa* and *Portulaca villosa* (Portulacaceae) assessed using SRAP makers

Principle Investigator: Clifford C. Morden

Abstract: The native and introduced *Portulaca* species known in Hawaiian as ʻihi are prostrate perennial or annual herbs with succulent stems and leaves (Wagner et al. 1999). Wagner et al (1999) noted *P. sclerocarpa* is closely related to *P. villosa* and differs only in the capsules, which have thick walls (0.18–0.5 mm thick vs. 0.05 mm in *P. villosa*) and are indehiscent (does not split open) or tardily dehiscent (vs. circumscissile near the base in *P. villosa*). *P. sclerocarpa* is also geographically distinct, occurring at higher elevations (1,030–1,630 m) on Hawaiʻi Island (a single report from an islet of Lanaʻi) where *P. villosa* is widespread, being reported from Nihoa and all the main islands except Kauaʻi and Niʻihau at lower elevations (sea level to 490 m). It is uncertain that the morphological character of the capsule features actually define a natural presentation of the populations or species. Because of their similarities, Geesink (1969) reduced *P. sclerocarpa* to a synonym of *P. villosa*. Wagner et al. (1990) questioned their distinction but maintained them as separate species until further evidence was available. To clarify taxonomic uncertainty between *P. sclerocarpa* and *P. villosa*, natural populations were investigated using Sequence Related Amplified Polymorphism (SRAP) analysis to detect a species boundary and genetic diversity among populations. Plants were collected from natural populations or from RPPF nursery material representing natural populations.

Title: Ungulate Distribution Models for Wildlife Conservation and Recreational Hunting: Hawaiʻi.
Principal Investigator: Melissa Price
Abstract: This study will produce models detailing the abundance, distribution, and impact of ungulates across Hawaiʻi Island using data acquired through field surveys. Abundance information allows areas to be prioritized in relative impact per islands and per ungulate game species. Approximately 50 survey sites were randomly selected across Hawaiʻi and were stratified by altitudinal bands. Cameras were deployed to sites for 2 weeks and surveyors searched the immediate area around each camera during deployment and noted ungulate disturbance sign. The average number of camera detections per site and ungulate sign data will be the primary model inputs. In addition, the following covariates known to correlate with ungulate abundance will be evaluated with the models: vegetation density, vegetation height, mean annual rainfall, elevation, native vegetative cover, distance to ungulate exclusion fences, distance to hiking trails, and distance to forests. The models for Hawaiʻi Island will be completed around March 2024.

7.6.7 USDA Agricultural Research Services

Title: Olive fly
Principal Investigator: Dr. Nickolas Manouki
Abstract: The latest of 5 tephritid species of economic importance established in Hawai'i, the olive fruit fly *Bactrocera oleae* (Diptera: Tephritidae) was detected on Maui and Hawai'i Islands in 2019, affecting yields and quality of the state's emerging olive oil industry. Given previous parasitoid releases to control other invasive frugivorous tephritids in Hawai'i, we were interested in determining whether (1) these parasitoids were found targeting olive flies in field, (2) whether cultivar differences affected parasitization, and (3) whether a seasonal pattern of parasitization exists that could inform future management decisions. To address these questions, we collected data from 2 olive growing

sites on the big island of Hawai'i as well as 2 sites on Maui during 2021. During 2022, we added an additional site on Hawai'i Island where we discovered *B. oleae* infested feral olives. During the fruiting season we collected monthly samples and reared out *B. oleae* in the lab. We detected 2 previously introduced braconid wasps: first *Diachasmimorpha tryoni* during 2021 and 2022 and later *Fopius arisanus* during the 2022 collection. Cultivar effects were limited to a single site in our study, where more *D. tryoni* were reared from 'Arbequina' olives. Seasonality of olive fruit fly and parasitoid activity was earlier in lower elevation sites, as expected based on tree phenology and temperature-dependent insect development. This represents the first report of *D. tryoni* parasitism activity against *B. oleae* and may reflect elevational effects combined with the ecological complexity in interactions between multiple invasive arthropod pests, their invasive and cultivated plant hosts, and introduced braconid parasitoids.

7.6.8 Acadia University

Title: The divergence of olfactory systems of moths of the tribe Heliothinae.
Principal Investigator: Dr. Kirk Hillier
Abstract: To use comparative studies of olfaction between insect species of economic importance to examine the divergence of olfactory systems, with a particular emphasis on moths of the tribe Heliothinae. One goal is to examine how pheromone blends shift during speciation events and in the context of allopatric and sympatric species ranges across continents. The Heliothinae fauna of the Hawaiian Islands is comparatively large for the genera *Heliothis* and *Helicoverpa* (Hardwick, 1965). This includes several endemic species such as *Helicoverpa hawaiiensis* (aka Hawaiian bud moth). The Hawaiian bud moth population at PTA has existed in relative isolation from all other species that have had their pheromone communication documented. This provides a great model for 'competitive release' in which this species may have had significantly less pressure in place to maintain species isolation, and will contribute significant information to include with other species being investigated from other regions. By combining this unique allopatric species data with that of others which are sympatric (overlapping) we will test the broad hypotheses: (1) speciation and reinforcement of prezygotic species isolation are hypothesized to be accompanied by diversification of sex pheromones, and (2) species of Heliothinae not subject to sympatric closely related species will experience a competitive release and a narrowing of blend complexity. Results of combined physiological and genetic study of *Helicoverpa hawaiiensis* will provide valuable information on speciation in this unique archipelago and evaluate if there has been cross-breeding between endemic species and closely related invasive species. Furthermore, by extracting brains, DNA, and male and female pheromones, the physiological, neuroanatomical and genetic data provided by this visit will provide a bank of information to be incorporated with global comparative studies on the Heliothinae for years to come. In addition, this research will contribute to the development of pesticide-free pheromone-based monitoring and disruption technologies for several agricultural moth pests that cause billions of dollars in crop damage per year. Furthermore, by understanding the presence and functional activity associated with pheromone receptors, current pheromone-monitoring technologies may be improved.

7.6.9 Lancaster University

Title: Hawaiian *Euphorbia* photosynthetic pathway

Principal Investigator: Sophie Young, PhD candidate

Abstract: The Hawaiian *Euphorbia* are exceptional with respect to their photosynthetic pathway: this group of plants contains the only known true C4 trees. C4 photosynthesis is a complex trait that has evolved from a series of modifications to the ancestral C3 type of photosynthesis, and is found in some of our most productive crop species such as maize and sugarcane. C_4 photosynthesis increases plant productivity in hot and dry conditions, and has evolved more than 60 times independently across the plant kingdom, but only one of these C_4 lineages includes trees. Despite periodic interest from scientists in the Hawaiian *Euphorbia*, the reason why C_4 trees are so rare—a longstanding question in ecology and evolution—has never been definitively established. During my PhD program, I have developed a new hypothesis as to why C_4 trees are so rare, which focuses on the interaction between the sugar and water transport systems of the plant with the photosynthetic system. To validate this hypothesis, I require data from living specimens of the Hawaiian *Euphorbia*. These data will allow me to address the 4 key objectives of this project: (1) characterize, in more detail, the photosynthetic diversity of the Hawaiian *Euphorbia* and their close relatives, (2) record data about the local habitat and ecology of the Hawaiian *Euphorbia*, (3) establish the sugar and water transport strategies of the Hawaiian *Euphorbia* compared to related non-C_4 species, and (4) apply these data to better understand why, in this rare case, C_4 photosynthesis has evolved in trees. The data collected in this study will highlight the uniqueness of the Hawaiian *Euphorbia* as the only known trees to use the C4 photosynthetic pathway, which is an area of great interest to plant scientists from a perspective of crop security and biodiversity conservation under climate change, as well as advancing our understanding of complex evolutionary processes. Demonstrating the importance of the Hawaiian *Euphorbia* to science will add to the existing reasons for, and promote, their conservation. Insights into the ecology and physiology of these unique species will also facilitate decision making regarding their conservation by revealing the environmental conditions that they are best suited to.

7.7 SPECIALIZED SERVICES

7.7.1 Oʻahu Army Natural Resources Program Seed Lab Support

The ONARP Rare Plant Program provided specialized services and technical assistance to the Pohakuloa NRP for managing, processing, storing, and germinating propagules of the TES plants found at PTA. Staff from the Universtiy of Hawaii, Office of the Vice President for Reseach and Innnovation work under cooperative agreement with USAG-HI in the OANRP to administer the rare plan program on Oʻahu, which includes the collection of rare plant propagules, managing and maintaining a seed bank, and implementing propagation and planting techniques to reintroduce these plants back to their former range. OANRP staff have provided support to the PTA NRP staff in the following areas: (1) training, (2) developing experimental germination techniques, (3) germination trials, and (4) long-term propagule storage in deep freeze. The OANRP seed bank will also serve as a secondary, backup collection of TES seeds for plants at PTA.

7.7.2 Aviation Support

To access some remote worksites, we retained aviation services and maintained an aviation safety and training program. Staff were required to obtain basic aviation safety certification via the Department of Interior's Office of Aviation Safety. Over the report period, we retained helicopter services, approximately quarterly, directly with a vendor familiar with resources and work locations at PTA.

7.7.3 Technical Support for Audio Recording Equipment and Audio Data Interpretation

We retained the services of Conservation Metrics, a company specializing in Hawaiian seabird acoustic data analysis. Conservation Metrics developed software to identify segments of audio recordings with Band-rumped Storm Petrel calls to aid in data analysis and population monitoring/modeling. See Section 4.2.5 project and data analysis details.

We worked with experts at Titley Scientific and EME Systems to diagnosis problems with audio recorders and associated weather monitoring systems used to monitor the Hawaiian hoary bat. When equipment malfunctioned, these experts assisted us with isolating and fixing the problems.

7.7.4 Wildland Fire Technical Assistance

In October 2021, we coordinated with the CEMML Wildfire Program Manager to participate in a 5-day, on-site wildland fire workshop at PTA. We provided technical and administrative assistance to organize and facilitate the workshop. During the week-long event, the CEMML Wildfire Program Manager met with the Army Biologists and PTA Fire and Range Control staff to discuss fires that occurred in summer 2021. Key messages and desired outcomes of the workshop included: (1) increase understanding of roles and responsibilities in the Integrated Wildland Fire Management Plan (IWFMP), (2) fire prevention is critical to protect resources in Western PTA and KMA, (3) improve efficient IWFMP implementation to include communicating the locations of protected natural and culture resources and firefighting assets (e.g., dip ponds), and to identify a pathway to completing the draft IWFMP for signature. The IWFMP was signed by PTA Commander Cronin in January 2022, but the plan was suspended in 2023 due to unresolved conflicts with wildland fire training requirements and issues with training. We met with PTA Fire personnel to review the draft IWFMP and reviewed the underpinning of the fire danger rating system and provided training to Range Control and Fire Department personnel.

In addition, the Wildland Fire Program Manager provided technical assistance for reviewing and updating a wildland fire risk assessment for the PBA following the July 2022 fire. Together, we and the Wildland Program Manager attended several PBA working group meetings to discuss ways to address fire suppression and measures to mitigate fire risk and to avoid/minimize ignitions. We provided recommendations for compiling weather forecasts and identifying and communicating periods elevated fire risk and recommended potential responses to reduce the risk of ignition.

7.7.5 Technical Support for Humane Treatment of Nuisance Animals

Staff who handle animals must complete Colorado State University training requirements under the Institutional Animal Care and Use Committee program. We implemented program guidelines to trap, transport, handle, or euthanize animals to ensure humane treatment. In addition, we contracted professional animal control services to humanely remove ungulates (sheep, goats, and pigs) with lethal force from conservation areas.

7.7.6 Training for Use and Maintenance of Specialized Equipment

Staff completed training in the safe use and maintenance of several power tools needed for management operations. During the reporting period, we coordinated training/certification for the safe operation of all-terrain vehicles for 3 staff members. Seven staff attended helicopter sling load operation training. Six staff who use chainsaws were trained/certified on safe use of the tool as well as safe felling operations. Two staff attended training for a new style of pig trap, Pig Brig.

7.8 Army Biologist and PTA Command

7.8.1 Installation Management Command Environmental Reporting System Data Support

During the reporting period, we assisted the PTA Army Biologists by gathering and summarizing information regarding natural resources at PTA as well as projects and accomplishments towards INRMP objectives to support written summaries of actions for upload to the national database by the Army Biologist.

7.8.2 Change of Command

We supported Change of Command ceremonies for the Command Sergent Major in November 2022 and the PTA Commander in June 2023. For each event reception, we displayed program information and live threatened and endangered plants and engaged event attendees regarding natural resources protection at PTA.

7.8.3 Tours for VIP Groups

Throughout the reporting period, we supported numerous Army Command and VIP Tours at PTA. We led groups to remote field locations and through the RPPF 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.

Field Tours Provided for

- 20 US Fish and Wildlife Service project leaders and field supervisors from the Region 1 field offices, including the Regional Director, Assistant Director of Ecological Services (Headquarters), and Department of Interior Office of Native Hawaiian Relations staff (20 January 2023)

- USAG-HI Program Manager and USAG-HI Army Biologist to visit the area burned by the 22 July fire (25 January 2023)
- 13 federal and state REPI partners including REPI leadership, Kristen Thomasgard, Rob Rule, Kaley Vatalaro, and Sentinel Landscapes representatives Carlos Castillo and Mark Fox (4 April 2023)
- 5 members of Aslan SERDP team (17 April 2023)
- 8 descendants of Edward Hosaka, the scientist that discovered the endangered plant *Isodendrion hosakae* (24 July 2023)
- Jenny Lechuga of the US Army Environmental Command (20 July 2023)
- ~30 Dryland Forest Hui members (13 September 2023)

Rare Plant Propagation Facility Tours for

- Congressional Representative Kai Kahele and entourage (19 April 2022)
- 15 Kohala Chamber of Commerce members (17 May 2022)
- The Secretary of the Army, Christine Wormuth; US Congressman, Ed Case; US Army Pacific Commander General Flynn; US 25th Infantry Division Commander, General Ryan; USAG-HI Commander, Colonel McGunegle; and associated entourages. We provided an overview of endangered species and plants found at PTA and spoke with the Secretary for about 15 minutes (23 January 2023)
- 10 Hawaiʻi National Guard Youth Challenge Academy cadets. We provided assistance and expertise to plant ʻōhiʻa trees on the PTA cantonment. The tree-planting event supported the responsible citizenship component of the cadet's education (23 February 2023)
- ~30 foreign Army military attaches from more than 12 countries. The visit was to provide a firsthand perspective of the US Army Pacific area of operations and some of the challenges (9 March 2023)
- Master Gardeners (14 April 2023)
- Hawaiʻi Island Chamber of Commerce members (30 May 2023)
- Staff Delegation for State Representative Jill Tokuda (29 June 2023)
- Assistant Secretary Defense (Energy, Installations, & Environment) (ASD EI&E) Honorable Brendan Owens along with Deputy Assistant Secretary Defense (Real Property) Mr. Ronald Tickle (2 August 2023)
- Congressional staff from the Military Construction Sub-committee (10 August 2023)
- Department of Land and Natural Resources staff in support of the ATLR EIS (23 August 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). To support these outreach and education efforts and to meet SOO tasks 3.2.9.7 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 Experience PTA Day

In April 2022 and 2023, 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.

Additionally, the Cultural Resources team demonstrated how it manages and preserves cultural resources. Visitors were able to participate in a hands-on petroglyph activity and learn about projects to preserve the cultural resources at PTA. 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 of recycling and upcycling.

7.9.2 Run for the Dryland Forest

In October 2022 and 2023, we participated in the annual Run for the Dryland Forest at the Puʻu Waʻawaʻa Forest Reserve. The event is hosted in partnership by the Akaka Foundation for Tropical Forests, US Forest Service, Institute for Pacific Islands Forestry, Hawaiʻi Experimental Tropical Forest, Hawaiʻi Wildlife Fund, and the Division of Forestry and Wildlife. Event coordinators invited land management agencies and other conservation organizations to display public education and outreach materials. About 400 to 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 26 TES, several live endangered plants, and brochures.

7.9.3 Waimea Fall Festival

On 14 October 2023, we participated in Waimea Fall Festival at the Waimea District Park Complex. 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.

PTA coordinated an aircraft display including a Blackhawk helicopter and an Osprey MV-22 tiltrotor aircraft. USAG-PTA 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 26 TES. We showcased our management of

TES and natural resources at PTA through educational displays, interactive games/activities, and live demonstrations. The annual festival attracts more than 5,000 people.

7.9.4 Waimea Library Display

In May 2023, we set up a display at the Waimea Public Library. The purpose of the display is 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 include photographs of TES, rare and native plants, staff conducting field work, the cantonment area, and PTA landscapes. We also display a TES fact sheet and a map of the installation. Full-size posters include:

- How the Army Combats Rapid ʻŌhiʻa Death, by CEMML staff
- PTA Natural Resources Office Overview
- Natural Resources Infrastructure at PTA (map)

The display was up for 1 month and received positive feedback from library staff and members of the public.

7.10 Meetings, Publications, and Presentations

7.10.1 ESRI User Conference

We attended the annual ESRI User Conference virtually in 2022. The conference provided a venue for training, support, and information that cannot be obtained elsewhere, especially given our remote location. Attending the ESRI User Conference provided our staff the opportunity to learn how to manage our resources most effectively and disseminate data most efficiently to our subject matter experts.

7.10.2 Journal Publications

<u>Wildlife Society Bulletin</u>

Title: Evaluating unmarked abundance estimators using remote camera and aerial surveys
Date: 21 November 2021
Authors: Brian T. Leo
Abstract: Reliable population abundance estimates are invaluable to wildlife management programs. Mark-recapture techniques are regarded as the gold standard for estimating abundance but can be financially or logistically prohibitive. Recent developments in remote camera analytical approaches have provided alternative methods to estimate unmarked populations efficiently but have undergone limited field testing. In September and October 2020, I assessed 2 camera methods that use the same set of time-lapse photographs; a space to event (STE) model and instantaneous sampling (IS), applied to a case study of feral sheep (*Ovis aries*) at the US Army's Pōhakuloa Training Area (PTA) on Hawai`i Island. Results of the camera methods were compared to an abundance estimate calculated from an

aerial distance sampling survey completed concurrently with camera sampling. A comparison of confidence intervals indicated no statistical difference between estimates, but the relative imprecision of IS suggested the STE model to be a more reliable estimator. The cost of camera sampling was approximately 3 times that of the aerial survey, but camera sampling became more economical if the area was resurveyed 3 or more times. My study showed the STE model to be a cost effective, practical abundance estimator of feral sheep when compared to well-established aerial distance sampling techniques, and therefore should offer considerable potential for the conservation and management of other easily identifiable species.

Systematic Botany

Title: *Tetramolopium stemmermanniae* (Asteraceae), a New Species from Pōhakuloa Training Area, Hawaiʻi Island
Date: 23 October 2023
Type: Article
Publication: Systematic Botany
Authors: Steve Evans, Nancy Hastings, Mitsuko Yorkston, Clifford Morden, and Luke Tembrock
Abstract: A new species endemic to Hawaiʻi Island, *Tetramolopium stemmermanniae*, is described and illustrated. Molecular and morphological evidence support *T. stemmermanniae* as being distinct from *T. arenarium* var. *arenarium*, *T. consanguineum* ssp. *leptophyllum*, and *T. humile* ssp. *humile*, which occur at Pōhakuloa Training Area, Hawaiʻi Island. Tetramolopium stemmermanniae shares an upright and multibranched habit with *T. arenarium* var. *arenarium* and *T. consanguineum* ssp. *leptophyllum* but differs in the number and color of ray and disc flowers, and in having an open, paniculate inflorescence. We provide a description of the new taxon, include a key to the *Tetramolopium* species of Hawaiʻi, and a brief description of the habitat where the newly described species occurs.

Although this article was published in FY 2024, we use the new name throughout this report. We decided to include the article to provide context.

7.10.3 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 New Species of Pamakani to Receive Scientific Recognition
Date:2022–2023 Issue
Type: Article
Publication: EMP Bulletin, US Army Garrison-Hawaiʻi
Author(s): Lena Schnell

Summary: Three decades after discovery at Pōhakuloa Training Area (PTA), an undescribed species of pamakani, a daisy-like plant in the genus *Tetramolopium*, is on the verge of receiving scientific recognition and a new name. The discovery of a species new to science and the journey to describe and name this new *Tetramolopium* species, referred to as *T*. species 1, intertwine with the taxonomic complexities of the genus and the discovery of the rich botanical resources found at PTA. To receive scientific recognition, a description of the new species must be published in a peer-reviewed, reputable scientific journal. A manuscript describing *T*. species 1 was submitted to the journal of Systematic Botany and pending revisions, is expected to be published in 2023 when the new, official name of the species can be revealed. Recognizing and naming this new species will help the U.S. Army Garrison-PTA Natural Resources staff to track and conserve this critically rare species.

7.10.4 Media Interviews/Publications

Title: The Army is managing species at risk on the Big Island, Hawaii[26]
Date: November 2020
Author(s): Dave Jones and Lena Schnell
Publication: Department of Defense Natural Resources Program Newsletter
Summary: This newsletter article describes the method used to assess the number of native species that fit the criteria established by the DoD to identify species at risk. Results were 26 plant and 24 animal SAR on PTA. Information will be used to guide management and support Recovery and Sustainment Partnership Initiative efforts between the USFWS and DoD.

Title: Saving Hawaiʻi's Endemic Plants, One Seed at a Time
Author: Cynthia Wessendore
Media Release: Defense Virtual Information Distribution Service, 1 February 2022
Publication(s): Hawaii Business News, 13 October 2021
Summary: Many endemic Hawaiian plant species are at risk of extinction. The Army maintains programs to safeguard the genetics of rare Hawaiian plants federally listed as endangered or threatened. Staff collect seed from wild plant populations on Oʻahu and Hawaiʻi Islands and store them at a seed storage facility and laboratory on Oʻahu. Seeds are also germinated at the lab and grown for reintroduction to suitable environments.

Title: Army stays vigilant for rapid ʻōhiʻa death at Pōhakuloa Training Area
Author: Pamela Sullivan
Media Release: Defense Virtual Information Distribution Service, 1 February 2022
Publication(s): Honolulu Star Advertiser, 2022 Military Appreciation, online edition[27]
Summary: The PTA Natural Resources Program continues to partner with State Department of Forestry and Wildlife staff to monitor the forests at PTA for trees exhibiting symptoms of Rapid ʻŌhiʻa

[26] Because this publication was not reported in the *Army Natural Resources Program at Pōhakuloa Training Area Biennial Report 01 October 2019 to 30 September 2021* (2022), we include it here.
[27]https://hawaii-newspaper.com/special_sections/2022_military_appreciation/index-h5.html?page=1&fbclid=IwAR1SEdT9Ae5uKa4KOQ_OTvTMRjDZQYNnpJZ677jiAoRa3_KtKj41ckUNluM#page=1

Death (ROD). To date, ROD has not been detected in any trees sampled and the ʻōhiʻa forests at PTA look healthy. PTA has several characteristics that may help prevent or slow the establishment of ROD including large ungulate-free fenced areas and an environment that is high, dry and cool.

Title: Nēnē population increases in Saddle Region under Army Program
Author(s): U.S. Army Garrison Pōhakuloa Training Area
Media Release: Defense Virtual Information Distribution Service, 1 July 2022
Publication(s): Big Island Now, 25 June 2022, *Army Teaming up to Help Nēnē Take Flight*
Hawaiian Tribune Herald and West Hawaii Today 27 June 2022, *Nurturing nēnē: Army program sees increase in Hawaiian goose population in the Saddle region.* Local Radio news (KBig FM).
Summary: The PTA Natural Resources Program is working in partnership with the USFWS to manage Hawaiian Geese (Nēnē) at HFNWR. The Army's efforts during the 2021-2022 breeding season assisted 8 goslings to fledge. The Army controls predators, manages foraging areas, and assists with monitoring and banding geese. The Army's efforts to support the island-wide goose population significantly contributes to the conservation efforts of this iconic Hawaiian bird.

Title: A new active Band-rumped Storm Petrel burrow discovered by conservation detector dog at Pōhakuloa Training Area
Author(s): Amy Phillps (Rogelio Doratt)
Media Release: Defense Virtual Information Distribution Service, 9 September 2022
Publication(s): Big Island Now, 9 September 2022, *Detector Dog Discovers Burrow of Endangered Hawaiian Sea Bird at Pōhakuloa Training Area*
Summary: Conservation detector dog, Slater, discovered the Band-rumped Storm Petrel, or ʻakeʻake, at U.S. Army Garrison Pōhakuloa Training Area, PTA, alongside natural resources staff. This is the sixth active burrow found since the ʻakeʻake breeding colony was first discovered at PTA in 2015.

Title: Training Lands and Infrastructure top Sectary of the Army's visit to Pōhakuloa: State officials and Hawaiian activists are increasingly voicing concern over the Big Island training site
Author: Amy Phillips
Media Release: Defense Virtual Information Distribution Service, 24 January 2023
Publication: *Hawaii Tribune Herald,* 22 February 2023
Summary: The Sectary of the Army, the honorable Christine E. Wormuth, visited PTA to see first-hand the training area and what it means to training and readiness in the Pacific. She learned about land lease and infrastructure requirements, natural and cultural resource programs and challenges, and community mutual aid agreements.

Title: The Fight for Pōhakuloa
Author: Kevin Kendall
Publication: *Honolulu Star Advertiser*, 13 November 2022
Summary: The Army wants to retain lands leased from the State of Hawaii when the current lease expires in 2029. The story summarized the importance of the lands to the Army's training mission, but highlights concern from State officials and Hawaiian activities over the condition of the leased lands,

pollution, impacts from live-fire training, etc. The article summarizes the Army's efforts to manage natural resources and features a front-page picture of CEMML staff in the RPPF.

Title: Pōhakuloa Training Area Receives Department of Defense 2023 REPI Challenge Funding
Author(s): U.S. Army Garrison Pōhakuloa Training Area
Media Release: Defense Virtual Information Distribution Service, 31 January 2023
Summary: The DoD's Readiness and Environmental Integration Program (REPI) awarded $2.6 M to the State DOFAW for conservation work at Napuʻu. The project will improve habitat for federally listed threatened and endangered species on State lands in Puʻu Anahulu and Puʻu Waʻawaʻa.

Title: Pilot Acoustic Monitoring System Fielded at Pōhakuloa Training Area
Author(s): U.S. Army Garrison Pōhakuloa Training Area
Media Release: Defense Virtual Information Distribution Service, 3 February 2023
Summary: As part of a pilot acoustic monitoring project, conservation partners with the US Army Engineer Research and Development Center (ERDC) University of Illinois and Cornell University installed 3 autonomous recording units (ARU) at PTA. These monitoring units will help detect and report at-risk species in near real-time to help reduce conflicts with humans and wildlife. The project was funded by a grant from the DoD's Environmental Security Technologies Certification Program to test the feasibility of this technology to effectively detect the target species.

Title: Experience PTA Day Returns to Showcase Cultural, Environmental Efforts at Facility
Author(s): Grant Philips
Publication: *Hawaii Tribune Herald,* 13 May 2023
Summary: After a 3-year hiatus, PTA hosted Experience PTA Day to highlight community partnerships and efforts to conserve and protect cultural and natural resources.

7.10.5 Social Media and Good News Stories

Over the past 2 years, social media has played an increasingly large role in public outreach. The PTA Facebook page is maintained by the Army's Public Affairs Officer (PAO). We wrote short information papers and participated in interviews to help the PAO develop many posts. In addition, the PAO accompanied important visitors to PTA and often wrote about environmental stewardship and posted pictures of visitors in the PTA RPPF with Army Biologists and CEMML staff. We also provided *Good News Stories* about natural resources to the PAO and PTA Command Team.

- 09 September 2021, Pōhakuloa Training Area Facebook. Post featured the NRP display installed at the Waimea public library.
- 15 September 2021, Pōhakuloa Training Area Facebook. Post featured the conservation fencing program.
- 27 September 2021, Pōhakuloa Training Area Facebook. Post featured the recreational hunting program.

- 14 October 2021, Pōhakuloa Training Area Facebook. Post featured the rare plant propagation and seed storage/collection at PTA with links to an article published by the *Hawaiʻi Business News* (see publications in Section 7.10.4).
- 13 November 2021, Pōhakuloa Training Area Facebook. Post featuring the recreational hunting program.
- 06 January 2022, Pōhakuloa Training Area Facebook. Post featured work conducted at the Oʻahu Army Natural Resources Program Seed Lab which included cooperation with the PTA NRP with links to an article published previously by the *Hawaiʻi Business News* (see publications in Section 7.10.4).
- 05 February 2022, Pōhakuloa Training Area Facebook. Post featured ʻōhiʻa forests at PTA and the NRP partnership with the State DOFAW to monitor for Rapid ʻŌhiʻa death at the installation with a link to the press release on the Defense Virtual Information Distribution Service (DIVIDS) website.
- 21 April 2022, Pōhakuloa Training Area Facebook. Post featured the visit of Congressman Kai Kahele to PTA. The NRP hosted the congressman for a tour of the RPPF and to discuss ongoing environmental stewardship actions by the Army at PTA. The post included pictures of the Congressman and his staff in the RPPF with the Army Biologists and CEMML staff.
- 08 May 2022, Pōhakuloa Training Area Facebook. Post featured ʻōhiʻa forests at PTA and the NRP partnership with the State DOFAW to monitor for Rapid ʻŌhiʻa death at the installation with a link to a story published by the *Honolulu Star-Advertiser, Military Appreciation* edition (see publications in Section 7.10.4).
- 18 May 2022. Pōhakuloa Training Area Facebook. Post featured the visit of the Kona-Kohala Chamber of Commerce members to PTA. The NRP hosted the chamber members for a tour of the RPPF. The post included pictures of the Chamber members in the RPPF with the Army Biologists and CEMML staff.
- 18 May 2022, Pōhakuloa Training Area Facebook. Post featured Experience PTA Day 2022, an event open to the public to highlight PTA and work done at the installation. The post included several pictures of Army Biologists and CEMML staff engaging with the public through interactive activities and dialogue.
- 09 June 2022, Pōhakuloa Training Area Facebook. Post featured the visit of the State of Hawaiʻi Senators Donna Mercado Kim, Laura Acasio, Kurt Fevella, and Gill Riviere. The NRP hosted the Senators for a tour of the RPPF and to discuss ongoing environmental stewardship actions by the Army at PTA. The post included pictures of the Senators in the RPPF with the Army Biologists and CEMML staff.
- 01 July 2021, Pōhakuloa Training Area Facebook. Post featured the Army's work in partnership with the USFWS, Refuges to manage Hawaiian Geese at HFNWR. The post focused on the

successful 2021-2022 breeding season with a link to the press release on the Defense Virtual Information Distribution Service (DIVIDS) website. Links to stories published by *Big Island News Now, Hawaii Tribune Herald,* and *West Hawaii Today* were provided (see publications in Section 7.10.4).

- 26 September 2022, Pōhakuloa Training Area Facebook. Post featured the visit of Mr. Ivan Bolden, Chief of the Army, Partnership Programs. The NRP hosted Mr. Bolden for a tour of the RPPF and to discuss ongoing environmental stewardship actions by the Army at PTA. The post included pictures of Mr. Bolden with the Army Biologists and CEMML staff.
- 27 September 2022, Pōhakuloa Training Area Facebook. Post featured the Hawaiian ʻakoko tree and NRP's role in hosting scientific research at PTA with a link to the press release on the Defense Virtual Information Distribution Service (DIVIDS) website. A link to the story published by the *Hawaii Tribune Herald* was provided (see publications in Section 7.10.4).
- 17 October 2022, Pōhakuloa Training Area Facebook. Post featured a visit by scientists from the National Resource Council Service. The scientists visited KMA to review grazing implementation and soil conditions. The post included pictures of the Army Biologists with the scientists in KMA
- 20 October 2022, Pōhakuloa Training Area Facebook. Post featured the visit of the PTA Advisory Council and the Hawaiʻi Civilian Aid to the Sectary of the Army, D. Noelani Kalipi to PTA. The NRP hosted the visitors for a tour of the RPPF and to discuss ongoing environmental stewardship actions by the Army at PTA. The post included pictures of the visitors in the RPPF with the Army Biologists and CEMML staff.
- 19 January 2023, Pōhakuloa Training Area Facebook. Post featured the ongoing partnership between the Army and DOFAW. The meeting explored several topics such as support for recreational hunting at PTA and access/boundary issues. staff
- 24 January 2023, Pōhakuloa Training Area Facebook. Post featured the visit of the Sectary of the Army, Christine E. Wormuth, Congressman, Ed Case, Commander of the US Army Pacific, General Flynn, Commander of the 25th Infantry Division, General Ryan, USAG-HI Commander, Colonel McGunegle and staff to PTA. The NRP hosted the Sectary, Congressman, and Army leaders for a tour of the RPPF and to discuss ongoing environmental stewardship actions by the Army at PTA. The post included pictures of the Sectary in the RPPF with the Army Biologists and CEMML staff.
- 26 January 2023, Pōhakuloa Training Area Facebook. Post featured additional information about the Sectary of the Army, Congressional, and Army Leadership visit to PTA. The post featured a picture of the Sectary smelling the flowers of the endangered plant *K. coriacea* in the RPPF.
- 31 January 2023, Pōhakuloa Training Area Facebook. Post featured the selection of PTA and its conservation partners for 2023 REPI Challenge funds.
- 06 February 2023, Pōhakuloa Training Area Facebook. Post featured installation of near real-time acoustic recording units by a team of scientists working under a grant from the DoD program for

Environmental Security Technology Certification Program with a link to the press release on the Defense Virtual Information Distribution Service (DIVIDS) website.

- 28 February 2023, Pōhakuloa Training Area Facebook. Post featured NRP's role in assisting students from the Youth Challenge Academy to plant ʻōhiʻa trees at PTA. The post has pictures of RNP staff assisting the students.
- 02 March 2023, Pōhakuloa Training Area Facebook. Post featured additional information and photographs of the NRP and students from the Youth Challenge Academy planting ʻōhiʻa tree.
- 10 March 2023, Pōhakuloa Training Area Facebook. Post featured the visit of the Foreign Military Attaches and their spouses to PTA. The NRP hosted the visitors for a tour of the RPPF and to discuss ongoing environmental stewardship actions by the Army at PTA. The post included pictures of the Attaches and their spouses in the RPPF with the Army Biologists and CEMML staff.
- 17 April 2023, Pōhakuloa Training Area Facebook. Post featured a visit by the Master Gardeners club to the RPPF. The post included pictures of the visitors with CEMML staff.
- 19 April 2023, Pōhakuloa Training Area Facebook. Post featured ʻōhiʻa forests at PTA and the NRP partnership with the State DOFAW to monitor for Rapid ʻŌhiʻa death at the installation.
- 19 April 2023, Pōhakuloa Training Area Facebook. Post featured preparations for Experience PTA Day 2023. Included pictures of NRP displays and pictures CEMML staff being interviewed by KITV's Jeremy Lee.
- 20 April 2023, Pōhakuloa Training Area Facebook. Post featured Experience PTA Day 2023, an event open to the public to highlight PTA and work done at the installation. The post included several pictures of Army Biologists and CEMML staff engaging with the public through interactive activities and dialogue.
- 04 May 2023, Pōhakuloa Training Area Facebook. Post featured the NRP display installed at the Waimea public library.
- 06 May 2023, Pōhakuloa Training Area Facebook. Post provided additional information about Experience PTA Day 2023 and NRP displays and participation.
- 08 May 2023, Pōhakuloa Training Area Facebook. Post featured the translocation of a Hawaiian Goose family, parents and 3 goslings, from PTA to a protected area on State land. The Geese were captured and moved by DOFAW staff with assistance from NRP. The post includes photographs of DOFAW and Army/CEMML staff working together to move the birds.
- 15 May 2023, Pōhakuloa Training Area Facebook. Post featured the visit of US Representative Marilyn Stickland to PTA. The NRP hosted the Congresswoman for a tour of the RPPF and to discuss ongoing environmental stewardship actions by the Army at PTA. The post included pictures of the Congresswoman in the RPPF with the Army Biologists and CEMML staff.

- 01 June 2023, Pōhakuloa Training Area Facebook. Post featured the visit of the Hawaiʻi Chamber of Commerce members to PTA. The NRP hosted the chamber members for a tour of the RPPF. The post included pictures of the Chamber members in the RPPF with the Army Biologists and CEMML staff.
- 06 June 2023, Pōhakuloa Training Area Facebook. Post featured Dr. Kirk Hillier's research on native moths and the NRP's role in hosting scientific research at PTA.
- 30 June 2023, Pōhakuloa Training Area Facebook. Post featured the visit of US Representative Jill Tokuda's staff to PTA. The NRP hosted the Congresswoman's staff for a tour of the RPPF and to discuss ongoing environmental stewardship actions by the Army at PTA. The post included pictures of the Congresswoman's staff in the RPPF with the Army Biologists and CEMML staff.
- 24 July 2023, Pōhakuloa Training Area Facebook. Post featured a visit from the Hosaka family to see the endangered plant *Isodendrion hosakae*, which was named for Edward Hosakae after he discovered the plants growing on what was then Parker Ranch. The post includes pictures of the Hosaka family with Army leadership, Army Biologists, and CEMML staff in the RPPF and looking at the plants in the wild.
- 10 August 2023, Pōhakuloa Training Area Facebook. Post featured the visit of the Congressional staff from the Military Construction Sub-Committee to PTA. The NRP hosted the committee members for a tour of the RPPF and to discuss ongoing environmental stewardship actions by the Army at PTA. The post included pictures of the committee members in the RPPF with the Army Biologists and CEMML staff.
- 30 October 2023, Pōhakuloa Training Area Facebook. Post features the naming of a plant species new to science. The scientific description for *Tetramolopium stemmermanniae* was published in the journal *Systematic Botany* in Fall 2023. This newly recognized species only occurs at PTA.
- FY 2022 Q1, we developed a good-news story regarding the rare plant survey efforts in Training Area 23 at the request of the USAG-PTA Deputy Garrison Commander.
- FY 2022 Q3, we wrote a short good-news story about the Band-rumped Storm Petrel breeding season.
- FY 2023 Q1, we hosted a reporter from the Honolulu-Star Advertiser in the RPPF. A story about PTA, including actions implemented by the Natural Resources Program, was published in the paper in November 2022.
- FY 2023 Q1, we participated in an interview with a reporter from the Honolulu Civil Beat in October 2022.

7.10.6 2021 Conserving Biodiversity on Military Lands—A Handbook for Natural Resource Managers, Third Edition

Through the Legacy Resources Management Program, the Department of Defense developed a publication titled *Conserving Biodiversity on Military Lands—A Handbook for Natural Resources Managers* (1996) and, in 2008 updated the document and made it into an online resource. In 2021, the DoD funded another update to the online resource. The updated handbook was made publicly available in June 2021 online via the DoD Environment, Safety & Occupational Health Network and Information Exchange (DENIX) website (https://www.denix.osd.mil/biodiversity/). We did not report this publication in the FY 2020 to FY 2021 Biennial Report, so we include it here. We contributed 2 case studies to the 2021 updated handbook.

Title: A Landscape Approach to Managing Multiple Stressors for Multiple Federally Listed Species, Pōhakuloa Training Area, Hawaiʻi[28]
Date: 4 June 2021
Type: Case Study Article
Publication: 2021 Conserving Biodiversity on Military Lands—A Handbook for Natural Resource Managers
Authors: Lena Schnell and Dave Jones
Summary: At PTA, landscape-scale management is a viable approach to address complex interactions of multiple stressors on a plethora of rare species and their habitats. Removing ungulates reduced direct and indirect stressors, and mitigated the compounding impacts of ecological interactions between the animals, invasive plants, and fire. Moreover, monitoring of rare plants after animals were removed from the system showed positive recruitment for some species (Litton et al. 2018). Removing animals also can reduce selective feeding on native plants, especially post-fire, and may help slow the alteration of native plant communities (Hughes and Vitousek 1993). Fuels management across the landscape and within localized buffers helped contain fires and reduced the loss of native woody species, rare plants, and habitats. Reducing fire spread, severity, and frequency is critical to conserving Hawaiian dry forests and their obligate rare species. Managing for multiple stressors, especially stressors with complex ecological interactions that promote accelerated changes in Hawaiian dry forests, is crucial to slowing the conversion of these forests to grasslands. Because fire, invasive plants, and introduced ungulates can have wide-ranging effects across the landscape, it is imperative to design and implement management on a similarly broad scale to be effective at supporting native ecosystems and the rare species that depend on them. Ultimately, healthy populations of rare species at PTA will help to minimize constraints and maximize flexibility for military training and operations, while conserving the native plant communities ensures a realistic training environment. Accomplishing both endeavors provides maximum opportunity for the Army to achieve their primary mission and sustain readiness.

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[28] Because this publication was not reported in the *Army Natural Resources Program at Pōhakuloa Training Area Biennial Report 01 October 2019 to 30 September 2021* (2022), we include it here.

Title: Nēnē Conservation: U.S. Army Garrison-Pōhakuloa Training Area Helps with Endangered Species Success Story for the Hawaiʻi State Bird Using Off-Site Management

Date: 4 June 2021

Type: Case Study Article

Publication: 2021 Conserving Biodiversity on Military Lands—A Handbook for Natural Resource Managers

Authors: Rogelio Doratt and Lena Schnell

Summary: Establishing a functional partnership between the Army, USFWS, and Hakalau National Wildlife Refuge (HFNWR) allowed the Army to implement conservation actions that contributed to increased numbers of Hawaiian Goose fledglings at HFNWR. By fostering a good working relationship between the partners, an agreement was made to postpone building a predator-proof fence and to focus on other important conservation actions to help improve the successful recruitment of geese. Goose and nest monitoring, predator control, and habitat management yielded successful outcomes for the goose at HFNWR. For example, following the implementation of habitat enhancement activities in Army-managed areas at HFNWR, geese are regularly attracted to and use these areas. Regular grass maintenance has produced a relatively uniform lawn with periodic grass regrowth that supplements the available forage for geese at the site. With augmented and improved predator removal, geese survivorship and numbers are expected to gradually increase and contribute positively towards the continued success of conservation efforts at the Hakalau Forest Refuge and statewide.

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 IWFMP (USAG-PTA 2021) and 2003 BO (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.

Per the Incidental Take Statement in the 2003 BO, incidental take for the Hawaiian hoary bat is indirectly measured by degradation or destruction of potential available treeland 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 Army is authorized for the incidental take of all bats associated with the loss of no more than 48 ha of roosting habitat outside the Impact Area per year, and no more than 1,345 ha cumulatively, for the duration covered by the Incidental Take Statement.

Below we summarize key findings from the post-disturbance assessments that were submitted to the Army during the reporting period.

8.1 MAUNA LOA ERUPTION AND LAVA FLOW

On 27 November 2022, the Mauna Loa volcano erupted. The eruption began at the summit caldera, Mokuʻāweoweo. Lava flowed downslope for about 12 days total and the eruption ended on 12 December 2022. On 30 November (day 3), lava flowed onto PTA and breached the ungulate-exclusion fence in TA 21. The lava continued to advance into PTA, eventually breaching the TA 21 fence a second time and exiting PTA between 6 and 7 December about 4 km downslope, northeast of the entry point.

The lava flow covered habitat that harbored 2 ESA-listed plants prior to the eruption—*Exocarpos menziesii* and *Silene hawaiiensis.* Following the eruption, we found 15 *E. menziesii* and no *Silene hawaiiensis* remaining. The lava impacted up to 242 *E. menziesii* individuals and 3 *Silene hawaiiensis*. For more details on the Mauna Loa eruption, refer Section 2.6.2 and to the *Technical Report Technical Report and Post-Disturbance Assessment, December 2022 Mauna Loa Eruption, Pōhakuloa Training Area, Island of Hawaiʻi* (CEMML 2023d).

8.2 TRAINING AREA 21 FIRE

On 20 May 2022, at approximately 1405 hours, PTA Range Control was notified of a wildland fire near Range 11 in Training Area 21. The specific cause of the fire was unclear and may have ignited from lightning. The fire burned approximately 10.9 ha.

8.2.1 Effects to ESA-listed Plant Species and Hawaiian Hoary Bat Roosting Habitat

There were no fire-related impacts to ESA-listed plants.

The burn area is occupied by 4 vegetation communities (Shaw and Castillo 1997): Myoporum–Chamaesyce Treeland, Myoporum Shrubland, Open Metrosideros Treeland with sparse shrub understory, and Sparse Metrosideros Treeland. The 2003 BO defines these community types as being potential treeland roosting habitat for the Hawaiian hoary bat. However, if the fire was ignited naturally by lightning, the damage to the bat roosting habitat is not considered incidental take.

For more details on the May 2022 TA 21 Fire, refer Section2.2.6 and to the *Technical Report Technical Report and Post-Disturbance Assessment, May 2022 Wildland Fire: Training Area 21, Pōhakuloa Training Area, Island of Hawaiʻi* (CEMML 2023e).

8.3 Leilani Brush Fire

In July-August 2022, the Leilani Fire affected 2,126 ha of threatened and endangered species habitat at Pōhakuloa Training Area (CEMML 2023f). The fire impacted 10 ESA-listed plant species and burned potential available treeland roosting habitat for the endangered Hawaiian hoary bat. The cause and progression of the fire is still being officially investigated and whether incidental take occurred, and the extent, cannot be determined until the investigation is completed[29].

The overall effect of the Leilani Fire on native vegetation communities is assumed to be negative. Wildland fire destroys native woody vegetation and facilitates invasion by non-native, invasive grasses that sustain more frequent and intense fires. Successive burns continue to degrade native vegetation communities and hasten ecosystem transition from native shrubland and woodland to invasive grass savannahs.

Changes reported were not necessarily solely a result of the fire but were influenced by the many factors that impact plant community dynamics over time. The *Technical Report and Post-Disturbance Assessment, Leilani Fire in Training Area 22, July and August 2022* documents differences in species status based on the sum of these factors (CEMML 2023f). It is not possible to isolate fire-specific impacts to species in the burn area with available data.

8.3.1 Effects to ESA-listed Plant Species

Ten ESA-listed species occurred in the area that burned: *F. hawaiiensis, H. haplostachya*, *K. coriacea*, *P. sclerocarpa*, *P. villosa*, *Silene hawaiiensis*, *S. lanceolata*, *S. incompletum*, *S. angustifolia*, and *Z. hawaiiense.*

[29] The text reflects the status of the Leilani Brush Fire investigation during the report period (01 October 2021–30 September 2023). Since, the Army has provided supplemental letters with additional details regarding the fire to the US Fish and Wildlife Service on 30 October 2023 and 18 April 2024. The investigation determined that the most probable cause of the fire was illumination rounds.

Festuca hawaiiensis

Following the fire, the abundance of *F. hawaiiensis* was estimated at 76 individuals (90% CI: 0–172) within the burn area. The difference in pre- and post-fire mean abundance for *F. hawaiiensis* was statistically non-significant (paired t-test, $\alpha \geq 0.1$, $p = 0.39$). Multiple factors likely influenced the post-fire mean abundance of *F. hawaiiensis*, such as the unevenness of the burn and recruitment following the fire. Although the mean abundance was similar pre- and post-fire, the fire negatively affected *F. hawaiiensis* by burning the native habitats that support it.

Haplostachys haplostachya

Following the fire, the abundance of *H. haplostachya* was estimated at 6,028 individuals (90% CI: 1,337–10,718) within the burn area. The difference in pre- and post-fire mean abundance for *H. haplostachya* was statistically non-significant (paired t-test, $\alpha \geq 0.1$, $p = 0.11$). Multiple factors likely influenced the post-fire mean abundance of *H. haplostachya*, such as the unevenness of the burn and recruitment following the fire. Although the mean abundance was similar pre- and post-fire, the fire negatively affected *H. haplostachya* by burning the native habitats that support it.

Kadua coriacea

In 2020, there were 155 wild *K. coriacea* at PTA. One individual was in the area that burned, representing 1% of the entire PTA population. In addition, 1 outplanted *K. coriacea* occurred within the area that burned. Both plants were present after the fire; therefore, the fire likely had minimal effect on these individuals.

Portulaca sclerocarpa

In 2020, there were 217 wild *P. sclerocarpa* at PTA, of which 177 individuals occurred in the area that burned, representing 82% of the entire PTA population. We observed a decline of 85 plants within the burn area following the fire, representing a 48% decline in abundance within the burn area. Outside the burn area, the abundance of *P. sclerocarpa* increased by 83% between the pre- and post-fire monitoring periods. These changes within and outside the burn area strongly suggest the fire had a substantial impact on this species and its population at PTA.

Portulaca villosa

In 2020, there were 11 wild *P. villosa* at PTA, 2 of which occurred in the area that burned, representing 18% of the entire PTA population. Within the burn area, 1 plant was not found during post-fire monitoring, representing a 50% decline in abundance within the burn area. However, outside the burn area, we observed a decline from 9 to 6 individuals following the fire, representing a 33% decline in abundance. Because abundance declined both outside and within the burn area, the effect of the fire is less clear for *P. villosa*. Other factors such as drought likely contributed to the observed declines in abundance. Regardless, the loss of 4 of 11 *P. villosa* is substantial for the population at PTA.

Silene hawaiiensis

Following the fire, the abundance of *Silene hawaiiensis* was estimated at 48 individuals (90% CI: 0–126) within the burn area. Because the pre-fire data for *Silene hawaiiensis* were minimal, we were unable to compare pre- and post-fire mean abundance for this species using statistical t-tests. For the single monitoring plot where pre- and post-fire plants counts were available, we observed an increase in plant counts from 9 to 19 individuals following the fire in an area classified as no/low burn severity.

Silene lanceolata

Following the fire, the abundance of *S. lanceolata* was estimated at 1,456 individuals (90% CI: 638–2,275) within the burn area. Prior to the fire, the area that burned supported a large proportion of the *S. lanceolata* population at PTA. We used a paired t-test to compare the mean abundance from before and after the fire and found a statistically significant decline (paired t-test, $\alpha \geq 0.1$, $p = 0.05$). However, there is a 3-to-5-year gap in time between pre-fire and post-fire monitoring efforts. Therefore, caution is advised when trying to evaluate the effects of the fire on this species. Factors other than fire, such as drought, rainfall, and natural mortality and recruitment, also likely contributed to the observed changes in abundance between monitoring periods.

Solanum incompletum

No wild individuals of *S. incompletum* occurred within the burn area. Several outplanted individuals were present in 2021 at an outplanting site located within the burn area. The number of outplanted *S. incompletum* decreased from 20 to 14 individuals following the fire. However, because we control invasive grass within the outplanting site, the fire burned around the site leaving the habitat and outplants unharmed. The *S. incompletum* outplants at this site have declined at each monitoring event since 2014. Therefore, factors such as drought or pests likely influenced the observed decline in number after the fire.

Stenogyne angustifolia

Following the fire, the abundance of *S. angustifolia* was estimated at 1,160 individuals (90% CI: 875–1,731) within the burn area. Prior to the fire, the area that burned supported most of the *S. angustifolia* population at PTA. We used a paired t-test to compare the mean abundance from before and after the fire and found a statistically significant decline (paired t-test, $\alpha \geq 0.1$, $p = 0.06$). However, there is a 3-to-5-year gap in time between pre-fire and post-fire monitoring efforts. Therefore, caution must be used when trying to evaluate the effects of the fire on this species. Factors other than fire, such as drought, rainfall, and natural mortality and recruitment, also likely contributed to the observed changes in abundance between monitoring periods.

Zanthoxylum hawaiiense

In 2020, there were 493 wild *Z. hawaiiense* at PTA, of which 85 individuals occurred within the area that burned, representing 17% of the entire PTA population. After the fire, we found 46 trees and 39 trees were missing, representing a 46% decline in abundance within the burn area. The loss of 39 trees represents an 8% reduction in the overall population of 493 trees.

8.3.2 Hawaiian Hoary Bat Roosting Habitat

The fire burned approximately 1,216 ha of vegetation considered potential available treeland roosting habitat for the Hawaiian hoary bat. It has not been determined if the fire, in part or in whole, constitutes incidental take of potential available roosting habitat outside the Impact Area. Per the 2003 BO, the annual and cumulative allowances for incidental take are 48 ha and 1,345 ha, respectively. In addition, the fire did not burn completely or uniformly throughout the roosting habitat, but rather resulted in a mosaic of burn intensities across the vegetation communities. Due to the unevenness of fire impacts, some roost trees will likely persist within the areas reported as burned.

The Leilani Fire had a substantial impact on the vegetation communities on PTA and adjacent State land in Puʻu Anahulu. The fires burned a total of 7,168 ha, 2,126 ha on Army-controlled land and 5,042 ha on State land. On PTA, 10 ESA-listed species occurred in the burn area before the fire. Following the fire, we found a net decline in the abundance for some of the federally listed species across the affected area. Post-fire abundance was substantially lower for *P. sclerocarpa* and *Z. hawaiiense.* The lower post-fire estimated abundance was statically significant for *S. lanceolata* and *S. angustifolia*. Following the fire, we observed recruitment of *H. haplostachya*, *Silene hawaiiensis*, *S. lanceolata,* and *S. angustifolia* within the burn area on PTA*.* Although some ESA-listed species can regenerate following fire, repeated burns likely affect their populations negatively and continue to degrade their habitats.

For more details on the Leilani Brush Fire in TA 22, refer to Section 2.2.6 and to the *Technical Report Technical Report and Post-Disturbance Assessment, Leilani Fire in Training Area 22, July and August 2022, Pōhakuloa Training Area, Island of Hawaiʻi* (CEMML 2023f).

8.4 Keʻāmuku Maneuver Area Complex Fire

The Keʻāmuku Maneuver Area (KMA) Complex Fire started at approximately 1520 h on 12 February 2023 and consisted of 2 fires started by lightning strikes. The fires were 100% contained by the afternoon of 15 February 2023. The 2 fires combined burned approximately 333 ha (823 ac).

8.4.1 Effects to ESA-listed Plant Species and Hawaiian Hoary Bat Roosting Habitat

The KMA Complex Fire burned semi-natural vegetation communities that are dominated by non-native species. No ESA-listed plants were found during previous surveys of the burn area (Arnett 2002). Therefore, we did not survey the burn area post-fire. Although the last botanical survey of the burn area was completed in 2002, we do not expect that federally listed plants were present because high numbers of feral sheep, goats, and pigs are present in this area and the nearest populations of ESA-listed plants are ~4 km distant. The KMA Complex Fire likely did not change the baseline abundance or distribution for any federally listed plant species at PTA.

The fire burned ~97 ha (240 ac) of the following woodland vegetation communities: *Eucalyptus* spp. Semi-natural Woodland Alliance and *Olea europaea* Semi-natural Woodland Alliance. Although the fire affected woodland habitat, we anticipate the loss of this habitat to be of limited consequence to Hawaiian hoary bats. First, bats are assumed to have fled the area while the fire was burning. Second, the fire occurred when young, flightless bats are not expected to be present in the population. Lastly, due to their mobility, bats are expected to use adjacent unburned woodland habitat for roosting and foraging.

The cause of the KMA Complex Fire was natural and not related to military training activity; therefore, no indirect incidental take occurred because of Army activities. No bat carcasses were reported from the burn area during operations or other field assessments and direct impacts to Hawaiian hoary bat are assumed to be negligible.

For more details on the KMA Complex Fire, refer to the *Technical Report Technical Report and Post-Disturbance Assessment, Keʻāmuku Maneuver Area Complex Fire, February 2023, Pōhakuloa Training Area, Island of Hawaiʻi* (CEMML 2023g).

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-21-2-0027 to provide a biennial report (see Section 1.2.4). 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 Army's NRP 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 NRP at PTA.

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APPENDIX A ANNUAL REPORT FOR THE ARMY'S NATURAL RESOURCES PROGRAM AT PŌHAKULOA TRAINING AREA

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 2023 (01 October 2022 through 30 September 2023). A report covering FY 2022 (01 October 2019 through 30 September 2022) 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.

A.1 BOTANICAL PROGRAM

A.1.1 INTRODUCTION

To manage botanical resources at PTA, we implement Statement of Objectives tasks 3.2.1.1 through 3.2.1.5 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.

The Botanical Program implements conservation measures for 20 ESA-listed plants listed at PTA: *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), *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* (Mauna Kea pāmakani), *Vigna o-wahuensis* (Oʻahu cowpea), and *Zanthoxylum hawaiiense* (Hawaiian yellow wood or aʻe).

Additionally, some conservation measures are implemented for *Tetramolopium stemmermanniae*, which is not ESA-listed but managed due to its rarity and limited distribution.

Conservation measures for ESA-listed plants include delimiting plant species distribution and abundance, species monitoring, 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

To guide management at PTA, we assign each rare plant species to 1 of 2 management tiers based on each species' abundance at PTA (Table A.1):

- Management Tier 1—Plant species with fewer than 500 individuals at PTA.
- Management Tier 2—Plant species with greater than 500 individuals at PTA.

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

Table A.1. Management tiers for rare plant species at Pōhakuloa Training Area

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

(E) Endangered; (T) Threatened

The information contained herein satisfies annual reporting requirements identified in the 2003, 2008 and 2013 BOs. Genetic conservation and outplanting reporting requirements are addressed in the *2023 Annual Recovery Permit Report for Pōhakuloa Training Area, Hawaiʻi Island, Hawaiʻi, Recovery Permit TE-40123A-3* (CEMML 2024).

A.1.2 Plant Survey and Monitoring

PTA harbors 20 ESA-listed plant species, some found nowhere else. We implement management actions for the benefit of these species and to comply with statutory and regulatory requirements. The primary aim of the Botanical Program is to quantify status and trends in the status of species populations through survey and monitoring actions.

A.1.2.1 Plant Surveys

The purpose of plant surveys is to document the distribution and quantify abundance of ESA-listed plant species at PTA. The plant surveys meet SOO task 3.2.1.1 and INRMP and Army Regulation-100 requirements for Planning Level Surveys.

No plant surveys were conducted this fiscal year.

A.1.2.2 Monitoring in FY 2023

Monitoring for Tier 1 Plant Species

Table A.2. Number of monitoring visits for Tier 1 plant species in FY 2023

	Wild Adult/Juvenile		Outplanted Adult/Juvenile	
Species	**Alive**	**Dead/Not Found**	**Alive**	**Dead/Not Found**
Isodendrion hosakae	7	0	4	0
Kadua coriacea	153	3	54	23
Lipochaeta venosa	351	2	2	0
Neraudia ovata	61	7	89	2
Portulaca sclerocarpa	66	29	15	25
Portulaca villosa	7	0	0	0
Schiedea hawaiiensis	2	3	12	4
Solanum incompletum	91	11	735	47
Tetramolopium arenarium	2	3	0	0
Tetramolopium stemmermanniae	98	43	278	103
Vigna o-wahuensis	150	0	0	0
Zanthoxylum hawaiiense[a]	394	84	3	1

[a]In FY 2023 this species was monitored within the Leilani fire burn area, and again as part of a total PTA-wide census. This census was not part of the first cycle of Tier 1 species monitoring (monitoring for this species takes place every 3 years as opposed to annually) so these numbers were not reported in Section 2.2.3.

Monitoring for Tier 2 Plant Species

Table A.3. Monitoring of Tier 2 plant species in FY 2023. Totals include the number of wild adult and juvenile individuals observed

Species	Wild Adult/Juvenile[a]
Asplenium peruvianum var. *insulare*	21
Exocarpos menziesii	271
Festuca hawaiiensis	1,044
Haplostachys haplostachya	4,977
Silene hawaiiensis	77
Silene lanceolata	1,750
Spermolepis hawaiiensis	469
Stenogyne angustifolia	1,122

[a]Count classes were used to estimate the number of plants at each 5.6 m radius location where more than 25 plants were observed. This is a sum of "minimum counts", representing the lowest count value for the count class (26-50, 51-75, 76-100, >100) recorded for each location where plants were observed.

A.1.3 WILDLAND FIRE IMPACTS TO PLANTS

The 2003 BO (USFWS 2003) and the INRMP (USAG-P 2020) 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.

During the reporting period no military-related wildland fires occurred at PTA:

A.2 WILDLIFE PROGRAM

A.2.1 INTRODUCTION

To manage wildlife resources at PTA, we implement Statement of Objective (SOO) tasks 3.2.2.1 through 3.2.2.5 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 Army is preparing to consult with the USFWS under Section 7 (2)(a) of the ESA for ESA-listed animal species that occur at or near PTA, as well as the 20 species of ES3A-listed plants[30].

We implement management to meet SOO tasks and regulatory requirements for 3 ESA-listed species that occasionally use habitat at PTA and/or periodically transit the installation: Hawaiian hoary bat

[30] The text reflects the status of the PBA during the report period (01 October 2021 through 30 September 2023). Since, the Army has worked to develop additional wildland fire planning and preparedness documents to support the PBA preparation process and the fire model used for the effects analysis was updated with data from wildland fires that occurred in 2021 and 2022.

(*Aeorestes semotus*[31]), Hawaiian Goose (*Branta sandvicensis*), and Hawaiian Petrel (*Pterodroma sandwichensis*). Since 2006, 15 bird species protected under the MBTA have been observed at PTA (USAG-PTA 2020).

In 2016, we determined that Hawaiian Petrels do not use habitat at PTA; rather, they fly over the installation (CEMML 2016). Therefore, we will continue to record Hawaiian Petrel detections at the installation. In December 2019, USFWS finalized a ruling to down-list the Hawaiian Goose from endangered to threatened with a Section 4(d) rule (USFWS 2019); all previous measures, conditions, and terms from previous consultation documents remain unchanged. In January 2020, USFWS also finalized a ruling to remove the Hawaiian Hawk (*Buteo solitarius*) from the federal list of endangered and threatened wildlife (USFWS 2020). We implement management for the Hawaiian Hawk under the INRMP and in accordance with the MBTA.

The wildlife section of this report has 4 sub-sections:

(1) Hawaiian Goose
(2) Hawaiian Hoary Bat
(3) Wildland Fire Impacts to Wildlife
(4) Migratory Bird Incidental Take Summary

The information herein satisfies annual reporting requirements identified in regulatory and guiding documents for PTA.

A.2.2 HAWAIIAN GOOSE

A.2.2.1 Hawaiian Goose Management at Pōhakuloa Training Area

We implement management for Hawaiian Geese to meet SOO tasks and objectives in the INRMP and regulatory documents. In January 2013, the USFWS issued a BO that addressed installation-wide impacts to the Hawaiian Goose from military training at PTA. The 2013 BO includes an Incidental Take Statement for the goose, removing several earlier restrictions imposed on military training. Elements of the BO and the Incidental Take Statement require annual reporting to USFWS. The 2013 BO supersedes the requirements of the 2008 BO for surveying, monitoring, and managing Hawaiian Geese, and removes restrictions on military personnel training at live-fire ranges and vehicle maneuver areas when geese are present. A discussion of off-site Hawaiian Goose mitigation is presented in Sectio.

[31] In February, USFWS published a final rule in the Federal Register changing the taxonomic names for the Hawaiian hoary bat from *Lasiurus cinereus semotus* to *Aeorestes semotus* (Endangered and Threatened Wildlife and Plants; Technical Corrections for 62 Wildlife and Plant Species on the lists of Endangered and Threatened Wildlife and Plants, 88 Fed. Reg. 7134 [Feb. 2, 2023]).

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 who are training and working at PTA.

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 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 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). Observation data are reported by survey date and core area.

Foot surveys consist of 1 or 2 biologists traversing the area and recording the presence of Hawaiian Geese. Vehicle surveys consist of 1 or 2 biologists driving on roads using binoculars to search for geese. We record monitoring type (systematic 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 are observed molting (e.g., missing flight feathers) or breeding (e.g., exhibiting aggressive behavior, brood patches, or 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. These observation data are a rough measure of goose presence for the core monitoring areas but are helpful in estimating trends in presence/usage and guiding management efforts.

Systematic Monitoring Results

In the core management areas, we detected a total of 15 geese during 7 of 193 surveys (Figure A.1). Three individual geese were identified by their leg-bands (Table A.4). We observed geese at 2 of the 4 core areas.

Table A.4. Hawaiian Goose systematic monitoring data and geese leg-band information in core monitoring areas in FY 2023 at Pōhakuloa Training Area

Survey Areas	No. of Surveys	Surveys with Goose Presence	Total Goose Observations[a]	With Bands	W/out Bands	Band not Identified
Range 1 Complex	42	0	0	0	0	0
FOB[b] Warrior Search Area	51	5	12	1	4	6
Bradshaw Army Airfield	52	2	3	2	0	1
Training Areas 6 and 7	48	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

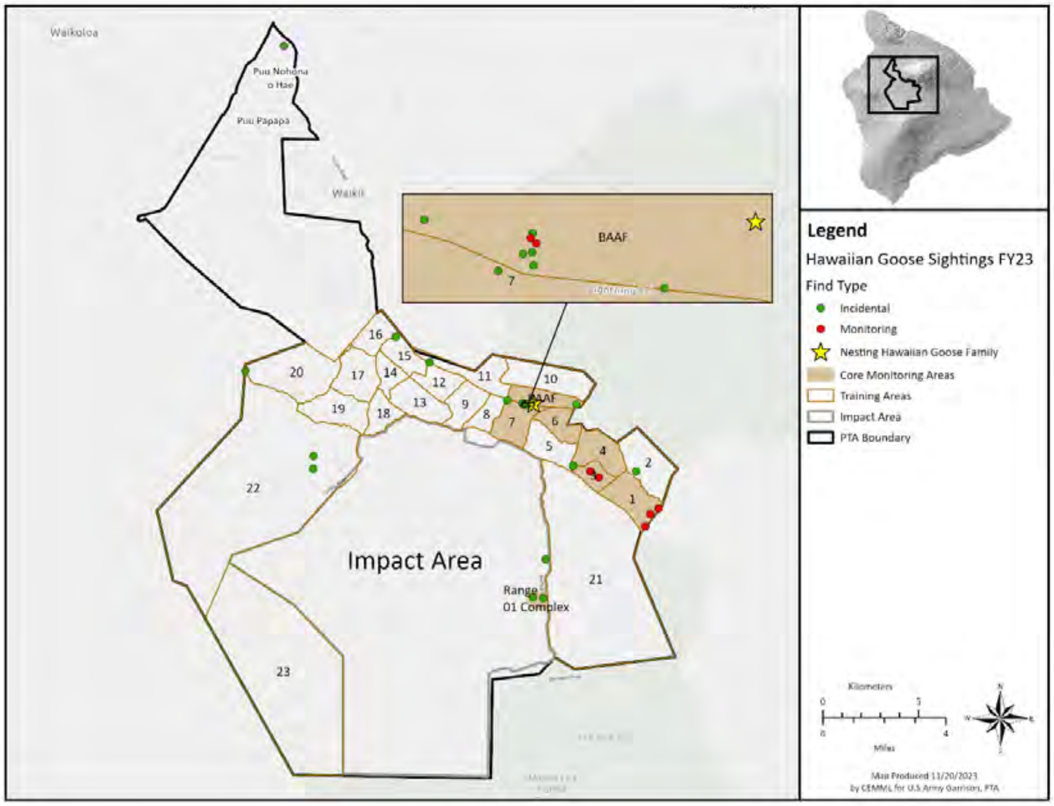

Figure A.1. Hawaiian Goose sightings in FY 2023 and core monitoring areas at Pōhakuloa Training Area

Incidental Sightings Methods

All personnel working and training at PTA are instructed to 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 geese are located, we may monitor them, especially if breeding or molting behavior is observed. Monitoring may continue until the birds are no longer found in the area.

Incidental Sightings Results

In the core monitoring areas, we observed a total of 25 geese (all observations pooled including repeat visits) from 12 incidental sighting events (Table A.5). From the 25 observations, we identified 9 individual geese by their unique leg-bands and we were unable to determine the presence of leg-bands for the other 13 observations; therefore, we cannot determine the number of individual birds these observations represent.

In non-core monitoring areas, we observed a total of 21 geese (all observations pooled including repeat visits) from 8 incidental sighting events. From the 21 observations, we identified 1 individual goose by its unique leg-bands, but we were unable to determine the presence of leg-bands for the other 20 observations; therefore, we cannot determine the number of individual birds these observations represent.

Table A.5. Hawaiian Goose incidental sightings by location and geese leg-band information in core and non-core areas in FY 2023 at Pōhakuloa Training Area

Survey Areas	Incidental Sighting Events	Total Goose Observations[a]	With Bands	W/out Bands	Band not Identified
Core Area					
Range 1 Complex	2	6	2	0	4
FOB Warrior Search Area	3	7	3	0	4
Bradshaw Army Airfield	3	6	3	0	1
Training Areas 6 and 7	4	6	2	0	4
Non-Core Areas	8	21	1	0	20

FOB, Forward Operating Base
[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.

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.

Targeted Monitoring Results

On 27 March 2023, 2 banded geese (Grey/Black A97 and Green/White KZP) were observed molting at BAAF. Between March 27 to April 24, the geese were monitored, and predator control was implemented.

On 21 April 2023, another banded goose (Grey/Black A98) and 3 goslings were observed with the other 2 banded geese. On April 24, we assisted State of Hawaiʻi Department of Forestry and Wildlife (DOFAW) personnel in the capture and translocation of the goose family (Grey/Black A97 and A98 and 3 gosling) away from BAAF. These geese were safely captured with long handle nets and caged in a large plastic animal carrier. Green/White KZP was not captured, and it remained at BAAF and it was last seen on 17 July 2023. For more information regarding the goslings' discovery and the capture and translocation of the goose family please refer to Appendix C. The goose nest was also discovered and contained several eggshell fragments and 1 unhatched egg (Figure A.1).

Other Survey Efforts

We did not detect geese at PTA during the statewide annual Hawaiian Goose surveys. Surveys occurred in FY 2023 (24 August 2023). These surveys are coordinated by DOFAW and we have participated since 2016.

Management Activities

Actions to Monitor and Manage Hawaiian Goose Breeding Activity

As previously stated above on 27 March 2023, 2 geese, Grey/Black A97 and Green/White KZP were observed molting at BAAF. On 21 April 2023, a family of geese (Grey/Black A98, A97 and 3 goslings) and Green/White KZP were observed at BAAF. On April 24, we assisted DOFAW personnel in the capture and translocation of the goose family away from BAAF.

To protect the breeding geese from predators, between March and April 2023, we deployed 5 live traps spaced approximately 200 m apart and equipped each trap with a Skyhawk™ electronic sensor The traps captured 4 mongooses and 1 feral cat. Two (Erckel's Spur Fowl (*Pternistis erckelii*), non-target game birds, were captured and safely released.

Actions to Minimize Conflicts between Training and Hawaiian Geese

The 2013 BO requires the Army to manage 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 sources 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 designated area at the complex where Hawaiian Geese often feed and loaf (Figure A.2).

Hawaiian Goose habitat enhancement occurs within the WEA fence unit proximate to the Range 1 Complex (Figure A.2). 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.

We selectively applied 30 gallons of herbicide (1.5% Roundup PowerMax herbicide (A.I. glyphosate) and 0.22% Oust XP per gallon (A.I. sulfometuron-methyl) to approximately 13 ha in the Range 1 Complex. Post-treatment evaluations indicate that Roundup PowerMax was effective in controlling *R. pilosum*. In addition, there was very little fireweed and fountain grass growth and lots of *R. pilosum* growing at the WEA. Therefore, cutting or spraying for invasive plants did not occur during this reporting period and no geese were observed in the WEA.

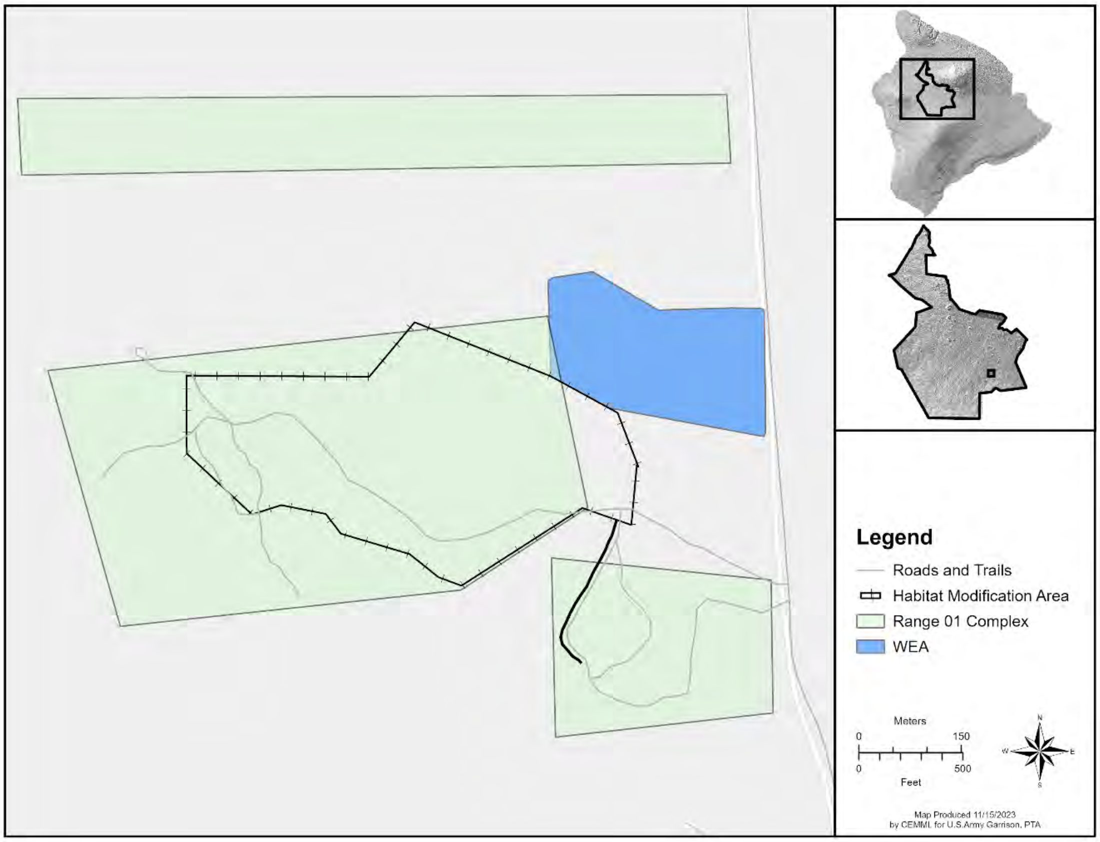

Figure A.2. Hawaiian Goose habitat modification area and the Wildlife Enhancement Area at Range 1 Complex, Pōhakuloa Training Area

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) on their responsibilities to protect geese at PTA, especially while driving and conducting live-fire exercises.

We delivered 7 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 5 years despite an increase in the number of surveys (Table A.6). 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 habitat management actions to discourage geese from feeding and loafing in high-conflict areas.

Table A.6. Total number of goose observations per survey effort in core monitoring areas in FY 2019 to FY 2023 at Pōhakuloa Training Area.

	Systematic Sightings					Incidental Sightings				
	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023
Total goose observations	20	17	4	2	15	30	25	4	12	25
Number of Surveys	140	145	191	198	193	9	10	3	4	12
Mean # Geese/Survey	0.14	.011	0.02	0.01	0.07	--	--	--	--	--

We continue to receive a fair number of Hawaiian Goose incidental sighting reports from many people working at PTA (military personnel, PTA directorates staff, and contractors/cooperators). In FY 2023 we received 20 incidental sighting reports (1 military, 5 PTA directorate staff and 14 NRP staff). When conducting systematic surveys down range, when possible, we stop and speak with military units, PTA directorates, and contractors about reporting Hawaiian Goose sightings. This education and outreach have proven to be effective and is an important component of the Wildlife Program.

A.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 manages for geese in the Pua ʻĀkala and Middle Road management areas of HFNWR, collectively referred to hereafter as the Army-managed areas (Figure A.3). 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 6 September 2023, we submitted the *2022/2023 Breeding Season Report for Hawaiian Goose Conservation Project, Hakalau Forest National Wildlife Refuge* to HFNWR and USFWS (CEMML 2023). This report 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 are increased when managed.

In FY 2023, we cut ~1.2 ha of kikuyu grass (*Cenchrus clandestinus*) with weed whackers and a large deck mower within the Pua ʻĀkala management area 2 times (Figure A.2). We also spot-sprayed blackberry (*Rubus discolor*), bull thistle (*Cirsium vulgare*), and gorse (*Ulex europaeus*). Six small wooden shelters were deployed around the mowed area to provide additional protection for geese.

Hawaiian Goose Monitoring

Between October 2022 and May 2023, we observed a total of 79 geese with unique leg bands, as well as multiple unbanded geese in the Army-supported management areas. Sixty-two (78%) of the 79 geese were resighted from last year's breeding season.

During goose monitoring activities, we also discovered 3 Hawaiian Goose carcasses adjacent to the Pua ʻĀkala management area. The causes of death are unknown, with no direct evidence connecting these 3 mortalities to our management activities. In addition, on 28 December 2022, we observed 2 feral dogs inside the Pua ʻĀkala management area, which was the same day 2 of the 3 carcasses were found. We reported the feral dog sighting to HFNWR staff the same day. After each carcass was discovered, we notified HFNWR staff, and they removed the carcasses. Refer to Appendix E for more detailed information on the incidents.

Hawaiian Goose Nest Searching and Monitoring

Between October 2022 and May 2023, we found and monitored 32 nests (Figure A.3). Twenty-seven nests in the Army-supported management areas, 2 nests in the administration building area, and 3 outside of Army-supported management areas. All 32 nests were monitored with Reconyx® cameras. We monitored the nests until the eggs hatched and then continued monitoring the goslings until they fledged to estimate survivorship for each life stage. In total, 4 goslings fledged from the Army-managed areas. This was 15% of our target production of 26 fledglings per year established in the 2013 BO. However, USFWS acknowledged in the BO that this conservation project will likely take several years to refine before production targets can be fully actualized. In FY 2024, we plan to continue to refine management and monitoring techniques to improve nesting success and fledging rates.

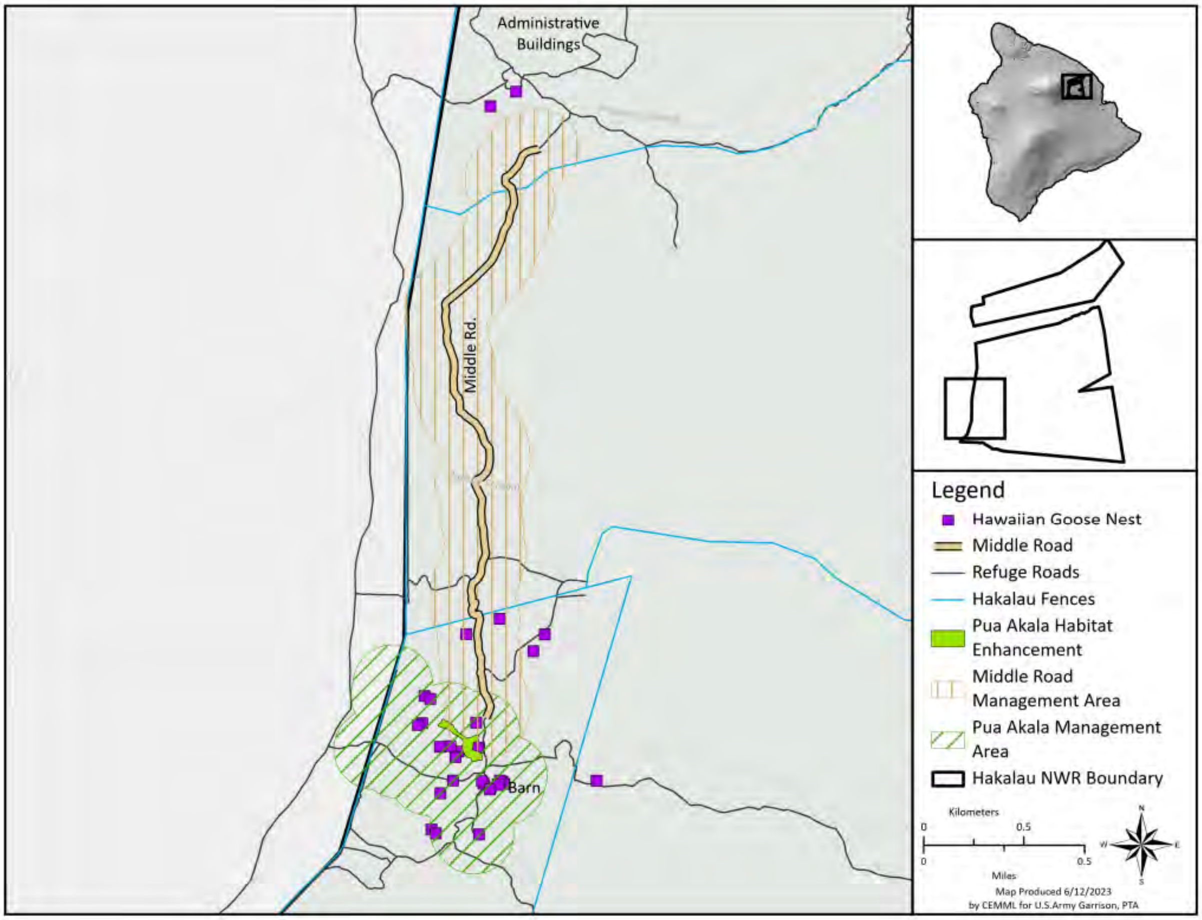

Figure A.3. Hawaiian Goose nest locations (32 nests) in the Army-supported management areas at Hakalau Forest National Wildlife Refuge during the 2022–2023 breeding season

Predator Control at Hakalau Forest National Wildlife Refuge

On 11 October 2022, we deployed 71 live-traps (45 large and 26 small) around the Pua ʻĀkala and Middle Road management areas (Figure A.4). On 06 April 2023, we removed 29 live-traps (15 large and 14 small) from the Middle Road management area and maintained the remaining 42 live-traps (30 large and 12 small) inside the Pua ʻĀkala tract until the end of the season. We left live-traps open for 2-3 consecutive nights each week over a 33-week period totaling 5,754 adjusted trap-nights. For each capture, we adjust the trap night from 1.0 to 0.5 to estimate the time the trap is not available to capture additional animals. We also adjust for traps not set. We completed live-trapping on 25 May 2023. With the live-traps, we captured and removed 8 mongooses from the Army-supported management areas. We also captured and safely released 2 Erckel's Spur Fowl (non-native game birds, *Pternistis erckelii*).

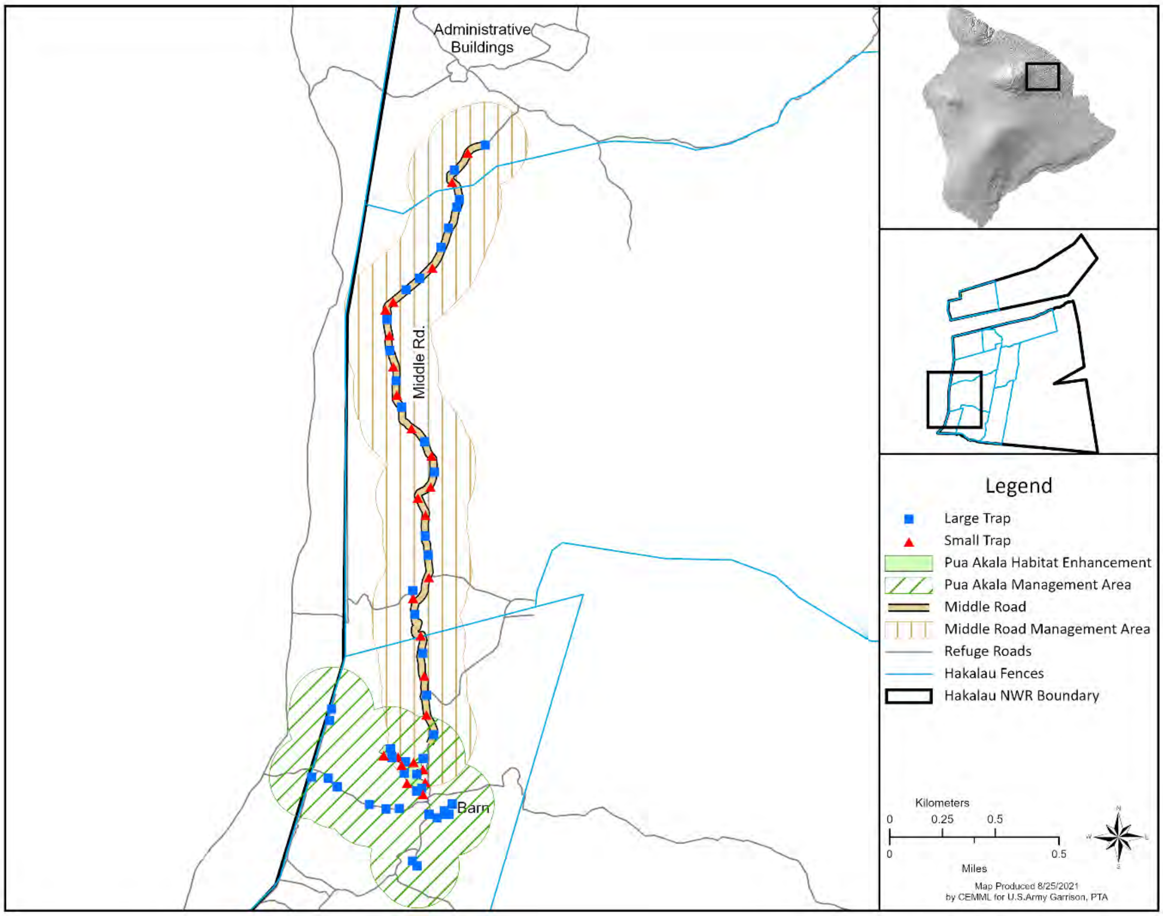

Figure A.4. Predator trap layout during FY 2023 Hawaiian Goose breeding season at Hakalau Forest National Wildlife Refuge

Between October 2022 and May 2023, we deployed up to 4 A24 traps (Goodnature® rodent kill traps), spaced approximately 25 m away from each Hawaiian Goose nest. We removed 48 predators (1 rat, and 47 mice). Because carcasses may be on the ground for up to 2 weeks, some carcasses may have been scavenged before we found them. No geese or non-targets were killed in lethal traps during the trapping period. No geese or non-targets were captured during the trapping period.

Discussion for Hawaiian Goose Management at Hakalau Forest National Wildlife Refuge

Our management activities at HFNWR continue to support Hawaiian Goose conservation in Hawaii and off-sets impacts on the Hawaiian Goose due to military training activities at PTA. Our actions within the Army-supported management areas, Pua ʻĀkala and Middle Road, and the administration building area contributed to the successful fledging of 4 goslings this breeding season. By successfully fledging 4 goslings we reached 15% of the target production of 26 fledglings per year (Table A.7).

Table A.7. Summary of Hawaiian Goose nest fate records in Army-supported management areas at Hakalau Forest National Wildlife Refuge during geese breeding seasons, 2017–2023

Breeding Season	# of Nests Monitored	Eggs Laid	Eggs Hatched	Max Goslings Seen	Fledglings from Monitored Nests	Total Fledglings[a]
2017-2018	6	20	6	–	4	7
2018-2019	13	46	33	21	18	20
2019-2020	12	40	20	18	12	12
2020-2021	18	61	34	28	10	10
2021-2022	16	48	30	24	3	10
2022-2023	32	111	69	54	4	4

[a] Criteria to determine if fledglings observed in Army-supported management areas count toward compliance targets: (1) Fledglings that hatched from nests within management areas are counted if they are banded, seen flying, or seen alive after 10 weeks since hatching, (2) Fledglings that hatched from unknown locations that are found utilizing the Army-supported management areas are counted if they appear at least 10 weeks of age, and (3) During the leg banding process, any fledglings near or within the Army-supported management areas that were considered at least 10 weeks of age or older were captured and banded.

Despite 2022/2023 having the highest number of nests monitored, number of eggs laid, number of eggs hatched, and max gosling seen, only 4 goslings (4%) survived to fledge. The 2 feral dogs observed on 28 December 2022 are a likely cause of the low gosling survivorship. Prior to sighting the dogs, we observed, via camera or in person, 32 goslings with their parents. By 5 January 2023, we observed these same parents with zero goslings. In addition, throughout the breeding season, we observed Hawaiian Hawks perched or circling in the sky above where the goslings' families were located. Although we did not witness hawks depredating goslings, hawks may have captured and consumed goslings contributing to the lower survivorship this breeding season.

This breeding season we removed at least 56 predators (live traps and A24 traps). Despite similar trapping efforts to previous years, no cats were caught this trapping season. Mongoose captures returned numbers more comparable to prior years despite the relatively large number captured last year (Table A.8). We assume this increased removal conferred a positive conservation benefit to the nesting geese in the Army-supported management areas.

The work performed for Hawaiian Goose conservation at HFNWR continues to support and benefit the goose population with predator removal and enhanced nesting/foraging habitat for geese, which are important steps toward the overall success of goose conservation at the refuge.

Table A.8. Predators captured in live traps on Army-supported management areas of Hakalau Forest National Wildlife Refuge during geese breeding seasons, 2017–2022

Breeding Season	Traps Deployed	Total Captured	Cats	Mongoose	Rats
2017/2018[a]	102	11	1	10	0
2018/2019	55	16	2	8	6
2019/2020	55	12	2	9	1
2020/2021	71	15	5	8	2
2021/2022	71	28	3	23	2
2022/2023	71	8	0	8	0
Total		**90**	**13**	**66**	**11**

[a] Trappings for the 2017/2018 breeding season began in October.

A.2.3 Hawaiian Hoary Bat

A.2.3.1 Introduction

We implement management for the Hawaiian hoary bat at PTA to meet SOO task 3.2.2.1 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 was to determine occupancy and seasonal activity patterns throughout the installation between 2014 and 2023. The project was aimed to identify habitat association based on 5 vegetation classes, and bat prevalence in potential treeland roosting habitats more generally.

A.2.3.2 Monitoring for the Hawaiian Hoary Bat at PTA

In FY 2023, we collected occupancy data during the peak of activity (September 2023 to December 2023) at the 45 sites previously sampled and we collected seasonal bat activity at the 5 permanent monitoring locations. Due to staff shortage the seasonal and occupancy bat activity data was not incorporated into the analysis for this reporting period. We plan to incorporate the data in FY 2024.

Incidental Take Statement Requirements

Direct Take due to Military Activities

No Hawaiian hoary bats were directly taken (e.g., injured or killed) at PTA during the reporting period. See Section A.2.4 for a discussion regarding indirect take as a result of habitat loss.

Direct Take due to Bat Entanglements on Barbed Wire Security Fences

No Hawaiian hoary bat entanglements were discovered at PTA during the reporting period.

Discussion for Hawaiian Hoary Bat Management

In previous years, acoustic occupancy and activity analyses showed that bats are present across the installation throughout the year and that activity peaks during the autumn months. These analyses complement each other by emphasizing time-of-year effects on bat prevalence. 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). Similar to trends in bat prevalence in other studies (Gorresen et al. 2013, Gorresen et al. 2015), bat activity peaked at PTA between the end of the lactation cycle (August) and the beginning of the fledging cycle (September). Despite the uncertainties, the increase in activity from August to September appears to be significant and may be a cause of interannual variation in bat prevalence.

Despite having limitations in completing the bat seasonal activity and occupancy data analysis this reporting period. We know that the 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 Hawaiʻi Island not previously studied.

In FY 2024, we will continue to monitor bats and improve knowledge of seasonal activity and occupancy estimates at PTA to help evaluate the impact of potential hazards to bats such as fire, military training, or construction. In addition, in FY 2024 we plan to complete 2 technical reports and 1 conservation plan, *5 year Hawaiian Hoary Bat Occupancy and Activity at PTA, Changes in Treeland Roosting Habitat at PTA ,* and *Hawaiian Hoary Bat Conservation Management Plan at PTA*. These documents will help manage the Hawaiian hoary bat and its associated habitats at PTA, minimize long-term constraints to military training, and satisfying requirements to develop and coordinate such a plan with agency partners.

A.2.4 WILDLAND FIRE IMPACTS TO WILDLIFE

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.

A.2.4.1 Keʻāmuku Maneuver Area Complex Fire

On 12 February 2023, at approximately 1520 hours, a wildland fire ignited at KMA. Post-fire inspection revealed that lightning strikes ignited 2 fires, which together burned approximately 97 ha of woodland vegetation believed to provide Hawaiian hoary bat roosting habitat. The cause of the KMA Complex Fire was natural and not related to military training activity; therefore, no indirect incidental take occurred because of Army activities. No bat carcasses were reported from the burn area during operations or other field assessments and direct impacts to Hawaiian hoary bat are assumed to be negligible. Refer to Section 8.0 of this report for additional information regarding the wildland fires.

A.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 deemed military-readiness activities. NEPA documents for military activities and the PTA INRMP (USAG-PTA 2020) both address management for MBTA-protected species. The INRMP also establishes annual reporting requirements for incidental take resulting from military readiness activities. No incidental take occurred for migratory birds due to military readiness activities at PTA in FY 2023.

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[USFWS] United States Fish and Wildlife Service. 2019. Federal Register Vol. 84 No. 244: Endangered and threatened wildlife and plants; reclassifying the Hawaiian Goose from endangered to threatened with a Section 4(d) Rule. 84 FR 69918. Washington (DC): Department of the Interior, US Fish and Wildlife Service. 26 p.

[USFWS] United States Fish and Wildlife Service. 2020. Federal Register Vol. 85 No. 1: Endangered and threatened wildlife and plants; removing the Hawaiian Hawk from the federal list of endangered and threatened wildlife. 85 FR 164. Washington (DC): Department of the Interior, US Fish and Wildlife Service. 26 p.

APPENDIX B ABUNDANCE ESTIMATE CORRECTIONS FOR 6 SPECIES

This appendix documents errors discovered in CEMML's 2020 analysis of federally listed species data to produce estimates of species abundance for the following 6 species:

- *Exocarpos menziesii*
- *Festuca hawaiiensis*
- *Haplostachys haplostachya*
- *Silene hawaiiensis*
- *Silene lanceolata*
- *Stenogyne angustifolia*

Incorrect abundance estimates were published and distributed for these species in regulatory and interagency documents including:

(1) 2019–2021 Biennial Report
(2) 2020 and 2022 Annual Compliance Reports
(3) 2020–2022 Quarterly Progress Reports
(4) 2020, 2021, and 2022 INRMP Update Presentations to Agency Partners
(5) 2020, 2021, and 2022 Recovery Permit Reports
(6) 2023 Post-Disturbance Assessment for the 2022 Leilani Fire in Training Area 22

Incorrectly calculated data were also distributed to DoD partners and contractors in support of (1) the Draft Programmatic Biological Assessment (PBA) in preparation for the upcoming ESA Section 7 consultation, and (2) a Draft Environmental Impact Statement (EIS) in support of upcoming negotiations for a land lease renewal between the Army and the State of Hawaii. Contractors affected on these projects include ERDC-CERL for the PBA and G70 for the AATLR EIS. These data have also been used in the first public review draft of the EIS.

B.1 BACKGROUND AND INITIAL PROJECT DESIGN

In 2016 the PTA Natural Resources Program began a botanical resurvey of the installation to meet environmental compliance obligations stemming from the 2003 Biological Opinion. This effort was called *Installation Wide Survey 2* (IWS 2) and served to refresh data collected during the first round of installation wide surveys (IWS 1) that took place between 2011 and 2015 (CEMML 2022). The main goal of this project was to document the abundances and distributions of 16 rare species occurring at PTA that are listed and protected under the Endangered Species Act.

The initial approach taken for IWS 2 was to systematically survey all known focal species distributions across the installation using transects spaced 10 meters apart as a guide to ensure all appropriate areas of the installation were accounted for (a multi-species complete survey). Importantly, with this survey design it was not necessary to take species-specific distributions into consideration since all areas would be searched, and all species would be documented wherever they were found. However, in 2018, due to shifts in project goals and timelines driven by the need to inform PBA and EIS development, the project was converted from a multi-species survey into a species-specific sampling design to yield results more quickly.

B.2 SAMPLING FRAMEWORK

To accurately estimate plant species abundances and to efficiently meet expedited timelines, we used a simple random sampling approach, where abundance estimates are derived using data collected from a sample of plots covering the entire known distribution of species occurrences. These distributions were based on data from IWS 1 collected between 2011 and 2015. Plots were selected for sampling so that all areas in proximity to known listed species occurrences had an equal probability of selection. This was done for each species independently so that we could clearly track species-specific data elements needed to calculate abundance estimates. Data elements included:

(1) The total number of plots present across each species' distribution.
(2) A 30% sample of those plots randomly selected and spatially dispersed by fence unit.
(3) Plant counts for all species in each selected plot (including zeros when no plants were found).

The process used to calculate species abundances from these data is as follows:

(1) For each species, calculate the average number of plants per plot (including zeros) across all selected sample plots.
(2) Using each species' average per-plot count, multiply the average count by the total number of known plots in each species' overall distribution
(3) This value represents the total estimated abundance for each species.
(4) We then calculate a 90% Confidence Interval (CI) for each species based on the between-plot variance in plant counts.
(5) This 90% CI represents the upper and lower estimates of abundance for each species between which we are 90% confident the true estimate lies.

Again, it is imperative that ALL data are included in the calculation of the average count per plot, including plots with no plants present (i.e., zero-count plots), for this approach to yield accurate results.

B.3 ISSUES AND ERRORS STEMMING FROM DESIGN CONVERSION

The conversion of this project from a multi-species full census to a species-specific simple random sampling design was complicated, requiring the establishment of an appropriate plot size for sampling units, defining a sample universe of plots for each species based on known IWS 1 distributions, and sample selection criteria that were unbiased while also accounting for the large variation in habitat characteristics and clustering tendencies among different species—to ensure this was considered in sample plot selection, we included a spatial dispersion component where we selected species-specific plots for sampling by fence unit, where 30% of all plots containing a given species within each fence unit were selected for sampling.

The overall process required layering many complex geoprocessing tasks in a GIS to yield the data elements needed to perform this analysis for each species as described above. During this process, some data elements became difficult to track through to the end products—the most important of these being the species-specific components of the design (i.e., species-specific plot selections and sampling universes). To design and build a data collection framework for botanical survey crew to begin data collection in a timely manner, we focused on providing the framework of *plots to read,* since operationally, surveyors would be looking for all species in all plots selected for sampling regardless of which species the plot was initially selected to be sampled for. Because of this, we lost focus of which plots were selected for which species, and similarly which plots comprised species-specific sample universes. Therefore, our ability to ensure all appropriate data were incorporated in species-specific calculations became compromised.

When data were extracted for analysis, it was pulled down for all plots for which we had count data. These data included some zero values in plots where multiple species were known to co-occur, but when one or more of the species were not found at the time of survey (Figure B.1). As seen in the figure, when a plot that was selected for a given species had no individuals present for that species, but did contain other species, a value of *zero* was recorded for the target species. If, as in plot B, there were no plants of any target species present, no data were taken at all for the plot. However, for the purposes of data analysis it was important that a *zero* be recorded for the target species (the species the plot was selected to sample). Because we did not account for species-specific attributes of the design, we did not appropriately incorporate zero counts from plots that were read for a given species where no plants were present. These errors were difficult to detect because of the presence of zero data from multi-species plots as described above—this served to obfuscate the exclusion of single-species plot zero data. In other words, our design did not fully account for all plots that were selected for sampling for a given species, as should have been the case.

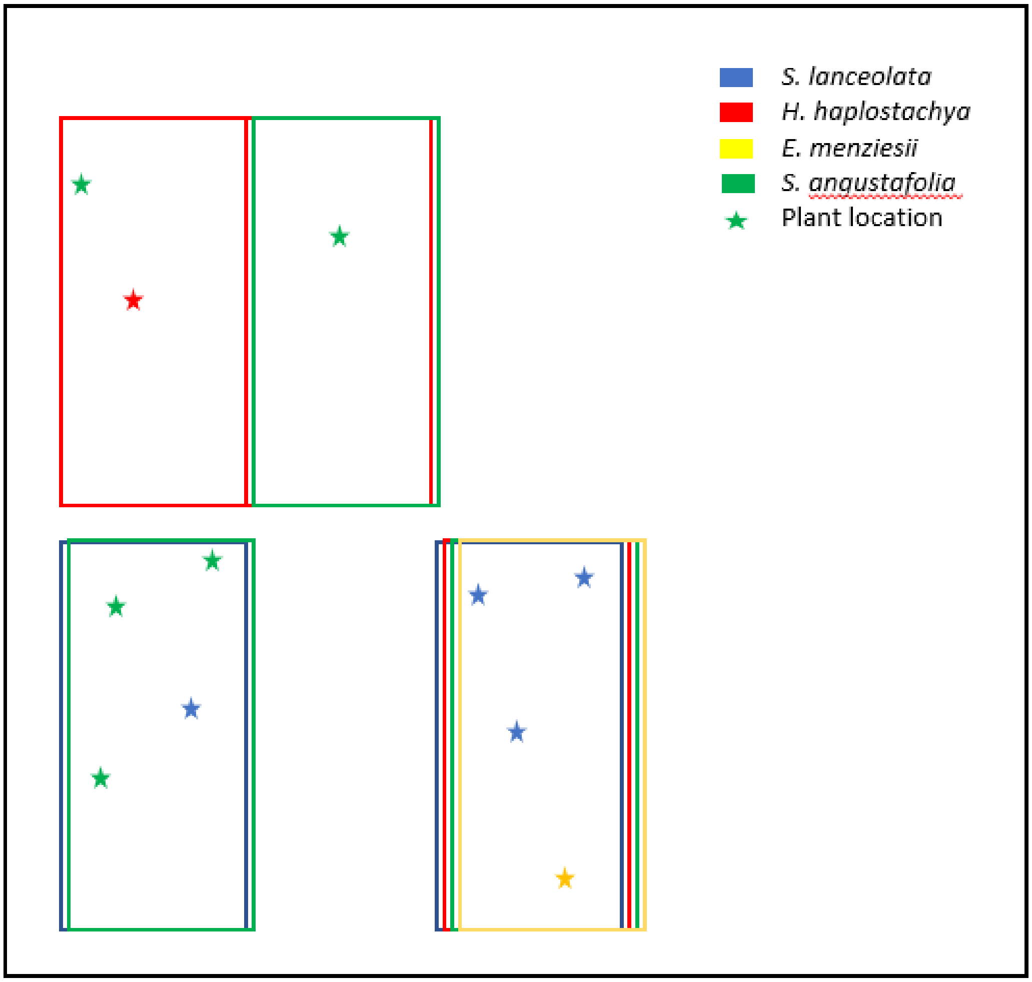

Figure B.1. Illustration of zero data being generated from species-specific monitoring plots where multiple species co-occur

For the analysis to have been correct, we needed to manually include zero values for every plot selected for sampling for a given species in which no plants were present. For example, if for a given species we selected 100 plots for sampling, and after extracting the data collected for those plots, we had 62 count values (i.e., data for 62 of the plots), we needed to manually enter 38 zeros into the average count per plot calculation so that all species-specific plots selected for sampling (62 + 38 = 100) were accounted for. The exclusion of zero values generally creates artificially inflated average plot count values, and therefore artificially inflated abundance estimates. There was one exception to this effect, where *Festuca hawaiiensis* resulted in a net underestimation (Table B.1, Table B.2, Table B.3). This was caused by this species being incidentally present in plots selected for other species (an incorrectly inflated number of plots to calculate average counts for that species). Once we incorporated the correct count of *F. hawaiiensis*-specific plots into plot average calculations, its abundance estimate increased by improperly excluding zero values also affects our calculations of between-plot variance in counts and therefore also impacted our calculated 90% confidence intervals, rendering those calculations incorrect as well.

Table B.1. INCORRECTLY calculated estimated abundance and 90% confidence intervals for plant species listed under the Endangered Species Act sampled at Pōhakuloa Training Area in 2020

Species	Estimated Abundance	1/2 Confidence Interval	Lower 90% Confidence Interval	Upper 90% Confidence Interval
Exocarpos menziesii	2,068	224.13	1,844	2,292
Festuca hawaiiensis	9,905	1,437	8,468	11,342
Haplostachys haplostachya	24,010	5,336	18,674	29,346
Silene hawaiiensis	9,076	1,125	7,951	10,200
Silene lanceolata	11,772	1,853	9,919	13,624
Stenogyne angustifolia	14,044	3,100	10,945	17,144

Table B.2. CORRECTED estimated abundance and 90% confidence intervals for plant species listed under the Endangered Species Act sampled at Pōhakuloa Training Area in 2020

Species	Estimated Abundance	1/2 Confidence Interval	Lower 90% Confidence Interval	Upper 90% Confidence Interval
Exocarpos menziesii	1,875	417	1,458	2,292
Festuca hawaiiensis	11,699	3,334	8,365	15,033
Haplostachys haplostachya	17,215	7,992	9,223	25,206
Silene hawaiiensis	7,479	1,927	5,552	9,406
Silene lanceolata	10,326	3,354	6,972	13,679
Stenogyne angustifolia	12,038	5,354	6,684	17,392

Table B.3. PERCENT DIFFERENCE between incorrect and corrected abundance estimates and 90% confidence intervals for plant species listed under the Endangered Species Act sampled at Pōhakuloa Training Area in 2020

Species	Estimated Abundance	Lower 90% Confidence Interval	Upper 90% Confidence Interval
Exocarpos menziesii	-9%	-21%	0%
Festuca hawaiiensis	18%	-1%	33%
Haplostachys haplostachya	-28%	-51%	-14%
Silene hawaiiensis	-18%	-30%	-8%
Silene lanceolata	-12%	-30%	0%
Stenogyne angustifolia	-14%	-39%	1%

B.4 REASONS FOR DELAYED DISCOVERY

We did not discover the issues described in this appendix until November 2023 during the analysis of new Tier 2 project data and compilation of results for the Fiscal Year 2022-2023 Biennial Report. The reasons for this eluding our knowledge for as long as it did are severalfold. All these factors have been explored thoroughly with the intent of ensuring we put in place fail-safes so that issues like this are highly unlikely to occur again. Factors impacting our detection of this error were: (1) resultant estimates of species abundances were comparable to past estimates, and any deviations could be reasonably explained as functions of environmental factors, management actions, and species characteristics; (2) data extracted for analysis from the GIS appeared to include zero values, since some plots with zero counts were incorporated into the averaging calculations; (3) inexperience with converting one large study design into another large, more complex design—as a result we were not aware of potential problems (4) lack of a process to vet this work with the entire team at various key points of the analysis and, in hindsight, we should have reviewed the work after initial summarization, data extraction , and again at the time final results were available; and (5) inconsistent staffing at the time of project implementation and analysis—most significantly in the position of Botanical Program Manager. Because the Botanical Program Manager position was vacant at the time of analysis, we were missing a key reviewer that may have recognized the mistake earlier. As a result of this error, we have developed new processes and system-checks to prevent similar issues from happening again.

B.5 REMEDY AND RESPONSE

When we discovered the improper exclusion of zero-count plot data, we reran all data extractions and analyses to produce corrected abundance estimates for all species affected (Table B.1, Table B.2, Table B.3). The actual recalculation of these values was straightforward and quick after the mistake was identified. Beyond ensuring the best, most accurate results possible, we will apply the important lessons learned from this incident to all current and future projects.

A letter summarizing the corrected abundance estimates will be transmitted directly to the US Fish and Wildlife Service and the State of Hawaii Department of Land and Natural Resources in FY 2024.

B.6 REFERENCE

[CEMML] Center for Environmental Management of Military Lands. 2022. Army natural resources program at Pōhakuloa Training Area biennial report, 01 Oct 2019 – 30 Sep 2021. Fort Collins (CO): Colorado State University. 465 p.

APPENDIX C PLANT AND ANIMAL SPECIES LISTS

In 2023, we updated the plant species list and plan a similar update for the animal species list in 2024. To generate the updated plant list, we reviewed and compiled data from survey and monitoring reports dating back to 1977 and in-house data. Where possible we included the date the plant species was last documented at PTA.

To ensure taxonomic names are current for plants and animals, we validated all names using the online Interagency Taxonomic Information System tool (https://www.itis.gov/) curated by the USGS and the Smithsonian Institute. For bird names we follow naming guidance and conventions of the American Ornithological Society, and have updated our bird species names to reflect new guidance for English common names for several bird species that occur at PTA. However, for federally species, we use the taxonomic name published in the Federal Register in a listing rule or a species list until the USFWS publishes a technical correction to species' name in the Federal Register.

The plant species at risk list was generated from the installation wide surveys 2015-2020 (a copy of the master listed used for the analysis was not saved). For the plant species with subtaxa at PTA (e.g., varieties or subspecies), if the species meets SAR criteria, only the species is listed and all subtaxa are assumed to also be SAR. The animal species at risk list was generated from several survey and monitoring efforts (Gon et al. 2003, Howarth and Stone 1996, Hawaiʻi Natural Heritage Program and Oboyski 1998, Oboyski et al. 2001, Daly and Magnacca 2003, Magnacca and King 2013). Abridged versions of the master plant and animal SAR spreadsheet are presented below.

Table C.1. Plant species at risk at PTA per Department of Defense criteria

Scientific Name	Common Name	Hawaiian Name	Nature Serve Status	IUCN Status	HI SCO	Last seen at PTA
Alphitonia ponderosa	Kauila	Kauila	G2	VU	Y	2023
Argemone glauca	Smooth prickly-poppy	Pua kala	G2	NE	N	2023
Bidens menziesii	Menzies' bur-marigold	Koʻokoʻolau	G2T2	NE	N	2019
Carex wahuensis ssp. *wahuensis*	Oʻahu sedge	n/a	T2	NE	N	2023
Euphorbia multiformis var. microphylla	Variable sandmat	ʻAkoko	G3T2	NE	?	?
Ephorbia olowaluana	Alpine sandmat	ʻAkoko	G2	NT	N	2023
Cystopteris douglasii	Douglas' bladder fern	n/a	G2	NE	Y	2019
Dubautia arborea	Mauna Kea dubautia	Naʻenaʻe	G1	NE	Y	2023
Dubautia linearis ssp. hillebrandii	Hillebrand's dubautia	Naʻenaʻe	G3T2	NE	?	?
Eragrostis deflexa	Pacific lovegrass	n/a	G2	NE	Y	2023
Eragrostis leptophylla	Mountain lovegrass	n/a	G2	NE	N	2019
Exocarpos gaudichaudii	Gaudichaud's Exocarpos	Au	G1	EN	Y	2023
Ipomoea tuboides	Hawaiʻi morning glory	Koaliʻawa	G2	NE	Y	2023
Korthalsella latissimi	Hawaiian mistletoe	Hulumoa	G2G3	NE	N	2019
Lindsaea repens var. macaraena	Creeping necklace fern	n/a	G5T2	NE	?	?
Melanthera subcordata	Grassland nehe	Nehe	G2	NE	N	2019
Melicope hawaiensis	Alani	Alani	G2	VU	Y	2020
Metrosideros var. *glaberrima*	ʻōhiʻa lehua	ʻōhiʻa lehua	G5T2	VU	?	?
Panicum konaense	Kona panicgrass	Pili uka	G2G3	NE	N	2019
Panicum pellitum	Collie panicgrass	Kaiʻoiʻo	G2G3	NE	N	2019
Phytolacca sandwicensis	Hawaiian pokeberry	Pōpolo kū mai	G2	NE	Y	2019
Pittosporum terminalioides	Cream cheesewood	Hoʻawa	G2	VU	Y	2023
Rumex giganteus	Climbing dock	Pāwale	G2G3	NE	N	2019
Rumex skottsbergii	Lava dock	Pāwale	G2	NE	N	2019
Santalum ellipticum	Coast sandalwood	ʻIliahi	G2	NE	Y	2023

Table C.1. Plant species at risk at PTA per Department of Defense criteria (cont.)

Scientific Name	Common Name	Hawaiian Name	Nature Serve Status	IUCN Status	HI SCO	Last seen at PTA
Santalum paniculatum var. *paniculatum*	Paniculate sandalwood	ʻIliahi	G3T2	NE	N	2019
Santalum paniculatum var. *pilgeri*	Pilgerʻs sandalwood	ʻIliahi	G3T2	NE	N	2019
Sicyos anunu	Lava bur cucumber	ʻAnunu	G2	NE	N	2023
Sicyos lasiocephalus	Hualālai bur cucumber	ʻAnunu	G2	NE	N	2023
Stenogyne rugosa	Wrinkled stenogyne	Māʻohiʻohi	G2	NE	?	?
Tetramolopium consanguineum	Narrow-leaf pāmakani	Pāmakani	G1	NE	Y	2023
Tetramolopium humile var. *sublaeve*	Alpine tetramolopium	--	G3T1	NE	?	1997 (2023?)
Trisetum glomeratum	Mountain pili	Pili uka	G2	NE	N	2019
Wikstroemia pulcherrima	Kohala false ohelo	ʻĀkia	G2	NE	?	2023

Table C.2. Master plant species list

Family	Scientific Name	Common Name	Hawaiian Name	Origin	ESA	Nature Serve Rank	IUCN Rank	DoD SAR
Moss and Lichens (Bryophyta and Ascomycota)								
Stereocaulaceae	*Stereocaulon vulcani*	Pioneer lichen	–		–	G3	–	–
Grimmiaceae	*Racomitrium lanuginosum*	Hoary rock moss	–		–	G5	–	–
Fern and Fern Allies (Pteridophyta)								
Aspleniaceae	*Asplenium adiantum-nigrum*	Black spleenwort	ʻIiwaʻiwa	IND	–	G5	none	N
Aspleniaceae	*Asplenium aethiopicum*	Egyptian/ African spleenwort	ʻIwaʻiwa a Kane	IND	–	–	VU	N
Aspleniaceae	*Asplenium peruvianum* var. *insulare*	Fragile fern	–	END	FE	G1	none	N
Aspleniaceae	*Asplenium trichomanes*	Maidenhair spleenwort	ʻOāliʻi	IND	–	G5	none	N
Blechnaceae	*Sadleria cyatheoides*	Amaumau fern	ʻAmaʻu	END	–	–	none	–

Table C.2. Master plant species list (cont.)

Family	Scientific Name	Common Name	Hawaiian Name	Origin	ESA	Nature Serve Rank	IUCN Rank	DoD SAR
Dennstaedtiaceae	*Pteridium aquilinum* ssp. *decompositum*	Decomposition bracken fern	–	END	–	T3	none	N
Dryopteridaceae	*Cyrtomium caryotideum*	Dwarf netvein hollyfern	ʻĀhina kuahiwi	IND	–	G5	none	N
Dryopteridaceae	*Cyrtomium falcatum*	Japanese netvein hollyfern	–	INT	–	–	–	N
Dryopteridaceae	*Cystopteris douglasii*	Douglas' bladderfern	–	END	–	G2	–	Y
Dryopteridaceae	*Dryopteris wallichiana*	Alpine woodfern	Laukahi	IND	–	G4	none	N
Polypodiaceae	*Lepisorus thunbergianus*	Weeping fern	Pakahakaha	IND	–	G5	none	N
Polypodiaceae	*Polypodium pellucidum* var. *vulcanicum*	Dotted polypody	ʻAe	END	–	–	none	–
Psilotaceae	*Psilotum complanatum*	Flatfork fern	Moa	IND	–	G4	none	N
Psilotaceae	*Psilotum nudum*	Whisk fern	Moa	IND	–	G5	LC	N
Pteridaceae	*Adiantum hispidulum*	Rough maidenhair fern	–	INT	–	–	–	–
Pteridaceae	*Adiantum raddianum*	Maidenhair fern	–	INT	–	–	–	–
Pteridaceae	*Doryopteris decora*	Lance fern	–	END	–	G4	none	N
Pteridaceae	*Pellaea ternifolia*	Cliffbrake	Kalamoho	IND	–	–	–	–
Pteridaceae	*Pteris cretica*	Cretan brake	ʻŌali	IND	–	G5	none	N
Thelypteridaceae	*Cyclosorus parasiticus*	Parasitic maiden fern	–	INT/IND	–	–	–	–
Thelypteridaceae	*Macrothelypteris torresiana*	Swordfern	–	NA	–	–	–	–
Conifers (Coniferophyta)								
Pinaceae	*Pinus coulteri*	Coulter pine	–	INT	–	–	–	–
Pinaceae	*Pinus radiata*	Monterey pine	–	INT	–	–	–	–
Monocots (Anthophyta)								
Cyperaceae	*Bulbostylis capillaris*	Densetuft hairsedge	–	INT	–	–	–	–
Cyperaceae	*Carex inversa*	Knob sedge	–	INT	–	–	–	–
Cyperaceae	*Carex wahuensis* ssp. *rubiginosa*	Oahu sedge	–	END	–	T3	none	N
Cyperaceae	*Carex wahuensis* ssp. *wahuensis*	Oʻahu sedge	–	END	–	T2	–	Y

Table C.2. Master plant species list (cont.)

Family	Scientific Name	Common Name	Hawaiian Name	Origin	ESA	Nature Serve Rank	IUCN Rank	DoD SAR
Cyperaceae	*Cyperus hillebrandii* var. *decipiens*	Hillebrand's flatsedge	–	END	–	T3	none	N
Cyperaceae	*Cyperus hillebrandii* var. *hillebrandii*	Hillebrand's flatsedge	–	END	–	T3	none	N
Cyperaceae	*Morelotia gahniiformis*	Gaudichaud's sawsedge	–	IND	–	G3	none	N
Juncaceae	*Juncus planifolius*	Broadleaf rush	–	INT	–	–	–	–
Juncaceae	*Luzula hawaiiensis* var. *hawaiiensis*	Hawaiʻi woodrush	–	END	–	T3	none	N
Liliaceae	*Dianella sandwicensis*	Hawaiian lily	ʻUkiʻuki	IND	–	G4	none	N
Poaceae	*Agrostis sandwicensis*	Hawaiʻi bentgrass	–	IND	–	G3	none	N
Poaceae	*Anthoxanthum odoratum*	Sweet vernalgrass	–	INT	–	–	–	–
Poaceae	*Avena fatua*	Oatgrass	–	INT	–	–	–	–
Poaceae	*Bothriochloa pertusa*	Pitted beardgrass	–	INT	–	–	–	–
Poaceae	*Briza minor*	Little quaking grass	–	INT	–	–	–	–
Poaceae	*Bromus catharticus*	Rescuegrass	–	INT	–	–	–	–
Poaceae	*Bromus diandrus*	Ripgut brome	–	INT	–	–	–	–
Poaceae	*Cenchrus ciliaris*	Buffelgrass	–	INT	–	–	–	–
Poaceae	*Cenchrus clandestinus*	Kikuyu grass	–	INT	–	–	–	–
Poaceae	*Cenchrus echinatus*	Common sandbur	–	INT	–	–	–	–
Poaceae	*Cenchrus polystachios*	Mission grass	–	INT	–	–	–	–
Poaceae	*Cenchrus setaceus*	Fountain grass	–	INT	–	–	–	–
Poaceae	*Chloris barbata*	Swollen fingergrass	–	INT	–	–	–	–
Poaceae	*Chloris gayana*	Rhodes grass	–	INT	–	–	–	–
Poaceae	*Chloris radiata*	Radiate fingergrass	–	INT	–	–	–	–
Poaceae	*Chloris virgata*	Feather fingergrass	–	INT	–	–	–	–
Poaceae	*Cymbopogon refractus*	Barbwire grass	–	INT	–	–	–	–
Poaceae	*Cynodon dactylon*	Bermuda grass	–	INT	–	–	–	–
Poaceae	*Cynodon nlemfuensis*	African Bermudagrass	–	INT	–	–	–	–

Table C.2. Master plant species list (cont.)

Family	Scientific Name	Common Name	Hawaiian Name	Origin	ESA	Nature Serve Rank	IUCN Rank	DoD SAR
Poaceae	*Dactylis glomerata*	Cocksfoot	–	INT	–	–	–	–
Poaceae	*Deschampsia nubigena*	Alpine hairgrass	–	END	–	–	none	N
Poaceae	*Digitaria ciliaris*	Henry's crabgrass	–	INT	–	–	–	–
Poaceae	*Ehrharta calycina*	Perennial veldtgrass	–	INT	–	–	–	–
Poaceae	*Ehrharta stipoides*	Meadow ricegrass	–	INT	–	–	–	–
Poaceae	*Eragrostis atropioides*	Hardstem lovegrass	–	END	–	–	none	N
Poaceae	*Eragrostis cilianensis*	Candy grass	–	INT	–	–	–	–
Poaceae	*Eragrostis cumingii*	Sheepgrass	–	INT	–	–	–	–
Poaceae	*Eragrostis deflexa*	Pacific lovegrass	–	END	–	G2	–	Y
Poaceae	*Eragrostis leptophylla*	Mountain lovegrass	–	END	–	G2	–	Y
Poaceae	*Eragrostis monticola*	Kalamālō	Kalamālō	END	–	G3	none	N
Poaceae	*Eragrostis tenuifolia*	Elastic grass	–	INT	–	–	–	–
Poaceae	*Festuca hawaiiensis*	Hawaii fescue	–	END	FE	G1	none	N
Poaceae	*Gastridium ventricosum*	Nitgrass	–	INT	–	–	–	–
Poaceae	*Holcus lanatus*	Velvet grass	–	INT	–	–	–	–
Poaceae	*Hordeum murinum* ssp. *leporinum*	Leporinum barley	–	INT	–	–	–	–
Poaceae	*Koelaria macrantha*	Prairie Junegrass	–	INT	–	–	–	–
Poaceae	*Lachnagrostis filiformis*	Pacific bentgrass	–	IND	–	–	–	–
Poaceae	*Lolium perenne*	Perennial ryegrass	–	INT	–	–	–	–
Poaceae	*Megathyrsus maximus*	Guinea grass	–	INT	–	–	–	–
Poaceae	*Melinis minutiflora*	Molasses grass	–	INT	–	–	–	–
Poaceae	*Melinis repens*	Natal redtop	–	INT	–	–	–	–
Poaceae	*Nassella cernua*	Needlegrass	–	INT	–	–	–	–
Poaceae	*Oplismenus hirtellus*	Bristle basketgrass	Honohono kikui	INT	–	–	–	–
Poaceae	*Panicum konaense*	Kona panicgrass	Pili uka	END	–	G2	–	Y

Table C.2. Master plant species list (cont.)

Family	Scientific Name	Common Name	Hawaiian Name	Origin	ESA	Nature Serve Rank	IUCN Rank	DoD SAR
Poaceae	*Panicum pellitum*	Maui panicgrass	Kaiʻoiʻo	END	–	G2	–	Y
Poaceae	*Panicum tenuifolium*	Mountain pili	Pili uka	END	–	G3	none	N
Poaceae	*Paspalum dilatatum*	Dallis grass	–	INT	–	–	–	–
Poaceae	*Paspalum notatum*	Bahia grass	–	INT	–	–	–	–
Poaceae	*Piptatherum miliaceum*	Smilograss rice millet	–	INT	–	–	–	–
Poaceae	*Poa annua*	Annual bluegrass	–	INT	–	–	–	–
Poaceae	*Poa pratensis*	Kentucky bluegrass	–	INT	–	–	–	–
Poaceae	*Polypogon interruptus*	Ditch polypogon	–	INT	–	–	–	–
Poaceae	*Polypogon monspeliensis*	Rabbitfoot grass	–	INT	–	–	–	–
Poaceae	*Rytidosperma pilosum*	Hairy wallaby grass	–	INT	–	–	–	–
Poaceae	*Rytidosperma semiannulare*	Tasmanian wallaby grass	–	INT	–	–	–	–
Poaceae	*Schedonorus arundinaceus*	Tall fescue	–	INT	–	–	–	–
Poaceae	*Sporobolus africanus*	African dropseed	–	INT	–	–	–	–
Poaceae	*Sporobolus indicus*	West Indian dropseed	–	INT	–	–	–	–
Poaceae	*Trisetum glomeratum*	Mountain pili	Pili uka	END	–	G2	–	Y
Poaceae	*Vulpia bromoides*	Brome fescue	–	INT	–	–	–	–
Poaceae	*Vulpia myuros*	Rat tail fescue	–	INT	–	–	–	–
Smilaceaae	*Smilax melastomifolia*	Catbrier	Hoi kuahiwi	END	–	G3	none	N
Dicots (Magnoliopsida)								
Adoxaceae	*Sambucus nigra* ssp. *canadensis*	Elderberry	–	INT	–	–	none	–
Aizoaceae	*Carpobrotus edulis*	Ice plant	–	INT	–	–	–	–
Aizoaceae	*Lampranthus amoenus*	Midday flower	–	INT	–	–	–	–
Aizoaceae	*Lampranthus glomeratus*	Ice plant	ʻĀulikuli lei	INT	–	–	–	–
Amaranthaceae	*Amaranthus spinosus*	Spiny amaranth	–	INT	–	–	–	–
Amaranthaceae	*Atriplex semibaccata*	Australian saltbush/saltweed	–	INT	–	–	–	–
Amaranthaceae	*Atriplex suberecta*	Peregrine saltbush	–	INT	–	–	–	–

Table C.2. Master plant species list (cont.)

Family	Scientific Name	Common Name	Hawaiian Name	Origin	ESA	Nature Serve Rank	IUCN Rank	DoD SAR
Amaranthaceae	*Chenopodium album*	White goosefoot	–	INT	–	–	–	–
Amaranthaceae	*Chenopodium murale*	Nettle leaf goosefoot	–	INT	–	–	–	–
Amaranthaceae	*Chenopodium oahuense*	ʻĀweoweo	ʻĀweoweo	END	–	G3	none	N
Amaranthaceae	*Dysphania ambrosioides*	Mexican tea	–	INT	–	–	–	–
Amaranthaceae	*Dysphania pumilio*	Clammy goosefoot	–	INT	–	–	–	–
Amaranthaceae	*Nototrichium sandwicense*	Hawaiʻi rockwort	Kūluʻi	END	–	G3	none	N
Amaranthaceae	*Salsola tragus*	Russian thistle	–	INT	–	–	–	–
Anachardiaceae	*Schinus molle*	American pepper	–	INT	–	–	–	–
Annonaceae	*Annona cherimola*	Cherimoya	–	INT	–	–	–	–
Apiaceae	*Cyclospermum leptophyllum*	Fir-leaved celery	–	INT	–	–	–	–
Apiaceae	*Daucus pusillus*	American carrot	–	IND	–	G5	LC	N
Apiaceae	*Foeniculum vulgare*	Fennel	–	INT	–	–	–	–
Apiaceae	*Petroselinum crispum*	Parsley	–	INT	–	–	–	–
Apiaceae	*Spermolepis hawaiiensis*	Hawaiʻi scaleseed	–	END	FE	G2	none	N
Apocynaceae	*Alyxia stellata*	Maile	Maile	IND	–	G3	none	N
Apocynaceae	*Asclepias curassavica*	Bloodflower	–	INT	–	–	–	–
Apocynaceae	*Gomphocarpus physocarpus*	Balloon plant	–	INT	–	–	–	–
Apocynaceae	*Nerium oleander*	Oleander	–	INT	–	–	–	–
Araucariaceae	*Araucaria heterophylla*	Norfolk Island pine	–	INT	–	–	–	–
Asparagaceae	*Agave americana*	American century plant	–	INT	–	–	–	–
Asparagaceae	*Agave sisalana*	Sisal hemp	–	INT	–	–	–	–
Asparagaceae	*Yucca gloriosa*	Spanish dagger	–	INT	–	–	–	–
Asparagaceae	*Cordyline fruticosa*	Tiplant	–	INT	–	–	–	–
Asteraceae	*Achillea millefolium*	Common yarrow	–	INT	–	–	–	–
Asteraceae	*Ageratina adenophora*	Crofton weed	–	INT	–	–	–	–
Asteraceae	*Ageratina riparia*	Spreading snakeroot	–	INT	–	–	–	–
Asteraceae	*Ageratum conyzoides*	Tropical whiteweed	–	INT	–	–	–	–

Table C.2. Master plant species list (cont.)

Family	Scientific Name	Common Name	Hawaiian Name	Origin	ESA	Nature Serve Rank	IUCN Rank	DoD SAR
Asteraceae	*Ageratum houstonianum*	Bluemink	–	INT	–	–	–	–
Asteraceae	*Ambrosia artemisiifolia*	Annual ragweed	–	INT	–	–	–	–
Asteraceae	*Ambrosia psilostachya*	Cuman ragweed	–	INT	–	–	–	–
Asteraceae	*Ambrosia pumila*	Dwarf bur ragweed	–	INT	–	–	–	–
Asteraceae	*Anthemis cotula*	Chamomile	–	INT	–	–	–	–
Asteraceae	*Bidens menziesii*	Menzies' bur-marigold	Koʻokoʻolau	END	–	G2	–	Y
Asteraceae	*Bidens menziesii* ssp. *filiformis*	Mauna Loa beggarticks	Koʻokoʻolau	END	–	G2T2	–	Y
Asteraceae	*Bidens pilosa*	Spanish needles	–	INT	–	–	–	–
Asteraceae	*Centaurea melitensis*	Napa thistle, tocalote,	–	INT	–	–	–	–
Asteraceae	*Cirsium vulgare*	Bull thistle	–	INT	–	–	–	–
Asteraceae	*Conyza bonariensis*	Hairy fleabane	–	INT	–	–	–	–
Asteraceae	*Conyza canadensis* var. *canadensis*	Canadian horseweed	–	INT	–	–	–	–
Asteraceae	*Conyza canadensis* var. *pusilla*	Canadian horseweed	–	INT	–	–	–	–
Asteraceae	*Crassocephalum crepidioides*	Redflower ragleaf	–	INT	–	–	–	–
Asteraceae	*Crepis capillaris*	Smooth hawksbeard	–	INT	–	–	–	–
Asteraceae	*Delairea odorata*	Cape ivy	–	INT	–	–	–	–
Asteraceae	*Dubautia arborea*	Mauna Kea dubautia	Kupaoa	END	–	G1	EN	Y
Asteraceae	*Dubautia ciliolata* ssp. *ciliolata*	Lava dubautia	Kupaoa	END	–	T3	none	N
Asteraceae	*Dubautia linearis*	Narrow-leaf dubautia	Kupaoa	END	–	G3	none	N
Asteraceae	*Dubautia linearis* ssp. *hillebrandii*	Hillebrand's dubautia	Kupaoa	END	–	T2	–	Y
Asteraceae	*Dubautia scabra*	Rough dubautia	Kupaoa	END	–	G3	none	N
Asteraceae	*Emilia fosbergii*	Florida tasselflower	–	INT	–	–	–	–
Asteraceae	*Emilia sonchifolia*	Lilac tasselflower	–	INT	–	–	–	–
Asteraceae	*Euchiton japonicus*	Father-and-child plant	–	INT	–	–	–	–
Asteraceae	*Euchiton sphaericus*	Tropical creeping cudweed	–	INT	–	–	–	–
Asteraceae	*Galinsoga parviflora*	Gallant soldier	–	INT	–	–	–	–
Asteraceae	*Galinsoga quadriradiata*	Shaggy soldier	–	INT	–	–	–	–

Table C.2. Master plant species list (cont.)

Family	Scientific Name	Common Name	Hawaiian Name	Origin	ESA	Nature Serve Rank	IUCN Rank	DoD SAR
Asteraceae	*Gamochaeta purpurea*	Purple cudweed	–	INT	–	–	–	–
Asteraceae	*Helichrysum foetidum*	Stinking strawflower	–	INT	–	–	–	–
Asteraceae	*Heterotheca grandiflora*	Telegraph weed	–	INT	–	–	–	–
Asteraceae	*Hypochaeris radicata*	Hairy cat's ear	–	INT	–	–	–	–
Asteraceae	*Lactuca sativa*	Garden lettuce	–	INT	–	–	–	–
Asteraceae	*Lactuca serriola*	Prickly lettuce	–	INT	–	–	–	–
Asteraceae	*Lipochaeta venosa*	Spreading nehe	Nehe	END	FE	G1	none	N
Asteraceae	*Melanthera subcordata*	Grassland nehe	Nehe	END	–	G2	–	Y
Asteraceae	*Parthenium hysterophorus*	False ragweed	–	INT	–	–	–	–
Asteraceae	*Picris hieracioides*	Hawkweed oxtongue	–	INT	–	–	–	–
Asteraceae	*Pluchea carolinensis*	Cure for all	–	INT	–	–	–	–
Asteraceae	*Pseudognaphalium sandwicensium* var. *hawaiiense*	ʻEnaʻena	ʻEnaʻena	END	–	G3T3	none	N
Asteraceae	*Pseudognaphalium sandwicensium* var. *kilaueanum*	ʻEnaʻena	ʻEnaʻena	END	–	G3T3	none	N
Asteraceae	*Pseudognaphalium sandwicensium* var. *sandwicensium*	ʻEnaʻena	ʻEnaʻena	END	–	G3T3	none	N
Asteraceae	*Reichardia tingitana*	False sowthistle	–	INT	–	–	–	–
Asteraceae	*Senecio madagascariensis*	Fireweed	–	INT	–	–	–	–
Asteraceae	*Senecio sylvaticus*	Wood groundsel	–	INT	–	–	–	–
Asteraceae	*Senecio vulgaris*	Common groundsel	–	INT	–	–	–	–
Asteraceae	*Sigesbeckia orientalis*	Small yellow crown-beard	–	INT	–	–	–	–
Asteraceae	*Sonchus asper*	Spiny sow thistle	–	INT	–	–	–	–
Asteraceae	*Sonchus oleraceus*	Common sow thistle	–	INT	–	–	–	–
Asteraceae	*Sphagneticola trilobata*	Wedelia	–	INT	–	–	–	–
Asteraceae	*Tagetes minuta*	Stinkweed	–	INT	–	–	–	–
Asteraceae	*Tetramolopium arenarium*	Maui tetramolopium	–	END	FE	G1	none	N

Table C.2. Master plant species list (cont.)

Family	Scientific Name	Common Name	Hawaiian Name	Origin	ESA	Nature Serve Rank	IUCN Rank	DoD SAR
Asteraceae	*Tetramolopium consanguineum* ssp. *leptophyllum*	Forest tetramolopium	Pāmakani	END	–	G1T1	–	Y
Asteraceae	*Tetramolopium humile*	Alpine tetramolopium	–	END	–	G3	none	N
Asteraceae	*Tetramolopium humile* var. *humile*	Alpine tetramolopium	–	END	–	T3	none	N
Asteraceae	*Tetramolopium humile* var. *sublaeve*	Alpine tetramolopium	–	END	–	T1	–	Y
Asteraceae	*Tetramolopium stemermanninae*		–	END	–	–	none	–
Asteraceae	*Verbesina encelioides*	Golden crownbeard	–	INT	–	–	–	–
Asteraceae	*Xanthium strumarium*	Rough cockelbur	–	INT	–	–	–	–
Asteraceae	*Youngia japonica*	Oriental false hawksbeard	–	INT	–	–	–	–
Asteraceae	*Zinnia peruviana*	Peruvian zinnia	–	INT	–	–	–	–
Bignoniaceae	*Jacaranda mimosifolia*	Black poui	–	INT	–	–	–	–
Brassicaceae	*Brassica juncea*	Chinese mustard	–	INT	–	–	–	–
Brassicaceae	*Brassica nigra*	Black mustard	–	INT	–	–	–	–
Brassicaceae	*Brassica rapa*	Field mustard	–	INT	–	–	–	–
Brassicaceae	*Capsella bursa-pastoris*	Shepherd's purse	–	INT	–	–	–	–
Brassicaceae	*Cardamine flexuosa*	Woodland bittercress	–	INT	–	–	–	–
Brassicaceae	*Lepidium africanum*	African pepperwort	–	INT	–	–	–	–
Brassicaceae	*Lepidium bonariense*	Argentine pepperweed	–	INT	–	–	–	–
Brassicaceae	*Lepidium virginicum*	Virginia pepperweed	–	INT	–	–	–	–
Brassicaceae	*Lepidium didymum*	Lesser swinecress	–	INT	–	–	–	–
Brassicaceae	*Raphanus raphanistrum*	Wild radish	–	INT	–	–	–	–
Brassicaceae	*Raphanus sativus*	Wild radish	–	INT	–	–	–	–
Brassicaceae	*Sisymbrium altissimum*	Tumble mustard	–	INT	–	–	–	–
Brassicaceae	*Sisymbrium irio*	Rocket mustard	–	INT	–	–	–	–
Brassicaceae	*Sisymbrium officinale*	Hedge mustard	–	INT	–	–	–	–
Cactaceae	*Opuntia ficus-indica*	Tuna cactus	–	INT	–	–	–	–

Table C.2. Master plant species list (cont.)

Family	Scientific Name	Common Name	Hawaiian Name	Origin	ESA	Nature Serve Rank	IUCN Rank	DoD SAR
Campanulaceae	*Triodanis perfoliata* ssp. *biflora*	'Venus' looking-glass	–	INT	–	–	–	–
Campanulaceae	*Wahlenbergia gracilis*	Southern rockbell	–	INT	–	–	–	–
Campanulaceae	*Wahlenbergia marginata*	Southern rockbell	–	INT	–	–	–	–
Caryophyllaceae	*Arenaria serpyllifolia*	Thyme-leaved sandwort	–	INT	–	–	–	–
Caryophyllaceae	*Cerastium fontanum* ssp. *vulgare*	Common mouse-ear chickweed	–	INT	–	–	–	–
Caryophyllaceae	*Petrorhagia dubia*	Hairy pink	–	INT	–	–	–	–
Caryophyllaceae	*Polycarpon tetraphyllum*	Fourleaf manyseed	–	INT	–	–	–	–
Caryophyllaceae	*Schiedea hawaiiensis*	Island schiedea	Māʻoliʻoli	END	FE	G1	none	N
Caryophyllaceae	*Silene gallica*	Small-flowered catchfly	–	INT	–	–	–	–
Caryophyllaceae	*Silene hawaiiensis*	Hawaiʻi catchfly	–	END	FT	G2	none	N
Caryophyllaceae	*Silene lanceolata*	Kauai catchfly	–	END	FE	G1	none	N
Caryophyllaceae	*Silene struthioloides*	Alpine catchfly	–	END	–	G2	–	Y
Caryophyllaceae	*Stellaria media*	Chickweed	–	INT	–	–	–	–
Casuarinaceae	*Casuarina glauca*	Longleaf ironwood	–	INT	–	–	–	–
Convolvulaceae	*Ipomoea indica*	Blue morning glory	–	IND	–	NS	none	–
Convolvulaceae	*Ipomoea tuboides*	Hawaiʻi morning glory	Koaliʻawa	END	–	G2	–	Y
Convolvulaceae	*Ipomoea violacea*	Heavenlyblue morning-glory	–	INT	–	–	–	–
Crassulaceae	*Crassula sieberiana*	Siberian pygmyweed	–	INT	–	–	–	–
Crassulaceae	*Kalanchoe delagoensis*	Chandelier plant	–	INT	–	–	–	–
Cucurbitaceae	*Cucumis dipsaceus*	Hedgehog cucumber	–	INT	–	–	–	–
Cucurbitaceae	*Sicyos anunu*	Lava bur cucumber	ʻĀnunu	END	–	G2	–	Y
Cucurbitaceae	*Sicyos hillebrandii*	Maui Bur Cucumber	ʻĀnunu	END	–	GH	–	Y
Cucurbitaceae	*Sicyos lasiocephalus*	Hualalai bur cucumber	ʻĀnunu	END	–	G2	–	Y
Cucurbitaceae	*Sicyos macrophyllus*	Alpine bur cucumber	ʻĀnunu	END	FE	G1	none	N
Cupressaceae	*Callitropsis lusitanica*	Mexican cypress	–	INT	–	–	–	–
Cupressaceae	*Cupressus macrocarpa*	Monterey cypress	–	INT	–	–	–	–
Cupressaceae	*Cupressus sempervirens*	Italian cypress	–	INT	–	–	–	–

Table C.2. Master plant species list (cont.)

Family	Scientific Name	Common Name	Hawaiian Name	Origin	ESA	Nature Serve Rank	IUCN Rank	DoD SAR
Cyperaceae	*Bulbostylis capillaris*	Densetuft hairsedge	–	INT	–	–	–	–
Cyperaceae	*Carex inversa*	Knob sedge	–	INT	–	–	–	–
Cyperaceae	*Carex wahuensis* ssp. *rubiginosa*	Oahu sedge	–	END	–	T3	none	N
Cyperaceae	*Carex wahuensis* ssp. *wahuensis*	Oʻahu sedge	–	END	–	T2	–	Y
Cyperaceae	*Cyperus hillebrandii* var. *decipiens*	Hillebrand's flatsedge	–	END	–	T3	none	N
Cyperaceae	*Cyperus hillebrandii* var. *hillebrandii*	Hillebrand's flatsedge	–	END	–	T3	none	N
Cyperaceae	*Morelotia gahniiformis*	Gaudichaud's sawsedge	–	IND	–	G3	none	N
Ericaceae	*Leptecophylla tameiameiae*	Pūkiawe	Pūkiawe	IND	–	G5	none	N
Ericaceae	*Vaccinium reticulatum*	Netted blueberry	ʻOhelo ʻai	END	–	G3	none	N
Euphorbiaceae	*Euphorbia cyathophora*	Fire on the mountain	–	INT	–	–	–	–
Euphorbiaceae	*Euphorbia hirta*	Hairy spurge	–	INT	–	–	–	–
Euphorbiaceae	*Euphorbia hyssopifolia*	Hyssop-leaf sandmat	–	INT	–	–	–	–
Euphorbiaceae	*Euphorbia multiformis* var. *microphylla*	Variable sandmat	ʻĀkoko	END	–	T2	–	Y
Euphorbiaceae	*Euphorbia olowaluana*	Alpine sandmat	ʻĀkoko	END	–	G2	NT	Y
Euphorbiaceae	*Euphorbia peplus*	Petty spurge	–	INT	–	–	–	–
Euphorbiaceae	*Euphorbia albomarginata*	Rattlesnake weed	–	INT	–	–	–	–
Euphorbiaceae	*Ricinus communis*	Castor bean	–	INT	–	–	–	–
Fabaceae	*Acacia mearnsii*	Black wattle	–	INT	–	–	–	–
Fabaceae	*Chamaecrista nictitans* var. *glabrata*	Partridge pea	–	INT	–	–	–	–
Fabaceae	*Crotalaria incana*	Shakeshake	–	INT	–	–	–	–
Fabaceae	*Crotalaria pallida*	Smooth rattlebox	–	INT	–	–	–	–
Fabaceae	*Desmodium sandwicense*	Spanish clover	–	INT	–	–	–	–
Fabaceae	*Indigofera suffruticosa*	Indigobush	–	INT	–	–	–	–
Fabaceae	*Leucaena leucocephala*	Koa haole	–	INT	–	–	–	–

Table C.2. Master plant species list (cont.)

Family	Scientific Name	Common Name	Hawaiian Name	Origin	ESA	Nature Serve Rank	IUCN Rank	DoD SAR
Fabaceae	*Lupinus arboreus*	Yellow bush lupine	–	INT	–	–	–	–
Fabaceae	*Macroptilium lathyroides*	Wild bush bean	–	INT	–	–	–	–
Fabaceae	*Macrotyloma axillare* var. *axillare*	Perennial horsegram	–	INT	–	–	–	–
Fabaceae	*Medicago lupulina*	Black medic clover	–	INT	–	–	–	–
Fabaceae	*Medicago polymorpha*	Burclover	–	INT	–	–	–	–
Fabaceae	*Medicago sativa*	Alfalfa	–	INT	–	–	–	–
Fabaceae	*Melilotus albus*	White sweet clover	–	INT	–	–	–	–
Fabaceae	*Melilotus indicus*	Annual yellow sweet clover	–	INT	–	–	–	–
Fabaceae	*Neonotonia wightii*	Tinarro glycine	–	INT	–	–	–	–
Fabaceae	*Prosopis pallida*	Mesquite	–	INT	–	–	–	–
Fabaceae	*Samanea saman*	Monkeypod	–	INT	–	–	–	–
Fabaceae	*Sophora chrysophylla*	Māmane	Māmane	END	–	G3	none	N
Fabaceae	*Trifolium arvense*	Rabbit-foot clover	–	INT	–	–	–	–
Fabaceae	*Trifolium campestre*	Field clover	–	INT	–	–	–	–
Fabaceae	*Trifolium hybridum*	Alsike clover	–	INT	–	–	–	–
Fabaceae	*Trifolium pratense*	Red clover	–	INT	–	–	–	–
Fabaceae	*Trifolium repens*	White clover	–	INT	–	–	–	–
Fabaceae	*Vicia sativa* ssp. *nigra*	Common vetch	–	INT	–	–	–	–
Fabaceae	*Vicia villosa*	Hairy vetch	–	INT	–	–	–	–
Fabaceae	*Vigna o-wahuensis*	Oʻahu cowpea	–	END	FE	G1	none	N
Fagaceae	*Quercus suber*	Cork oak	–	INT	–	–	–	–
Gentianaceae	*Centaurium erythraea*	European centaury	–	INT	–	–	–	–
Geraniaceae	*Erodium cicutarium*	Redstep filaree	–	INT	–	–	–	–
Geraniaceae	*Geranium cuneatum* ssp. *cuneatum*	Cranesbill	Nohoanu	END	–	T3	none	–
Geraniaceae	*Geranium cuneatum* ssp. *hololeucum*	Cunate-leaf crane's bill	Nohoanu	END	–	T3	none	N
Geraniaceae	*Geranium homeanum*	Australasian crane's bill	–	INT	–	–	–	–

Table C.2. Master plant species list (cont.)

Family	Scientific Name	Common Name	Hawaiian Name	Origin	ESA	Nature Serve Rank	IUCN Rank	DoD SAR
Geraniaceae	*Geranium retrorsum*	New Zealand geranium	–	INT	–	–	–	–
Geraniaceae	*Pelargonium graveolens*	Sweet scented geranium	–	INT	–	–	–	–
Gleicheniaceae	*Dicranopteris linearis*	False staghorn fern	Uluhe	END	–	G5	LC	N
Heliotropiaceae	*Euploca procumbens*	Fourspike heliotrope	–	INT	–	–	–	–
Lamiaceae	*Haplostachys haplostachya*	Hawaiian mint	Honohono	END	FE	G1	none	N
Lamiaceae	*Marrubium vulgare*	White horehound	–	INT	–	–	–	–
Lamiaceae	*Plectranthus parviflorus*	Little spurflower	–	INT	–	–	–	–
Lamiaceae	*Salvia coccinea*	Blood sage	–	INT	–	–	–	–
Lamiaceae	*Stenogyne angustifolia*	Narrowleaf stenogyne	–	END	–	G2	–	Y
Lamiaceae	*Stenogyne angustifolia* var. *angustifolia*	Narrowleaf stenogyne	–	END	FE	G2T2	none	N
Lamiaceae	*Stenogyne microphylla*	Little leaf stenogyne	–	END	–	G3	none	N
Lamiaceae	*Stenogyne rugosa*	Wrinkled stenogyne	Māʻohiʻohi	END	–	G2	–	Y
Lauraceae	*Cassytha filiformis*	Devils gut	Kaunaʻoa pehu	IND	–	G4	none	N
Liliaceae	*Dianella sandwicensis*	Hawaiian lily	ʻUkiʻuki	IND	–	G4	none	N
Lindsaeaceae	*Lindsaea repens var. macaraena*	Creeping necklace fern	–	END	–	T2	–	Y
Lomariopsidaceae	*Nephrolepis cordifolia*	Narrow sword fern	Kupukupu	IND	–	G4	none	N
Lomariopsidaceae	*Nephrolepis exaltata*	Boston swordfern	ʻOkupukupu	IND	–	G5	LC	N
Lomariopsidaceae	*Nephrolepis exaltata* ssp. *hawaiiensis*	Boston fern	ʻOkupukupu	END	–	G5 (species)	LC (species)	N
Lycopodiaceae	*Lycopodium venustulum*	Hairtip clubmoss	Wāwaeʻiole	IND	–	G4	none	N
Lycopodiaceae	*Lycopodium venustulum* var. *verticale*	Hairtip clubmoss	Wāwaeʻiole	END	–	G4	none	N
Lythraceae	*Lythrum maritimum*	Pukamole	Pūkāmole	IND/INT	–	NS	none	N
Malvaceae	*Abutilon grandifolium*	Hairy indian malo	–	INT	–	–	–	–
Malvaceae	*Malva parviflora*	Cheeseweed	–	INT	–	–	–	–

Table C.2. Master plant species list (cont.)

Family	Scientific Name	Common Name	Hawaiian Name	Origin	ESA	Nature Serve Rank	IUCN Rank	DoD SAR
Malvaceae	*Sida ciliaris*	Bracted fanpetals	–	INT	–	–	–	–
Malvaceae	*Sida fallax*	Yellow ʻilima	ʻilima	IND	–	G3	none	N
Malvaceae	*Sida rhombifolia*	Cuba jute	–	INT	–	–	–	–
Malvaceae	*Waltheria indica*	Sleepy morning	ʻUhaloa	IND	–	G5	LC	N
Menispermaceae	*Cocculus orbiculatus*	Queen coralbead	Huehue	IND	–	NS	none	N
Myrtaceae	*Corymbia citriodora*	Lemon scented gum	–	INT	–	–	–	–
Myrtaceae	*Eucalyptus robusta*	Swamp mahogany	–	INT	–	–	–	–
Myrtaceae	*Eucalyptus saligna*	Sydney blue gum	–	INT	–	–	–	–
Myrtaceae	*Metrosideros polymorpha*	ʻŌhiʻa lehua	ʻŌhiʻa lehua	END	–	G5	none	–
Myrtaceae	*Metrosideros polymorpha* var. *glaberrima*	ʻŌhiʻa lehua	ʻŌhiʻa lehua	END	–	T2	VU	Y
Myrtaceae	*Metrosideros polymorpha* var. *polymorpha*	ʻŌhiʻa lehua	ʻŌhiʻa lehua	END	–	T3	VU (species)	N
Myrtaceae	*Morella faya*	Firetree	–	INT	–	–	–	–
Myrtaceae	*Psidium guajava*	Guava	–	INT	–	–	–	–
Oleaceae	*Ligustrum lucidum*	Glossy privet	–	INT	–	–	–	–
Oleaceae	*Olea europaea* ssp. *cuspidata*	African olive	–	INT	–	–	–	–
Oleaceae	*Olea europaea* ssp. *europaea*	European olive	–	INT	–	–	–	–
Onagraceae	*Epilobium billardierianum* ssp. *cinereum*	Aboriginal willowherb	–	INT	–	–	–	–
Onagraceae	*Oenothera stricta*	Chilean evening primrose	–	INT	–	–	–	–
Onagraceae	*Oenothera stricta* ssp. *stricta*	Evening primrose	–	INT	–	–	–	–
Oxalidaceae	*Oxalis corniculata*	Yellow wood sorrel	ʻIhi	IND/INT	–	NS	none	N
Papaveraceae	*Argemone glauca* var. *decipiens*	Hawaiian prickly poppy	Pua kala	END	–	T1	–	Y
Papaveraceae	*Eschscholzia californica*	California poppy	–	INT	–	–	–	–
Passifloreaceae	*Passiflora tarminiana*	Banana poka	–	INT	–	–	–	–

Table C.2. Master plant species list (cont.)

Family	Scientific Name	Common Name	Hawaiian Name	Origin	ESA	Nature Serve Rank	IUCN Rank	DoD SAR
Phytolaccaceae	*Phytolacca sandwicensis*	Hawai‘i pokeweed	–	END	–	G2	–	Y
Piperaceae	*Peperomia tetraphylla*	Acorn peperomia	‘Ala‘ala wainui	IND	–	NS	none	N
Pittosporaceae	*Pittosporum confertiflorum*	Ho‘awa	Hō‘awa	END	–	G3	none	N
Pittosporaceae	*Pittosporum terminalioides*	Cream cheesewood	Hō‘awa	END	–	G2	VU	Y
Pittosporaceae	*Pittosporum viridiflorum*	Cape cheesewood	–	INT	–	–	–	–
Plantaginaceae	*Lophospermum erubescens*	Roving sailor	–	INT	–	–	–	–
Plantaginaceae	*Plantago lanceolata*	Narrow-leaved plantain	–	INT	–	–	–	–
Plantaginaceae	*Veronica plebeia*	Trailing speedwell	–	INT	–	–	–	–
Plantaginaceae	*Veronica serpyllifolia*	Thyme-leafed speedwell	–	INT	–	–	–	–
Polygonaceae	*Emex spinosa*	Devil's thorn	–	INT	–	–	–	–
Polygonaceae	*Persicaria capitata*	Pinkhead smartweed	–	INT	–	–	–	–
Polygonaceae	*Rumex acetosella*	Sheep sorrel	–	INT	–	–	–	–
Polygonaceae	*Rumex brownii*	Slender dock	–	INT	–	–	–	–
Polygonaceae	*Rumex giganteus*	Climbing dock	Pāwale	END	–	G2	–	Y
Polygonaceae	*Rumex skottsbergii*	Lava dock	Pāwale	END	–	G2	–	Y
Portulacaceae	*Portulaca oleracea*	Pigweed	–	INT	–	–	–	–
Portulacaceae	*Portulaca pilosa*	Hairy pigweed	–	INT	–	–	–	–
Portulacaceae	*Portulaca sclerocarpa*	Hard fruit purslane	‘Ihi mākole	END	FE	G2	EN	N
Portulacaceae	*Portulaca villosa*	Hairy purslane	‘Ihi	END	FE	G1	none	N
Primulaceae	*Anagallis arvensis*	Scarlet pimpernel	–	INT	–	–	–	–
Primulaceae	*Myrsine lanaiensis*	Lanai colicwood	Kōlea	END	–	G3	none	N
Primulaceae	*Myrsine lanaiensis*	Lanai colicwood	Kōlea	END	–	G3	none	N
Proteaceae	*Grevillea banksii*	Red silky oak	–	INT	–	–	–	–
Proteaceae	*Grevillea robusta*	Silky oak	–	INT	–	–	–	–
Rhamnaceae	*Alphitonia ponderosa*	Kauila	Kauila	END	–	G2	VU	Y
Rhamnaceae	*Rhamnus californica* ssp. *californica*	Coffeberry	–	INT	–	–	–	–

Table C.2. Master plant species list (cont.)

Family	Scientific Name	Common Name	Hawaiian Name	Origin	ESA	Nature Serve Rank	IUCN Rank	DoD SAR
Rosaceae	*Heteromeles arbutifolia*	California holly	–	INT	–	–	–	–
Rosaceae	*Osteomeles anthyllidifolia*	Hawaii hawthorn	ʻŪlei	IND	–	G4	none	N
Rosaceae	*Pyrus calleryana*	Bradford pear	–	INT	–	–	–	–
Rosaceae	*Prunus cerasifera*	Cherry plum	–	INT	–	–	–	–
Rosaceae	*Prunus sp.*	Plum	–	INT	–	–	–	–
Rosaceae	*Rubus niveus*	Hill raspberry	–	INT	–	–	–	–
Rosaceae	*Rubus rosifolius*	Thimbleberry	–	INT	–	–	–	–
Rubiaceae	*Coffea arabica*	Arabian coffee	–	INT	–	–	–	–
Rubiaceae	*Coprosma cymosa*	Hawaii mirrorplant	Pilo	END	–	G3	none	N
Rubiaceae	*Coprosma ernodeoides*	Kūkaenēnē	Kūkaenēnē	END	–	G3	none	N
Rubiaceae	*Coprosma montana*	Mountain pilo	Pilo	END	–	G3	VU	N
Rubiaceae	*Coprosma ochracea*	Maui mirrorplant	Hupilo	END	–	G3	VU	N
Rubiaceae	*Galium divaricatum*	Lamarckʻs bedstraw	–	INT	–	–	–	–
Rubiaceae	*Kadua affinis*	Variable starviolet	Manono	END	–	–	none	N
Rubiaceae	*Kadua coriacea*	Leather-leaf sweet ear	Kioʻele	END	FE	G1	CR	N
Rubiaceae	*Psydrax odorata*	Alaheʻe	Alaheʻe	IND	–	G5	LC	N
Rutaceae	*Melicope hawaiensis*	Alani	Alani	END	–	G2	VU	Y
Rutaceae	*Zanthoxylum hawaiiense*	Hawaiian yellow wood	Aʻe	END	FE	G1	EN	N
Santalaceae	*Exocarpos gaudichaudii*	Gaudichaud's exocarpos	Au	END	–	G1	EN	Y
Santalaceae	*Exocarpos menziesii*	Menzie's ballart	Heau	END	FE	G2	none	N
Santalaceae	*Korthalsella taeniodes*	Hawaiian mistletoe	Hulumoa	END	–	G2	–	Y
Santalaceae	*Santalum ellipticum*	Coastal sandalwood	ʻIliahi	END	–	G2	–	Y
Santalaceae	*Santalum paniculatum*	Mountain sandalwood	ʻIliahi	END	–	G3	VU	N
Santalaceae	*Santalum paniculatum* var. *pilgeri*	Pilger's sandalwood	ʻIliahi	END	–	T2	VU	Y
Santalaceae	*Santalum paniculatum* var. *paniculatum*	Mountain sandalwood	ʻIliahi	END	–	T2	VU	Y
Sapindaceae	*Dodonaea viscosa*	Purple hopbush	ʻAʻaliʻi	IND	–	G5	LC	N

Table C.2. Master plant species list (cont.)

Family	Scientific Name	Common Name	Hawaiian Name	Origin	ESA	Nature Serve Rank	IUCN Rank	DoD SAR
Schrophulariaceae	*Verbascum thapsus*	Common mullein	–	INT	–	–	–	–
Schrophulariaceae	*Verbascum virgatum*	Wand mullein	–	INT	–	–	–	–
Scrophulariaceae	*Myoporum sandwicense*	False sandalwood	Naio	END	–	G3	none	N
Solanaceae	*Capsicum annuum* var. *frutescens*	Hawaiian chili pepper	–	INT	–	–	–	–
Solanaceae	*Datura stramonium*	Jimson weed	Kikania	INT	–	–	–	–
Solanaceae	*Nicandra physalodes*	Apple of Peru	–	INT	–	–	–	–
Solanaceae	*Nicotiana glauca*	Tree tobacco	–	INT	–	–	–	–
Solanaceae	*Nicotiana tabacum*	Tobacco	Paka	INT	–	–	–	–
Solanaceae	*Physalis peruviana*	Peruvian groundcherry	Poha	INT	–	–	–	–
Solanaceae	*Solanum americanum*	Glossy nightshade	Pōpolo	IND	–	G5	none	N
Solanaceae	*Solanum incompletum*	Hawaiian pricke leaf	Pōpolo kū mai	END	FE	G1	CR	N
Solanaceae	*Solanum linnaeanum*	Apple of sodom	–	INT	–	–	–	–
Solanaceae	*Solanum nigrescens*	Nightshade	–	INT	–	–	–	–
Solanaceae	*Solanum pseudocapsicum*	Jerusalem cherry	–	INT	–	–	–	–
Thymelaeaceae	*Wikstroemia phillyreifolia*	False ohelo	ʻĀkia	END	–	G3	none	N
Thymelaeaceae	*Wikstroemia pulcherrima*	Kohala false ohelo	ʻĀkia	END	–	G2	–	Y
Urticaceae	*Hesperocnide sandwicensis*	Hawaii stingingnettle	–	END	–	G3	none	N
Urticaceae	*Neraudia ovata*	Maʻaloa	Maʻaloa	END	FE	G1	CR	N
Urticaceae	*Urtica urens*	Burning nettle	–	INT	–	–	–	–
Verbenaceae	*Lantana camara*	Lantana	–	INT	–	–	–	–
Verbenaceae	*Verbena litoralis*	Verbena	Ōwī,	INT	–	–	–	–
Violaceae	*Isodendrion hosokae*	Aupaka	Aupaka	END	FE	G1	none	N
Zygophyllaceae	*Tribulus terrestris*	Goathead	–	INT	–	–	–	–

Table C.3. Animal species at risk at PTA per Department of Defense criteria

Scientific Name	Common Name	Hawaiian Name	NatureServe Status	IUCN Status	HI SOC	Last seen at PTA
Aves (Birds)						

Scientific Name	Common Name	Hawaiian Name	NatureServe Status	IUCN Status	HI SOC	Last seen at PTA
Asio flammeus sandwichensis	Short-eared Owl	Pueo	T2	NE	Y	2020
Buteo solitarius	Hawaiian Hawk	ʻIo	G2	NT	Y	
Chasiempis sandwichensis	Hawaiʻi ʻElepaio	ʻElepaio	G5S2	VU	Y	2008
Chlorodrepanis virens	Hawaiʻi ʻAmakihi	ʻAmakihi	G3	LC	Y	2020
Himatione sanguinea	ʻApapane	ʻApapane	G3	LC	Y	2020
Myadestes obscurus	Hawaiʻi Thrush	ʻŌmaʻo	G3	VU	Y	2020
Insecta						
Agrotis microreas	Noctuid moth	n/a	GH	NE	Y	1998
Caconemobius varius	Kaumana Cave cricket	n/a	G1	VU	Y	1996
Deinomimesa hawaiiensis	Hawaiian deinomimesan sphecid wasp	n/a	G2	NE	Y	1935
Deinomimesa punae	Puna deinomimesan sphecid wasp	n/a	G2	NE	Y	1998
Helicoverpa confusa	Confused moth	n/a	G1	EX	Y	1998
Hylaeus dimidiatus	Dimidiatan yellow-faced bee	Nalo Meli Maoli	GNR	NE	Y	1999
Hylaeus kona	Kona yellow-faced bee	Nalo Meli Maoli	GNR	NE	Y	2012
Hylaeus laetus	Hawaiian yellow-faced bee	Nalo Meli Maoli	GNR	NE	Y	2012
Hylaeus ombrias	Ombrias yellow-faced bee	Nalo Meli Maoli	GNR	NE	Y	2012
Hylaeus paradoxicus	Hawaiian yellow-faced bee	Nalo Meli Maoli	GNR	NE	Y	1999
Hypocala velans	Native underwing moth	n/a	n/a	NE	Y	1996
Neanura hawaiiensis	Cave springtail	n/a	G1	NE	Y	1996
Nesidiolestes ana	Ana wingless thread bug	n/a	G1	NE	Y	1996
Oliarus polyphemus	Blind cixiid planthopper	n/a	G1	NE	Y	1996
Rhyncogonus giffardi	Giffard's rhyncogonus weevil	n/a	G1	NE	Y	1998
Sinella yosiia	Springtail	n/a	G2	NE	Y	1996
Thaumatogryllus cavicola	Volcanoes cave cricket	n/a	G1	VU	Y	1996

Table C.3. Animal species at risk at PTA per Department of Defense criteria (cont.)

Scientific Name	Common Name	Hawaiian Name	NatureServe Status	IUCN Status	HI SOC	Last seen at PTA
Gastropod						
Leptachatina lepida	Amastrid land snail	n/a	G1	EN	Y	1995
Arachnid						
Vulcanochthonius pohakuloae	False scorpion	n/a	G1	n/a	Y	1996

The Master list of animal species was taken from the 2020 INRMP and is not a full accounting of invertebrate and reptile inventories from PTA. Sources include Bird names were updated per the American Ornithological Society 2023 guidelines. Taxonomy for invertebrates, reptiles, and mammals was not updated.

Table C.4. Master animal species list

Scientific Name	Common Name	Hawaiian Name	Origin	ESA	MBTA	Nature Serve Rank	ICUN Rank	DoD SAR	HI SOC
Aves									
Acridotheres tristis	Common Myna	–	NAT	–	–	G5	–	–	–
Alauda arvensis	Eurasian Skylark	–	NAT	–	x	G5	–	–	–
Alectoris chukar	Chukar	–	NAT	–	–	G5	–	–	–
Amandava amandava	Red Avadavat	–	NAT	–	–	G5	–	–	–
Arenaria interpres	Ruddy Turnstone	‘Akekeke	IND	–	x	G5	–	–	–
Asio flammeus sandwichensis	Hawaiian Short-eared Owl	Pueo	END	–	x	G5T2	NE	x	x
Branta sandvicensis	Hawaiian Goose	Nēnē	END	FT	x	G1	–	–	x
Buteo solitarius	Hawaiian Hawk	‘Io	END	–	x	G2	NT	x	x
Calidris alba	Sanderling	–	NAT	–	x	G5	–	–	–
Callipepla californica	California Quail	–	NAT	–	–	G5	–	–	–
Cardinalis cardinalis	Northern Cardinal	–	NAT	–	x	G5	–	–	–
Haemorhous mexicanus	House Finch	–	NAT	–	x	G5	–	–	–

Table C.4. Master animal species list (cont.)

Scientific Name	Common Name	Hawaiian Name	Origin	ESA	MBTA	Nature Serve Rank	ICUN Rank	DoD SAR	HI SOC
Chasiempis sandwichensis sandwichensis (2008)	Hawai'i Elepaio	Elepaio	END	–	–	G3T2	VU	x	x
Columba livia	Rock Dove	–	NAT	–	–	G5	–	–	–
Coturnix japonica	Japanese Quail	–	NAT	–	–	G5	–	–	–
Corvus hawaiiensis (1978)	Hawaiian Crow	–	END	FE	x	GXC	–	–	–
Glaucestrilda caerulescens	Lavender Waxbill	–	NAT	–	–	G5	–	–	–
Pternistis erckelli	Erckel's Spur Fowl	–	NAT	–	–	G5	–	–	–
Francolinus francolinus	Black Francolin	–	NAT	–	–	G5	–	–	–
Ortygornis pondicerianus	Grey Francolin	–	NAT	–	–	G5	–	–	–
Gallus domesticus	Chicken	–	NAT	–	–	–	–	–	–
Garrulax canorus	Chinese Hwamei	–	NAT	–	–	G4	–	–	–
Geopelia striata	Zebra Dove		NAT	–	–	G4	–	–	–
Hemignathus wilsoni (1995)	'Akiapola'au	'Akiapola'au	END	FE	x	G1	–	–	–
Hemignathus virens	Hawai'i 'Amakihi	'Amakihi	END	–	x	G3	LC	x	x
Himatione sanguinea	Apapane	Apapane	END	–	x	G3	LC	x	x
Leiothrix lutea	Red-billed Leiothrix	–	NAT	–	–	G4	–	–	–
Euodice cantans	African Silverbill	–	NAT	–	–	G5	–	–	–
Lonchura punctulata	Scaly-breasted Munia	–	NAT	–	–	G5	–	–	–
Lophura leucomelanos	Kalij Pheasant	–	NAT	–	–	G5	–	–	–
Loxioides bailleui (1983)	Palila	Palila	END	FE	x	G1	–	–	–
Loxops coccineus (unknown, not detected since 1998)	Hawai'i 'Akepa	'Akepa		FE	x	G1	–	–	x
Meleagris gallopavo	Wild Turkey	–	NAT	–	–	G5	–	–	–

Table C.4. Master animal species list (cont.)

Scientific Name	Common Name	Hawaiian Name	Origin	ESA	MBTA	Nature Serve Rank	ICUN Rank	DoD SAR	HI SOC
Mimus polyglottos	Northern Mockingbird	–	NAT	–	x	G5	–	–	–
Myadestes obscurus	ʻŌmaʻo	ʻŌmaʻo	END	–	x	G3	VU	x	x
Hydrobates castro	Band-rumped Storm-Petrel	ʻAkeʻake	IND	FE	x	G3	–	–	–
Passer domesticus	House Sparrow	–	NAT	–	–	G5	–	–	–
Phasianus colchicus	Ring-necked Pheasant	–	NAT	–	–	G5	–	–	–
Pluvialis fulva	Pacific Golden-Plover	Kolea	IND	–	x	G5	–	–	–
Pterocles exustus	Chestnut-bellied Sandgrouse	–	NAT	–		G5	–	–	–
Pterodroma sandwichensis	Hawaiian Petrel	ʻUaʻu	IND	FE	x	G2	–	–	–
Crithagra mozambica	Yellow-fronted Canary	–	NAT	–	–	G5	–	–	–
Sicalis flaveola	Saffron Finch	–	NAT	–	–	G5	–	–	–
Spilopelia chinensis	Spotted Dove	–	NAT	–	–	G5	–	–	–
Tyto alba	Barn Owl	–	NAT	–	x	G5	–	–	–
Drepanis coccinea (1992)	Iʻiwi	–	END	FT	x	G4	–	–	–
Zenaida macroura	Mourning Dove	–	NAT	–	x	G5	–	–	–
Zosterops japonicus	Warbling White-eye	–	NAT	–	–	G5	–	–	–
Gastropoda									
Euconulus gaetanoi	–	–	END	–	–	GNR	–	–	–
Nesopupa subcentrailis	–	–	END	–	–	GNR	–	–	–
Nesovitrea hawaiiensis	–	–	END	–	–	GNR	–	–	–
Leptachatina spp.	–	–	END	–	–	GNR	–	–	–
Leptactina lepida	Amastrid land snail		END	–	–	GS1	EN	x	–
Striatura ssp.	–	–	END	–	–	GNR	–	–	–
Succinea konaensis	–	–	END	–	–	GNR	–	–	–

Table C.4. Master animal species list (cont.)

Scientific Name	Common Name	Hawaiian Name	Origin	ESA	MBTA	Nature Serve Rank	ICUN Rank	DoD SAR	HI SOC
Philonesia sp.	Zonitid land snail		END	–	–	GNR	–	–	–
Vitrina tenella	–	–	END	–	–	GNR	–	–	–
Insecta									
Agrotis melanoneura	Black-veined agrotis noctuid moth	–	END	–	–	GH	–	–	–
Agrotis microreas	Microreas agrotis noctuid moth	–	END	–	–	GH	–	–	–
Cardiocondyla venustula	ant	–	NAT	–	–	–	–	–	–
Coleotichus blackburniae	Koa shield bug	–	END	–	–	GNR	–	–	–
Helicoverpa confusa	Confused helicoverpan moth	–	NAT	–	–	G1	–	–	–
Hylaeus albonitens	Hawaiian yellow-faced bee	–	NAT	–	–	–	–	–	–
Hylaeus anthracinus	Anthricinan yellow-faced bee	Nalo Meli Maoli	END	FE	–	GNR	–	–	–
Hylaeus difficilis	Difficult yellow-faced bee	Nalo Meli Maoli	END	–	–	GNR	–	–	–
Hylaeus dimidiatus	Dimidiatan yellow-faced bee	Nalo Meli Maoli	END	–	–	GNR	–	–	–
Hylaeus flavipes	Yellow-foot yellow-faced bee	Nalo Meli Maoli	END	–	–	GNR	–	–	–
Hylaeus kona	Kona yellow-faced bee	Nalo Meli Maoli	END	–	–	GNR	–	–	–
Hylaeus laetus	Laetan yellow-faced bee	Nalo Meli Maoli	END	–	–	GNR	–	–	–
Hylaeus ombrias	Ombrias yellow-faced bee	Nalo Meli Maoli	END	–	–	GNR	–	–	–
Hylaeus paradoxicus	Hawaiian yellow-faced bee	Nalo Meli Maoli	END	–	–	GNR	–	–	–
Hylaeus pele	Pele yellow-faced bee	Nalo Meli Maoli	END	–	–	GNR	–	–	–
Hylaeus specodoides	Sphecodoid yellow-faced bee	Nalo Meli Maoli	END	–	–	GNR	–	–	–

Table C.4. Master animal species list (cont.)

Scientific Name	Common Name	Hawaiian Name	Origin	ESA	MBTA	Nature Serve Rank	ICUN Rank	DoD SAR	HI SOC
Hypoponera opaciceps	ant	–	NAT	–	–	–	–	–	–
Deinomimesa punae	Puna deniomimesan sphecid wasp	–	END	–	–	G2	–	–	–
Linepithema humile	Argentine ant	–	NAT	–	–	GNR	–	–	–
Monomorium latinode	ant	–	NAT	–	–	–	–	–	–
Pheidole megacephala	Big-headed ant	–	NAT	–	–	–	–	–	–
Rhyncogonus giffardi	Giffard's rhyncogonus weevil	–	END	–	–	G1	–	–	–
Schrankia sp.	Schrankia moth	–	END?	–	–	GU	–	–	–
Tapinoma melanocephalum	Ghost ant	–	NAT	–	–	GNR	–	–	–
Technomyrmex albipes	ant	–	NAT	–	–	–	–	–	–
Udara blackburni	Hawaiian blue butterfly	–	END	–	–	G4	–	–	–
Thaumatogryllus cavicola	Volcanoes cave cricket	–	END	–	–	G1	–	–	–
Archnid									
Vulcanochthonius pohakuloae	False scorpion	–	END	–	–	G1	NE	Y	Y
Mammalia									
Canus familiaris	Feral domestic dog	–	NAT	–	–		–	–	–
Capra hircus hircus	Feral domestic goat	–	NAT	–	–	GNA	–	–	–
Felis catus	Feral domestic cat	–	NAT	–	–	GNA	–	–	–
Herpestes auropunctatus	Mongoose	–	NAT	–	–	–	–	–	–
Aeorestes semotus	Hawaiian hoary bat, ʻŌpeʻapeʻa	–	END	FE	–	T2	–	–	x
Mus musculus	House Mouse	–	NAT	–	–	G5	–	–	–
Ovis aries	Feral sheep	–	NAT	–	–	G5	–	–	–
Ovis musimon	Muflon sheep	–	NAT	–	–	–	–	–	–

Table C.4. Master animal species list (cont.)

Scientific Name	Common Name	Hawaiian Name	Origin	ESA	MBTA	Nature Serve Rank	ICUN Rank	DoD SAR	HI SOC
Ovis musimon X O. aries	Hybrid muflon x feral sheep	–	NAT	–	–	–	–	–	–
Rattus ssp.	Rat	–	NAT	–	–	G5	–	–	–
Sus scrofa	Feral Pig	–	NAT	–	–	–	–	–	–

Origin: NAT, naturalized; END, endemic; IND, indigenous
Status: FE, federally listed endangered; FT, federally listed threatened; MBTA, federally listed; CAN, candidate for federal listing; SAR, species at risk
Global Conservation Status (NatureServe http://explorer.natureserve.org/granks.htm). GX, Presumed Extinct, GH, Possibly Extinct, G1 Critically Imperiled, G2, Imperiled, G3, Vulnerable, G4, Apparently Secure, G5, Secure, G#G#, Range Rank (range of uncertainty), GU, Unrankable, GNR, Unranked, GNA, Not Applicable
Dates following scientific names indicate the last observation of the taxon.

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APPENDIX D 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 D.1). Several of these plant species occur exclusively on the installation (in bold below). 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***
(19)***Tetramolopium* stemmermanniae (not ESA-listed)**
(20)*Vigna o-wahuensis*
(21)*Zanthoxylum hawaiiense*

One mammal species, 3 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 (*Aeorestes semotus*)
(2) Hawaiian Goose (*Branta sandvicensis*)
(3) Band-rumped Storm Petrel (*Hydrobates castro*)
(4) Hawaiian Petrel (*Pterodroma sandwichensis*)
(5) Anthricinan yellow-faced bee (*Hylaeus anthracinus*)
(6) Blackburn's sphinx moth (*Manduca blackburni*)

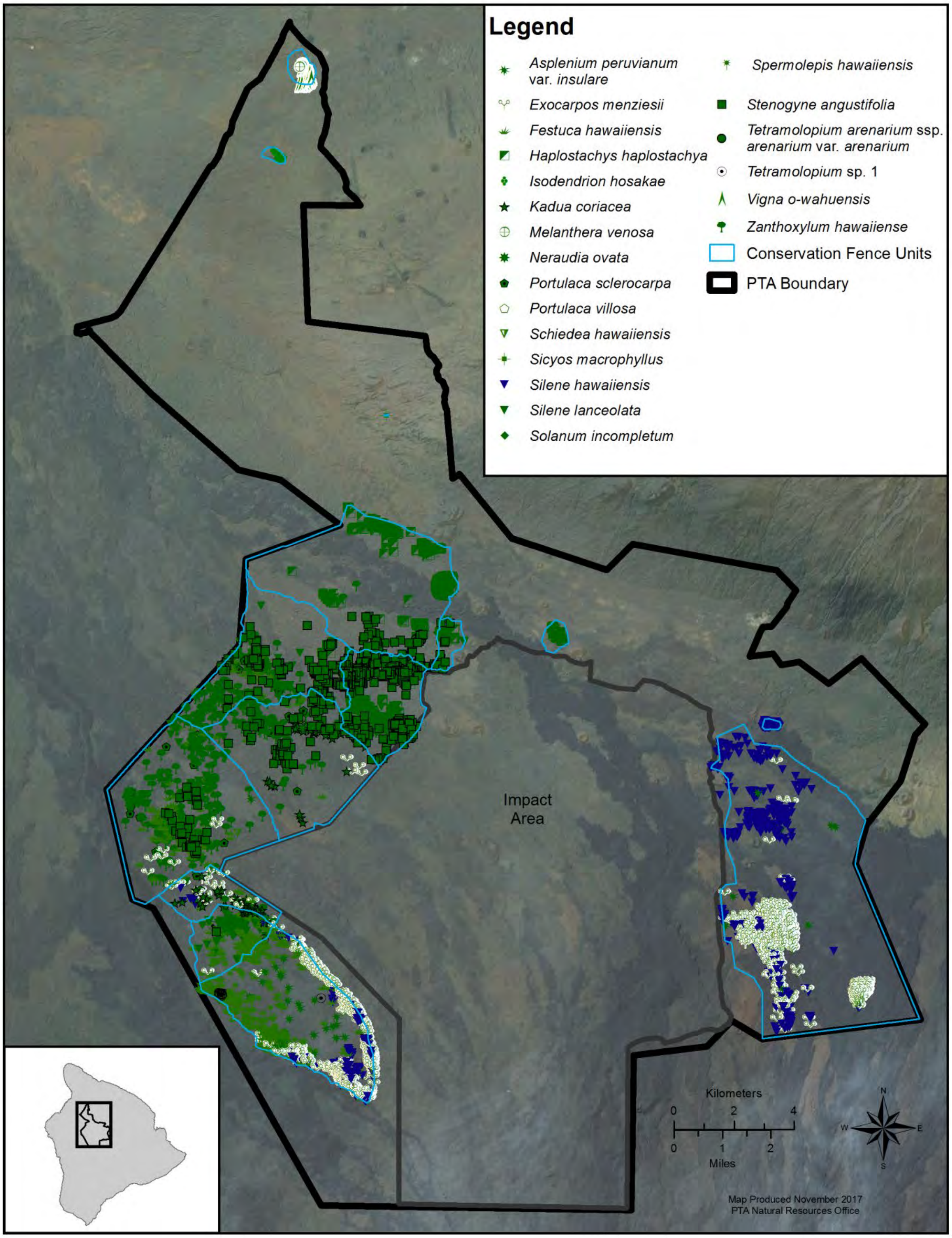

Figure D.1. Known distribution of threatened and endangered plant species at PTA.

***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 3–12 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 2020, there were 714 wild adults and juveniles and 192 wild gametophytes 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 *Exocarpos* 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. We estimate that there are 1,875 (90% CI: 1,458–2,292) wild individuals with in the fence units and 3,674 (90% CI: 2,940–4,410) outside the fence units 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. We estimate that there are 11,699 (90% CI: 8,365–15,033) wild individuals 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 30–60 cm tall. The leaves are fleshy, heart-shaped, and narrowly cordate. The upper surface of the leaves is light green, densely puberulent, 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. We estimate that there are 17,215 (90% CI: 9,223–25,206) wild individuals 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 3–7 cm long and 0.6–2.0 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 12–16 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. As of March 2023, there are 243 wild adults and juveniles and 69 wild 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 3–8 cm long with 5–10 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. As of March 2023, there are 142 wild adults and juveniles and 7 wild seedlings 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 2.1–2.8 cm long and 1.5–2.2 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 2–2.4 mm long and 1.5–1.8 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 under greenhouse conditions 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 March 2023, there are 351 wild adults and juveniles and 490 wild seedlings at the installation. Locations are 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*, *Myrsine* 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 to 2004 and 2013 to 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 March 2023, there are 53 wild 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 3–6 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 *Lipochaeta 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 March 2023, there are 164 wild adults and juveniles and 45 wild seedlings at the installation. 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 in TA 16 and on Puʻu Nohona o Hae in KMA. As of March 2023, there are 7 wild adults and juveniles and 1 wild seedling at the installation. Locations are within the Kīpuka Kālawamauna East Fence Unit.

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, 4–7.8 cm long and 1.7–2.8 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. As of March 2023, there are 4 wild adults and juveniles at the installation.

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, *S. macrophyllus* was discovered in a KMA gulch in 2015 and was enclosed by a 1.8 m conservation fence. There are currently 5 wild individuals (4 adults, 1 juvenile) and 26 wild seedlings at the location.

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 15–40 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 6–15 mm long and 0.5–0.8 mm wide. Flowers are borne in loosely arranged, elongate, sticky clusters. The calyx is fused, 5-toothed, purple-tinged, and 11–14 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. We estimate there are 7,479 (90% CI: 5,552–9,406) wild individuals at the installation (within and outside fence units). 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. lanceolata* 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 –80 mm long and 2–11 mm wide. Flowers are small and arranged in open clusters with stalks 8–23 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 8–9 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. We estimate there are 10,326 (90% CI: 6,972—13,679) wild individuals 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 1–4-lobed on each side. Leaves are oval to elliptic, 10–15 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 March 2023, there are 94 wild adults and juveniles 25 wild seedling. 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 5–20 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 2–6 flowers with white elliptic to ovate petals. Fruits are oval, laterally compressed, and constricted at the line where the 2 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. We estimate there are at least 595 wild individuals at the installation.

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 2–6 cm long and 6–12 mm wide. Flowers are tubular, smooth, and distinctly veined with a lip, 8–13 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. We estimate there are 12,038 (90% CI: 6,684–17,392) wild individuals 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 0.8–1.3 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 15–35 mm and in width from 3–9 mm. Flower clusters are at the end of each stem and have 5–10 heads. Each head has 20–34 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 March 2023, there are 94 wild adults and juveniles and 37 wild seedlings at the installation. Individual counts vary with precipitation and can fluctuate widely.

Tetramolopium stemmermanniae (Tooth-leaf Pāmakani)

The plant in the sunflower family was recently described and is 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. stemmermanniae* 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.

This species was discovered at PTA in 1990 and is relatively new to science. We completed a scientific description of this species; with the submission and acceptance of the manuscript to a peer-reviewed journal, this species received a name more than 30 years after its discovery—*Tetramolopium stemmermanniae*.

Habitat: *T. stemmermanniae* 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 fallax.* 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. stemmermanniae*. 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 under greenhouse conditions.

Distribution: At PTA, *T. stemmermanniae* occurs in TAs 22 and 23. As of March 2023, there are 82 wild adults and juveniles and 42 wild seedlings at the installation.

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 3 leaflets that are 1.2–8 cm long and 0.1–2.5 cm wide. Coarse hairs sparsely to moderately cover the leaflets. Flowers occur in clusters of 1–4 and have thin, translucent, pale yellow or greenish-yellow petals 2–2.5 cm long. The calyx is sparsely hairy and 4–8.0 mm long with asymmetrical lobes. Fruits are slender pods of 4–9 cm in length and 5 mm in width. Pods may be slightly inflated and contain between 7–15 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. 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 March 2023, there are 150 wild adults and juveniles and 137 wild seedlings at the installation. Locations are on Puʻu Nohona o Hae.

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 3–8 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 3.4–10 cm long and 1.5–5 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 15–20 flowers with 4 triangular sepals each. Fruits are sickle-shaped follicles that range in length from 8–10 mm. The fruits contain a single black seed 6–8 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. 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. We estimate there are 498 wild individuals 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 (*Aeorestes* ***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 threatened 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.

Band-rumped Storm Petrel, ʻAkēʻakē (*Hydrobatesa 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 visits puʻu to swoop and call. The species' breeding biology in Hawaiʻi is not well known, but individuals likely 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 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 and 2015 (May to 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 to 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 Hawaiʻi. 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 from sea level to 1,525 m. Larvae feed on plants in the nightshade family, Solanaceae, especially native ʻaiea (*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 Kauaʻi, Kahoʻolawe, Oʻahu, Molokaʻi, Maui, and Hawaiʻi. Most historical records were from coastal or lowland dry forest habitats in areas receiving less than 120 cm annual rainfall. By the 1970s, the species 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, Kahoʻolawe and Hawaiʻi. 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 E WILDLIFE ENCLOSURES

E.1 ARMY NATURAL RESOURCES PROGRAM AT PŌHAKULOA TRAINING AREA RARE AND FEDERALLY LISTED SPECIES AND MIGRATORY BIRD SPECIES INCIDENT REPORT FORM

E.1.1 HAWAIIAN GOOSE INCIDENTAL FIND 29 NOVEMBER 2021

US Army Garrison, Pōhakuloa Training Area Natural Resource Program

Rare, Federally listed Species and Migratory Bird Species Incident Report

INCIDENT INFORMATION

Date of Incident: 29 November 2021

Time Observed: 0942h

Observer Name: Michael Loquet

Incidental or Routine Search: Incidental

Species Name: Hawaiian Goose (*Branta sandvicensis*)

Species Status (ESA, MBTA): ESA

Age (Adult/Juvenilely), if known: Juvenile

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): The Hawaiian Goose carcass appeared intact with no visible signs of injury (lacerations, bite marks). The carcass was completely intact, on its back with legs outstretched and head on its side and no evidence of predation (Figure 1 and Figure 2). Flies were present when the carcass was found and fly eggs were visible on the back of the carcass. No signs of rigor mortis was detected.

General Location: Hakalau Forest National Wildlife Refuge, in the Pua ʻĀkala Tract area

GPS Coordinates (UTM Easting, Northing): (255676.93, 2189658.33)

Distance to Base of Closest Structure and or Landmark: 15 meters from the Pua ʻĀkala cabins

Ground Cover Type: Grass

Temperature (°F): 60°F

Precipitation (Inches): 0.25

Max Wind Speed (mph): 5.0

Cloud Cover (%): 90

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 due to the lack of visible signs of predation.

Additional Comments: On 29 November 2021, at 0942h Mr. Michael Loquet (CEMML Wildlife Technician) was checking cat traps at Hakalau Forest National Wildlife Refuge, in the Pua ʻĀkala Tract area when he discovered a Hawaiian Goose gosling carcass. After the discovery Mr. Loquet and Mr. Silas Pelkey (CEMML Wildlife Biologist) notified Mr. Rogelio Doratt (CEMML Wildlife Program Manager) about the goose carcass. At 1023h Mr. Doratt notified Ms. Donna Ball (Deputy Manager Hakalau Forest NWR) and Mr. Mackey Bishop (Hakalau Staff) that a gosling carcass had been discovered. At 1108h Mr. Loquet met Mr. Bishop and Mr. Bishop collected the carcass.

Figure 1. Hawaiian Goose gosling carcass discovered at Hakalau Forest National Wildlife Refuge, in the Pua ʻĀkala Tract area

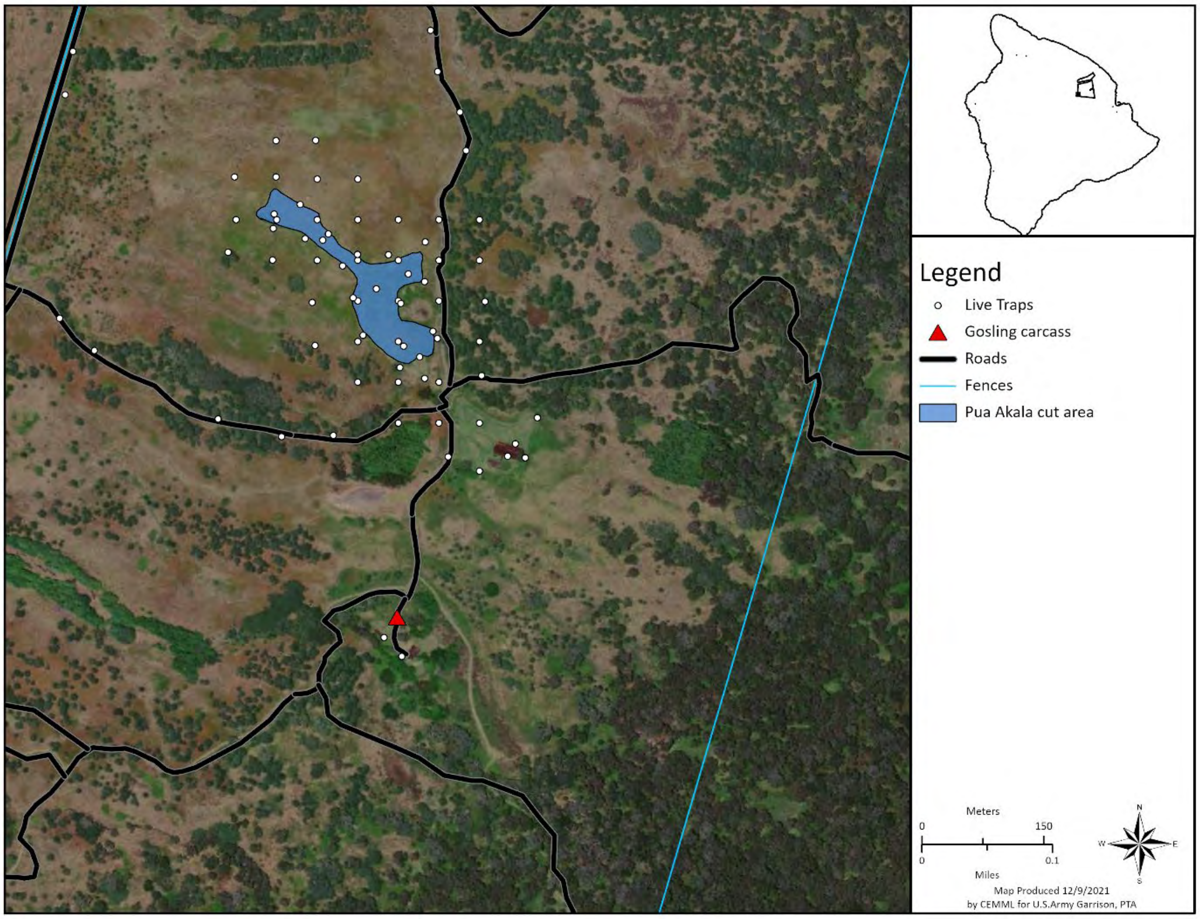

Figure 2.Hawaiian Goose gosling carcass discovered at Hakalau Forest National Wildlife Refuge, in the Pua ʻĀkala Tract area

E.1.2 HAWAIIAN GOOSE INCIDENTAL FIND 13 DECEMBER 2021

US Army Garrison, Pōhakuloa Training Area Natural Resource Program

Rare, Federally listed Species and Migratory Bird Species Incident Report

INCIDENT INFORMATION

Date of Incident: 13 December 2021

Time Observed: 1010h

Observer Name: Michael Loquet

Incidental or Routine Search: Incidental

Species Name: Hawaiian Goose (*Branta sandvicensis*)

Species Status (ESA, MBTA): ESA

Age (Adult/Juvenile), if known: Juvenile

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): The Hawaiian Goose gosling carcass appeared intact with a small visible laceration on the left wing tip. The carcass was completely intact, on its back with legs outstretched and head on its side and no evidence of predation (Figure 1). Flies were present when the carcass was found and rigor mortis had set in.

General Location: Hakalau Forest National Wildlife Refuge, in the Pua ʻĀkala Tract area

GPS Coordinates (UTM Easting, Northing): (255736, 218977)

Distance to Base of Closest Structure and or Landmark: 120 meters from the Pua ʻĀkala barn

Ground Cover Type: Gravel along the road

Temperature (°F): 65°F

Precipitation (Inches): 0.25

Max Wind Speed (mph): 5.0

Cloud Cover (%): 100

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. No signs of vehicle strike or predation. There is no direct evidence that our management activities caused the gosling's death.

Additional Comments: On 13 December 2021, at 1010h Mr. Michael Loquet (CEMML Wildlife Technician) was checking cat traps at Hakalau Forest National Wildlife Refuge, in the Pua ʻĀkala Tract area when he discovered a Hawaiian Goose gosling carcass. After the discovery Mr. Loquet notified Mr. Rogelio Doratt (CEMML Wildlife Program Manager) about the goose carcass. At 1023h Mr. Doratt notified Ms. Donna Ball (Deputy Manager Hakalau Forest NWR) and Mr. Mackey Bishop (Hakalau Staff) that a gosling carcass had been discovered. At 1055h Mr. Loquet met Mr. Bishop and Mr. Bishop collected the carcass.

Figure 1. Hawaiian Goose gosling carcass (red circle) discovered at Hakalau Forest National Wildlife Refuge, in the Pua ʻĀkala Tract area

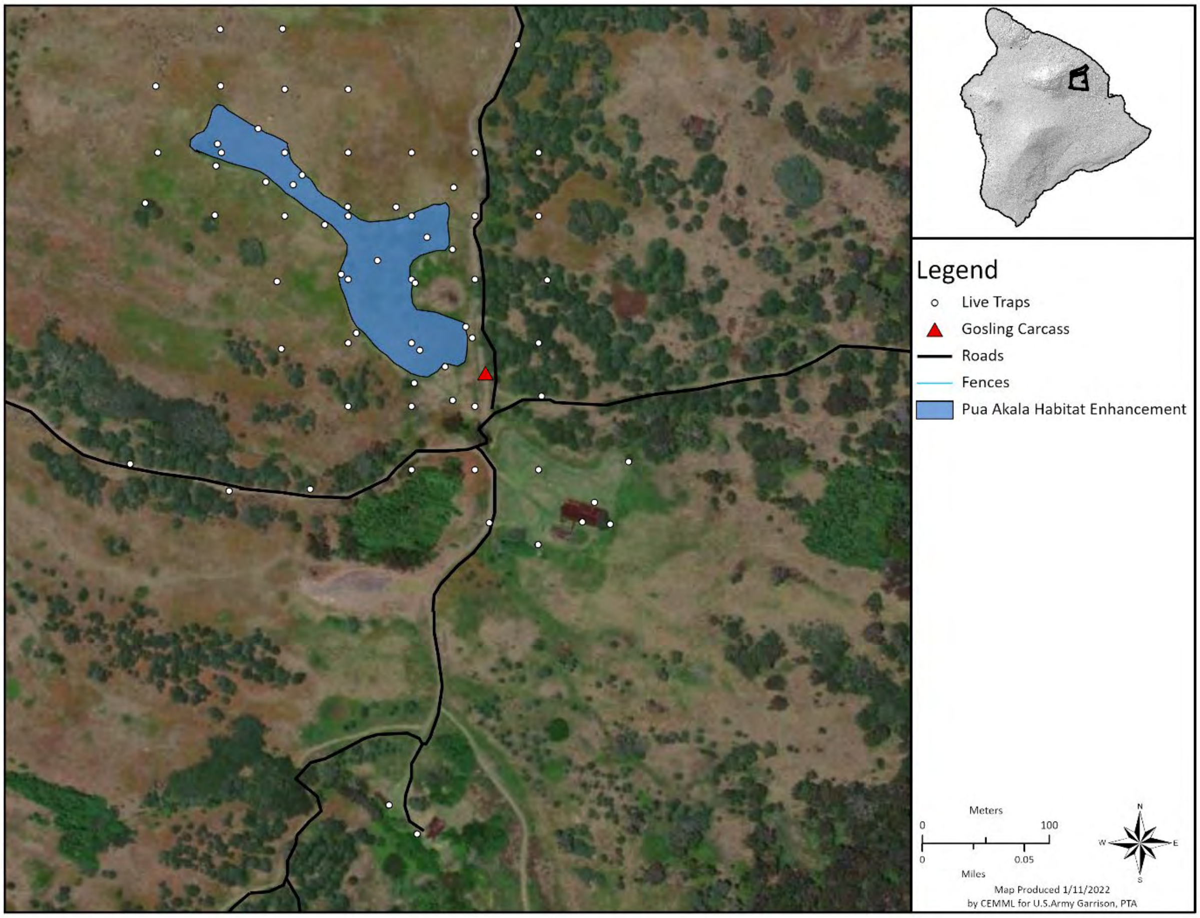

Figure 2. Hawaiian Goose gosling carcass discovered at Hakalau Forest National Wildlife Refuge, in the Pua ʻĀkala Tract area

Please contact Lena Schnell, Senior Cooperator Program Manager, CSU-CEMML, PTA NRP at

(808) 315-0300 or email Lena.Schnell@colostate.edu for further information.

Report generated by Rogelio E. Doratt and Mike P. Loquet 1/13/2022.

E.1.3 HAWAIIAN GOOSE INCIDENTAL FIND 16 DECEMBER 2021

US Army Garrison, Pōhakuloa Training Area Natural Resource Program

Rare, Federally listed Species and Migratory Bird Species Incident Report

INCIDENT INFORMATION

Date of Incident: 16 December 2021

Time Observed: 0925h

Observer Name: Silas Pelkey

Incidental or Routine Search: Incidental

Species Name: Hawaiian Goose (*Branta sandvicensis*)

Species Status (ESA, MBTA): ESA

Age (Adult/Juvenilely), if known: Juvenile

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): Both Hawaiian Goose gosling carcasses appeared intact with no visible signs of injury. Carcasses were completely intact, on their backs with legs extended and head outstretched on its side. Flies had begun laying eggs on the underside of the carcasses. One goose was limp, while the other goose showed signs of rigor mortis.

General Location: Hakalau Forest National Wildlife Refuge, in the Pua ʻĀkala Tract area

GPS Coordinates (UTM Easting, Northing): (255671, 2189640)

Distance to Base of Closest Structure and or Landmark: 7 meters from the Pua ʻĀkala cabins

Ground Cover Type: Grass

Temperature (°F): 58°F

Precipitation (Inches): 0

Max Wind Speed (mph): 0

Cloud Cover (%): 20

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. No signs of vehicle strike or predation.

Additional Comments:

On 16 December 2021, at 0925h Mr. Silas Pelkey (CEMML Wildlife Technician) was closing cat traps at Hakalau Forest National Wildlife Refuge, in the Pua ʻĀkala Tract area when he observed 2 Hawaiian Goose gosling on a grass area near the Pua ʻĀkala cabins. Upon investigating the goslings Mr. Pelkey saw that 1 gosling appeared to be non-responsive and lying on the grass. A half meter from the dead gosling Mr. Pelkey also observed the other gosling (alive) sitting in the grass (Figure 1. Approximately 3 meters from both goslings Mr. Pelkey saw 2 adult Hawaiian Geese laying in a bed of vines, observing the goslings. Mr. Pelkey did not record leg bands of the adult geese.

After the discovery Mr. Silas Pelkey contacted Mr. Rogelio Doratt (CEMML Wildlife Program Manager) about the gosling carcass. At 0935h Mr. Doratt notified Ms. Donna Ball (Deputy Manager Hakalau Forest NWR), that a gosling carcass had been discovered. At 1313h Mr. Silas Pelkey returned to the area and he observed that the second gosling was unresponsive. Mr. Pelkey again contacted Mr. Doratt who contacted Ms. Donna Ball and they told Mr. Pelkey to collect the 2 gosling carcasses. At 1336h Mr. Pelkey collected both carcasses in a plastic bag and stored them at Pōhakuloa Training Area. On 17 December 2021, at approximately, 0800h Mr. Doratt delivered the 2 gosling carcasses (previously stored in a refrigerator) to Mr. Raymond McGuire (State of Hawaii. Department Land and Natural Resource, Division of Forestry and Wildlife, Biologist). Mr. McGuire and Ms. Ball told Mr. Doratt that they were planning to coordinated with Dr. Thierry Works (National Wildlife Health Center, Wildlife Disease Specialist) to perform a necropsy on the 2 gosling carcasses.

Figure 1. Hawaiian Goose gosling carcass next to a living gosling discovered at Hakalau Forest National Wildlife Refuge Pua ʻĀkala tract. Photo taken at 0925h

Figure 2. The second Hawaiian Goose gosling carcass discovered next to the previous recorded gosling carcass at Hakalau Forest National Wildlife Refuge Pua ʻĀkala tract. Photo taken at 1313h

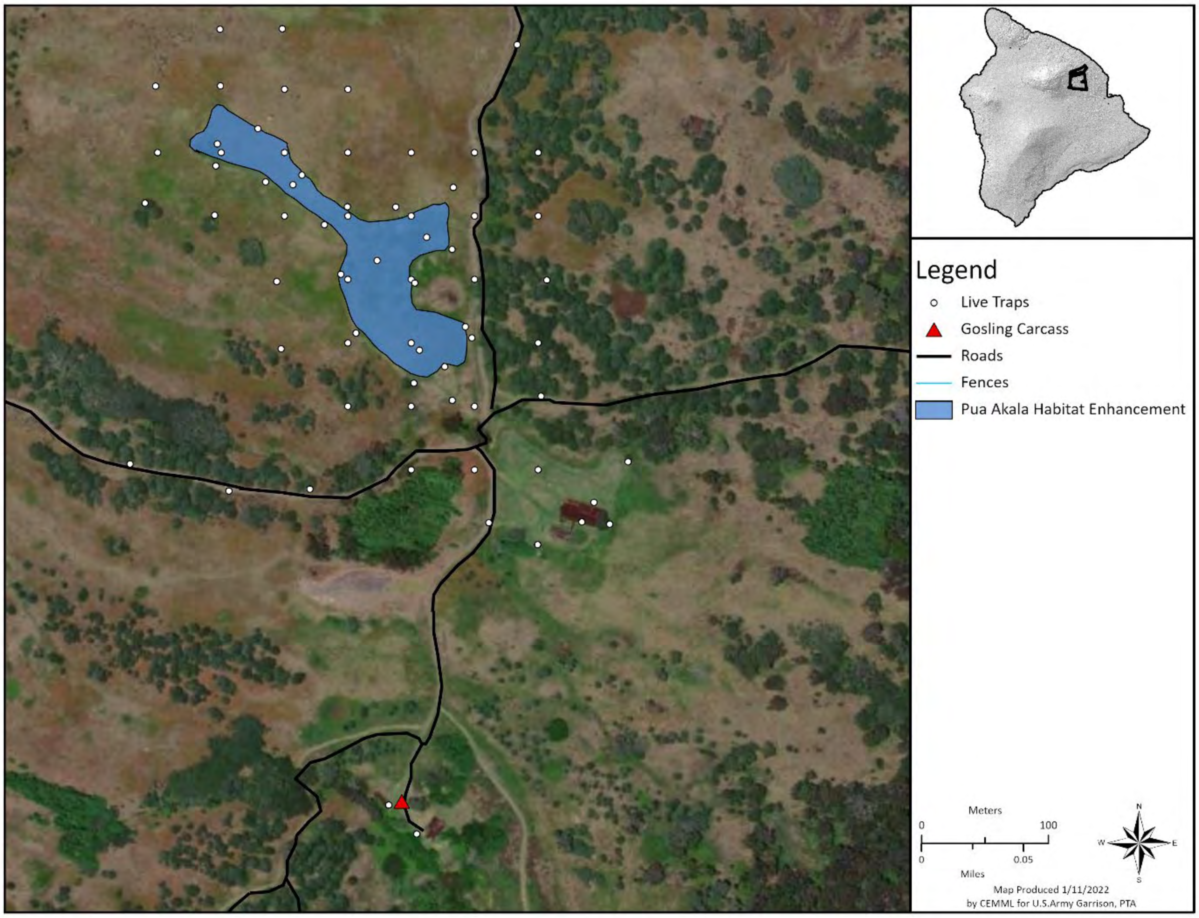

Figure 3. Hawaiian Geese gosling carcasses discovered at Hakalau Forest National Wildlife Refuge, in the Pua ʻĀkala Tract area

Please contact Lena Schnell, Senior Cooperator Program Manager, CSU-CEMML, PTA NRP at (808) 315-0300 or email Lena.Schnell@colostate.edu for further information.

Report generated by Rogelio E. Doratt and Silas G. Pelkey 1/27/2022.

E.1.4 Discovery of an injured Hawaiian Goose gosling on 16 February 2022

US Army Garrison, Pōhakuloa Training Area Natural Resource Program

Rare, Federally listed Species and Migratory Bird Species Incident Report

INCIDENT INFORMATION

Date of Incident: 16 February 2022

Time Observed: 1305h

Observer Name: Martha Kawasaki

Incidental or Routine Search: Incidental

Species Name: Hawaiian Goose, (*Branta sandvicensis*)

Species Status (ESA, MBTA): ESA

Age (Adult/Juvenilely), if known: Juvenile

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): A Hawaiian Goose gosling (possibly 6-8 weeks old) with a clear break in its wing was observed walking up the road from the quarry towards the barn with 2 banded adults (Grey/Black K61 and Green/White 717). The wing appeared to be broken at the elbow and bleeding was observed. Upon capture and inspection of the injury it was observed that the gosling was growing in pin feathers and much of the bleeding seem to be associated with the pin feathers around the break in the wing.

General Location: Hakalau Forest National Wildlife Refuge, in the Pua ʻĀkala Tract area (Figure 1).

GPS Coordinates (UTM Easting, Northing): (255759, 2189859)

Distance to Base of Closest Structure and or Landmark: 7 meters from the Pua ʻĀkala barn

Ground Cover Type: Grass

Temperature (°F): 60°F

Precipitation (Inches): 0.25

Max Wind Speed (mph): 5.0

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 injury is unknown. No signs of vehicle strike or predation. There is no direct evidence that our management activities caused the injury to the gosling.

Additional Comments: At 1305h, 16 February 2022, a Hawaiian Goose family with an injured gosling was observed walking up the road from the quarry towards the Pua ʻĀkala barn. At 1312h Ms. Kawasaki (Wildlife Biologist) informed Mr. Rogelio Doratt (Wildlife Program Manager) about the injury. At this time Mr. Doratt notified Ms. Donna Ball (Deputy Manager Hakalau Forest NWR) and Mr. Raymond McGuire (State of Hawaii, Department Land and Natural Resource, Division of Forestry and Wildlife, Biologist) about the injured gosling. Both Ms. Ball and Mr. McGuire approved for Ms. Kawasaki to capture the injured gosling and transport it to Hawaii Wildlife Center. The gosling was safely captured and placed inside cardboard box. At 1510h, the gosling was then transferred over to a Hawaii Wildlife Center (HWC) volunteer at Puʻu Huluhulu.

On 16 February, Mr. Juan Guerra (Hawaii Wildlife Center, DMV) emailed Ms. Ball, Mr. McGuire, Mr. Doratt, and others a summary of the status of the gosling and the decision to euthanize the gosling due to the severity of the injury (Enclosure 1).

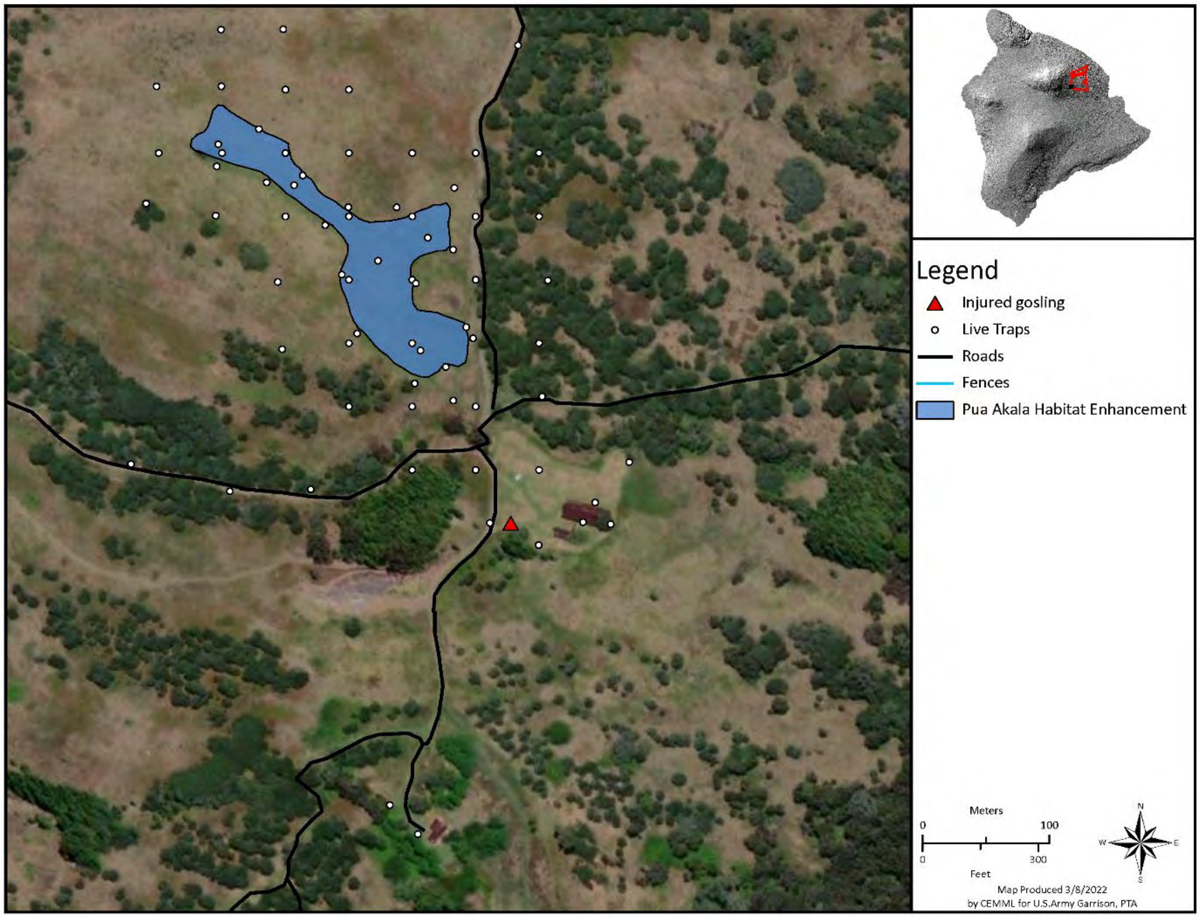

Figure 1. Injured Hawaiian Goose gosling discovered at Hakalau Forest National Wildlife Refuge, in the Pua ʻĀkala Tract area

Enclosure 1

Email Correspondence between Hawaii Wildlife Center, Hakalau Forest National Wildlife Refuge, Pōhakuloa, and US Fish and Wildlife Staff.

From: Doratt Rogelio
To: Ball, Donna L
Subject: RE: [EXTERNAL] Hawaiian Goose (22-24) Admitted and Final Disposition Hawaii Wildlife Center
Date: Thursday, February 17, 2022 9:47:00 AM

Thank you for including us.

Rogelio

From: Ball, Donna L <Donna_L_Ball@fws.gov>
Sent: Thursday, February 17, 2022 9:44 AM
To: Doratt Rogelio <Rogelio.Doratt@colostate.edu>
Subject: Fw: [EXTERNAL] Hawaiian Goose (22-24) Admitted and Final Disposition Hawaii Wildlife Center

**** Caution: EXTERNAL Sender ****

Here is the follow-up email from HWC on the injured nene your team recovered yesterday at Hakalau.

Donna L. Ball
Deputy Manager
Hakalau Forest NWR
60 Nowelo St.
Hilo, HI 96720
of. 808-854-2629
Cell 808-895-9496
https://www.fws.gov/refuge/hakalau_forest/

From: Ball, Donna L <Donna_L_Ball@fws.gov>
Sent: Thursday, February 17, 2022 8:10 AM
To: Juan Carlos Guerra <juan@hawaiiwildlifecenter.org>; PermitsR1MB, FW1 <permitsr1mb@fws.gov>; jason.d.omick@hawaii.gov <jason.d.omick@hawaii.gov>
Cc: raymond.b.mcguire@hawaii.gov <raymond.b.mcguire@hawaii.gov>; kanalu.sproat@hawaii.gov <kanalu.sproat@hawaii.gov>; ian.w.cole@hawaii.gov <ian.w.cole@hawaii.gov>; linda@hawaiiwildlifecenter.org <linda@hawaiiwildlifecenter.org>; james.p.ridzon@hawaii.gov <james.p.ridzon@hawaii.gov>; Bogardus, Michelle <michelle_bogardus@fws.gov>; Kawabata, Cory F <cory_kawabata@fws.gov>; Roth, Jennifer N <jennifer_roth@fws.gov>; Martinez Soriano, Jose D <jose_martinezsoriano@fws.gov>; Hawaii Wildlife Center <birdhelp@hawaiiwildlifecenter.org>
Subject: Re: [EXTERNAL] Hawaiian Goose (22-24) Admitted and Final Disposition Hawaii Wildlife Center

Mahalo everyone, Unfortunate outcome. Your follow-up is much appreciated

Donna L. Ball
Deputy Manager
Hakalau Forest NWR

60 Nowelo St
Hilo, HI 96720
of 808-854-2629
Cell 808-805-9496
https://www.fws.gov/refuge/hakalau_forest/

From: Juan Carlos Guerra <juan@hawaiiwildlifecenter.org>
Sent: Wednesday, February 16, 2022 5:18 PM
To: PermitsR1MB, FW1 <permitsr1mb@fws.gov>; jason.d.omick@hawaii.gov <jason.d.omick@hawaii.gov>
Cc: raymond.b.mcguire@hawaii.gov <raymond.b.mcguire@hawaii.gov>; kanalu.sproat@hawaii.gov <kanalu.sproat@hawaii.gov>; jan.w.cole@hawaii.gov <jan.w.cole@hawaii.gov>; linda@hawaiiwildlifecenter.org <linda@hawaiiwildlifecenter.org>; james.p.ridzon@hawaii.gov <james.p.ridzon@hawaii.gov>; Bogardus, Michelle <michelle_bogardus@fws.gov>; Kawabata, Cory F <cory_kawabata@fws.gov>; Roth, Jennifer N <jennifer_roth@fws.gov>; Martinez Soriano, Jose O <jose_martinezsoriano@fws.gov>; Ball, Donna L <Donna_L_Ball@fws.gov>; Hawaii Wildlife Center <birdhelp@hawaiiwildlifecenter.org>
Subject: [EXTERNAL] Hawaiian Goose (22-24) Admitted and Final Disposition Hawaii Wildlife Center

This email has been received from outside of DOI - Use caution before clicking on links, opening attachments, or responding.

Hi everyone,

Today we received another injured Nene (HWC ID# 22-24). The bird was found at the Hakalau Wildlife Refuge by Marty Kawasaki and was reported to us by Donna Ball. On examination the bird is a hatch year nene of 1.38kg. An open distal humeral fracture was present on the left wing. The bone was exposed about 5cm, the end of it was dry and dark. The wing distal to the fracture was severely swollen and cool to the touch compared to the normal wing. Due to the severity of the injury the bird would lose the wing proximal to the elbow. Because of this we euthanized the bird. Let me know if you have any questions.

-Juan

--
Juan Carlos Guerra, DVM
Hawaii Wildlife Center

Please contact Lena Schnell, Senior Cooperator Program Manager, CSU-CEMML, PTA NRP at (808) 315-0300 or email Lena.Schnell@colostate.edu for further information

Report generated by Martha Kawasaki and Rogelio E. Doratt 3/8/2022.

6

E.1.5 HAWAIIAN GOOSE INCIDENTAL FIND 28 DECEMBER 2022

US Army Garrison, Pōhakuloa Training Area Natural Resource Program

Rare, Federally listed Species and Migratory Bird Species Incident Report

INCIDENT INFORMATION

Date of Incident: 28 December 2022

Time Observed: 0934h

Observer Name: Michael Loquet

Incidental or Routine Search: Incidental

Species Name: Hawaiian Goose (*Branta sandvicensis*)

Species Status (ESA, MBTA): ESA

Age (Adult/Juvenilely), if known: Juvenile

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): A Hawaiian Goose gosling carcass was discovered lying on its side in a grassy area near a dilapidated shed located near the Pua ʻĀkala cabin (Figure 1). The carcass was found next to a significant amount of adult Hawaiian Goose scat. No visible injuries were detected on the carcass.

General Location: Hakalau Forest National Wildlife Refuge, in the Pua ʻĀkala Tract area

GPS Coordinates (UTM Easting, Northing): (255657, 2189652)

Distance to Base of Closest Structure and or Landmark: 10 meters from the shed structure.

Ground Cover Type: Grass

Temperature (°F): 70°F

Precipitation (Inches): 0

Max Wind Speed (mph): 0

Cloud Cover (%): 20

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. No signs of vehicle strike or predation.

Additional Comments:

On 28 December 2022 at 0830h Mr. Michael Loquet (CEMML, Wildlife Biologist) was notified by Ms. Donna Ball (Deputy Manager, Hakalau Forest NWR), that 2 feral dog sightings were reported that morning near the Pua ʻĀkala barn.

At 0934h while monitoring cat traps and surveying for geese in the Pua ʻĀkala Tract area Mr. Loquet discovered 1 Hawaiian Goose gosling carcass on a grass area near a dilapidated shed near the Pua ʻĀkala cabin (Figure 1 and Figure 2). No visible injuries were detected on the carcass. Mr. Loquet contacted Mr. Rogelio Doratt (CEMML, Wildlife Program Manager) and reported to Mr. Doratt and Ms. Ball about the discovery. Ms. Ball told the CEMML staff that a Hakalau staff member would be collecting the gosling carcass and to continue reporting any other carcasses or feral dog sightings.

At 1001h Mr. Loquet saw and heard a dog barking west of the Pua ʻĀkala habitat enhancement area (Figure 3). Then at 1015h Mr. Loquet discovered a pile of Hawaiian Goose feathers and bones (Figure 2). Both the feral dog sighting and the goose feather and bone pile were reported to Hakalau staff.

Figure 1. Hawaiian Goose gosling carcass at Hakalau Forest National Wildlife Refuge Pua ʻĀkala tract. Photo taken at 0935h

Figure 2. Hawaiian Goose feathers and bones pile at Hakalau Forest National Wildlife Refuge Pua ʻĀkala tract. Photo taken at 0935h

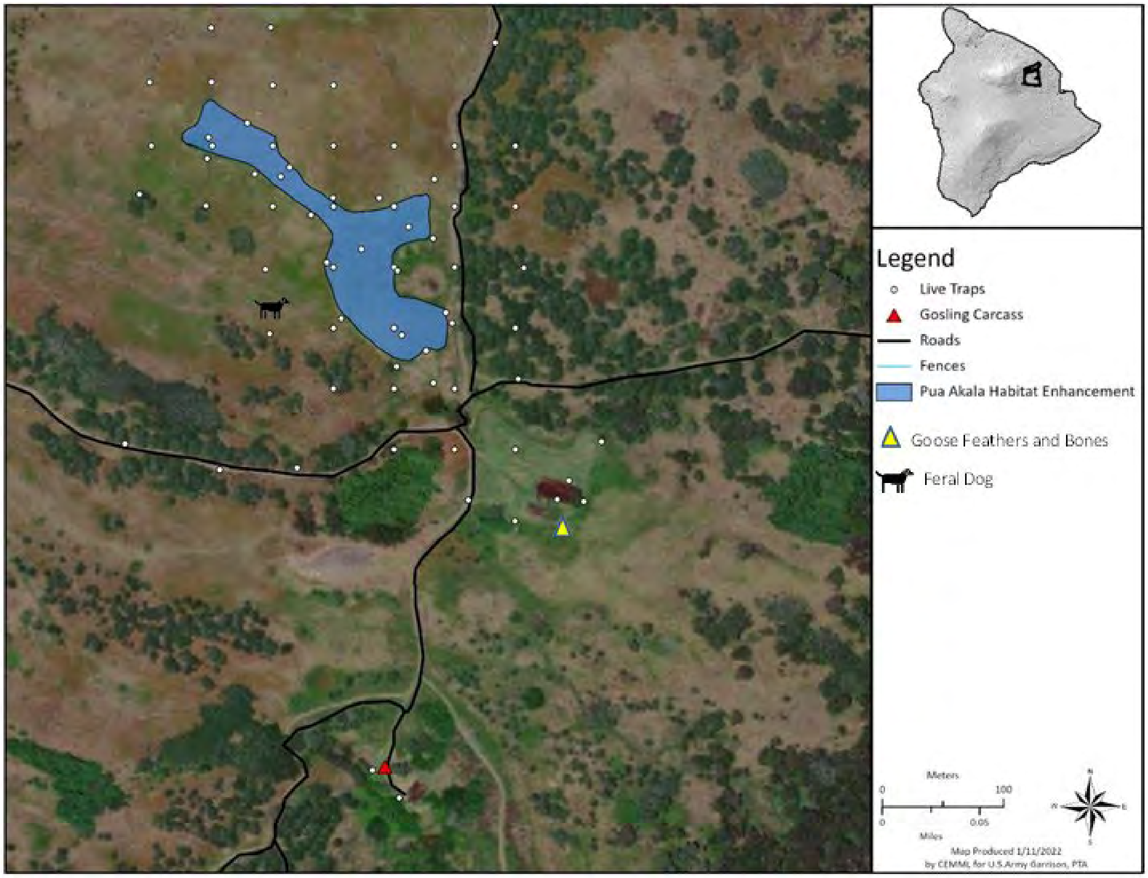

Figure 3. Hawaiian Goose gosling carcass, goose feathers and bone pile, and feral dog locations at Hakalau Forest National Wildlife Refuge, in the Pua ʻĀkala Tract area.

Please contact Lena Schnell, Senior Cooperator Program Manager, CSU-CEMML, PTA NRP at (808) 315-0300 or email Lena.Schnell@colostate.edu for further information

Report generated by Mike Loquet and Rogelio Doratt 1/4/2023

E.1.6 HAWAIIAN GOOSE INCIDENTAL FIND 22 MARCH 2023

US Army Garrison, Pōhakuloa Training Area Natural Resource Program

Rare, Federally listed Species and Migratory Bird Species Incident Report

INCIDENT INFORMATION

Date of Incident: 22 March 2023

Time Observed: 1130h

Observer Name: Paul Regrutto

Incidental or Routine Search: Incidental

Species Name: Hawaiian Goose (*Branta sandvicensis*)

Species Status (ESA, MBTA): ESA

Age (Adult/Juvenilely), if known: adult

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): A Hawaiian Goose carcass was discovered underneath an ohelo bush, about 50 meters west of Middle Road. The carcass was decomposed and looked to have been predated or scavenged (Figure 1). The carcass had feathers and some bones, but was missing the head, legs, and the majority of the body.

General Location: Hakalau Forest National Wildlife Refuge, in the Pua Akala Tract area

GPS Coordinates (UTM Easting, Northing): (19.793332 N and 155.331710 W)

Distance to Base of Closest Structure and or Landmark: 50 meters west of Middle Road.

Ground Cover Type: Grass

Temperature (°F): 60°F

Precipitation (Inches): Heavy Rain

Max Wind Speed (mph): 5

Cloud Cover (%): 100

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 due to state of carcass but was likely predated or scavenged.

Additional Comments:

On 22 March 2023 at 1130h Mr. Paul Regrutto (CEMML, Wildlife Technician) was Surveying for geese in the Pua Akala Tract and discovered 1 Hawaiian Goose adult carcass on a grass area underneath an ohelo bush, about 50 meters west of Middle Road. The carcass was heavily predated or scavenged. Mr. Regrutto contacted NRO employee Dan Jensen, who confirmed the location and status of the bird.

At 1200h Mr. Regrutto informed Mr. Michael Loquet (Wildlife Biologist) of the carcasses discovery. Mr. Loquet reported the carcasses discovery to Donna Ball, Springer Kaye, and Eldridge. Donna Ball told CEMML staff that Eldridge would check the carcass for tags.

Figure 1. Hawaiian Goose adult carcass at Hakalau Forest National Wildlife Refuge Pua Akala tract. Photo taken at 1130h

Please contact Lena Schnell, Senior Cooperator Program Manager, CSU-CEMML, PTA NRP at (808) 315-0300 or email Lena.Schnell@colostate.edu for further information.

Report generated by Mike Loquet and Rogelio Doratt 3/22/2023.

E.1.7 HAWAIIAN GOOSE INCIDENTAL FIND 24 APRIL 2023

US Army Garrison, Pōhakuloa Training Area Natural Resource Program

Rare, Federally listed Species and Migratory Bird Species Incident Report

INCIDENT INFORMATION

Capture and translocation of Hawaiian Goose (*Branta sandvicensis*) family from Bradshaw Army Airfield, Pōhakuloa Training Area (PTA) to Puʻu Oʻo Ranch, Hawai'i.

Date of Incident: 24 April 2023

Time Observed: 1012h

Observer Name: Mr. Mike Loquet (Colorado State University (CSU) Center for Environmental Management of Military Lands (CEMML) Wildlife Biologist

Incidental or Routine Search: Routine

Species Name: Hawaiian Goose (*Branta sandvicensis*)

Species Status (ESA, MBTA): ESA

Age (Adult/Juvenilely), if known: 3 Adults, 3 goslings

Leg Band Information/Sex (if known):

1. Grey/Black A97 (Male)
2. Grey/Black A98 (Female)
3. Green/White KZP (Unknown)
4. Gosling (Unknown)
5. Gosling (Unknown)
6. Gosling (Unknown)

General Location: Bradshaw Army Airfield (BAAF), Pōhakuloa Training Area

GPS Coordinates (UTM Easting, Northing): (232303 E, 2186642 N)

Distance to Base of Closest Structure and or Landmark: ~40 Meters from the Bradshaw Army Airfield Fire Station.

Vegetation Cover Type: kikuyu grass (*Cenchrus clandestinus*), fountain grass (*Cenchrus setaceus*), Bermuda grass (*Cynodon dactylon*), red-stem filaree (*Erodium cicutarium*), telegraph weed (*Heterotheca grandiflora*), cheese weed (*Marva parviflora*), bur clover (*Medicago polymorpha*), yellow sweet clover (*Melilotus indica*), Russian thistle (*Salsola tragus*), fireweed (*Senecio madagascariensis*), London rocket (*Sisymbrium irio*), and golden crown beard (*Verbesina encelioides*).

Temperature (°F): 51°F

Precipitation (Inches): 0

Max Wind Speed (mph): 5

Cloud Cover (%): 10

Incident occurred during military training (Yes/No): No

Additional Comments:

On 21 April 2023, while monitoring for the 2 molting geese (Grey/Black A97 and Green/White KZP) at 0740h Mr. Rogelio E. Doratt (CSU CEMML, Wildlife Program Manager) observed a Hawaiian Goose family (2 adults and 3 goslings), leg bands (Grey/Black A97 and A98 and 3 unbanded) walking under a māmane (*Sophora chrysophylla*), in the Bradshaw Army Airfield footprint. Mr. Doratt first observed the 2 adults then the 3 goslings running behind them as he approached the family. At 0840h Mr. Doratt observed Green/White KZP alone ~141 meters away from the family.

After the discovery Mr. Doratt contacted Mrs. Joy Anamizu (PTA Army Biologist), Mrs. Lena Schnell (CSU CEMML Senior Cooperator Program Manager), and Raymond McGwire (Division of Forestry and Wildlife (DOFAW), Wildlife Biologist) about the finding. Mr. McGwire told Mr. Doratt that on Monday 24 April 2023 he would come to PTA and capture and translocate the family. Mr. McGwire told Mr., Doratt that he would contact his supervisor Mr. Ian Cole (DOFAW) and Ms. Annie Marshall (U.S. Fish and Wildlife Service) about assisting in the translocation of the family off PTA.

On 24 April 2023 at 1012 h, Mr. McGwire, Mr. Cole, and Mr. Jupiter Crosson (DOFAW, technician) and Mr. Loquet and Mr. Paul Regrutto (CSU CEMML, Wildlife technician) captured the 3 goslings and the parents (Grey/Black A97 and A98) from BAAF (Figure 1). On the same day, the goose family was translocated to Puʻu Oʻo Ranch. All the geese were safely captured with long handle nets and caged in a large plastic animal carrier (Figure).

Figure 1. State of Hawaii, Department Land and Natural Resource, Division of Forestry and Wildlife, Biologists, capturing Hawaiian Geese goslings at Bradshaw Army Airfield, Pōhakuloa Training Area, Hawai'i

Figure 2. The Hawaiian Geese family (mother, father and 3 goslings) captured and housed in a large plastic animal carrier, before being transported to Pu'u O'o Ranch, Hawai'i

Please contact Lena Schnell, Senior Cooperator Program Manager, CSU-CEMML, PTA NRP at (808) 315-0300 or email Lena.Schnell@colostate.edu for further information.

Report generated by Michael Loquet and Rogelio Doratt 5/22/2023.

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APPENDIX F FY 2022–FY 2023 COMPLETED DOCUMENT DELIVERABLES FOR THE ARMY'S NATURAL RESOURCES PROGRAM AT PŌHAKULOA TRAINING AREA

We produced the following document deliverables during the FY 2022 to FY 2023 reporting period (01 October 2021 through 30 September 2023). This list includes technical reports, protocols, standard operating procedures, survey summaries, important memoranda for record, 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.

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).

FY 2022 (Oct 2021 to 30 Sep 2022)

- **2020/2021 Breeding Season Report for Hawaiian Goose Conservation Project Hakalau Forest National Wildlife Refuge Hakalau, Hawaiʻi Island, Hawaiʻi, Special Use Permit 12516-19006-G. (2021 10 01):** this technical report summaries the management activities (Hawaiian Goose habitat management, goose monitoring, nest monitoring, and predator control) we conducted for the 2021/2022 Hawaiian Goose breeding season. This report was submitted to comply with the Hakalau SUP annual report requirement. 41 p.

- **US Army Garrison, Pōhakuloa Training Area, Natural Resource Program, Ungulate Exclusion Fence and Gate Damage Incident Report (2021 10 12**): this report summarizes the finding of an open vehicle gate at one of the ungulate exclusion fence units at PTA. This unlocked and open gate occurred in the Kipuka Kālawamauna North fence unit. 8 p.

- **US Army Garrison, Pōhakuloa Training Area, Natural Resource Program, Rare, Federally listed Species and Migratory Bird Species Incidental Report Hawaiian Goose (2021 12 08):** this incident report documents the finding a Hawaiian Goose gosling carcass at Hakalau Forest National Wildlife Refuge. The gosling carcass was reported on the same day that it was discovered to the Refuge and on 29 November 2021 Hakalau staff collected the carcass. Cause of death is unknown. 3.p.

- **2020–2021 Annual Report for the Hawaiʻi Experimental Tropical Forest Research Permit for Pōhakuloa Training Area, Hawaiʻi Island, Hawaiʻi (2021 12 09)**: permit report produced to update NRP reporting status with the State of Hawaiʻi, DLNR DOFAW to outplant TES plants on State lands. 5 p.

- **US Army Garrison, Pōhakuloa Training Area, Natural Resource Program, Rare, Federally listed Species and Migratory Bird Species Incidental Report Hawaiian Goose (2022 01 13):** this incident report documents the finding a Hawaiian Goose gosling carcass at Hakalau Forest National Wildlife Refuge. The gosling carcass was reported on the same day that it was discovered to the Refuge and on 13 December 2021 Hakalau staff collected the carcass. Cause of death is unknown. 3.p

- **2022 Annual Report for Pōhakuloa Training Area, Hawaiʻi Island, Hawaiʻi, Recovery Permit TE-40123A-3, State of Hawai'i Natural Area Reserve, Rare Plant and Native Invertebrate Research Permit 12942 and State of Hawai'i Protected Wildlife Permit for the Purpose of Scientific Collecting WL21-15. (2022 01 21):** technical report documenting activities performed collectively by the Army and CEMML staff during 2022 and to satisfy annual recovery permit reporting requirements. Includes activities authorized under the USFWS recovery permit TE-40123A-3. 94 p.

- **US Army Garrison, Pōhakuloa Training Area, Natural Resource Program, Rare, Federally listed Species and Migratory Bird Species Incidental Report Hawaiian Goose (2022 01 27):** this incident report documents the finding 2 Hawaiian Goose gosling carcass at Hakalau Forest National Wildlife Refuge. The gosling carcasses were reported on the same day that they were discovered to the Refuge and on 16 December 2021 Hakalau staff collected the carcass. Cause of death is unknown. 3.p.

- **2021 Annual Report for Pōhakuloa Training Area, Hawaiʻi Island, Hawaiʻi, USFWS Recovery Permit TE-40123A-3, State of Hawaiʻi Natural Area Reserve, Rare Plant and Native Invertebrate Research Permit I2689, and State of Hawai'i Protected Wildlife Permit for the Purpose of Scientific Collection WL19-24 (2022 01 31):** technical report documenting activities performed collectively by the Army and CEMML staff during 2021 and to satisfy annual recovery permit reporting requirements. Includes activities authorized under the USFWS recovery permit TE-40123A-3 and State of Hawai'i permits I2689 and LW19-42. 116 p.

- **MBTA Scientific collecting for BSTP 2021 Annual Report (2022 01 31):** this annual report summarizes the collections of any Band-rump Storm Petrels found during the 2019 petrel breeding season (USFWS migratory bird permit: MB95880B-0). 1 p.

- **US Army Garrison, Pōhakuloa Training Area, Natural Resource Program, Rare, Federally listed Species and Migratory Bird Species Incidental Report Hawaiian Goose (2022 02 17):** this incident report documents the finding an injured Hawaiian Goose gosling at Hakalau Forest National Wildlife Refuge. The injured gosling was reported on the same day that it was discovered to the Refuge and on 16 February 2022 the gosling was captured and transferred to the Hawaii Wildlife Center. Cause of injury is unknown. 7.p

- **2021 Annual Report for the State of Hawai'i Protected Wildlife Permit WL21-for the Purpose of Scientific Collection WL20-12 (2022 02 15):** technical report documenting activities performed collectively by the Army and CEMML staff during 2021 and to satisfy permit reporting requirements. Includes activities authorized under the State protected wildlife permit WL20-12. 14 p.

- **US Army Garrison, Pōhakuloa Training Area, Natural Resource Program, Ungulate Exclusion Fence Incident Report (2022 02 17**): this report summarizes the detection of 2 unknown people trespassing onto PTA property and climbing over a vehicle gate at the Puu Nohona O Hae ungulate exclusion fence. 3 p.

- **US Army Garrison, Pōhakuloa Training Area, Natural Resource Program, Ungulate Exclusion Fence and Gate Damage Incident Report (2022 04 28**): this report summarizes the finding of an open vehicle gate at one of the ungulate exclusion fence units at PTA. This unlocked and open gate occurred in the Kipuka Kālawamauna North fence unit. 7 p.

- **US Army Garrison, Pōhakuloa Training Area, Natural Resource Program, Ungulate Exclusion Fence and Gate Damage Incident Report (2022 06 08**): this report summarizes the finding of 4 open vehicle gates at 4 of the ungulate exclusion fence units at PTA. This unlock and open gates occurred in the Kipuka Kālawamauna North fence unit, Kipuka Kālawamauna East fence unit, Nāʻōhuleʻelua fence unit, and Mixed Tree fence unit. 5 p.

- **US Army Garrison, Pōhakuloa Training Area, Natural Resource Program, Ungulate Exclusion Fence and Gate Damage Incident Report (2022 07 21**): this report summarizes the finding of an open vehicle gate at one of the ungulate exclusion fence units at PTA. This unlock and open gate occurred in the Kipuka Kālawamauna East fence unit. 4 p.

- **2021/2022 Breeding Season Report for Hawaiian Goose Conservation Project Hakalau Forest National Wildlife Refuge Hakalau, Hawaiʻi Island, Hawaiʻi, Special Use Permit 12516-21020-G. (2022 08 20):** this technical report summaries the management activities (Hawaiian Goose habitat management, goose monitoring, nest monitoring, and predator control) we conducted for the 2021/2022 Hawaiian Goose breeding season. This report was submitted to comply with the Hakalau SUP annual report requirement. 41 p.

- **2022/2023 Hawaiian Goose Conservation Project Plan, Hakalau (2022 09 15):** this project plan proposes the 2022/2023 management activities (Hawaiian Goose habitat management, goose monitoring, nest monitoring, and predator control) that we plan for the Hawaiian Goose breeding season. 3 p.

- **Hakalau Forest National Wildlife Refuge Special Use Permit 12516-22023-R (2022 09 16)**: special use permit issued to the Army by the USFWS providing access to and allowing activities on be conducted at HFNWR for the Hawaiian Goose (e.g., nest searches, predator control, nest monitoring, habitat management). Valid 1 July 2022 through 30 Jun 2023. 16 p.

FY 2023 (Oct 2022 to Sep 2023)

- **US Army Garrison, Pōhakuloa Training Area, Natural Resource Program, Ungulate Exclusion Fence and Gate Damage Incident Report (2022 10 28**): this report summarizes the finding of an open vehicle gate at one of the ungulate exclusion fence units at PTA. This unlock and open gate occurred in the Mixed Tree fence unit. 2 p.

- **Army Natural Resources Program at Pōhakuloa Training Area, Biennial Report, 01 October 2019–30 September 2021 (2022 12):** report documenting the work performed jointly by CEMML and USAG-PTA regarding the management of natural resources at PTA during the 2-year period of FY 2019–FY 2021. 497 p.

- **MBTA Scientific Collecting for Band-rumped Storm Petrel 2022 Annual Report (2023 01 31):** this annual report summarizes the collections of any Band-rump Storm Petrels found during the 2020 petrel breeding season (USFWS migratory bird permit: MB95880B-0). 1 p.

- **2022 Annual Report for Pōhakuloa Training Area, Hawaiʻi Island, Hawaiʻi, USFWS Recovery Permit TE-40123A-3, State of Hawaiʻi Natural Area Reserve, Rare Plant and Native Invertebrate Research Permit I2942, and State of Hawai'i Protected Wildlife Permit for the Purpose of Scientific Collection WL21-15 (2023 01 31):** technical report documenting activities performed collectively by the Army and CEMML staff during 2021 and to satisfy annual recovery permit reporting requirements. Includes activities authorized under the USFWS recovery permit TE-40123A-3 and State of Hawai'i permits I2942 and LW21-15. 94 p.

- **2022 Annual Report for the State of Hawai'i Protected Wildlife Permit WL21-for the Purpose of Scientific Collection WL21-11 (2023 01 31):** technical report documenting activities performed collectively by the Army and CEMML staff during 2022 and to satisfy permit reporting requirements. Includes activities authorized under the State protected wildlife permit WL-21-11. 94 p.

- **US Army Garrison, Pōhakuloa Training Area, Natural Resource Program, Rare, Federally listed Species and Migratory Bird Species Incidental Report Hawaiian Goose (2023 01 04):** this incident report documents the finding a Hawaiian Goose gosling carcass at Hakalau Forest National Wildlife Refuge. The gosling carcass was reported on the same day that it was discovered to the Refuge and on 28 December 2023 Hakalau staff collected the carcass. Cause of death is unknown. 6.p.

- **Results of DeLuz Quarry Inspection on 11 January 2023 (2023 01 12):** this memorandum summarizes the invasive species survey results for the aggregate inspection conducted at DeLuz quarry. 7 p.

- **Results of DeLuz Quarry Inspection on 13 January 2022 (2023 01 20):**this memorandum summarizes the invasive species survey results for the aggregate inspection conducted at DeLuz quarry. 8 p.

- **US Army Garrison, Pōhakuloa Training Area, Natural Resource Program, Rare, Federally listed Species and Migratory Bird Species Incidental Report Hawaiian Goose (2023 03 22):** this incident report documents the finding a Hawaiian Goose carcass at Hakalau Forest National Wildlife Refuge. The goose carcass was reported on the same day that it was discovered to the Refuge and on 22 December 2023 Hakalau staff collected the carcass. Cause of death is unknown. 2.p

- **Results of DeLuz Quarry Inspection on 11 April 2023 (2023 04 11):** this memorandum summarizes the invasive species survey results for the aggregate inspection conducted at DeLuz quarry. 7 p.

- **US Army Garrison, Pōhakuloa Training Area, Natural Resource Program, Ungulate Exclusion Fence and Gate Damage Incident Report (2023 05 06**): this report summarizes the finding of an open vehicle gate at one of the ungulate exclusion fence units at PTA. This unlocked and open gate occurred in the Kipuka Kālawamauna North fence unit. 4 p.

- **US Army Garrison, Pōhakuloa Training Area, Natural Resource Program, Ungulate Exclusion Fence and Gate Damage Incident Report (2023 05 14**): this report summarizes the finding of an open vehicle gate at one of the ungulate exclusion fence units at PTA. This unlocked and open gate occurred in the Kipuka Kālawamauna North fence unit. 6 p.

- **FY 2022 Annual Report for the Army Natural Resources Program at Pōhakuloa Training Area (2023 05)**: report produced to satisfy annual reporting requirements mandated in regulatory and guiding documents. The report covers the period of FY 2018 (01 October 2021 through 30 September 2022). 62 p.

- **2022–2023 Annual Report for the State of Hawaiʻi Access for Pōhakuloa Training Area, Hawaiʻi Island, Hawaiʻi (2023 06)**: permit report produced to update NRP reporting status with the State of Hawaiʻi, DLNR DOFAW to outplant TES plants on State lands. 6 p.

- **History and Status of the Puʻu Waʻawaʻa Forest Reserve Cone Unit (2023 08 03):** technical report summarizing the status of outplanting sites at Puʻu Waʻawaʻa. Includes site summaries and evaluation, species summaries and evaluation, and species conclusions. 42 p.

- **Status of Puʻu Huluhulu Outplanting Sites on Department of Land and Natural Resources Lands (2023 05 11):** technical report summarizing the status of PTA outplanting sites at Puʻu Huluhulu under the jurisdiction of DLNR, Division of Forestry and Wildlife lands. Includes outplanting background, site summary and evaluation, outplanting results, and species conclusions. 17 p.

- **2023/2024 Hawaiian Goose Conservation Project Plan, Hakalau (2023 08):** this project plan proposes the 2019/2020 management activities (Hawaiian Goose habitat management, goose monitoring, nest monitoring, and predator control) that we plan for the Hawaiian Goose breeding season. 3 p.

- **2022/2023 Breeding Season Report for Hawaiian Goose Conservation Project Hakalau Forest National Wildlife Refuge Hakalau, Hawaiʻi Island, Hawaiʻi (2023 08):** this technical report summaries the management activities (Hawaiian Goose habitat management, goose monitoring, nest monitoring, and predator control) we conducted for the 2022/2023 Hawaiian Goose breeding season. This report was submitted to comply with the Hakalau SUP annual report requirement. 32 p.

Technical Assistance for Military Initiatives

- PTA Nat Res Comments for REC for Roadside mowing along the Main Supply Route in the Keʻāmuku Maneuver Area (2021 12 14): comments on proposed road-side mowing in the KMA to reduce fire risk. Provided input regarding NR on Puʻu Nahona O Hae and Puʻu Pāpapa and the Hawaiian Short-eared Owl (Pueo *Asio flammeus sandwichensis*).

- PTA Nat Res Comments for 4777 BAAF Airfield Pads (2021 09): comments on proposed upgrades provided. Prevention of invasive species memo provided for the construction contractor.

- PTA Nat Res Comments for 4795 BAAF Airfield Operations Building (2021 09): comments on proposed upgrades provided. Prevention of invasive species memo provided for the construction contractor.

- REC 4804 Install Warning Flagpole (2021 09): comments on proposed upgrades provided. Prevention of invasive species memo provided for the construction contractor.

- PTA Nat Res Comments for 4830 NRAO Portable Weather Station (2021 11): comments regarding installation and operations of a portable weather station in the southern portion of TA 21. NR concern included BSTP strikes and prevention of invasive species.

- PTA Nat Res Comments for 4873 T-Storm Swarm Capability (2022 05 24): comments regarding proposed used of UAS systems, swarms of up to 30 units, at PTA. Potential NR issues included interactions (i.e., strikes) between the UAS and birds and bats. Recommended restricting use with a 1 km buffer of the BSTP colony.

- PTA Nat Res Comments for 5036 Remove and replace fencing (2023 07 19): comments regarding the installation of new fencing topped with barbed wire around the Troop Issuance and Supply Area (TISA). NR concerns included HHB entanglement in barbed wire and increased workload to inspect barbed wire monthly per BO requirements.

- PTA Nat Res Comments for 5059 Cooper Airstrip Extension (2023 09 05): comments regarding the expansion of the Cooper Airstrip pavement. NR concerns included removal of trees, potential impacts to federally protected bird species (ESA and MBTA), and importation of soil/aggregate.

<u>Assessments After Disturbance Events</u>

For more complete descriptions of the assessments see Chapter 8.0

- Mauna Loa Eruption (2023 07 11)
- Training Area 21 Post-Fire Assessment (2022 08 24)
- Leilani Post-Fire Assessment (2023 10 30)
- Keʻāmuku Post-Fire Assessment (2023 07)

<u>Presentations and Publications</u>

For more complete descriptions of the items see Section 7.10

- **The Army is managing species at risk on the Big Island, Hawaii (2020 11)**: article published in the DoD Natural Resources Program Newsletter.
- **Nēnē Conservation: U.S. Army Garrison-Pōhakuloa Training Area Helps with Endangered Species Success Story for the Hawaiʻi State Bird Using Off-Site Management (2021 06 04)**: article published in the DoD's Conserving Biodiversity on Military Lands—A Handbook for Natural Resource Managers.
- **Army stays vigilant for rapid ʻōhiʻa death at Pōhakuloa Training Area (2022 02 01)**: media release via the Defense Virtual Information Distribution Service.

- **Turning sunlight into sugar—Hawaiian ʻakoko trees do it differently (2022 09 27)**: media release via the Defense Virtual Information Distribution Service.
- **A New Species if Pamakani to Receive Scientific Recognition (2022-2023 Issue)**: article published in the USAG-HI Ecosystem Management Bulletin
- **Evaluating unmarked abundance estimators using remote camera and aerial surveys (2021 11 21)**: journal article published in the Wildlife Society Bulletin.
- ***Tetramolopium stemmermanniae* (Asteraceae), a New Species from Pōhakuloa Training Area, Hawaiʻi Island (2023 10 23)**: journal article published in Systematic Botany.

APPENDIX G TARGET WEED ASSESSMENT PROCEDURE

This appendix provides additional details for target weed identification, risk assessment and management priority. See the *Protocol for Detection, Monitoring, and Control of Target Invasive Plants Outside of Weed Control Buffers at USAG-PTA* (CEMML, in prep.)

G.1 HAWAIʻI- PACIFIC WEED RISK ASSESSMENT (HPWRA) SCORE

The first step we take in determining a species' potential impact is to review the species' Hawaiʻi-Pacific Weed Risk Assessment (HPWRA) score. The HPWRA score was designed to identify species which have a high likelihood of becoming invasive in Hawaiʻi. The HPWRA integrates available knowledge on the species' biology, environmental requirements, history of invasion, and human interactions, and has rigorous data quality requirements (Daehler et al. 2004). Based on the HPWRA scores, plants species are placed in one of 3 categories: (1) Accept (score < 1, not likely to be invasive), (2) Reject (score > 6, likely to be invasive), or (3) Evaluate Further (score is between 1 and 6). The procedure was found to correctly identify 95% of major pest plants, and 84% of minor pest plants of both native and managed (agricultural) ecosystems, and 95% of major pests and 87% of minor plant pests of native ecosystems (Daehler et al. 2004).

G.1.1 WEED SPECIES EFFECT ON SYSTEM SCORE

The second step we take in determining a species' potential impact is to assign each species an Effect on System (EOS) score. The EOS score attempts to capture certain species which may not score high on the HPWRA (usually due to lack of empirical data) but may still have significant ecological impacts. EOS scores are not held to the same rigorous data quality requirements as HPWRA scores, allowing the evaluator to include information from personal observation or communication. Effects on composition and structure of native communities, suppression of regeneration of native species, and agriculture are ranked on a 0 to 3 scale, with 3 being a major effect, and 0 being no effect (Table G.1).

Table G.1. Weed species effect on system criteria and scores

	Criteria and Scores			
Effect on System	**0**	**1**	**2**	**3**
Composition and structure of terrestrial native communities	Does not affect structurally dominant species	Minor change in composition of dominant species; little change to basic structure.	Modest effect on composition or structure of community.	Major change to composition or structure of community.
Suppression of regeneration of native species	No significant effect.	Some effect on some species.	Major effect on some species or some effect on dominant species.	Major effect on many species; or major effect on dominant species.
Effect on Agriculture	No effect.	Minor effect on agriculture.	Moderate effect.	Major effect: forms dense stands in pasture or cropland, has spines, unpalatable to herbivores

Adopted from Imada et al. (2007).

G.1.2 WEEDINESS SCORE (WEED RISK CATEGORIES)

We then add the HPWRA and EOS scores together to determine a Weediness score. We use the Weediness score to place the species in 1 of 5 Weed Risk Categories (A-E), with category A having the highest potential for weediness, and category E having the lowest (Table G.2).

Table G.2. Weed risk scores and categories

Category	Weediness Score	Description
A	26 and up	Highest priority, highly invasive
B	17-25	Invasive
C	7-16	Likely to be invasive
D	1-6	Further evaluation necessary
E	Below 1	Not likely to be invasive

Adapted from Imada et al. (2007).

G.1.3 WEED SPECIES FEASIBILITY OF CONTROL

We give each potential target species a Feasibility of Control (FOC) score between 5 to 10 based on the estimated time (staff hours) required to control all the known individuals and/or populations of that species (Table G.3). Estimated staff hours are based on the number of populations, population size, density, remoteness, and staff time required for previously documented management actions.

Table G.3. Weed Species feasibility of control score

Score	Control Effort Required
10	Eradication or control requires less than 36 staff hours per year.
9	Initial control requires 36-72 staff hours, with up to 36 staff hours per year required for maintenance.
8	Initial containment or control requires 72-144 staff hours, with up to 72 staff hours per year required for maintenance.
7	Initial containment or control requires 72-144 staff hours with 72-144 staff hours per year required for maintenance.
6	Containment or control requires 144-684 staff hours each year.
5	Containment or control requires greater than 684 staff hours per year.

[a] Adapted from Imada et al. (2007).

G.1.4 Weed Species Priority Score and Management Tier

We combine the Weediness score (A-E) and the FOC score (5-10) to arrive at the Priority Score (Table G.4). These scores (e.g., A7) are arranged into 4 management tiers, each with a corresponding management decision (Table G.4).

Table G.4. Weed Species management tiers

Management Tier	Priority Score	Default Action
1	A10, B10	Control population immediately.
2	A7-9, B8-9, C8-10	High priority population, schedule for control.
3	A6, B6-7, C7, D8-10	Control likely performed; reevaluate after further surveys.
4	A5, B5, C5- 6, D5-7	Control possibly performed; assess for containment or site-led strategies

[a] Adapted from Imada et al. (2007).

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APPENDIX H REGULATORY DRIVERS FOR SECTIONS AND PROJECTS OF THE ARMY'S NATURAL RESOURCES PROGRAM AT PŌHAKULOA TRAINING AREA

Table H.1. Regulatory drivers for the Army's natural resources program at Pōhakuloa Training Area

Program	Section	Project	Program Plan Requirement Wording (2017)	Regulatory Document(s)	W9126G-21-2-0027 SOO Task
Botanical Program – INRMP (2019) Objective 4.1.2					
Rare Plant Survey and Monitoring Section					
Botanical	Plant Survey and Monitoring	Planning	Develop and update Botanical Program Plan.	Biological Opinion 2003	3.2.1
Botanical	Plant Survey and Monitoring	Plant Surveys	Surveys for *Asp per, Hap hap, Iso hos, Kad cor, Lip ven, Ner ova, Por scl, Silene hawaiiensis, Sil lan, Sol inc, Spe haw, Ste ang, Tet are, Vig owa*, *Zan haw,* and SAR to document abundance, distribution, and in-situ reproduction.	Biological Opinion 2003	3.2.1.1 / 3.2.5.1 / 3.2.6.1
Botanical	Plant Survey and Monitoring	Plant Surveys	Survey for *Exo men, Fes haw, Por vil, Sic mac* to document abundance, distribution, and *in-situ* reproduction.	INRMP	3.2.1.1 / 3.2.5.1 / 3.2.6.1
Botanical	Plant Survey and Monitoring	Plant Monitoring	Monitor Tier 1 species annually - *Iso hos, Kad cor, Lip ven, Ner ova, Por scl, Sol inc, Tet are, Vig owa*, and *Zan haw.*	Biological Opinion 2003	3.2.1.2
Botanical	Plant Survey and Monitoring	Plant Monitoring	Monitor Tier 1 species annually *Por vil, Schiedea hawaiiensis, Sic mac* and *Tet* sp. 1.	INRMP	3.2.1.2
Botanical	Plant Survey and Monitoring	Plant Monitoring	Monitor a portion of Tier 2 populations annually - *Asp per, Hap hap, Silene hawaiiensis, Sil lan, Spe haw,* and *Ste ang.*	Biological Opinion 2003	3.2.1.2

Table H.1. Regulatory drivers for the Army's natural resources program at Pōhakuloa Training Area (cont.)

Program	Section	Project	Program Plan Requirement Wording (2017)	Regulatory Document(s)	W9126G-21-2-0027 SOO Task
Botanical	Plant Survey and Monitoring	Plant Monitoring	Monitor a portion of Tier 2 populations annually - *Exo men* and *Fes haw.*	INRMP	3.2.1.2
Botanical	Plant Survey and Monitoring	Plant Monitoring	Outline the monitoring protocols for plants in the KMA (*Iso hos, Lip ven,* and *Vig owa*). Assess population structure, vigor, and damage.	Biological Opinion 2003	3.2.1.2
Botanical	Plant Survey and Monitoring	Vegetation Monitoring	Monitor trends in treeland vegetation to determine the extent of regeneration of tree species, for Hawaiian hoary bat roosts, post-ungulate removal.	Biological Opinion 2003	3.2.1
Botanical	Plant Survey and Monitoring	Vegetation Monitoring	Develop tree land vegetation cover monitoring and reporting protocols.	Biological Opinion 2003	3.2.1
Botanical	Plant Survey and Monitoring	Vegetation Monitoring	Evaluate reasons for lack of māmane recruitment in Palila Critical Habitat Area B.	Biological Opinion 2003	N/A
Botanical	Plant Survey and Monitoring	Vegetation Monitoring	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.	Biological Opinion 2003	N/A
Botanical	Plant Survey and Monitoring	Vegetation Monitoring	Determine dust effects on māmane/naio woodland and to assess the efficacy of the Palila Critical Habitat buffer.	Biological Opinion 2003	N/A
Botanical	Plant Survey and Monitoring	Vegetation Monitoring	Determine the long-term effect of dust deposition on listed plants near high traffic and/or off-road areas.	Biological Opinion 2003	N/A
Botanical	Plant Survey and Monitoring	Vegetation Monitoring	Evaluate the long-term effects of dust on *Hap hap* located in the southwest corner of KMA.	Biological Opinion 2003	N/A
Botanical Program - continued **Genetic Conservation and Outplanting Section**					
Botanical	Genetic Conservation and Outplanting	Genetic Conservation	Collect and maintain genetic material for all new occurrences of KMA TES plants (outside existing populations) for propagation and eventual outplanting.	Biological Opinion 2003	3.2.1.4

Table H.1. Regulatory drivers for the Army's natural resources program at Pōhakuloa Training Area (cont.)

Program	Section	Project	Program Plan Requirement Wording (2017)	Regulatory Document(s)	W9126G-21-2-0027 SOO Task
Botanical	Genetic Conservation and Outplanting	Genetic Conservation	Collect and maintain a genetic stock ex-situ for *Asp per, Hap hap, Iso hos, Kad cor, Lip 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.	Biological Opinion 2003	3.2.1.4
Botanical	Genetic Conservation and Outplanting	Genetic Conservation	Collect and maintain genetic material for *Hap hap* from BAX occurrences. Collect enough material to adequately replace the individuals affected by the construction of the BAX.	Biological Opinion 2003	3.2.1.4
Botanical	Genetic Conservation and Outplanting	Genetic Conservation	Maintain a list of *Hap hap, Iso hos, Lip ven, and Vig owa* plants/seeds available and make the list available to other authorized agencies.	Biological Opinion 2003	3.2.1.4
Botanical	Genetic Conservation and Outplanting	Genetic Conservation	Provide *Iso hos* and *Vig owa* seeds and/or plants to appropriate agencies or private organizations to increase occurrences offsite.	Biological Opinion 2003	3.2.1.4
Botanical	Genetic Conservation and Outplanting	Genetic Conservation	Collect and maintain genetic stock ex-situ of *Exo men, Fes haw, Por vil, Schiedea hawaiiensis, Sic mac*, and *Tet* Sp. 1 for long-term storage, propagation, and eventual outplanting.	INRMP	3.2.1.4
Botanical	Genetic Conservation and Outplanting	Genetic Conservation	Collect and maintain *Silene hawaiiensis* seeds ex-situ prior to AALFTR and BAX construction for propagation and eventual outplanting.	Biological Opinion 2003	3.2.1.4
Botanical	Genetic Conservation and Outplanting	Genetic Conservation	Collect seed and cuttings from the *Vig owa* located along the western border of KMA.	Biological Opinion 2003	3.2.1.4
Botanical	Genetic Conservation and Outplanting	RPPF Activities	Propagate and outplant genetic material for all new occurrences of KMA TES plants (outside existing exclosures).	Biological Opinion 2003	3.2.1.5
Botanical	Genetic Conservation and Outplanting	RPPF Activities	Propagate and outplant *Asp per, Hap hap, Iso hos, Kad cor, Lip ven, Ner ova, Por scl, Silene hawaiiensis, Sil lan, Sol inc, Ste ang, Tet are, Vig owa,* and *Zan haw.*	Biological Opinion 2003	3.2.1.5 / 3.2.5.3

Table H.1. Regulatory drivers for the Army's natural resources program at Pōhakuloa Training Area (cont.)

Program	Section	Project	Program Plan Requirement Wording (2017)	Regulatory Document(s)	W9126G-21-2-0027 SOO Task
Botanical	Genetic Conservation and Outplanting	RPPF Activities	Propagate and grow *Hap hap* from the BAX propagules to adequately replace individuals affected by BAX construction.	Biological Opinion 2003	3.2.1.5 / 3.2.5.3
Botanical	Genetic Conservation and Outplanting	RPPF Activities	Propagate and outplant *Sil haw* lost from AALFTR and BAX construction and off-road maneuvers.	Biological Opinion 2003	3.2.1.5 / 3.2.5.3
Botanical	Genetic Conservation and Outplanting	Outplanting and Monitoring	Annually monitor outplanted plants.	Biological Opinion 2003, 10(a)(1)(A) Species Recovery Permit	3.2.1.5 / 3.2.5.3
Botanical	Genetic Conservation and Outplanting	Hawaiian Goose Off-site	Collect seeds, for propagation and outplanting from common native species to provide Hawaiian Goose food plants and escape cover inside the predator-proof fences.	Biological Opinion 2013	3.2.1.5 / 3.2.5.3
Invasive Plants Program – INRMP (2019) Objective 4.1.3					
Vegetation Control Section					
Invasive Plants	Vegetation Control	Planning	Develop and update Invasive Plants Program Plan including cinder cones in KMA.	Biological Opinion 2003	3.2.4
Invasive Plants	Vegetation Control	Weed Control Buffer	Control invasive plants in proximity to natural occurrences of *Asp per, Hap hap, Iso hos, Kad cor, Lip ven, Ner ova, Por scl, Silene hawaiiensis, Sil lan, Spe haw, Sol inc, Ste ang, Tet are, Vig owa,* and *Zan haw*.	Biological Opinion 2003	3.2.1.3 / 3.2.4.1
Invasive Plants	Vegetation Control	Weed Control Buffer	Control invasive plants in proximity to outplanted *Asp per, Hap hap, Iso hos, Kad cor, Lip ven, Ner ova, Por scl, Silene hawaiiensis, Sil lan, Sol inc, Ste ang, Tet are, Vig owa,* and *Zan haw.*	Biological Opinion 2003	3.2.1.3 / 3.2.4.1
Invasive Plants	Vegetation Control	Weed Control Buffer	Control invasive plants in proximity to natural occurrences of *Exo men, Fes haw, Por vil, Schiedea hawaiiensis,* and *Sic mac* within PTA.	INRMP	3.2.1.3 / 3.2.4.1

Table H.1. Regulatory drivers for the Army's natural resources program at Pōhakuloa Training Area (cont.)

Program	Section	Project	Program Plan Requirement Wording (2017)	Regulatory Document(s)	W9126G-21-2-0027 SOO Task
Invasive Plants	Vegetation Control	Weed Control Buffer	Evaluate the effect of *Cen set* on *Hap hap* at Puʻu Kapele.	Biological Opinion 2003	3.2.1.3 / 3.2.4.1
Invasive Plants	Vegetation Control	Hawaiian Goose	Modify Hawaiian Goose habitat at the Range 1 complex, by herbiciding food plants that attract Hawaiian Geese.	Biological Opinion 2013	3.2.2.2
Invasive Plants	Vegetation Control	Hawaiian Goose Off-site	Mow and control invasive plants inside predator-proof fences.	Biological Opinion 2013	3.2.2.2
Invasive Plants Program - continued **Invasive Plants Survey and Monitoring**					
Invasive Plants	Invasive Plants Survey and Monitoring	Planning	Develop and implement a non-native invasive plant monitoring program.	Biological Opinion 2003	3.2.4.1
Invasive Plants	Invasive Plants Survey and Monitoring	Planning	Respond to requests for consultation for all auxiliary construction support sites and consult with DPW for approval or alternatives.	Biological Opinion 2003	3.2.4.1
Invasive Plants	Invasive Plants Survey and Monitoring	Survey	Inspect Bradshaw Airfield perimeter quarterly for alien species and remove invasive plants.	Biological Opinion 2003	3.2.4.1
Invasive Plants	Invasive Plants Survey and Monitoring	Survey	Inspect landing zones, trails, and roadsides for newly identified non-native plants.	Biological Opinion 2003	3.2.4.1
Invasive Plants	Invasive Plants Survey and Monitoring	Survey	Quarterly inspect construction and auxiliary support sites for invasive plant species.	Biological Opinion 2003	3.2.4.1
Invasive Plants	Invasive Plants Survey and Monitoring	Survey	Inspect the areas affected by the construction of High-Altitude trails and landing zones and UCAS.	Informal Consultations 2013	3.2.4.1
Invasive Plants	Invasive Plants Survey and Monitoring	Survey	Inspect the areas affected by the construction of the IPBA and monitor for introduction of incipient invasive plant species.	Biological Opinion 2013	3.2.4.1

Table H.1. Regulatory drivers for the Army's natural resources program at Pōhakuloa Training Area (cont.)

Program	Section	Project	Program Plan Requirement Wording (2017)	Regulatory Document(s)	W9126G-21-2-0027 SOO Task
Invasive Plants	Invasive Plants Survey and Monitoring	Survey	Inspect the areas affected by site preparation at Hole No. 2 for the Deep Well project.	Informal Consultation Well, 2014	3.2.4.1
Invasive Plants	Invasive Plants Survey and Monitoring	Monitoring and Control	Implement a non-native invasive plant monitoring program within, and adjacent to, landing zones, trails, and roadsides.	Biological Opinion 2003	3.2.4.1
Invasive Plants	Invasive Plants Survey and Monitoring	Monitoring and Control	Eradicate, contain, or control, as needed, newly found non-native plants species found during surveys.	Biological Opinion 2003	3.2.4.1
Invasive Plants Program - continued Fuels Control					
Invasive Plants	Fuels Control	Planning	In the Invasive Plant Program Plan address management to reduce fire-related training impacts for *Asp per* and *Ner ova.*	Biological Opinion 2003	3.2.4.2
Invasive Plants	Fuels Control	Planning	Coordinate with Range Control to cease live-fire training if fuels exceed standards in FMC.	Biological Opinion 2013	3.2.4.3
Invasive Plants	Fuels Control	Fuel Break System	Modify fuel loads, reduce fuels by invasive plant control, and create fire/fuel breaks and fuel corridors to IWFMP standards.	Biological Opinion 2003	3.2.4.2
Invasive Plants	Fuels Control	Fuel Monitoring Corridors System	Establish and maintain fuel corridors and fire breaks.	Biological Opinion 2003	3.2.4.2
Invasive Plants	Fuels Control	Fuel Break System	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.	Biological Opinions 2003 & 2008	3.2.4.2
Invasive Plants	Fuels Control	Fuel Break System	Remove all trees and shrubs in firebreaks and fuel breaks.	Biological Opinion 2003	3.2.4.2

Table H.1. Regulatory drivers for the Army's natural resources program at Pōhakuloa Training Area (cont.)

Program	Section	Project	Program Plan Requirement Wording (2017)	Regulatory Document(s)	W9126G-21-2-0027 SOO Task
Invasive Plants	Fuels Control	Fuel Break System	Control invasive non-native plants to minimize and offset HHB potential habitat losses from live-fire and wildfire.	Biological Opinion 2003	3.2.4.2
Invasive Plants	Fuels Control	Fuel Break System	Monitor the Fuels Monitoring Corridors every 5 years beginning in 2015.	Biological Opinion 2013	3.2.4.3
Invasive Plants	Fuels Control	Fuel Break System	If FMC fuel loads exceed established standards, implement fuels reduction.	Biological Opinion 2013	3.2.4.3
Wildlife Program – INRMP (2019) Objective 4.1.4 Management Section – Hawaiian Goose Project					
Wildlife	Wildlife Survey and Monitoring	Planning	Develop and update Wildlife Program Plan.	Biological Opinions 2003 & 2008	3.2.2
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Monitor Hawaiian Goose take limits and coordinate with the Service if the Army approaches take limits.	Biological Opinion 2013	3.2.2.1 / 3.2.8.1
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Notify the Service within one (1) business day of a take incident. Submit a written report describing the incident within 3 (3) business days of the incident.	Biological Opinions 2003 & 2013	3.2.2.2 /3.2.8.1
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Report Hawaiian Goose helicopter strikes to the Service to determine if this risk can be avoided in the future.	Biological Opinions 2003 & 2013	3.2.2.2 / 3.2.8.1
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Send dead Hawaiian Geese to the National Wildlife Health Center, Honolulu Field Station for a necropsy.	Biological Opinion 2008	3.2.2.2 /3.2.8.1
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Brief military units re: Natural Resources issues/restrictions.	Biological Opinion 2013	3.2.2.2
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Coordinate with Range Control and other PTA Directorates to report Hawaiian Goose information.	Biological Opinion 2008	3.2.2.2
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Modify Hawaiian Goose habitat at the Range 1 Complex prior to utilizing hazing options.	Biological Opinion 2013	3.2.2.2

Table H.1. Regulatory drivers for the Army's natural resources program at Pōhakuloa Training Area (cont.)

Program	Section	Project	Program Plan Requirement Wording (2017)	Regulatory Document(s)	W9126G-21-2-0027 SOO Task
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Haze Hawaiian Geese from on or near any training range installation-wide at PTA when in conflict with training.	Biological Opinion 2013	3.2.2.2
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Direct hazing operations in a manner that will minimize and avoid adverse impacts to Hawaiian Geese.	Biological Opinion 2013	3.2.2.2
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Report overall hazing operations results at the end of each fiscal year to the Service.	Biological Opinion 2013	3.2.2.2 / 3.2.8.1
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	With prior approval and direction from the Service, relocate nests and goslings to a safe area when in conflict with training.	Biological Opinion 2013	3.2.2.2
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Notify and coordinate with the Service when a Hawaiian Goose nest is found.	Biological Opinions 2003 & 2013	3.2.2.2 / 3.2.8.1
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Notify the USFWS in 24 hours Service if a nest being monitored for translocation fails.	Biological Opinions 2003 & 2013	3.2.2.2 / 3.2.8.1
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Immediately notify the Service if a Hawaiian Goose egg hatches. Service coordinates translocation efforts.	Biological Opinions 2003 & 2013	3.2.2.2 / 3.2.8.1
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Coordinate with the Service if Hawaiian Goose adults and/or goslings require banding at PTA.	Biological Opinions 2003 & 2013	3.2.2.2 / 3.2.8.1
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Implement regular monitoring and adaptive management of the WEA site to prevent attracting additional geese to PTA.	Biological Opinions 2003 & 2013	3.2.2.1 / 3.2.2.2
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Trap predators around the WEA when molting geese are present.	Biological Opinion 2013	3.2.2.2
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose Off-site	Fund an off-site Hawaiian Goose conservation project for 20 years.	Biological Opinion 2013	3.2.2.2
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose Off-site	Develop a MOA with a selected partner for the Hawaiian Goose conservation project.	Biological Opinion 2013	3.2.2.2
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose Off-site	Strive to produce an average of 26 fledglings per year for the duration of the Hawaiian Goose conservation project.	Biological Opinion 2013	3.2.2.2

Table H.1. Regulatory drivers for the Army's natural resources program at Pōhakuloa Training Area (cont.)

Program	Section	Project	Program Plan Requirement Wording (2017)	Regulatory Document(s)	W9126G-21-2-0027 SOO Task
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose Off-site	Fund, construct, maintain, and repair two, 20-ac predator-proof fences.	Biological Opinion 2013	3.2.2.2
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose Off-site	Encourage Hawaiian Geese to use the predator-proof fenced areas both passively and aggressively.	Biological Opinion 2013	3.2.2.2
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose Off-site	Control predators inside and outside of the predator-proof fences.	Biological Opinion 2013	3.2.2.2
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose Off-site	Improve vegetation and maintain habitat by mowing 1 to 2 times per year inside the predator-proof fences.	Biological Opinion 2013	3.2.2.2
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose Off-site	Construct a permanent water source inside each predator-proof fence.	Biological Opinion 2013	3.2.2.2
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose Off-site	Construct a shade structure inside each predator-proof fence.	Biological Opinion 2013	3.2.2.2
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose Off-site	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.	Biological Opinion 2013	3.2.2.1
Wildlife Program - continued **Management Section – Hawaiian Hoary Bat Project**					
Wildlife	Wildlife Survey and Monitoring	Planning	Develop and update Wildlife Program Plan.	Biological Opinion 2003	3.2.2
Wildlife	Wildlife Survey and Monitoring	Planning	Complete a comprehensive HHB project plan to implement the Terms and Conditions of the 2003 BO.	Biological Opinion 2003	3.2.2
Wildlife	Wildlife Survey and Monitoring	Planning	Develop appropriate HHB monitoring, survey, and research methodologies plus reporting protocols.	Biological Opinion 2003	3.2.2.1
Wildlife	Wildlife Survey and Monitoring	Hawaiian hoary bat	Coordinate efforts to minimize direct and indirect effects on survival and reproduction of HHBs in the action area.	Biological Opinion 2003	3.2.2

Table H.1. Regulatory drivers for the Army's natural resources program at Pōhakuloa Training Area (cont.)

Program	Section	Project	Program Plan Requirement Wording (2017)	Regulatory Document(s)	W9126G-21-2-0027 SOO Task
Wildlife	Wildlife Survey and Monitoring	Hawaiian hoary bat	Notify the Service within 3 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.	Biological Opinion 2003	3.2.2 / 3.2.8.1
Wildlife	Wildlife Survey and Monitoring	Hawaiian hoary bat	Deposit bat remains with the B.P. Bishop Museum or the Service's Division of Law Enforcement.	Biological Opinion 2008	3.2.2
Wildlife	Wildlife Survey and Monitoring	Hawaiian hoary bat	Coordinate with the Army to cease training-related actions if HHB take is exceeded. Immediately consult with the Service.	Biological Opinion 2008	3.2.2 / 3.2.8.1
Wildlife	Wildlife Survey and Monitoring	Hawaiian hoary bat	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.	Biological Opinion 2003	3.2.2 / 3.2.8.1
Wildlife	Wildlife Survey and Monitoring	Hawaiian hoary bat	Report annually to the Service Hawaiian hoary bat monitoring results and whether the estimated annual level of incidental take has been exceeded.	Biological Opinion 2003	3.2.2 / 3.2.8.1
Wildlife	Wildlife Survey and Monitoring	Hawaiian hoary bat	Minimize loss and degradation of roosting habitat for Hawaiian hoary bats in the action area.	Biological Opinion 2003	3.2.2 / 3.2.8.1
Wildlife	Wildlife Survey and Monitoring	Hawaiian hoary bat	Dedicate one or more staff as the Hawaiian hoary bat project lead.	Biological Opinion 2003	3.2.2.1
Wildlife	Wildlife Survey and Monitoring	Hawaiian hoary bat	Monitor trends in Hawaiian hoary bat occupancy at PTA.	Biological Opinion 2003	3.2.2.1
Wildlife	Wildlife Survey and Monitoring	Hawaiian hoary bat	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.	Biological Opinion 2003	3.2.2.1
Wildlife	Wildlife Survey and Monitoring	Hawaiian hoary bat	Coordinate efforts to minimize noise and ground disturbance to Hawaiian hoary bats resulting from military activities in the action area.	Biological Opinion 2003	3.2.2 / 3.2.8.1

Table H.1. Regulatory drivers for the Army's natural resources program at Pōhakuloa Training Area (cont.)

Program	Section	Project	Program Plan Requirement Wording (2017)	Regulatory Document(s)	W9126G-21-2-0027 SOO Task
Wildlife	Wildlife Survey and Monitoring	Hawaiian hoary bat	Avoid construction activities and fuel modification (i.e., felling trees from June 1 to September 15, to the maximum extent possible.	Biological Opinions 2003 & 2013	3.2.2 / 3.2.8.1
Wildlife	Wildlife Survey and Monitoring	Hawaiian hoary bat	Coordinate efforts to minimize noise and ground disturbance to Hawaiian hoary bats resulting from military activities in the action area.	Biological Opinion 2003	3.2.2 / 3.2.8.1
Wildlife	Wildlife Survey and Monitoring	Hawaiian hoary bat	Brief military units: to minimize and avoid impacts to Hawaiian hoary bats and to report all bat strikes.	Biological Opinion 2003	3.2.2 / 3.2.8.1
Wildlife	Wildlife Survey and Monitoring	Hawaiian hoary bat	Coordinate with Range Control to implement conservation measures in the 2013 BO for the IPBA.	Biological Opinion 2013	3.2.2 / 3.2.8.1
Wildlife Program - continued Management Section - Seabirds Project					
Wildlife	Wildlife Survey and Monitoring	Planning	In the Wildlife Program Plan address monitoring and definitions of success for the Hawaiian Petrel.	Biological Opinion 2003	3.2.2
Wildlife	Wildlife Survey and Monitoring	Seabirds	Survey for Hawaiian Petrel presence, abundance, and habitat use. Coordinate survey methods with the Service.	Biological Opinion 2003	3.2.2.1
Wildlife	Wildlife Survey and Monitoring	Seabirds	Conduct radar surveys for Hawaiian Petrel. Coordinate methods with the Service.	Biological Opinion 2003	3.2.2.1
Wildlife	Wildlife Survey and Monitoring	Seabirds	Coordinate with Range Control to implement conservation measures in the 2013 BO for the IPBA.	Biological Opinion 2013	3.2.2 / 3.2.8.1
Wildlife	Wildlife Survey and Monitoring	Seabirds	Coordinate with Range Control to implement minimization measures for UCAS.	Informal Consultation UCAS, 2013	3.2.2 / 3.2.8.1
Wildlife	Wildlife Survey and Monitoring	Seabirds	Monitor nesting and call activity for Band-rumped Storm Petrel	INRMP 2019	3.2.2.1
Wildlife Program - continued Management Section – Avian Project					

Table H.1. Regulatory drivers for the Army's natural resources program at Pōhakuloa Training Area (cont.)

Program	Section	Project	Program Plan Requirement Wording (2017)	Regulatory Document(s)	W9126G-21-2-0027 SOO Task
Wildlife	Wildlife Survey and Monitoring	Avian Survey	Conduct periodic surveys for Palila and MBTA-protected species within PTA.	INRMP	3.2.2
Wildlife	Wildlife Survey and Monitoring	Avian Survey	Make information available for inclusion in environmental documentation, specifically for the NEPA process.	INRMP	3.2.2 / 3.2.8.1
Wildlife	Wildlife Survey and Monitoring	Avian Survey	Document and report birds "taken" during military readiness activities.	INRMP	3.2.2 / 3.2.8.1
Wildlife	Wildlife Survey and Monitoring	Avian Survey	Confer with USFWS if military readiness activities will result in a significant adverse effect to the population of a species protected under the MBTA.	INRMP	3.2.2 / 3.2.8.1
Wildlife Program - continued Threats Management Section					
Wildlife	Wildlife Threat Management	Planning	Develop and update the Wildlife Program Plan.	Biological Opinion 2003	3.2.2
Wildlife	Wildlife Threat Management	Ungulate Control	Aerial survey each fenced area annually to detect ingress. Maintain all fence units as ungulate free as practicable.	Biological Opinion 2003	3.2.2.3
Wildlife	Wildlife Threat Management	Small Mammal Control	Control predators for Band-rumped Storm Petrels in the colony in TA 21	INRMP	3.2.2.3
Wildlife	Wildlife Threat Management	Small Mammal Control	Provide assistance, possibly financial, to complete the registration and National Environmental Policy Act (NEPA) compliance for aerial broadcast of rodenticide at PTA.	Biological Opinion 2003	3.2.2.3
Wildlife	Wildlife Threat Management	Small Mammal Control	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.	Biological Opinion 2003	3.2.2.3
Wildlife	Wildlife Threat Management	Early Detection and Control	Brief military units and PTA personnel that all snake and lizard sightings must be reported.	Biological Opinion 2003	3.2.8

Table H.1. Regulatory drivers for the Army's natural resources program at Pōhakuloa Training Area (cont.)

Program	Section	Project	Program Plan Requirement Wording (2017)	Regulatory Document(s)	W9126G-21-2-0027 SOO Task
Wildlife	Wildlife Threat Management	Early Detection and Control	Coordinate mandatory reporting of all snake and lizard sightings to US FWS, DOFAW, and HDOA.	Biological Opinion 2003	3.2.8
Wildlife	Wildlife Threat Management	Early Detection and Control	Inspect all plant or plant products for frogs, lizards or snakes.	Biological Opinion 2003	3.2.2.4
Wildlife	Wildlife Threat Management	Early Detection and Control	Inspect the perimeter of the Bradshaw Airfield quarterly for newly introduced animal species and remove any found.	Biological Opinion 2003	3.2.2.4
Wildlife	Wildlife Threat Management	Early Detection and Control	Inspect construction and auxiliary sites quarterly for alien animal species and control or eradicate newly found species.	Biological Opinion 2003	3.2.2.4
Wildlife	Wildlife Threat Management	Early Detection and Control	Document newly introduced animals after initial discovery, implement surveys, and control, or eradicate.	Biological Opinion 2008	3.2.2.4
Wildlife	Wildlife Threat Management	Fence Maintenance	Ground surveys will ensure the fence lines are intact.	Biological Opinion 2003	3.2.2.5
Wildlife	Wildlife Threat Management	Fence Maintenance	Inspect barbed wire on security fences, quarterly, for entangled bats.	Biological Opinion 2003	3.2.2.5
Wildlife	Wildlife Threat Management	Fence Maintenance	Maintain large-scale fence units at a replacement rate of 3.5% annually.	Biological Opinion 2003	3.2.2.5
Wildlife	Wildlife Threat Management	Fence Maintenance	Address the frequency and logistics associated with fence maintenance to maintain fences ungulate free.	Biological Opinion 2013	3.2.2.5
Wildlife	Wildlife Threat Management	Fence Maintenance	Install established signage to identify areas that are off limits due to the presence of federally listed species.	Biological Opinion 2003	3.2.2.5
Wildlife	Wildlife Threat Management	Fence Maintenance	Maintain and repair predator-proof fences on partner lands and outside PTA.	INRMP	3.2.2.5
Wildlife	Game Management	Planning	Review hunting protocols and update to ensure that all privately owned vehicles will be restricted to established roads and trails.	INRMP	3.2.2

Table H.1. Regulatory drivers for the Army's natural resources program at Pōhakuloa Training Area (cont.)

Program	Section	Project	Program Plan Requirement Wording (2017)	Regulatory Document(s)	W9126G-21-2-0027 SOO Task
Wildlife	Game Management	Game Mammal Surveys	Survey for game mammals and game birds in the hunting units.	INRMP	3.2.2
Wildlife	Game Management	Physical Resources for Hunting Management	Construct facilities and control vegetation as needed to support the hunting project.	INRMP	3.2.3.1
Wildlife	Game Management	Physical Resources for Hunting Management	Repair and maintain facilities to support the hunting project.	INRMP	3.2.3.1
Wildlife	Game Management	Project Coordination Outreach	Attend public meeting and outreach activities.	N/A	3.2.8.2
Ecological Data Program – INRMP (2019) Objective 4.1.5					
General			Coordinate with Range Control to implement training restrictions in IPBA per 2013 BO.	Biological Opinion 2013	3.2.8.1 / 3.2.8.4
General			Brief military troops to adhere to the 15-mph speed limit, except when a waiver has been approved by the PTA CDR.	Biological Opinion 2013	3.2.8.1 / 3.2.8.4
General	Data Management Support	Data Management Systems	Develop and maintain data management systems. Develop tools for efficient reporting. Increase efficiency and effectiveness of data collection.	N/A	3.2.7.1 / 3.2.7.2 / 3.2.7.5
General	Community Relations	Public Outreach	Maintain a GIS to support natural resources management	N/A	3.2.7.3
General	Community Relations	Public Outreach	Produce various products to support management. Ensure GIS data is compatible with Army system	N/A	3.2.7.4

Table H.1. Regulatory drivers for the Army's natural resources program at Pōhakuloa Training Area (cont.)

Program	Section	Project	Program Plan Requirement Wording (2017)	Regulatory Document(s)	W9126G-21-2-0027 SOO Task
Technical and Administrative Support					
General	Technical Support	General	Respond to requests for information in matters of environmental concern or T&E issues.	N/A	3.2.8.1
General	Technical Support	Consultations and Coordination	Participate in meeting with partners.	N/A	3.2.8.2
General	Technical Support	Consultations and Coordination	Provide information to support environmental analysis of proposed Army actions which may lead to NEPA documents	N/A	3.2.8.3
General	Technical Support	Consultations and Coordination	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.	Biological Opinions 2003 & 2008	3.2.8.1 / 3.2.8.2
General	Technical Support	Consultations and Coordination	Reinitiate consultation if prescribed burns are conducted and each time fire affects lands beyond the action area.	Biological Opinion 2003	3.2.8.1 / 3.2.8.2
General	Technical Support	Consultations and Coordination	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.	Biological Opinions 2003 & 2008	3.2.8.1 / 3.2.8.2
General	Technical Support	Consultations and Coordination	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.	Biological Opinion 2003	3.2.8.1 / 3.2.8.2
General	Technical Support	Consultations and Coordination	Report incidental take to the Service according to Take Statement requirements for each animal species.	Biological Opinions 2003 & 2008	3.2.8.1 / 3.2.8.2

Table H.1. Regulatory drivers for the Army's natural resources program at Pōhakuloa Training Area (cont.)

Program	Section	Project	Program Plan Requirement Wording (2017)	Regulatory Document(s)	W9126G-21-2-0027 SOO Task
General	Technical Support	Consultations and Coordination	Report dead nēnē to the Service within 48 hours.	Biological Opinion 2008	3.2.8.1 / 3.2.8.2
General	Technical Support	Consultations and Coordination	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.	Biological Opinion 2008	3.2.8.1 / 3.2.8.2
General	Technical Support	Consultations and Coordination	Coordinate night-time construction activities with the Service for all construction and maintenance activities of all Transformation construction projects.	Biological Opinion 2003	3.2.5.2 / 3.2.8.1
General	Technical Support	Planning	Develop and update Natural Resources Program Plan.	Biological Opinion 2003	3.2.5.2 / 3.2.8.4
General	Technical Support	Planning	In Nat Res Program Plan, address dust abatement measures if dust is determined to be detrimental to woodland habitat in Palila Critical Habitat.	Biological Opinion 2003	3.2.5.2 / 3.2.8.4
General	Technical Support	Planning	Management Team identifies dust abetment measures.	Biological Opinion 2003	3.2.5.2 / 3.2.8.4
General	Technical Support	Planning	In the Nat Res Program Plan address a study to determine if rodents are limiting germination and recruitment of māmane.	Biological Opinion 2003	3.2.5.2 / 3.2.8.4
General	Technical Support	Training Coordination	Adhere to the fire threat minimization measures in the most recent version of the IWFMP.	Biological Opinion 2013	3.2.4.4
General	Technical Support	Training Coordination	Support updates to PTA SOPs and INRMP	N/A	3.2.8.4
General	Technical Support	Training Coordination	Coordinate requests from aviators for alternative landing and pickup zones not already pre-approved and provide concurrence or suggest alternative sites.	Biological Opinion 2003	3.2.8.1 / 3.2.8.4
General	Technical Support	Training Coordination	Coordinate requests for new bivouac sites. Survey sites, establish buffers, and provide concurrence or suggest alternative sites.	Biological Opinion 2003	3.2.5.2 / 3.2.8.4

Table H.1. Regulatory drivers for the Army's natural resources program at Pōhakuloa Training Area (cont.)

Program	Section	Project	Program Plan Requirement Wording (2017)	Regulatory Document(s)	W9126G-21-2-0027 SOO Task
General	Technical Support	Training Coordination	Coordinate with military units to train in Training Area 21.	Biological Opinion 2008	3.2.5.2 / 3.2.8.4
General	Technical Support	Training Coordination	Review all current and future training scenarios to ensure compliance with this biological opinion.	Biological Opinion 2003	3.2.5.2 / 3.2.8.4
General	Technical Support	Training Coordination	Review SOPs for Stryker Brigade Combat Team Transformation and all training plans for potential impacts to listed species.	Biological Opinion 2003	3.2.8.2 / 3.2.8.4
General	Technical Support	Training Coordination	Develop and implement environmental awareness training for soldiers using PTA.	Biological Opinion 2003	3.2.8
General	Technical Support	Training Coordination	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.	Biological Opinion 2003	3.2.8
General	Technical Support	Training Coordination	Establish signage to identify areas that are off limits due to the presence of federally listed species.	Biological Opinion 2003	3.2.8
General	Program Administration	Program Execution	Review hunting protocols and update to ensure that all privately owned vehicles will be restricted to established roads and trails.	Biological Opinion 2003	3.2.3.1
General	Program Administration	Program Execution	Provide public outreach regarding natural resources management at USAG-PTA.	N/A	3.2.9.7
General	Program Administration	Program Execution	Prepare and track budgets for program execution.	N/A	3.2.9.1
General	Program Administration	Program Execution	Provide support purchasing.	N/A	3.2.9.2
General	Program Administration	Program Execution	Develop and implement a safety program	N/A	3.2.9.3

Table H.1. Regulatory drivers for the Army's natural resources program at Pōhakuloa Training Area (cont.)

Program	Section	Project	Program Plan Requirement Wording (2017)	Regulatory Document(s)	W9126G-21-2-0027 SOO Task
General	Program Administration	Program Execution	Provide training to staff to meet safety program and OSHA requirements	N/A	3.2.9.4
General	Program Administration	Program Execution	Provide HR support to hire and manage staff.	N/A	3.2.9.5
General	Program Administration	Program Execution	Comply with IACU requirements	N/A	3.2.9.6