Army Natural Resources Program at Pōhakuloa Training Area

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LIST OF ACRONYMS

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

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

EXECUTIVE SUMMARY

Introduction

This biennial report documents the work performed jointly by the 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 Agreements W9126G-16-2-0014 and W9126G-21-2-0027 to provide a biennial report (see Section 1.2.4). The report is 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 towards 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, stand-alone technical report is produced for annual regulatory reporting requirements. Annual reporting requirements for FY 2021 (01 October 2020 through 30 September 2021) are contained in Appendix E 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* ssp. *arenarium* var. *arenarium*, *Vigna o-wahuensis*, and *Zanthoxylum hawaiiense.* We also manage the undescribed species *Tetramolopium* sp. 1 due to its rarity and limited distribution even though this plant is not ESA-listed.

The Botanical Program is composed of 2 sections:

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

The purpose of the Plant Survey and Monitoring Section is to delimit listed species distributions, estimate and monitor plant populations, monitor for emerging threats, and monitor vegetation and habitat conditions. Projects in this section include plant surveys, 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.

During the reporting period, we recategorized the threatened and endangered plant species into 2 management tiers. Tier 1 includes species with less than 500 adults and juveniles at PTA. Tier 2 includes species with more than 500 adults and juveniles at PTA.

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 collected quarterly count data from which we can accurately track population patterns and status. We used this information to develop a new Tier 1 monitoring protocol in FY 2021, which we expect to implement in early FY 2022. The new monitoring methods will allow us to track abundance more efficiently and precisely for all Tier 1 species at PTA and potentially model future population status. In addition, we began developing a second monitoring protocol for the Tier 2 species based on a random sampling approach. The aim will be to annually 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 5-year period thus also refreshing species distribution data. We anticipate completing and implementing the Tier 2 species monitoring protocol in FY 2022-2023.

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

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

We are adopting 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. Along with improved tracking and monitoring, these measures will include adopting new naming conventions that will be applied throughout the Botanical Program to maintain consistency in the monitoring of wild and outplanted plants.

We drafted a 5-year outplanting plan and submitted it to USAG-P in July 2021 for review and approval before sending the plan to Installation Management Command Headquarters for final approval. This plan supports INRMP objectives and will support the draft Programmatic Biological Assessment.

The *Genetic Conservation and Outplanting Plan* (CEMML 2017) is the foundational to guide genetic conservation for the 20 ESA-listed plants. The strategy developed in the plan guides management priorities, collection and propagation targets, and outplanting activities. The 5-year outplanting plan drafted in 2021 provides a framework for implementing the 2017 outplanting strategy to work toward INRMP objectives. In 2022, we plan to develop site-specific planting plans based on projects identified in the 5-year plan. These more detailed site-specific plans will establish planting targets and long-term site monitoring plans to evaluate outplanting success and our efforts in relation to our goals and compliance obligations for each ESA-listed plant species.

We continue to reconcile past record-keeping systems and naming conventions to ensure accurate, reliable information is available for inventories and monitoring. We aim to overhaul our database, inventory species and founders in the *ex situ* propagule bank, and streamline the accounting process to accurately track seeds from collection and storage to propagation and outplanting.

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

Invasive Plants Program

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

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

The purpose of the 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 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. 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 desired outcomes. All ASRs on the current schedule, except 2, received weed control during the reporting period. We also implemented weed control in 1 new ASR in the KMA for *S. macrophyllus*. Our vegetation control actions at HFNWR also appear to be benefitting Hawaiian Geese by providing preferred habitat.

We increased monitoring and control efforts overall by 3.7-fold and survey and control efforts in site-specific grids by 3.6-fold compared to the last reporting period. Our data shows that we have made considerable progress in reducing plant abundance and distribution in most if not all site-specific survey grids. Moreover, our preliminary attempts to quantify the efficacy of our control efforts in these grids have highlighted areas that need improvement and will inform our future planning. We drafted a preliminary technical report detailing the status, locations, habitat, and phenology of each secondary target weed species at PTA. In FY 2022, we plan to re-evaluate our methods and overall approach for assessing, prioritizing, and controlling secondary target weeds to best achieve our goals and associated requirements.

The purpose of the Fuels Management Section is to reduce the threat of wildland fire to TES and their habitats at the installation. Projects implemented to achieve these goals include the implementation and maintenance of firebreaks 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 the summer of 2021, several wildland fires occurred at PTA. Two of these fires occurred in the KMA in areas where firefighters utilized our conservation fuel breaks. Our fuels management actions contributed to a positive outcome for ESA-listed plants during the July 2021 fire in the northern section of KMA. Our fuel breaks were a critical asset for firefighters and helped to prevent impacts to ESA-listed plant species on the 2 puʻu (cinder cones) during one of the largest wildland fires in Hawaiʻi. The PTA Fire Department noted that our fuel breaks significantly aided in fire suppression and containment efforts, underscoring their value as safe and effective pre-suppression assets.

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 the Blackburn's sphinx moth (*Manduca blackburni*). Since 2006, 12 additional bird species protected under the MBTA have been observed at PTA (USAG-P 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 impacts from wildlife to military activities that may degrade training realism or quality at PTA. This section is divided into the following projects: Hawaiian Goose management, Hawaiian hoary bat, seabird management, avian monitoring, anthricinan yellow-faced bee, and Blackburn's sphinx moth. Section objectives include surveying to determine presence of species, monitoring activity patterns, identifying habitat use, and reporting incidental take (direct and indirect) for the Hawaiian Goose, Hawaiian hoary bat, and bird species protected under the MBTA.

During the reporting period, we continued to monitor Hawaiian Geese at PTA and to implement management to reduce conflicts with military training. Our management efforts at Hakalau Forest National Wildlife Refuge supported the fledging of 30 geese during the reporting period. With 18 goslings successfully fledging in FY 2021, we reached 69% of the target production of 26 fledglings per year.

Acoustic occupancy and activity analyses show that Hawaiian hoary bats are present across the installation throughout the year and that activity peaks during the autumn months. A *Hawaiian Hoary Bat Conservation Management Plan at PTA* has been drafted and 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.

We continue to improve our monitoring of Band-rumped Strom 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 feral cat captures 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. In FY 2022, we plan to issue a technical report analyzing the bird monitoring dataset from 1998 through 2021. We plan to use the pending data and trend analysis to develop management plans for target 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*.

With the recent listing of the anthricinan yellow-faced bee in 2016, 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 from military activities to the bee and its habitat. For FY 2022, we will continue to provide information about this species for a formal consultation under section 7 of the ESA.

Because Blackburn's sphinx moth 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 from military activities to the species and its habitat. In FY 2021, we trained our staff to recognize and report this species. We plan to survey for the moth at PTA to better understand the potential effects to the species from military activities and better manage this species.

The purpose of the Threat Management Section is to reduce or eliminate impacts to TES and their habitats from non-native animals (ungulates, small mammals, and invertebrates), to prevent the introduction and establishment of new invasive animals via military actions, and to monitor and preserve the ungulate exclusion fence units that protect TES and their habitats. Our objectives include detecting and reporting the presence of incipient or previously undocumented invasive animal species, especially reptiles, controlling invasive animal species that threaten TES, and maintaining the integrity of the ungulate exclusion fences. This section is divided into the following projects: ungulate management, small mammal (i.e., predator) management, 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 in the at the Band-rumped Storm Petrel breeding colony, maintaining an ungulate-free status in all the ungulate exclusion fence units, and controlling invasive ants, particularly the early detection and successful control of Little Fire Ants on cantonment.

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.

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

Ecological Data Program

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

1) Develop and maintain ESA-listed and rare plant and animal management actions databases for the purposes of monitoring, collection, evaluation, and dissemination of 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 provided 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.

Using relational databases, we designed targeted queries to organize and extract data from complex data sets for analysis. We used our expertise in ecology, experimental design, and data management as needed to assist technical programs to develop project-specific strategies to collect and manage complex ecological data for all facets of work done at PTA. This support included seabird presence and activity patterns, Hawaiian Goose nesting behaviors and success, Hawaiian hoary bat occupancy, and rare plant surveys and monitoring.

The primary focus of the EDP regarding programmatic-level spatial data support continues to be the development and improvement of mobile GIS frameworks that streamline the collection, organization, analysis, and use of geospatial data collected in the field to facilitate operations of technical programs.

EDP continues to provide high-end cartographic/GIS/spatial analysis support for all natural resource related facets 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. One major initiative recently undertaken was to bring all spatial data into compliance with Federal metadata standards. This also directly benefits our ability to share data among the Army and agency partners.

EDP has on-staff experts in the fields of remote data acquisition, utilization, and management. EDP staff include small aircraft and unmanned aircraft systems (UAS) pilots with expertise in planning and implementing UAS flight missions to collect environmental data. We can leverage our in-house capacity to access and utilize publicly available remotely sensed data including satellite imagery, LiDAR, and other multi-spectral datasets toward the effective accomplishment our tasks. We provided support during a recent fire event by accessing and processing Sentinel-2 satellite imagery to provide near real-time situational updates regarding the advancement of the fire and how it relates to natural, cultural, civilian and DoD assets on the ground to personnel fighting the fire as well as to our command structure. We use these data to provide delineated burn footprints and acreage estimates to support the planning of direct on-the-ground assessments of impacts to natural resources from the fire.

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

<u>Area 2: Technical Assistance for Military Initiatives</u>

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

1) ESA and NEPA Projects
2) INRMP
3) Conservation Reimbursable Programs
4) Collaborations with Partner Agencies
5) External Research Support
6) Specialized Services
7) Direct Assistance to Army Biologist
8) On-site Support to PTA Command
9) Permits
10) Public Outreach
11) 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 Integrate Wildland Fire Management Plan (IWFMP) and 2003 Biological Opinion (BO) require the Army to assess and report all military training-related wildland fires occurring on the installation outside of the Impact Area to determine potential effects to TES and incidental take of Hawaiian hoary bats. During the reporting period, we provided assessments following 5 wildland fire events in July and August 2021.

Firing Point 519 (Training Area 16) Fire

On 15 July 2021, at approximately 1520 hours, a wildland fire ignited at Firing Point 519 in Training Area 16 at PTA. The fire was started during military training exercises (smoke grenade). The fire was declared 100% contained that same evening. The fire burned approximately 4 ha in the *Eragrostis atropioides* Herbaceous Alliance (Block et al. 2013). There were no effects to ESA-listed plant species or Hawaiian hoary bat habitat.

For more details on the 15 July 2021 wildland fire at Firing Point 519 refer to the "*Technical Report and Post-Disturbance Assessment for the July 2021 Wildland Fires: Keʻāmuku Maneuver Area (LZ Dove)/Palila Critical Habitat, Firing Point 519 (Training Area 16), Pōhakuloa Training Area, Island of Hawaiʻi*" (CEMML 2021d).

Keʻāmuku Maneuver Area (LZ Dove)/Palila Critical Habitat Fire

On 17 July 2021, at approximately 1330 hours, a wildland fire ignited near LZ Dove in KMA. The fire was started during military training exercises (blank ammunition). The fire spread quickly and jumped Fuel Break 313 (Scout Trail) which runs from Keʻekeʻe Road to the northern edge of the Kilohana Girl Scout Camp. Firefighters used Fuel Break 313 to fight the fire. The fire wrapped around the north end of the fuel break where fuels control ends but did not jump Old Saddle Road at that location. The fire burned approximately 508 ha in KMA.

There were no known locations of ESA-listed plant species within the burn footprint; however, a single location of *Sicyos macrophyllus* was within the vicinity of the fire. An emergency firebreak bulldozed during fire response operations successfully stopped the fire approximately 200 m from the *S. macrophyllus* location. On 1 September 2021, we surveyed the *S. macrophyllus* location and confirmed there were no effects to the ESA-listed plant species.

On the evening of 17 July 2021, the fire jumped Old Saddle Road near the Kilohana Hunter Station and spread into Palila Critical Habitat (PCH). The fire burned approximately 99 ha of PCH on adjacent state land. The fire was declared 90% contained on 19 July 2021.

The 17 July 2021 fire burned 3 ha of vegetation considered potential available Hawaiian hoary bat roosting habitat, approximately 6% of the allowable 48 ha per year. No bat carcasses were reported in the burned area and impacts to the Hawaiian hoary bat are assumed to be negligible.

For more details on the 17 July 2021 wildland fire in KMA (LZ Dove) and PCH refer to the "*Technical Report and Post-Disturbance Assessment for the July 2021 Wildland Fires: Keʻāmuku Maneuver Area (LZ Dove)/Palila Critical Habitat, Firing Point 519 (Training Area 16), Pōhakuloa Training Area, Island of Hawaiʻi*" (CEMML 2021d).

Mana Road/Mauna Kea/ Keʻāmuku Maneuver Area Fire

On 30 July 2021, at approximately 1100 hours, a wildland fire ignited off-PTA near Mana Road in the town of Waimea. Fueled by high winds, the fire spread quickly and burned significant acreage on Parker Ranch and state lands on Mauna Kea. On 31 July 2021, the fire jumped Old Saddle Road and burned onto KMA near Puʻu Nohona o Hae and Puʻu Pāpapa. One of the largest wildland fires in recorded Hawaiʻi history, the fire burned approximately 1,273 ha in KMA and more than 17,000 ha overall. The fire was declared 100% contained on 6 August 2021.

There were no known locations of ESA-listed plant species within the burn footprint near Puʻu Nohona o Hae and Puʻu Pāpapa in KMA. Emergency firebreaks that were bulldozed in KMA during fire response operations, combined with conservation fuel breaks encircling both puʻu, successfully stopped the fire from the nearest plant locations. Nonetheless, we assessed direct and indirect impacts to ESA-listed plant species with locations in the general vicinity of the fire and no direct or indirect fire impacts were observed.

The 30 July 2021 fire burned 12 ha of vegetation considered potential available Hawaiian hoary bat roosting habitat, approximately 25% of the allowable 48 ha per year. No bat carcasses were reported in the burned area and impacts to the Hawaiian hoary bat are assumed to be negligible.

For more details on the 30 July 2021 wildland fire in KMA near Puʻu Nohona o Hae and Puʻu Pāpapa refer to the "*Technical Report and Post-Disturbance Assessment for the July 2021 Wildland Fire: Mana Road/Mauna Kea/Keʻāmuku Maneuver Area, Pōhakuloa Training Area, Island of Hawaiʻi*" (CEMML 2021e).

Daniel K. Inouye Highway (MM48) Fires

On 11 and 13 August 2021, 2 fires occurred south of the DKI Highway near MM 48 in KMA. Mop up operations continued until the morning of 15 August 2021. The fires burned approximately 100 ha: 33 ha in KMA and 67 ha on adjacent state land. The cause of both fires was suspected arson. Because the fires were not training related, any loss of treeland roosting habitat is not considered incidental take of the Hawaiian hoary bat and the Army was not required to produce a technical report for USFWS. We produced a memorandum to document the post-disturbance assessment.

No known locations of ESA-listed plant species were within the burn footprint (Arnett 2002). Due to the continued presence of feral ungulates, it is highly unlikely that any ESA-listed plant species occur in the area; therefore, we did not conduct post-fire surveys. The fires did not have any known impacts on ESA-listed plant species.

To assess impacts to Hawaiian hoary bat habitat, we overlaid vegetation types that may provide treeland roosting habitat with the burn footprint using ArcGIS. No potential available treeland roosting habitat was within the burned area; therefore, no incidental take of Hawaiian hoary bats occurred from the fires.

For more details on the August 2021 wildland fires in KMA near DKI Highway refer to the MFR "*Post-disturbance assessment for the fires that occurred near the DK Inouye Highway (MM 48) in the Keʻāmuku Maneuver Area in August 2021*" (CEMML 2022).

Conclusion

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

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

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

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1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

1.1.1 Function of the Report

This biennial report documents the work performed jointly by the Center for Environmental Management of Military Lands (CEMML) and for 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 is 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 in a manner so that the reader understands the essential purpose of each project in a regulatory and ecological context.

The Army Biologist and Natural Resources Program Manager are the main audiences for this report; however, it 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 2020–FY 2021 (01 October 2019 through 30 September 2021).

Report purposes include:

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

1.1.2 Report Organization

This report is organized into 3 areas:

1) Compliance with regulatory mandates and reporting requirements

2) Technical assistance for military initiatives
3) Assessments after disturbance events

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

We produce a comprehensive biennial report every 2 years. The report includes an appendix that satisfies annual reporting requirements for the most recently completed fiscal year. In interim years, a report addressing reporting requirements is produced as a stand-alone document and delivered separately (CEMML 2021c). Annual reporting requirements for FY 2021 (01 October 2020 through 30 September 2021) are contained in Appendix E of this report.

1.2 PTA NATURAL RESOURCES PROGRAM BACKGROUND

1.2.1 Natural Resources Program Authorities and Regulatory Framework

The Army is committed to environmental stewardship and sustainability in all actions as an integral part of its mission. To this end the Army promulgated Army Regulation 200-1 to implement federal, state, and local environmental laws and Department of Defense (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.

Per the Sikes Act Improvement Act (1997), the PTA INRMP (USAG-P 2020) is the foundational document of the Army's Natural Resources Program at PTA and sets objectives for managing native plant species, including ESA-listed plants (Chapter 5.1.3). The plan also identifies objectives to manage the ecosystem at the landscape scale to protect habitats that are home to 26 ESA-listed threatened and endangered species (TES). The US Fish and Wildlife Service (USFWS) considers invasive species and their associated impacts to be major threats to the ESA-listed plants at PTA (USFWS 2003b).

Because of the active management of these threats under the PTA INRMP, the USFWS did not designate critical habitat on Army lands at PTA for 12 plant species in 2003[1].

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

1.2.2 2003, 2008, and 2013 Biological Opinions

In 2003, the USFWS issued a BO to the Army as part of a formal consultation under section 7(a)(2) of the ESA (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. The 2003, 2008, and 2013 BOs are summarized below:

2003 BO

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

[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.*

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, Hawai'i*. Reinitiation of the 2003 BO was necessary to address impacts to *Asplenium peruvianum* var. *insulare*, *Silene hawaiiensis*, and *Solanum incompletum* associated with new construction, training, and conservation actions at PTA. Consultation with USFWS was also reinitiated due to a change in status of the Hawaiian Goose and the Hawaiian hoary bat at the installation.

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

<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, Hawai'i*. The BO was divided into 2 parts for analytical purposes. Part I evaluated potential impacts to TES from the construction, maintenance, and operation of a proposed Infantry Platoon Battle Area (IPBA) at PTA. This discrete action is one component in a long-range plan to modernize training ranges and training support infrastructure at PTA. Part II evaluated ongoing military training actions and related activities at PTA that may affect the Hawaiian Goose. The 2008 BO required the Army to reconsult on potential effects to the Hawaiian Goose from general military training actions and propose new conservation measures as necessary.

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

The BO included an incidental take statement 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).

1.2.3 Upcoming Sec-7 Consultation

The 2003, 2008, and 2013 BOs established conservation measures for 15 species of ESA-listed plants (*Asplenium peruvianum* var. *insulare*, *Haplostachys haplostachya*, *Isodendrion hosakae*, *Kadua coriacea*, *Lipochaeta venosa*, *Neraudia ovata*, *Portulaca sclerocarpa*, *Silene hawaiiensis*, *Silene lanceolata*, *Solanum incompletum*, *Spermolepis hawaiiensis*, *Stenogyne angustifolia* var. *angustifolia*, *Tetramolopium arenarium* spp. *arenarium* var. *arenarium*, *Vigna o-wahuensis*, and *Zanthoxylum hawaiiense*) and 3 species of ESA-listed animals at PTA: Hawaiian hoary bat (*Lasiurus cinereus semotus*), Hawaiian Goose (*Branta sandvicensis*), and Hawaiian Petrel (*Pterodroma sandwichensis*).

Since the issuance of these BOs, several species that occur on the installation have subsequently been listed under the ESA. In October 2013, the USFWS listed *Schiedea hawaiiensis* as an endangered plant species. In September 2016, the following species were also listed as endangered: *Exocarpos menziesii*, *Festuca hawaiiensis*, *Portulaca villosa*, *Sicyos macrophyllus*, Band-rumped Storm Petrel (*Oceanodroma castro*), and Anthricinan yellow-faced bee (*Hylaeus anthracinus*). Additionally, in July 2019, 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.

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 2022.

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). Because this report covers FY 2020 and FY 2021, the reporting period roughly corresponds to the previous Cooperative Agreement option years 3 and 4 which spanned July 2019 through July 2021 (W9126G-16-2-0014).

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-16-2-0014. For a list of corresponding SOO tasks from Cooperative Agreement W9126G-21-2-0027 please refer to Appendix C.

1.2.5 CEMML Organizational Structure at PTA

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

3) The Wildlife Program manages for 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 is 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 the effective execution of management planning, scheduling, implementation, tracking, and reporting. Additionally, this program facilitates the coordination and incorporation of research results from external agencies toward the effective accomplishment of the Army's mission.

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

1.2.6 PTA Natural Resources Program Plan

A comprehensive program plan documents the goals, objectives, and methods for fulfilling regulatory requirements to protect and conserve natural resources at the installation. The plan strategically aligns the overall purpose and execution of each component of the Natural Resources Program at PTA. Projects are directly linked to the INRMP, regulatory mandates, and SOO requirements to track compliance. The program plan provides detail regarding how projects are to be implemented and is intended to work in conjunction with documents that guide natural resource management at PTA, including the BOs, INRMP, and IWFMP. The program plan was intended to update the PTA Implementation Plan (2010) required by the 2003 BO. The Army Biologist and USFWS personnel have not yet reviewed/approved the plan completed in 2017. The plan will be updated once every 5 years to be synchronized with the installation's INRMP (USAG-P 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 have been discussing strategies to modify CEMML's organizational structure 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. We are finalizing a restructuring strategy and will implement modifications toward the end of the fiscal year. At that time, all new projects will require a detailed protocol prior to implementation, and existing projects will be reviewed to ensure adequately described and detailed protocols are in place.

1.3 ECOSYSTEM MANAGEMENT AT PTA

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

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

Most landscape-level actions that we implement are aimed at managing invasive species and their associated negative effects. We have made significant strides toward minimizing some of these negative effects to the native ecosystems at PTA. By 2017, we removed all goats, sheep, and pigs from 15 ungulate exclusion fences that encompass a total of 15,092 ha (CEMML 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-P 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 currently totaling about 199 ha around most of the critically rare ESA-listed plant populations. These efforts to reduce fuels positively contributed to firefighting efforts and helped minimize fire impact to ESA-listed plants and Hawaiian hoary bat habitat during 2 wildfire events in 2012 and 2018, and 3 wildfire events in July 2021 (CEMML 2014, CEMML 2018, CEMML 2019b, CEMML 2021c, CEMML 2021d, CEMML 2021e, CEMML 2022).

1.4 INSTALLATION DESCRIPTION

1.4.1 PTA History

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

PTA is a primary tactical training area for mission-essential training and contributes to the Army's mission by providing resources and facilities for active and reserve component units that train on the installation throughout the year. The largest live-fire range and training complex belonging to the US

Army Pacific is located at PTA. Installation assets are geared toward live-fire range training and maneuvers at ranges, dismounted maneuver training, and artillery live-fire. Artillery units use PTA to conduct 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 was 409 ha of previously leased maneuver lands.

1.4.2 Location and Physical Description

PTA is located in the saddle region between Mauna Kea, Mauna Loa, and Hualālai volcanoes on the island of 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 Preserve, and Parker Ranch to the north, Department of Hawaiian Home Lands to the northeast, the Mauna Loa Forest Reserve to the east and south, and Kamehameha School lands and state lands to the west. PTA is comprised of a cantonment area, Bradshaw Army Airfield, and training areas that include KMA and a centrally located Impact Area.

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

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

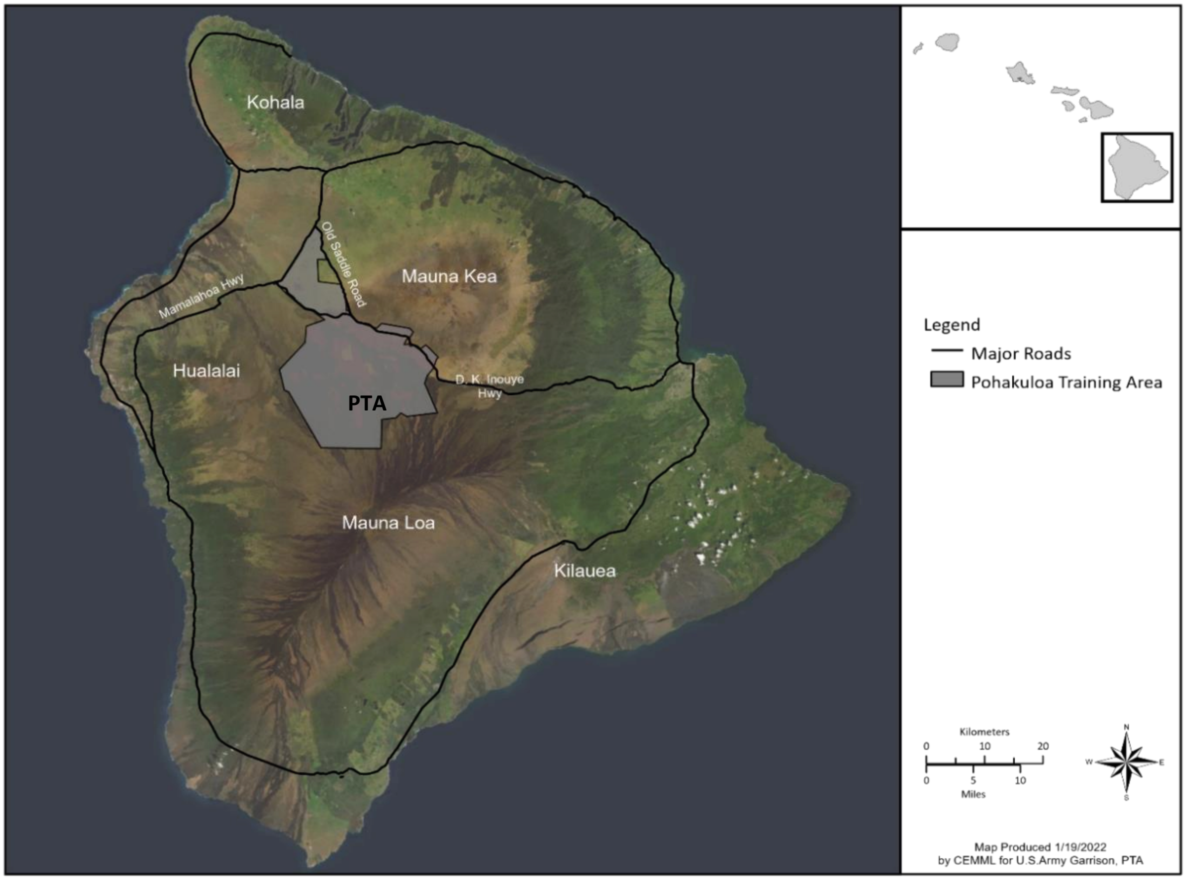

Figure 1. Location of Pōhakuloa Training Area on Hawaiʻi Island

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

1.4.3 Climate Change, Habitat Vulnerability Assessment, and Adaptation Planning

In 2016, the 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 are considered during INRMP development. The INRMP identifies several ongoing conservation actions that help retain ecosystem resiliency as climate conditions change such as (USAG-P 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. In FY 2022, we plan to update the INRMP with additional climate change considerations including:

- Identifying information sources to characterize regional climate change and scenarios upon which to base climate change adaptation planning.
- Determining likely ecosystem-level effects of climate change to assess potential impacts including probable complex and indirect changes that are likely to happen in the future.
- Developing or utilizing existing habitat vulnerability assessments and adaptation recommendations (e.g., EcoAdapt reports) as a framework to develop new and/or improve existing natural resources management strategies to protect species of concern.
- Developing vulnerability assessments and climate adaptation plans for the at-risk, threatened, and endangered species at PTA.
- Developing and updating the INRMP and implementation table to request funding to complete climate change-related projects.

1.4.4 Vegetation Classification

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

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

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

1.5 THREATENED AND ENDANGERED SPECIES

PTA includes a portion of the last remaining sub-alpine tropical dryland ecosystem in the world. In addition, parts of the installation (Training Area 2 and parts of Training Areas 1, 4, 10 and 11) contain critical habitat for the endangered Palila (*Loxioides bailleui*). The installation provides potential habitat for a total of 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, and wildland fire.

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

1.5.1 Plants Listed under the Endangered Species Act

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

1. *Asplenium peruvianum* var. *insulare*
2. *Exocarpos menziesii*
3. *Festuca hawaiiensis*
4. *Haplostachys haplostachya*
5. *Isodendrion hosakae*
6. *Kadua coriacea*
7. *Lipochaeta venosa*
8. *Neraudia ovata*
9. *Portulaca sclerocarpa*
10. *Portulaca villosa*

11. *Schiedea hawaiiensis*
12. *Sicyos macrophyllus*
13. *Silene hawaiiensis*
14. *Silene lanceolata*
15. *Solanum incompletum*
16. *Spermolepis hawaiiensis*
17. *Stenogyne angustifolia*
18. *Tetramolopium arenarium*
19. *Tetramolopium* sp.1 (not ESA-listed)
20. *Vigna o-wahuensis*
21. *Zanthoxylum hawaiiense*

1.5.2 Animals Listed under the Endangered Species Act

One mammal species, 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 Migratory Bird Treaty Act (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

1.6 Management Definitions

1.6.1 Ungulate Exclusion Fences

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

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

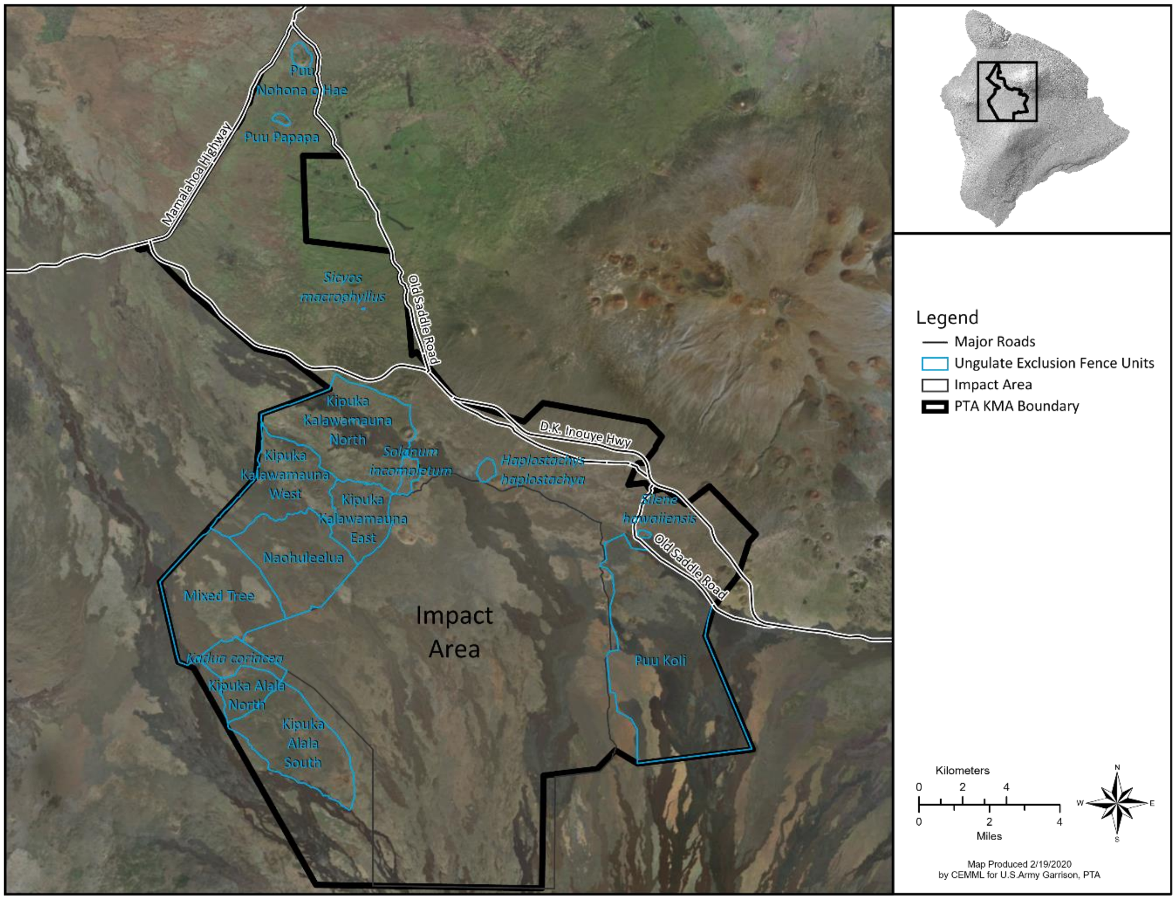

Figure 2. Ungulate exclusion fence units at Pōhakuloa Training Area

1.6.2 Areas of Species Recovery

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

1) Wildland fire flame lengths of 40–50 m
2) An area large enough for ESA-listed plant populations to expand
3) Maximum size that is feasible for sustained management over time

Currently, there are 45 ASRs at PTA that comprise 1,146 ha. The ASR boundaries are periodically reviewed and adjusted as population extent and conditions change. The degree of management effort within the ASRs varies based on prioritization criteria such as natural resource value, threats, quality of habitat, and rarity of species. Prioritization allows us to use resources efficiently and to systematically implement management over large-scale areas for multiple species in various habitats.

1.6.3 Management Projects

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

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AREA 1: COMPLIANCE WITH REGULATORY MANDATES AND REPORTING REQUIREMENTS

2.0 BOTANICAL PROGRAM

2.1 INTRODUCTION

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

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

To meet these requirements, we manage native plant species and their habitats including 20 ESA-listed plant species: *Asplenium peruvianum* var. *insulare* (fragile fern), *Exocarpos menziesii* (Menzie's ballart or heau), *Festuca hawaiiensis* (Hawaiian fescue), *Haplostachys haplostachya* (Hawaiian mint or honohono), *Isodendrion hosakae* (aupaka), *Kadua coriacea* (leather-leaf sweet ear or kioʻele), *Lipochaeta venosa* (nehe), *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 the Army BOs with conservation measures for 15 ESA-listed plants[2]. The Army has not consulted with the USFWS under section 7(a)(2) of the ESA for 5 ESA-listed plants found at PTA: *E. menziesii*, *F. hawaiiensis*, *P. villosa*, *S. macrophyllus,* and *Schiedea hawaiiensis*. Without an ESA consultation, these species lack formal conservation measures. We also

[2] *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*.

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

We are currently preparing documents to formally consult with the USFWS 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 2022.

To work with TES, we obtained state and federal permits authorizing our activities. In 2020, the USFWS issued us an 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 (I1347, expired 31 December 2020; and I2689, expired on 31 December 2021). We also maintain permits that authorize our work on State of Hawaiʻi lands and lands jointly administered by federal and state agencies. Under the authorizations of the permits, we collect, store, propagate, and outplant propagules, including seeds, inflorescences, spores, fruits, cuttings, and leaves, of the 20 ESA-listed plant species to further genetic conservation of these species. Our management complies with permit conditions and separate reports addressing these conditions are provided annually to USFWS and the State of Hawaiʻi.

The Botanical Program is composed of 2 sections:

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

Each Botanical Program section addresses specific SOO tasks, INRMP objectives, and regulatory requirements, which dictate the goals and objectives within that section. Specifically, projects reported in this section address SOO task 3.2.1 Botanical Program Support. SOO sub-tasks 3.2(1)(b) and 3.2(1)(c)[3] are primarily implemented by the Invasive Plants and Wildlife Programs, respectively, and are addressed in Chapters 3 and 4. For a list of drivers associated with each of the projects and sections in the Botanical Program, please refer to Appendix C.

This report summarizes project methods and general results for each Botanical Program section. This information applies collectively to all managed plant species at PTA. Next, this report provides summaries for each ESA-listed plant species (e.g., survey data and genetic conservation activity). The species sections are arranged by management tiers (Table 1) and then alphabetically by species. The species-specific summaries include distribution maps for each species.

<u>Management of Plant Species Listed under the Endangered Species Act</u>

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

[3] In agreement W9126G-21-2-0027, tasks 3.2(1)(b) and 3.2(1)(c) are consolidated into task 3.2.1.3.

but very restricted distributions (e.g., *N. ovata*, *S. incompletum*, *T. arenarium*), some species with sparser distributions occurring across many thousands of acres (e.g., *A. peruvianum* var. *insulare*, *P. sclerocarpa*), and some species with a combination of dense and sparse distributions over thousands of hectares (e.g., *H. haplostachya*, *Silene hawaiiensis*, *Z. hawaiiense*). These factors make managing ESA-listed plant species and natural resources at PTA a significant challenge, requiring efficient methods to understand patterns in species distributions and abundances so that natural resources program objectives can be fulfilled.

To guide management across this complex landscape, we assign each rare plant species to 1 of 2 management tiers based on each species' abundance at PTA (Table 1):

- Tier 1 – Plant species with fewer than 500 individuals at PTA.
- Tier 2 – Plant species with more 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 1. Management tiers for plant species listed under the Endangered Species Act at Pōhakuloa Training Area.

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

[a] Undescribed, not listed under the Endangered Species Act

[b] *Silene hawaiiensis* is threatened; all other species are endangered.

Bold = most of the statewide population is found at Pōhakuloa Training Area; Underline = species found only at Pōhakuloa Training Area

In previous reports we assigned each rare plant species to 1 of 3 management priority levels based on each species' distribution and abundance. The species assigned to each level were referred to as Priority Species (PS) 1 to 3. After review of the PS ranking system, we decided that the 2-tiered classification better suited the management objectives for the species at PTA.

In 2008, we developed Areas of Species Recovery (ASRs) to prioritize and focus management efforts for ESA-listed species based on a set of criteria including species rarity, fire risk, non-native plant density, and exposure to ungulate browse. The ASRs are defined as 100-m buffers around rare plant populations where we focus management (see Section 1.6.2). There are currently 44 ASRs at PTA; however, we aim to update ASR designations in 2022 to reflect current understanding of ESA-listed plant distributions and changes in other factors.

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

2.2 PLANT 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) surveys 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. Investigating the status of ESA-listed plant populations is essential to determining if the selected strategies are creating favorable conditions to adequately sustain each ESA-listed plant species.

The overall operational goals of the PSMS are to:

- Refresh rare plant distributions on an approximate 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.
- Monitor selected ESA-listed plant species to guide management.

- Protect ESA-listed plant species directly impacted by military activities.
- Monitor vegetation communities over time and, where possible, document changes.

2.2.2 Plant Surveys

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

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.

General Plant Surveys within Ungulate Exclusion Fence Units

In 2017, we began a second inventory of 56 km^2 of area previously surveyed (2011–2015) within the fence units. The intent was to refresh the distribution and abundance of the ESA-listed plant species over a 5-year period and evaluate changes between surveys. In 2017, we implemented a new procedure to count individual plants at a location (5-m radius circle) to achieve greater granularity in the number of plants encountered.

In 2019, we attempted to summarize changes in species distributions and abundances for both survey cycles for 6 plant species (CEMML 2019b). However, the count class data collected during the initial survey (2011–2015) limited our ability to quantitatively describe changes in species abundance between the cycles.

Because of the inability to adequately assess changes in species abundance between surveys and the need to efficiently estimate species abundances for the planned Programmatic Biological Assessment (PBA), we decided to expedite completion of the second cycle of surveys and then focus on developing a new, more effective and efficient monitoring approach to address management needs directly. For the PBA, we needed updated abundance estimates for 6 Tier 2 species: *E. menziesii, F. hawaiiensis, H. haplostachya, Silene hawaiiensis, S. lanceolata*, and *S. angustifolia*. Therefore, in 2019 we implemented a sampling approach focused on these species to complete the second survey cycle by March 2020.

Methods

In August 2019, we adopted a new strategy to complete the second survey cycle expeditiously and to more reliably estimate the abundances for 6 Tier 2 species. The strategy entailed randomly sampling approximately 30% of the known distribution of these 6 species within ungulate exclusion fence units. To approximate the extent of the PTA population for each target species of interest, we used species point observations recorded during surveys between 2011 and 2019 buffered by 5 m to account for potential Global Positioning System (GPS) error.

Using the existing plant survey grid, we clustered transects into macroplots for sampling (250-m x 100-m polygons comprising 10 transects, each 250 m in length and spaced 10 m apart). Macroplots that contained known species locations were included in the population of interest. For each species, we then selected ~30% of these macroplots for sampling (Table 2).

Table 2. Macroplot selection by species.

Species	**Total Number of Macroplots**	**Sampled Macroplots**	**Sampling Intensity (% of distribution on PTA)**
Exocarpos menziesii	322	92	29%
Festuca hawaiiensis	444	147	33%
Haplostachys haplostachya	186	37	20%
Silene hawaiiensis	343	85	25%
Silene lanceolata	184	49	27%
Stenogyne angustifolia	427	113	27%

We stratified the selection of macroplots by fence unit to ensure adequate spatial dispersion and representation[4]. Using this approach, we calculated the number of macroplots to be selected for sampling in each fence unit for each species. We then randomly selected the number of macroplots within each fence unit. No other criteria were used in macroplot selection (e.g., no preference for proximity to roads or any other geographic features). Therefore, there was no bias in the selection of macroplots for sampling, and data were analyzed based on a simple random sampling design.

Spermolepis hawaiiensis was not included in the 2020 survey effort 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

[4] The number of macroplots that were randomly selected to sample in each fence unit was based on the weighted proportion of "active" macroplots for each species (that is, the proportion of macroplots containing a given species within each fence unit relative to the total number of macroplots across the installation containing that species).

same time each year to help minimize interannual variation and to improve the detectability of the species.

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

Results

During the report period, we surveyed 624 linear kilometers and recorded 1,969 plant locations with federally listed plants and *Tetramolopium* sp.1 (Table 3). Abundance estimates for each species are provided later in this section.

Table 3. Number of plant locations found by species during rare plant surveys FY 2020–FY2021.

Species	Number of locations
Asplenium peruvianum var. *insulare*	5
Exocarpos menziesii	262
Festuca hawaiiensis	470
Haplostachys haplostachya	263
Kadua coriacea	11
Portulaca sclerocarpa	8
Silene lanceolata	361
Silene hawaiiensis	129
Solanum incompletum	9
Spermolepis hawaiiensis	1
Stenogyne angustifolia	414
Tetramolopium arenarium	3
Tetramolopium sp. 1	1
Zanthoxylum hawaiiense	32

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

We compiled data from the plant surveys (2011–2021), monitoring data, and locations of incidental finds of federally listed plants to generate a composite plant distribution map (Figure 3)[6].

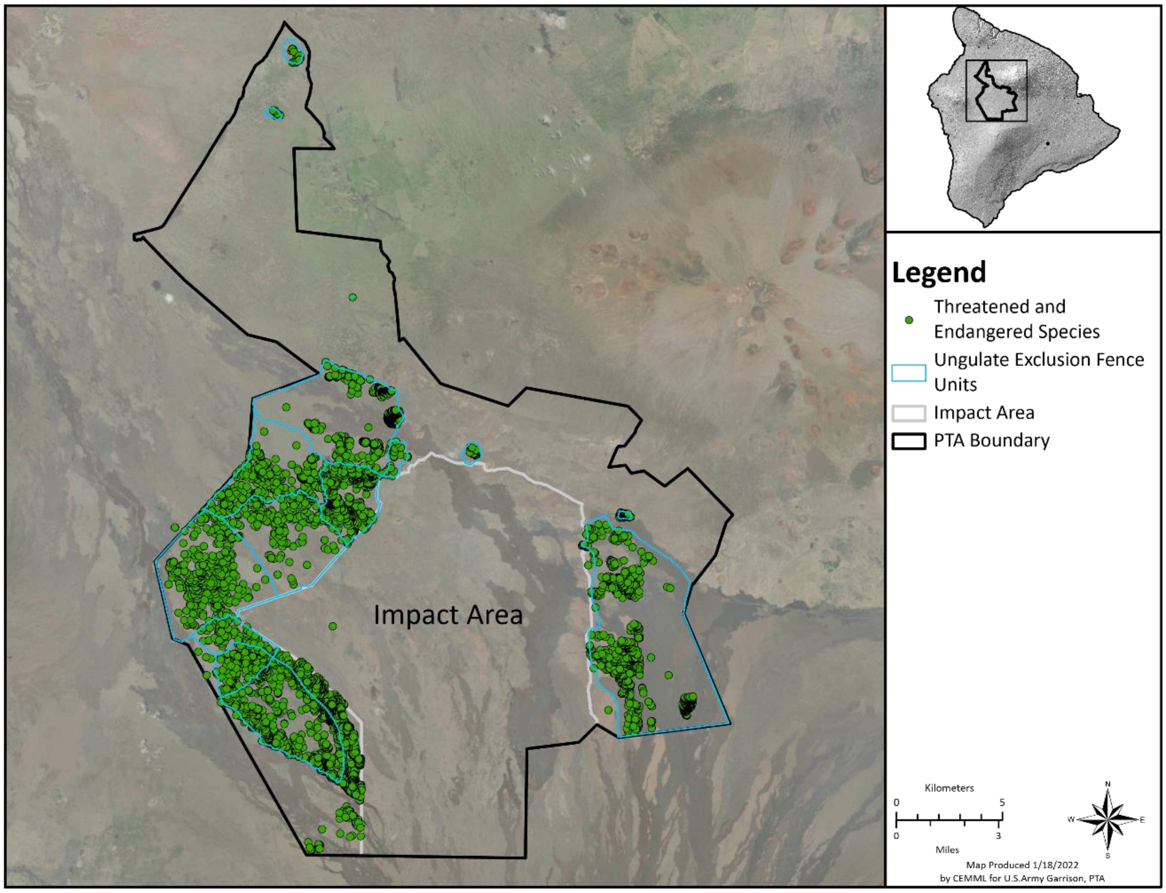

Figure 3. Known distribution of plant species listed under the Endangered Species Act at Pōhakuloa Training Area

Results for the 6 Tier 2 species sampled in 2020 are shown in Table 4. Estimates for the number of individuals in each conservation fence unit can also be inferred from the sample data.

[6] The composite plant distribution data set is comprised of: 1) rare plant survey data collected between 2011–2021 (with overlap areas removed and only showing the most current data) for Tier 2 species; 2) Tier 1 monitoring plots (5-m radius circle) from September 2020; 3) locations of *Zanthoxylum hawaiiense* from 2020 surveys; and 4) locations of incidental finds of federally listed plants, removing any points that occur in a 6-m radius of a point of the same species (unless the notes specified that this is a new location).

Table 4. 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	Upper 90% Confidence Interval	Lower 90% Confidence Interval
Exocarpos menziesii	2,068	224.13	2,292	1,844
Festuca hawaiiensis	9,905	1,436.95	11,342	8,468
Haplostachys haplostachya	24,010	5,336.06	29,346	18,674
Silene hawaiiensis	9,076	1,124.50	10,200	7,951
Silene lanceolata	11,772	1,852.69	13,624	9,919
Stenogyne angustifolia	14,044	3,099.53	17,144	10,945

Discussion

In August 2019, we implemented surveys based on a random selection of macroplots designed to sample populations of 6 Tier 2 species. Plant count data collected during surveys was used to estimate the abundance of these species at PTA.

In previous reports, the abundance for these 6 Tier 2 species was reported as the minimum number of individuals at PTA that was derived from count class data recorded at each plant location during surveys from 2011 to 2015. We used the lower boundary of each count class to quantify the minimum number of individuals for descriptive purposes only. However, compared to the abundance estimates derived from the sampled populations, the minimum number estimates (2011 to 2015) underrepresent the population size for 3 species, *F. hawaiiensis, Silene hawaiiensis,* and *S. lanceolata*, and for 2 species, *E. menziesii* and *H. haplostachya*, the minimum number estimate and the sampled abundance estimate were relatively similar (Table 5). Some natural recruitment likely occurred between the 2 surveys, especially since the ungulates were cleared from the fences by 2017. However, we are likely seeing such dramatic changes in population estimates because the previous estimation method was a poor predictor of population size for some of the Tier 2 species. Based on the questionable success of the sampling approach, we plan to improve the sampling approach to meet future monitoring requirements for these Tier 2 species.

Table 5. Comparison between abundance estimates for Tier 2 species.

Species	Estimated Mean Abundance (2020)	Minimum Number (2011–2015)
Exocarpos menziesii	2,608	1,802
Festuca hawaiiensis	9,905	1,803
Haplostachys haplostachya	24,010	24,268
Silene hawaiiensis	9,076	2,344
Silene lanceolata	11,772	3,882
Stenogyne angustifolia	14,044	2,517

Overall, the value of plant surveys lies in delineating the geographic extent and number of occurrences associated with each taxon. This data will be extremely useful in developing and implementing revised sampling designs for selected listed species in FY 2022. Plant surveys are a cornerstone of the natural resources program and directly support INRMP objectives and BO conservation measures. Per Army Regulation-100, Planning Level Surveys should be updated every 5 years. Updating spatial information regarding locations of ESA-listed plants, plants at risk of becoming listed, and invasive plants helps to facilitate natural resources management, identifies potential encroachment issues for the military, and can provide baseline information for land use planning and future military operations.

Plant Surveys in Training Area 23 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.

Methods

To continue to develop accurate abundance estimates for the ESA-listed plants at PTA for the PBA, we surveyed the unfenced portions of TA 23. *E. menziesii* and *Silene hawaiiensis* were the primary targets for the survey. To determine the survey area, we used species point observations collected between 2011 and 2019 to identify associations with vegetation classifications. We then created survey transects within the same vegetation classification outside the fence units as the complete survey universe. Survey transects were arranged into macroplots (250 m x 100 m polygons comprising 10 transects, each 250 m in length and spaced 10 m apart).

At the outset of the project, we intended to survey all macroplots for a total of 1,128 km. However, due to the remoteness of TA 23 and time and personnel limitations, in September 2021 we decided to implement a sampling design that would provide reliable estimates of ESA-listed species abundance as needed to support the PBA. We used a simple random sampling approach at ~30% sampling intensity with design elements that ensured adequate spatial dispersion of transects to be surveyed. This approach reduced our project targets to 2,352 transects and 397.2 km (35% of original goal).

During surveys, we use GPS-equipped devices to record spatial coordinates of "priority species" (i.e., ESA-listed and species identified by the Botanical Program Manager). Because plants are often found in clusters, we record a single GPS coordinate to represent all individuals within a 5-m radius area. This area is termed a plant “location”. If plants are in larger and continuous groupings, we record location coordinates every 10 m along transects. For each location, we count all individuals up to 25 and then assign a count class[7] based on the number of individuals present within a 5-m radius at each recorded location.

Results

From June 2021 through August 2021, we surveyed 326 linear kilometers. Endangered plant species found during the surveys include *Asplenium peruvianum* var. *insulare*, *Exocarpos menziesii*, and *Festuca hawaiiensis* as well as the threatened species *Silene hawaiiensis* (Table 6 and Figure 4). However, some data collected during this period cannot be used directly for species abundance estimation within the context of the sampling design implemented in September 2021 because it covers area that ultimately was not selected for sampling. Nevertheless, all data will be used to ensure we provide the best, most accurate results possible.

Table 6. Count of plant species listed under the Endangered Species Act found during surveys in the unfenced area of Training Area 23 June through August 2021.

Species	Seedlings	Juveniles	Adults	Total to August 2021[a]
Asplenium peruvianum var. *insulare*	0	3	1	4
Exocarpos menziesii	0	0	919	1,079
Festuca hawaiiensis	0	1	0	5
Silene hawaiiensis	0	0	6	6

[a] Totals represent the cumulative number of adults and juveniles found June 2021 through August 2021.

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

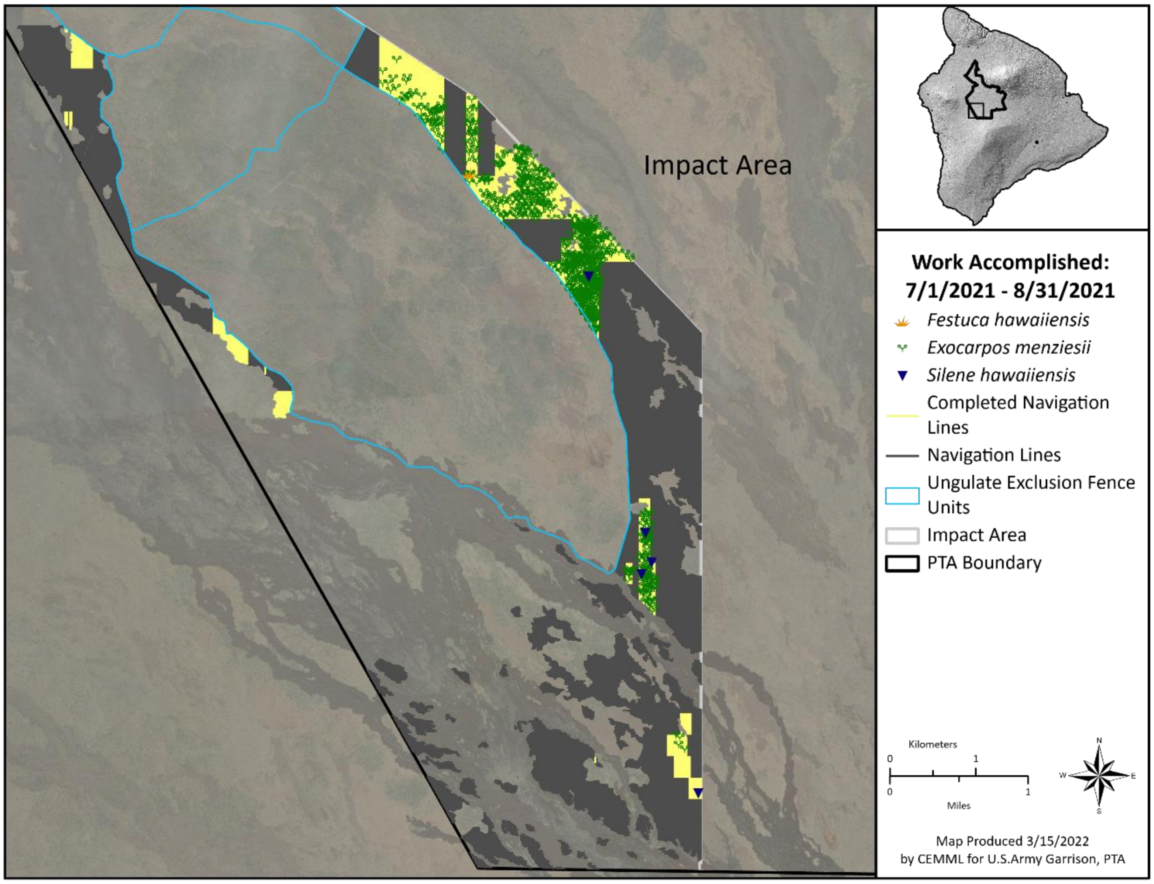

Figure 4. Plant survey area in Training Area 23. The initial survey area of 1,128 km is shown by dark gray navigation lines. Navigation lines completed between July–August 2021 are shown in yellow with threatened and endangered species locations superimposed.

In September 2021, we shifted the 30% random sampling design. For the month of September, we surveyed 127.6 linear km (Figure 5). ESA-listed species found during the surveys included the endangered species *Exocarpos menziesii*, and the threatened species *Silene hawaiiensis* (Table 7).

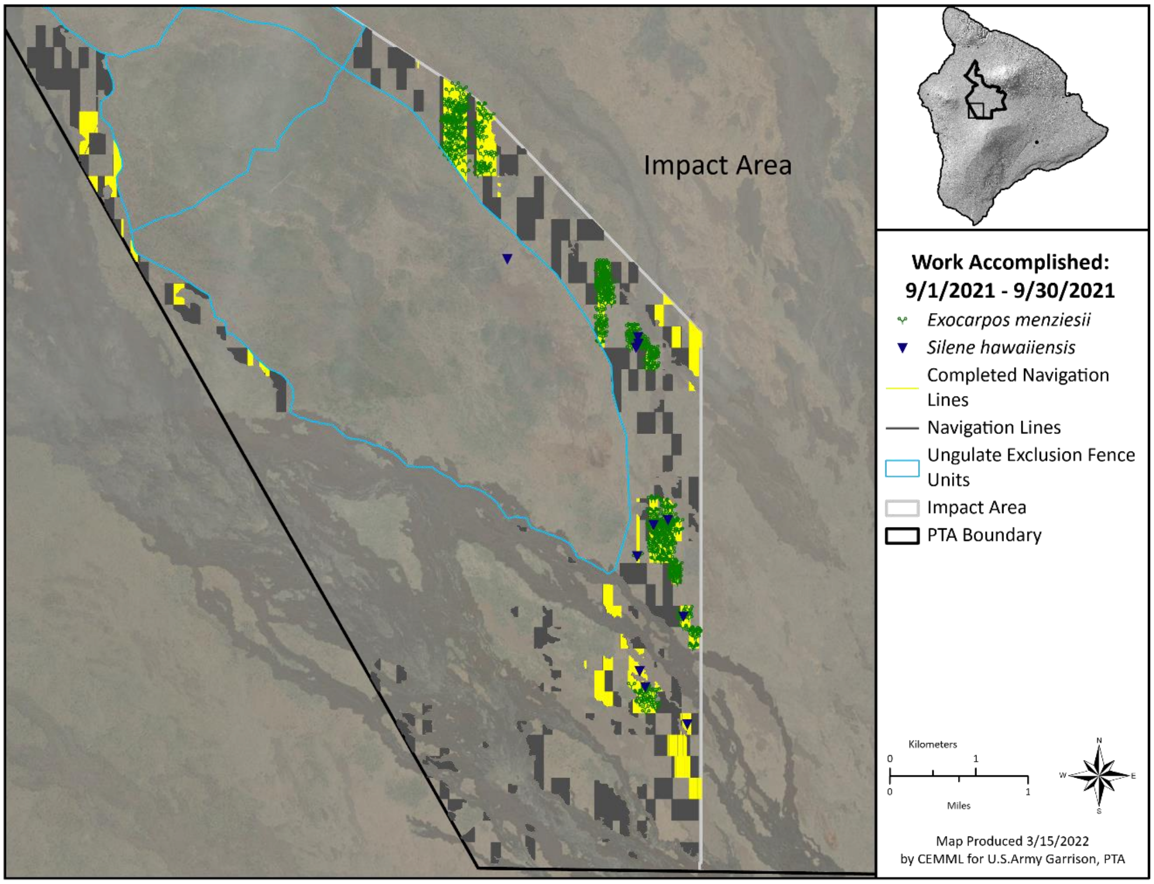

Figure 5. Plant survey progress in Training Area 23. The survey area is shown by navigation lines (dark gray), which represent a random selection of 30% of the original survey area. Navigation lines completed in September 2021 are shown in yellow with threatened and endangered plant locations superimposed.

Table 7. Counts by life stage of plant species listed under the Endangered Species Act found during surveys in the unfenced area of Training Area 23 in September 2021.

Species	Seedlings	Juveniles	Adults	Total through September 2021 [a]
Exocarpos menziesii	0	0	594	2,267
Silene hawaiiensis	0	0	11	17

[a] Totals represent the cumulative number of adults and juveniles found June 2021 through September 2021.

Discussion

We began surveys in June 2021 with the goal of completing surveys in 4 to 5 months. Due to the remoteness and lack of road access to a large portion of the survey area, we realized 9 to 12 months would be needed to complete the surveys. However, the information was intended to support development of the PBA and information was needed by the end of calendar year 2021. Therefore, we implemented a sampling approach where macroplots within suitable habitat for *E. menziesii* and *Silene hawaiiensis* were randomly selected for survey. Based on the random selection of macroplots, we anticipate completing the surveys in early FY 2022.

We found 2,267 *E. menziesii* outside the fence unit during surveys from June through September 2021, which is more than double the estimated abundance of the species at PTA (2,068, 90% CI 1,844–2,292). Moreover, we have only surveyed a fraction of the potential suitable habitat in the unfenced portion of TA 23. Based on this preliminary information, the abundance estimates from within the fence units underrepresents the *E. menziesii* population at PTA. The plants found outside the fence appeared to be well-established adults and no young plants were observed. Fruit was present, but there is ample evidence of rodent depredation throughout the surveyed area.

We also encountered *Silene hawaiiensis* during surveys from June to September 2021, but at a low frequency. The number of individuals encountered is not expected to change the overall abundance estimate for this species at PTA. Because feral ungulates selectively browse *Silene hawaiiensis,* we did not expect to find large numbers of individuals in unfenced areas.

<u>Plant Surveys at the Infantry Platoon Battle Course</u>

The Army proposes to soften up to 30 ac of ground (selective ripping and crushing of lava) to allow soldiers to conduct dismounted maneuvers while training at the Infantry Platoon Battle Course (IPBC, Figure 6). To support this range development proposal, we surveyed approximately 12 ha (30 ac) within the IPBC for rare plant species. We verified that one individual of the endangered species *Kadua coriacea* was still present in the proposed project footprint, but no other TES were found. To avoid potential impacts, the *Kadua coriacea* location will be avoided during ground softening operations.

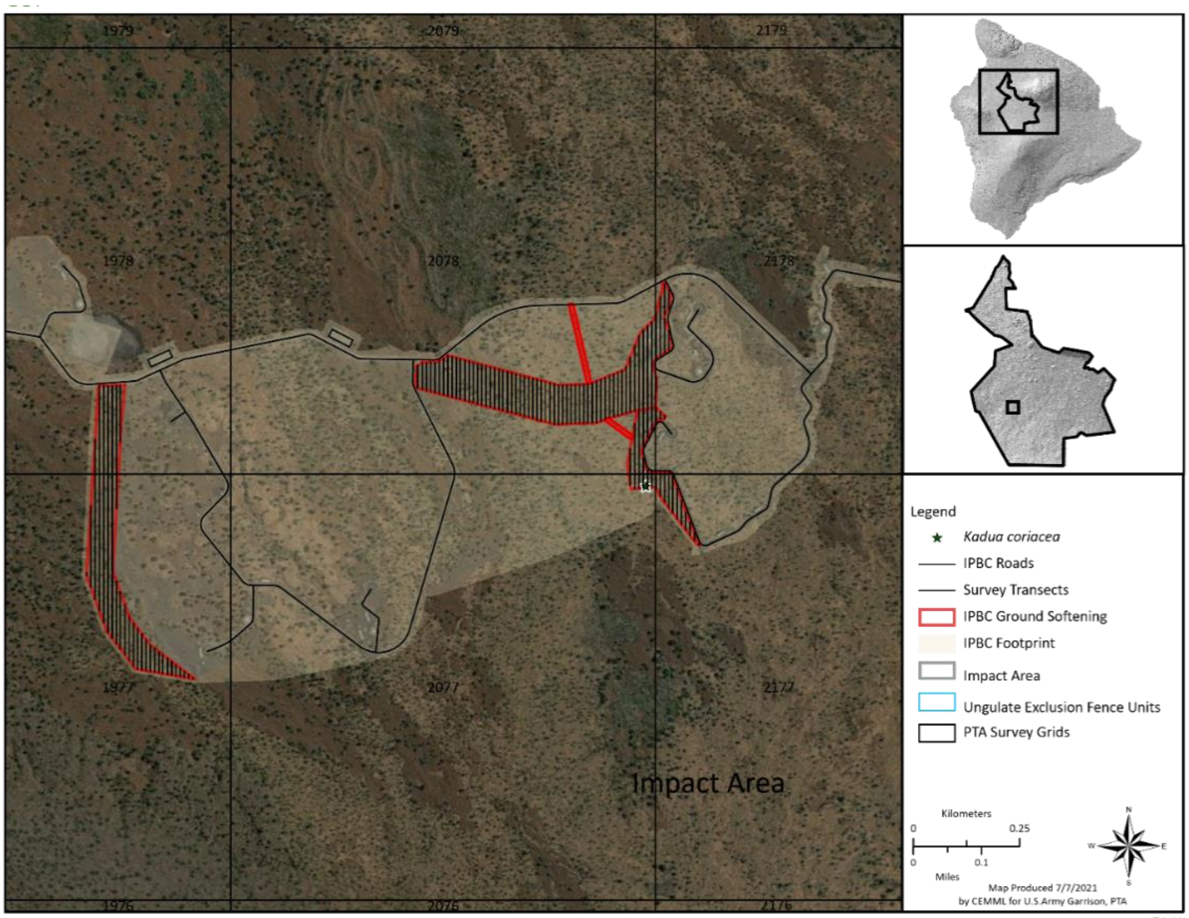

Figure 6. Infantry Platoon Battle Course ground softening area and location of *Kadua coriacea.*

<u>Surveys for *Tetramolopium* sp. 2 in Training Area 22</u>

In December 2019, an unknown plant was found in TA 22 (Figure 7). Based on plant growth and structure, the plant was thought to be a member of the *Tetramolopium* genus. Pictures of the plant were sent to several botanists around the state, but because no flowers were present on the single plant, it could not be accurately identified.

Figure 7. Unidentified plant species, possibly *Tetramolopium conyzoides.* The plant died before its identification could be confirmed.

The plant was visited in February 2020 with Joshua VandeMark, the Coordinator for the State of Hawaiʻi Plant Extinction Prevention Program. The plant still did not have flowers and we did not find additional plants after conducting a meander survey within 50 m of the plant. We collected leaves for possible genetic testing. The leaves were sent to Dr. Mathew Knope at the University of Hawaiʻi - Hilo in April 2020, but the leaves have not been tested to date due to the COVID-19 pandemic.

The plant was found dead in August 2020. We collected the plant and the soil beneath it. The plant was submitted to the Bishop Museum and keyed closest to the extinct species *Tetramolopium conyzoides.* The soil was taken to Hilo and Joshua VandeMark attempted to propagate any seed in the soil. To date, no *Tetramolopium* plants germinated. In April 2021, we surveyed an approximately 75-ha buffer around the *Tetramolopium* sp. location. Seven surveyors walked about 23 km to cover the area during a 2-day period. No new locations of the *Tetramolopium* sp. were discovered.

<u>Surveys for *Portulaca* Species at Sites Previously Occupied</u>

The identification of some species in the genus *Portulaca* are difficult to distinguish because there is significant overlap between some of the physical characteristics used to identify each species. Two such species are found at PTA – *P. sclerocarpa* and *P. villosa.* Both species are listed as endangered; therefore, correct identification of each species is critical for management. Because the physical characteristics overlap greatly between these species, we are collaborating with a team of scientists to investigate the genetic differences of the 2 species and the plants at PTA (see Section 2.4.6 for more information regarding the genetic work).

To support the genetic investigation and to confirm the current distribution of *Portulaca* species at PTA, we surveyed locations that were formerly occupied by *Portulaca* species at Puʻu Keʻekeʻe and Puʻu Nohona o Hae.

Portulaca was first reported from Puʻu Keʻekeʻe between 1994 and 1996 (Figure 8). The plants were identified as *P. villosa* and the population was estimated at fewer than 150 individuals. In 1998, 66 plants were recorded during monitoring. The plants were next monitored between 2009–2011 and no plants were found. Since this species was not listed as endangered until 2016, we did not monitor the plants after 2011.

In March 2021, 3 surveyors approximately 10 m apart canvased the formerly occupied locations on Puʻu Keʻekeʻe. Old flagging was located at some locations, but no plants were found.

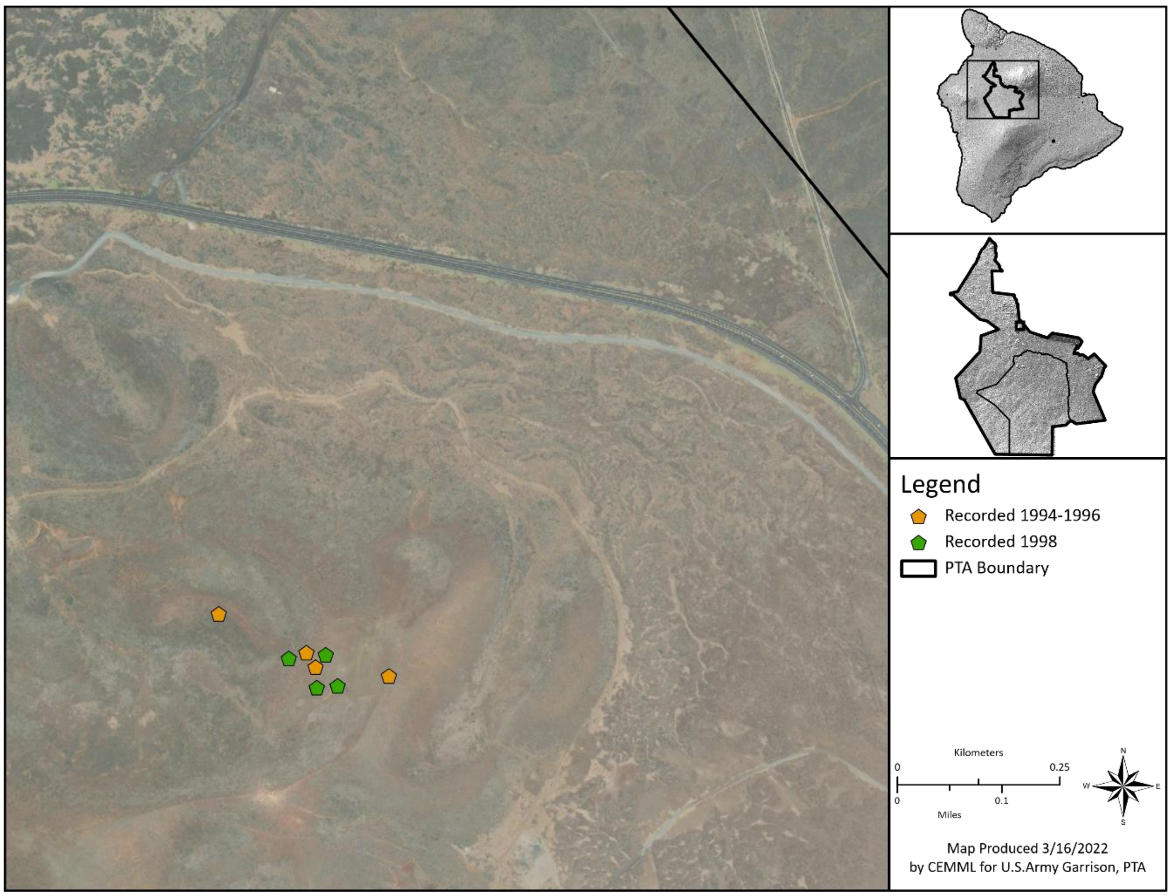

Figure 8. Location of plants identified as *Portulaca villosa* on Puʻu Keʻekeʻe.

Portulaca was first reported from Puʻu Nohona o Hae and Puʻu Pāpapa in 1983 (Figure 9). State biologists identified the plants as *P. sclerocarpa.* In 2002, plants were reported from Puʻu Nohona o Hae but were located 100 m from the location reported in 1983. In 2011, *Portulaca* was reported within 35 m of the 2002 locations, but the number of individuals was not reported. In 2010, 10–15 individuals were reported at the same location. However, surveys of the area in 2014 failed to detect the plants.

In March 2021, 3 surveyors approximately 10 m apart canvased the formerly occupied locations on Puʻu Nohona o Hae. Old flagging was located at locations discovered in 2002 and 2011, but no plants were found at these locations or at the location recorded in 1985.

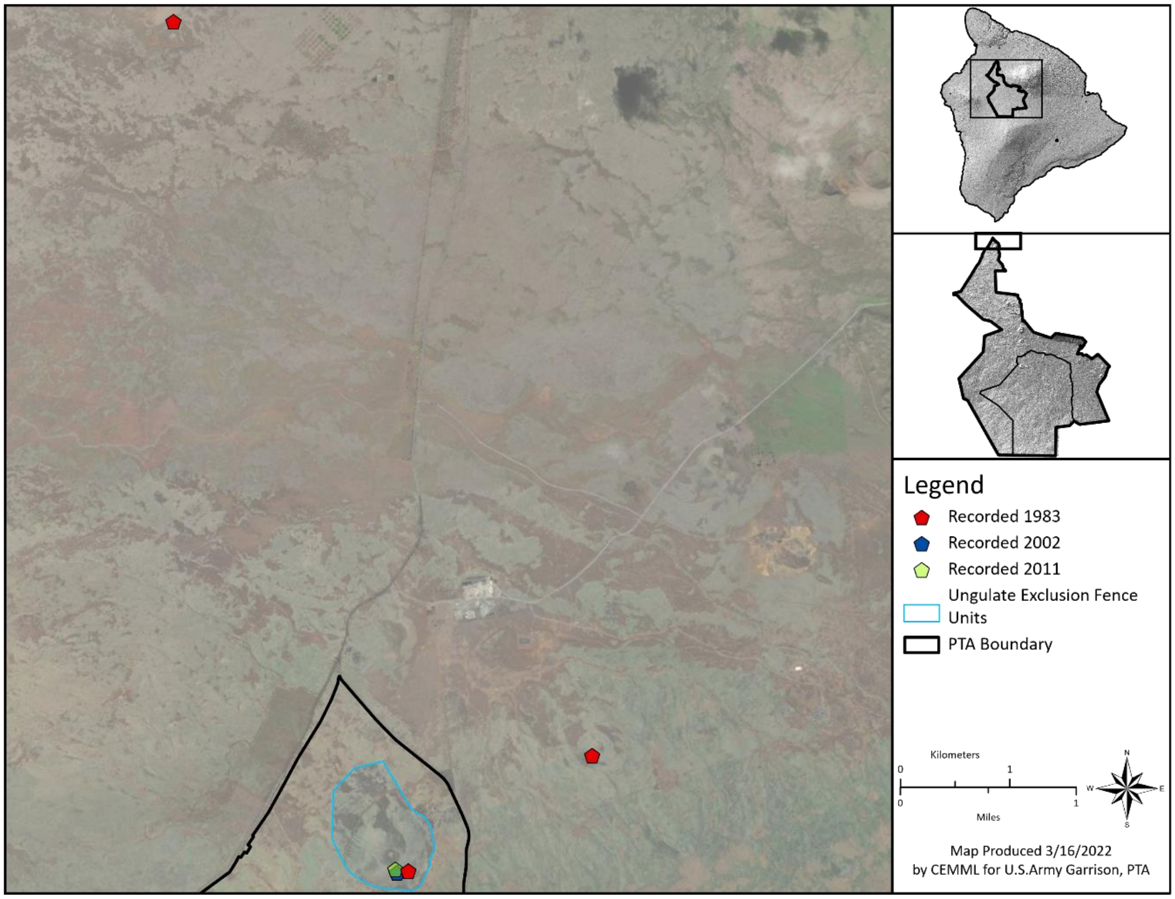

Figure 9. *Portulaca* locations recorded on Puʻu Nohona o Hae.

Discussion for Surveys for Portulaca species at historic sites

We did not locate any *Portulaca* during the surveys at Puʻu Keʻekeʻe and Puʻu Nohona o Hae. Ungulates at Puʻu Keʻekeʻe likely caused the extirpation of those individuals. The plants were last seen in 1998 and plants are unlikely to regenerate at this site due to the density of ungulates.

The historic locations at Puʻu Nohona o Hae are fenced and protected from feral ungulates. There may be a seedbank at the historic locations. We recommend periodic site visits of these locations to monitor for regeneration.

2.2.3 Plant Monitoring

Annual monitoring was a required conservation measure for most of the ESA-listed plant species at PTA (USFWS 2003a). To achieve these monitoring requirements, we implemented a multi-faceted approach including: 1) monitoring of Tier 1 species to track abundance, identify emerging threats, and investigate specific management needs, 2) estimating abundance of most Tier 2 species based on survey data, and 3) monitoring of known *Zanthoxylum hawaiiense* and select species-at-risk (SAR) locations. Together, these projects provided information about the status of the ESA-listed plant species. Investigating the status of ESA-listed plant populations and vegetation communities was essential for determining if selected management strategies helped foster favorable conditions to adequately to sustain each ESA-listed plant species. Monitoring actions met SOO Tasks 3.2(1)(d), INRMP objectives, and conservation measures in the 2003 BO.

Tier 1 Species Monitoring

Our monitoring objectives are to document changes in abundance and to identify emerging threats to implement management actions as appropriate. We monitor the following Tier 1 species quarterly: *A. peruvianum* var. *insulare, K. coriacea, L. venosa, N. ovata, P. sclerocarpa, P. villosa, Schiedea hawaiiensis*, *S. macrophyllus, S. incompletum, T. arenarium*, *T*. sp.1, and *V. o-wahuensis.* We use a similar but different monitoring method for *I. hosakae*, which is reported in Section 2.4.2. We did not monitor *Z. hawaiiense* quarterly.

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

Methods

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

Each monitoring period we visited each plot for each Tier 1 species. For data collected before July 2019, we recorded the proportion of total individuals in the plot by life stage in increments of 10%. In July 2019, we began recording the number of individuals in the plot by life stage. We counted all individuals up to 25 and assigned count classes when the number of individuals exceeded 25 (26–50, 51–100, and >101). When count classes were assigned, we used the minimum values of the count class as a proxy for abundance. This value is summed with counts from other plots to provide a total value for abundance.

From 2016 through September 2020, we aimed to monitor all known individuals of the Tier 1 species each calendar quarter (except *Z. hawaiiense*); monitoring efforts occasionally extended into the first few weeks of the following quarter. This mostly occurred in 2016 when plots were being established. For this report, if data collection extended into the next quarter, we grouped that data with the data from the previous quarter to ensure plots were not double counted in any quarter. In addition, in 2016 and 2017 the number of plots monitored each quarter sometimes changed due to several factors including removing plots due to dead plants, adding plots due to finding new live plants, and limited personnel resources. In 2018, we updated the methods to add/remove plots once per year to facilitate evaluating changes in plant number between the quarters.

Results

We monitored all Tier 1 species over 8 to 10 census periods between April 2016 and September 2020, except we did not monitor Tier 1 species between October 2017 and June 2018. Detailed monitoring results for each Tier 1 species are presented in the Species Summaries (Section 2.4).

We pooled the census data by life stage class for all monitoring plots for each species and derived the total number of Tier 1 individuals present between July and September 2020 (Table 8).

Table 8. Plant counts by life stage for Tier 1 species monitoring results, July–September 2020, summed for all plots.

Species	Total Number of Plants	Adults	Juveniles	Seedlings/ Gametophytes
Asplenium peruvianum var. *insulare*	906	217	497	192
Isodendrion hosakae	637	57	553	27
Kadua coriacea	150	146	4	0
Lipochaeta venosa	50	49	1	0
Neraudia ovata	56	53	3	0
Portulaca sclerocarpa	274	185	86	3
Portulaca villosa	11	9	2	0
Schiedea hawaiiensis	18	6	12	0
Sicyos macrophyllus	0	0	0	0
Solanum incompletum	99	82	17	0
Tetramolopium arenarium	307	225	82	0
Tetramolopium s.1	280	97	77	106
Vigna o-wahuensis	102	36	64	2

Sicyos macrophyllus

In February 2021, during a routine visit to the *Sicyos macrophyllus* fence unit, we discovered 3 young *S. macrophyllus* growing inside. *S. macrophyllus* was last recorded growing inside the fence in 2017. For more details see the species summary in Section 2.4.9.

Zanthoxylum hawaiiense

To update the distribution and abundance data for *Z. hawaiiense,* in March 2020 we revisited 575 previously documented locations and counted all individuals present. *Z. hawaiiense* individuals were tagged with a preprinted metal tag attached with copper wire around the base of the tree. We found 492 living trees and 140 recruits or seedlings. For more details see the species summary in Section 2.4.14.

Discussion

The seasonal monitoring of these extremely rare ESA-listed plants provided PTA-specific data related to plant abundance, population structure, plant establishment, the timing of phenological events such as seedling establishment, and qualitative evidence of plant damage from threats and stressors. Understanding patterns and timing of recruitment may be helpful in planning genetic conservation actions such as seed collection, timing of monitoring, and identifying bottlenecks in the population structure. The data also informed our understanding of the range of variability for these attributes, which supports interpretation of future monitoring results and understanding the ecology of the species at PTA. We tracked *in situ* reproduction for these species to better understand different reproductive strategies for each of the species and learned that observed reproduction is extremely limited for some species (e.g., *K. coriacea*). This data will help us identify gaps in our understanding of the basic biology of some of these species that is needed to better manage them.

Quarterly monitoring was designed to generally track individual ESA-listed plants by counting the number of plants present on plots each quarter. However, because the plants were not tagged, we could not always be accurate with counts, and we could not track individual plants through time. To gain a better understanding of population dynamics and life history of the Tier 1 species, we decided to implement a new monitoring approach.

In 2021, we began developing a new monitoring protocol for Tier 1 species and articulated new conservation management and monitoring objectives:

Conservation Management Objective 1: Abundance

For all Tier 1 species maintain or increase the number of juvenile and adult plants within ungulate exclusion fence units (both naturally occurring and outplanted individuals) and any other known occurrences on PTA between 2020 and 2025; document seedling recruitment; and manage threats to increase seedling survival and plant reproduction.

Conservation Monitoring Objective 1: Abundance

Count the number of adults, juveniles, and gametophytes or seedlings of each Tier 1 species within ungulate exclusion fence units, outplanting areas and any other known occurrences on PTA between 2020 and 2025. The following objectives will support abundance objectives:

Conservation Monitoring Objective 1A:

One hundred percent survey, approximately every 5 years, to count and record location data for known individuals and new plants, by life stage, within each species population footprint and a surrounding buffer area to record additional individuals in proximity to known occurrences. This will refresh the distribution map for each species.

Conservation Monitoring Objective 1B:

Revisit/monitor all known plant locations and count individuals by life stage class yearly. This will provide status and trends for population size, age structure, and life stage structure for each species. The focus is on known/tagged juvenile and adult plants at specific locations; seedlings (these are not tagged) will also be counted (up to 25 individuals, then classed as ">25") within 5.6 m of each occurrence (100-m^2 plot). Record (all life stages) and tag (adults and juvenile stages only) any incidental finds for Tier 1 species.

Conservation Management Objective 2: Extent

Maintain or increase the geographic distribution of each Tier 1 species within ungulate exclusion fence units (native and outplanting sites) and any other known occurrences on PTA between 2020 and 2025. Report results in a variety of ways, including by fence unit and by USFWS reporting unit.

Conservation Monitoring Objective 2: Extent

Delineate geographic distribution of each Tier 1 species within ungulate exclusion fence units and any other known locations on PTA approximately every 5 years using data from the 100% surveys (see conservation monitoring objective 1A above).

We anticipate implementing the new Tier 1 monitoring protocol in early FY 2022. By implementing the new monitoring protocol, we will be better able to track population trends and distribution over time for Tier 1 species, which are extremely rare. Data on locations, numbers, population structure, habitat quality, stressors affecting the survival of mature plants, and plant recruitment is important for designing management actions to meet NEPA and ESA commitments and requirements.

2.2.4 Plant Species at Risk (SAR)

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 SAR.

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.

Twenty-seven plant species meet the DoD criteria to be classified as a SAR (Table 9). Although accurate population estimates are not available for PTA or the state for many of the species, many of the SAR species are encountered frequently at PTA (e.g., *Bidens menziesii* spp. *filiformis, Chamaesyce olowaluana, Tetramolopium consanguineum*). However, other species are relatively uncommon. To gain a better understanding of some SAR believed to be uncommon at PTA, we selected a subset of species to monitor. We selected species based on the following criteria: 1) long-lived, 2) less than 200 historic locations at PTA, and 3) locations co-located in vegetation communities with *Z. hawaiiense* (so that we could check the SAR while monitoring *Z. hawaiiense*). Four species met the criteria: *Alphitonia ponderosa, Exocarpos menziesii, Melicope hawaiiensis*, and *Pittosporum terminalioides.*

Monitoring Methods

While monitoring for *Z. hawaiiense,* we concurrently revisited all historic locations of *A. ponderosa, E. gaudichaudii, M. hawaiensis*, and *P. terminalioides.* SARs were not tagged, but pink flagging was used to assist with finding the plant locations in the future.

Monitoring Results

Between July and December 2020, we visited the 320 documented historical locations of 4 target SAR to complete the monitoring. We also recorded additional locations for all species (Table 10 and Figure 10). For all species there was a decrease in the number of historic locations occupied, which we assume corresponds to a reduction in both the area occupied by the species and the number of individuals. While most species declined slightly, *P. terminalioides* showed the largest decrease (67%) from 112 occupied locations to only 37 occupied locations. However, this reduction was buffered by finding new locations of *P. terminalioides* during the field surveys and the observed number of recruits.

Table 9. Species found at Pōhakuloa Training Area that meet the Department of Defense criteria as species at risk.

Scientific Name	Common Name	Origin	Nature Serve	IUCN	HI SCI	PTA Total	State Total
Alphitonia ponderosa	Kauila	End	G2	VU	Y	61	2,500
Argemone glauca	Smooth Prickly-poppy	End	G2	--	N	--	--
Bidens menziesii ssp. *filiformis*	Mauna Loa beggartick	End[a]	G2T2	--	N	--	--
Carex wahuensis ssp. *wahuensis*	Oʻahu sedge	End	G3T2	--	N	--	--
Chamaesyce olowaluana	Alpine sandmat	End	G2	NT	N	--	10,000
Cystopteris douglasii	Douglas' bladderfern	End	G2	--	Y	--	<5,000
Dubautia arborea	Mauna Kea dubautia	End[a]	G1	EN	Y	1	--
Dubautia scabra ssp. *scabra*	Rough dubautia	End	G3T2	--	N	--	--
Eragrostis deflexa	Pacific lovegrass	End	G2	--	Y	3,503	2,000
Eragrostis leptophylla	Mountain lovegrass	End	G2G3	--	N	--	--
Exocarpos gaudichaudii	Gaudichaud's exocarpus	End	G1	EN	Y	42	300
Ipomoea tuboides	Hawaii morning glory	End	G2	--	Y	--	1,000+
Korthalsella latissima	Mistletoe	End	G2G3	--	N	--	--
Melanthera subcordata	Grassland nehe	End	G2	--	N	--	--
Melicope hawaiensis	Manena	End	G2	VU	Y	60	100+
Panicum konaense	Kona panicgrass	End	G2G3	--	N	--	--
Panicum pellitum	Collie panicgrass	End	G2G3	--	N	--	--
Phytolacca sandwicensis	Hawaiian pokeberry	End	G2	--	Y	--	500
Pittosporum terminalioides	Cream cheesewood	End	G2	VU	Y	40	24+
Rumex giganteus	Climbing dock	End	G2G3	--	N	--	--
Rumex skottsbergii	Lava dock	End	G2	--	N	--	--
Santalum ellipticum	Coast sandalwood	End	G2G3	--	Y	--	--
Santalum paniculatum var. *pilgeri*	Sandalwood	End	G3T2	--	N	--	--
Sicyos anunu	Lava bur cucumber	End	G2	--	N	--	--
Sicyos lasiocephalus	Hualalai bur cucumber	End	G2	--	N	--	5,000
Tetramolopium consanguineum	Narrow-leaf pamakani	End	G1	--	Y	--	10,000
Trisetum glomeratum	Mountain Pili	End	G2G3	--	N	--	--

End, endemic to the State of Hawaiʻi.

NatureServe ranks: G1, critically imperiled; G2, imperiled; G3, vulnerable; T1, imperiled subspecies; G#G#, exact status of a taxon is uncertain. Source: https://explorer.natureserve.org/

IUCN, International Union for the Conservation of Nature ranks: EN, endangered; NT, near threatened; VU, vulnerable. Source: https://www.iucnredlist.org/

HI SCI, Hawaiʻi State Species of Conservation Interest: Y, yes; N, No. Source: https://laukahi.org/wpcontent/uploads/2021 /06/ SCI_Hawaii.pdf

PTA, Pōhakuloa Training Area.

[a] Endemic to Hawaiʻi Island.

Table 10. Species at risk survey results for 2020.

Species	Historic Locations (Loc)			New Locations			Total Adults / Juveniles (Recruits)
	Loc Occupied (Loc Checked)	Adults / Juveniles	Recruits[a] (Loc)	Loc Found	Adults / Juveniles	Recruits (Loc)	
Alphitonia ponderosa	58 (72)	59	30 (9)	2	2	0 (0)	**61 (30)**
Exocarpos gaudichaudii	40 (62)	40	1 (1)	2	2	0 (0)	**42 (1)**
Melicope hawaiensis	56 (75)	57	5 (3)	3	3	0 (0)	**60 (5)**
Pittosporum terminalioides	19 (112)	21	78 (12)	19	19	63 (6)	**40 (141)**
Total	**173 (321)**	**177**	**114 (25)**	**26**	**26**	**63 (6)**	**203 (177)**

[a] Recruits includes all plants less than 1 meter in height. We counted these individuals separately to account for the potential for high mortality in younger life stage classes.

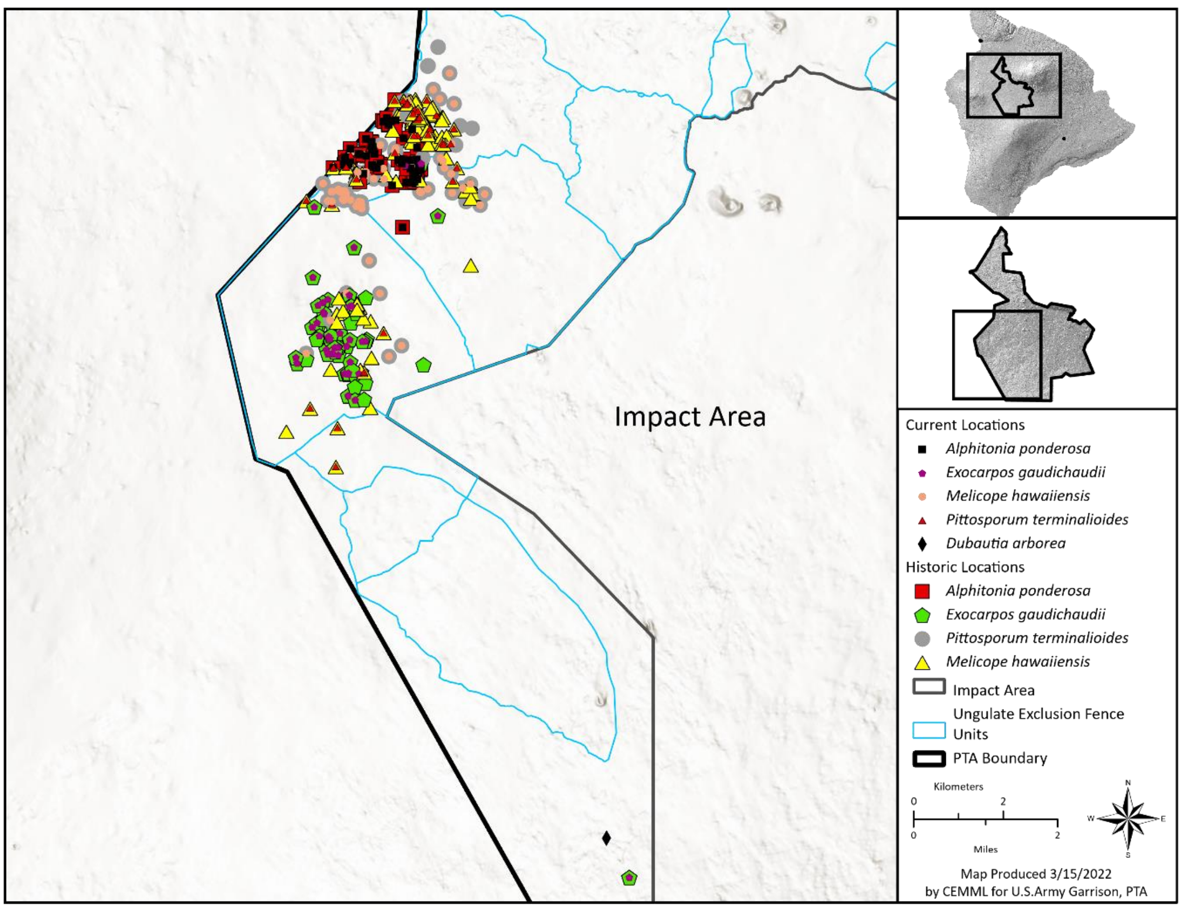

Figure 10. Species at risk locations monitored in 2020.

Dubautia arborea

Dubautia arborea is a SAR with few known individuals at PTA. The first plant was discovered in 1998 in the remote, southern reaches of TA 23. At the time of discovery, the plant was growing about 5 m up entwined with *Myoporum sandwicense* and had a single thick trunk. A second plant was found in TA 18 around 2006. Around the same time, flowers and seeds were collected from both plants. Flowers and seeds were given to Dr. Robert Robichaux, University of Arizona, and he confirmed that the plant in TA 23 was *D. arborea* and that the plant in TA 18 was likely a *D. arborea / linearis* hybrid. In 2013, another *D. arborea* was discovered during the first rare plant survey cycle within the Kīpuka ʻAlalā South fence. This individual was confirmed alive in 2019 during plant surveys.

In August 2021, we visited the individual located outside the fence in southern TA 23 and confirmed that the plant is still alive (Figure 11). It had fallen and the 2 main branches continued to grow despite evidence of browse where animals could reach new shoots. One branch remained entwined with a young *M. sandwicense* growing to more than 3 m in height. We collected seeds during the visit. We recommend fencing this individual to prevent further browse and damage from feral ungulates. In 2022, we plan to revisit the plant inside TA 18, which is now within the *Solanum incompletum* fence.

Discussion

Identifying and proactively managing SAR can help to minimize future listing of species under the ESA. Avoiding species listings can increase installation and mission resilience by minimizing regulatory burden and training restrictions related to TES management. Threats to plant SAR populations include habitat loss and degradation, predation by non-native animals (e.g., feral ungulates and rodents), wildland fire, extreme weather events (e.g., drought), land development, military activities, and invasive species. A changing climate will likely exacerbate invasive plant competition, wildland fire risk, and drought stress.

The analysis to identify SAR was a critical first step in identifying these species at PTA and to evaluate management needs to help maintain the overall biodiversity and health of the ecosystem. On-going management, consistent with the INRMP, includes fencing, removing introduced feral ungulates, controlling non-native predators, and managing fuels. These actions help prevent SAR losses due to direct threats such as fire or herbivory by introduced ungulates. They also increase resilience by reducing stressors from predators, invasive species, and other resource competition. Protecting species and their habitats will provide many ecosystem benefits to the installation for years to come.

This work with SAR lead to 2 publications in 2020. An article was published in the U.S. Army Garrison, Hawaii Ecosystem Management Bulletin and detailed the status and nascent recovery of *P. terminalioides* within the ungulate exclusion fences (USAG-HI 2020). In addition, an article was published in the DoD Natural Resources Program national newsletter – Natural Selections – regarding the SAR analysis and on-going management at PTA (DoD 2020). These publications not only highlight the excellent conservation work occurring at PTA but also serve as examples for other land managers and agencies.

Figure 11. *Dubautia arborea* located in the remote, unfenced southern portion of Training Area 23. The fallen trunk (foreground) splits and 1 branch extends toward the orange backpack and the other toward the green backpack (Panel A). Resprouting along a main trunk (Panel B). Flowers and seeds (Panels C and D, respectively). Main branches reach over 3 m in height (Panels E and F).

To continue with SAR management at PTA, we recommend continued monitoring of *A. ponderosa, E. gaudichaudii, M. hawaiensis*, and *P. terminalioides* as time permits and funding allows. These species appear to be fairly limited in distribution and abundance at PTA and state-wide. Existing landscape level management may be sufficient to allow these species to passively recover as appears to be occurring with *P. terminalioides.*

For the other species that meet the SAR criteria at PTA we recommend using information collected during plant surveys between 2011 and 2019 to generate coarse species distribution maps. The distribution information can be used to include these SAR species in the Tier 2 monitoring protocol to collect preliminary abundance information. Lastly, we recommend that information regarding SAR distribution and abundance be transferred to appropriate (i.e., Army-approved) national databases such as NatureServe so that the status of these species can be more accurately evaluated.

2.2.5 Vegetation Community Monitoring

Under the current SOO, there is no explicit requirement to monitor vegetation communities or dynamics and we have not implemented regular vegetation community monitoring. We have worked collaboratively with researchers to support research projects aimed at better understanding vegetation community dynamics. During the reporting period we collaborated with researchers from the University of Hawaiʻi at Hilo under a grant from the DoD Legacy Resource Management Program.

Post-wildfire plant regeneration in arid ecosystems: Overcoming biotic and abiotic soil limitations (Project # 16-831).

The study investigated biotic and abiotic factors in the soil that may prevent regeneration of the native tree *Sophora chrysophylla* (māmane). This tree is a keystone species in dry forest ecosystems in Hawaii and is the sole food source for the endangered Hawaiian honeycreeper, Palila (*Loxioides bailleui*). Critical habitat for this species occurs within the northeast portion of PTA and *S. chrysophylla* is considered a primary constituent of the habitat. There are many threats to *S. chrysophylla,* such as browse by feral ungulates, wildland fire, competition for invasive plants, and sometimes trees fail to regenerate after disturbances such as wildland fire.

A conservation measure from the 2003 BO was to investigate factors that limit the regeneration of *S. chrysophylla*. Therefore, we collaborated with researchers from the University of Hawaii and the US Forest Service to investigate biotic and abiotic factors in the soil that may be limiting regeneration.

Previous research studies were unable to stimulate *S. chrysophylla* germination at the study sites despite watering, fertilizing, seed scarification, and protection from ungulate browse. Therefore, to test for germination, the team added scarified seeds to the soil then implemented treatments with fertilizer and a micro-organism, *Rhizobium,* known to promote germination and survival of *S. chrysophylla.* Test units were located in areas that had previously burned and areas not burned to address potential impacts of increased anthropogenic fire on germination.

The team found that 1) there were no treatment effects on survival; 2) basal diameter growth was highest in the fertilizer treatments; 3) fertilizer plus *Rhizobium* also increased basal diameter growth and these effects were more pronounced in the burned site; and 4) trees were taller at the burned site but there was no impact of the treatment on height.

The team concluded that wildfire does not seem to negatively affect *S. chrysophylla* regeneration. While nutrient availability appears to be a limiting factor, *Rhizobium* does not. The researchers suggest that low *S. chrysophylla* regeneration is linked to other soil characteristics and that further studies on water-holding capacity and microbial communities are recommended.

2.2.6 Plant Surveys and Monitoring Discussion

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

For Tier 1 monitoring, we collected quarterly count data from which we can accurately track population patterns and status. We used this information to develop the new Tier 1 protocol in FY 2021, which we expect to implement in early FY 2022. The new Tier 1 monitoring methods will allow us to track abundance more efficiently and precisely for all Tier 1 species at PTA and potentially model future population status.

We are developing a new monitoring protocol for the Tier 2 species based on sampling a random selection of macroplots occupied by each Tier 2 species. The aim will be to survey all occupied macroplots for each Tier 2 species over a 5-year period thus also refreshing the species distribution data at PTA. We anticipate completing and implementing the Tier 2 species monitoring protocol in FY 2022-2023.

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 (i.e., ungulate removal) and natural 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, to increase the distribution and abundance of the ESA-listed plant species. Genetic conservation and outplanting to increase species distribution and abundance are conservation measures identified in the 2003 and 2013 BOs for 13 of the ESA-listed plant species at PTA (USFWS 2003a, USFWS 2013a). In addition, our 2020 PTA recovery permit (TE40123A-3) authorizes genetic conservation and outplanting actions for the 20 ESA-listed species at PTA. Several INRMP objectives for genetic conservation overlap with the BO conservation measures and permitted activities.

To achieve these requirements and objectives, we implement projects under SOO tasks 3.2(1)(e) and 3.2(1)(f) 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 genetics we track the provenance of the collected propagules through collection, storage, propagation, and outplanting. In this report, we refer to the plant that propagules are collected from as the “founder”. Monitoring is essential to track success of plantings as well as to track the genetic representation of founders by species at each outplanting site.

We are adopting new data management standards for the tracking and monitoring of plants in the Rare Plant Propagation Facility (RPPF), at outplanting sites, and for naturally occurring plants at PTA. Measures are taken to ensure improved tracking and monitoring to include adopting new naming conventions. For the new naming convention, we will assign a unique number to every Tier 1 plant. Each plant will be tagged with the number and an associated bar code. This naming convention will be applied throughout the Botanical Program to maintain consistency in the monitoring of natural and outplanted plants.

We drafted a 5-year outplanting plan for Army review and approval per Army Regulation 200-1. In July 2021 we submitted the plan to USAG-P for review and approval before sending the plan to Installation Management Command Headquarters for final approval. 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.

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 impacted by military construction projects, preserve genetic variability via propagule collection and propagate plants for outplanting.

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

<u>Genetic Conservation and Outplanting Strategy</u>

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 (pending approval) details new 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 11). 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 of its distribution, 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 11. 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)	*Silene lanceolata* (E)
Exocarpos menziesii (E)	*Spermolepis hawaiiensis* (E)
Festuca hawaiiensis (E)	*Stenogyne angustifolia* (E)
Haplostachys haplostachya (E)	*Zanthoxylum hawaiiense* (E)
Silene hawaiiensis (T)	

E, Endangered; T, Threatened

Between 2002 and 2014 we established 20 outplanting sites (also referred to as ASRs), 15 at PTA and 5 on lands under the jurisdiction of Hawaiʻi County or the State of Hawaiʻi, i.e., outside the PTA installation boundary (Table 12 and Figure 12). We mostly planted at sites off PTA because fenced, ungulate-free areas were not available on the installation. In 2019, following animal removal from the fence units, we established 9 additional outplanting sites at PTA.

Table 12. Outplanting sites established between 2004 and 2020.

Site Number	Location in Relationship to PTA
201	Offsite
202	Offsite
203	Offsite
204	Offsite
205	Offsite
206	Onsite
207	Onsite
208	Onsite
209	Onsite
210	Onsite
211	Onsite
212	Onsite
213	Onsite
214	Onsite
215	Onsite
216	Onsite
217	Offsite
218	Onsite
219	Onsite
220	Onsite
Temp 2019-001	Onsite
Temp 2019-002	Onsite
Temp 2019-003	Onsite
Temp 2019-004	Onsite
Temp 2019-005	Onsite
Temp 2019-006	Onsite
Temp 2019-007	Onsite
Temp 2019-008	Onsite
Temp 2019-009	Onsite

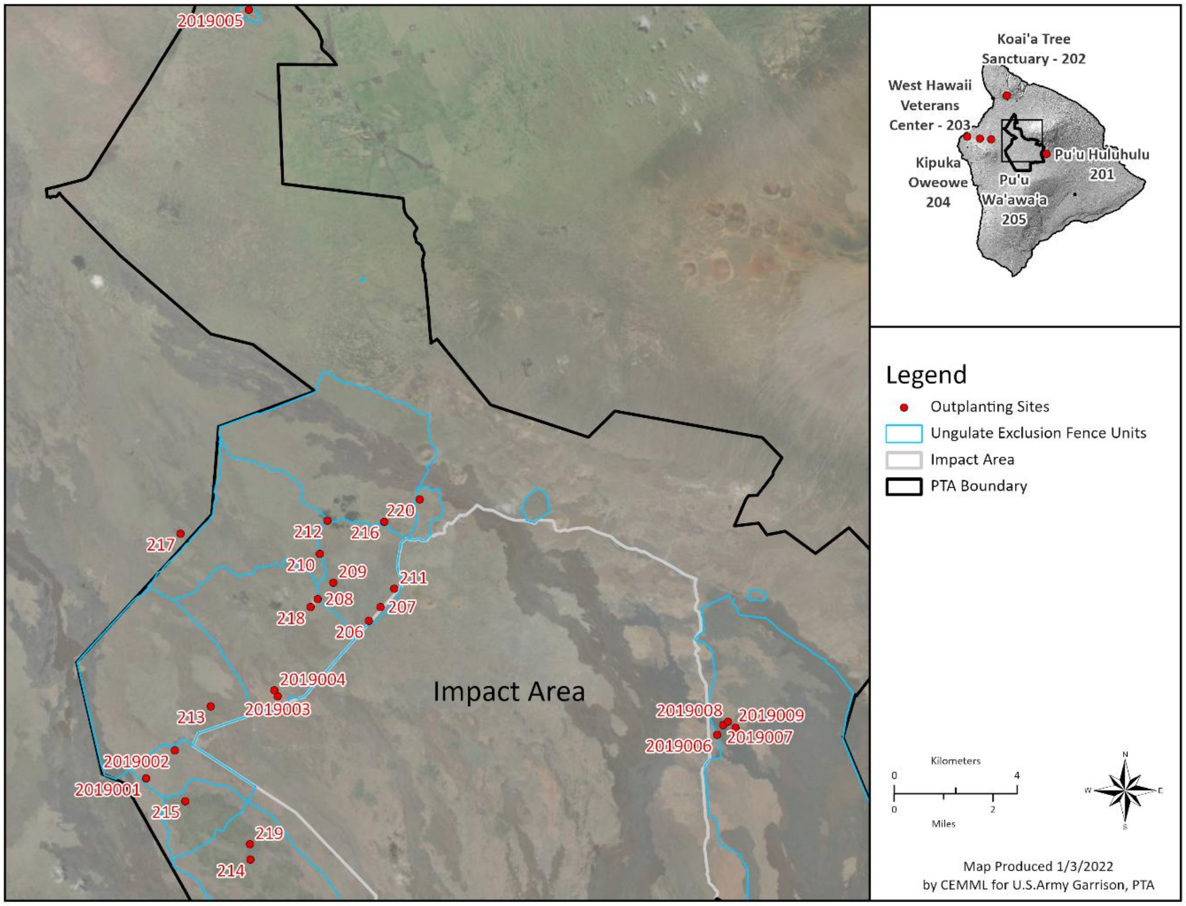

Figure 12. Location of outplanting sites on and off Pōhakuloa Training Area[a].

[a] The temporary outplanting site names are abbreviated to the year/site number (e.g., 2019001).

Per the 5-year outplanting plan submitted to the Army in 2021, we plan to focus outplanting sites on Army-controlled lands at PTA. With the goal of establishing self-sustaining populations of ESA-listed plant species 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 2022.

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)(e) and that address INRMP objectives and conservation measures as required by the 2003 and 2013 BOs. Through seed and propagule collection and storage, we strive to maintain genetic representation of each species in propagule banks (i.e., *ex situ* storage facilities) and to propagate and outplant species in accordance with the *Genetic Conservation and Outplanting Plan* (CEMML 2017). Please refer to Table 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' genetics. Unlike living plant collections, plant material stored in propagule banks is not susceptible to the extreme variability of biotic and abiotic factors. We plan to maintain *ex situ* collections in a primary, on-site propagule bank and in a secondary, off-site propagule bank. The primary propagule bank provides easy access to test seed viability and to propagate plants for outplanting. We plan to establish a secondary off-site propagule bank to serve as an additional safeguard.

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

<u>Propagule Collection Methods</u>

We systematically collect propagules to meet propagation and *ex situ* storage needs in accordance with 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 Hawai'i 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, we use the USFWS source population areas as discrete collection units (Figure 13). However, these source population areas do not necessarily imply biological meaning or genetically distinct populations of rare plants within PTA; they are a tool for obtaining a comprehensive genetic representation throughout the species' distribution at PTA.

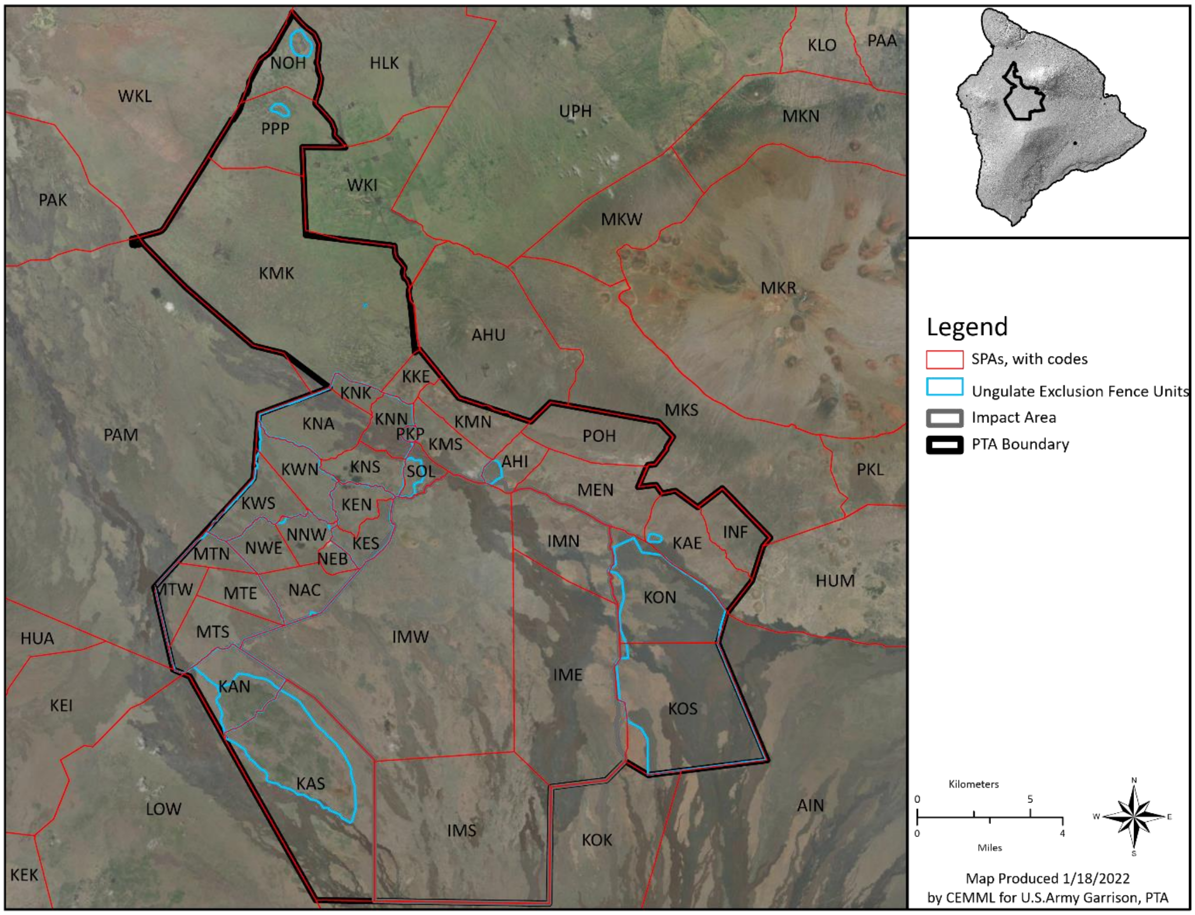

Figure 13. US Fish and Wildlife Service population reference areas (SPAs) to guide propagule collection from plants listed under the Endangered Species Act and planting site selection at Pōhakuloa Training Area.

To further track plant/founder locations, we assign a collection site number[8], which includes the collection site information and founder plant designation. This information is tracked in a database.

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

Seed collection is prioritized by species abundance, level of natural recruitment, and current representation in storage. Because fruit set is highly variable at PTA, we plan frequent, but less intensive, harvests over multiple years as recommended in the peer-reviewed literature (Brown and Briggs 1991; Brown and Marshall 1995; Guerrant et al. 2004). Leaving sufficient material to maintain the natural seed bank is extremely important in sustaining *in situ* population numbers and genetic variability. We aim to collect, where possible, from at least 50 founders from each source population area at PTA as defined by the USFWS (Figure 13.) However, these source population areas do not necessarily imply biological meaning or genetically distinct populations of rare plants within PTA; they are a tool for obtaining a comprehensive genetic representation throughout the species' distribution at PTA.

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

We limit collections per conditions of the PTA Recovery Permit (TE40123A-3). We place the collected seeds or fruits in a labeled coin envelope, which is placed in a sealed plastic bag for transport to the office. Other propagules are transported to the office in appropriate containers following collection.

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

Propagule Storage Methods

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

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

Propagule Collection and Storage Results

We collected propagules from seeds/spores and/or fruit from 5 ESA-listed species (Table 13). We collected 35 seeds from a single *Zanthoxylum hawaiiense* (Table 13). The seeds were transferred and accessioned to the USAG-HI NRP seed lab for storage (accession number A200806001).

Table 13. Summary record of propagule collections of plant species listed under the Endangered Species Act at Pōhakuloa Training Area, October 2019 through September 2021.

Species	Type Collected	Total No. Founders	Total Amount Collected	Disposition
Exocarpos menziesii	Seed	Bulk	47	Propagation
Portulaca sclerocarpa	Fruit	2	4	Storage
Sicyos macrophyllus	Fruit	1	7	Propagation
Sicyos macrophyllus	Fruit	1	31	Propagation/Storage[a]
Stenogyne angustifolia	Seed	1	3	Propagation/Storage[a]
Zanthoxylum hawaiiense	Seed	1	35	Storage[b]

[a] Seeds are in short-term storage and will likely be propagated in the near-term without being sent to the long-term, *ex situ* storage
[b] *Zanthoxylum hawaiiense* seeds were transferred to the seed lab at the US Army Garrison-Hawai'i, Natural Resources Program, accession number A200806001.

To support a genetic study of *P. sclerocarpa* and *P. villosa*, we collected leaves and cuttings from a total of 24 wild *P. sclerocarpa* founders and 5 wild *P. villosa* founders (Table 14). For *P. sclerocarpa*, voucher cuttings were collected from a total of 14 wild founders and leaves were collected from 13 of these 14 founders. Leaves only were collected from an additional 10 wild *P. sclerocarpa* founders. For *P. villosa,* voucher cuttings were collected from 2 founders (1 from each location). In 2020, 5 leaves were collected from 1 founder at each *P. villosa* location. In 2021, per a request from the lab conducting the genetic analysis, we collected an additional 3 leaves from each of 4 founders at one location and 4 leaves from 1 founder at the other *P. villosa* location. See the species summaries in Section 2.4 for collection details.

Table 14. Summary record of leaves and cutting collections of plant species listed under the Endangered Species Act at Pōhakuloa Training Area, October 2019 through September 2021

Species	Type Collected	Total No. Founders	Total Amount Collected	Disposition[a]
Portulaca sclerocarpa	Leaves	23	105	Genetic testing
	Cutting	14	14	Voucher
Portulaca villosa	Leaves	5	21	Genetic testing
	Cutting	2	2	Voucher

[a] Leaves were submitted to Dr. Clifford Morden at the University of Hawai'i at Mānoa for genetic testing. Vouchers were pressed and sent to the Bishop Museum herbarium for disposition.

Propagule Collection and Storage Discussion

Propagule collections were limited in 2020 and 2021 primarily due to reorganization of the genetic conservation project.

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

We continue to improve current information systems to improve tracking propagules from collection through storage and propagation to outplanting. We reconciled several different propagule number systems and can more accurately count the number of propagules in storage at PTA by founder and type (Table 15). However, inconsistencies remain, and we plan to continue to reconcile the multiple naming conventions to improve data accuracy so that we can evaluate if adequate founders and propagules are represented in storage and when accessions need to be refreshed.

Table 15. Summary of propagules in *ex situ* storage at Pōhakuloa Training Area as of 31 July 2021.

Species	Source	Propagule Type	Total by Propagule Type
Asplenium peruvianum var. *insulare*	Field/Natural Population	Spore	1
	Field/Natural Population	Blade	119
	Rare Plant Propagation Facility	Blade	492
Exocarpos menziesii	Field/Natural Population	Fruit	677
Festuca hawaiiensis	Field/Natural Population	Seed	184
	Rare Plant Propagation Facility	Seed	198
	Outplanted Population	Seed	47
Haplostachys haplostachya	Field/Natural Population	Fruit	9,289
	Field/Natural Population	Seed	41,850
	Rare Plant Propagation Facility	Fruit	25,504
	Rare Plant Propagation Facility	Seed	11,768
Isodendrion hosakae	Field/Natural Population	Seed	1,985
Kadua coriacea	Field/Natural Population	Seed	103,331
	Rare Plant Propagation Facility	Seed	280
Lipochaeta venosa	Field/Natural Population	Seed	20
	Rare Plant Propagation Facility	Seed	42
Neraudia ovata	Field/Natural Population	Seed	6,130
	Field/Natural Population	Cutting	148
	Rare Plant Propagation Facility	Seed	236,474
Portulaca sclerocarpa	Field/Natural Population	Fruit	610
	Field/Natural Population	Seed	32,761
	Rare Plant Propagation Facility	Fruit	8,734

Table 15. Summary of propagules in *ex situ* storage at Pōhakuloa Training Area as of 31 July 2021 (cont.).

Species	Source	Propagule Type	Total by Propagule Type
Portulaca villosa	Field/Natural Population	Seed	4,833
Schiedea hawaiiensis	Field/Natural Population	Seed	315
	Rare Plant Propagation Facility	Seed	331,418
Sicyos macrophyllus	Field/Natural Population	Seed	31[a]
Silene hawaiiensis	Field/Natural Population	Seed	11,425
	Rare Plant Propagation Facility	Seed	28,520
Silene lanceolata	Field/Natural Population	Seed	473,988
	Rare Plant Propagation Facility	Seed	1,043,321
	Outplanted Population	Seed	26,430
Solanum incompletum	Field/Natural Population	Fruit	2,517
	Field/Natural Population	Seed	3,390
	Rare Plant Propagation Facility	Fruit	8,363
	Rare Plant Propagation Facility	Seed	3,672
	Outplanted Population	Fruit	21
Spermolepis hawaiiensis	Field/Natural Population	Seed	3,096
	Rare Plant Propagation Facility	Seed	506,320
	Outplanted Population	Seed	5,039
Stenogyne angustifolia	Field/Natural Population	Seed	2,178
	Rare Plant Propagation Facility	Seed	1,926
	Outplanted Population	Seed	119
Tetramolopium arenarium	Field/Natural Population	Seed	71,916
	Rare Plant Propagation Facility	Seed	3,932
	Outplanted Population	Seed	8,318
Tetramolopium sp1	Field/Natural Population	Seed	19,316
	Rare Plant Propagation Facility	Seed	99,497
	Outplanted Population	Seed	65,838
Vigna o-wahuensis	Field/Natural Population	Seed	3,356
	Rare Plant Propagation Facility	Seed	32,399
Zanthoxylum hawaiiense	Field/Natural Population	Seed	5,706

[a] The total number of accessioned seeds for *Sicyos macrophyllus* does not include the seeds collected in February 2021 because these seeds were propagated.

In 2022, we plan to refine our collection goals for each species, refine the process to track progress toward stated targets, inventory the physical seeds in storage, rectify issues with founder numbers, evaluate the viability of the older accessions, and determine which collections need to be refreshed, especially for Tier 1 species. We plan to work closely with the US Army Garrison-Hawaiʻi Natural Resources Program on Oʻahu to test seed viability and dormancy and to curate a second *ex situ* storage collection.

Collections for Portulaca Genetic Testing

See *Section 2.4.6 Portulaca sclerocarpa* for a discussion of genetic testing on Portulaca samples.

2.3.3 Propagation

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

Propagation Strategy and Methods

For propagation, we withdraw a predetermined number of seed 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.

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 wet sand, paper towels, and various combinations of perlite, vermiculite, cinder and peat. After use, media is discarded and not re-used.

Sown seed trays are kept 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 in the RPPF.

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

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

In April 2021, we purchased a seed gemination chamber, which 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. Improved germination success is especially valuable if seed is limited and can ease seed collection efforts and potentially inform outplanting site selection.

Propagation Methods

Data collected for propagation includes species, founder, date collected, date planted, media utilized, number of seeds used, treatments used to promote germination, and the date and number of seeds germinated. We have not yet 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.

Historical germination and propagation information is stored on data sheets and is not stored electronically. We plan to move data management to a database in 2022.

Propagation Results

No ESA-listed plants were germinated from cuttings and no common native plants were germinated from seed or cuttings during the reporting period.

We attempted to propagate 7 seeds from *S. macrophyllus.* In February 2021, 7 *S. macrophyllus* fruits were collected with the intention of directly propagating the fruit. Although 3 young plants were observed at the location in February, none of the plants were mature; therefore, the seeds collected were likely from the plant that previously occupied the site in 2017.

All 7 fruits were processed similarly, as described below. We did not score or remove the seed coat. No additional desiccation or treatments occurred other than listed below.

In February 2021, 4 seeds were dehusked from their woody fruits. The woody husk surrounding these seeds was softer and slightly more decomposed, suggesting that these fruits may have been older than the other 3 fruits collected at the same time. Moreover, the seeds, once removed, were slightly more sickle-shaped possibly due to a longer period of aging within the fruit.

The remaining 3 seeds were dehusked in May 2021 following a method used by Hawaiʻi Volcanoes National Park to remove the tough woody fruit husk without damaging the seed inside (Pratt 2010).

In May 2021, all 7 seeds were soaked in a 400 PPM solution of GA3 per advice from the USAG-HI NRP (T. Chambers, personal communication, 17 November 2020). When we put the seeds in the solution, 1 orbital and 4 sickle-shaped seeds immediately sank, and 2 orbital seeds floated. The seeds remained in this solution for 24 hours and then were removed. At some point during the soak, the remaining 2 orbital seeds sank. Three of the sickle-shaped seeds took on an orange hue during the soak.

On the same day that seeds were removed from the solution, they were sown into 2x2 inch pots in a soil mixture of 3 parts Sunshine 4 potting mix, 1 part vermiculite, 1 part perlite, and 1 part cinder. They were sown to a depth of half the total length of the seed, so just barely covered.

According to PTA protocol plants are not labeled until they are planted into 4x4 inch pots. However, the smaller pots with *S. macrophyllus* have been given temporary labels indicating the seed shape and whether they floated or sank in the GA3 treatment. The pots are currently held in the RPPF. As of 31 December 2021, none have germinated.

Discussion for Propagation

In 2021, we processed and sowed 7 *S. macrophyllus* seeds that were collected in 2021. We plan to establish individuals in the RPPF and eventually outplant some individuals. To learn more about *S. macrophyllus* germination requirements, we consulted Cindy Yamamoto of Lyon Arboretum and Tim Chambers of USAG-HI NRP. We also purchased a germination chamber that will enable us to contribute to ongoing research on germination in the genus *Sicyos*. This work will lead to improved SOPs for the harvest, processing, and germination of *S. macrophyllus*.

Although we have made substantial progress with germinating several ESA-listed plant species in previous years, there is still more to learn to germinate all species reliably and consistently. In FY 2022, we plan to investigate procedural changes to better plan and track germination trials to investigate which seed treatments are influencing seed germination. Because we lack laboratory facilities and expertise, we recommend leveraging the resources and experts at the Army's NRP on O'ahu to investigate seed dormancy issues and to assist with developing propagation protocols.

We maintain ESA-listed plants and common native Hawaiian plants in the RPPF that were germinated in previous years (Table 16 and Table 17).

Table 16. Rare Plant Propagation Facility inventory of plants listed under the Endangered Species Act accessioned as of August 2021.

Species	Total Plants Accessioned
Asplenium peruvianum var. insulare	0
Exocarpos menziesii	31
Festuca hawaiiensis	1
Haplostachys haplostachya	1
Isodendrion hosakae	88
Kadua coriacea	76
Lipochaeta venosa	4
Neraudia ovata	79
Portulaca sclerocarpa[a]	57
Portulaca villosa	37
Schiedea hawaiiensis	2
Sicyos macrophylla	0
Silene hawaiiensis	23
Silene lanceolata	7
Spermolepis hawaiiensis	1
Solanum incompletum	150
Stenogyne angustifolia	0
Tetramolopium arenarium	1
Vigna o-wahuensis	25
Zanthoxylum hawaiiense	8

[a] The total for *P. sclerocarpa* includes 3 plants marked as *P.* sp. in the inventory.

Table 17. Common native Hawaiian plant species accessioned to the Rare Plant Propagation Facility as of July 2021.

Species	Common Name	Hawaiian Name	Total Plants Accessioned
Acacia koa	Koa	Koa	28
Alphitonia ponderosa	none	Kauila	3
Alyxia stellata	none	Maile	5
Chamaesyce olowaluana	Alpine sandmat	ʻAkoko	2
Disopyros sandwicensis	Hawaiian persimmon	Lama	16
Erythrina sandwichensis	Hawaiian coral tree	Wiliwili	8
Ipomea tuboides	Hawaiian moon flower	Koaliʻawa	1
Luzula hawaiiensis var. *hawaiiensis*	Hawaiʻi wood-rush	--	1
Metrosideros polymorpha	Ohia lehua	Ohiʻā lehua	225
Osteomeles anthyllidifolia	Hawaiian rose	ʻŪlei	20
Panicum tenuifolia	Mountain Pili	Konakona	2
Peperomia sp.	Peperomia	ʻAlaʻala wai nui	2
Pittosporum terminalioides	Cream cheesewood	Hoʻawa	31
Santalum paniculatum	Sandalwood	ʻIliahi	44
Sophora chrysophylla	Māmane	Māmane	16
Wikstoemia phillyreifolia	Hawaiʻi false ohelo	ʻĀkia	58

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). Currently, we manage 29 established outplanting sites (Figure 12).

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 with site-specific goals. The selected site is designated as an Area of Species Recovery (ASR). We implement management in phases: Phase 1: control weeds as needed and collect seeds to meet project goals; Phase 2: propagate plants, usually common species, to improve the habitat; Phase 3: plant the propagated plants from Phase 2; and Phase 4: plant ESA-listed plant species. We control invasive plants during all phases of management. The common plant species we select for habitat improvement are site-specific and determined by historical records, herbarium records, species distribution models, and species lists from plant survey data. We also consider future climate conditions when selecting species.

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

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

Outplanting Results

We did not outplant during the reporting period.

Outplanting Monitoring

In December 2021 we monitored federally listed species at 29 outplanting sites that were established between 2004 and 2019 (Table 12 and Figure 12). We propagated 18 species of ESA-listed species and planted thousands of individuals (CEMML 2019b, CEMML 2020b).

Methods

We count all individuals of each species, including recruits, by life stage (seedling, juvenile, adult) at each of the 29 outplanting sites. Each adult and juvenile is assigned GPS coordinates and marked with flagging. Any historical information remaining on tags is recorded. For seedlings, we count all individuals up to 25 within an outplanting site and assign count classes when the number of individuals exceeds 25 (25-50, 51-100, and >100). When calculating the total number of seedlings at a site, count classes are converted to the minimum value for the class (i.e., 25, 51, or 101).

We used similar count methods to monitor sites 2019 Temp 001-009. Because each outplant is marked with a unique number, no additional plantings occurred at the sites, and the sites were monitored each year since planting, we also present the annual monitoring totals for 2019-2021 and calculate the survivorship for each species for each site in Table 19.

Results

We monitored all 29 outplanting sites in 2020 by counting all individuals, including recruits, present at the sites in each life stage. For ASRs 201 to 220 (planted between 2004 and 2014), monitoring was not consistently completed annually, and records of new planting and recruitment are not clear; therefore, we report the number of individuals for each species, by life-stage for each site (Table 18). Monitoring data were collected consistently between 2019 and 2020 and the percent change in numbers of adults and juveniles is presented in Table 18. While a few species showed increases at some sites, most species declined at most sites. Net survivorship for each species by outplanting site is presented in the species summaries (Section 2.4 and Section 2.5).

Table 18. Monitoring results from 2019 and 2020 for plant species listed under the Endangered Species Act remaining at outplanting sites.

Outplanting Site	Species	Total Planted[a]	Total Adults / Juv (Seedlings) 2019	Total Adults / Juv (Seedlings) 2020	% Change 2019-2020[b]
Puʻu Huluhulu (ASR 201)	*Neraudia ovata*	117	3	4	+33%
	Schiedea hawaiiensis	259	12	13	+8%
	Silene lanceolata	51	29	4	-86%
	Solanum incompletum	455	62	57	-8%
	Stenogyne angustifolia	121	21	21	0%
	Zanthoxylum hawaiiense	2	1	1	0%
KTA (ASR 202)	No plants found	--	--	--	--
WHVC (ASR 203)	*Isodendrion hosakae*	4		1	--
Kīpuka ʻOwēʻowē (ASR 204)	Neraudia ovata	42	2	4	+100%
	Silene lanceolata	199	1	0	-100%
	Solanum incompletum	225	7	10	+42%
Puʻu Waʻawaʻa (ASR 205)	*Isodendrion hosakae*	44	15	13	-13%
	Kadua coriacea	316	16	7	-56%
	Lipochaeta venosa	234	104	33	-68%
	Neraudia ovata	132	15	13 (4)	-13%
	Schiedea hawaiiensis	374	4	1	-75%
	Silene lanceolata	340	27	2	-93%
	Solanum incompletum	406	18	9	-50%
	Stenogyne angustifolia	78	103	9	-91%
	Vigna o-wahuensis	47	2	2	0%
	Zanthoxylum hawaiiense	22	10	12	+20%
ASR 206	*Neraudia ovata*	4	1	1	0%
	Schiedea hawaiiensis	24	31	26	-16%
ASR 207	*Schiedea hawaiiensis*	5	5	4	-20%
ASR 208	No plants found	--	--	--	--
ASR 209	*Solanum incompletum*	40	27	29 (1)	+7%
ASR 210	No plants found	--	--	--	--
ASR 211	*Haplostachys haplostachya*	32	1	1	0%
	Kadua coriacea	20	1	1	0%
	Silene lanceolata	59	409	210	-49%
	Zanthoxylum hawaiiense	2	1	1	0%
ASR 212	No Plants Found	--	--	--	--

Table 18. Monitoring results from 2019 and 2020 for plant species listed under the Endangered Species Act remaining at outplanting sites (cont.).

Outplanting Site	Species	Total Planted[a]	Total Adults / Juv (Seedlings) 2019	Total Adults / Juv (Seedlings) 2020	% Change 2019-2020[b]
ASR 213	*Neraudia ovata*	54	56	58	+4%
	Schiedea hawaiiensis	14	1	0	-100%
	Silene lanceolata	3	6	22	+72%
	Solanum incompletum	21	25	23	-8%
	Zanthoxylum hawaiiense	4	2	2	0%
ASR 214	*Festuca hawaiiensis*	7	86	40	-56%
	Haplostachys haplostachya	95	2	3	+50%
	Isodendrion hosakae	7	3	4	+33%
	Schiedea hawaiiensis	69	25	12	-52%
	Silene hawaiiensis	10	6	6	0%
	Silene lanceolata	75	637	462	-27%
	Solanum incompletum	170	320	271	-15%
	Spermolepis hawaiiensis	21	2	0	-100%
	Stenogyne angustifolia	30	83	85	+2%
ASR 215	No plants found	--	--	--	--
ASR 216	No plants found	--	--	--	--
ASR 217	No plants found	--	--	--	--
ASR 218	No plants found	--	--	--	--
ASR 219	*Asplenium peruvianum* var. *insulare*	23[c]	4	72	18x
	Haplostachys haplostachya	18	9	8	+11%
	Schiedea hawaiiensis	5	3	11 (14)	+3.6x
	Solanum incompletum	4	4	16	+4x
ASR 220	*Silene lanceolata*	24		38	
	Solanum incompletum		2	2	0%
	Zanthoxylum hawaiiense	3	1	1	0%

ASR, Area of Species Recovery, Juv, Juvenile, WHVC, KTS, Koaiʻa Tree Sanctuary, West Hawaiʻi Veteran's Cemetery

[a] The data source for total planted is CEMML 2015. This is a cumulative total of all plants planted between 2004 and 2014. However, only species that were present during monitoring in 2020 are included in this table.

[b] The percent change of adults/juveniles remaining at each site between 2019 and 2020. A negative sign indicates a decrease and a positive sign an increase in individuals. For species with greater than 100% increase, the change is shown as the fold increase from the 2019 total.

[C] During FY 2106-2017, 15 *Asplenium peruvianum* var. *insulare* were transplanted from ASR 218 to ASR 219 bringing the total planted at ASR 219 from 8 to 23.

We report results separately for the 2019 Temp sites because the monitoring was designed to track annual and overall survivorship (Table 19). This is possible because all individuals planted were tagged and no additional planting has occurred at these sites. Overall survivorship varied among species and sites.

Table 19. Annual monitoring results for plant species listed under the Endangered Species Act outplanted at Pōhakuloa Training Area between March and April 2019.

Site	Species	Total Planted	Nov 2019	Mar 2020	Survivorship[a]
Temp 2019-001	*Kadua coriacea*	18	6	6	33%
Temp 2019-002	*Kadua coriacea*	20	14	10	50%
Temp 2019-003	*Kadua coriacea*	21	11	14	67%
Temp 2019-003	*Portulaca sclerocarpa*	18	12	9	50%
Temp 2019-004	*Kadua coriacea*	24	24	24	100%
Temp 2019-005	*Lipochaeta venosa*	16	13	14	88%
Temp 2019-005	*Vigna o-wahuensis*	11	2	0	0%
Temp 2019-006	*Kadua coriacea*	4	1	0	0%
Temp 2019-007	*Kadua coriacea*	9	3	3	33%
Temp 2019-008	*Kadua coriacea*	7	3	2	29%
Temp 2019-009	*Kadua coriacea*	4	3	3	75%
Temp 2019-009	*Neraudia ovata*	9	4	3	33%
Temp 2019-009	*Schiedea hawaiiensis*	2	1	2	100%

[a] The percent survivorship value is calculated by dividing the number of plants remaining in December 2020 by the initial number of plants planted in March/April 2019 for each species at each site.

Outplanting Site Maintenance at Locations on State of Hawaiʻi Land

In February, May, and June 2021, we managed the outplanting sites at Puʻu Waʻawaʻa. We hand-cleared the ESA-listed plants and used herbicide to control *Rubus parviflorus* and other targeted noxious weeds. However, we are allowing the *Cenchrus clandestinus* to reinvade the sites to cover bare ground and to minimize the presence of less-desirable weeds such as *R. parviflorus.*

We did not manage the outplanting sites at Puʻu Huluhulu in 2021.

Outplanting Discussion

For plantings that occurred prior to 2014, annual monitoring was not designed and implemented in a way to allow for tracking individual plants over time. 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 18). There are a few exceptions such as *S. lanceolata* at site 211 and *F. hawaiiensis* at site 214; however, these Tier 2 species are also doing well across their distribution at PTA and future outplanting is likely unnecessary to maintain or increase the abundance of these species.

Between 2020 and 2021, *Schiedea hawaiiensis* declined at sites 206 and 207. Plants have persisted consistently at these locations since the original plantings in 2002 (almost 20 years). In 2021, the plants at site 206 declined by 74% (26 to 8 plants) and no plants were found at site 207 (5 to 0 plants). 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 these locations.

For the plants planted in March/April 2019, we more closely tracked individuals. Over the course of 2 years, all species have declined at all sites (Table 19). 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, as of December 2021, *K. coriacea* survivorship was greater than 20% at 5 of the 8 sites. At the remaining 3 sites (Temp 2019-006 to Temp 2019-008), *K. coriacea* survivorship was 0. These 4 sites are located outside the projected habitat range for *K. coriacea* (Price et al. 2012), so it is not surprising these plants did not persist. Site Temp 2019-009 is also outside the projected range for *K. coriacea* and it is surprising that the plants persist at this location.

We continue to see challenges with planting *P. sclerocarpa* and *V. o-wahuensis. P. sclerocarpa* showed a steady decline in plants in each monitoring period with an overall survivorship of 17% (March 2019 through December 2021). In past planting efforts, we have not successfully established *P. sclerocarpa* at any of our outplanting sites (CEMML 2016). Within 6 months of planting only 2 *V. o-wahuensis* plants remained, then zero plants. In 2021, a single *V. o-wahuensis* was located but this plant was believed to be a recruit. Historically, we have also had little success with *V. o-wahuensis* persisting at outplanting sites.

Per the strategy developed in the *Genetic Conservation and Outplanting Plan* (CEMML 2017), our focus for 2022 will be on establishing planting locations in KMA for *I. hosakae, L. venosa,* and *V. o-wahuensis* per the 5-year outplanting plan submitted to the Army for approval. We will continue to explore options to plant common native species to restore native habitats at KMA sites. However, before we initiate additional work, we need to develop a process to vet and receive approval for all planting sites from the Army, especially when ESA-listed plants will be planted. Additionally, we will continue to develop site-specific planting plans that outline planting targets for common and ESA-listed species and to ensure we consider the genetic makeup of plants included at a particular location.

At this time, we are exploring options to close-out the outplanting projects at Puʻu Waʻawaʻa and Puʻu Huluhulu. To minimize 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 drafted reports detailing the planting history and remaining plants for Puʻu Waʻawaʻa and Puʻu Huluhulu, which are pending Army review. We plan to meet with our state partners on-site in 2022 to discuss an acceptable exit strategy for each site.

The PTA Interpretive Garden

We planted several species in the PTA Interpretive Garden located on the PTA cantonment behind the Natural Resources Program buildings. Plants in the garden are not counted toward the species recovery efforts; therefore, we do not accurately track survivorship and founder information.

In 2020 and 2021, we found several small *S. lanceolata* and *V. o-wahuensis* that were growing between NRP buildings 226 and 227 at the PTA cantonment. The plants germinated from seed from plants that were stored temporarily in this sheltered location while the RPPF was being moved in 2018. To prevent plants from establishing in this area, in 2020 we coordinated with the USFWS to salvage plants that germinated between the buildings and replant them in our interpretive garden (L. Weisenberger, personal communication, 9 July 2020).

In 2020, we did not record the number of plants moved directly to the garden. No plants were moved to the RPPF in 2020. In 2021, we potted 7 *S. lanceolata* and 26 *V. o-wahuensis,* and when they are larger, we will plant them in our interpretive garden. We carefully inspected all transplants from between buildings for any pests or pathogens before introducing them into the RPPF. All tools and implements used during the transplantation were disinfected by soaking for 3 minutes in a 10% bleach solution before and after relocation. Transplants were rinsed of all soil material before being replanted into appropriately sterilized medium. Transplants were isolated for 24 hours in the potting shed area before being introduced into the main RPPF collection facility. A similar approach will be taken when transplants are eventually moved from the RPPF to the Interpretive Garden. Physosanitation protocols outlined by the HRPRG will be followed.

2.3.5 Genetic Conservation and Outplanting Discussion

The *Genetic Conservation and Outplanting Plan* (CEMML 2017) is an excellent foundation to guide genetic conservation for the 20 ESA-listed plants. The strategy developed in the plan will guide management priorities, collection and propagation targets, and outplanting activities. The 5-year outplanting plan (pending Army approval) provides a framework for implementing the outplanting strategy to work toward INRMP objectives. In 2022, we plan to develop site-specific planting plans based on projects identified in the 5-year plan. These more detailed site-specific plans will establish planting targets and long-term site monitoring plans to evaluate outplanting success and our efforts in relation to our goals and compliance obligations for each ESA-listed plant species.

Ex situ storage of propagules in banks is an effective and efficient means to safeguard the genetics of ESA-listed plant species against catastrophic loss of individuals in the natural population due to natural or human-caused disturbances (e.g., wildland fire). Thousands of seeds can be stored per species inside refrigerators (short-term) or freezers (long-term). However, for this to be a viable conservation strategy, research into seed characteristics such as dormancy, viability, and germination requirements is needed to ensure stored seeds are of high quality and that they can be germinated reliably for reintroduction back to 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 most seeds have been stored in the refrigerator. 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 and dried to about 30% moisture and sealed in foil packets prior to storage. However, we have limited capacity to freeze seeds, so most are placed in a refrigerator. We recommend partnering with the USAG-HI Hawaiʻi NRP on Oʻahu to leverage their seed lab resources to investigate seed viability, dormancy, germination requirements, and for long-term storage in freezers under optimal conditions.

In April 2021, we purchased a seed gemination chamber to facilitate propagation and to improve our understanding about optimal storage conditions and duration to maximize the viability of stored seeds. With the chamber, we will be able to control environmental parameters more accurately during germination and hopefully 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. Improved germination success is especially valuable if seed is limited and can ease seed collection efforts and potentially inform outplanting site selection.

We continue to reconcile past record-keeping systems and naming conventions to ensure accurate, reliable information is available for inventories and monitoring. We aim to overhaul our database, inventory species and founders in the *ex situ* propagule bank and streamline the accounting process to accurately track seeds from collection and storage to propagation and outplanting.

2.4 TIER 1 SPECIES SUMMARIES

We present the species summaries arranged by management tiers (Table 1) and then alphabetically by species. For all species we present the distribution of the species in a series of maps based on the complete dataset from plant surveys completed between 2011 and 2015. For Tier 1 plants, abundance is derived from quarterly monitoring data. 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 requirements.

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 the outplanting sites were monitored in 2016, 2019, and 2020, we cannot reliably distinguish the original outplants from recruits due to issues with the plant tags. 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 2020.

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

As a Tier 1 species, we monitored all known *A. peruvianum* var. *insulare* locations quarterly in FY 2020. For genetic conservation, *A. peruvianum* var. *insulare* is ranked as implementation priority 4 (low) and propagule collection and storage are the primary genetic conservation tools.

Plant Surveys and Monitoring

During the reporting period, we surveyed a subset of transects and encountered 5 locations of *A. peruvianum* var. *insulare* within the fence units. We found a new location in TA 23 outside the fence units with 1 adult and 3 juvenile plants.

Based on survey work from 2011 to 2021, there are 67 locations at PTA. The distribution for *A. peruvianum* var. *insulare*, including outplanting sites, is shown in Figure 14.

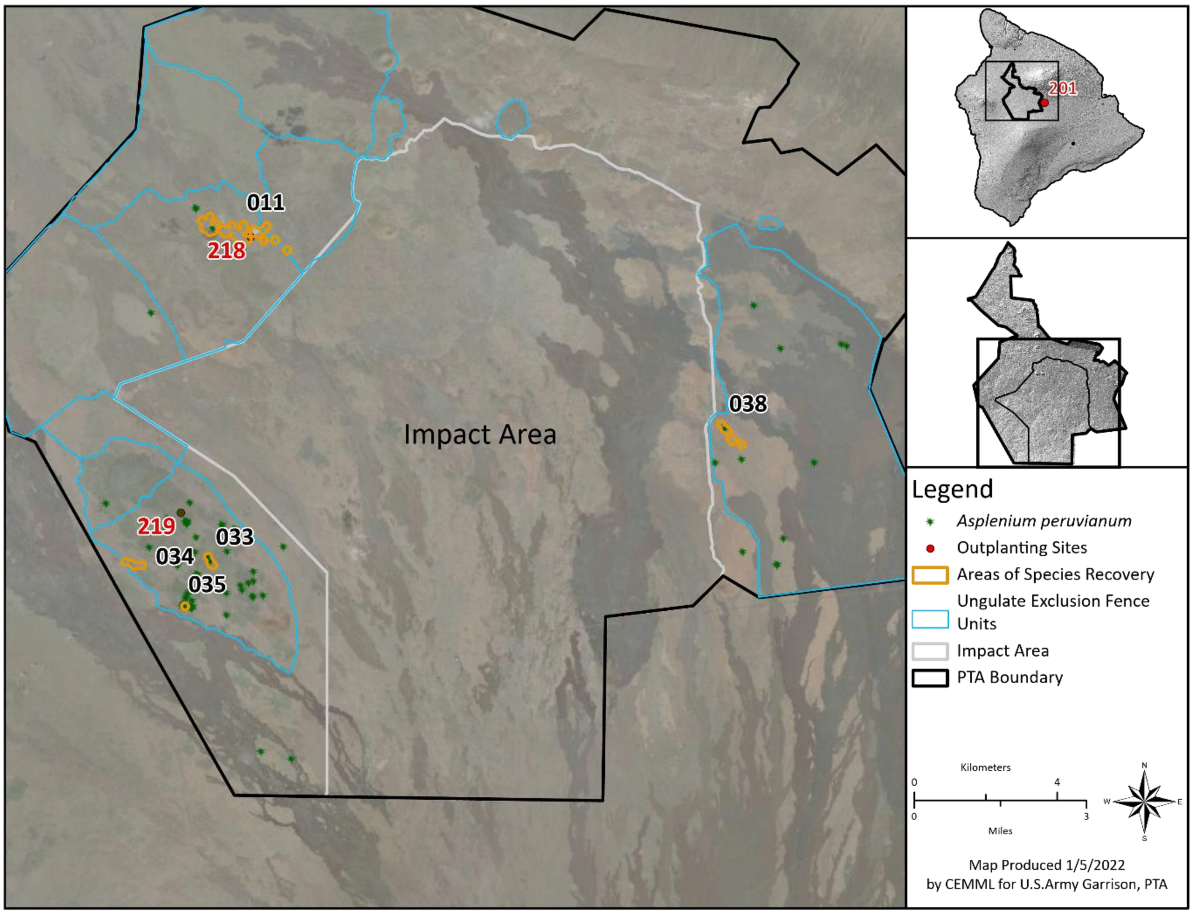

Figure 14. Current known distribution of *Asplenium peruvianum* var. *insulare*[a].

[a] The distribution is derived from a compilation of plant survey data (2011–2021), monitoring data, and incidental rare plant finds.

We monitored *A. peruvianum* var. *insulare* over 11 periods between April 2016 and September 2020. Monitoring data were pooled across all plots for each monitoring cycle (Figure 15). Juveniles and adults combined appear to steadily increase over the 4-year period. Gametophytes were generally more abundant during the summer. Variability among seasons is evident, but the seasonality of data collection over the period does not allow for trend analysis across fixed season dates. Some variability and patterns in the data over time may be related to rainfall patterns and decreased ungulate pressure.

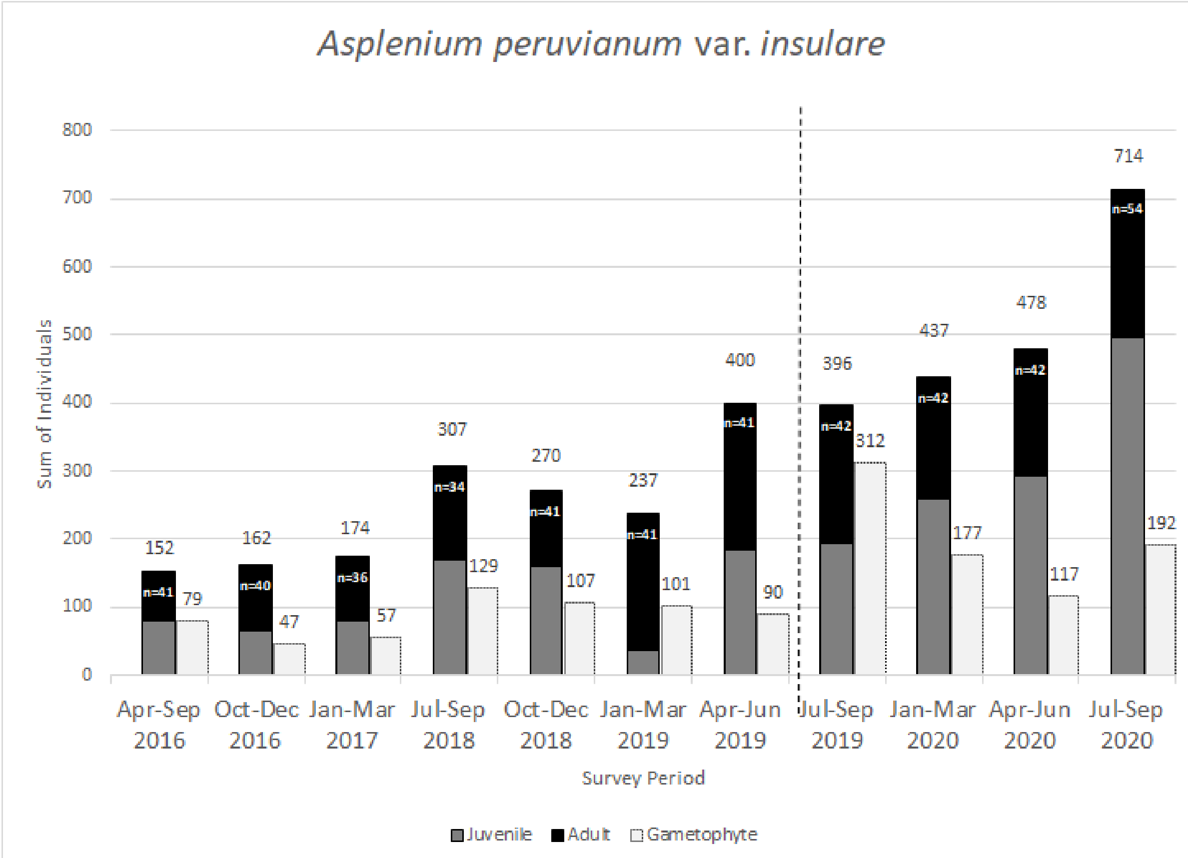

Figure 15. Quarterly monitoring results for *Asplenium peruvianum* var*. insulare* from April 2016 through September 2020[a].

[a] For census periods left of the dotted line, we estimated life stage composition using proportion and to the right we counted each plant present by life stage (n=number of plots read). For census periods right of the dotted line, totals may include count class data. When this occurs the minimum value of the count class is used and summed with the counts from other plots to provide the total value for abundance. This is because the actual values represented within count classes were often not normally distributed. Therefore, these numbers represent the minimum number of individuals present during the census period.

<u>Genetic Conservation</u>

Propagule Collection and Propagation

No propagule collections or propagation occurred during the reporting period for *A. peruvianum* var. *insulare.* There are no *A. peruvianum* var. *insulare* accessioned to the RPPF as of 31 July 2021. Please refer to Table 15 for a complete summary of genetic conservation status for *A. peruvianum* var. *insulare*.

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 three ASRs (Figure 14). At last monitoring in 2020, there were 72 adults and juveniles present at ASR 218, but ferns were no longer present at ASRs 201 or 218 (Table 20).

Table 20. Monitoring results as of December 2020 for *Asplenium peruvianum* var. *insulare* outplanted between 2004 and 2014.

Location	Area of Species Recovery	Total Outplanted 2004-2014	Total Present 2014		Total Present 2020		% Change 2014-2020	Seedlings 2020
			Adult	Juvenile	Adult	Juvenile		
Off PTA	201	10	1	0	0	0	-100%	0
On PTA	218	15[a]	29	0	0	0	-100%	0
	219	23[a]	9[b]	0	10	62	+213%[b]	0

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

[a] During FY 2106-2017, 15 *Asplenium peruvianum* var. *insulare* were transplanted from ASR 218 to ASR 219 bringing 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 survey, monitor, and conserve genetics for *A. peruvianum* var. *insulare* address SOO tasks 3.2(1)(a, d–f) as well as several INRMP objectives and conservation measures from the 2003 and 2013 BO.

The greatest distribution and abundance of *A. peruvianum* var. *insulare* occurs within the Puʻu Koli and Kīpuka ʻAlalā South Fence Units. This species is also found within the Nāʻōhuleʻelua Fence Unit (Figure 14). *A. peruvianum* var. *insulare* is currently found predominantly outside of the ASRs designated for the species (Figure 14). We are evaluating where management is most needed and if current ASR designations need to be changed to reflect these needs.

Quarterly counts of *A. peruvianum* var. *insulare* steadily increased from April 2016 through September 2019. Gametophytes were present each census period. Although our monitoring was not designed to directly track transition from one life stage to another, there are patterns in the quarterly count numbers that suggest that transition from gametophyte and juvenile life stages supported gains in the adult life stage (Figure 15). There is little known about optimal *A. peruvianum* var. *insulare* population structures and/or ratios between the life stages that support healthy and resilient populations. In addition, we do not know which, if any, of the life stages is most vulnerable and/or may regulate population dynamics. These life history attributes are key to designing management actions to increase the abundance and distribution of this species, especially with changing climate conditions.

We have not implemented invasive plant control for most *A. peruvianum* var. *insulare* locations. When invasive plant management for Tier 1 plants was first implemented, *A. peruvianum* var. *insulare* was ranked as a Tier 2 and, therefore, did not receive management at the same time as other Tier 1 species. In 2018 we changed the rank of *A. peruvianum* var. *insulare* to Tier 1 because the ferns at PTA now represent a larger proportion of the state-wide population following a population decline in Hawaiʻi Volcanoes National Park. With this change to a rank of Tier 1, we plan to further parse quarterly monitoring information to see if invasive plants are a threat at specific sites. From this additional analysis, we plan to develop further management actions for *A. peruvianum* var. *insulare*.

We have made progress towards genetic conservation targets for *A. peruvianum* var. *insulare*. Although we made no collections this reporting period, the propagule bank contains 119 blades from wild founders each with multiple fertile sori attached and 492 blades from plants in the RPPF. In addition, there are 492 blades from individuals grown in the RPPF.

Efforts to propagate and outplant *A. peruvianum* var. *insulare* have been minimal and have mixed results. Outplants did not persist at ASR 201 and ASR 218 and no recruitment was observed. In FY 2016-2017, due to poor site conditions at ASR 218, the 15 remaining ferns were transplanted to ASR 219 (CEMML 2019b). Based on the 2014 monitoring, the initial 8 ferns outplanted established successfully. Because the 15 ferns were transplanted to ASR 219 in FY 2016, we used the outplanting monitoring data from FY 2106 to calculate the percent change between 2016 and 2020 (Table 20). Between 2016 and 2020, the number of adults and juveniles (combined) of *A. peruvianum* var. *insulare* present at ASR 219 increased by 213%. We believe the careful selection of cave openings with a balance of soil substrate, light/shade, and moisture has facilitated the persistence of the ferns at this site. However, we still know relatively little about the environmental conditions that are most favorable to the establishment and persistence of this species and recommend further investigation into habitat requirements for this species.

Progress toward Compliance with Endangered Species Act Biological Opinion Conservation Measures

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

To address these conservation measures for *A*. *peruvianum* var. *insulare*, we implement landscape-level projects to reduce fire risk and ungulate browse for most known *A*. *peruvianum* var. *insulare* individuals at PTA (see Section 1.3). However, we, recently discovered a new location of *A*. *peruvianum* var. *insulare* in August 2021 and the 4 ferns at this location are not managed. We actively conserve *A*. *peruvianum* var. *insulare* genetics; the propagule bank contains 119 blades from the wild population and 492 blades from individuals grown in the RPPF. To date, we have outplanted a combined total of 48 ferns at 3 ASRs (201, 218, and 219). As of 2021, 4 outplanted ferns survived; however, recruits observed in previous years at ASR 218 were not present in 2021. Propagation and finding suitable outplanting sites remain limiting factors for this species. Other than outplanting sites with ASRs, we have not implemented weed control buffers specifically for *A*. *peruvianum* var. *insulare.* Between 2016 and 2019, we documented *in situ* reproduction at 13 of the 43 (30%) quarterly monitoring plots.

Although we monitored *A*. *peruvianum* var. *insulare* quarterly to assess population patterns, we are unable to attribute changes in numbers to effects from training or management.

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

2.4.2 *Isodendrion hosakae* (Endangered)

As a Tier 1, we monitored all known *I. hosakae* locations each quarter in FY 2020. For genetic conservation, *I. hosakae* is an implementation priority 1 (high). We plan to collect propagules for storage and propagation and to outplant to augment the existing population and to establish new populations.

<u>Plant Surveys and Monitoring</u>

We did not find/reconfirm any locations for *I. hosakae* during the reporting period. This is not surprising because we did not survey within the known distribution of this species.

Based on survey work from 2011 to 2021, there are 30 locations of *I. hosakae* at PTA. The distribution for *I. hosakae*, including outplanting sites, is shown in Figure 16.

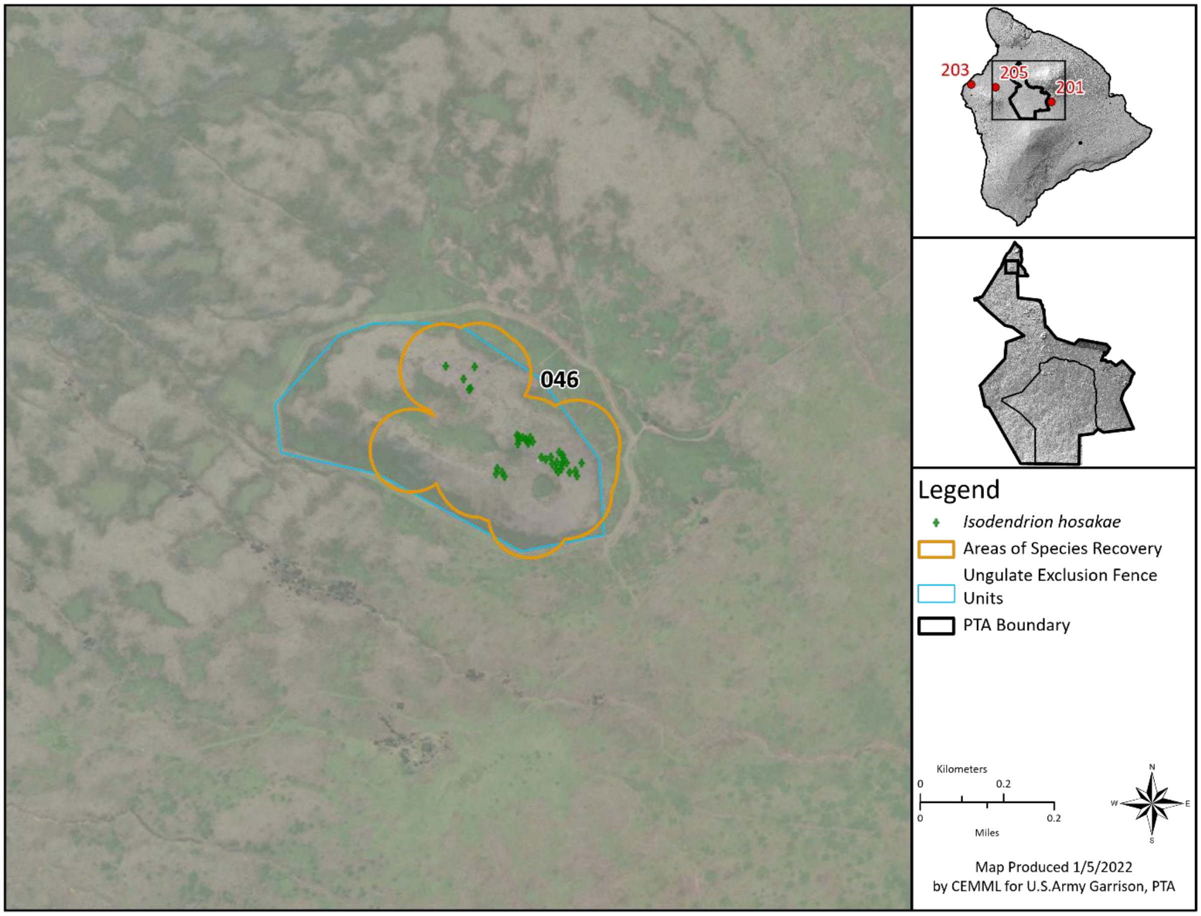

Figure 16. Current known distribution and outplanting sites for *Isodendrion hosakae*[a].

[a] The distribution is derived from a compilation of plant survey data (2011–2021), monitoring data, and incidental rare plant finds.

We monitored *I. hosakae* over 13 periods between April 2016 and September 2020. There was an increase in overall number of *I. hosakae* present at PTA from the first to the last census (Figure 17), largely driven by an increase in the number of juveniles. The number of mature individuals remained relatively static across seasons and years. Seedling abundance was extremely high in winter and spring most years. This flush of individuals in the seedling and juvenile cohorts was likely due to opportunistic regeneration driven by pulses in plant-available water (i.e., rainfall).

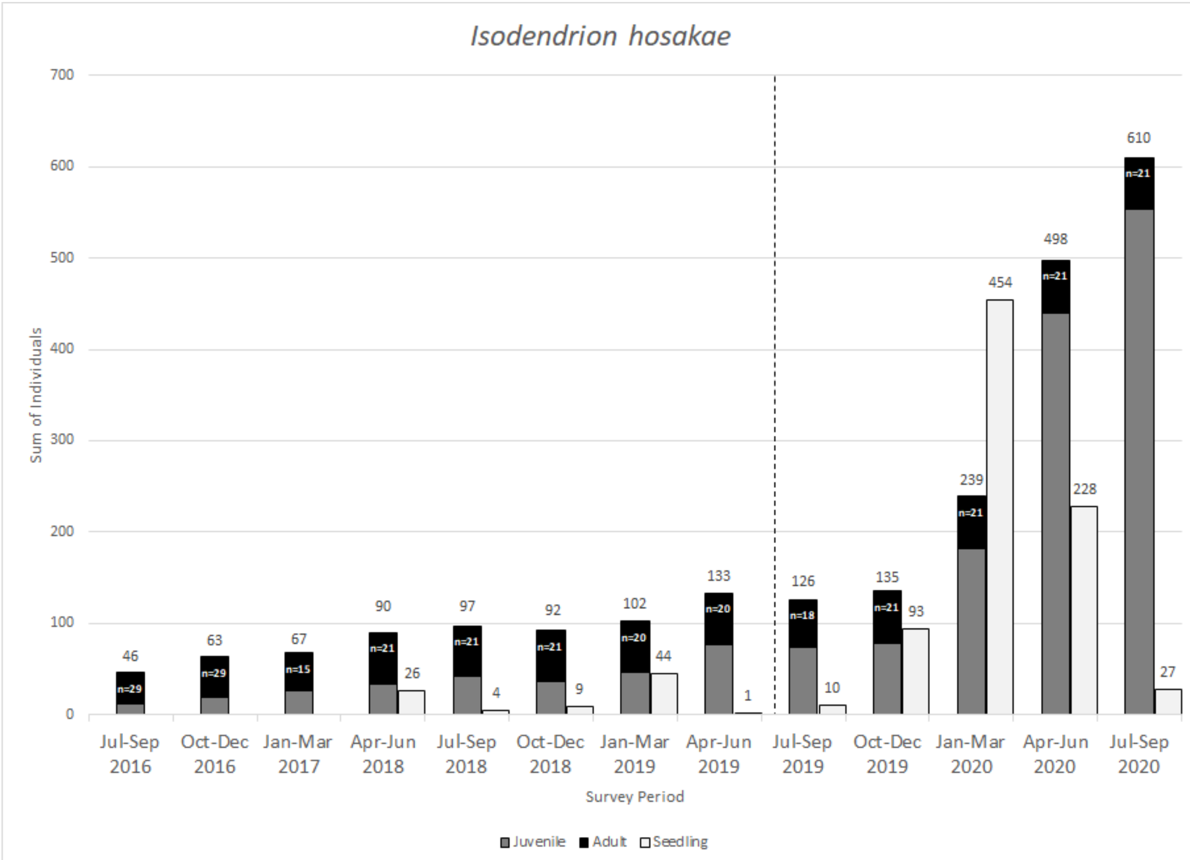

Figure 17. Monitoring results for *Isodendrion hosakae* from April 2016 through September 2020[a].

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

Genetic Conservation

Propagule Collection and Propagation

No propagule collection or propagation occurred during the reporting period. From previous propagation efforts there were 88 *I. hosakae* accessioned to the RPPF as of 31 July 2021. Please refer to Table 15 for a complete summary of genetic conservation status for *I. hosakae*.

Outplanting and Monitoring

We did not outplant *I. hosakae* during the reporting period. In previous years, we planted a combined total of 58 *I. hosakae* at 4 ASRs (Figure 16). At last monitoring in 2020, adults were present at ASR 203, 205, and 214 (Table 21). However, all sites showed a decrease the number of adults and juveniles (combined) present between 2014 and 2020.

Table 21. Monitoring results as of December 2020 for *Isodendrion hosakae* outplanted between 2004 and 2014.

Location	Area of Species Recovery	Total Outplanted 2004-2014	Total Present 2014		Total Present 2020		% Change 2014-2020	Seedlings 2020
			Adult	Juvenile	Adult	Juvenile		
Off PTA	201	3	0	2	0	0	-100%	0
	203	4	3	1	1	0	-75%	0
	205	44	13	10	13	0	-43%	0
On PTA	214	7	5	1	4	0	-33%	0

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

Discussion

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

The current distribution of *I. hosakae* is scattered and patchy across approximately 7 ha on Puʻu Pāpapa (Figure 16). The distribution of *I. hosakae* has contracted since 1982 when it was reported from three cinder cones in South Kohala (Cuddihy et al. 1982). Two of these cinder cones, Puʻu Pāpapa and Puʻu Nohona o Hae, were purchased by the Army in 2006 as part of KMA. In addition to range contraction, the population of *I. hosakae* has declined from 870 individuals in 2002 to 46 individuals in 2016 (a 95% reduction). Although this decline is extreme, similar population declines followed by rebounds have been recorded in the past. Over the last 36 years, the *I. hosakae* population has experienced large fluctuations in the number of plants present (25 to 870). Between 2016 and 2020, the number of *I. hosakae* increased by almost 9-fold, reenforcing the pattern of large fluctuations in plant abundance. With such large swings in population numbers, it is difficult to understand the overall health and viability of this population. These dramatic changes in abundance may be a natural response of this species to environmental conditions. Future monitoring strategies will seek to address these issues.

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

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

We continue to make progress with genetic conservation of *I. hosakae*. Many of the accessions in storage were collected in 2009 and their viability is likely decreasing. We do not know how aging affects the viability of the seed, but in 2019 we had moderate germination success from older seed lots. Germinating these older seeds is critical to conserving *I. hosakae* genetics because many of the founders are no longer extant in the wild population. As seed viability decreases, we may have less success recovering these genetics via seed propagation. There are 88 *I. hosakae* accessioned to the RPPF.

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 its possible range (Price et al. 2012). We are challenged to select suitable planting sites due to the lack of good information about this species' range. The ASRs where we planted *I. hosakae* are outside the historic and possible ranges identified by Price et al. (2012). Based on outplant performance, elevation may be a factor in the successful establishment of *I. hosakae.* For example, ASR 201 is about 1,000 m higher in elevation than the wild *I. hosakae* population. The initial outplants failed to establish at ASR 201 and were dead by 2014 (Table 21). At ASR 214, about 700 m higher in elevation than the wild population, *I. hosakae* survived moderately well. 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. We recommend continuing to monitor the success of previous plantings to help better understand this species' habitat requirements and to guide site selection and preparation as we implement outplanting over the next 5 years.

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 browse pressure, maintenance of genetic stock *ex situ*, outplanting, reproduction *in situ*, non-native plant control, and annual monitoring.

To address these conservation measures for *I. hosakae*, we implement landscape-level projects to reduce fire risk and ungulate browse for all known individuals at PTA (see Section 1.3). In addition, we actively conserve *I. hosakae* genetics; the propagule bank contains 1,985 seeds from the wild population. To date, we have outplanted a combined total of 58 individuals at 4 ASRs. In 2021, 23 outplanted adults and juveniles were alive. In 2018, we implemented an extensive weed control project specifically designed to minimize negative impacts to *I. hosakae* from rapid changes in environmental conditions that can result from grass removal. Non-native plants are controlled in approximately 2.6 ha for *I. hosakae* (Table 44). Between 2016 and 2019, we documented *in situ* reproduction at 1 of the 36 (3%) quarterly monitoring plots. Although we monitored *I. hosakae* quarterly in FY 2020 to assess population patterns, we are unable to attribute changes in numbers to effects from training or management.

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

2.4.3 *Kadua coriacea* (Endangered)

As a Tier 1 species, we monitored all known *K. coriacea* locations each quarter in FY 2020. For genetic conservation, *K. coriacea* is an implementation priority 2 (high). We plan to collect propagules for storage and propagation and to outplant to augment the existing population and to establish new populations.

Plant Surveys and Monitoring

During the reporting period, we reconfirmed 11 locations of *K. coriacea.*

Based on survey work from 2011 to 2021, there are 128 locations of *K. coriacea* at PTA. The distribution for *K. coriacea*, including outplanting sites, is shown in Figure 18.

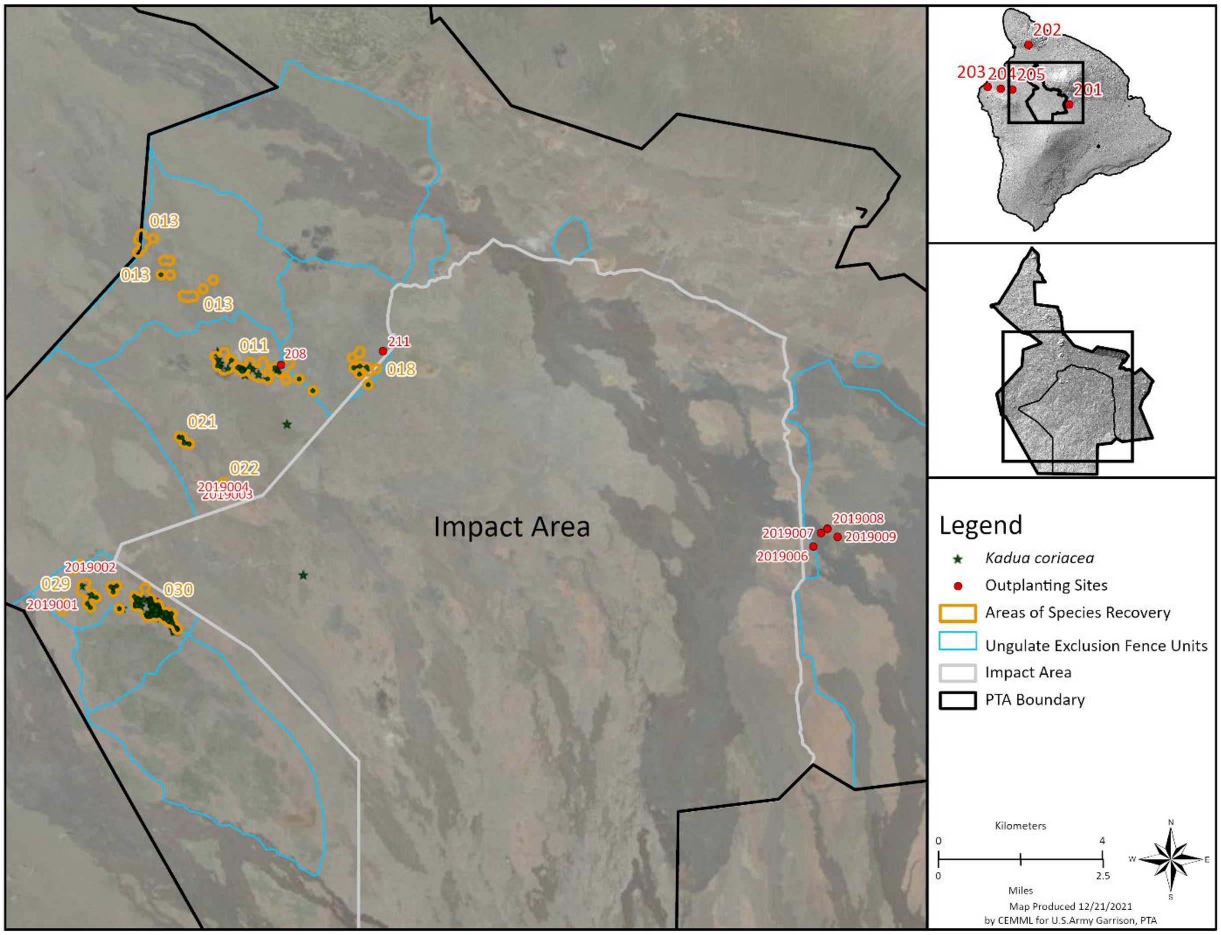

Figure 18. Current known distribution and outplanting sites for *Kadua coriacea*[a].

[a] The distribution is derived from a compilation of plant survey data (2011–2021), monitoring data, and incidental rare plant finds.

We counted *K. coriacea* individuals over 11 periods between April 2016 and September 2020. The population structure of this species is dominated by adults, with many of these individuals found over 10 years ago (Figure 19). Mortality appears to be very low, with some recruitment from the juvenile class to adult class, but no seedlings have been observed. Limited recruitment has occurred since ungulates were removed from the fence units. Rodents or game birds may be consuming propagules, seedlings, and juveniles. Further investigations into factors affecting recruitment are warranted.

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

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

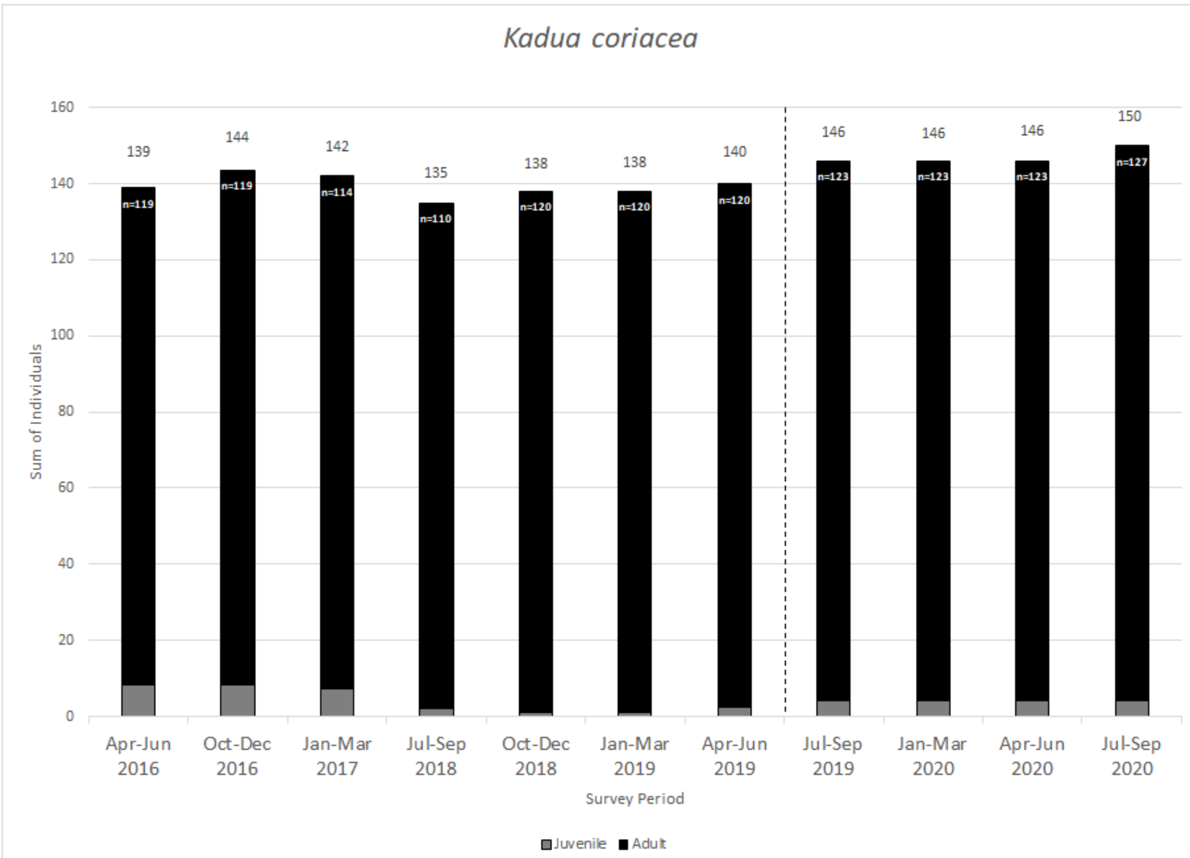

Figure 19. Monitoring results for *Kadua coriacea* from April 2016 through September 2020[a].

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

<u>Genetic Conservation</u>

Propagule Collection and Propagation

No propagule collection or propagation occurred during the reporting period. From previous propagation efforts there were 76 *K. coriacea* accessioned to the RPPF as of 31 July 2021. Please refer to Table 15 for a complete summary of genetic conservation status for *K. coriacea.*

Outplanting and Monitoring

We did not outplant *K. coriacea* this reporting period. In previous years, we planted a combined total of 583 *K. coriacea* at 7 ASRs (Table 22). At last monitoring in 2020, we found 7 adults at ASR 205 and 1 adult at ASR 211. Overall, there was a decline in the number of adults and juveniles (combined) present from 2104 to 2020.

Table 22. Monitoring results as of December 2020 for *Kadua coriacea* outplanted between 2004 and 2014.

Location	Area of Species Recovery	Total Outplanted 2004-2014	Total Present 2014		Total Present 2020		% Change 2014-2020	Seedlings 2020
			Adult	Juvenile	Adult	Juvenile		
Off PTA	201	75	0	0	0	0	0%	0
	202	63	0	0	0	0	0%	0
	203	19	5	11	0	0	-100%	0
	204	85	2	0	0	0	-100%	0
	<u>205</u>	316	72	73	7	0	-95%	0
On PTA	208	5	0	0	0	0	0%	0
	211	20	3	0	1	0	-67%	0

Note: The data source for planting activity between 2004-2014 and 2014 monitoring data is CEMML 2015. For Areas of Species Recovery, underline denotes juvenile/adult recruits were present in 2014.

In March/April 2019, we planted 107 *K. coriacea* at 8 sites on PTA (Table 23). As last monitoring in December 2020, there were 37 plants remaining at the sites.

Table 23. Monitoring results (2020) for *Kadua coriacea* outplanted in 2019.

Outplanting Site	Total Outplanted 2019	Outplants Remaining	Survivorship
Temp 2019-001	18	6	33%
Temp 2019-002	20	10	50%
Temp 2019-003	21	14	52%
Temp 2019-004	24	24	100%
Temp 2019-006	4	0	0%
Temp 2019-007	9	3	33%
Temp 2019-008	7	2	29%
Temp 2019-009	4	3	75%

Sites Temp 2019 001-004 were located in TA 22 and TA 23 near existing natural *K. coriacea* populations and sites Temp 2019 006-009 are all clustered within TA 21. Although TA 21 is outside the known or modeled distribution of *K. coriacea* (Price et al. 2012), planting at these locations allows us to evaluate this species' performance at higher elevations. Overall, survivorship was high for *K. coriacea* for the first 20 months following planting. The initial performance of the outplants at these sites is encouraging compared to previous outplanting efforts (Table 22).

Discussion

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

Kadua coriacea is found in the *Metrosideros* woodlands on the west side of the installation and found in the *Kadua coriacea*, Nāʻōhuleʻelua, and Kīpuka Kālawamauna East and West Fence Units (Figure 18). 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* population age distributions support healthy and resilient populations. In addition, we do not know which, if any, of the life stages is most vulnerable and/or may regulate population dynamics. Knowing these life history attributes is important for designing management actions to maximize the likelihood that *K. coriacea* will persist, and potentially increase, especially with changing climate conditions. We recommend exploring opportunities for basic research into life history characteristics to support science-based management of this species.

We continue to make progress with genetic conservation of *K. coriacea;* however, many of the seed accessions are older and we do not know how aging affects the viability of the seed. Prom previous propagation efforts, there were 76 *K. coriacea* accessioned to the RPPF as of 31 July 2021. 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.

Previous outplanting efforts conducted between 2004–2014 for *K. coriacea* have declined (Table 22). The only recruitment observed in 2014 was 1 juvenile at ASR 205. 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, the outplanting sites were within the historic or projected possible range for this species (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.

The *K. coriacea* planted in 2019 showed high survivorship at sites Temp 2019-001-004, which are all within the historic and possible range of *K. coriacea* (Price et al. 2012). Sites Temp 2019-006-009 are located at higher elevations outside the historic and possible range of *K. coriacea.* The outplant survivorship at these sights was moderately good and higher than expected 20 months after planting.

We recommend continuing to monitor all outplants, especially at the 2019 sites to help better understand habitat characteristics that may influence persistence overtime.

Exclosure Management

In April 2020, we removed wire fencing from 7 plant locations in ASR 11 and 3 plant locations in ASR 22. The small fences are redundant with the larger surrounding fences and may inhibit/restrict plant growth, require maintenance, and complicate monitoring the plants.

Progress toward compliance with Endangered Species Act Biological Opinion Conservation Measures

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

To address these conservation measures for *K. coriacea*, we implement landscape-level projects to reduce fire risk and ungulate browse for all known individuals at PTA (See Section 1.3). In addition, we actively conserve *K. coriacea* genetics; the propagule bank contains 103,331 seeds from the wild population and 280 seeds from individuals grown in the RPPF. To date, we have outplanted a combined total of 583 individuals at several ASRs. In 2021, only 5 individuals were present across all sites. We control invasive plants at all known locations of *K. coriacea* in an area of approximately 30 ha (Table 44). We have observed minimal *in situ* reproduction for *K. coriacea.* Although we monitor *K. coriacea* quarterly to assess population patterns, we are unable to attribute changes in numbers to effects from training or management.

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

2.4.4 *Lipochaeta venosa* (Endangered)

As a Tier 1 species, we monitored all known *L. venosa* locations each quarter in FY 2022. For genetic conservation, *L. venosa* is an implementation priority 1 (high). We plan to collect propagules for storage and propagation and outplant to augment the existing population and to establish new populations.

Plant Surveys and Monitoring

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

Based on survey work from 2011 to 2021, there were 17 locations of *L. venosa* at PTA. The distribution for *L. venosa*, including outplanting sites, is shown in Figure 20. This species is restricted to a single puʻu at PTA.

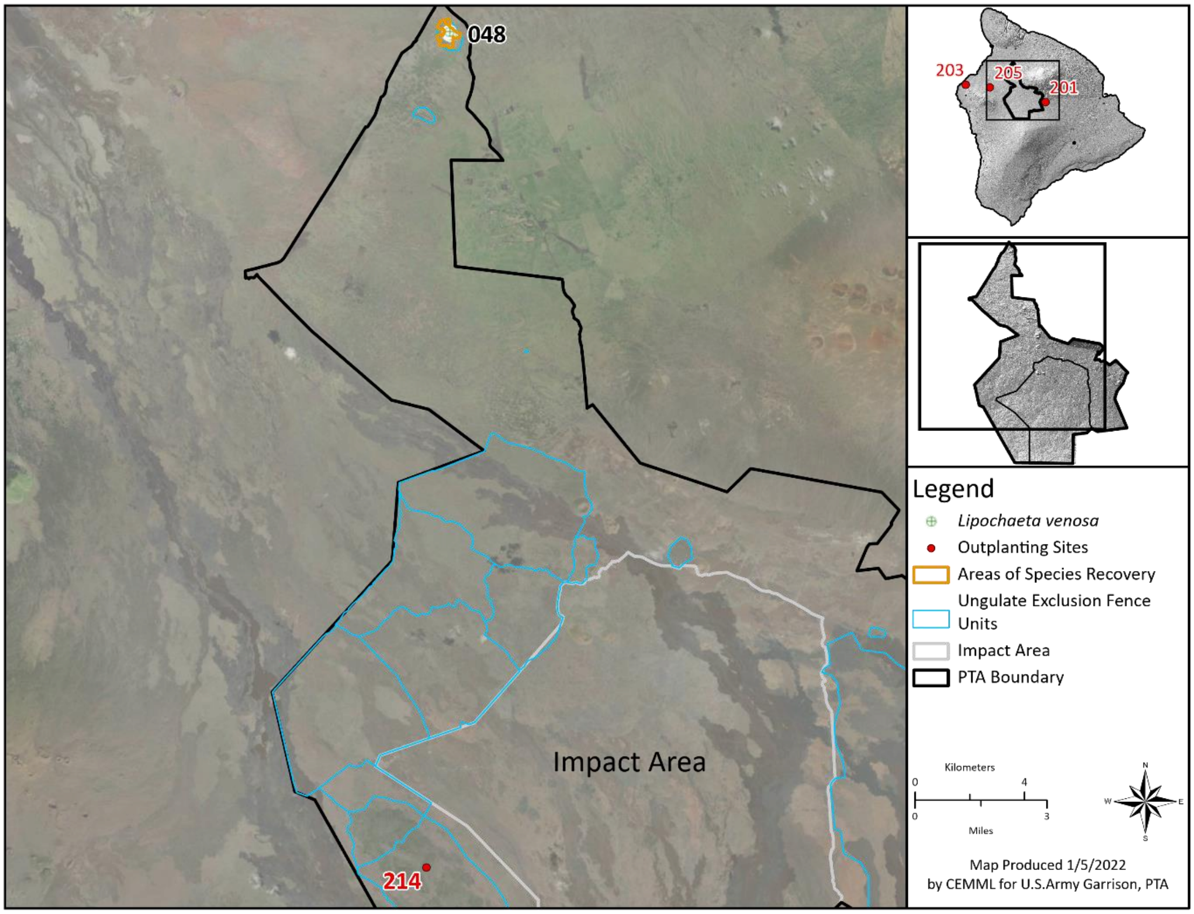

Figure 20. Current known distribution and outplanting sites for *Lipochaeta venosa*[a].

[a] The distribution is derived from a compilation of plant survey data (2011–2021), monitoring data, and incidental rare plant finds.

We counted all known *L. venosa* individuals over 12 periods between April 2016 and September 2019. The abundance of *L. venosa* fluctuated over the monitoring period (Figure 21). Juvenile counts were most variable among seasons and over time. Seedling counts were highly variable, with totals between zero and 10 most years. This variability in numbers and population structure is consistent with life history characteristics of short-lived, semi-woody herbs such as this species. Variability may have been influenced by growing conditions/available moisture and invasive plant management such as removal of the dominant fountain grass (*Cenchrus setaceus*) within *L. venosa* habitat.

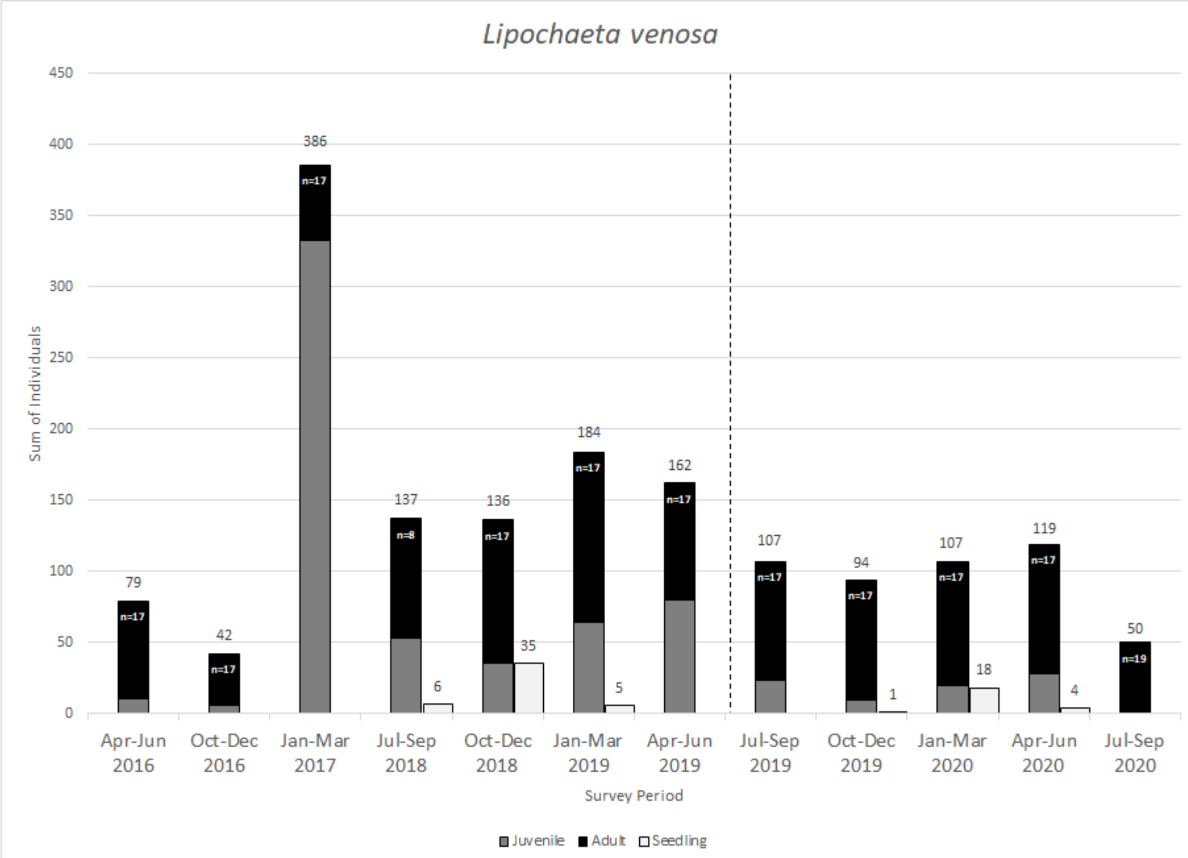

Figure 21. Monitoring results for *Lipochaeta venosa* from April 2016 through September 2020[a].

[a] For census periods left of the dotted line, we estimated life stage composition using proportion and to the right we counted each plant present by life stage (n= number of plots read). For census periods right of the dotted line, totals may include count class data. When this occurs the minimum value of the count class is used and summed with the counts from other plots to provide the total value for abundance. This is because the actual values represented within count classes were often not normally distributed. Therefore, these numbers represent the minimum number of individuals present during the census period.

<u>Genetic Conservation</u>

Propagule Collection and Propagation

No propagule collection or propagation occurred during the reporting period. From previous propagation efforts, there were 4 *L. venosa* accessioned to the RPPF as of 31 July 2021. Please refer to Table 15 for a complete summary of genetic conservation status for *L. venosa.*

Outplanting and Monitoring

We did not outplant *L. venosa* this reporting period. In previous years, we planted a combined total of 265 *L. venosa* at 4 ASRs. As of December 2020, adults and juveniles remained at ASRs 205 and 201 (Table 24). Plants at ASR 205 are growing in thick mats and up into trees and plants have recruited on site. However, there was a large decline in adults and juveniles (combined) present between 2014 and

2020. At ASR 201, the number of adults is low, but at least 4 adults recruited between 2014 and 2020 (400 % change in numbers present).

Table 24. Monitoring results as of December 2020 for *Lipochaeta venosa* outplanted between 2004 and 2014.

Location	Area of Species Recovery	Total Outplanted 2004-2014	Total Present 2014		Total Present 2020		% Change 2014-2020	Seedlings 2020
			Adult	Juvenile	Adult	Juvenile		
Off PTA	201	2	1	0	5	0	+400%	0
	203	28	0	0	0	0	0%	0
	205	234	176	5	28	5	-82%	0
On PTA	214	1	0	0	0	0	0%	0

Note: The data source for planting activity between 2004-2014 and 2014 monitoring data is CEMML 2015. For Areas of Species Recovery, underline denotes juvenile/adult recruits were present in 2014.

In 2019, we planted 16 *L. venosa* on Puʻu Pāpapa in the Keʻāmuku Maneuver Area in 2019. The plants represented 6 founders. Although historically known from Puʻu Pāpapa, *L. venosa* 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 2020, there were 14 *L. venosa* remaining at site Temp 2019-005. The survivorship for *L. venosa* was 88% about 20 months after planting. We are encouraged by the initial survivorship of *L. venosa* at site Temp 2019-005. However, outplanted *L. venosa* have not performed well at some outplanting sites but at ASRs 201 and 205 some outplants appear to be doing well and new plants are recruiting from the seed bank (Table 24).

Discussion

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

Lipochaeta venosa is restricted to 0.5 ha on Puʻu Nohona o Hae in the KMA. Since 2002, the *L. venosa* population has declined and its distribution contracted. Prior to 2002, *L. venosa* was believed to be present on 6 puʻu in Parker Ranch lands including Puʻu Nohona o Hae and Puʻu Pāpapa (Arnett 2002). In 2002, *L. venosa* was estimated at 1,250 plants on Puʻu Nohona o Hae and no plants were found on Puʻu Pāpapa (Arnett 2002). Since 2002, *L. venosa* decreased by 97% to 42 plants in 2017 (Figure 20). Additionally, the distribution on Puʻu Nohona o Hae contracted from 225 ha to 0.5 ha (99%).

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

In response to the decline, in 2016 we initially removed *Cenchrus setaceus* from about 1.7 ha in ASR 48 on Puʻu Nohona o Hae to reduce resource competition, to improve community structure, and to promote favorable microsite conditions likely to support the persistence of *L. venosa*. Following grass removal and a period of increased precipitation, the common native species increased in size, and we observed recruitment of common native plants from the seed bank. In addition, *L. venosa* numbers increased coincidentally with the pulse in moisture. The number of extant adults was relatively stable for FY 2017–2019 (census periods 5 through 9 in Figure 21).

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

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

Very few *L. venosa* were planted from 2004 to 2014 with most plants planted at ASR 205 (Table 24). Although there were 33 *L. venosa* adults and juveniles (combined) present at ASR 205 in December 2020, this represents an 83% decline from the number present in 2014. ASR 205 is the only site where we documented recruitment; however, the level of recruitment is not high enough to off-set losses. The number of *L. venosa* increased from 2014 to 2020 at ASR 201. We were 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 projected possible range for *L. venosa* (Price et al. 2012), so we are keenly tracking the performance to learn more about its performance at high elevation. Outplanting is a high priority for *L. venosa* 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.

The *L. venosa* planted in 2019 showed moderate survivorship at site Temp 2019-005, which is within the historic and possible range of *L. venosa* (Price et al. 2012). We recommend continuing to monitor all outplants, especially at the 2019 sites to help better understand habitat characteristics that may influence persistence overtime.

Progress toward Compliance with Endangered Species Act Biological Opinion Conservation Measures

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

To address these conservation measures for *L. venosa*, we implement landscape-level projects to reduce fire risk and ungulate browse for all known individuals at PTA (See Section 1.3). In addition, we actively conserve *L. venosa* genetics; the propagule bank contains 336 seeds from the natural population and 37 seeds from individuals grown in the RPPF. In 2019, we planted 15 *L. venosa* on Puʻu Pāpapa, representing 6 founders. In addition, prior to 2019, we outplanted a combined total of 265 individuals at 4 ASRs, but *L. venosa* has only persisted at ASR 205 (Puʻu Waʻawaʻa) where it has spread vegetatively to cover large areas. We consider this group of *L. venosa* to be self-sustaining because of its persistence, the suite of founders planted, and successful vegetative reproduction. We continue weed management in ASR 48 across about 1.7 ha (Table 44). Between 2016 and 2019, we observed *in situ* reproduction in 3 of 17 (18%) monitoring plots for *L. venosa.* Although we monitor *L. venosa* quarterly to assess population patterns, we are unable to attribute changes in numbers to effects from training or management.

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

2.4.5 *Neraudia ovata* (Endangered)

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

Plant Surveys and Monitoring

During the reporting period, we did not find any natural occurrences of *N. ovata.* This outcome is not surprising because we did not survey within the known distribution of this species.

Based on survey work from 2011 to 2021, there were 24 locations of *N. ovata* at PTA. The abundance of this species is tracked quarterly and reported below. The distribution for *N. ovata*, including outplanting sites, is shown in Figure 22.

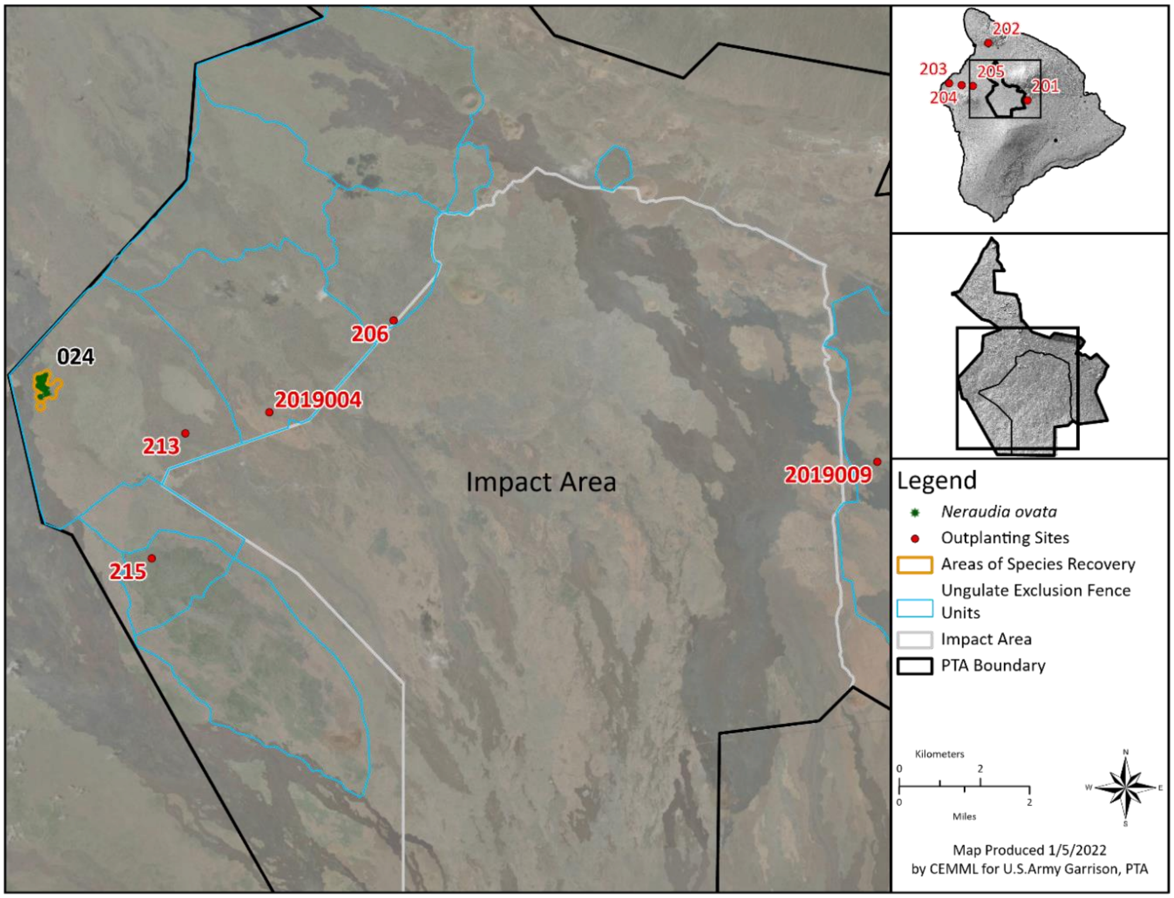

Figure 22. Current known distribution and outplanting sites for *Neraudia ovata*[a].

[a] The distribution is derived from a compilation of plant survey data (2011–2021), monitoring data, and incidental rare plant finds.

We counted *N. ovata* over 12 periods between July 2016 and September 2019. Overall, the number of *N. ovata* known to occur at PTA has remained relatively stable over the 4-year monitoring period (Figure 23). The number of juveniles and adults combined was lowest during several summer/fall cycles. The abundance of adults remained generally constant, with periodic recruitment into the seedling and juvenile life stages between quarters. *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 stage, is consistent with expected life history characteristics.

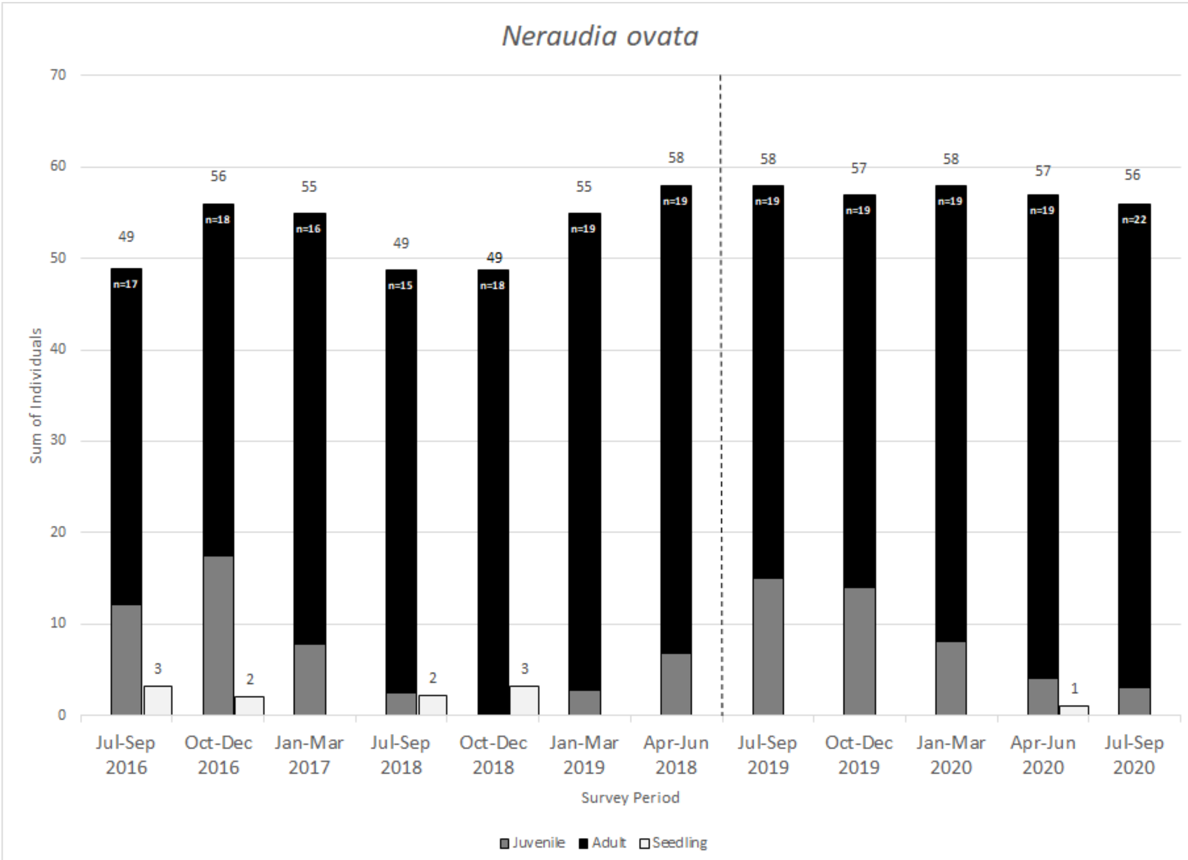

Figure 23. Monitoring results for *Neraudia ovata* from April 2016 through December 2020[a].

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

Genetic Conservation

Propagule Collection and Propagation

No propagule collection or propagation occurred during the reporting period. From previous propagation efforts, there were 79 *N. ovata* accessioned to the RPPF as of 31 July 2021. Please refer to Table 15 for a complete summary of genetic conservation status for *N. ovata.*

Outplanting and Monitoring

We did not outplant *N. ovata* during the reporting period. In previous years, we planted a combined total of 419 *N. ovata* at 10 ASRs (Table 25). As of December 2020, 73 adults and 7 juveniles remained at the sites. In addition, we documented seedlings at ASR 205. At all sites the number of adults and juveniles (combined) present declined between 2014 and 2020, except for ASR 213 where the number of *N. ovata* increased substantially.

Table 25. Monitoring results as of December 2020 for *Neraudia ovata* outplanted between 2004 and 2014.

Location	Area of Species Recovery	Total Outplanted 2004-2014	Total Present 2014		Total Present 2020		% Change 2014-2020	Seedlings 2020
			Adult	Juvenile	Adult	Juvenile		
Off PTA	201	117	63	0	4	0	-94%	0
	202	16	0	0	0	0	0%	0
	203	31	39	86	0	0	-100	0
	204	42	2	270	4	0	-99%	0
	205	132	50	10	9	4	-78%	17
On PTA	206	4	2	1	1	0	-67%	0
	211	3	0	0	0	0	0%	0
	213	54	2	0	55	3	+2,800%	0
	215	12	1	0	0	0	-100%	0
	217	8	0	0	0	0	0%	0

Note: The data source for planting activity between 2004-2014 and 2014 monitoring data is CEMML 2015. For Areas of Species Recovery, bold denotes seedlings and underline denotes juvenile/adult recruits were present in 2014.

In 2019, we outplanted 9 *N. ovata*, representing 5 founders, at a new planting location Temp 2019-009 in TA 21. The 9 plants were propagated from cuttings from founders that were established in the RPPF. As of December 2020, 3 adult plants remained at the site (33% survivorship).

Although TA 21 is outside the historical or projected range of *N. ovata*, we continue to explore the upper elevational range of this species using founder clones. In past years, we have documented survivorship of *N. ovata*, but no recruitment, at Puʻu Huluhulu (ASR 201), which is higher in elevation than the new planting location in TA 21. We have documented survivorship and recruitment at ASR 213, which is outside the historical and projected range for *N. ovata*, but lower in elevation than the new planting site.

Discussion

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

N. ovata naturally occurs as solitary individuals or small isolated groups only within ASR 24 at PTA (Figure 22). In 1997, *N. ovata* was reduced to 10 mature individuals at PTA. Since then, extensive management at ASR 24 has included small- and large-scale fencing to protect the plants from ungulate browse, invasive plant control and rodent management. *N. ovata* recruits from the seed bank in an episodic manner, with large recruitment events occurring during favorable environmental conditions. Quarterly monitoring shows a relatively stable adult population with periodic flushes of seedlings and juvenile plants. As of the last quarterly monitoring between July and September 2020, 56 *N. ovata* adults and juveniles were present. However, we know little about *N. ovata* age distributions that support healthy and resilient populations. In addition, we do not know which, if any, of the life stages is most vulnerable and/or may regulate population dynamics. Knowing these life history attributes is important for designing management actions to maximize the likelihood that *N. ovata* will persist, and potentially increase, especially with changing climate conditions. We recommend exploring opportunities for basic research into life history characteristics to support science-based management of this species.

We continue to make progress with genetic conservation of *N. ovata.* Many of the accessions in storage are older and we do not know how aging affects the viability of the seed. Seed gemination remains low and success with cuttings is moderate. We need to know more about seed characteristics prior to sowing and the influence of these characteristics on germination outcomes. Without more basic information about seed quality and viability, we will likely continue to experience variability in seed germination success. There are 79 *N. ovata* accessioned to the RPPF. We are developing planting strategies and plan to continue investigating outplant performance and planting site characteristics in 2022 to maximize the successful establishment of new self-sustaining groupings.

Previous outplanting efforts for *N. ovata* have not established self-sustaining populations and at most sites the number of adults and juveniles (combined) present declined from 2014 to 2020 (Table 25). *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 ASR 203 and ASR 204, but *N. ovata* failed to establish a self-sustaining population at ASR 203 and showed a sharp decline in numbers at ASR 204. However, *N. ovata* increased in number at ASR 213 between 2014 and 2020 by 29-fold. The reasons why *N. ovata* has performed so well at ASR 213 are as unclear as the reasons why it did so poorly at the other sites. As we continue to work with outplanting *N. ovata,* we recommend monitoring site conditions in conjunction with plant performance to help better understand habitat requirements for this species to better design planting protocols.

The *N. ovata* planted in 2019 showed moderate survivorship at site Temp 2019-009, which is outside the historic and possible range of *N. ovata* (Price et al. 2012). However, we anticipate these plantings will not persist over the long-term due to the elevation of the sites. We recommend future planting be done with the modeled range for this species. We recommend continuing to monitor all outplants, especially at the 2019 sites to help better understand habitat characteristics that may influence persistence overtime.

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 browse pressure, maintenance of genetic stock *ex situ*, outplanting, reproduction *in situ*, non-native plant control, and annual monitoring.

To address these conservation measures for *N. ovata*, we implement landscape-level projects to reduce fire risk and ungulate browse for all known individuals at PTA (See Section 1.3). In addition, we actively conserve *N. ovata* genetics; the propagule bank contains 6,130 seeds from the wild population and 236,474 seeds from individuals grown in the RPPF as living collections. To date, we have outplanted a combined total of 419 individuals at 10 ASRs and *N. ovata* has persisted at 5 ASRs. However, *N. ovata* outplants appear to perform better and recruit offspring at lower elevation sites. We continue invasive plant management in ASR 24 across about 7.8 ha (Table 44). Between 2016 and 2019, we observed *in situ* reproduction in 1 of 19 (5%) monitoring plots for *N. ovata.* Although we monitored *N. ovata* quarterly to assess population patterns, we are unable to attribute changes in numbers to effects from training or management.

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

2.4.6 *Portulaca sclerocarpa* (Endangered)

As a Tier 1 species, we monitored all known *P. sclerocarpa* locations each quarter in FY 2020. For genetic conservation, *P. sclerocarpa* is an implementation priority 3 (moderate). We plan to collect propagules for storage and propagation and to outplant judiciously to establish new populations.

Plant Surveys and Monitoring

During the reporting period, we found or reconfirmed 8 locations of *P. sclerocarpa.* In addition to surveys within the fence units, we also surveyed historic locations on Puʻu Nohona o Hae in KMA that were identified as *P. sclerocarpa* in 1985 (Pratt et al. 2010), but no *P. sclerocarpa* were found at those locations. See Section 2.2.2 for survey details.

Based on survey work from 2011 to 2021, there are 60 locations of *P. sclerocarpa* at PTA. The abundance of this species is tracked quarterly and reported below. The distribution for *P. sclerocarpa*, including outplanting sites, is shown in Figure 24.

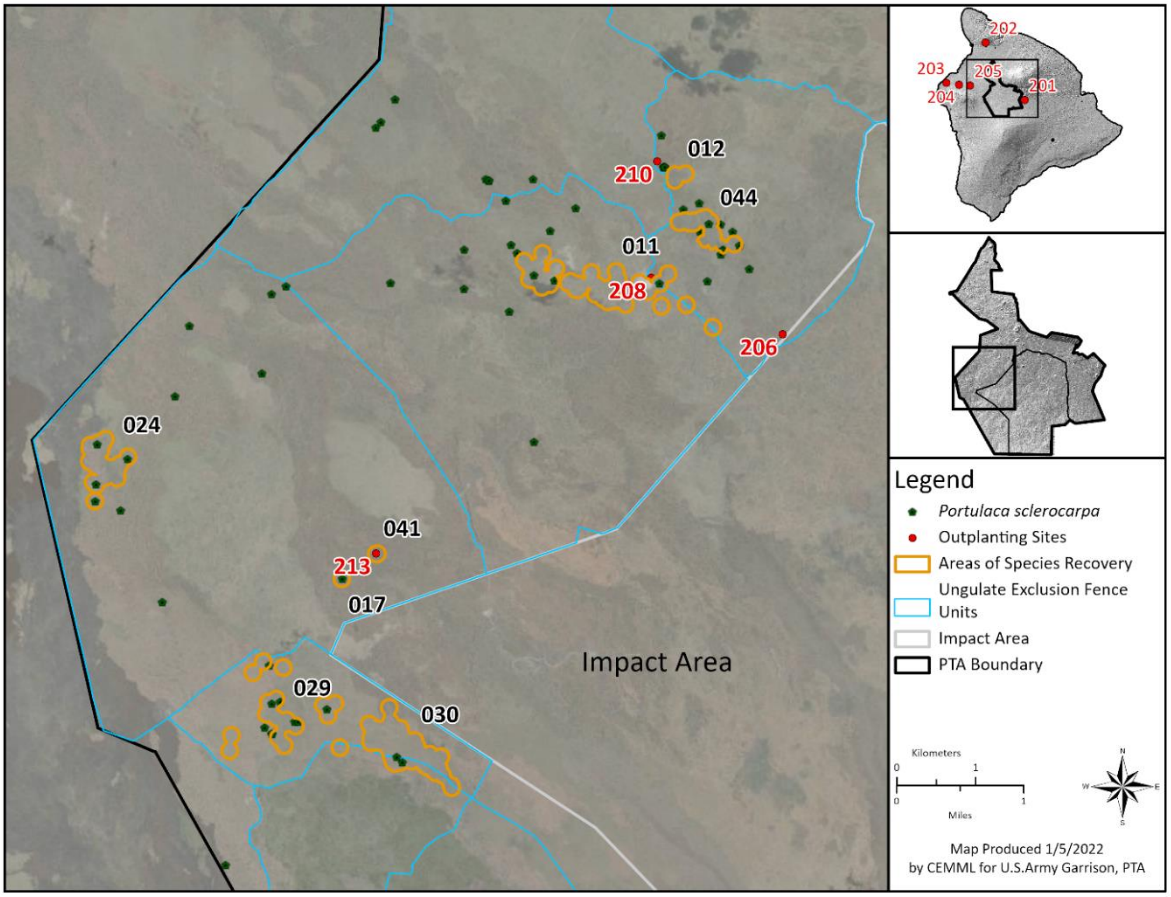

Figure 24. Current known distribution of *Portulaca sclerocarpa*[a].

[a] The distribution is derived from a compilation of plant survey data (2011–2021), monitoring data, and incidental rare plant finds.

We monitored *P. sclerocarpa* over 12 periods between April 2016 and September 2020. For all *P. sclerocarpa* plots visited each monitoring cycle, we counted all individuals present in each life stage: seedling, juvenile, and adult. Overall, there was a large increase in *P. sclerocarpa* between the first and last monitoring cycles (Figure 25). Seedling abundance is highly variable and was highest during 2019; mortality of seedlings and juveniles cannot be determined from the available data. Increased population size in 2019 and 2020 may be related to favorable growing conditions and management of stressors through ungulate exclusion and weed control.

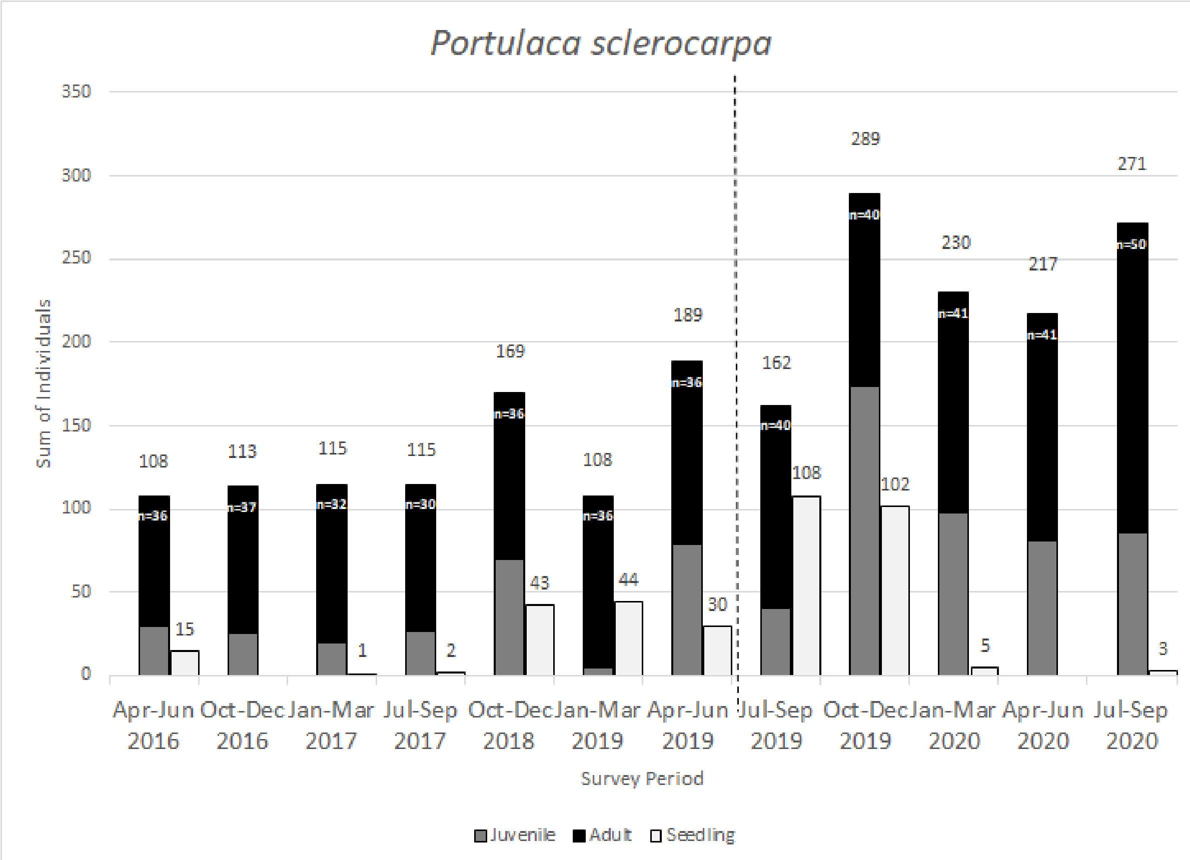

Figure 25. Monitoring results for *Portulaca sclerocarpa* from April 2016 through September 2020[a].

[a] For census periods left of the dotted line, we estimated life stage composition using proportion and to the right we counted each plant present by life stage (n=number of plots read). For census periods right of the dotted line, totals may include count class data. When this occurs the minimum value of the count class is used and summed with the counts from other plots to provide the total value for abundance. This is because the actual values represented within count classes were often not normally distributed. Therefore, these numbers represent the minimum number of individuals present during the census period.

<u>Genetic Conservation</u>

Propagule Collection and Propagation

We collected 6 fruits for *ex situ* storage (Table 26). In addition, we collected leaves and voucher specimens to support a genetic analysis (Table 27). Leaves were sent to University of Hawaii for genetic testing and the cuttings were pressed and sent as voucher specimens to the Bernice Pauahi Bishop Museum herbarium for disposition. Information about the genetic analysis is reported in the discussion below.

Table 26. Propagule collections of *Portulaca sclerocarpa* for *ex situ s*torage.

Founder No.	Source	USFWS Pop Ref Code	Propagule Type	Amount Collected	Prop. Accession Number	Disposition
520-1677-002-002	Field	KAN	Fruit	2	2020002	Storage
520-1577-050-001	Field	KAN	Fruit	2	2020001	Storage
520-1577-001-003	Field	KAN	Fruit	2	2020003	Storage

KAN, Kīpuka Kālawamauna; NRP, Natural Resource Program

Table 27. Propagule collections of *Portulaca sclerocarpa* for genetic analysis.

Founder No.	USFWS Pop Ref Code	Propagule Type	Amount Collected	Prop. Accession Number
515-2183-001-001	KEN	Leaves	5	Genetic testing
		Cutting	1	Voucher
515-2083-017-001	KEN	Leaves	5	Genetic testing
		Cutting	1	Voucher
515-2183-020-002	KEN	Leaves	5	Genetic testing
		Cutting	1	Voucher
515-2183-052-201	KEN	Leaves	5	Genetic testing
		Cutting	1	Voucher
515-2184-007-101	KEN	Leaves	5	Genetic testing
		Cutting	1	Voucher
517-1882-032-101	NWE	Leaves	5	Genetic testing
		Cutting	1	Voucher
517-1883-029-001	NNW	Leaves	5	Genetic testing
		Cutting	1	Voucher
517-1883-029-003	NNW	Leaves	5	Genetic testing
		Cutting	1	Voucher
517-1883-030-101	NNW	Leaves	5	Genetic testing
517-1883-046-101	NWE	Leaves	5	Genetic testing
		Cutting	1	Voucher
517-1983-026-001	NNW	Leaves	5	Genetic testing
		Cutting	1	Voucher
517-1983-026-002	NNW	Leaves	5	Genetic testing
518-1481-049-001	KWS	Leaves	5	Genetic testing
		Cutting	1	Voucher
519-1380-001-101	MTW	Leaves	5	Genetic testing
		Cutting	1	Voucher
519-1380-002-005	MTW	Leaves	5	Genetic testing
		Cutting	1	Voucher
519-1380-008-101	MTW	Leaves	5	Genetic testing
519-1380-010-002	MTW	Leaves	5	Genetic testing
520-1577-001-003	KAN	Leaves	5	Genetic testing
520-1577-003-002	KAN	Leaves	3	Genetic testing

Table 27. Propagule collections of *Portulaca sclerocarpa* for genetic analysis (cont.).

Founder No.	USFWS Pop Ref Code	Propagule Type	Amount Collected	Prop. Accession Number
520-1577-003-003	KAN	Leaves	2	Genetic testing
520-1577-048-001	KAN	Leaves	5	Genetic testing
520-1577-050-001	KAN	Leaves	5	Genetic testing
		Cutting	1	Voucher
520-1677-002-001	KAN	Leaves	1	Genetic testing
520-1677-002-002	KAN	Leaves	4	Genetic testing
520-1677-002-002	KAN	Cutting	1	Voucher

KAN, Kīpuka ʻAlalā North Fence; KEN, Kīpuka Kālawamauna East Fence – North Old Bobcat Trail; KWS, Kīpuka Kālawamauna West Fence - South; NNW, Nāʻōhuleʻelua Fence – Northwest of Old Bobcat Trail; NWE, Nāʻōhuleʻelua Fence – West; MTW, Mixed Tree Fence – West

No propagation occurred this reporting period. From previous propagation efforts, there were 57 *P. sclerocarpa* accessioned to the RPPF as of 31 July 2021. Refer to Table 15 for a complete summary of genetic conservation status for *P. sclerocarpa.*

Outplanting and Monitoring

We did not outplant *P. sclerocarpa* during the reporting period. In previous years, we planted a combined total of 271 *P. sclerocarpa* in 10 ASRs (Table 28). As of December 2020, no outplanted plants remained at any of the sites. 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.

Table 28. Monitoring results as of December 2020 for *Portulaca sclerocarpa* outplanted between 2004 and 2014.

Location	Area of Species Recovery	Total Outplanted 2004-2014	Total Present 2014		Total Present 2020		% Change 2014-2020	Seedlings 2020
			Adult	Juvenile	Adult	Juvenile		
Off PTA	201	117	0	0	0	0	-100%	0
	202	16	0	0	0	0	-100%	0
	203	31	0	0	0	0	-100%	0
	204	42	0	0	0	0	-100%	0
	<u>205</u>	132	10	1	0	0	-100%	0
On PTA	206	4	0	0	0	0	-100%	0
	208	3	0	0	0	0	-100%	0
	210	54	0	0	0	0	-100%	0
	213	12	2	0	0	0	-100%	0
	214	8	6	0	0	0	-100%	0

Note: The data source for planting activity between 2004-2014 and 2014 monitoring data is CEMML 2015. For Areas of Species Recovery, underline denotes juvenile/adult recruits were present in 2014.

In 2019, we outplanted 18 *P. sclerocarpa*, representing 2 founders, in TA 22 at planting site Temp 2019-003). Although *P. sclerocarpa* is not a high implementation priority for outplanting per the 2017

Genetic and Outplanting Plan, several plants were ready for planting, and we continue to investigate appropriate planting site characteristics.

In December 2020, there were 9 *P. sclerocarpa* remaining at site Temp 2019-003 (50% survivorship). We are encouraged by the survivorship about 20 months after planting in March/April 2019. The performance of *P. sclerocarpa* outplants at other locations has been very poor.

Discussion

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

At PTA, *P. sclerocarpa* occurs in small clusters of plants and is widely distributed with several kilometers between plant clusters, which typically range from 1 to 5 plants. Most *P. sclerocarpa* locations are outside designated ASRs (Figure 24). Due to a decline in the *P. sclerocarpa* population at Hawaiʻi Volcanoes National Park (estimated at 200 individuals in 2010), the population at PTA now represents a large proportion of the state-wide population (USFWS 2010). At last quarterly monitoring, we counted 271 *P. sclerocarpa* (adults and juveniles). In 2010, the USFWS estimated the statewide population to be about 200 natural individuals, underscoring the importance of the *P. sclerocarpa* at PTA to the persistence of this species globally.

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

We continue to make progress with genetic conservation for *P. sclerocarpa.* Many of the accessions in storage are from plants growing in the RPPF. Past efforts to propagate seed was variable and ranged from none to 100%. We need to know more about seed characteristics prior to sowing and the influence of these characteristics on germination outcomes. Without more basic information about seed quality and viability, we will likely continue to experience variability in seed germination success. In addition, we noted that relatively few seedlings successfully transition to established plants. More investigation is needed to understand this critical step to improve cultivation success. There are 57 *P. sclerocarpa* accessioned to the RPPF.

Portulaca sclerocarpa is not self-sustaining at any of the outplanting sites; outplants were relatively short-lived, and no recruitment was documented. Of the 18 *P. sclerocarpa* planted in 2019, 9 remained in December 2020. Over the 20-month period survivorship was 50%, which is relatively high for this species. Other outplanting efforts for *P. sclerocarpa* at PTA (CEMML 2016) and at Hawaiʻi

Volcanoes National Park (Belfield et al. 2011) also resulted in low survivorship and overall success. The factors limiting establishment are poorly understood. We plan to continue investigating outplant performance and planting site characteristics to better understand this species' habitat requirements.

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*. Since *P. villosa* was listed by the USFWS as endangered in 2016, we are interested to know if both species are present at PTA to prepare TES consultation documents more accurately.

Dr. Cliff Morden at the University of Hawaiʻi performed a sequence related amplified polymorphism (SRAP) test on the samples to evaluate the genetic relatedness among the samples submitted. A total of 51 samples from across the state were submitted for the study. In 2021, additional samples from the plants identified as *P. villosa* at PTA were requested to re-run the analysis for those samples.

Preliminary results from the genetic study indicate that there is a distinct difference between plants identified as *P. sclerocarpa* and *P. villosa* from across the state (C. Morden, personal communication, 20 October 2021). Plants identified as *P. villosa* at PTA showed some genetic variation from the plants identified as *P. sclerocarpa.* However, it remains unclear if the genetic difference detected between the plants at PTA indicates 2 distinct species. We will continue to track the locations identified as *P. villosa* separately from *P. sclerocarpa* until the outcome of the study is finalized.

Progress toward Compliance with Endangered Species Act Biological Opinion Conservation Measures

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

To address these conservation measures for *P. sclerocarpa*, we implement landscape-level projects to reduce fire risk and ungulate browse for all known individuals at PTA (See Section 1.3). Between 2016 and 2019, we observed *in situ* reproduction in 7 of 41 (17%) monitoring plots for *P. sclerocarpa.* Although not specifically mentioned in the 2003 BO, as part of the INRMP objectives we actively conserve *P. sclerocarpa* genetics; the propagule bank contains 610 fruit and 32,761 seeds from founders in the field and 8,734 fruits from founders in the RPPF. To date, we have outplanted a combined total of 271 individuals at 10 ASRs, but *P. sclerocarpa* has only persisted at Temp 2019-003. In addition, per INRMP objectives, *P. sclerocarpa,* in conjunction with *S. lanceolata,* receives the benefits of weed management in ASR 44 across about 3 ha (Table 44). Although we monitor *P. sclerocarpa* quarterly to assess population patterns, we are unable to attribute changes in numbers to effects from training or management.

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

2.4.7 *Portulaca villosa* (Endangered)

As a Tier 1 species, we monitored all known *P. villosa* locations each quarter in FY 2020. For genetic conservation, *P. villosa* is an implementation priority 3 (moderate). We plan to collect propagules for storage and propagation and to outplant judiciously to establish new populations.

<u>Plant Surveys and Monitoring</u>

No locations of *P. villosa* were recorded during the reporting period. In addition to surveys within the fence units, we also surveyed historic locations on Puʻu Keʻekeʻe in TA 16 and Puʻu Nohona o Hae in KMA that were identified as *P. villosa* in 1997 (Shaw 1997) and 2002 (Arnett 2002), respectively. No *P. villosa* locations were found. See Section 2.2.2 for survey details.

Based on survey work from 2011 to 2021, there are 2 locations considered *P. villosa* at PTA. The distribution for *P. villosa* is shown in Figure 26.

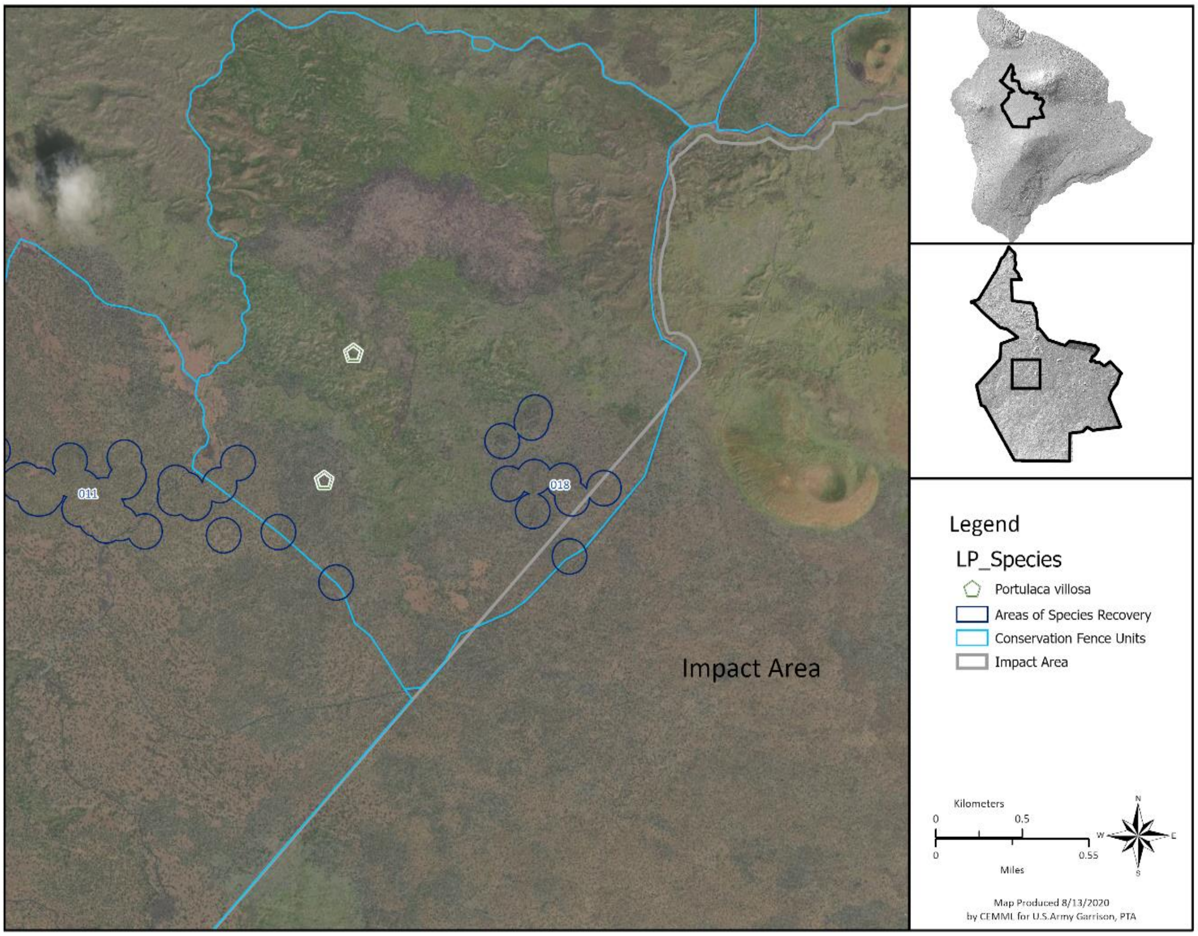

Figure 26. Current known distribution of *Portulaca villosa*[a].

[a] The distribution is derived from a compilation of plant survey data (2011–2021), monitoring data, and incidental rare plant finds.

We counted *P. villosa* over 12 periods between April 2016 and September 2020. We counted all individuals of this species by life stage: seedlings, juveniles, and adults (Figure 27). The *P. villosa* population at PTA occurs at the highest elevation documented for this species. *P. villosa* has not been very abundant at PTA historically (Shaw 1997). This is perhaps due to this population existing on the edge of its ecological range.

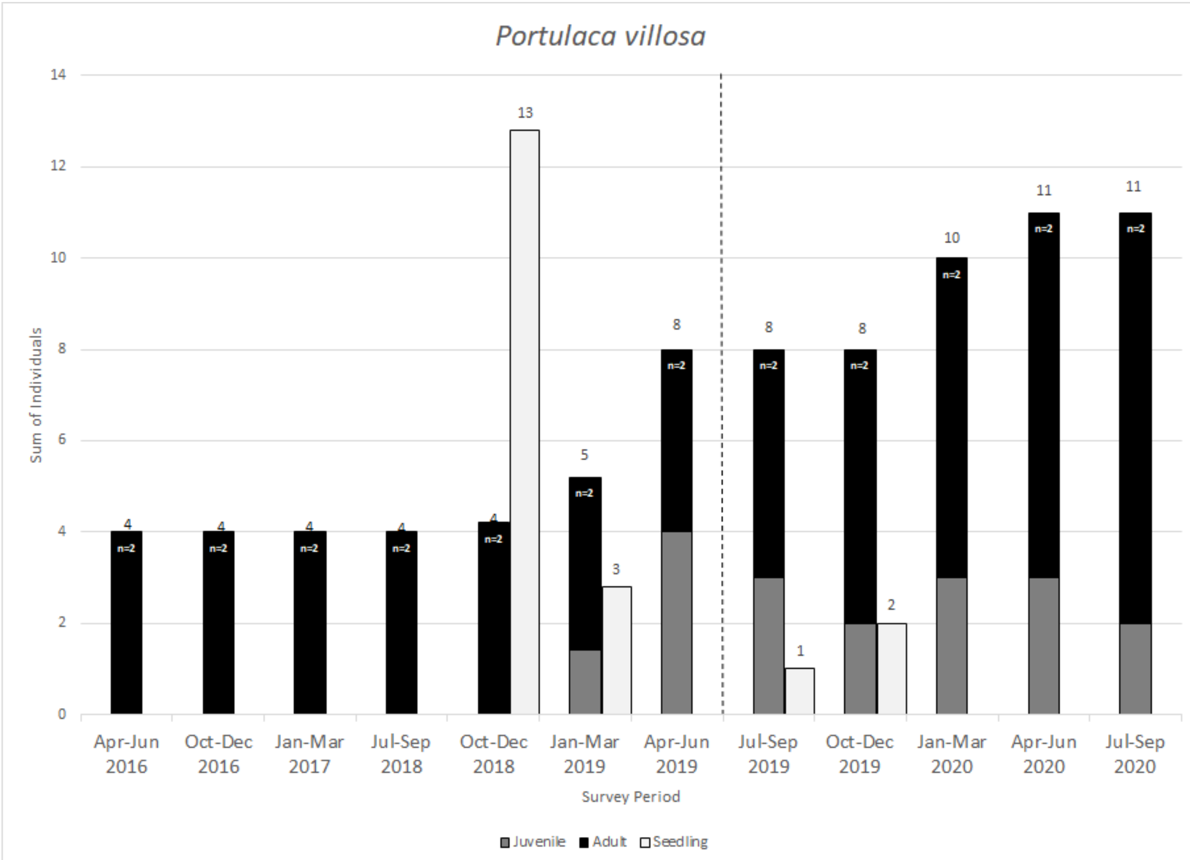

Figure 27. Monitoring results for *Portulaca villosa* from April 2016 through September 2020[a].

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

Genetic Conservation

Propagule Collection and Propagation

We collected leaves and voucher specimens to support a genetic analysis (Table 29). Leaves were sent to University of Hawaii for genetic testing and the cuttings were pressed and sent as voucher specimens to the Bernice Pauahi Bishop Museum herbarium for disposition. See the discussion in Section 2.4.6 for details regarding the genetic study.

No propagation occurred during the reporting period. From past propagation efforts, there were 37 *P. villosa* accessioned to the RPPF as of 31 July 2012. Refer to Table 15 for a complete summary of genetic conservation status for *P. sclerocarpa.*

Table 29. Propagule collections of *Portulaca villosa* for genetic analysis.

Founder No.	USFWS Pop Ref Code	Propagule Type	Amount Collected	Prop. Accession Number
515-2183-001-001	KEN	Leaves	9	Genetic testing
		Cutting	1	Voucher
516-2183-002-001[a]	KEN	Leaves	3	Genetic testing
516-2183-002-002	KEN	Leaves	3	Genetic testing
516-2183-002-004	KEN	Leaves	8	Genetic testing
		Cutting	1	Voucher
516-2183-002-005	KEN	Leaves	3	Genetic testing

KEN, Kīpuka Kālawamauna East Fence – North Old Bobcat Trail, KES, Kīpuka Kālawamauna East Fence - South of Old Bobcat Trail.

Note: Some *Portulaca villosa* founder numbers are slightly differently between this report, the 2020 Recovery Permit Report, and the samples submitted for genetic testing due to a mistake in the plant location number. The following *P. villosa* founder numbers refer to the same location (GPS coordinate E 221136 N2183044): 515-2183-003 (genetic samples), 516-2183-003 (2020 report), and 516-2183-002 (2021 report).

[a] Samples from founder 516-2183-002-001 were submitted for genetic testing under the number 515-2183-003-003.

Outplanting and Monitoring

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

Discussion

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

At PTA, the plants believed to be *P. villosa* occur in small clusters within the Kīpuka Kālawamauna East Fence Unit and the plant clusters are widely distributed with several kilometers between the clusters (Figure 26). At last quarterly monitoring, we counted 11 adults and juveniles.

Although quarterly monitoring is not designed to specifically track transition between life stages, patterns in the quarterly counts suggest that seedling flushes support recruitment to juvenile and adult classes. However, we know little about *P. villosa* age distributions to support healthy and resilient populations. We know little about the ecological requirements of *P. villosa* at the high elevations of PTA. We aim to gather basic life history information for *P. villosa* as we continue to monitor and manage this species.

There are 37 *P. villosa* accessioned to the RPPF. We are developing planting strategies and plan to continue investigating outplant performance and planting site characteristics in 2022 to maximize the successful establishment of new self-sustaining groupings.

Genetic Study for Portulaca Species

See the discussion in Section 2.4.6 for details regarding the genetic study of *Portulaca* specimens.

In addition, inconsistencies in plant location numbers have contributed to the misidentification and mislabeling of samples collected for the genetic analysis. The *P. villosa* location within the Kīpuka Kālawamauna East Fence – South of Old Bobcat Road was given 2 location numbers under 2 numbering systems – 06-2183-003 (older, no longer used) and 516-2183-002 (current number). In 2020, leaf and voucher samples were taken from location 516-2183-002 from plant 004, but were submitted for analysis under number 516-2183-003-004, which is a hybrid of the old and new numbering systems. Then in 2021, leaf samples were again taken from location 516-2183-002 from plants 002-005 but were submitted under number 515-2183-003. In addition, leaf samples were taken from plant 001 and not plant 003 as verified by photos taken at the time of collection. So, sample 515-2183-003-003 is actually from plant 001. We are certain that all samples submitted with slightly different location numbers are in fact from the same GPS coordinates. The issues we experienced with this small project underscored the issues with the existing plant location naming convention. Moving forward, we recommend discontinuing use of these long, complex numbers and moving to a system of sequential integers to denote plant locations.

Progress toward INRMP Objectives

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

To manage threats proactively for *P. villosa*, we implement landscape-level projects to reduce fire risk and ungulate browse for all known individuals at PTA (see Section 1.3). Between 2016 and 2019, we observed *in situ* reproduction in 1 of 2 (50%) monitoring plots for *P. villosa.* We actively conserve *P. villosa* genetics and have 4,833 seeds representing 3 natural founders in the propagule bank. At this time, we have not implemented weed control for this species. Although we monitored *P. villosa* quarterly to assess population patterns, we are unable to attribute changes in numbers to effects from training or management.

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

2.4.8 *Schiedea hawaiiensis* (Endangered)

As a Tier 1 species, we monitored all known *Schiedea hawaiiensis* locations each quarter in FY 2020. For genetic conservation, *Schiedea hawaiiensis* is an implementation priority 3 (moderate). We plan to collect propagules for storage and propagation and to outplant judiciously to establish new populations.

Plant Surveys and Monitoring

We did not find or reconfirm any locations of *Schiedea hawaiiensis* during the reporting period. This is not surprising because this species is extremely limited in distribution and abundance.

Based on survey work from 2011 to 2021, there are 2 wild locations of *Schiedea hawaiiensis* at PTA. The distribution for *Schiedea hawaiiensis*, including outplanting sites, is shown in Figure 28.

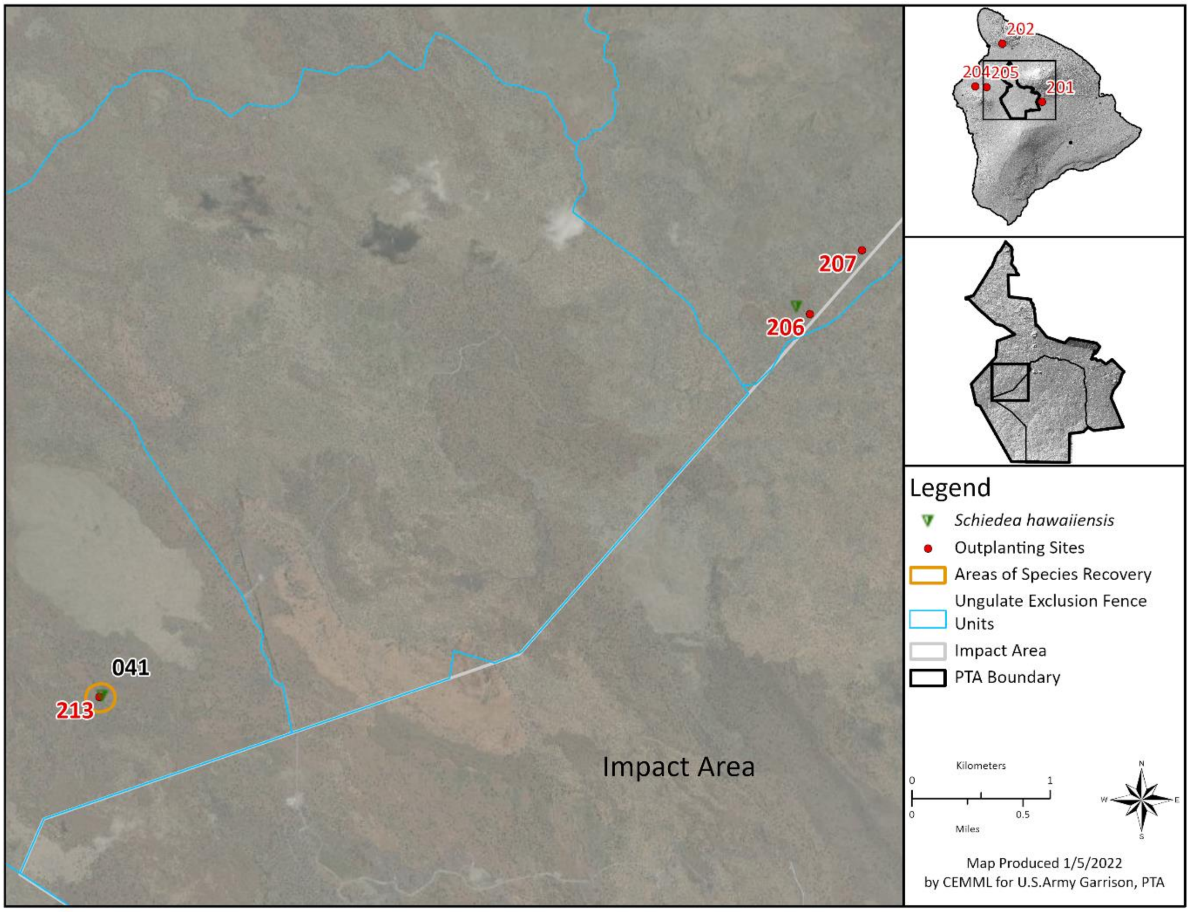

Figure 28. Current known distribution and outplanting sites for *Schiedea hawaiiensis*[a].

[a] The distribution is derived from a compilation of plant survey data (2011–2021), monitoring data, and incidental rare plant finds.

We counted *Schiedea hawaiiensis* over 11 periods between January 2017 and September 2020. We counted all individuals of this species by life stage: seedlings, juveniles, and adults (Figure 29). Overall, the number of adults did not change much over the 4-year period, the number of juveniles was more variable, and seedlings were generally absent or very sparse. Changes in the number of plants are typically driven by gains and losses of seedling/juvenile plants and mortality of unprotected plants. 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 and have implemented management including installation of netting to reduce game bird access to plants and monitoring to assess the need for additional management.

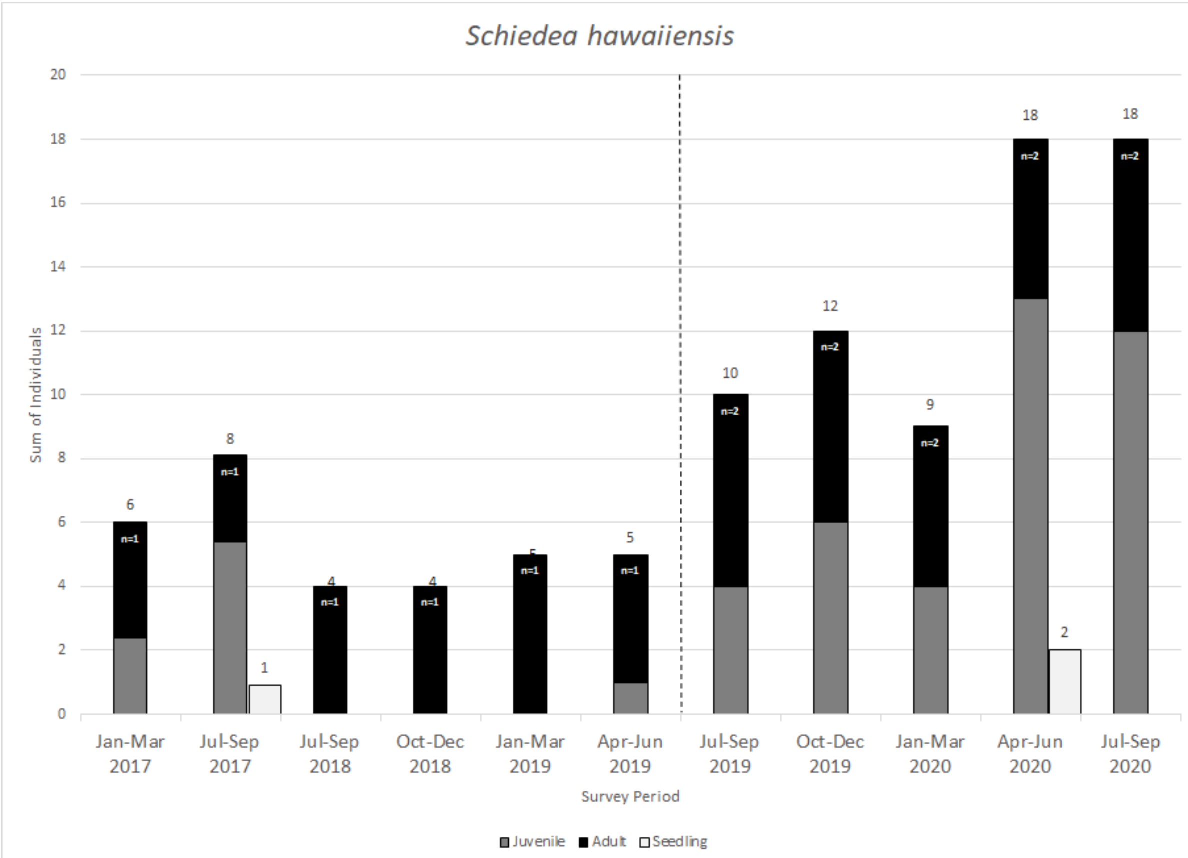

Figure 29. Monitoring results for *Schiedea hawaiiensis* from April 2016 through September 2020[a].

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

<u>Genetic Conservation</u>

Propagaule Collection and Propagation

No propagule collection or propagation occurred during the reporting period. From previous propagation efforts, there were 2 *Schiedea hawaiiensis* accessioned to the RPPF as of 31 July 2021. Refer to Table 15 for a complete summary of genetic conservation status for *P. sclerocarpa.*

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 ASR (Table 30). As of December 2020, at least 130 adults and juveniles were living, and 80 seedlings were present at ASR 219. For all sites the number of adults and juveniles (combined) present declined between 2014 and 2020, except for ASR 219 where there was a positive increase in the number of adults and juveniles (combined) present.

Table 30. Monitoring results as of December 2020 for *Schiedea hawaiiensis* outplanted between 2004 and 2014.

Location	Area of Species Recovery	Total Outplanted 2004–2014	Total Present 2014		Total Present 2020		% Change 2014–2020	Seedlings 2020
			Adult	Juvenile	Adult	Juvenile		
Off PTA	**201**	259	71	150	1	12	-92%	0
	202	40	0	0	0	0	0%	0
	204	204	0	45	0	0	-100%	0
	205	374	59	1	1	0	-98%	0
On PTA	**206**	24	15	30	26	0	-42%	0
	207	5	1	33	4	0	-88%	0
	213	14	8	0	0	0	-100%	0
	214	69	76	150	11	1	-94%	0
	219	5	5	0	3	8	+120%	14

Note: The data source for planting activity between 2004-2014 and 2014 monitoring data is CEMML 2015. For Areas of Species Recovery, bold denotes seedlings and underline denotes juvenile/adult recruits were present in 2014.

In 2019, we outplanted 2 individuals of *Schiedea hawaiiensis* in TA 21 at planting site Temp 2019-009. In December 2020, the 2 outplanted individuals were alive (100% 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 as well.

Discussion

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

Schiedea hawaiiensis has the most restricted distribution of any ESA-listed plant species at PTA. The main grouping of plants is restricted to approximately 1 m^2 (Figure 28).

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

We continue to investigate wildlife threats to *Schiedea hawaiiensis*. Deployment of A24 traps appears to effectively reduce observed damage from rodent browse. We continue to monitor the plants for interactions with game birds. In addition, a graduate student from the University of Illinois, Rene Tam, investigated wildlife interactions with *Schiedea hawaiiensis* and we expect the results of the study in 2022. We continue to monitor the impact of leaf cutter bees on *Schiedea hawaiiensis*. Based on the biology of leaf cutter bees and the current level of observed damage to *Schiedea hawaiiensis,* we do not plan to control the bees. If the level of damage rises and poses a threat to the survival of the plants, we can investigate control options.

The number of *Schiedea hawaiiensis* adults and juveniles (combined) present at most outplanting sites declined between 2014 and 2020 (Table 30). After almost 20 years, the *Schiedea hawaiiensis* at ASR 207 declined by 88% and at ASR 206, plants declined from 45 in 2014 to 26 in 2020 (a 42% decline). However, at ASR 219, *Schiedea hawaiiensis* adults and juveniles (combined) increased in number by 120%. Because the natural population of *Schiedea hawaiiensis* is limited to one small area with only a few individuals, the establishment of plants in new areas with successful recruitment is an important achievement towards the conservation of this species. Continuing to investigate planting site characteristics and the performance of the outplants will help us to better select new planting sites and improve the likelihood of establishing successful plantings. There are 2 *Schiedea hawaiiensis* accessioned to the RPPF. We are developing planting strategies and plan to continue investigating outplant performance and planting site characteristics in 2020 to maximize the successful establishment of new self-sustaining groupings.

Progress toward INRMP Objectives

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

To manage threats proactively for *Schiedea hawaiiensis*, we implement landscape-level projects to reduce fire-risk and browse and damage from ungulates, rodents, and game birds for all known individuals at PTA (see Section 1.3). Between 2016 and 2019, we observed *in situ* reproduction in 1 of 2 (50%) monitoring plots for *Schiedea hawaiiensis.* We actively conserve *Schiedea hawaiiensis* genetics; the propagule bank contains 315 seeds from the wild population and 331,418 seeds from individuals grown in the RPPF. To date, we outplanted a combined total of 994 *Schiedea hawaiiensis* at 9 ASRs. We control invasive plants at the wild and outplanted population across a combined total of about 1.4 ha (Table 44). Although we monitored *Schiedea hawaiiensis* quarterly to assess population patterns, we are unable to attribute changes in numbers to effects from training or management.

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

2.4.9 *Sicyos macrophyllus* (Endangered)

As a Tier 1 species, we monitor all known *Sicyos macrophyllus*, but the only known individual at PTA died in 2017; therefore, we did not quarterly monitor this species in FY 2020. For genetic conservation, *S. macrophyllus* is an implementation priority 1 (high). We plan to collect propagules for storage and propagation and to outplant to augment the existing population and to establish new populations.

Plant Surveys and Monitoring

We did not find any new locations of *S. macrophyllus* during surveys during the reporting period.

Based on survey work from 2011 to 2021, there is 1 location of *S. macrophyllus* at PTA. The plant at this location died in 2017. The distribution for *S. macrophyllus* is shown in Figure 30.

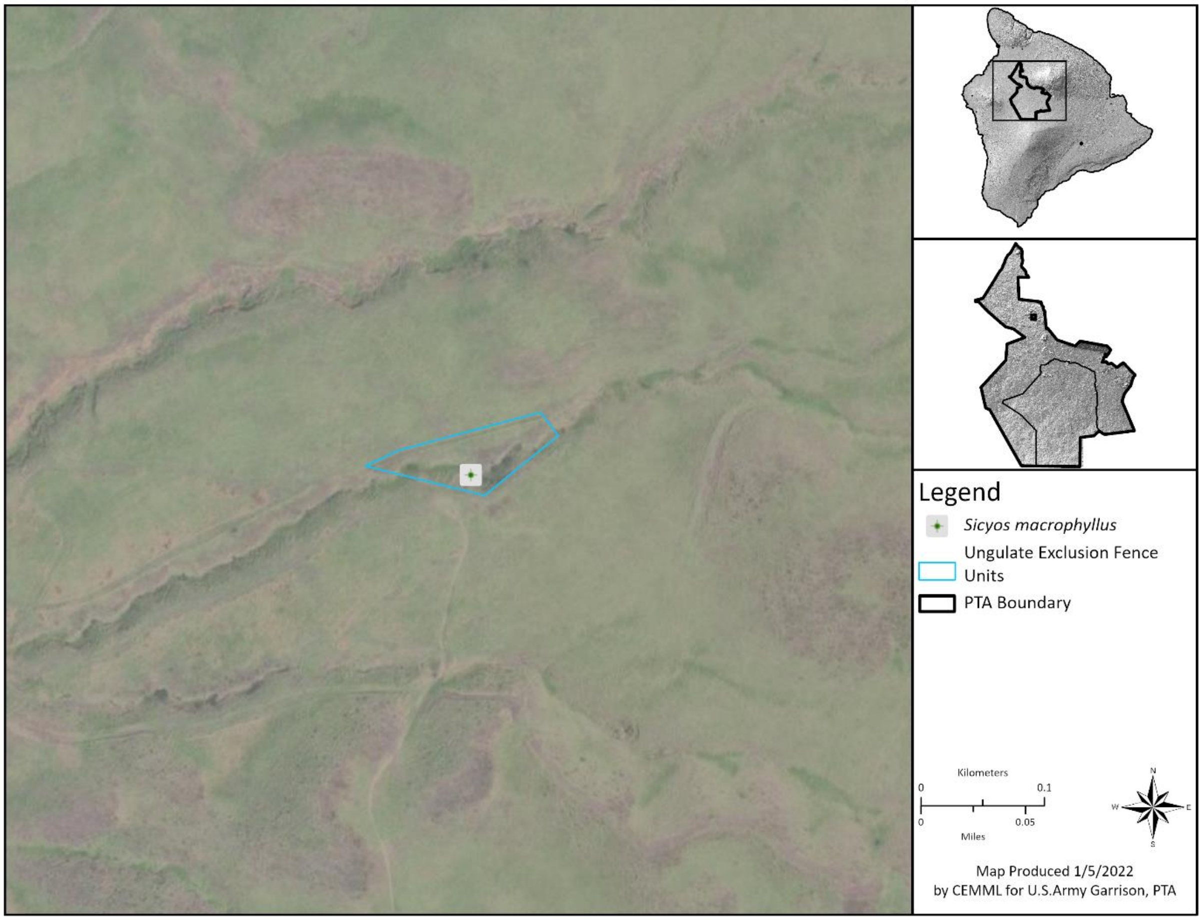

Figure 30. Current known distribution of *Sicyos macrophyllus*[a].

[a] The distribution is derived from a compilation of plant survey data (2011–2021), monitoring data, and incidental rare plant finds.

Although the only known *S. macrophyllus* plant at PTA died in 2017, we periodically monitored the plot where it previously occurred. In February 2021, we discovered 3 *S. macrophyllus* individuals growing within the small fence unit that surrounds the previous plant location (Figure 31). These new plants comprise the only known population of *S. macrophyllus* at PTA.

After the *S. macrophyllus* plant died in 2017, we suspended habitat management at the site. Between 2017 and 2020, the grass grew thickly within the fence unit, possibly curtailing recruitment. In an attempt to create conditions for germination, we applied herbicide to the grass within the fence unit in March/April 2020. This management coupled with favorable environmental conditions in early 2021, including ample precipitation, likely supported the germination from the existing seedbank.

We visited the plants in September and December 2021. During both visits, 4 mature individuals and one seedling/juvenile were observed at the site. We continue to closely monitor and manage the plants. As of December 2021, mature plants and fruit were present at the site.

Figure 31. Young *Sicyos macrophyllus* plants discovered in February 2021 at a Pōhakuloa Training Area location that was previously occupied by an adult plant last seen alive in 2017.

<u>Genetic Conservation</u>

Propagule Collection

Approximately 38 fruits were collected from the *S. macrophyllus* plant location (Table 31). Seven fruits were collected in February 2021 on the day the plants were discovered. Although one of the plants may have reached maturity, the seven seeds collected were likely from the mature plant that occupied the site in 2017. In September 2021, we collected another 31 seeds from the mature plants that currently occupy the site. We believe there are at least 4 mature individuals present at the location. However, because the plants are entwined, it is difficult to distinguish one plant from another. Therefore, we cannot be certain if the seeds were collected from one or more plants that occupy the site.

The seeds collected are being processed, cleaned and stored short-term until being propagated. We do not intend any of the seed collected in 2021 for long-term cold storage.

Table 31. Propagule collections of *Sicyos macrophyllus* for propagation.

Founder No.	Source	USFWS Pop Ref Code	Propagule Type	Amount Collected	Prop. Accession Number	Disposition
503-2193-001	Field	KMK	Fruit	7	210218001	Propagation
503-2193-001	Field	KMK	Fruit	31	210901002	Prop/Storage[b]

USFWS, US Fish and Wildlife Service

[b] The fruit/seed are in short-term storage while cleaning and processing are completed. These collections will likely be propagated, and none are planned for long-term, cold storage in the *ex situ* collection.

Propagation

We attempted to propagate 7 seed from *S. macrophyllus.* See Section 2.3.3 for details.

Outplanting and Monitoring

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

Discussion

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

The *Sicyos macrophyllus* plants occurs in a highly degraded gulch in KMA (Figure 30). The original plant was found in 2015 and 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 recommend working in partnership with the USFWS and seed researchers to investigate germination requirements, seed viability, and outplanting techniques.

In 2019, the USFWS contacted us due to concerns that the *Sicyos macrophyllus* seeds collected in 2017 and in storage at PTA were decreasing in viability. Seeds of *Sicyos macrophyllus* are believed to be short-lived and recalcitrant and both traits likely hamper germination as the seeds age. Because we did not have staff at the time to germinate the seed at PTA, we coordinated the transfer of the *Sicyos macrophyllus* seeds from storage at PTA to Lyon Arboretum and to the USAG-HI NRP on Oʻahu.

At the time of withdrawal, the accession label on the seed storage bag and information in the accession database (Date March 4, 2020) documented that accession #2016001 contained 479 fruit/seed. However, propagation records maintained by the Genetic Conservation Leader documented that he attempted to propagate 50 *Sicyos macrophyllus* seeds from this accession in 2019. Based on the propagation records, we assumed the *S. macrophyllus* accession #2016001 likely had 429 fruit/seeds remaining.

On March 4, 2020, Lena Schnell transferred 50 *Sicyos macrophyllus* seeds to staff at Lyon Arboretum. Seeds were received by Nellie Sugii of the Hawaiʻi Rare Plant Program. The remaining 379 fruit/seed were transferred to the USAG-HI NRP on Oʻahu. Seeds were received by Kapua Kawelo, the USAG-HI NRP Manager.

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 from military activities to *S. macrophyllus.* Therefore, we implement management for this species under INRMP objectives. We constructed a fence to prevent ungulate browse at the only known location of *S. macrophyllus.* We are working to conserve *S. macrophyllus* genetics. We are currently propagating 7 seeds and have 31 seeds in short-term storage awaiting propagation. In 2020, we transferred *S. macrophyllus* accession #2016001 from the PTA propagule bank to Lyon Arboretum (50 seeds) and to the USAG-HI NRP on Oʻahu (379 fruit/seed). We control invasive plants in about 0.1 ha around the wild population (Table 44).

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

2.4.10 *Solanum incompletum* (Endangered)

As a Tier 1 species, we monitored all known *S. incompletum* locations each quarter in FY 2020. For genetic conservation, *S. incompletum* is an implementation priority 3 (moderate). We plan to collect propagules for storage and propagation and to outplant judiciously to establish new populations.

Plant Surveys and Monitoring

We found/reconfirmed 9 location of *S. incompletum* during the reporting period.

Based on survey work from 2011 to 2021 and monitoring data from ASR 40 in 2021, there are 21 *S. incompletum* locations at PTA. The distribution for *S. incompletum*, including outplanting sites, is shown in Figure 32.

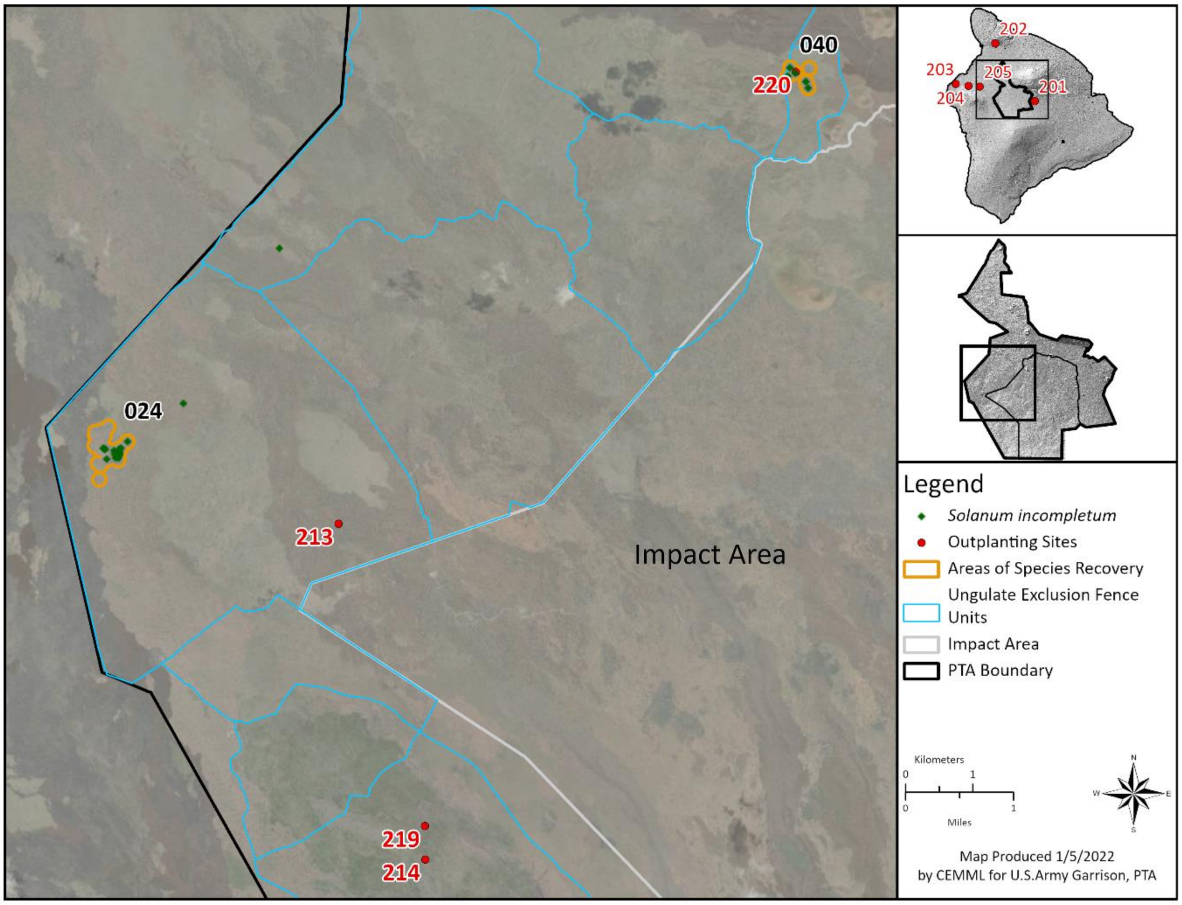

Figure 32. Current known distribution and outplanting sites for *Solanum incompletum*[a].

[a] The distribution is derived from a compilation of plant survey data (2011–2021), monitoring data, and incidental rare plant finds.

We counted *S. incompletum* over 12 periods between April 2016 and September 2020. We counted all individuals by life stage: seedling, juvenile, and adult. Overall, the number of plants remained relatively stable (Figure 33). As a long-lived perennial, the *S. incompletum* population is expected to be dominated by adults. However, most observations recorded no seedlings; the limited recruitment warrants further monitoring.

S. incompletum presents challenges for monitoring because some individuals produce clones. The original stems can die off and leave the remaining clonal stems. A genetic study may be useful to understand genetic diversity within and among plant locations and to better understand the species' life history and reproductive strategies.

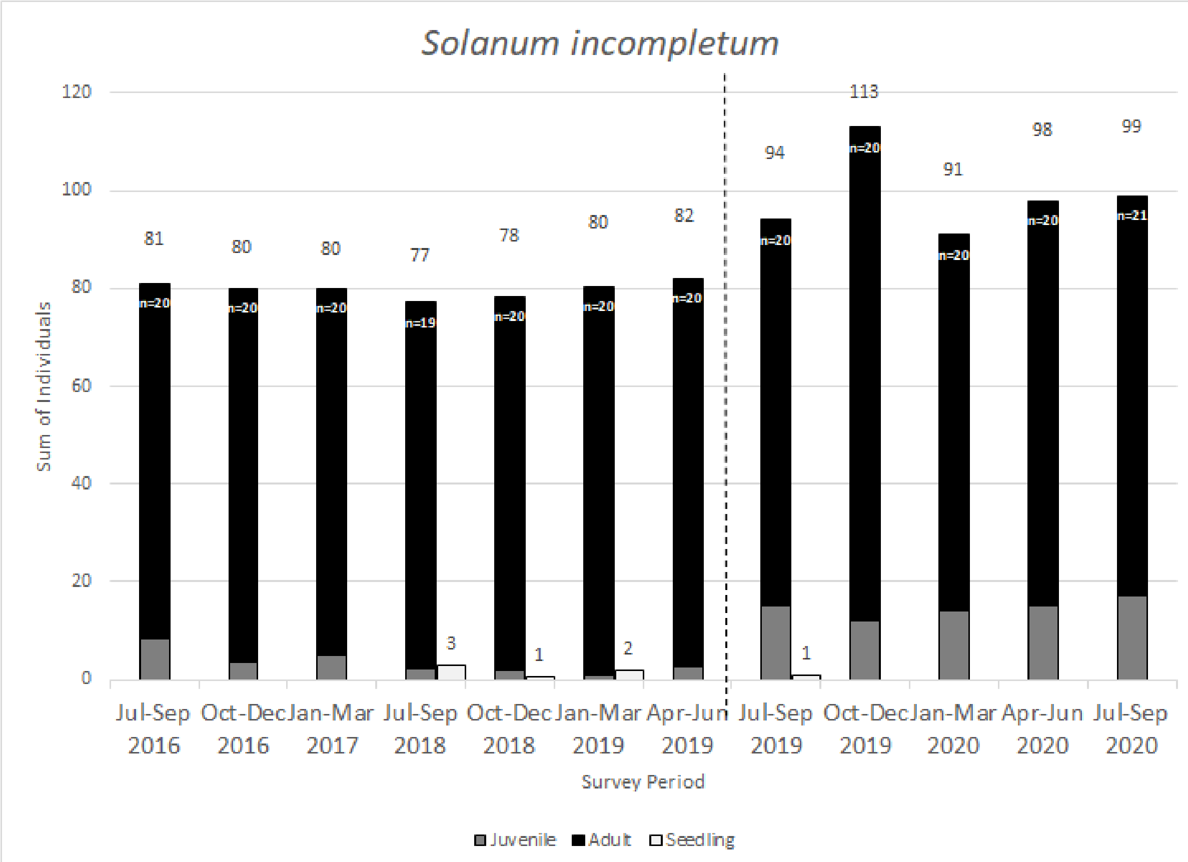

Figure 33. Monitoring results for *Solanum incompletum* from April 2016 through September 2020[a].

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

Genetic Conservation

Propagule Collection and Propagation

No propagule or propagation occurred between October 2019 and September 2021.

Outplanting and Monitoring

We did not outplant *S. incompletum* during the reporting period. In previous years we planted a combined total of 1,427 *S. incompletum* at 11 ASRs (Table 32). Although we outplanted over a thousand plants between 2004 and 2014, *S. incompletum* persisted at very few sites. Recruitment has occurred at several ASRs. Some sites (ASRs 204, 213, 214 and 219) increased in the number of adults and juveniles (combined) present between 2014 and 2020.

Table 32. Monitoring results as of December 2020 for *Solanum incompletum* outplanted between 2004 and 2014.

Location	Area of Species Recovery	Total Outplanted 2004-2014	Total Present 2014		Total Present 2020		% Change 2014-2020	Seedlings 2020
			Adult	Juvenile	Adult	Juvenile		
Off PTA	**201**	455	182	47	49	17	-71%	0
	202	78	0	0	0	0	0%	0
	203	11	4	0	0	0	-100%	0
	204	225	7	2	0	10	+11%	0
	205	406	134	42	9	0	-95%	0
On PTA	**209**	40	29	6	24	5	-17%	1
	211	14	1	0	0	0	-100%	0
	213	21	15	6	23	0	+10%	0
	214	170	168	83	162	109	+8%	0
	219	4	4	0	3	13	+300%	0
	220	3	3	0	2	0	-33%	0

Note: The data source for planting activity between 2004-2014 and 2014 monitoring data is CEMML 2015. For Areas of Species Recovery, bold denotes seedlings and underline denotes juvenile/adult recruits were present in 2014.

Discussion

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

At PTA, *S. incompletum* naturally occurs in soil and rocky substrates in 3 habitat types: *Dodonaea* shrubland, *Myoporum* shrubland, and *Metrosideros* treeland. It occurs in ASRs 24, 40, and 49 (Figure 32). The population of *S. incompletum* is comprised mostly of adults with a low but consistent number of juvenile plants. We documented periodic recruitment during quarterly monitoring and the data suggests some level of transition between life stages. However, we do not know which, if any, of the life stages is most vulnerable and/or may regulate population dynamics. Knowing these life history attributes is important for designing management actions to maximize the likelihood that *S. incompletum* will persist, and potentially increase, especially with changing climate conditions. We recommend exploring opportunities for basic research into life history characteristics to support science-based management of this species.

We continue to make progress with genetic conservation for *S. incompletum.* Many of the accessions in storage are older and we do not know how long seeds or fruit will store. We need to know more about seed characteristics prior to sowing and the influence of these characteristics on germination outcomes.

We outplanted over 1,000 *S. incompletum* individuals between 2004 and 2014. There does not appear to be an overall pattern of persistence between the sites – adults and juveniles (combined) decreased in number at 6 sites and increased in number at 4 sites. We planted over 400 plants at ASRs 201 and 205 each and the numbers of adults and juveniles (combined) present at both sites declined sharply between 2014 and 2020. We documented recruitment at these locations, but the level of recruitment was not sufficient to off-set losses. Three of the sites in which adults and juveniles increased in numbers are at PTA. Plants are doing especially well at ASR 219 with an increase of 300% in number of adults and juveniles present. Despite the success of *S. incompletum* at some sites, we still know relatively little about the habitat preferences of this species. We recommend continuing outplanting efforts for this species to better understand factors that help maximize the successful establishment of new self-sustaining groupings.

There are 150 *S. incompletum* accessioned to the RPPF. We are developing planting strategies and plan to continue investigating outplant performance and planting site characteristics in 2022 to maximize the successful establishment of new self-sustaining groupings.

In March 2021, we discovered an infestation of scales and aphids, and the ants that tend them, on *S. incompletum* in ASR 40. The Hawai'i State Department of Agriculture identified the invertebrates as *Ceroplastes* sp. (Wax scale-soft scale) and *Linepithema humile* (Argentine ant), but the samples of immature aphids sent could not be identified. The *S. incompletum* plants with scale were in poor health with only a few small leaves. The scales were removed by hand from these plants. Several other *S. incompletum* individuals had heavy infestations of aphids but looked relatively healthy and were flowering.

Between July and September 2020, there were 23 *S. incompletum* at ASR 40 (15 adults and 8 juveniles). In April 2021, following discovery of the infestation, there were 11 *S. incompletum* present. In May 2021, we initiated invertebrate control at ASR 40 to help minimize effects from invertebrates to *S. incompletum* (see Section 4.3.3). In June and September, we selectively applied 4.0 pounds of pesticide (Maxforce Complete Granular Insect Bait®) over 2.8 acres surrounding the *S. incompletum* locations.

In September 2021, there were 11 *S. incompletum* present. However, 2 of the plants appeared dead, but each had what appeared to be living, viable root suckers. No live aphids or ants were observed on the plants, but live scales were found on 2 plants and dead scale on 1 plant. All discovered scales were removed by hand.

The treatments appeared to be effective in reducing live invertebrates found on the *S. incompletum.* We assume that removal of these invasive invertebrates will have a positive conservation benefit to the *S. incompletum* and recommend further treatments to prevent future impacts to and/or loss of plants. We also recommend increasing monitoring of *S. incompletum* in ASR 40 to quarterly to minimize potential further loss.

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.

Progress toward Compliance with Endangered Species Act Biological Opinion Conservation Measures

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

To address these conservation measures for *S. incompletum*, we implement landscape-level projects to reduce fire risk and ungulate browse for all known individuals at PTA (see Section 1.3). In addition, we actively conserve *S. incompletum* genetics; the propagule bank contains 2,517 fruit and 3,390 seeds from the wild populations and another 8,384 fruit and 3,672 seed from individuals grown in the RPPF or from individuals outplanted. To date, we have outplanted a combined total of 1,427 individuals at 11 ASRs and, as of December 2021, plants remain at 5 ASRs and recruitment was documented at 4 sites. We manage invasive plants in several ASRs for wild and outplanted populations, with all areas totaling about 11.7 ha for *S. incompletum* (Table 44). Between 2016 and 2019, we observed *in situ* reproduction in 1 of 20 (5%) monitoring plots for *S. incompletum.* Although we monitor *S. incompletum* quarterly to assess population patterns, we are unable to attribute changes in numbers to effects from training or management.

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

2.4.11 *Tetramolopium arenarium* (Endangered)

As a Tier 1 species, we monitored all known *T. arenarium* locations each quarter in FY 2020. For genetic conservation, *T. arenarium* is an implementation priority 3 (moderate). We plan to collect propagules for storage and propagation and to outplant judiciously to establish new populations.

<u>Plant Survey and Monitoring</u>

Three locations of *T. arenarium* were recorded/reconfirmed during the reporting period.

Based on previous survey work from 2011 to 2021, there are 27 locations of *T. arenarium* at PTA. The distribution for *T. arenarium*, including outplanting sites, is shown in Figure 34.

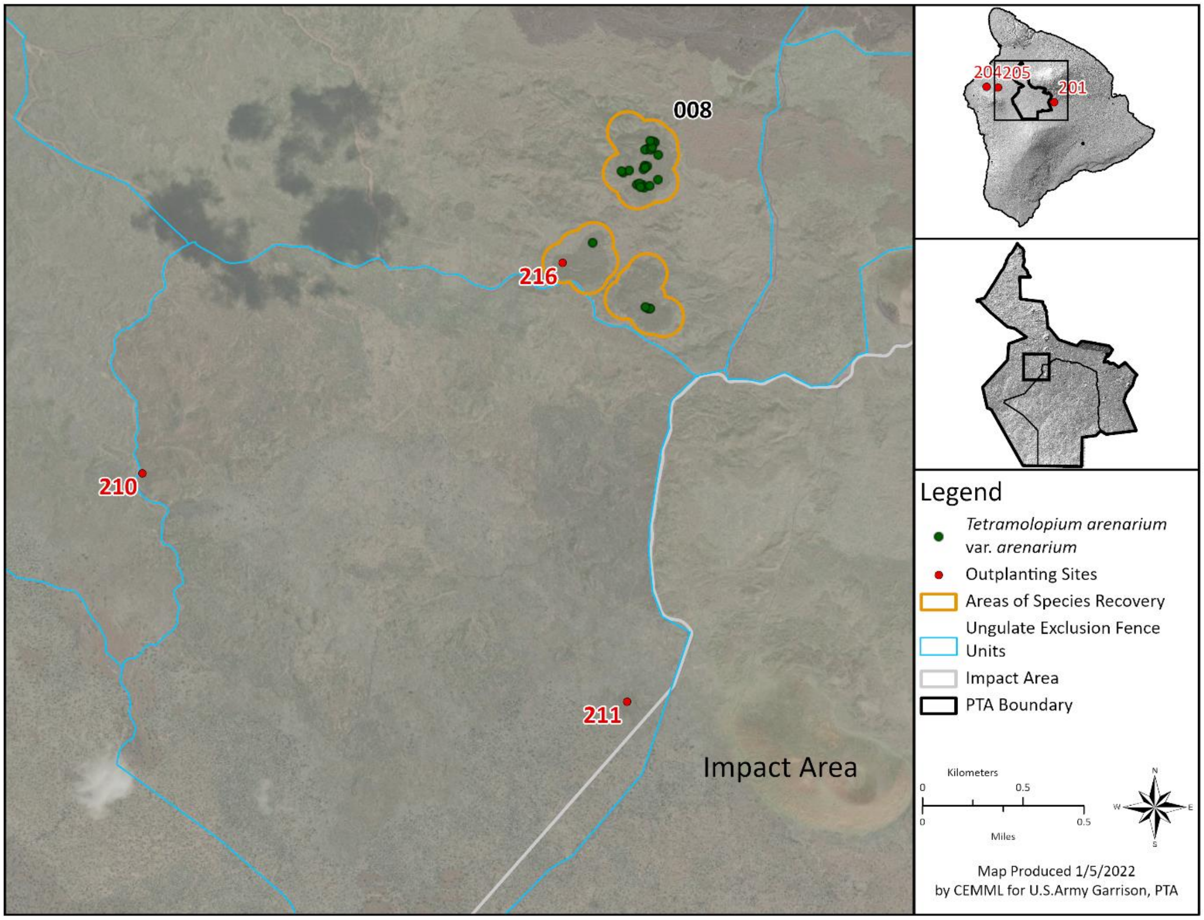

Figure 34 . Current known distribution and outplanting sites for *Tetramolopium arenarium*[a].

[a] The distribution is derived from a compilation of plant survey data (2011–2021), monitoring data, and incidental rare plant finds.

We counted *T. arenarium* over 11 periods between April 2016 and September 2020 (Figure 35). We counted all individuals by life stage: seedling, juvenile, and adult. Monitoring data show large fluctuations in the number of plants present as well as in population structure A large flush of seedlings took place in 2016, followed by high seedling mortality. Some recruitment into the juvenile class is evident between fall 2016 and winter 2017. Data from 2019 and 2020 show a decline in the number of juveniles over time. The amount of recruitment from the juvenile to adult class and the rate of adult mortality is unknown. *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).

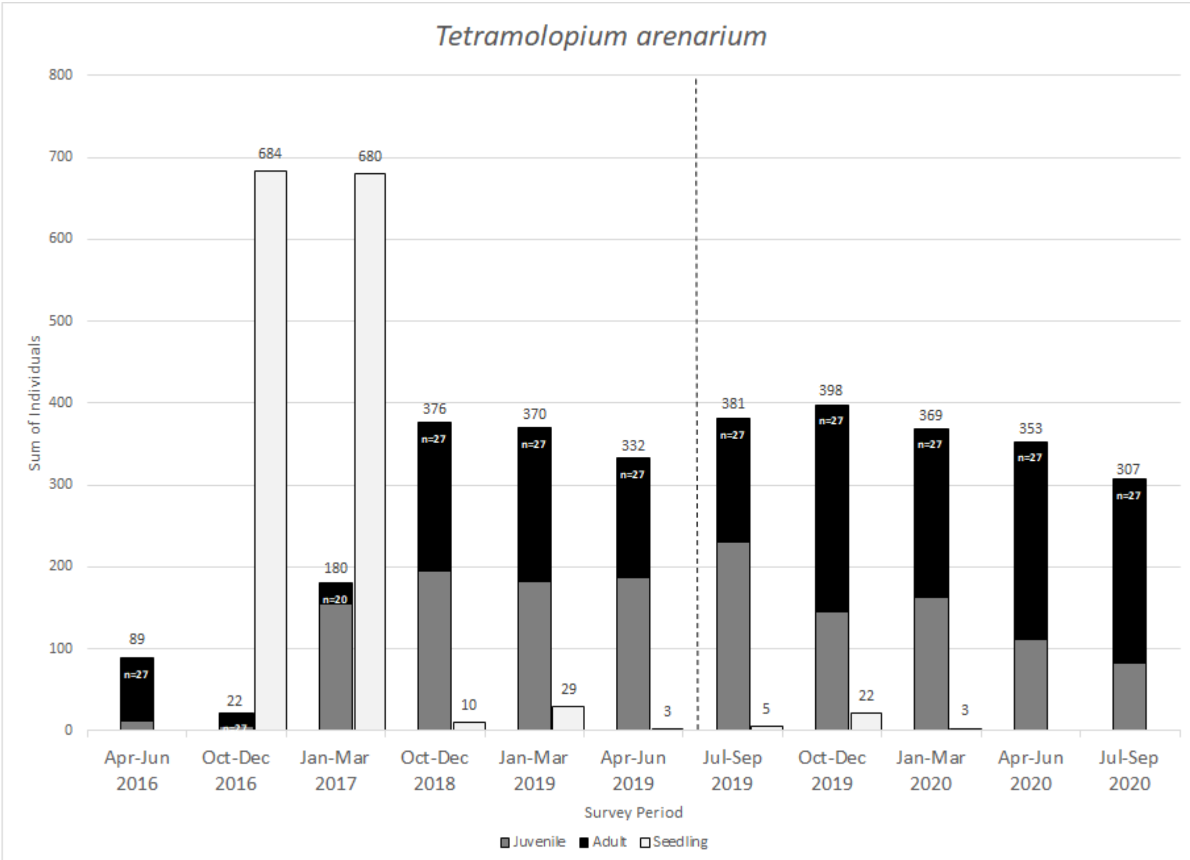

Figure 35. Monitoring results for *Tetramolopium arenarium* from April 2016 through September 2020[a].

[a] For census periods left of the dotted line, we estimated life stage composition using proportion and to the right we counted each plant present by life stage (n=number of plots read). For census periods right of the dotted line, totals may include count class data. When this occurs the minimum value of the count class is used and summed with the counts from other plots to provide the total value for abundance. This is because the actual values represented within count classes were often not normally distributed. Therefore, these numbers represent the minimum number of individuals present during the census period.

<u>Genetic Conservation</u>

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

Propagule Collection and Propagation

No propagule collection or propagation occurred between October 2019 and September 2021. Please refer to Table 15 for a complete summary of genetic conservation status for *T. arenarium.*

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 ASRs (Table 33). No individuals remained at any ASR as of December 2020. 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. We plan to investigate further site suitability and species requirements needed to successfully establish self-sustaining populations.

Table 33. Monitoring results as of December 2020 for *Tetramolopium arenarium* outplanted between 2004 and 2014.

Location	Area of Species Recovery	Total Outplanted 2004-2014	Total Present 2014		Total Present 2020		% Change 2014-2020	Seedlings 2020
			Adult	Juvenile	Adult	Juvenile		
Off PTA	201	32	0	0	0	0	-100%	0
	204	18	0	0	0	0	-100%	0
	205	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

Note: The data source for planting activity between 2004-2014 and 2014 monitoring data is CEMML 2015. For Areas of Species Recovery, bold denotes seedlings and underline denotes juvenile/adult recruits were present in 2014.

Discussion

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

At PTA, *T. arenarium* naturally occurs in the *Dodonaea* shrubland. It occurs in 3 clusters distributed over fewer than 2 ha within the Kīpuka Kālawamauna North Fence Unit in ASR 8 (Figure 34). *Tetramolopium arenarium* can fluctuate in numbers, sometimes dramatically, especially in the seedling life stage. We documented a large decline in adults and juveniles in census period 2 (October 2016 to December 2016). In census periods 2 and 3 (January 2017 to March 2017), we recorded high numbers of seedlings, of which some number of seedlings recruited into the juvenile and adult life stages in subsequent census periods. We have documented similar declines in juveniles and adults in 2007 and 2010/2011 with a similar population rebound driven by a large flush of seedlings (CEMML 2010; CEMML 2011).

Other monitoring and research projects have also documented high mortality in adults (Laven et al. 1991; Aplet et al. 1994). 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 delaying germination until favorable conditions exist (e.g., high soil moisture) are both consistent with r strategies, which in turn are consistent with life history characteristics of early-successional plants (Huston and Smith 1987). To date, we have applied general management actions to the *T. arenarium* 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 month (*Orthomecyna* 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 2007–2009 suggests 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.

For most sites, previous outplanting efforts for *T. arenarium* were unsuccessful. Data from the 2014 monitoring show that outplants failed to establish at most sites but were present at ASRs 205 and 214 and recruitment was only documented at ASR 205. As of December 2020, *T. arenarium* has failed to establish self-sustaining populations 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.

Progress toward Compliance with Endangered Species Act Biological Opinion Conservation Measures

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

To address these conservation measures for *T. arenarium*, we implement landscape-level projects to reduce fire risk and ungulate browse for all known individuals at PTA (see Section 1.3). In addition, we actively conserve *T. arenarium* genetics; the propagule bank contains 71,916 seeds from the wild population and another 12,250 seeds from individuals grown in the RPPF or from individuals outplanted. To date, we have outplanted a combined total of 510 individuals at 6 ASRs, 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 (Table 44). Between 2016 and 2019, we observed *in situ* reproduction in 5 of 27 (19%) monitoring plots for *T. arenarium.* Although we monitor *T. arenarium* quarterly to assess population patterns, we are unable to attribute changes in numbers to effects from training or management.

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

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

Tetramolopium sp. 1 is undescribed and not ESA-listed, but per INRMP objectives we manage the species due to its rarity and limited distribution. As a Tier 1, we monitor all known *Tetramolopium* sp. 1 individuals each quarter. For genetic conservation, *Tetramolopium* sp. 1 is a priority, but was not included in the *Genetic Conservation and Outplanting Plan* (CEMML 2017) because it is not ESA-listed. We plan to collect propagules for storage and propagation and to outplant to augment the existing population and to establish new populations.

Plant Survey and Monitoring

During the reporting period, we recorded/reconfirmed 1 location of *Tetramolopium* sp. 1.

Based on previous survey work from 2011 to 2021, there are 70 locations of *Tetramolopium* sp. 1 at PTA. The distribution for *Tetramolopium* sp. 1, including outplanting sites, is shown in Figure 36.

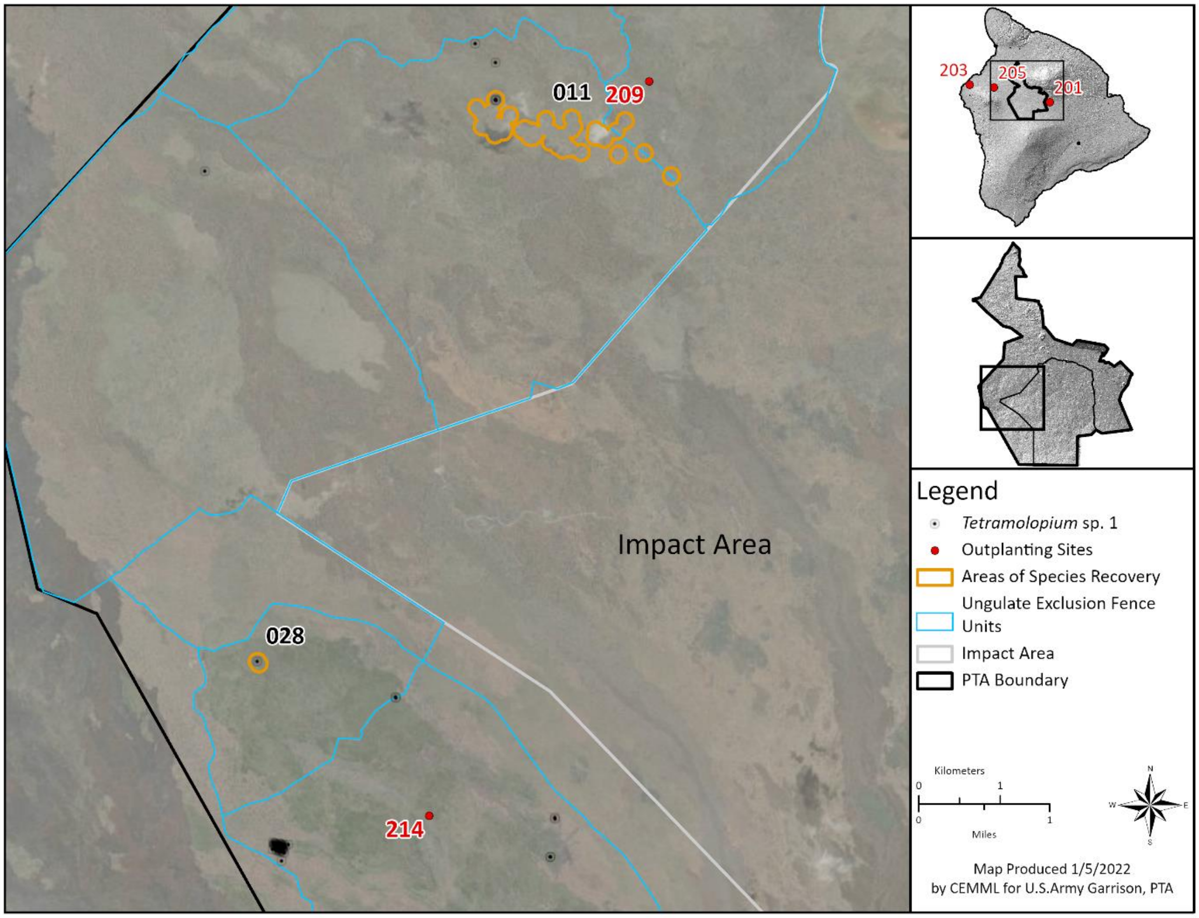

Figure 36. Current known distribution and outplanting sites for *Tetramolopium* sp. 1[a].

[a] The distribution is derived from a compilation of plant survey data (2011–2021), monitoring data, and incidental rare plant finds.

We counted *T.* sp. 1 over 12 periods between April 2016 and September 2020 (Figure 37). Between July and December 2016, the number of plants present appears to have doubled; however, we installed and monitored twice the number of plots over this period, which accounts for the apparent increase in plant numbers. The overall pattern of change seems to be largely driven by fluctuation in the juvenile life stage, but the overall pattern of change is difficult to interpret because the number of plots read in each period differs. Seedlings are present for most periods, but in low numbers. The data suggest that between quarterly visits seedlings are germinating and growing to a large enough size to be considered juveniles, which gives the appearance of recruitment directly to the juvenile life stage in the graph.

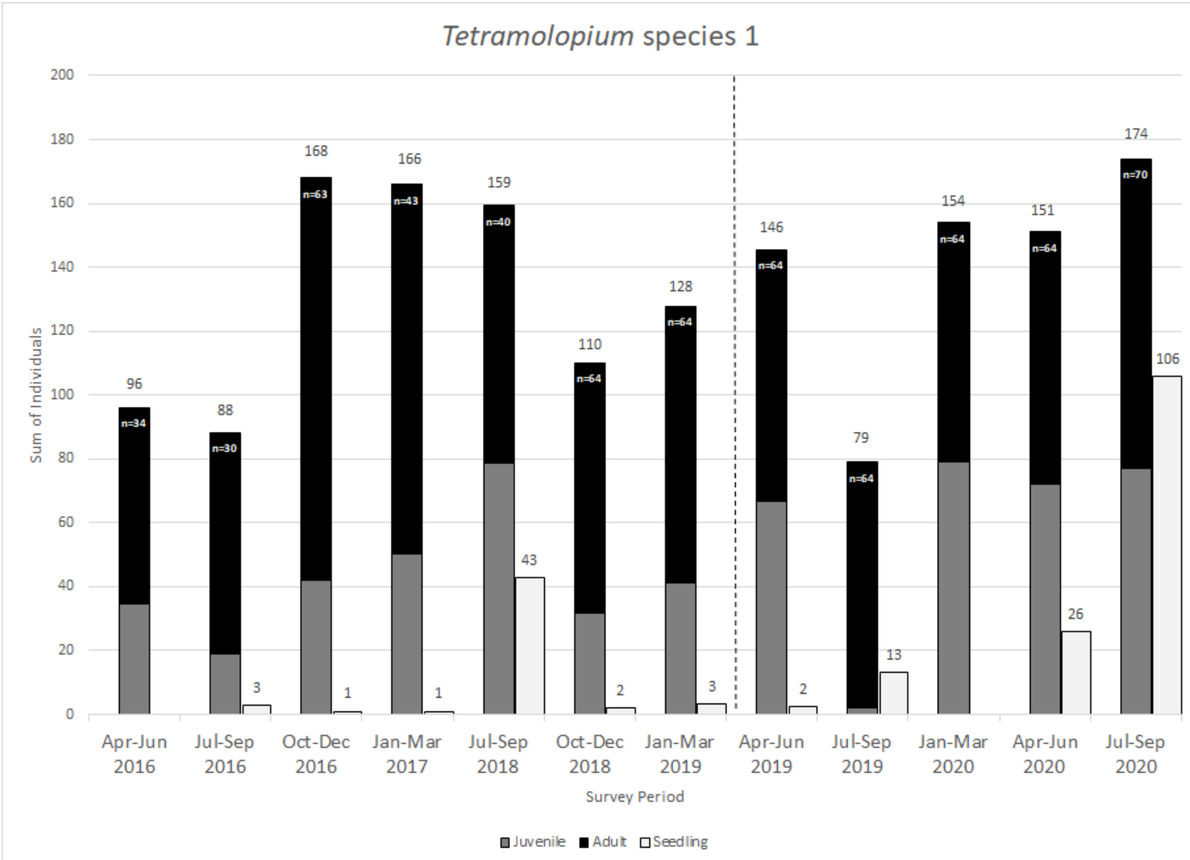

Figure 37. Monitoring results for *Tetramolopium* species 1 from April 2016 through September 2020[a].

[a] For census periods left of the dotted line, we estimated life stage composition using proportion and to the right we counted each plant present by life stage (n=number of plots read). For census periods right of the dotted line, totals may include count class data. When this occurs the minimum value of the count class is used and summed with the counts from other plots to provide the total value for abundance. This is because the actual values represented within count classes were often not normally distributed. Therefore, these numbers represent the minimum number of individuals present during the census period.

Genetic Conservation

Propagule Collection and Propagation

No propagule collection or propagation was completed this report period. Please refer to Table 15 for a complete summary of genetic conservation status for *Tetramolopium* sp. 1.

Outplanting and Monitoring

We did not outplant *Tetramolopium* sp. 1 during the reporting period. In previous years we planted a combined total of 357 *Tetramolopium* sp. 1 individuals at 4 ASRs (Table 34). At ASR 214, *Tetramolopium* sp. 1 established well, and plants have been self-sustaining. Recruitment occurs annually and the occupied area continues to expand, especially in areas where grass is managed.

Table 34. Monitoring results as of December 2020 for *Tetramolopium* sp. 1 outplanted between 2004 and 2014.

Location	Area of Species Recovery	Total Outplanted 2004-2014	Total Present 2014		Total Present 2020		% Change 2014-2020	Seedlings 2020
			Adult	Juvenile	Adult	Juvenile		
Off PTA	**201**	83	1	0	0	0	0%	0
	202	69	0	0	0	0	0%	0
On PTA	**<u>209</u>**	66	1	0	0	0	0%	0
	<u>214</u>	139	197	1,500	156	294	-73%	0

Note: The data source for planting activity between 2004–2014 and 2014 monitoring data is CEMML 2015. For Areas of Species Recovery, bold denotes seedlings and underline denotes juvenile/adult recruits were present in 2014.

<u>Discussion</u>

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

At PTA, *Tetramolopium* sp. 1 naturally occurs in the Nāʻōhuleʻelua Fence unit and in the Kīpuka ʻAlalā North and South Fence units (Figure 36). The species grows in the *Metrosideros polymorpha* Woodland alliance and the *Myoporum sandwicense - Sophora chrysophylla* Shrubland alliance. This species remains undescribed and therefore does not have a scientifically accepted specific epithet. Because this plant is not scientifically accepted as a species, it has no protections under the law. However, this plant is only known from PTA, and due to its apparent rarity, we manage this species similar to other Tier 1 ESA-listed plant species.

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

Little is known about the life history characteristics of this species, but it likely shares some characteristics with other congeners. *Tetramolopium* sp. 1 likely has some life history characteristics in common with early-successional species (r strategists) and with *T. arenarium*. Based on lessons learned with *T. arenarium*, we plan to investigate monitoring and management approaches suited for early successional species. However, we recommend exploring opportunities for basic research into life history characteristics to support science-based management of this species. Knowing these attributes is important for designing management actions to maximize the likelihood that *Tetramolopium* sp. 1 will persist, and potentially increase, especially with changing climate conditions.

Since its discovery at PTA in the early 1990's, *T.* sp.1 has 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 the scientific rigors to credibly name the species. Results from a 2015 collaborative study with Dr. Clifford Morden of the University of Hawaiʻi confirmed that *T.* sp. 1 is genetically distinct from other species of *Tetramolopium* found at PTA (Morden and Yorkston 2015). In 2019, we began drafting a manuscript to finally publish a botanical description of *T.* sp.1 for publication in a peer reviewed journal and finally officially name the species. In 2020 and 2021, additional measurements of plants from the field were taken to develop a botanical description and dichotomous key and to produce an accurate technical illustration (Figure 38). At the end of this reporting period, a final draft manuscript was submitted to the Army for review and approval for submission to a peer-reviewed journal.

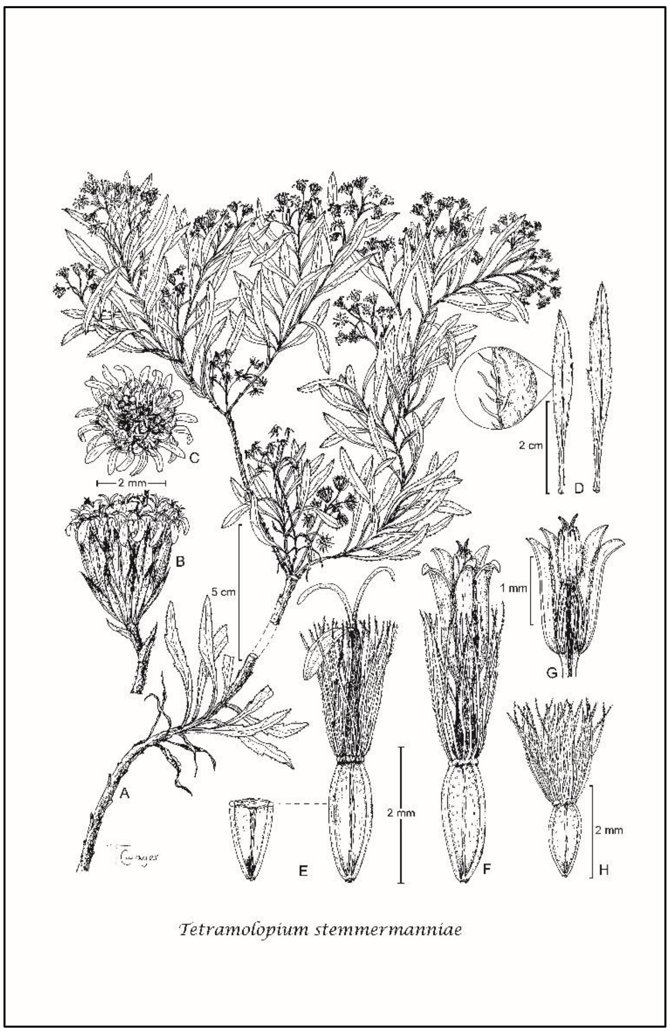

Figure 38. Technical illustration of *Tetramolopium* species 1 to be included in the manuscript to name the species *Tetramolopium stemmermanniae.*

We continue to make progress toward genetic conservation targets for *T.* sp. 1. There are 19,316 seeds from the wild population and over 150,000 seeds from outplants and plants in the RPPF. 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 2017–2019 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.* sp. 1 outplanted between 2004 and 2014 showed poor establishment at most sites, except at ASR 214. At the lower elevation sites, ASRs 201 and 204, no recruitment was observed. Although recruitment was observed at ASR 209, plants failed to persist to 2020. Plants initially established well at ASR 214 but after 2014, the numbers of adults and juveniles declined sharply. However, the magnitude of the change appears to be driven by the very high number of juveniles present during 2014. The difference in the numbers of adults present between the 2 periods is much less drastic (197 vs. 156 – a 21% decline). In contrast to the very poor performance at other sites, *T.* sp. 1 appears to be doing well at ASR 214. Similar to its close relative *T. arenarium*, we suspect that *T.* sp. 1 may rely on bonanza recruitment events, like what occurred in 2014, as a life history strategy to recruit adequate adults to sustain the population (Laven et al. 1991). Because *T.* sp. 1 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.* sp. 1 in all future outplanting plans.

Progress toward Compliance with INRMP Objectives

Because *Tetramolopium* sp. 1 is an undescribed and unlisted species, we implement management for *Tetramolopium* sp. 1 under INRMP objectives that minimize threats to Hawaiian plants from wildfire and invasive species. In addition, we strive to conserve the genetics of *Tetramolopium* sp. 1.

To manage threats for *Tetramolopium* sp. 1, we implement landscape-level projects to reduce fire risk and browse from ungulates for all known individuals at PTA (see Section 1.3). Between 2016 and 2019, we observed *in situ* reproduction in 8 of 64 (13%) monitoring plots for *Tetramolopium* sp. 1. We actively conserve *Tetramolopium* sp. 1 genetics; the propagule bank contains 19,316 seeds from the natural population and 165,335 seeds from individuals grown in the RPPF or from outplanted individuals. To date, we have outplanted a combined total of 357 *Tetramolopium* at 4 ASRs. We control weeds in ASR 28 for the wild population of *T.* sp. 1, for a total area of 0.9 ha (Table 44). Although we monitor *Tetramolopium* sp. 1 quarterly to assess population patterns, we are unable to attribute changes in numbers to effects from training or management.

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

2.4.13 *Vigna o-wahuensis* (Endangered)

As a Tier 1 species, we monitored all known *V. o-wahuensis* locations each quarter in FY 2022. For genetic conservation, *V. o-wahuensis* is an implementation priority 1 (high). We plan to collect propagules for storage and propagation and to outplant to augment the existing population and to establish new populations.

Plant Surveys and Monitoring

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

Based on previous survey work from 2011 to 2021, there are 45 locations of *V. o-wahuensis* at PTA. The distribution for *V. o-wahuensis*, including outplanting sites, is shown in Figure 39.

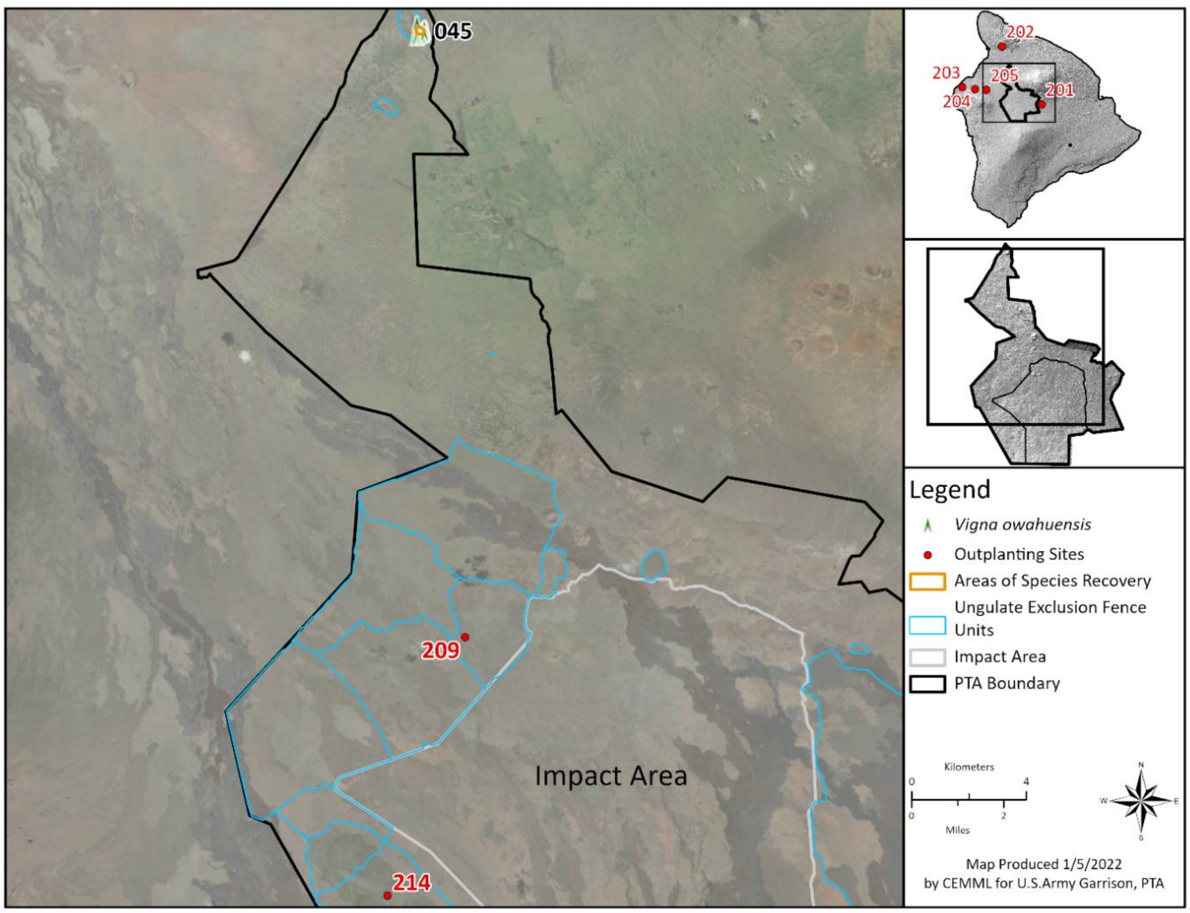

Figure 39. Current known distribution and outplanting sites for *Vigna o-wahuensis*[a].

[a] The distribution is derived from a compilation of plant survey data (2011–2021), monitoring data, and incidental rare plant finds.

We counted *V. o-wahuensis* over 10 periods between April 2016 and September 2019 (Figure 40). We counted all individuals by life stage: seedling, juvenile, and adult. *V. o-wahuensis* has shown consistent and successful recruitment from the seedbank, likely due to beneficial weather conditions. The number of juveniles and adults combined varied widely over the 5-year period, ranging from 42 to 498. *V. o-wahuensis* is an ephemeral species and may not be present for extended periods of time at a particular location. The species is currently found in highly degraded habitat dominated by *C. setaceum*. 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.

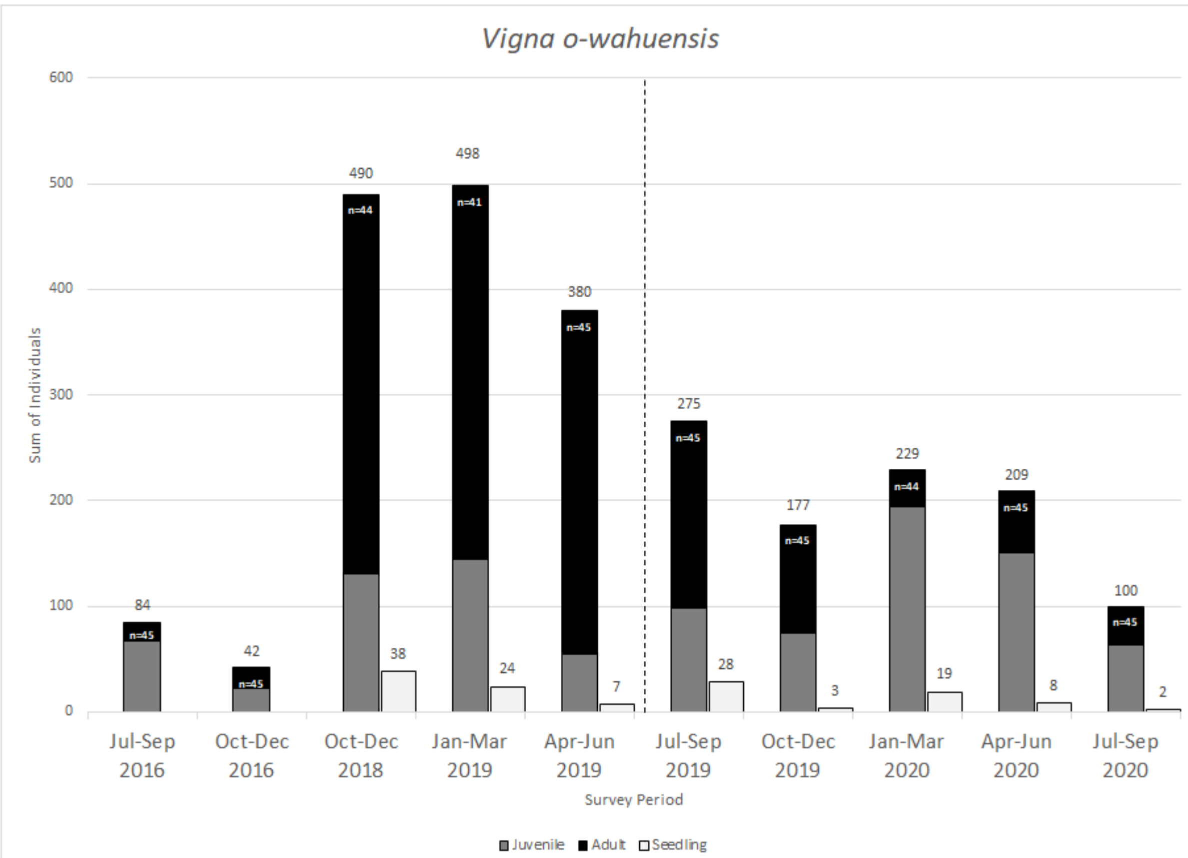

Figure 40. Monitoring results for *Vigna o-wahuensis* from April 2016 through September 2020[a].

[a] For census periods left of the dotted line, we estimated life stage composition using proportion and to the right we counted each plant present by life stage (n=number of plots read). For census periods right of the dotted line, totals may include count class data. When this occurs the minimum value of the count class is used and summed with the counts from other plots to provide the total value for abundance. This is because the actual values represented within count classes were often not normally distributed. Therefore, these numbers represent the minimum number of individuals present during the census period.

Genetic Conservation

Propagule Collection and Propagation

No propagule collection or propagation occurred over the reporting period. Please refer to Table 15 for a complete summary of genetic conservation status for *V. o-wahuensis.*

Outplanting and Monitoring

We did not outplant *V. o-wahuensis* during the reporting period. In previous years, we planted a combined total of 85 *V. o-wahuensis* at 7 ASRs (Table 35). In addition, we broadcast seed at 4 ASRs. As December 2020, all outplants were dead.

Table 35. Monitoring results as of December 2020 for *Vigna o-wahuensis* outplanted between 2004 and 2014.

Location	Area of Species Recovery	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

Note: The data source for planting activity between 2004–2014 and 2014 monitoring data is CEMML 2015. For Areas of Species Recovery, underline denotes juvenile/adult recruits were present in 2014.
+ 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. In 2002, Arnett (2002) found 3 *V. o-wahuensis* plants Puʻu Pāpapa. Reintroduction of *V. o-wahuensis* to Puʻu Pāpapa was established as a goal in the *Genetic Conservation and Outplanting Plan* (CEMML 2017). In December 2020, we found a single juvenile outplant and 3 juveniles that appeared to be recruits from seed. Outplant survivorship was low (9%); however, we are encouraged those 3 young plants apparently recruited from seed at the site.

Discussion

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

At PTA, *V. o-wahuensis* naturally occurs on Puʻu Nohona o Hae and is short-lived and ephemeral (Figure 39). Quarterly monitoring shows that the abundance of *V. o-wahuensis* fluctuates over time. Seedlings were present in most periods, but at low levels. However, the numbers adults steadily decreased over the 4-year period. In 2020, some plants recruited to the juvenile life stage, but relatively few appeared to transition to the adults. *V. o-wahuensis* may rely on episodic recruitment during favorable environmental conditions to sustain the population. Like many other species that occur at PTA, we know very little about the life history characteristics of *V. o-wahuensis*. Knowing these life history attributes is important for designing management actions to maximize the likelihood that *V. o-wahuensis* will persist, and potentially increase, especially with changing climate conditions. We recommend exploring opportunities for basic research into life history characteristics to support science-based management of this species.

We continue to make progress with genetic conservation of *V. o-wahuensis*. Many of the accessions in storage were collected prior to 2015. We do not know how aging affects the viability of the seed, but past work demonstrated similar levels of germination between seed collected in 2014 and seed collected in 2019. There are 25 *V. o-wahuensis* accessioned to the RPPF.

We have had minimal success in outplanting *V. o-wahuensis*. We are unsure why outplants are not persisting. The *V. o-wahuensis* planted in 2019 showed poor survivorship Temp 2019-005, which is within the historic and possible range of this species (Price et al. 2012). Previous outplanting efforts with this species have also resulted in poor survivorship and little to no persistence at outplanting sites. We plan to continue to investigate planting site characteristics and ways to improve our success in establishing outplants. We are developing planting strategies and plan to continue investigating outplant performance and planting site characteristics. In 2022, we plan to implement a project focused on Puʻu Nohona o Hae and *V. o-wahuensis*.

Progress toward Compliance with Endangered Species Act Biological Opinion Conservation Measures

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

To address these conservation measures for *V. o-wahuensis*, we implement landscape-level projects to reduce fire-risk and ungulate browse for all known individuals at PTA (see Section 1.3). In addition, we actively conserve *V. o-wahuensis* genetics; the propagule bank contains 3,356 seeds from the wild population and 32,399 seeds from individuals grown in the RPPF. To date, we have outplanted a combined total of 85 individuals at 6 ASRs; no outplants remain at the sites as of December 2021. Due to challenges on steep slopes and degraded habitat on Puʻu Nohona o Hae, we have not managed invasive plants specifically for *V. o-wahuensis.* However, *V. o-wahuensis* benefits from weed control actions in ASR 48, where it co-occurs with *L. venosa.* Between 2016 and 2019, we observed *in situ* reproduction in 18 of 46 (39%) monitoring plots for *V. o-wahuensis.* Although we monitor *V. o-wahuensis* quarterly to assess population patterns, we are unable to attribute changes in numbers to effects from training or management.

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

2.4.14 *Zanthoxylum hawaiiense* (Endangered)

As a Tier 1, we monitored all known plants in FY 2020. For genetic conservation, *Z. hawaiiense* is an implementation priority 5 (low). We plan to collect propagules for storage with little to no outplanting.

Plant Surveys 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 41). Of the 498 living trees observed, 208 were female, 4 were male, and the sex of the remaining 286 trees could not be determined.

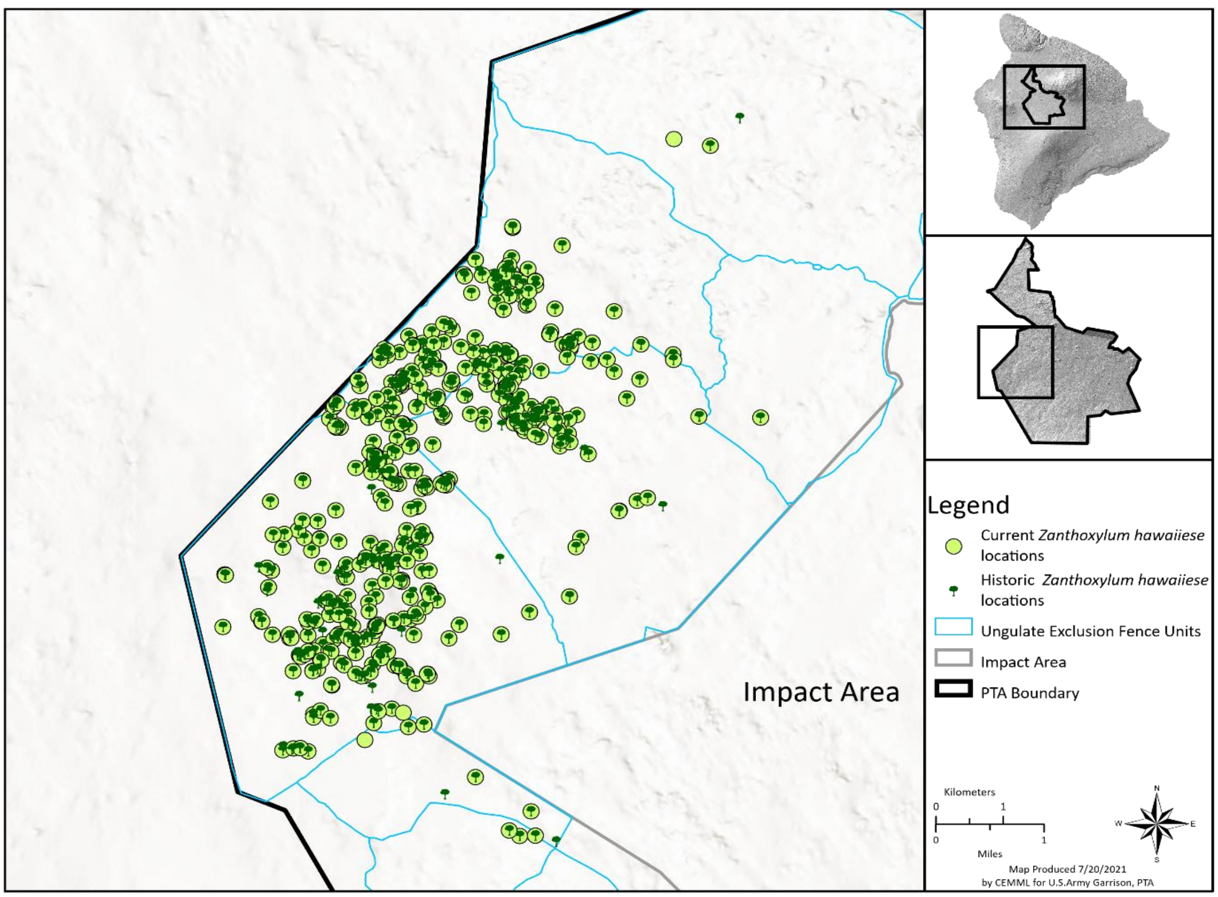

Figure 41. Historic and current locations of *Zanthoxylum hawaiiense* monitored between April and September 2020.

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.

Genetic Conservation

Propagule Collection

During the reporting period, we collected 35 seeds from a single founder. Please refer to Table 15 for a complete summary of genetic conservation status for *Z. hawaiiense.*

Propagation

No propagation occurred during the reporting period.

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 ASRs (Table 36). During the last monitoring of the outplanting sites in December 2020, we documented 11 *Z. hawaiiense* alive (3 juveniles and 8 adults).

Table 36. Monitoring results as of December 2020 for *Zanthoxylum hawaiiense* outplanted between 2004 and 2014.

Location	Area of Species Recovery	Total Outplanted 2004-2014	Total Present 2014		Total Present 2020		% Change 2014-2020	Seedlings 2020
			Adult	Juvenile	Adult	Juvenile		
Off PTA	201	2	0	1	1	0	0%	0
	203	2	0	0	0	0	0%	0
	205	22	8	11	10	2	-37%	0
On PTA	208	5	0	1	0	0	-100%	0
	211	2	0	1	0	1	0%	0
	213[a]	4	0	0	1	1	+200%	0
	220	3	0	3	0	1	-67%	0

Note: The data source for planting activity between 2004-2014 and 2014 monitoring data is CEMML 2015. As of 2014, no seeds were observed at any Area of Species Recovery; therefore, no recruitment was noted during the 2014 monitoring.

[a] Because of the lack of seeds on outplants and the fact that wild *Zanthoxylum hawaiiense* were known to occur at ASR 213, the plants observed at ASR 213 in 2019 and 2020 are likely recruits from the wild seed bank.

Discussion

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

The distribution of *Z. hawaiiense* is nearly continuous across approximately 2,000 ha of the Kīpuka Kālawamauna West, Nāʻōhuleʻelua, and Mixed Tree Fence Units (Figure 41). Scattered individuals also occur in the Kīpuka Kālawamauna North, Kīpuka Kālawamauna East, *Kadua coriacea*, and Kīpuka ʻAlalā North Fence Units.

Like many other species that occur at PTA, we know very little about the life history characteristics of *Z. hawaiiense*. Knowing these life history attributes is important for designing management actions to maximize the likelihood that *Z. hawaiiense* will persist, and potentially increase, especially with changing climate conditions. We recommend exploring opportunities for basic research into life history characteristics to support science-based management of this species.

We continue to make progress with genetic conservation of *Z. hawaiiense*. Many of the accessions in storage are older and we do not know how aging affects the viability of the seed. 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. There are 8 *Z. hawaiiense* accessioned to the RPPF. We are developing planting strategies and plan to continue investigating outplant performance and planting site characteristics in 2022 to maximize the successful establishment of new self-sustaining groupings.

Progress toward Compliance with Endangered Species Act Biological Opinion Conservation Measures

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

To address these conservation measures for *Z. hawaiiense*, we implement landscape-level projects to reduce fire risk and ungulate browse for all known individuals at PTA (see Section 1.3). In addition, we actively conserve *Z. hawaiiense* genetics and have 5,706 seeds from the natural population in the propagule bank. To date, we have outplanted a combined total of 40 individuals at 7 ASRs. Seventeen trees were alive in 2020 during the last monitoring. Because *Z. hawaiiense* is a slow growing tree, it has not yet established self-sustaining populations. We have not implemented weed management specifically for *Z. hawaiiense*; however, this species benefits from invasive plant management where it occurs in weed control buffers that were implemented for other species. 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). We initiated monitoring for *Z. hawaiiense* in 2020 to track abundance annually.

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

2.5 Tier 2 Species Summaries

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 monitoring data to update the plant distributions. We report our survey results, to include the numbers of locations found during the reporting period (October 2019 through September 2021). In addition, we report the estimated abundance for 6 of Tier 2 species. For *Spermolepis hawaiiensis* we continue to report count class data collected between 2011–2015. 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 requirements.

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 the outplanting sites were monitored in 2016, 2019, and 2020, we cannot reliably distinguish the original outplants from recruits due to issues with the plant tags. 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 2020.

2.5.1 *Exocarpos menziesii* (Endangered)

As a Tier 2, we survey and monitor a portion of the known *E. menziesii* population at PTA each year to refresh the distribution and abundance estimates. The aim is to survey the entire population at PTA over a 5-year period. For genetic conservation, *E. menziesii* is an implementation priority 5 (low). We plan to collect propagules for storage with little to no outplanting.

<u>Plant Surveys and Monitoring</u>

During plant surveys for the reporting period, we recorded 262 locations *E. menziesii* within the fence units.

Based on previous survey work from 2011 to 2021, there are 3,309 locations within the fence units. In addition, from June to September we surveyed portions of TA 23 outside the fence units and recorded 1,079 adult *E. menziesii* (see Section 2.2.2 for survey details). The distribution for *E. menziesii*, including outplanting sites, is shown in Figure 42.

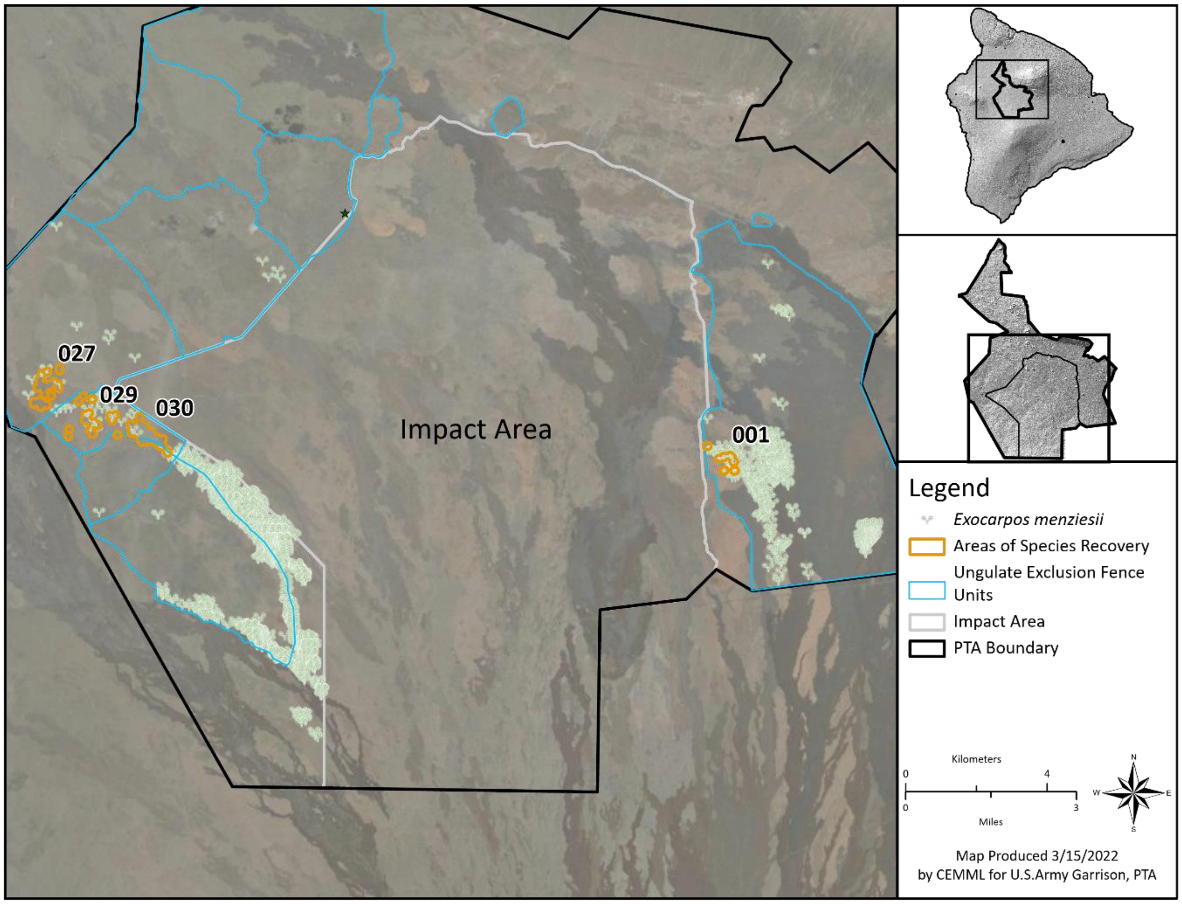

Figure 42. Current known distribution of *Exocarpos menziesii*[a].

[a] The distribution is derived from a compilation of plant survey data (2011–2021), monitoring data, and incidental rare plant finds.

In August 2019, we implemented surveys within the fence units based on a random selection of macroplots designed to sample about 30% of the *E. menziesii* population at PTA (see Section 2.2.2 for survey details). Data were analyzed based on a simple random sampling design. We estimate there are 2,068 *E. menziesii* individuals (90% confidence interval 1,844–2,292 individuals) at PTA (Table 4).

From June to September 2021, we surveyed 453.6 linear kilometers outside the ungulate exclusion fence units in TA 23 and found 2,068 *E. menziesii* individuals (see Section 2.2.2 for survey details).

Genetic Conservation

During this reporting period, we did not collect propagules, propagate or outplant *E. menziesii*. Please refer to Table 15 for a complete summary of genetic conservation status for *E. menziesii.*

Discussion

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

At PTA, *E. menziesii* naturally occurs primarily in sparse *Metrosideros* treeland and *Dodonaea* shrubland habitat types. The species was most abundant in the Kīpuka ʻAlalā South and Puʻu Koli Fence Units, and was also found in the Kīpuka ʻAlalā North, *Kadua coriacea*, Mixed Tree, and Nāʻōhuleʻelua Fence Units (Figure 42). It is currently found in 4 ASRs, but these ASRs were designated for other primary species and may not be well suited to address management needs of *E. menziesii.*

We completed surveys that sampled about 30% of the known *E. menziesii* population within the fence units at PTA in March 2020. From this data, we estimated there are 2,068 *E. menziesii* individuals at PTA within the fence units. Implementing the sampling approach to surveying the population proved to be an efficient use of staff resources and yielded data sufficient to calculate statistically valid abundance estimates with a high degree of confidence. We recommend implementing a similar approach to meet future monitoring requirements for *E. menziesii.*

In 2021, we initiated surveys in TA 23 outside the ungulate exclusion fence based on several incidental sightings of *E. menziesii* outside the fences. From June to September, we found 2,267 adult *E. menziesii* effectively doubling the known population at PTA. However, in September 2021, we shifted to the 30% random sampling design; therefore, not all of the data collected from June through August (1,079 individuals) will be included in the data analysis to estimate the abundance (see Section 2.2.2 for more details).

Based on our preliminary findings, more than half of the *E. menziesii* population at PTA occurs in TA 23 outside the ungulate exclusion fences and outside the Impact Area. This proportion is likely to increase as surveys continue and are completed in FY 2022. The plants at PTA comprise the majority of the statewide population of *E. menziesii,* so the doubling of the population at PTA is important for this species statewide. We expect to complete data collection by February 2022 and complete the data analysis by third quarter FY 2022.

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

We know very little about the life history characteristics of *E. menziesii.* Although the population of *E. menziesii* appears relatively robust in terms of numbers, we know little about the age distribution that will support healthy and resilient populations. In addition, with high levels of fruit and seed depredation and low levels of recruitment observed, this population may be at risk of rapid decline if adult mortality increases. Currently, we have ranked this species Tier 2 due to its relatively high numbers. However, the time to evaluate threats to the plants and investigate factors affecting recruitment is now while population numbers remain robust. Because thousands of individuals are present at PTA, we can experimentally test assumptions and threat control methods. Implementing these types of experiments will help us to better design science-based, targeted management approaches for *E. menziesii.*

Because *E. menziesii* is an implementation priority 5 (low) for genetic conservation, propagule collection and storage are our primary conservation actions. We collected 776 seeds representing more than 9 founders and propagated 276 seeds, which resulted in 27 seedlings of which a single plant grew to sufficient size to be accessioned to the RPPF. Because we have not worked extensively with *E. menziesii* in past years, there is still much to learn about germination requirements and seedling establishment and care. There are 31 *E. menziesii* accessioned to the RPPF.

Progress toward INRMP Objectives

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

To manage threats proactively for *E. menziesii*, we implement landscape-level projects to reduce fire risk and ungulate browse for all known individuals at PTA (see Section 1.3). We actively conserve *E. menziesii* genetics; the propagule bank contains 677 seeds from the natural population. We have not implemented weed control for this species. Although we monitor *E. menziesii* via rare plant surveys to estimate abundance, we are unable to attribute changes in numbers to effects from training or management.

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

2.5.2 *Festuca hawaiiensis* (Endangered)

As a Tier 2, we survey and monitor a portion of the known *F. 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 5-year period. For genetic conservation, *F. hawaiiensis* is an implementation priority 5 (low). We plan to collect propagules for storage with little to no outplanting.

Plant Surveys and Monitoring

During plant surveys for the reporting period, we recorded 470 locations of *F. hawaiiensis*.

Based on rare plant surveys from 2011 to 2021, there are 1,233 locations of *F. hawaiiensis.* The distribution for *F. hawaiiensis*, including outplanting sites, is shown in Figure 43.

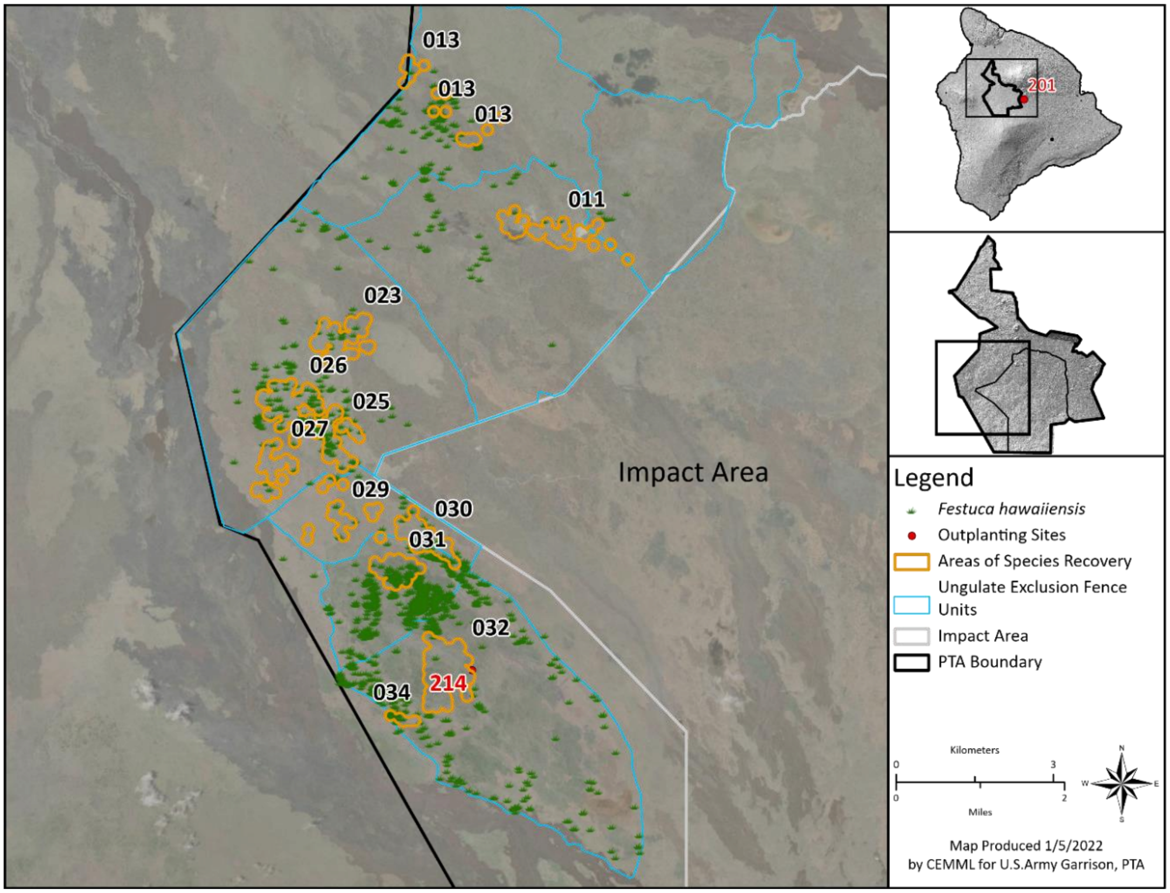

Figure 43. Current known distribution and outplanting sites for *Festuca hawaiiensis*[a].

[a] The distribution is derived from a compilation of plant survey data (2011–2021), monitoring data, and incidental rare plant finds.

In August 2019, we implemented surveys within the fence units based on a random selection of macroplots designed to sample about 30% of the *F. hawaiiensis* population at PTA (see Section 2.2.2 for survey details). Data were analyzed based on a simple random sampling design. We estimate there are 9,905 *F. hawaiiensis* individuals (90% confidence interval 8,465–11,342 individuals) at PTA (Table 4).

From June to September 2021, we surveyed 453.6 linear kilometers outside the ungulate exclusion fence units in TA 23 and found 5 *F. hawaiiensis* individuals (see Section 2.2.2 for survey details).

<u>**Genetic Conservation**</u>

During this reporting period, we did not collect propagules, propagate or outplant *F. hawaiiensis.* Please refer to Table 15 for a complete summary of genetic conservation status for *F. hawaiiensis.*

In previous years, we planted a total of 11 *F. hawaiiensis* individuals at 2 ASRs (Table 37). *F. hawaiiensis* did not establish at ASR 201. In 2016, we did not find *F. hawaiiensis* at ASR 214, but we found 86 and 40 juveniles and adults in 2019 and 2020, respectively. We assume the plants found at the site in 2019 and 2020 are from seeds of the plants planted between 2004 and 2014. Although the percent change is negative for the number of plants present from 2014 to 2020, 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, outplanting is not a priority for this this species.

Table 37. Monitoring results as of December 2020 for *Festuca hawaiiensis* outplanted between 2004 and 2014.

Location	Area of Species Recovery	Total Outplanted 2004-2014	Total Present 2014		Total Present 2020		% Change 2014-2020	Seedlings 2020
			Adult	Juvenile	Adult	Juvenile		
Off PTA	201	4	63	0	0	0	0%	0
On PTA	214	7	15	40	36	6	-11%	0

Note: The data source for planting activity between 2004–2014 and 2014 monitoring data is CEMML 2015. For Areas of Species Recovery, underline denotes juvenile/adult recruits were present in 2014.

Discussion

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

At PTA, *F. hawaiiensis* naturally occurs primarily in the Kīpuka Kālawamauna East, Kīpuka Kālawamauna West, Nāʻōhuleʻelua, Mixed Tree, *Kadua coriacea*, Kīpuka ʻAlalā North, and Kīpuka ʻAlalā South Fence Units (Figure 43). There are also 5 individuals outside the fence units in TA 23.

We completed surveys that sampled about 30% of the known *F. hawaiiensis* population within the fence units at PTA in March 2020. From this data, we estimated there are 9,905 *F. hawaiiensis* individuals at PTA within the fence units.

In previous reports, we reported the abundance of *F. hawaiiensis* as the minimum number of individuals at PTA which was derived from count class data recorded at each plant location during surveys from 2011 to 2015. We used the lower boundary of each count class to quantify the minimum number of individuals for descriptive purposes only. However, compared to the abundance estimate derived from the sampled populations (9,905 individuals), the minimum number estimates (1,803 individuals) derived from the 2011 to 2015 survey data underrepresented the population size for *F. hawaiiensis* (Table 5). Some natural recruitment likely occurred between the 2 surveys, especially since the ungulates were cleared from the fences by 2017. However, such dramatic changes in population estimates are likely because the previous estimation method was a poor predictor of population for *F. hawaiiensis.* Implementing the sampling approach to surveying the population proved to be an efficient use of staff resources and yielded data sufficient to calculate statistically valid abundance estimates with a high degree of confidence. We recommend implementing a similar approach to meet future monitoring requirements for *F. hawaiiensis.*

We plan to designate ASRs for *F. hawaiiensis* in 2022. This species was recently listed as endangered, and we know little about its life history characteristics or threats that may be limiting this species.

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. Although there was an 11% decline in numbers from 2014 to 2020, the number of plants remaining at the sites is almost 6-fold higher than the number planted. 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* used 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).

Progress toward INRMP Objectives

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

To manage threats proactively for *F. hawaiiensis*, we implement landscape-level projects to reduce fire risk and ungulate browse for all known individuals at PTA (see Section 1.3). We actively conserve *F. hawaiiensis* genetics; the propagule bank contains 184 seeds from the wild population and 245 seeds from individuals grown in the RPPF or from individuals outplanted. We have not implemented weed control for this species. Although we monitor *F. hawaiiensis* via rare plant surveys to estimate abundance, we are unable to attribute changes in numbers to effects from training or management.

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

2.5.3 *Haplostachys haplostachya* (Endangered)

As a Tier 2, we survey and monitor a portion of the known *H. haplostachya* population at PTA each year to refresh the distribution and abundance estimates. The aim is to survey the entire population at PTA over a 5-year period. For genetic conservation, *H. haplostachya* is an implementation priority 5 (low). We plan to collect propagules for storage with little to no outplanting.

Plant Surveys and Monitoring

During the reporting period, we recorded/reconfirmed 263 locations of *H. haplostachya* at PTA.

Based on previous survey work from 2011 to 2021, there are 3,110 locations of *H. haplostachya* at PTA. The distribution for *H. haplostachya*, including outplanting sites, is shown in Figure 44.

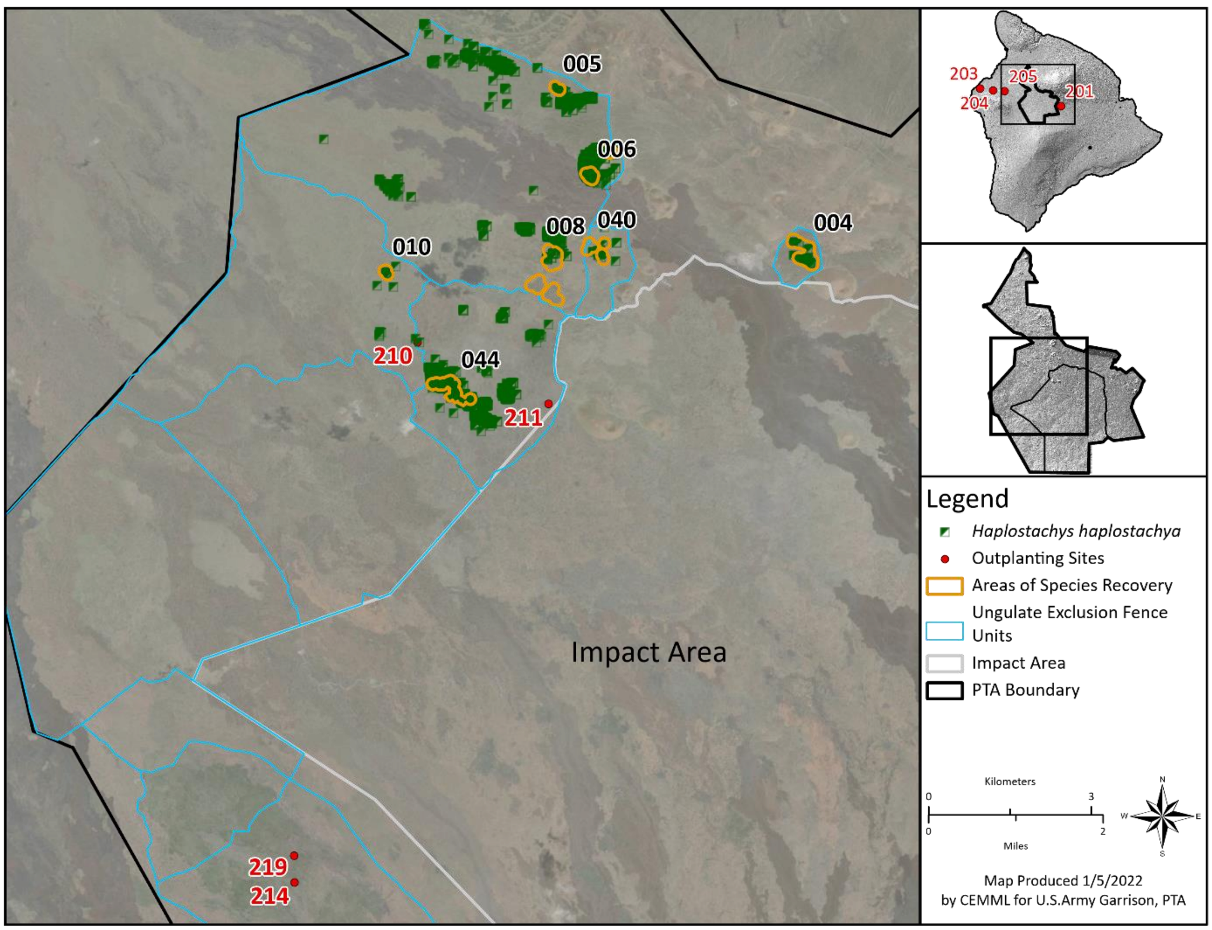

Figure 44. Current known distribution and outplanting sites for *Haplostachys haplostachya*[a].

[a] The distribution is derived from a compilation of plant survey data (2011–2021), monitoring data, and incidental rare plant finds.

In August 2019, we implemented surveys within the fence units based on a random selection of macroplots designed to sample about 30% of the *H. haplostachya* population at PTA (see Section 2.2.2 for survey details). Data were analyzed based on a simple random sampling design. We estimate there are 24,010 *H. haplostachya* individuals (90% confidence interval 18,647–29,346 individuals) at PTA (Table 4).

Genetic Conservation

During this reporting period, we did not collect propagules, propagate or outplant *H. haplostachya.* Please refer to Table 15 for a complete summary of genetic conservation status for *H. haplostachya.*

In previous years, we planted a total 531 *H. haplostachya* individuals at 8 ASRs (Table 38). During monitoring in December 2020, *H. haplostachya* adults and/or juveniles were present in low numbers at 3 ASR on PTA and no plants were present at ASRs 201 through 205.

Table 38. Monitoring results as of December 2020 for *Haplostachys haplostachya* outplanted between 2004 and 2014.

Location	Area of Species Recovery	Total Outplanted 2004-2014	Total Present 2014		Total Present 2020		% Change 2014-2020	Seedlings 2020
			Adult	Juvenile	Adult	Juvenile		
Off PTA	201	51	7	0	0	0	-100%	0
	203	69	0	0	0	0	0%	0
	204	8	0	1	0	0	-100%	0
	205	251	57	1	0	0	-100%	0
On PTA	**210**	10	0	9	0	0	-100%	0
	211	32	1	0	0	1	0%	0
	214	95	68	1	1	2	-96%	0
	219	18	16	0	8	0	-50%	0

Note: The data source for planting activity between 2004–2014 and 2014 monitoring data is CEMML 2015. For Areas of Species Recovery, bold denotes seedlings and underline denotes juvenile/adult recruits were present in 2014.

Discussion

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

At PTA, *H. haplostachya* naturally occurs primarily in the *Haplostachys haplostachya, Solanum incompletum,* Kīpuka Kālawamauna East, Kīpuka Kālawamauna West, and Kīpuka Kālawamauna North Fence Units (Figure 44).

We completed surveys that sampled about 30% of the known *H. haplostachya* population within the fence units at PTA in March 2020. From this data, we estimated there are 24,010 *H. haplostachya* individuals at PTA within the fence units. Implementing the sampling approach to surveying the population proved to be an efficient use of staff resources and yielded data sufficient to calculate statistically valid abundance estimates with a high degree of confidence. We recommend implementing a similar approach to meet future monitoring requirements for *H. haplostachya.*

Although *H. haplostachya* was one of the first endangered plants documented at PTA in the late 1970's, we still know relatively little about its life history and ecology. Flower morphology of *H. haplostachya* suggest the plant is pollinated by insects (Lindqvist and Albert 2002). However, Aslan et al. (2019) found that no native insects visited *H. haplostachya* but 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 find viable seed in the natural population. We also observe seedlings in the natural populations, sometimes in very high numbers, but our success with seed germination in the RPPF is low. In addition, genetic variation among plants is higher in larger groups possibly making smaller groups, with less genetic variation, more vulnerable to changes in environmental conditions (Morden and Loeffler 1999). We plan to incorporate this information into genetic conservation plans for collections and potential augmentation of small natural populations. We recommend exploring opportunities for basic research into life history characteristics to support science-based management of this species. Knowing these life history attributes is important for designing management actions to maximize the likelihood that *H. haplostachya* will persist, and potentially increase, especially with changing climate conditions.

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

We continue to monitor outplantings conducted between 2004 and 2014 (Table 38). Overall, sites have sharply decreased in the number of adults and juveniles present since planting was halted 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 from seed 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 impacted by construction of the Battel 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 adequately replacing the number of individuals impacted by the construction. Although the location of the *H. haplostachya* within the BAX was not directly impacted 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, as mentioned above, 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 ASRs, primarily ASR 213 and ASR 214. Similar to other outplanting sites, the *H. haplostachya* individuals have decline since 2014 and recruitment has only been observed 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 at outplanting sites and that are influencing the establishment of recruits from seed at the sites. We recommend, where possible, collaborating with other scientists, researchers, and students to address some of these research needs. We recommend that in-house germination trials continue, especially with the new seed germination chamber. 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.

Progress toward Compliance with Endangered Species Act Biological Opinion Conservation Measures

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

To address these conservation measures for *H. haplostachya*, we implement landscape-level projects to reduce fire-risk and ungulate browse for all known individuals at PTA (see Section 1.3). In addition, we actively conserve *H. haplostachya* genetics; the propagule bank contains 41,850 seeds and 9,289 fruits from the wild population and 11,768 seeds and 25,504 fruits from individuals grown in the RPPF or individuals outplanted. To date, we have outplanted 534 individuals at 8 ASRs and outplants have shown low success. We managed invasive plants across about 1.4 ha specifically for wild *H. haplostachya* in ASR 4 (Table 44). 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. This species also receives benefit from invasive plant management where it occurs in weed control buffers that were implemented for other species. Although we do not currently monitor for *H. haplostachya in situ* reproduction annually, in 2008 and 2009 we noted *H. haplostachya* seedlings in all 9 ASRs where we had monitoring plots. No seedlings were present at any of the 9 ASRs in 2007 and 2010. We monitor a portion of the *H. haplostachya* distribution annually and estimate abundance based on rare plant survey data. However, we are unable to attribute changes in numbers to effects from training or management.

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

2.5.4 *Silene hawaiiensis* (Threatened)

As a Tier 2, 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 5-year period. For genetic conservation, *Silene hawaiiensis* is an implementation priority 5 (low). We plan to collect propagules for storage with little to no outplanting.

Plant Surveys and Monitoring

During plant surveys for the reporting period, we recorded 361 locations of *Silene hawaiiensis.*

Based on previous survey work from 2011 to 2021, there are 1,581 locations of *Silene hawaiiensis* at PTA. The distribution for *Silene hawaiiensis*, including outplanting sites, is shown in Figure 45.

In August 2019, we implemented surveys within the fence units based on a random selection of macroplots designed to sample about 30% of the *Silene hawaiiensis* population at PTA (see Section 2.2.2 for survey details). Data were analyzed based on a simple random sampling design. We estimate there are 9,076 *Silene hawaiiensis* (90% confidence interval 7,951–10,200 individuals) at PTA (Table 4).

From June to September 2021, we surveyed 453.6 linear kilometers outside the ungulate exclusion fence units in TA 23 and found 17 *Silene hawaiiensis* individuals (see Section 2.2.2 for survey details).

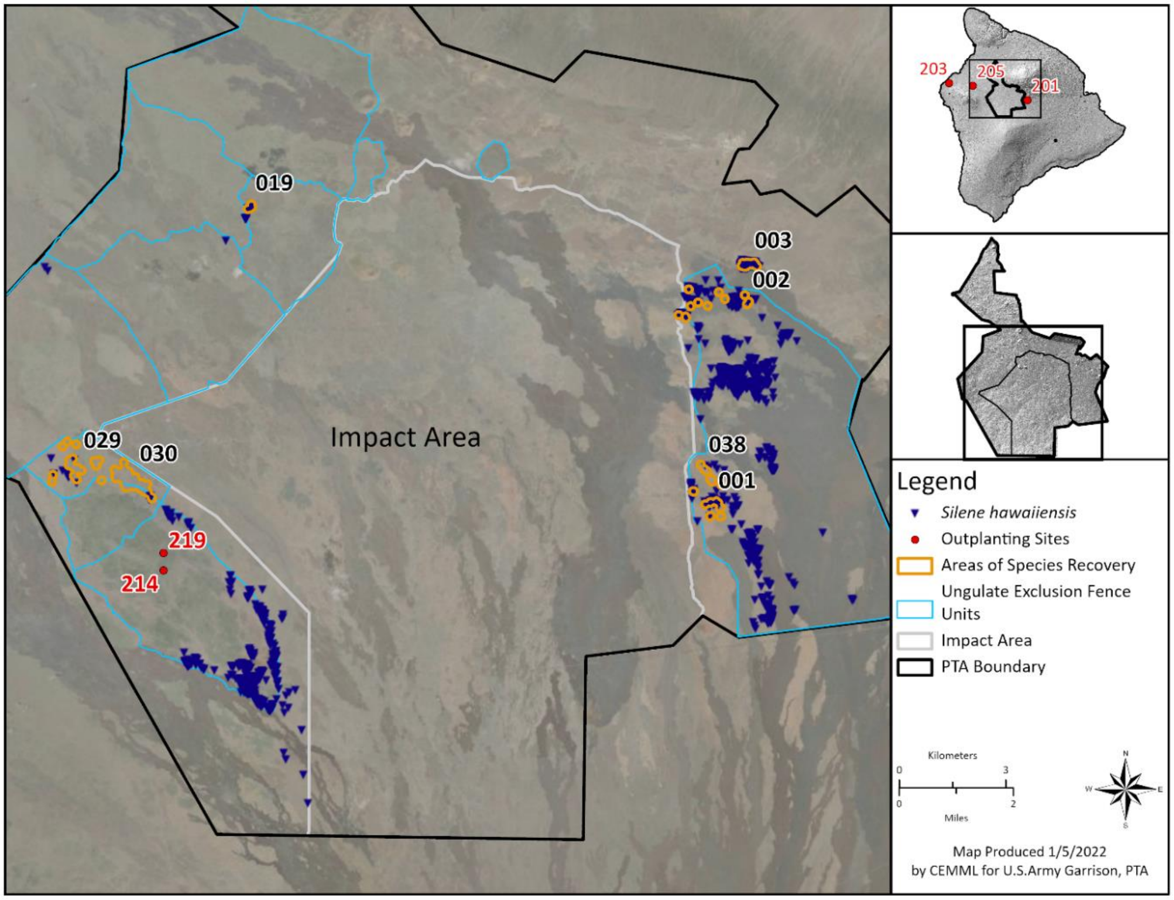

Figure 45. Current known distribution and outplanting sites for *Silene hawaiiensis*[a].

[a] The distribution is derived from a compilation of plant survey data (2011–2021), monitoring data, and incidental rare plant finds.

Genetic Conservation

During this reporting period, we did not collect propagules, propagate or outplant *Silene hawaiiensis.* Please refer to Table 15 for a complete summary of genetic conservation status for *Silene hawaiiensis.*

In previous years, we planted a total 83 *Silene hawaiiensis* individuals at 5 ASRs (Table 39). As of December 2020, adults were present only at ASR 214.

Table 39. Monitoring results as of December 2020 for *Silene hawaiiensis* outplanted between 2004 and 2014.

Location	Area of Species Recovery	Total Outplanted 2004-2014	Total Present 2014		Total Present 2020		% Change 2014-2020	Seedlings 2020
			Adult	Juvenile	Adult	Juvenile		
Off PTA	**201**	31	14	3	0	0	-100%	0
	203	18	0	0	0	0	-100%	0
	205	22	8	1	0	0	-100%	0
On PTA	**214**	10	6	3	6	0	-33%	0
	219	2	1	1	0	0	-100%	0

Note: The data source for planting activity between 2004–2014 and 2014 monitoring data is CEMML 2015. For Areas of Species Recovery, bold denotes seedlings and underline denotes juvenile/adult recruits were present in 2014.

Discussion

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

At PTA, *Silene hawaiiensis* naturally occurs primarily in the *Silene hawaiiensis*, Kīpuka Kālawamauna East, *Kadua coriacea*, Kīpuka ʻAlalā North, Kīpuka ʻAlalā South, and Pu'u Koli Fence Units (Figure 45). 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 and in 2021, we documented 17 individuals in TA 23 outside the fence units and outside the Impact Area.

We completed surveys that sampled about 30% of the known *Silene hawaiiensis* population within the fence units at PTA in March 2020. From this data, we estimated there are 9,076 *Silene hawaiiensis* individuals at PTA within the fence units.

In previous reports, we reported the abundance of *Silene hawaiiensis* as the minimum number of individuals at PTA which was derived from count class data recorded at each plant location during surveys from 2011 to 2015. We used the lower boundary of each count class to quantify the minimum number of individuals for descriptive purposes only. However, compared to the abundance estimate derived from the sampled populations (9,076 individuals), the minimum number estimates (2,344 individuals) derived from the 2011 to 2015 survey data underrepresented the population size for *Silene hawaiiensis* (Table 5). Some natural recruitment likely occurred between the 2 surveys, especially since the ungulates were cleared from the fences by 2017. However, such dramatic changes in population estimates are likely because the previous estimation method was a poor predictor of population for *Silene hawaiiensis.* Implementing the sampling approach to surveying the population proved to be an efficient use of staff resources and yielded data sufficient to calculate statistically valid abundance estimates with a high degree of confidence. We recommend implementing a similar approach to meet future monitoring requirements for *Silene hawaiiensis.*

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. We assume that many of the documented traits will be similar to plants at PTA, but this information should be used to guide local investigations as there may be seasonal shifts in phenology due to differences in climate and environmental conditions.

Between 2007 and 2010, we monitored *Silene hawaiiensis* in 5 ASRs and collected demographic information (CEMML 2010). Although we did not observe seedlings at any of the ASRs, we did note recruitment into the juvenile and adult life stages presumably from plants that germinated between monitoring periods. We plan to use life history information to design monitoring and management strategies for *Silene hawaiiensis* to support healthy and resilient populations under changing climate conditions.

We continue to make progress with genetic conservation of *Silene hawaiiensis.* We have had success germinating *Silene hawaiiensis* even from seeds that were more than 20 years old. However, at most outplanting sites, *Silene hawaiiensis* has not persisted to 2020, with the exception of ASR 214 where *Silene hawaiiensis* persisted in moderate numbers. However, even at this location, recruitment appears to be inefficient to off-set losses of individuals. 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.

Progress toward Compliance with Endangered Species Act Biological Opinion Conservation Measures

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

To address these conservation measures for *Silene hawaiiensis*, we implement landscape-level projects to reduce fire-risk and ungulate browse for all known individuals at PTA (see Section 1.3). In addition, we actively conserve *Silene hawaiiensis* genetics; the propagule bank contains 11,425 seeds from the wild population and 28,520 seeds from individuals grown in the RPPF. To date, we have outplanted about 83 individuals at 5 ASRs; however, we have not observed enough reproduction to consider *Silene hawaiiensis* self-sustaining at any of the ASRs. We managed invasive plants for wild *Silene hawaiiensis* in ASR 3 in about 13.4 ha (Table 44). This species also benefits from invasive plant management where it occurs in weed control buffers that were implemented for other species. Although we do not currently monitor for *Silene hawaiiensis in situ* reproduction annually, previous monitoring in 5 ASR for *Silene hawaiiensis* documented increases of plants (presumably from seedlings that germinated between monitoring periods). We monitor a portion of the *Silene* *hawaiiensis* distribution annually and estimate abundance based on rare plant survey data. However, we are unable to attribute changes in numbers to effects from training or management.

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

2.5.5 *Silene lanceolata* (Endangered)

As a Tier 2, we survey and monitor a portion of the known *S. lanceolata* population at PTA each year to refresh the distribution and abundance estimates. The aim is to survey the entire population at PTA over a 5-year period. For genetic conservation, *S. lanceolata* is an implementation priority 5 (low). We plan to collect propagules for storage with little to no outplanting.

Plant Surveys and Monitoring

During plant surveys for the reporting period, we found/reconfirmed 129 locations of *S. lanceolata.*

Based on previous survey work from 2011 to 2021, there are 650 locations of *S. lanceolata* PTA. The distribution for *S. lanceolata,* including outplanting sites, is shown in Figure 46.

In August 2019, we implemented surveys within the fence units based on a random selection of macroplots designed to sample about 30% of the *S. lanceolata* population at PTA (see Section 2.2.2 for survey details). Data were analyzed based on a simple random sampling design. We estimate there are 11,772 *S. lanceolata* individuals (90% confidence interval 9,919–11,772 individuals) at PTA (Table 4).

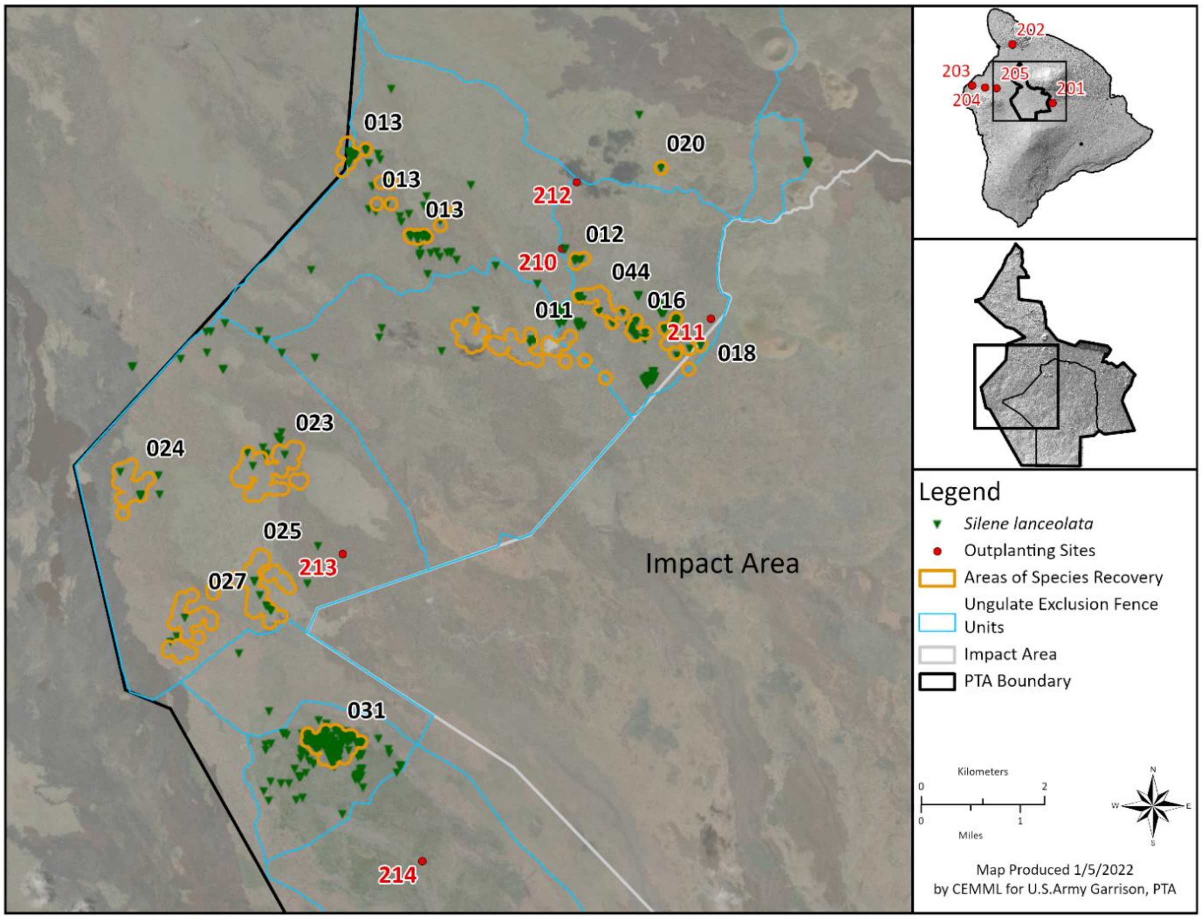

Figure 46. Current known distribution and outplanting sites for *Silene lanceolata*[a].

[a] The distribution is derived from a compilation of plant survey data (2011–2021), monitoring data, and incidental rare plant finds.

Genetic Conservation

During this reporting period, we did not collect propagules, propagate or outplant *S. lanceolata.* Please refer to Table 15 for a complete summary of genetic conservation status for *S. lanceolata.*

In previous years, we planted a total 917 *S. lanceolata* individuals at 10 ASRs (Table 40). The number of *S. lanceolata* adults and juveniles present increased at ASRs 213. At all other sites, the number of adults and juveniles present declined between 2014 and 2020.

Table 40. Monitoring results as of December 2020 for *Silene lanceolata* outplanted between 2004 and 2014.

Location	Area of Species Recovery	Total Outplanted 2004-2014	Total Present 2014		Total Present 2020		% Change 2014-2020	Seedlings 2020
			Adult	Juvenile	Adult	Juvenile		
Off PTA	**201**	51	10	13	4	0	-83%	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	1	1	-99%	0
On PTA	210	125	8	28	0	0	-100%	0
	211	59	25	86	159	51	-100%	0
	212	26	1	14	0	0	-100%	0
	213	3	3	0	11	11	+633%	0
	214	75	802	1,600	293	169	-81%	0

Note: The data source for planting activity between 2004–2014 and 2014 monitoring data is CEMML 2015. For Areas of Species Recovery, bold denotes seedlings and underline denotes juvenile/adult recruits were present in 2014.

Discussion

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

At PTA, *S. lanceolata* naturally occurs primarily in the Kīpuka Kālawamauna North, Kīpuka Kālawamauna East, Kīpuka Kālawamauna West, *Solanum incompletum*, Nāʻōhuleʻelua, Mixed Tree, *Kadua coriacea*, and Kīpuka ʻAlalā North, Fence Units (Figure 46).

We completed surveys that sampled about 30% of the known *S. lanceolata* population within the fence units at PTA in March 2020. From this data, we estimated there are 11,772 *S. lanceolata* individuals at PTA within the fence units.

In previous reports, we reported the abundance of *S. lanceolata* as the minimum number of individuals at PTA which was derived from count class data recorded at each plant location during surveys from 2011 to 2015. We used the lower boundary of each count class to quantify the minimum number of individuals for descriptive purposes only. However, compared to the abundance estimates derived from the sampled populations (11,772 individuals), the minimum number estimate derived from the 2011 to 2015 (3,882 individuals) underrepresents the population size for *S. lanceolata* (Table 5). Some natural recruitment likely occurred between the 2 surveys, especially since the ungulates were cleared from the fences by 2017. However, such dramatic changes in population estimates are likely because the previous estimation method was a poor predictor of population for *S. lanceolata*. Implementing the sampling approach to surveying the population proved to be an efficient use of staff resources and yielded data sufficient to calculate statistically valid abundance estimates with a high degree of confidence. We recommend implementing a similar approach to meet future monitoring requirements for *S. lanceolata.*

Although we have had some outplanting and management success with *S. lanceolata*, we still know relatively little about life history characteristics and population dynamics. We are still learning about ecological interactions between this species and animals. Aslan et al. (2019) found that no native insects visited *S. lanceolata* flowers and all pollination services were performed by non-native insects including honeybees, hover flies, fly species (*Diptra* spp.), and sweat bees (*Lasioglossum impavidum*). In addition, researchers concluded that ants, Argentine (*Linepithema humile*) in particular, are a threat to endangered plants (Christina Liang, personal communication, May 2018). We recommend exploring opportunities for basic research into life history characteristics to support science-based management of this species. Knowing these life history attributes and potential threats is important for designing management actions to maximize the likelihood that *S. lanceolata* will persist, and potentially increase, especially with changing climate conditions.

We continue to make progress with genetic conservation of *S. lanceolata*. Many of the accessions in storage are 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 some locations (Table 40). At ASRs 204 and 205, the initial performance of the outplants was extremely promising with strong recruitment; however, by 2020, the numbers of adults and juveniles present were very low, or they were not present. For ASR 205, the decline may be due in part to a gap in habitat management between 2017 and 2019 which allowed invasive grasses to overrun many of the planting areas. This may have increased competition with the invasive plants and or reduced the available germination sites. At ASR 214, initial recruitment also was high but since 2014 the number of adults and juveniles present declined sharply suggesting that recruitment was insufficient to replace losses. Although the losses at ASR 214 have been high, we are encouraged that a large number of adults and juveniles are still present and are hopefully moving toward a self-sustaining population. Additionally, the number of *S. lanceolata* adults and juveniles present increased at ASR 213. Initially, relatively few plants were planted at ASR 213, which suggests that the site conditions were favorable to establishment and recruitment and may lead to a self-sustaining population. Further, this result also suggests that for *S. lanceolata,* a few plants planted in the right location may result in successful establishment. 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.

Progress toward Compliance with Endangered Species Act Biological Opinion Conservation Measures

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

To address these conservation measures for *S. lanceolata*, we implement landscape-level projects to reduce fire risk and ungulate browse for all known individuals at PTA (see Section 1.3). In addition, we actively conserve *S. lanceolata* genetics; the propagule bank contains 473,998 seeds from the wild population and 1,069,751 seeds from individuals grown in the RPPF or from individuals outplanted. To date, we have outplanted 917 individuals at 10 ASRs and *S. lanceolata* has increased in number at 2 of the ASRs. 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 31 ha for *S. lanceolata* and other Tier 1 plants co-located in the control buffers (Table 44). This species also benefits from invasive plant management where it occurs in weed control buffers that were implemented for other species. Although we do not currently monitor for *S. lanceolata in situ* reproduction annually; in 2008 and 2009 we noted past *S. lanceolata* seedlings in all 10 ASRs monitored. No seedlings were recorded in 2007 or 2010, suggesting that *in situ* reproduction is not constant but occurs when environmental conditions are favorable. We monitor a portion of the *S. lanceolata* distribution annually and estimate abundance based on rare plant survey data. However, we are unable to attribute changes in numbers to effects from training or management.

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

2.5.6 *Spermolepis hawaiiensis* (Endangered)

As a Tier 2 species, we plan to survey and monitor a portion of the known *Spermolepis hawaiiensis* distribution each year. However, we derive distribution and estimate abundance for each species within the ungulate exclusion fences from the completed 5-year data set (2011 to 2015). For genetic conservation, *Spermolepis hawaiiensis* is an implementation priority 5 (low). We plan to collect propagules for storage with little to no outplanting.

Plant Survey and Monitoring

During plant surveys for the reporting period, we recorded 1 location of *Spermolepis hawaiiensis*.

Spermolepis hawaiiensis was not included in the 2020 survey effort 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 minimum number of plants at PTA. To generate this estimate, we used the lower boundary of each count class collected during the 2011–2015 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. The distribution for *Spermolepis hawaiiensis*, including outplanting sites, is shown in Figure 47.

Genetic Conservation

During this reporting period, we did not collect propagules, propagate or outplant *Spermolepis hawaiiensis.* Please refer to Table 15 for a complete summary of genetic conservation status for *Spermolepis hawaiiensis*.

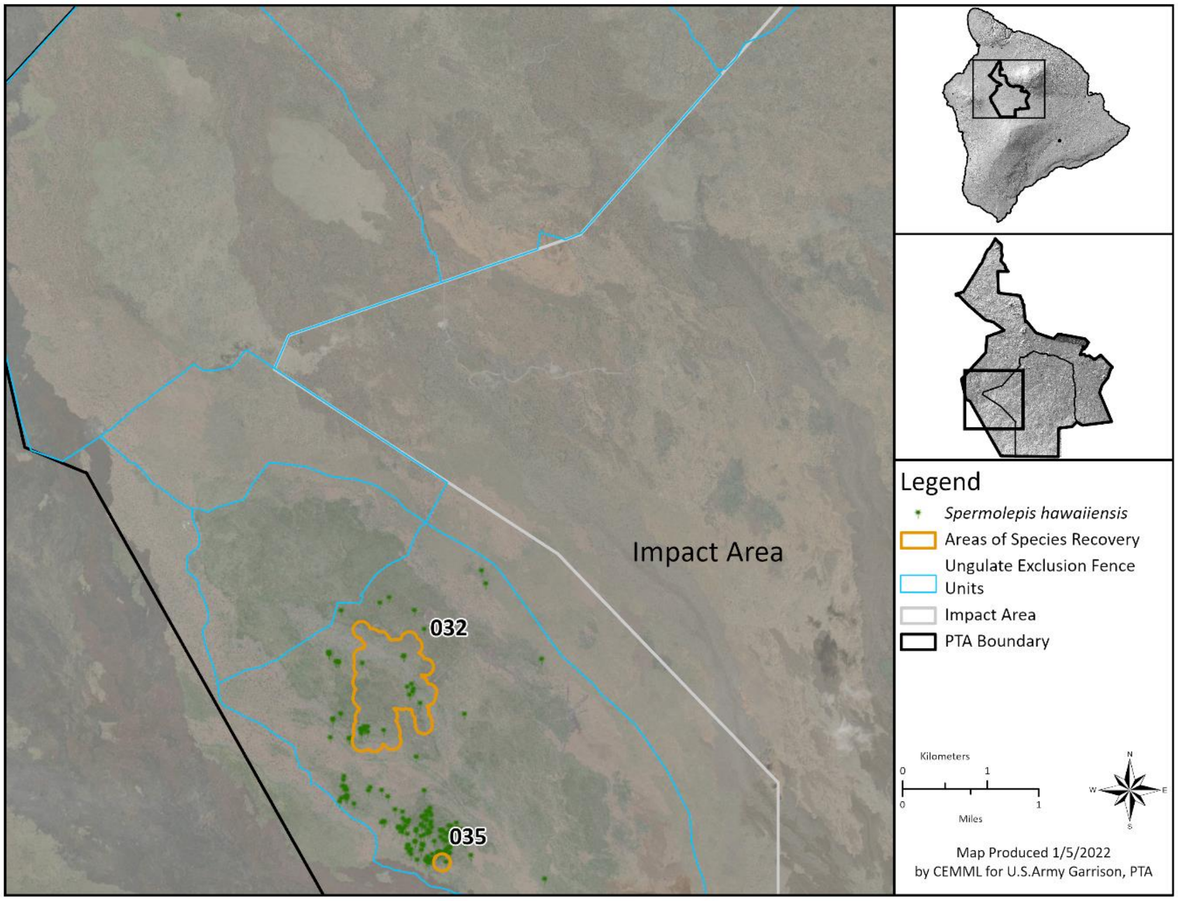

Figure 47. Current known distribution of *Spermolepis hawaiiensis*[a].

[a] The distribution is derived from a compilation of plant survey data (2011–2021), monitoring data, and incidental rare plant finds.

Genetic Conservation

During this reporting period, we did not collect propagules, propagate or outplant *Spermolepis hawaiiensis.* Please refer to Table 15 for a complete summary of genetic conservation status for *Spermolepis hawaiiensis.*

In previous years, we planted a total 49 *Spermolepis hawaiiensis* individuals at 5 ASRs and broadcast seed at 2 ASRs (Table 41). *Spermolepis hawaiiensis* no longer remains at any outplanting site. Since this species is an annual it is not surprising that no outplants remain. Due to the lack of plants at the sites, we also assume that seed banks failed to establish.

Table 41. Monitoring results as of December 2020 for *Spermolepis hawaiiensis* outplanted between 2004 and 2014.

Location	Area of Species Recovery	Total Outplanted 2004-2014	Adult	Juvenile	Seedlings
Off PTA	201	1	0	0	0
	203	8	0	0	0
	204	0+	0	0	0
	205	3+	0	0	0
On PTA	214	21	0	0	0
	216	16	0	0	0

Note: The data source for planting activity between 2004–2014 is CEMML. The number of *Spermolepis hawaiiensis* present was not reported for the 2014 monitoring, but recruitment was noted. For Areas of Species Recovery, underline denotes the presence of recruitment in 2014.
+ Broadcast seed

Discussion

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

At PTA, *Spermolepis hawaiiensis* naturally occurs primarily in the Kīpuka ʻAlalā North and South Fence Units with 2 additional locations within the Mixed Tree Fence Unit (Figure 47). *Spermolepis hawaiiensis* is an ephemeral species and although it is an annual it may not always be present throughout its entire range unless environmental conditions are favorable. Because of its ephemeral nature, we did not include *Spermolepis hawaiiensis* in the sampling methods for the plant surveys. Until we develop a monitoring approach more targeted to the unique life history characteristics of *Spermolepis hawaiiensis*, we will continue to use the abundance estimate developed from the first cycle of plant surveys (2011 to 2015).

We know very little about the life history characteristics of *Spermolepis hawaiiensis.* Its short-lived nature and episodic germination and recruitment make this a difficult species to study. We have made some progress with genetic conservation for *Spermolepis hawaiiensis*, but collection from the natural population can be unreliable due to its ephemeral nature. We recommend exploring opportunities for basic research into life history characteristics to support science-based management of this species.

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. Since *Spermolepis hawaiiensis* is an annual, we do not expect that any of the original outplants to still remain at any of the sites. However, 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 the ground and readily germinate. We recommend continuing to experiment with broadcast seeding into different habitats at outplanting sites.

To offset effects from military activities to *Spermolepis hawaiiensis,* the 2003 BO conservation measures include fuels management to reduce fire risk, fencing and ungulate control to reduce browse pressure.

To address these conservation measures for *Spermolepis hawaiiensis*, we implement landscape-level projects to reduce fire-risk and ungulate browse for all known individuals at PTA (see Section 1.3). In addition, we actively conserve *Spermolepis hawaiiensis* genetics; the propagule bank contains 3,096 seeds from the wild population and 511,359 seeds from individuals grown in the RPPF or from individuals outplanted. We have direct seeded *Spermolepis hawaiiensis* at 2 outplanting site ASRs. The outplanted *Spermolepis hawaiiensis* did not successfully established self-sustaining populations at any of the ASR.

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

2.5.7 *Stenogyne angustifolia* (Endangered)

As a Tier 2, we survey and monitor a portion of the known *S. angustifolia* population at PTA each year to refresh the distribution and abundance estimates. The aim is to survey the entire population at PTA over a 5-year period. For genetic conservation, *S. angustifolia* is an implementation priority 5 (low). We plan to collect propagules for storage with little to no outplanting.

Plant Surveys and Monitoring

During plant surveys for the reporting period, we recorded 414 locations of *S. angustifolia.* Based on plant survey work from 2011 to 2021, there are 1,268 locations of *S. angustifolia* at PTA. The distribution for *S. angustifolia*, including outplanting sites, is shown in Figure 48.

In August 2019, we implemented surveys within the fence units based on a random selection of macroplots designed to sample about 30% of the *S. angustifolia* population at PTA (see Section 2.2.2 for survey details). Data were analyzed based on a simple random sampling design. We estimate there are 14,044 *S. angustifolia* individuals (90% confidence interval 10,945–17,144 individuals) at PTA (Table 4).

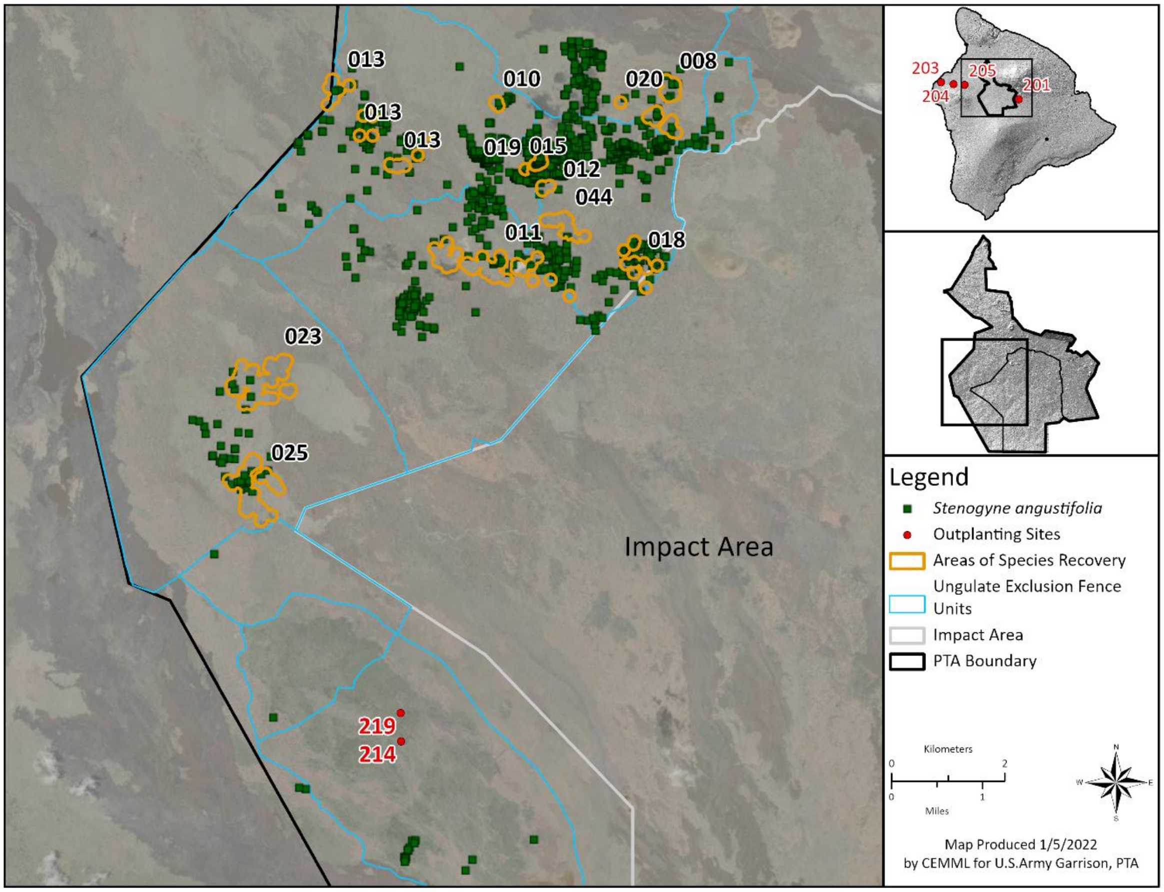

Figure 48. Current known distribution and outplanting sites for *Stenogyne angustifolia*[a].

[a] The distribution is derived from a compilation of plant survey data (2011–2021), monitoring data, and incidental rare plant finds.

Genetic Conservation

Propagule Collection

We collected 3 seeds from 1 founder (515-2084-101) during the reporting period. The seeds are being held in short-term storage with the intent to propagate the seed in 2022. Please refer to Table 15 for a complete summary of genetic conservation status for *S. angustifolia*.

Propagation, Outplanting and Monitoring

During this reporting period, we did not propagate or outplant *S. angustifolia.*

In previous years, we planted a total 246 *S. angustifolia* individuals at 6 ASRs (Table 42). Because *S. angustifolia* grows in mat-like clusters, it can be challenging identifying each individual during monitoring. As of December 2020, *S. angustifolia* remained at ASRs 201 and 205, but had decreased substantially in the number of adults and juveniles present. However, at ASR 214 the number of *S. angustifolia* adult and juvenile present was more than double the number planted. 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 42. Monitoring results as of December 2020 for *Stenogyne angustifolia* outplanted between 2004 and 2014.

Location	Area of Species Recovery	Total Outplanted 2004-2014	Total Present 2014		Total Present 2020		% Change 2014-2020	Seedlings 2020
			Adult	Juvenile[a]	Adult	Juvenile		
Off PTA	201	121	62	0	21	0	-66%	0
	203	8	0	0	0	0	0%	0
	204	8	0	0	0	0	0%	0
	205	78	48	0	8	1	-81%	0
On PTA	214	30	27	0	78	7	+215%	0
	219	1	1	0	0	0	-100%	0

Note: The data source for planting activity between 2004–2014 and 2014 monitoring data is CEMML 2015. For Areas of Species Recovery, bold denotes seedlings and underline denotes juvenile/adult recruits were present in 2014.

[a] In 2014, recruitment was noted for all sites, except ASR 203, but it was noted as colonel and was not quantified. There was a seedling noted at ASR 204.

Discussion

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

The distribution of *S. angustifolia* is nearly continuous across approximately 2,430 ha of the *Solanum incompletum*, Kīpuka Kālawamauna North, Kīpuka Kālawamauna East, Kīpuka Kālawamauna West, and Nāʻōhuleʻelua Fence Units (Figure 48). It is also scattered in the Mixed Tree Fence Unit and an isolated location in the Kīpuka ʻAlalā North Fence Unit.

We completed surveys that sampled about 30% of the known *S. angustifolia* population within the fence units at PTA in March 2020. From this data, we estimated there are 14,044 *S. angustifolia individuals* at PTA within the fence units.

In previous reports, we reported the abundance of *S. angustifolia* as the minimum number of individuals at PTA which was derived from count class data recorded at each plant location during surveys from 2011 to 2015. We used the lower boundary of each count class to quantify the minimum number of individuals for descriptive purposes only. However, compared to the abundance estimates derived from the sampled populations (14,044), the minimum number estimate derived from the 2011 to 2015 (2,517) underrepresents the population size for *S. angustifolia* (Table 5). Some natural recruitment likely occurred between the 2 surveys, especially since the ungulates were cleared from the fences by 2017. However, such dramatic changes in population estimates are likely because the previous estimation method was a poor predictor of population for *S. angustifolia*. Implementing the sampling approach to surveying the population proved to be an efficient use of staff resources and yielded data sufficient to calculate statistically valid abundance estimates with a high degree of confidence. We recommend implementing a similar approach to meet future monitoring requirements for *S. angustifolia.*

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* (Christina Liang, personal communication, May 2018). We recommend exploring opportunities for basic research into life history characteristics to support science-based management of this species. Knowing these life history attributes and potential threats is important for designing management actions to maximize the likelihood that *S. angustifolia* will persist, and potentially increase, especially with changing climate conditions.

We continue to make progress with genetic conservation of *S. angustifolia.* However, we need to better understand germination requirements of *S. angustifolia* so that we can reliably germinate seeds and effectively retrieve the stored genetics. We recommend partnering with the USAG-HI NRP on Oʻahu to leverage their expertise to establish reliable germination procedures. There are 4 *S. angustifolia* accessioned to the RPPF.

The number of *S. angustifolia* adults and juveniles present declined at most sites from 2014 and 2020, expect for at ASR 214 where the number adults and juveniles present increased substantially. The decline of *S. angustifolia* at ASR 205 is concerning because we previously thought this population was self-sustaining. We know little about the natural lifespan of *S. angustifolia* and natural attrition and insufficient recruitment may have contributed to the decline. Also, we were unable to maintain ASR 205 for about a year due to an expired permit. This lack of management may have contributed to the decline through increased competition for resources from invasive plants and a reduction in potential available germination sites. With the reduction of the group at ASR 205, we are closely monitoring the group at ASR 214. 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.

Progress toward Compliance with Endangered Species Act Biological Opinion Conservation Measures

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

To address these conservation measures for *S. angustifolia*, we implement landscape-level projects to reduce fire-risk and ungulate browse for all known individuals at PTA (see Section 1.3). In addition, we actively conserve *S. angustifolia* genetics; the propagule bank contains 2,178 seeds from the wild population and 2,045 seeds from individuals grown in the RPPF or from individuals outplanted. To date, we have outplanted 246 individuals at 6 ASRs and it has persisted at a few sites mostly in low numbers. Only at ASR 214, the number *S. angustifolia* is more than double what was originally planted. We have not implemented weed management specifically for *S. angustifolia*; however, this species benefits from invasive plant management where it occurs in weed control buffers that were implemented for other species. Although we do not currently monitor for *S. angustifolia in situ* reproduction annually, we have observed *in situ* reproduction of *S. angustifolia*, most recently in TAs 18, 19, and 22 in the area burned by the July 2018 fire. We monitor a portion of the *S. angustifolia* distribution annually and estimate abundance based on rare plant survey data. However, we are unable to attribute changes in numbers to effects from training or management.

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

2.6 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 that retain potential to persist under changing climate conditions.

Implementing ecosystem management coupled with a species-specific approach for protected plants supports a holistic approach to natural resources conservation. Many aspects of the Hawaiian ecosystem have changed since the arrival of people and the introduction of non-native plants and animals. We continue to witness the cascading effects of these ecosystem disruptions, sometimes years later (e.g., change in fire-regime from introduced grasses). Often, we are unaware of the negative cascading effects across trophic levels until there is a problem, such as introduced ants negatively impacting native pollinators and possibly disrupting or changing pollination services for endangered plants. This slow, or sometimes rapid, erosion of ecological relationships can reduce community resilience to additional invasions or changes in climate (Suding et al. 2004; Suding 2011). By managing elements in the environment, we reduce or eliminate some stressors from the ecosystem and from individual species, particularly endangered or rare species (e.g., the removal of feral ungulates). Managing at the ecosystem scale helps to maintain ecological relationships that support ESA-listed plants and affords the opportunity to investigate means to ensure these species persist.

Implementing Botanical Program projects supports Army readiness by helping to establish, document, and maintain robust baseline populations of ESA-listed plants. This may seem counterintuitive, but with high population numbers of ESA-listed plants, there is a reduced risk that military operations at PTA will impact a large proportion of a species' population and jeopardize its continued existence. With higher population numbers, it may be possible during formal ESA consultations to negotiate reduced restrictions on military activities and operations and to reduce regulatory-mandated management requirements. In addition, our ecosystem management efforts benefit other common and rare species and help to keep populations stable and to help minimize the potential that these species will need to be listed under the ESA in the future. Also, effective implementation of the INRMP to protect plant habitats at the landscape level demonstrates that the Army's 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[9] of these 15 plant species, a suite of conservation measures was aimed at setting conditions to allow for reproduction to occur in natural populations (i.e., *in situ* reproduction). Because we cannot control whether seeds will naturally germinate, we managed other aspects of the environment so that when seeds germinated, the seedlings had a chance to survive. Therefore, we view *in situ* reproduction as an indication that our management is providing a conservation benefit to the species.

From 2016 to 2019, we tracked the presence of seedlings for all Tier 1 plants. *Portulaca villosa, Sicyos macrophyllus,* and *Tetramolopium* sp. 1 were not included in the 2003 BO, but we report *in situ* reproduction for these species as well (Table 43). 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 Section 2.5).

Most Tier 1 species are reproducing in the field at most of the monitoring plots (Table 43). 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* was limited to a single monitoring plot during this time period. However, we had a gap in monitoring for *I. hosakae* from March 2017 through May 2018 and several individuals recruited to the population on various plots during this period (see Section 2.4.2 for details). Although data show that most Tier 1 plants are reproducing naturally, and are receiving conservation benefit from our management, our current monitoring methods do not allow us to accurately track how this reproduction contributes to population structure over time.

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

Table 43. Priority Species 1 monitoring plots with documented *in situ* recruitment at least once between 2016 and 2019 during quarterly monitoring.

Species	No. of Plots	No. of Plots w/ reproduction[a]	Percent of plots w/ reproduction[a]
Asplenium peruvianum var. *insulare*	43	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 sp. 1	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 reexamine many of our approaches. To maximize our effectiveness at integrating management at the ecosystem and localized scale, we need to reexamine how landscape-level management dovetails with species-specific management needs (e.g., rodent or invertebrate control). To this end, we plan to begin development of species-specific management plans based on known life history characteristics, to develop basic research needs and seek partnerships to implement projects, and to use science-based information to adjust ongoing management of ESA-listed plants. In addition, we plan to implement new protocols for Tier 1 and Tier 2 species survey and monitoring programs to better estimate population numbers and trends for the ESA-listed plants to better track compliance with regulatory commitments and, where possible, to assess the effectiveness of our management.

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3.0 INVASIVE PLANTS PROGRAM

3.1 INTRODUCTION

The Invasive Plants Program (IPP) encompasses both invasive plant and fuels control and has 2 purposes: 1) to reduce threats to TES (including plants and animals) from invasive plants and wildland fire, and 2) to protect TES and their habitats from habitat modification/degradation due to competition from invasive non-native plants, wildfires, and changes in fire regime. To manage invasive plants and fuels at PTA, we implement Statement of Objectives (SOO) tasks 3.2(1)(b) and 3.2(3)(a) through 3.2(3)(d) to comply with INRMP objectives (Sikes Act Improvement Act), ESA consultation requirements, regulatory outcomes from NEPA documents, and the IWFMP (USAG-P 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[10]. The Army has not consulted with the USFWS under section 7(a)(2) of the ESA for 5 endangered plants found at PTA: *Exocarpos menziesii*, *Festuca hawaiiensis*, *Portulaca villosa*, *Schiedea hawaiiensis,* and *Sicyos macrophyllus*. Without an ESA consultation, these species lack formal conservation measures. We also manage the undescribed species *Tetramolopium* sp. 1 due to its rarity and limited distribution even though this plant is not ESA-listed.

We are currently preparing documents to formally consult with the USFWS in 2022 under Section 7(a)(2) of the ESA regarding military activities at PTA and the potential effects to TES. We anticipate the issuance of a programmatic BO from the USFWS in 2022.

The IPP comprises 3 sections:

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

Each program section addresses specific SOO tasks, INRMP objectives, and regulatory requirements, which dictate the goals and objectives within that section. Specifically, projects implemented under the Vegetation Control Section and IPSM address SOO tasks 3.2(1)(b) and 3.2(3)(a) and projects implemented under Fuels Management Section address SOO tasks 3.2(3)(b) and 3.2(3)(c). SOO task 3.2(3)(d) is implemented by the Fire Ecologist at the CEMML office in Fort Collins, CO. For a list of drivers associated with each of the projects and sections in the IPP, please refer to Appendix C.

This report summarizes project methods and general results for each IPP section and documents our progress with SOO tasks.

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

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(1)(b) and 3.2(3)(a). Our mission is to improve habitat by reducing impacts from invasive plants to TES, primarily ESA-listed plants, and their habitats by implementing INRMP objectives and BO conservation measures. We strive to create areas around ESA-listed plant species relatively free from invasive plant competition, reduce fine fuels within a prescribed distance in fire-prone habitats, and improve native-dominated habitats in proximity to ESA-listed plant locations by reducing invasive plant cover.

Additionally, we support the Hawaiian Goose habitat improvement project at Hakalau Forest National Wildlife Refuge (HFNWR) by mowing and cutting grass in Army-managed areas frequented by geese.

To develop an effective strategy that efficiently controls invasive plant species and improves native habitat, we must balance many factors including invasiveness of species, proximity of invasive species to TES, native vegetation density and habitat quality, and site accessibility. These factors are highly variable between sites, requiring adjustments to control methods. Weather, specifically precipitation, is an uncontrollable factor that requires us to adjust our methods and strategies.

Operational goals to address issues and problems are as follows:

- Assess Weed Control Buffers (WCBs) in ASRs per the annual schedule to determine the need for weed control and schedule appropriately (e.g., quarter/month/week). See Section 1.6.2 for details about ASR establishment.
- Perform management actions appropriate to the site and conditions (e.g., hand pull, follow-up cutting or spraying), monitor weather conditions for effective herbicide application timing.
- Assess efficacy of management actions (e.g., response to herbicide application).
- Communicate with Botanical Program on results of monitoring to inform management.
- Ensure less than 20% weed cover is maintained in WCBs.

3.2.2 Weed Control in Delineated Areas of Species Recovery and Outplanting Sites

Weed control in ASRs meets SOO tasks 3.2(1)(b) and 3.2(3)(a). To accomplish these tasks for ESA-listed plant species, we focus invasive plant management in a series of WCBs within ASRs (Figure 49). WCBs are defined as areas that have had some form of weed control implemented. We aim to maintain WCBs at less than 20% weed cover as determined by visual inspection as to when a site approached the 20% threshold. Generally, we initially establish WCBs by controlling weeds within 25 m from plant locations (i.e., species for which the ASR was designated). Once a maintenance phase is established, we may expand the WCBs. However, only a few WCBs have been expanded to a maximum of 50 m as logistics, resources, new challenges and threats (e.g., new/expanding invasions) limit operational management capacity.

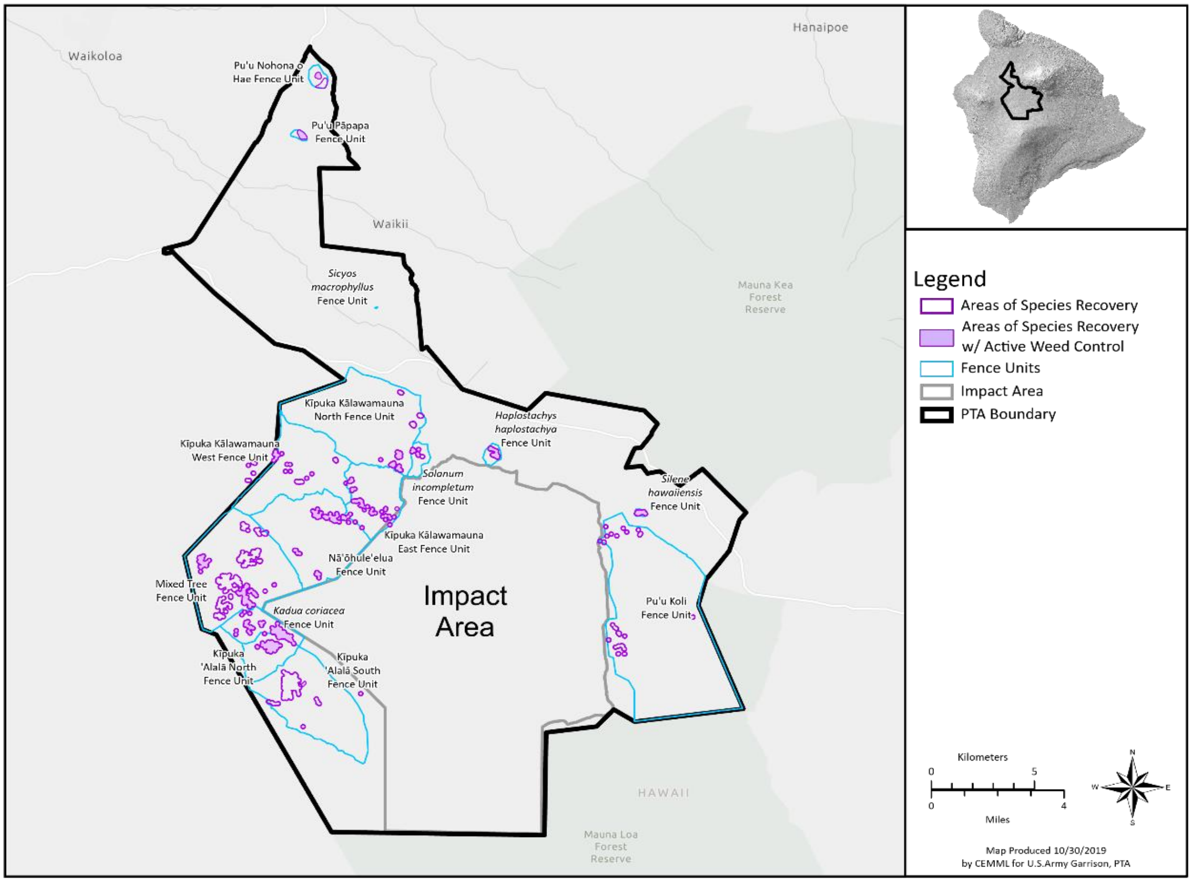

Figure 49. Areas of species recovery with and without active weed control at Pōhakuloa Training Area

Prior to the last biennial report for FY 2018–2019, we reported on ASRs and outplanting sites (OPs) separately. Outplanting sites are areas where ESA-listed plant species were planted to increase their distributions and abundances (see Section 2.3). ASRs were originally areas with wild ESA-listed plant species. Some outplanting sites were established within or adjacent to existing ASRs. Because we control and manage weeds the same way in outplanting sites as in ASRs, we now refer to outplanting sites as ASRs. Outplanting sites are assigned a 200-series number while ASRs with wild ESA-listed plants currently have a 1 or 2 digit number (e.g., ASR 1, ASR 24). Some outplanting sites were implemented within an original ASR and assigned a 200-series number but were later combined with the ASR in which they occurred to track vegetation control efforts (e.g., OP 213 is now part of ASR 41). In addition, outplanting sites within an existing ASR may be combined with that ASR as an additional WCB (e.g., OP 207 may be designated as WCB 207 within ASR 18) to track vegetation control efforts.

To control weeds over time, we repeat weed control treatments within WCBs. The frequency of weed control in any ASR depends on recent, local environmental conditions (e.g., precipitation) that influence the rate at which weeds grow in each area, and thus the need for weed control at any given time. We schedule each actively managed ASR to assess each actively managed ASR for percent weed cover ranging from quarterly to every 2 years depending on site characteristics and historical management data and implement weed control as needed.

Mechanical removal and herbicide application are the primary methods for weed control and fuels reduction in WCBs, with hand clearing conducted within 1 m of ESA-listed plant species. The 4-step approach to weed control in ASRs is: 1) hand-pull or cut weeds within 1 m of ESA-listed plant species, 2) cut weeds in WCB with weed whackers, 3) apply herbicides to re-growth of target weeds in the WCB, and 4) continue hand-clearing, cutting and spraying as needed to achieve and maintain less than 20% weed cover. The primary targets for weed control in ASRs are fountain grass (*Cenchrus setaceus)* and fireweed (*Senecio madagascariensis*) due to their invasiveness, habitat altering-nature, and, for *C. setaceus,* production of fine fuels. The term "primary target weed" is used to describe these species to distinguish them from secondary target weeds described in the IPSM Section of this report.

We prioritize ASRs for weed control using several criteria: management tier of ESA-listed plant species (see Section 2.2), ESA-listed plant species abundance, level of threats present, site access, recovery potential, and density of weeds. We schedule weed control in ASRs at frequencies based on projected need (e.g., quarterly for areas with dense weeds) and management actions data from the recent past (e.g., last 1 to 2 years). In general, ASRs containing the rarest plants, with dense weed cover and adequate access tend to receive higher priority and therefore more frequent management. We manage ASRs with lower priority plants and difficult or costly access less frequently. Further, some ASRs require more frequent weed control than others depending on the community type, substrate, level of previous disturbance, and invasion by primary and/or secondary target weeds. For example, ASRs with sparse vegetation do not typically need as much weed control as do ASRs within shrubland and grassland communities invaded by *C. setaceus*. We conduct weed control and other management actions (e.g., plant monitoring) in remote ASRs with high priority TES during camp trips to maximize mobilization of resources and reduce overall costs.

There are typically 1 or 2 high priority, or primary, ESA-listed plant species for which an ASR is designated. Additional or secondary ESA-listed plant species may fall within the 100-m boundary of an ASR. Although we typically initiate WCBs around the primary ESA-listed plant species within an ASR, if a secondary ESA-listed plant species is in proximity to a primary species, it may also benefit from weed control if it occurs within the WCB.

During the reporting period, we delineated a total of 92.4 ha of WCBs within ASRs (Table 44). The frequency of weed control efforts varied across ASRs. We did not control weeds within ASR 211 as weed densities were below management thresholds, nor in ASR 201 (an outplanting site on state lands) because we are still working on a plan forward with the State Division of Forestry and Wildlife. We controlled weeds in 3 ASRs that did not receive weed control during the prior period (ASRs 4, 206, 219) due to staffing and extreme weather issues (CEMML 2020b). Additionally, we decreased the WCB area in 2 ASRs where the focal ESA-listed plants were no longer present (ASRs 12 and 40). We decreased the WCB area significantly in 2 ASRs (8.1 ha in ASR 30 and 2.0 ha in ASR 214) because they included large areas with no recorded ESA-listed plants and served only as physical weed-free connections to the functional WCBs centered around ESA-listed plants. Further, our continued maintenance of these WCB areas had no obvious benefits to the ESA-listed plants in the remainder of the ASRs and took much needed resources away from other priorities. We suspended weed control in ASR 31 for *Silene lanceolata* because the plants occur under dense native vegetation which makes it challenging to apply herbicide without impacting non-target species by trampling and overspray. Also, several *S. lanceolata* plants were observed thriving outside the WCB leading us to assume that weed control was providing minimal benefit to this species in this ASR. However, we implemented weed control in the newly designated ASR for *Sicyos macrophylla* (ASR 49) beginning in March 2020 by hand-clearing and select spot spraying.

Table 44. Weed control in areas of species recovery in FY 2020–FY 2021.

ASR	Primary Species	WCB Hectares	WC Frequency
3	*Silene hawaiiensis*	13.4	4
4	*Haplostachys haplostachya*	1.6	3
8	*Tetramolopium arenarium*	11.7	4
11	*Kadua coriacea/ Silene lanceolata*	4.9	1
12	*Silene lanceolata*	1.3	4
13	*Silene lanceolata*	4.9	5
16	*Silene lanceolata*	2.8	4
18	*Kadua coriacea/ Silene lanceolata*	3.4	3
19	*Silene hawaiiensis*	1.2	2
20	*Silene lanceolata*	0.8	4
21	*Kadua coriacea*	1.0	1
22	*Kadua coriacea*	0.6	1
24	*Neraudia ovata/ Solanum incompletum/ Silene lanceolata*	7.8	6
25	*Silene lanceolata*	1.4	4
28	*Tetramolopium* sp. 1[a]	0.9	2
29	*Kadua coriacea*	1.7	2
30	*Kadua coriacea*	18.2	2
40	*Solanum incompletum*	1.5	3
41	*Schiedea hawaiiensis*	1.0	1
44	*Silene lanceolata/ Portulaca sclerocarpa*	3.0	4
46	*Isodendrion hosakae*	2.6	11
47	*Solanum incompletum*	0.3	4
48	*Lipochaeta venosa*	1.7	7
49	*Sicyos macrophyllus*	<0.1	2
201	Several ESA-listed plant species (Off PTA)	0.6	0
205	Several ESA-listed plant species (Off PTA)	0.4	3
206	*Schiedea hawaiiensis/Neraudia ovata*	0.2	2
207	*Schiedea hawaiiensis*	0.2	1
209	*Solanum incompletum*	1.6	3
211	*Silene lanceolata*	1.2	0
214	Several ESA-listed plant species	0.4	5
219	*Asplenium peruvianum var. insulare/Solanum incompletum*	0.1	3
	Total	**92.4**	

ASR, area of species recovery; WCB, weed control buffer; WC, weed control

[a] *Tetramolopium* sp. 1 is not aa ESA-listed plant. However, this undescribed species is managed due to its rarity.

There are 27 ASRs in which we either do not control weeds or we only control weeds for selected ESA-listed plant species (Table 45). 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).

Table 45. 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
45	*Vigna o-wahuensis*	Suspended	Management challenges

ASR, Area of Species Recovery

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.

3.2.3 Hakalau Forest National Wildlife Refuge Hawaiian Goose Habitat Management

Habitat management at Hakalau Forest National Wildlife Refuge (HFNWR) meets SOO tasks 3.2(2)(b) and conservation measures of the 2013 BO. We control vegetation (i.e., cutting and mowing grass, and select herbicide application on *Ulex europaeus* and *Rubus sp.*) to manage habitat for the Hawaiian Goose at HFNWR. To be consistent with refuge goals, we developed a management action plan with HFNWR to include: 1) Hawaiian Goose monitoring, 2) nest monitoring, 3) predator control, and 4) habitat management. We conducted habitat management actions between October 2019 and May 2021 (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. All but 2 ASRs on the schedule received weed control during the reporting period. We also implemented weed control in 1 new ASR in the KMA for *S. macrophyllus*. By conducting vegetation control in WCBs, with the objective of reducing threats from invasive plants to ESA-listed plants and their habitats, we believe we are achieving our goals as described. Our vegetation control actions at HFNWR also appear to be benefitting Hawaiian Geese by providing preferred habitat.

Our intent in controlling weeds in ASR WCBs, particularly *C. setaceus*, is to reduce invasive plant competition for resources needed by the native species, thereby increasing native cover, which ultimately creates conditions that we assume are favorable for ESA-listed plants to survive and reproduce. We 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 2020b). 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. 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 treatment of *S. madagascariensis* and timing control 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 herbicide application needed.

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 invasive 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 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 the invasive species have been established for many decades, consider the full suite of species present at a site to design a multi-species approach for invasive species management to 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 mission is to reduce the impacts of invasive plants on TES and their habitats by implementing INRMP objectives and BO conservation measures, to prevent the introduction and establishment of invasive plants, and to provide control and minimize ecological impacts per Executive Order 13112.

IPSM projects meet SOO task 3.2(3)(a) and address INRMP objectives and conservation measures identified in the 2003 BO regarding new invasive plants at PTA. The goals of the IPSM are to detect new introductions of invasive plant species before they become established, to contain or eradicate these species when possible, and to limit the ecological impacts of certain well-established, highly invasive or ecosystem-altering plant populations. These goals are met by conducting roadside weed surveys throughout the installation, identifying and ranking target invasive species according to risk level and potential for control, and implementing control measures as appropriate.

We developed methods for surveying, assessing, and prioritizing incipient and target invasive plant species (USAG-HI 2010). We use the term “secondary target weeds” to refer to highly invasive plant species occurring at PTA that could impact TES, high quality habitat, or alter the landscape and/or ecosystem if left unchecked, and for which eradication or control outside WCBs is deemed feasible. Thirty-two species have been designated secondary target weeds, and another 11 are on the proposed list, meriting some level of observation or action (Table 46). Five of these species are listed on the United States Department of Agriculture’s Hawaiʻi State Noxious Weed List.

The IPSM Section has several distinct operations, or projects, that work in concert to satisfy the requirements of the section. Annual roadside and quarterly Bradshaw Army Airfield (BAAF) and construction site surveys provide information on secondary target and incipient weed species in high-use, regularly traversed, and disturbed areas to allow early detection and eradication and to inform management and monitoring efforts to track the spread and distribution of weeds. Control and Monitoring (i.e., weed checks) provides information on efficacy of management actions and status of target weed locations and localized infestations. Site-specific surveys, which typically occur in more remote areas, provide more information on the spread and distribution of secondary target weeds, the potential impacts on high quality habitats and ESA-listed species, and alteration of the landscape and/or ecosystem. Each of these projects are discussed in more detail below.

Table 46. Secondary target weeds of Pōhakuloa Training Area.

Rank	Scientific Name	Common Name
1	*Sphagneticola trilobata*	wedelia
2	*Psidium guajava*	common guava
3	*Pluchea carolinensis*	sourbush
4	*Prosopis pallida*	kiawe
5	*Acacia mearnsii*[a]	black wattle
6	*Ricinus communis*	castorbean
7	*Lantana camara*	lantana
8	*Ambrosia artemisiifolia*	common ragweed
9	*Foeniculum vulgare*	fennel
10	*Schinus mole*	California peppertree
11	*Grevillea robusta*	silk oak
12	*Sambucus Mexicana*	Mexican elderberry
13	*Olea europaea*	olive
14	*Rubus rosifolius*	thimbleberry
15	*Rhamnus californica*	California coffeeberry
16	*Eschscholzia californica*	California golden poppy
17	*Portulaca Pilosa*	hairy pigweed
18	*Lophospermum erubescens*	larger roving sailor
19	*Leucaena leucocephala*	ekoa
20	*Parthenium hysterophorus*	false ragweed
21	*Cupressus* species	cypress
22	*Nicotiana glauca*	tree tobacco
23	*Rubus niveus*[a]	hill raspberry
24	*Kalanchoe tubiflora*	chandelier plant
25	*Asclepias physocarpa*	balloon plant
26	*Passiflora tarminiana*[a]	banana poka
27	*Cirsium vulgare*	bull thistle
28	*Centaurea melitensis*	malta star thistle
29	*Salsola tragus*[a]	Russian thistle
30	*Delairea odorata*	cape ivy
31	*Tribulus terrestris*	goat's head
32	*Datura stramonium*	jimson weed
N/A	*Emex spinosa*[a]	devil's thorn
N/A	*Festuca arundinacea*	tall fescue
N/A	*Glycine wightii*	glycine
N/A	*Heteromeles arbutifolia*	toyon
N/A	*Macrotyloma axillare*	perennial horsegram
N/A	*Melinis minutiflora*	molasses grass
N/A	*Nicotiana tabacum*	tobacco (smoking)
N/A	*Paspalum dilatatum*	dallisgrass
N/A	*Piptatherum miliaceum*	smilograss
N/A	*Portulaca pilosa*	hairy pigweed
N/A	*Trifolium pratense*	red clover

[a] Indicates species is on the United States Department of Agriculture's Hawaiʻi State Noxious Weed List

3.3.2 Roadside Surveys

We use roadside weed survey methods similar to other early detection programs in Hawaiʻi. Approximately 325 km of roads within defined geographic areas at PTA are surveyed by 2 people driving 5 mph, scanning each side of the road for incipient and secondary target weeds. For large areas, we limit efforts to a defined distance from roadsides (3 m on each side of the road) within the greater survey area.

Methods

We survey the perimeter of BAAF (Survey Area 1, Figure 50) quarterly and all earth works construction sites quarterly during construction and for 6 months after construction ends. Thereafter, we typically survey construction sites annually. We survey select roads in the KMA once each year (Figure 51). For scheduling purposes, the installation is divided into 4 geographic areas based on frequency of military use and vegetation cover types (Survey Areas 2–5, Figure 50).

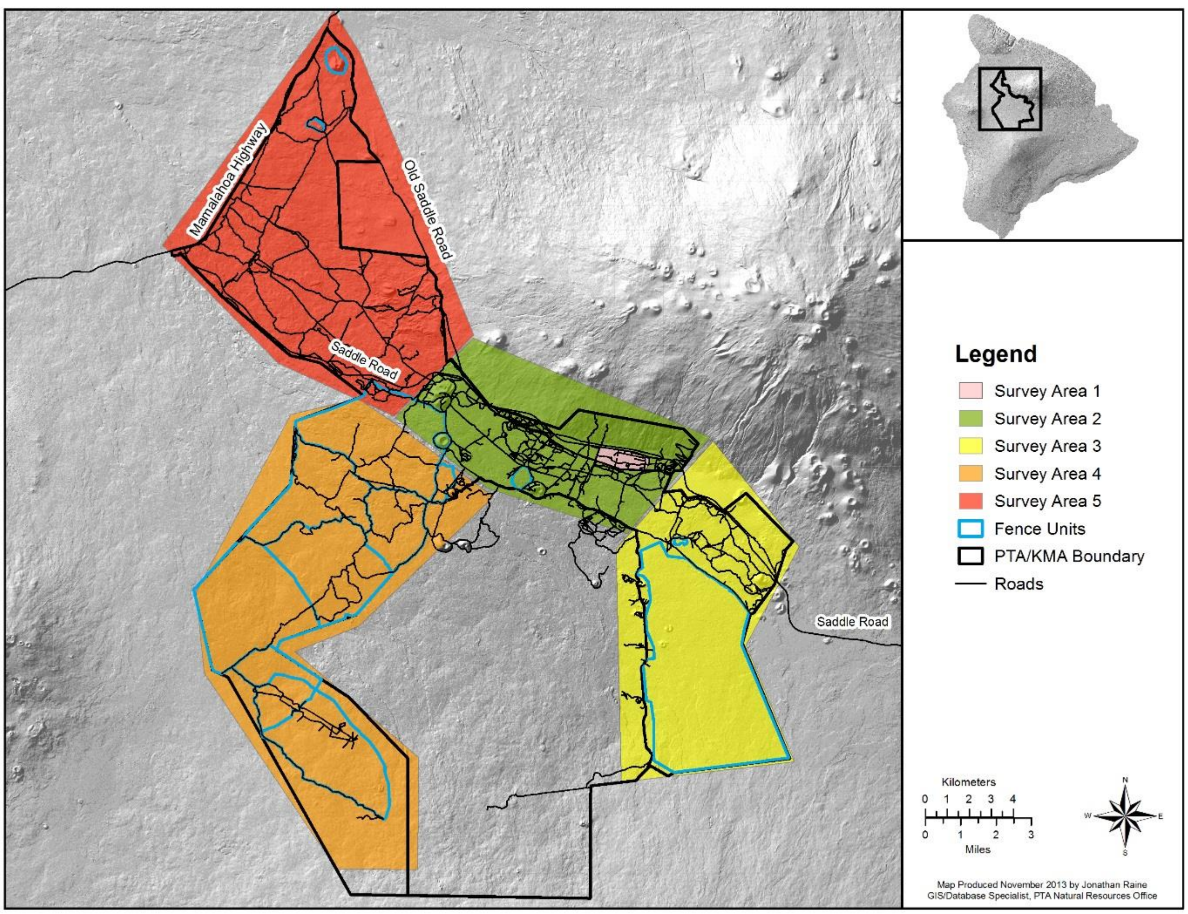

Figure 50. Invasive plant survey and monitoring areas at Pōhakuloa Training Area.

Typically, IPSM Survey Areas 2 – 5 are surveyed during different quarters to account for seasonality of growth and flowering that affects species detection. However, between July and October conditions may be so dry that finding live, identifiable plants becomes difficult. We may truncate, reschedule, or cancel surveys during periods of drought or when other events have reduced any reasonable likelihood of weed germination, identification, or detection.

We completed all roadside surveys as scheduled (Table 47), except for Survey Area 3, because approximately 1/3 of Survey Area 3 was surveyed at the end of FY 2019. Thus, we surveyed the remaining 2/3 (approx. 20.3 km) of the survey area in the beginning of FY 2020. We surveyed BAAF every quarter during the reporting period, as scheduled (Table 47). We surveyed earth-moving construction sites quarterly during construction (if access was available) and for 6 months following completion (Table 47).

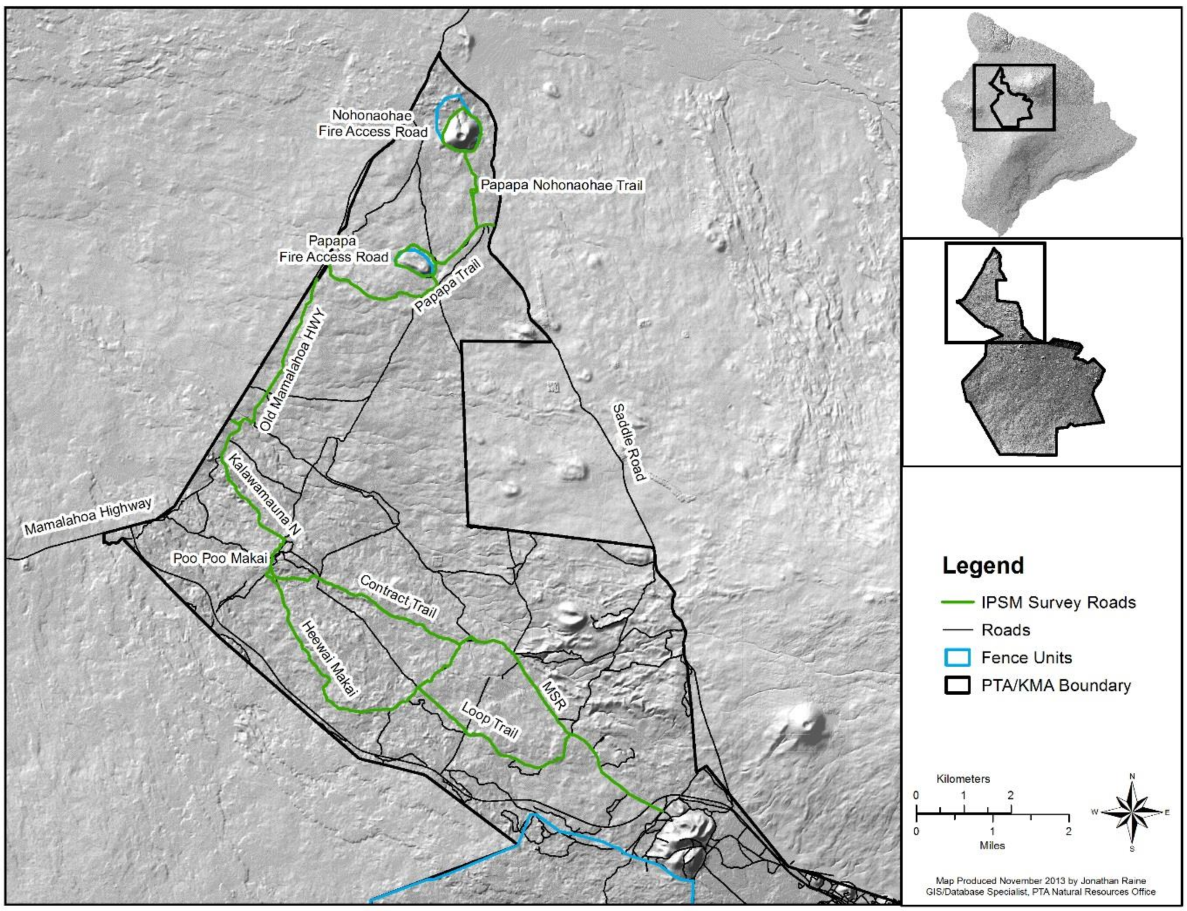

Figure 51. Invasive plant survey and monitoring roads in the Keʻāmuku Maneuver Area

Results

We did not find any incipient weeds in survey areas 1–4, although we did control secondary target weeds when found (unless in areas of known infestation, e.g., *P. tarminiana* in Kīpuka ʻAlalā). We found 2 incipient weed species in Survey Area 5, *Macrotyloma axillare* and *Sida ciliaris.*

We found approximately 10 locations (50–60 plants) of *M. axillare* (perennial horsegram) along Heʻewai Makai Trail in August 2021. The Heʻewai Makai Trail is part of the KMA Road Capping Completion construction project. This species was targeted for control due to its 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. *M. axillare* has a Hawaiʻi Pacific Weed Risk Assessment (HPWRA) score of 10 (high risk). This species is known to be present on Oʻahu in the northern Waianae mountains, including on the Makua Military Reservation and the Kahuku Training Area (Jane Beachy, personal communication, 2021). This species has not previously been reported on Hawaiʻi island.

We found a single location (about 5–6 plants) of *Sida ciliaris* (red ilima) in Survey Area 5. We requested a weed risk assessment for the species, and while it received a score of 7 (high risk), *S. ciliaris* is not currently targeted for control as it is primarily a weed of disturbed habitats with no documented negative impacts in areas in which it has become established (Chuck Chimera, personal communication, 2021). The species is found in a low priority area and not along a frequently traveled road, meaning that the likelihood of it spreading is low. We will continue to monitor this species and will schedule it for control if deemed necessary.

Table 47. Quarterly and annual surveys completed during FY 2020–FY 2021.

Survey Description	Survey Area	General Area(s)	Survey Units	Survey Frequency[a]
Quarterly BAAF Survey	1	BAAF	5 km	8
Annual Roadside Surveys	2	TA 5–16, cantonment	106 km	2
	3	TA 1–4, 21	61 km[b]	1.7
	4	TA 17–20, 22–23	102 km	3
	5	KMA	45 km	2
Quarterly Construction Site Surveys	1	BAAF perimeter	3.3 km	2
	4	CCFP 2020	2.5 km	3
	2	FIP	0.7 km	7
	5	KMARC 2021	0.4 ha	3

BAAF, Bradshaw Army Airfield; CCFP, Charlie Circle Firing Points; FIP, Facilities Improvement Plan; KMARC, KMA Road Capping Completion;
TA, Training Area

[a] Survey frequency refers to the number of times each general area was surveyed between the beginning of FY 2020 and the end of FY 2021. 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 2020 and FY 2021.

[b] Survey Area 3 contains approximately 61 km of roadside, roughly 2/3 of the survey area was surveyed this reporting period.

3.3.3 Control and Monitoring (Weed Checks)

We focus control and monitoring efforts on incipient and secondary target weeds. Generally, we treat incipient and secondary target weeds detected during roadside surveys immediately, if time and resources permit. However, if a weed population requires more resources than are available during surveys, or if conditions are not suitable for the treatment method selected, we schedule the treatment for a later date. Further, incipient and/or secondary target weeds found during regular field work are reported and scheduled for assessment and treatment as appropriate, based on priorities and as time and resources permit.

Treatments are selected based on the size of the population, recommendations from local experts and published literature, the herbicides and application tools currently stocked by the program, and safety to human health and the environment. Methods include hand pulling and various herbicide application techniques (e.g., spraying, cut/drip, drill-squirt, etc.). We strive to evaluate treatments of new species within several weeks to determine effectiveness. Regular monitoring and control are achieved through follow-up weed checks which include assessing the efficacy of the last treatment and re-treating as necessary. We schedule follow-up weed checks based on the reproductive period for the species and other factors, such as thoroughness or effectiveness of the initial treatment.

In general, secondary target weed species present in low numbers at PTA are treated installation-wide. However, we do not control widespread secondary targets due to lack of feasibility of control and low probability of having an overall benefit, except in ASRs or within close proximity to ESA-listed plants or other high value habitats

Nicotiana glauca, being a food source and nonnative 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 (1524 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 (Langer, personal communication, 29 Jan 2014) when controlling *N. glauca.*

We recorded and treated new locations of secondary target weeds when encountered, and monitored and treated existing locations when time and resources permitted (Table 48). In fact, we increased control and monitoring efforts by 270% from the previous reporting period.

Table 48. Results of installation-wide monitoring and control in FY 2020–FY 2021

Secondary Target Weeds	Known Locations	New Locations	Locations Treated at Least Once[a]
Acacia mearnsii	34	1	10
Ambrosia artemisiifolia	43	16	23
Asclepias physocarpa	261	45	56
Centaurea melitensis	130	1	1
Cirsium vulgare	166	8	9
Cupressus species	3	0	0
Datura stramonium	25	10	10
Delairea odorata	231	101	60
Emex spinosa	107	10	13
Eschscholzia californica	8	0	0
Festuca arundinacea	28	0	0
Foeniculum vulgare	23	3	6
Glycine wightii	3	0	2
Grevillea robusta	74	43	41
Heteromeles arbutifolia	2	0	0
Kalanchoe tubiflora	55	8	15
Lantana camara	14	4	5
Leucaena leucocephala	121	17	32
Lophospermum erubescensb	333	95	210
Melinis minutiflora	59	32	45
Nicotiana glauca	712	138	126
Nicotiana tabacum	14	5	6
Olea europaea	8	0	3
Parthenium hysterophorus	267	247	247
Paspalum dilatatum	3	0	0
Passiflora tarminianab	2286	351	525
Piptatherum miliaceum	267	11	1
Pluchea carolinensis	32	5	4
Portulaca pilosa	16	2	1
Prosopis pallida	6	0	0
Psidium guajava	2	0	1
Rhamnus californica	29	4	5
Ricinus communis	26	3	5
Rubus niveusb	1289	545	751
Rubus rosifolius	2	0	0
Salsola tragus	140	21	14
Sambucus mexicana	44	6	7

Table 48. Results of installation-wide monitoring and control in FY 2020–FY 2021 (cont.).

Secondary Target Weeds	Known Locations	New Locations	Locations Treated at Least Once[a]
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 49) and in outlying areas across the installation

3.3.4 Site-Specific Survey and Control of Secondary Target Species

Some secondary target species may be well-established throughout the installation or have dense infestations within specific areas but only receive control in delineated areas that contain or are near ASRs and/or high quality or TES habitat. Our goal in these instances is not necessarily eradication but rather to reduce the density and/or contain the population, thus controlling spread into TES habitat.

We survey 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 plan to survey most if not all grids at least once per year and to monitor and control locations within these grids 3 to 6 times per year, depending on species biology and available time and resources.

We increased survey and control efforts and monitoring and control efforts by 262%, cumulatively, since the last reporting period. To determine the efficacy of our survey, monitoring, and control efforts, we compiled data from repeat visits to established site-specific survey grids. Specifically, we looked at the number of live plant locations, number of live individuals, and number of locations with reproductive individuals at the beginning (start) and end of the reporting period for each grid that was visited more than once (Table 49). Note that in some instances the initial (start) values are from the quarter prior to the current reporting period.

Currently, there are defined survey grids in Kīpuka ʻAlalā in TA 23 for *Passiflora tarminiana* (Figure 52), *Rubus niveus* (Figure 53), and *Lophospermum erubescens* (Figure 54). There are also survey grids for *P. tarminiana* and *L. erubescens* in TA 22 (Figure 52 and Figure 54, respectively). Kīpuka ʻAlalā is a resource-rich area, providing habitat for several forest birds, the Hawaiian hoary bat (*Lasiurus cinereus 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 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 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

Table 49. Results of site-specific survey, monitoring, and control in FY 2020–FY 2021.

Species[a]	Grid	Area Surveyed	Visit Frequency [b]	No. Live Locations			No. Live Individuals			No. Reproductive Locations		
				Start	End	% Change[c]	Start	End	% Change[c]	Start	End	% Change[c]
Lophospermum erubescens	Loperu01A	15.5	4	47	15	-68	306	9	-97	24	7	-71
	Loperu01C	1.7	3	1	1	0	2	1	-50	0	0	N/A
	Loperu01D	1.0	3	1	0	-100	1	0	-100	0	1	N/A
	Loperu01E	1.9	4	3	1	-67	3	8	167	3	0	-100
	Loperu02	4.4	6	30	15	-50	116	27	-77	12	3	-75
	Loperu03	4.3	5	6	2	-67	13	5	-62	1	0	-100
	Loperu04	2.6	5	5	4	-20	16	12	-25	5	0	-100
	Loperu05	3.4	5	3	2	-33	3	6	100	2	1	-50
	Loperu06	14.1	5	20	23	15	171	121	-29	16	4	-75
	Loperu07	1.7	5	1	0	-100	3	0	-100	0	0	N/A
	Loperu08	2.3	3	3	3	0	20	14	-30	2	0	-100
	Loperu09	1.7	4	1	1	0	1	15	1400	1	0	-100
	Loperu11	2.1	4	2	1	-50	32	2	-94	1	0	-100
Passiflora tarminiana	Pastar22A	19.0	4	4	0	-100	7	0	-100	3	0	-100
	Pastar22B	32.2	3	32	24	-25	43	122	184	23	7	-70
	PastarNKA	212.2	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Rubus niveus	Rubniv01	59.2	2	336	166	-51	1119	474	-58	250	21	-92
	Rubniv02	41.6	2	266	170	-36	692	488	-30	204	5	-98
	Rubniv03B	12.2	2	106	32	-70	338	61	-82	65	7	-89

[a] *Lophospermum erubescens, Passiflora tarminiana*, and *Rubus niveus* are managed installation-wide. Note that plant locations presented in Table 49 are a subset of those presented in Table 48.
[b] Visit frequency includes both survey and monitoring efforts. Both types of visits include control.
[c] Percentages are rounded to the nearest whole number for % change.

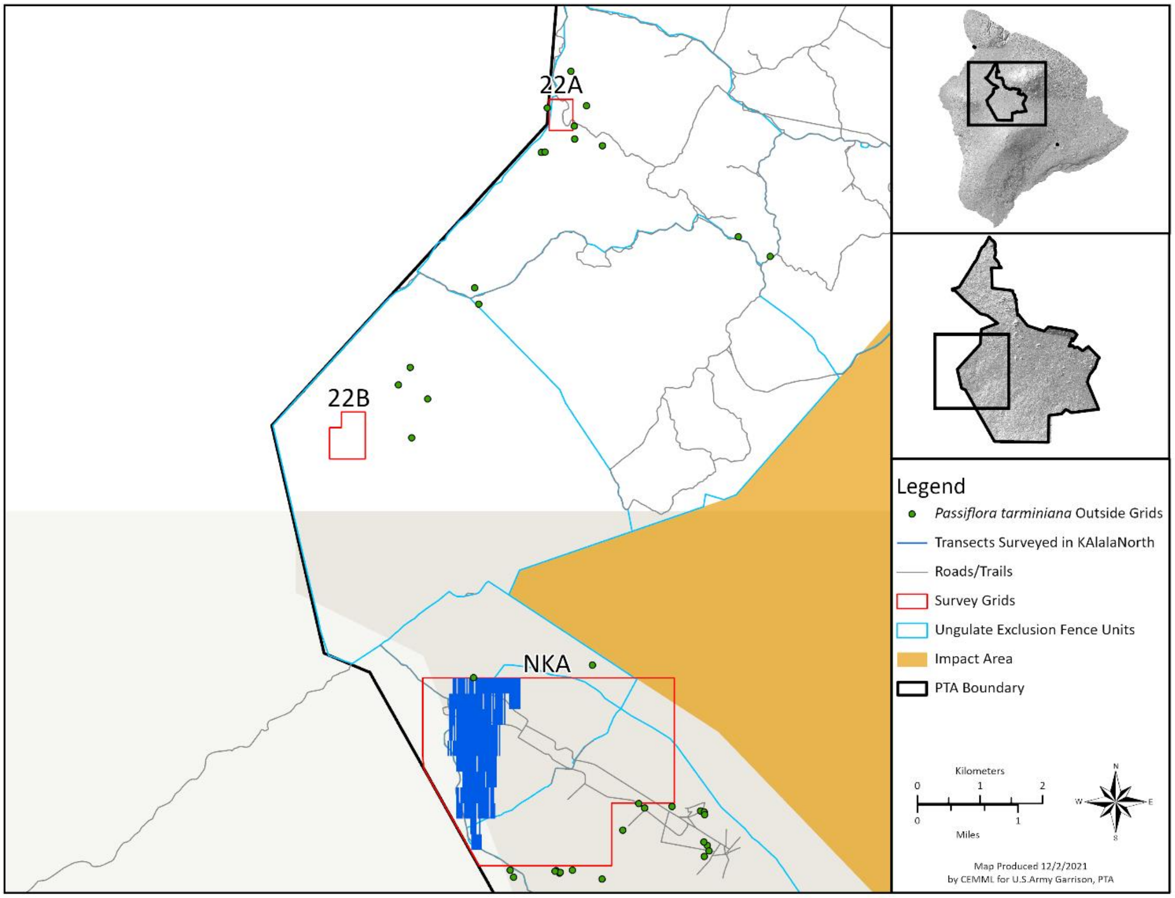

Figure 52. *Passiflora tarminiana* site-specific survey grids and known locations outside grids at Pōhakuloa Training Area.

secondary target species for which we don't apply the same effort due to our limited resources, their widespread distribution across the installation, remoteness of locations, and feasibility of control.

P. tarminiana is an invasive vine in mesic forests of Hawai'i, 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 *P. tarminiana* has begun establishing itself in recent years. We continued survey and control efforts in the grid established in 2019 (Pastar 22A, Figure 52) and established a new grid near ASR 24 (Pastar 22B, Figure 52). In addition, we continued survey and control efforts in Kipuka 'Alālā (Pastar NKA, Figure 52), where *P. tarminiana* is present at great densities, focusing on the northern-most section of the infestation in an effort to limit seed dispersal into TA 22. In total, we surveyed 263.4 ha for *P. tarminiana* across all grids (Table 49), treating a combined total of 503 plant locations using mechanical and chemical control.

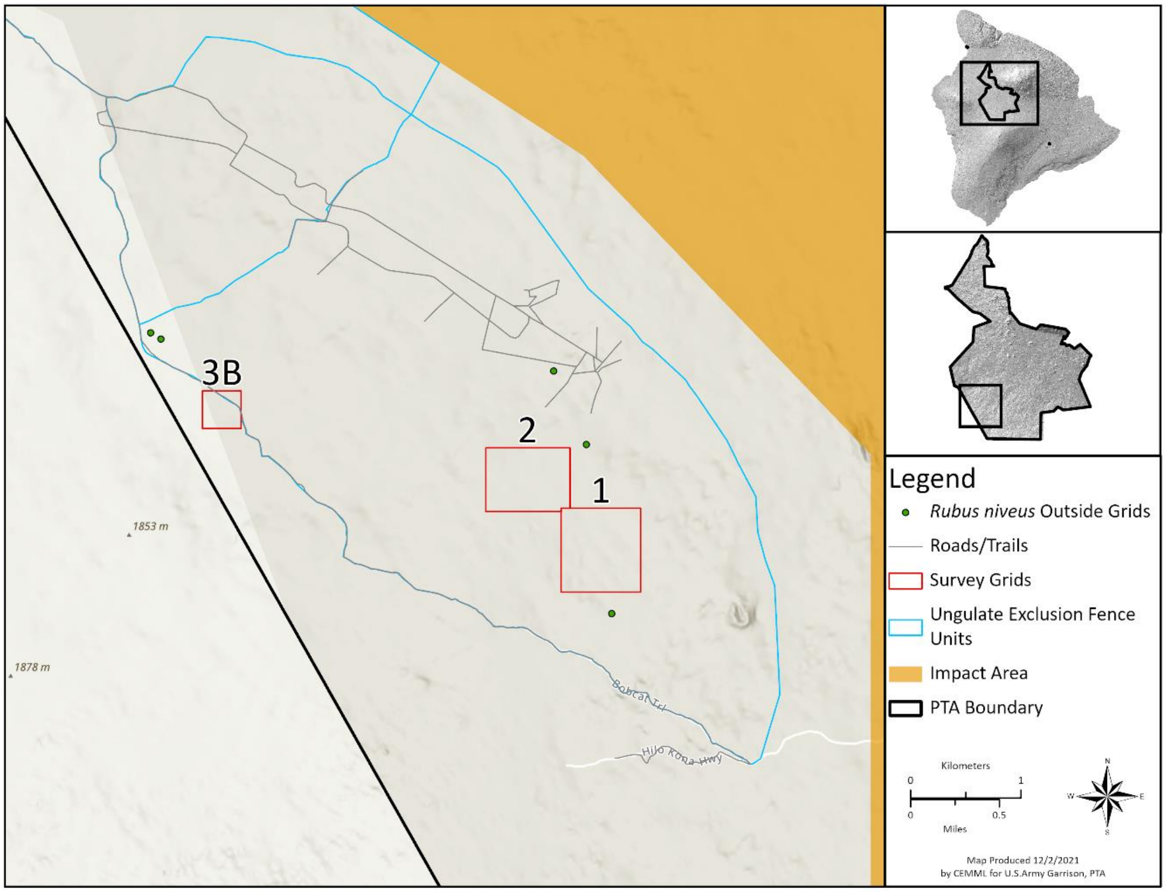

Figure 53. *Rubus niveus* site-specific survey grids and known locations outside grids at Pōhakuloa Training Area

We surveyed Pastar 22A grid once and monitored plant locations within the grid 3 times (Table 49). Over the course of the reporting period, we saw a decrease in all 3 metrics: number of live plant locations, number of live individuals, and number of locations with reproductive individuals (Table 49).

We surveyed Pastar 22B grid once and monitored plant locations within the grid twice (Table 49). While the number of live locations decreased during the reporting period, the number of living individuals increased. This is likely due to a flush of seedlings at locations where large reproductive individuals were previously controlled. We expect that over time the number of seedlings will decrease as the seedbank is depleted at these locations. The number of locations with reproductive individuals decreased steadily over the reporting period. However, the fact that reproductive individuals were found on repeat visits indicates that survey and monitoring efforts need to be performed at shorter time intervals.

We surveyed part (212.2 ha) of the Pastar NKA grid (Figure 52) and controlled 439 plant locations. Blue transect lines delineate the area surveyed in Figure 52. Due to the size of the grid, area surveyed, and density of *P. tarminiana* present, we were not able to complete a survey of the entire grid or make repeat survey and/or monitoring visits. Therefore, we do not have data to determine the efficacy of our control efforts within this grid.

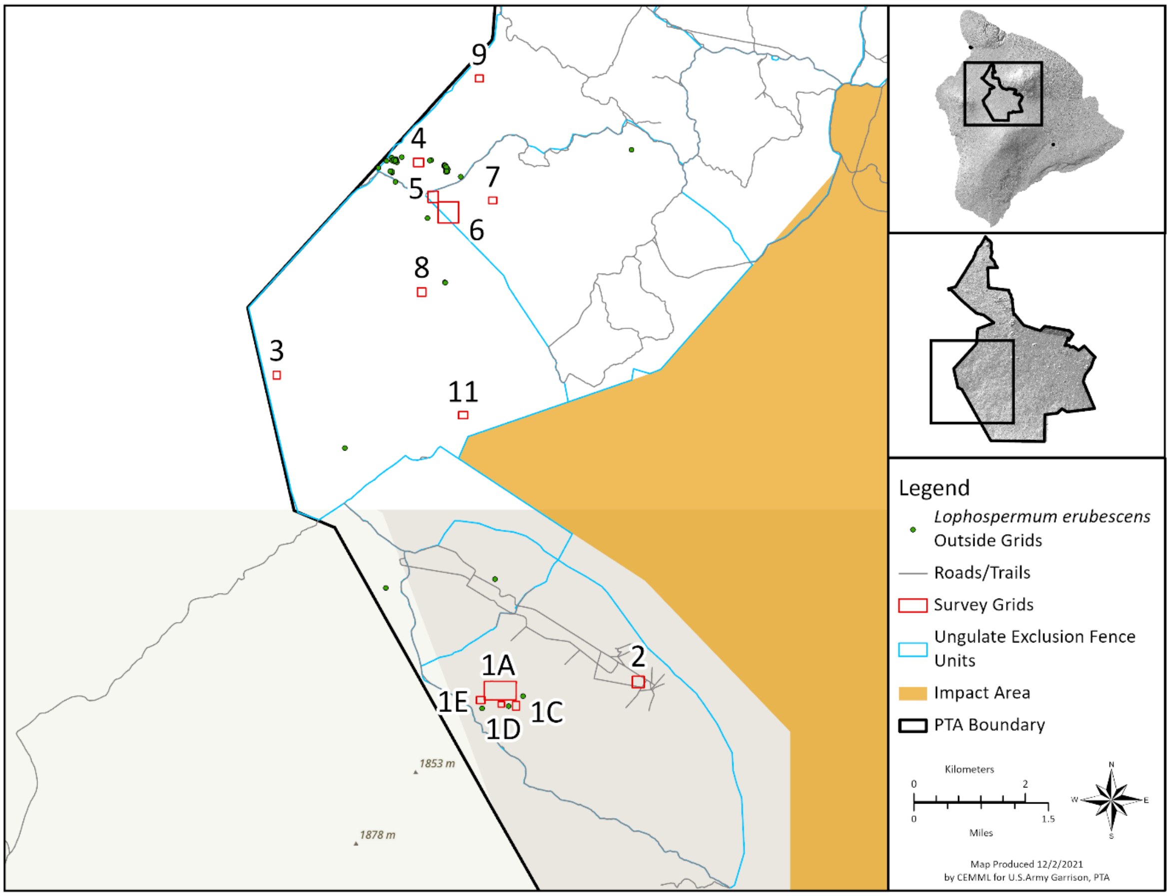

Figure 54. *Lophospermum erubescens* site-specific survey grids and known locations outside grids at Pōhakuloa Training Area.

R. niveus is an invasive shrub that forms dense, impenetrable thickets due to the arching and intertwining stems. It displaces native vegetation, impedes regeneration of native shrubs and trees and impacts wildlife habitats (Weber 2003). The main infestations for *R. niveus* are in Kīpuka ‘Alalā (Figure 53), with no individuals documented in other areas of the installation. In the first and second quarters of FY 2021, we surveyed 3 *R. niveus* grids (Rubniv 1, Rubniv 2 and Rubniv 3B), and returned to monitor plant locations within these grids once (Table 49). Rubniv 3B was expanded from 7.0 ha to 12.2 ha in November 2020 because additional plant locations were found outside of the grid.

The 3 *R. niveus* grids had not been surveyed since 2018 and all contained dense infestations of large reproductive plants. Our data shows dramatic decreases in number of live locations, individuals, and reproductive locations (Table 49).

L. erubescens is a fast-growing vine with a dense, smothering growth habit that can completely overtop trees. We have noted that *L. erubescens* has shown particularly aggressive growth at PTA when compared to other areas in Hawai'i, and control of this species was a key objective during this reporting period. There are 13 active grids for *L. erubescens* at PTA (Figure 54). We visited each of these grids 3-6 times, including survey and control efforts and monitoring and control efforts (Table 49). One of these grids (Loperu 1A, Figure 54) was expanded from 15.5 ha to 19.5 ha in November 2020 because additional plant locations were found outside the grid.

The number of live plant locations decreased in 9 of the 13 *L. erubescens* grids, did not change in 3 grids, and increased in 1 grid (Table 49). We documented 3 new plant locations in the vicinity of previously controlled large reproductive individuals in the Loperu 6 grid. This indicates that the seeds of this wind-dispersed species were able to spread before the individuals were controlled. The juvenile vegetative plants found at these new locations were controlled before they went to seed. The number of individuals decreased in 10 of the grids visited and increased in the other 3 (Table 49). We may continue to see an increase in both plant locations and individuals until the seedbank is exhausted in these grids. The number of plant locations with reproductive individuals decreased in 10 of the grids surveyed, increased in 1 grid, and were never present in 2 grids (Table 49). While most grids had few if any locations with reproductive individuals, the presence of any reproductive individuals indicates that shorter return intervals are needed.

Results of control efforts for 2 of the more densely populated grids are displayed graphically below (Figure 55 and Figure 56).

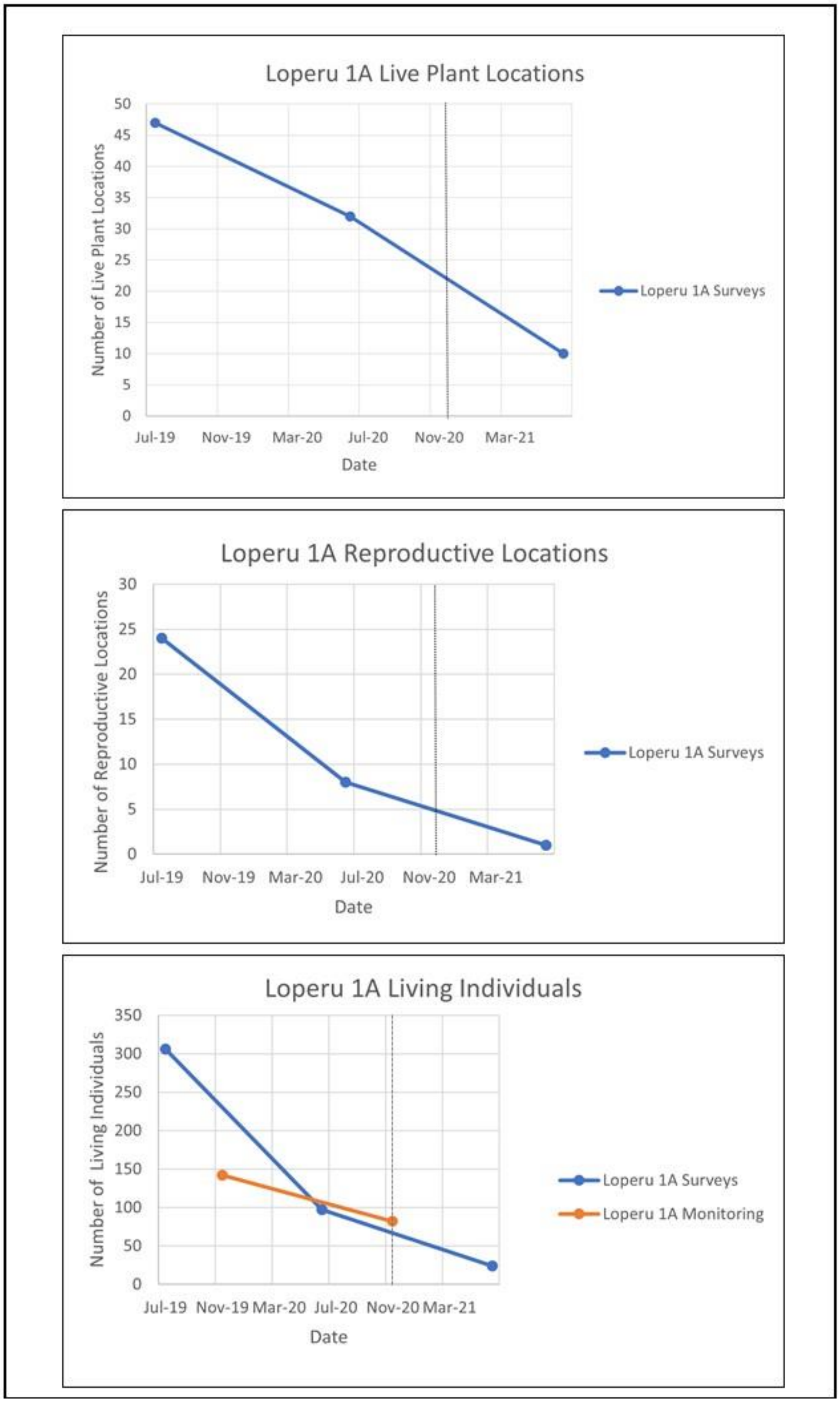

Figure 55. Graphs showing changes in number of live plant locations and live individuals in the *Lophospermum erubescens* (Loperu) 1A site-specific survey grid at Pōhakuloa Training Area. Dashed vertical lines represent the date the grid was expanded.

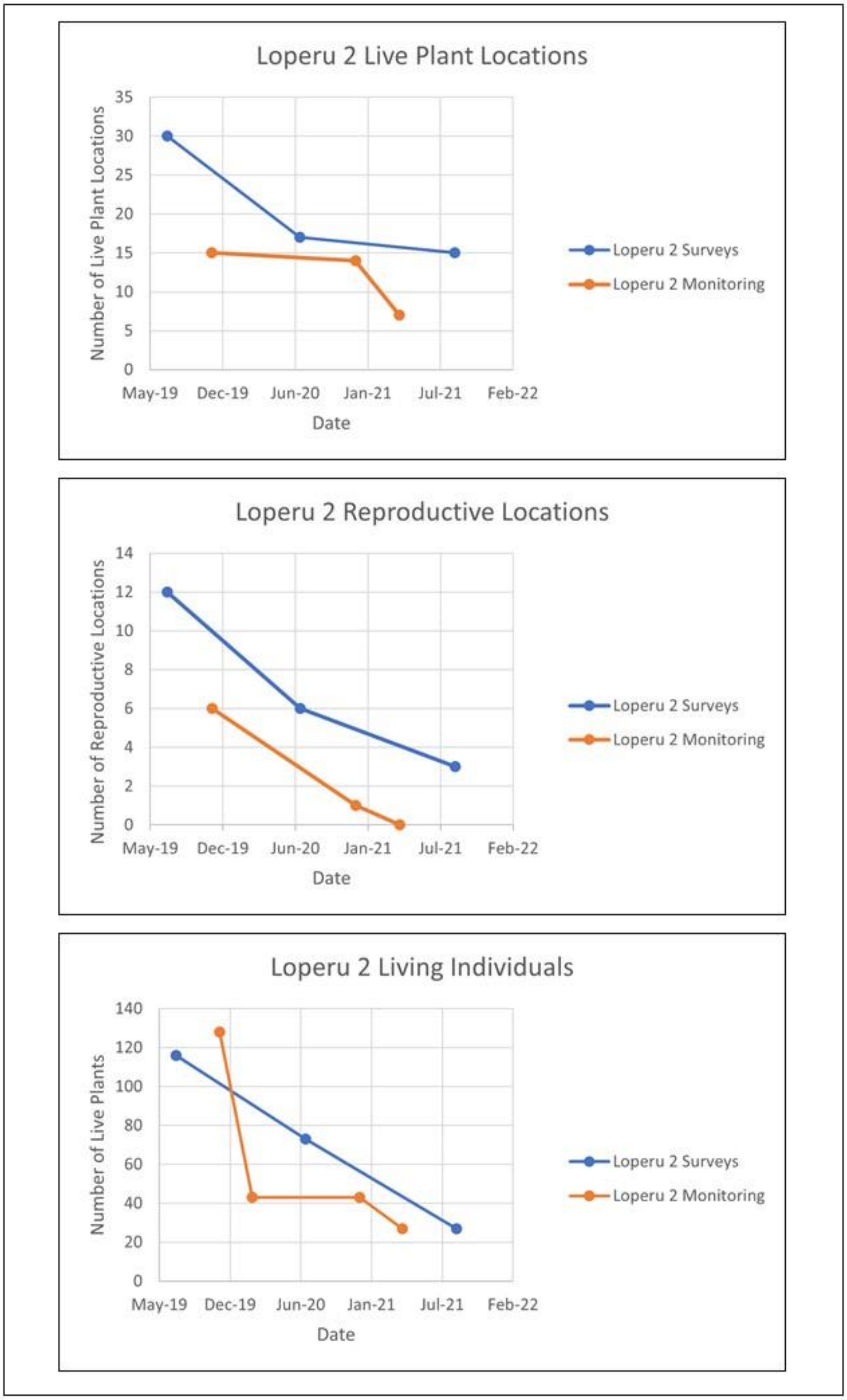

Figure 56. Graphs showing changes in number of live plant locations and live individuals in the *Lophospermum erubescens* (Loperu) 2 site-specific survey grid at Pōhakuloa Training Area.

3.3.5 Rapid ʻŌhiʻa Death Survey, Monitoring, and Sampling

Rapid ʻŌhiʻa Death (ROD) is a new fungal disease that attacks and kills ʻōhiʻa (*Metrosideros 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, impacting a tree more slowly and requiring several infections to kill trees.

Since PTA harbors approximately 5% (approximately 11,480 ha) of the total distribution of ʻōhiʻa forests on Hawaii Island, we collaborate with our state agency partners to survey for infected trees at PTA. Our surveys contribute to a statewide initiative to document the distribution of ROD-infected areas as part of an early detection and rapid response program. The objective is to map and monitor ROD-impacted areas, and track disease movement. The surveys are also important for informing the Army if further precautions need to be in place to prevent the spread of ROD to other areas, especially other islands and installations, by military personnel, vehicles and gear. If suspect ROD trees are identified during aerial surveys or incidentally by field staff, samples may be taken and delivered to the US Department of Agriculture (USDA) Agricultural Research Service pathology lab in Hilo for testing.

ROD has not been detected at PTA to date. We sampled 4 trees off Western Firebreak suspected of having ROD in December 2019 and January 2020. The USDA lab reported that *Ceratocystis* was not detected in the samples we submitted for testing. The State of Hawaiʻi Department of Land and Natural Resources, Big Island Invasive Species Committee, and the CEMML IPSM Specialist conducted an aerial survey of PTA ʻōhiʻa forests via helicopter in December 2020. A single ROD suspect ʻōhiʻa tree was identified during the survey; this tree was sampled and sent to the USDA lab, which reported that *Ceratocystis* was not detected in the sample. 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, with the minor timing modification for Survey Area 3 mentioned earlier. Thus, we surveyed the remaining 2/3 (approx. 20.3 km) of the survey area in the beginning of FY 2020. Although the immediate benefit of early detection programs may not be readily apparent, adequately funding and staffing such programs can help minimize potential future costs to control or manage new infestation of highly invasive species that degrade training lands and impact the mission (Boice et al. 2010). Supporting and implementing early detection and invasive control projects is aligned with Department of Defense Pest Management Program objectives (DoD 2008) and Army

Regulation 200-1. Preventing the establishment of new invasive species typically requires less time, effort, and funding than responding to and managing infestations of new invasive species.

We increased monitoring and control efforts overall by 3.7-fold and survey and control efforts in site-specific grids by 3.6-fold compared to the last reporting period. Our data shows that we have made considerable progress in reducing plant abundance and distribution in most if not all site-specific survey grids. Moreover, our preliminary attempts to quantify the efficacy of our control efforts in these grids have highlighted areas that need improvement and will inform our future planning.

Addressing aggressive secondary target weeds, such as *P. tarminiana*, *R. niveus,* and *L. erubescens*, and their associated negative impacts, is vitally important to conserving native habitats that harbor TES and other native species that may be at risk of declining populations and possible listing under the Endangered Species Act. Managing for the impacts of invasive species and promoting native species aligns with the Army's Ecosystem Management principles, AR 200-1, and INRMP objectives. Preventing native habitat degradation via control of these invasive species can help minimize negative impacts to ASRs and other high quality or TES habitat and is consistent with and supports endangered species management efforts on Army lands.

We drafted a prelimbary technical report detailing the status, locations, habitat, and phenology of each secondary target weed species at PTA. In FY 2022, we plan to re-evaluate our methods and overall approach for assessing, prioritizing, and controlling secondary target weeds to best achieve our goals and associated requirements in the BOs and INRMP. Subsequently, we will revise the current IPSM protocol to clarify these methods and strategies. In addition, we will 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(3)(b) and 3.2(3)(c) and addresses INRMP objectives and conservation measures in the 2003 and 2013 BOs. Our mission is to implement the Army's fire management plan and our goal is to reduce the threat of wildland fire to TES and their habitats through implementation and maintenance of selected firebreaks, fuel breaks, and fuel monitoring corridors per the IWFMP (USAG-P 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 62 km (Figure 57). Eleven fuel breaks in the west section of PTA have firebreak roads embedded within them. Three fuel breaks in the KMA do not contain firebreaks but rather fire access roads that are navigable with a 4-wheel-drive vehicle. The Fuel Break System in the west section of PTA employs a 3-6-9 standard, which consists of 3 m of vegetation control, a 6 m-wide firebreak road, and an additional 9 m of vegetation control. KMA fuel breaks are 18 m-wide swaths of vegetation control within and around fire access roads. Standards in the IWFMP (USAG-P 2021) dictate that fuel breaks be maintained at less than 20% crown cover via ocular estimation and grass less than 12 inches high. We monitor fuel loads within FMCs every 5 years, beginning in 2015, to ensure fuels do not exceed 20% total herbaceous cover.

The Fuel Break System and FMCs function together to protect valuable natural resources, including TES habitat and ESA-listed plants, from wildland fires occurring on the installation. Fuel breaks are designed for firefighters to conduct 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 57). The idea is that one catastrophic fire event will not destroy all individuals of a species that are located within more than one cell and gives firefighters several lines of defense for backburning operations. FMCs, described in Section 3.4.3 below, are natural barriers void of contiguous fuels within which fire is unlikely to spread. Thus, FMCs should function as a physical barrier to fire spread. Most FMCs are located around the border of the Impact Area, so they generally function to stop the spread of fires originating in the Impact Area, which firefighters do not and cannot contain or extinguish. Some fuel breaks and FMCs intersect or are located near each other (e.g., Keʻāmuku FMC located just north of the NW fuel break network). Thus, they create a mosaic of assets with little to no fuels, along with WCBs in fire-prone areas, that reduces threats to TES habitats from wildland fires.

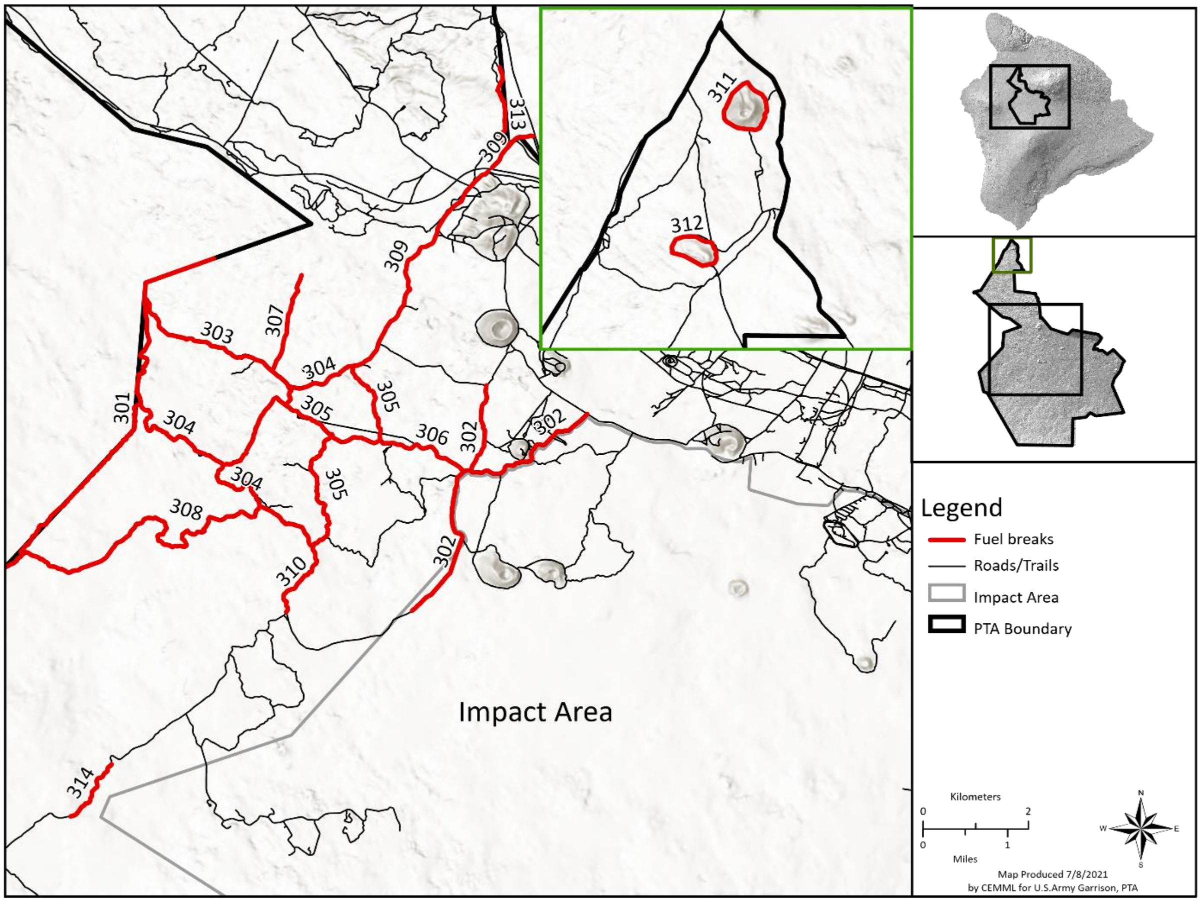

Figure 57. Fuel Break System at Pōhakuloa Training Area.

3.4.2 Maintenance of Fuel Breaks

We have fully implemented all fuel breaks and are currently maintaining fuels (Table 50). 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 58). The gap shown for the ʻAlalā FMC at the most western extent of the Impact Area (Figure 58) is where FB 314 is located (Figure 57).

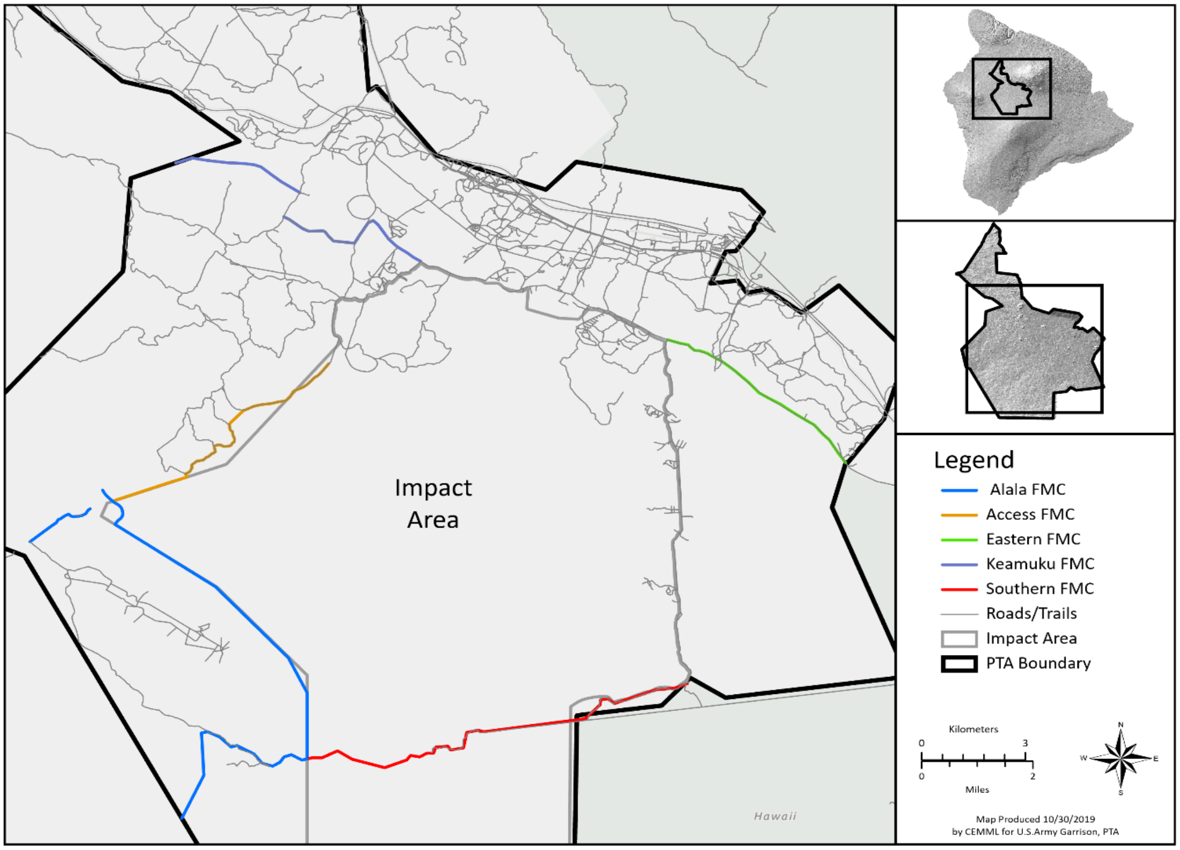

Figure 58. Fuel monitoring corridors at Pōhakuloa Training Area.

The original intent and purpose of FMCs as agreed upon during prior consultations and in the 2003 IWFMP, and approved by USFWS, was in lieu of fuel management control to ensure populations of ESA-listed plants were isolated and protected from wildland fire. We contended that several ESA-listed plant populations were already isolated by natural barriers (e.g., barren or sparsely vegetated lava flows), now designated as FMCs. As USFWS cautioned these areas could become invaded with fuels in the future, namely invasive grasses, we proposed monitoring these areas every 5 years for encroachment. Monitoring includes review of imagery, plotting a course, and flying over the FMCs via helicopter to make ocular estimates of fuels cover and determine if they are contiguous. FMCs are described in more detail in the current IWFMP (USAG-P 2021).

We monitored the FMCs in CY 2020. Results and subsequent actions of that effort were detailed in an MFR to the Army, currently under review. Based on results of the assessment, no management of surface fuels is required at this time. However, we identified 2 areas where invasive grasses are invading and 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 50. Assessment and maintenance effort for fuel breaks in FY 2020–FY 2021.

Fuel Break (FB)	Length (m)	Action	Frequency
301A	4,457	Assess FB	9
		Shrub/limb	2
		Spray	4
301B	2,380	Assess FB	11
		Spray	7
301C	1,687	Assess FB	8
		Spray	7
302A	2,858	Assess FB	6
		Spray	4
302B	1,946	Assess FB	9
		Shrub/limb	1
		Spray	9
302C	3,223	Assess FB	9
		Spray	7
303	4,029	Assess FB	10
		Shrub/limb	1
		Spray	9
304A	2,015	Assess FB	11
		Shrub/limb	1
		Spray	10
304B	1,440	Assess FB	9
		Shrub/limb	2
		Spray	8
304C	3,192	Assess FB	7
		Spray	6
304D	2,248	Assess FB	7
		Spray	5
305A	1,768	Assess FB	6
		Shrub/limb	1
		Spray	7
305B	2,186	Assess FB	11
		Shrub/limb	1
		Spray	9
305C	2,121	Assess FB	8
		Shrub/limb	1
		Spray	9
306	1,899	Assess FB	7
		Shrub/limb	1
		Spray	8
307	2,007	Assess FB	9
		Shrub/limb	1
		Spray	9
308	5,929	Assess FB	5
		Shrub/limb	1
		Spray	4
309A	3,041	Assess FB	8
		Spray	8

Table 50. Assessment and maintenance effort for fuel breaks in FY 2020–FY 2021 (cont.).

Fuel Break (FB)	Length (m)	Action	Frequency
309B	1,100	Assess FB	3
		Spray	5
309C	1,627	Assess FB	5
		Spray	2
310	2,212	Assess FB	8
		Shrub/limb	1
		Spray	5
311	2,719	Assess FB	7
		Mow	3
		Spray	9
		Weed whack	8
312	2,337	Assess FB	7
		Mow	8
		Weed whack	8
313	1,761	Assess FB	7
		Mow	2
		Weed whack	4
314	1,415	Assess FB	7
		Spray	5
Total	**61,597**		

3.4.4 Fuels Management Discussion

All fuel breaks have been fully implemented and were maintained during the reporting period to ensure compliance with standards per the current IWFMP (USAG-P 2021). The USAG-P IWFMP 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 the summer of 2021, several wildland fires occurred at PTA. Two of these fires occurred in the KMA in areas where firefighters utilized our conservation fuel breaks. Refer to Section 8.0 for more details about the wildland fires.

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 trigger the Army to reinitiate formal consultation under section 7 of the ESA for the affected species, which can be time-consuming, costly, and result in more restrictions of military activities. 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[11]. Through the implementation of our SOO tasks, we continue to work towards our program goals, INRMP objectives, and maintain compliance with several conservation measures from the 2003 and 2013 BOs. In general, we met standards for vegetation control within ASRs, at HFNWR, and along the Fuel Break System.

We are progressing toward our goal of protecting and improving habitats for ESA-listed plants by controlling vegetation in WCBs to reduce threats from invasive plants to natural resources, particularly rare plants. Although we currently do not formally evaluate habitat responses to our management, we observed regeneration of native shrubs and some ESA-listed plants within the WCBs. Based on these observations and other research demonstrating the benefits to native species from removing *C. setaceus* (Cabin et al. 2002; Cordell et al. 2002; Thaxton et al. 2012), we believe vegetation control within WCB is benefitting the species. In addition, our observations 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 and widespread (Boice et al. 2010). Likewise, control of secondary target weeds at newly found satellite locations, especially in high quality or TES habitat, are more cost effective and result in less impacts than the alternatives of no or delayed action. Thus, continued and consistent funding to manage invasive species is critical to ensure we can effectively address our goals of detecting, controlling, and/or eradicating invasive plants (i.e., secondary target weeds) to prevent impacts to TES and high value resources. Results from our data of site-specific survey grids indicate that our increased efforts in survey, monitoring, and control are having the desired effect of decreasing secondary target weed species metrics in several grids.

Our fuels management actions contributed to a positive outcome for ESA-listed plants during the July 2021 fire in the northern section of KMA. Our fuel breaks were a critical asset for firefighters and helped to prevent impacts to ESA-listed plant species on the 2 puʻu (cinder cones) during one of, if not the, largest wildland fire in Hawaiʻi. The PTA Fire Department noted that our fuel breaks significantly aided in fire suppression and containment efforts, underscoring their value as safe and effective pre-suppression assets.

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[11] Species at risk are defined as plant and animal species and associated habitats that are not federally listed as threatened or endangered under 16 USC Chapter 35 (ESA) but are either federally listed as candidates or are ranked by NatureServe as critically imperiled or imperiled throughout their range (AR 200-1, 2007).

We will continue to fine-tune our planning process to identify needs and establish priorities in FY 2022. We will also continue to refine existing and develop new protocols and SOPs to better align activities with program goals and objectives as driven by the SOO, the PTA INRMP, and other compliance obligations and to provide tight linkages in the adaptive management process.

4.0 WILDLIFE PROGRAM

4.1 INTRODUCTION

The purpose of the Wildlife Program is to gain insight and understanding of ESA-listed animal species distributions, habitat use, ecology, and the factors that impact their long-term survival to develop and implement appropriate and efficient management approaches in accordance with mandates that guide the Army's Natural Resources Programs. To this end, we monitor for presence and assess the distribution of ESA-listed animals to inform species management, military training and range development, and to report the status of the species. In addition, we manage introduced and invasive animals and their associated negative impacts to reduce effects on TES and their habitats.

To manage wildlife resources at PTA, we implement SOO tasks 3.2(2)(a) through 3.2(2)(e) to comply with INRMP objectives (Sikes Act Improvement Act), ESA consultation requirements, the Migratory Bird Treaty Act (MBTA), regulatory outcomes from NEPA documents, and the conditions of federal and state TES permits.

The Wildlife Program manages for 6 ESA-listed animal species that use habitat at PTA and/or periodically transit the installation: Hawaiian Goose (*Branta sandvicensis*), Hawaiian hoary bat (*Lasiurus cinereus semotus*), Band-rumped Storm Petrel (*Hydrobates castro)*, Hawaiian Petrel (*Pterodroma sandwichensis*), anthricinan yellow-faced bee (*Hylaeus anthracinus*), and the Blackburn's sphinx moth (*Manduca blackburni*). Since 2006, 12 additional bird species protected under the MBTA have been observed at PTA (USAG-P 2020).

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 the Hawaiian Petrel. The 2003 and 2008 BOs included Incidental Take Statements with Terms and Conditions to offset effects of military activities on the Hawaiian hoary bat. The 2008 and 2013 BOs included Incidental Take Statements with Terms and Conditions to offset effects of military training on the Hawaiian Goose.

In December 2019, USFWS finalized a ruling to downlist the Hawaiian Goose from endangered to threatened with a Section 4(d) rule (USFWS 2019). Despite downlisting of the Hawaiian Goose, 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 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 November 2020, the Band-rumped Storm-Petrel was added to the federal recovery permit issued under section 10(a)(1)(A) of the ESA. The permit authorizes activities consistent with the May 2020 informal consultation and with activities identified in an action plan that was submitted to the USFWS as part of the permit amendment application.

We have not consulted with the USFWS under section 7(a)(2) of the ESA for the Band-rumped Storm Petrel, the anthricinan yellow-faced bee, or the Blackburn's sphinx moth. Without an ESA consultation, these species lack formal conservation measures. 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 ESA-listed animal species that occur at or around PTA, as well as the 20 species of ESA-listed plants. Reporting requirements for anthricinan yellow-faced bee and the 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)(a) and 3.2(2)(b) and projects implemented under the Wildlife Threats Management Section address SOO tasks 3.2(1)(c), 3.2(2)(d) and 3.2(2)(e). For a list of drivers associated with each of the projects and sections in the Wildlife Program, please refer to Appendix C.

4.2 Wildlife Management

4.2.1 Introduction

We implement projects to manage and protect ESA-listed animal species as required by law, while minimizing impacts from wildlife to military activities that may degrade training realism or quality at PTA. Our objectives include surveying to determine presence of species, monitoring activity patterns, identifying habitat use, and reporting incidental take (direct and indirect) for the Hawaiian Goose, Hawaiian hoary bat, and bird species protected under the MBTA.

The overall operational goals of the Wildlife Management Section are to:

- Monitor Hawaiian Geese at PTA and implement management when needed.

- Manage conditions at an off-site location for Hawaiian Geese to improve nesting success and gosling survivorship to achieve an average production of 26 fledglings annually.
- Monitor Hawaiian Goose nest success and survival at an off-site location to evaluate progress toward annual fledgling production targets.
- Monitor Hawaiian hoary bat occupancy and seasonal activity patterns.
- Monitor for incidental take of the Hawaiian hoary bat and the Hawaiian Goose, including hazing events and nest and gosling relocations, and to comply with reporting requirements.
- Monitor for Hawaiian Petrel presence and habitat use at PTA.
- Monitor for Band-rumped Storm Petrels and manage conditions to promote nesting success.
- Monitor for Palila (*Loxioides bailleui*) presence and habitat use at PTA.
- Monitor for avian species listed under the MBTA presence and habitat use at PTA.
- Monitor for and report incidental take of avian species protected under the MBTA.
- Survey/monitor for anthricinan bee and Blackburn's sphinx moth presence and habitat use.
- Educate military unit leaders (e.g., Commanders, Officers in Charge, Range Safety Officers, and Non-commissioned Officers) to avoid and minimize take and/or negative impacts to ESA-listed animals.

4.2.2 Hawaiian Goose Management at Pōhakuloa Training Area

We manage for Hawaiian Geese at PTA to meet SOO tasks 3.2(2)(a) and 3.2(2)(b) and to address INRMP objectives and conservation measures and terms and conditions from the 2013 BO and Incidental Take Statement.

Hawaiian Goose management at PTA consists of: 1) monitoring for goose presence and behavior, 2) implementing actions to reduce military training/goose conflicts, 3) monitoring incidental take, and 4) briefing personnel training and working at PTA.

In addition, to implement terms and conditions of the 2013 BO Incidental Take Statement, we manage Hawaiian Geese at Hakalau Forest National Wildlife Refuge (HFNWR). The goal of this project is to create suitable goose habitat and maximize gosling survival to adulthood; specifically, to produce an average of 26 fledgling geese per year to compensate for the potential incidental take of 20 adult geese annually at PTA (USFWS 2013a).

<u>Hawaiian Goose Monitoring</u>

We systematically monitor Hawaiian Geese at PTA to better understand patterns of visitation and habitat use. We also monitor all nesting, breeding, molting, and incidental take that occurs at the installation. We collect and manage incidental goose sightings reported by military, 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 historic, or newly discovered, goose activity (hereafter these areas are referred to as core monitoring areas). The purposes of systematic monitoring in core areas are: 1) to better understand patterns of goose presence and 2) to direct management based on our observations. Core monitoring areas include the Range 1 Complex, the Forward Operating Base (FOB) Warrior Search Area in Training Areas (TAs) 1, 3, and 4, TAs 6 and 7, and Bradshaw Army Airfield (BAAF) (Figure 59).

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.

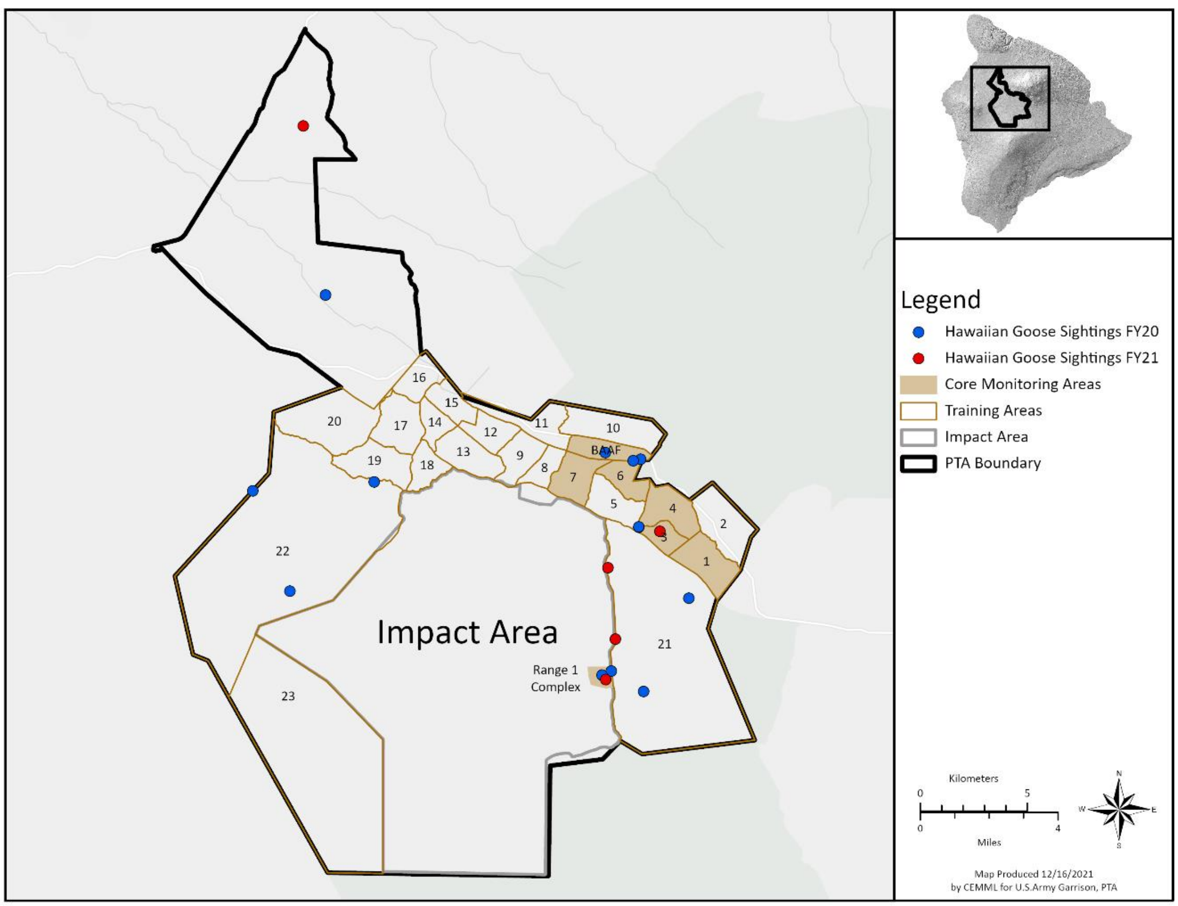

Figure 59. Hawaiian Goose sightings during FY 2020–FY 2021 in core and non-core monitoring areas at Pōhakuloa Training Area.

More than 1 core monitoring area may be surveyed in a single day; therefore, we report survey effort by the number of surveys in a core monitoring area within a reporting period to provide a measure of effort per area. We report the number of surveys in which we observed geese. All goose observations over the reporting period are pooled by core monitoring area and reported as total observations, which includes all repeated observations of banded individuals and all observations of geese that were not banded or where we could not determine if bands were present. We do not adjust the survey data to account for imperfect detection of geese, which likely biases the number of reported observations. These observation data are an approximate measure of goose presence (i.e., activity) for the core monitoring areas and are helpful in guiding management efforts.

Incidental Sightings Methods

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.

Targeted Monitoring Methods

We initiate targeted monitoring when breeding or molting activity is observed during systematic surveys or during a follow-up to incidental sighting reports. Targeted monitoring typically involves multiple visits to the same location to monitor the same individuals for as long as the individuals are present at the location. Targeted monitoring may involve nest monitoring as well.

Systematic Monitoring Results

During FY 2020–FY 2021, in the core management areas, we recorded a total of 21 goose observations during 5 of 336 surveys (Table 51). Geese were only observed at the Range 1 Complex and at FOB Warrior Search Area. From the leg-band information, we confirmed that 6 individuals with unique leg-bands visited these areas.

Table 51. Hawaiian Goose systematic monitoring data and leg-band information in core monitoring areas in FY 2020- FY 2021, 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	61	2	12	2	0	10
FOB[b] Warrior Search Area	93	3	9	4	0	5
Bradshaw Army Airfield	91	0	0	0	0	0
Training Areas 6 and 7	91	0	0	0	0	0

[a] Total goose observations includes all geese seen per core area and may include repeat visits by individual geese; therefore, the total number of goose observations may not equal the sum of the number of geese reported with bands, without bands and bands not identified for each core area.
[b] FOB, Forward Operating Base

Incidental Sighting Results

In the core monitoring areas, we observed a total of 6 geese (all observations pooled including repeat visits) from 4 incidental sighting events (Table 52). From the 6 observations, we identified 4 individual geese by their unique leg-bands, but we were unable to determine the presence of leg-bands for the other 2 observations; therefore, we cannot determine the number of individual birds these observations represent.

In non-core monitoring areas, we observed a total of 23 geese (all observations pooled including repeat visits) from 9 incidental sighting events. From the 23 observations, we were unable to determine the presence of leg-bands for all 23 geese. Therefore, we cannot determine the number of individual birds these observations represent.

Table 52. Hawaiian Goose incidental sightings by location and leg-band information in core and non-core areas in FY 2020–FY 2021 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	1	2	2	0	0
FOB[b] Warrior Search Area	1	2	2	0	0
Bradshaw Army Airfield	1	1	0	0	1
Training Areas 6 and 7	1	1	0	0	1
Non-Core Areas	9	23	0	0	23

[a] Total goose observations included repeat visits of geese with leg-bands and repeat visits of birds without or when the bands could not be identified.
[b] FOB, Forward Operating Base

Targeted Monitoring Results

No Hawaiian Goose molting or breeding was observed/reported at PTA during FY 2020–FY 2021 period.

Other Survey Efforts

We did not detect geese at PTA during the statewide annual Hawaiian Goose surveys. Surveys were canceled in FY 2020 but occurred in FY 2021 (28 July 2021). These surveys are coordinated by the State of Hawaiʻi Department of Forestry and Wildlife (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 (i.e., molting and breeding) to help guide management and to reduce potential conflicts with military activities. Although monitoring goose presence at PTA is not a specific conservation measure included in the 2013 BO, we monitor select locations that geese are known to frequent, based on historical observations or an uptick in incidental sightings, to better understand patterns of presence and to 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 years and between years.

To review activity patterns for FY 2019 through FY 2020, 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 53). Over the past 3 years, goose observations have declined at PTA. 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. There was also a corresponding decline in the number of incidental sightings reported between 2019 and 2021 Table 53.

Table 53. Total number of goose observations per survey effort in core monitoring areas in FY 2019–FY 2021 at Pōhakuloa Training Area.

	Systematic Sightings			Incidental Sightings		
	2019	2020	2021	2019	2020	2021
Total goose observations	20	17	4	30	25	4
Number of Surveys	140	145	191	9	10	3
Mean # Geese/Survey	0.14	0.11	0.02	--	--	--

The reason for the decline in goose observations at PTA over the past 3 years is not known. Movement and patterns of presence during flocking season (May–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 has been 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, *Rytidosperma pilosum*, (hairy wallaby oatgrass), has lessened the attractiveness of the range to geese (see the section below for details about habitat management activities).

Monitoring helps us to better manage potential conflicts between geese and military activities in a timely and efficient manner and to minimize disruptions to training. Because Hawaiian Geese are highly mobile animals, we recommend 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, how they use the habitat will continue to guide management and minimize potential conflicts with military training.

Management Activities at Pōhakuloa Training Area

To further Hawaiian Goose management at PTA, we manage habitat at the Range 1 Complex and control small mammals, under select circumstances, when we discover molting or nesting geese. In addition, we brief military unit leaders on their responsibilities to protect geese at PTA, especially while driving and conducting live-fire exercises. We also brief all personnel training or working on the installation, outside the cantonment, about training/working near Hawaiian Geese and the process to report geese to PTA Range Control. We summarize reported goose sightings and our efforts to brief personnel below.

Actions to Manage Hawaiian Goose Breeding Activity

We did not implement management during the reporting period because we did not detect breeding or molting activity at PTA.

Actions to Minimize Conflicts between Training and Hawaiian Geese

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 60).

Hawaiian Goose habitat enhancement occurs within the Wildlife Enhancement Area (WEA) fence unit proximate to the Range 1 Complex (Figure 60). Habitat enhancement includes promoting habitat and food availability by selectively cutting and applying herbicide to unwanted weed species such as *Senecio madagascariensis* (fire weed), *Cenchrus setaceus* (fountain grass), 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 (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, 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.

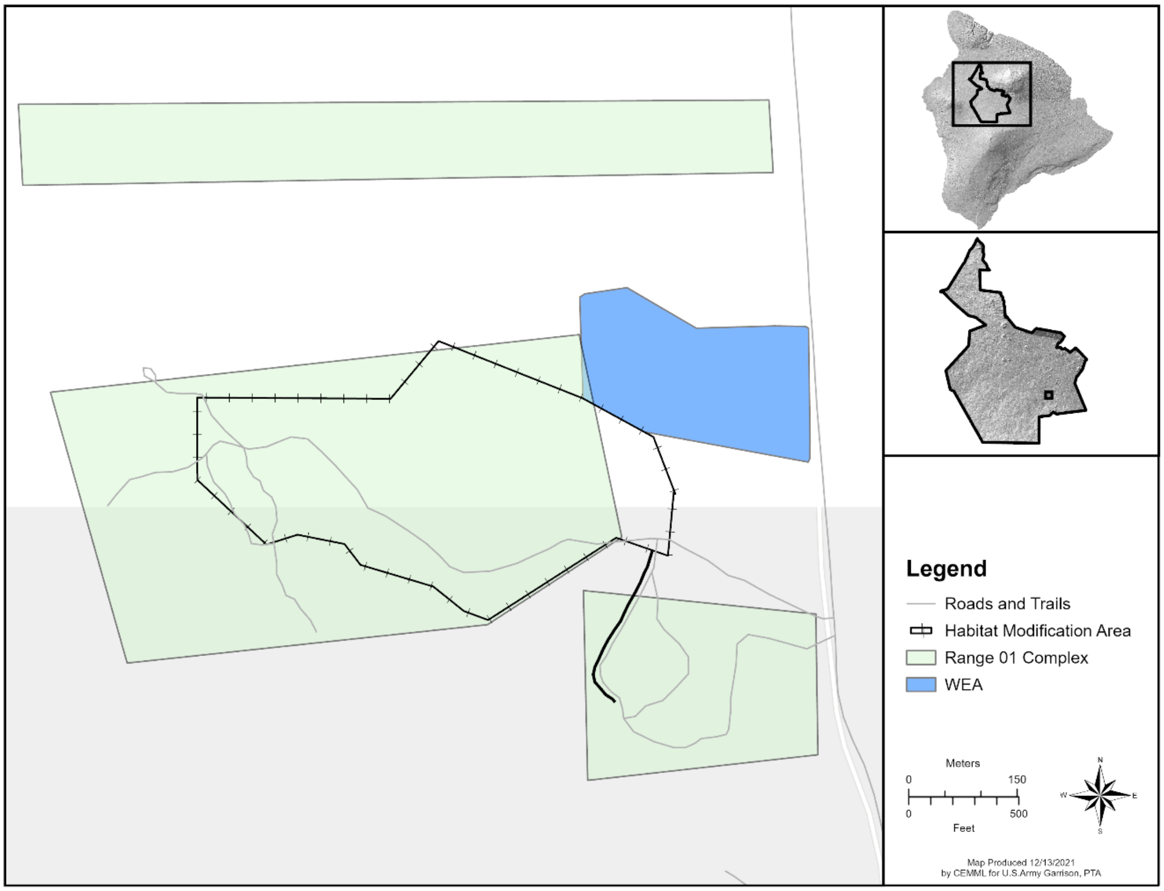

Figure 60. Hawaiian Goose habitat modification area and the Wildlife Enhancement Area at the Range 1 Complex, Pōhakuloa Training Area.

__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 2020–FY 2021 6 uniquely banded geese were observed incidentally or during systematic surveys at PTA: 1 (17%) came from the HFNWR population, 4 (67%) from the Puʻu ʻŌʻō Ranch population (translocated from Kauaʻi), and 1 (17%) from unknown origins. Since 2009, the majority of 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 are sighted more frequently at PTA, and they are the only group that has successfully nested at PTA (3 times) since 2014. We are uncertain what influences geese to visit and use PTA.

In FY 2022 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.

Projects implemented for Hawaiian Goose management at PTA meet SOO tasks 3.2(2)(a) and 3.2(2)(b) and address INRMP objectives and several conservation measures and terms and conditions from the 2013 BO. Although our monitoring results do not estimate numbers of geese using PTA, we have made fewer detections per survey effort over the past 3 years (Table 53).

We have also noted that requests to support military training due to the presence of geese at the Range 1 Complex have decreased. Although we cannot directly attribute a reduction in sightings to our management at the complex, we observe geese less often in areas where we have controlled their preferred food grass, *R. pilosum*. However, we have not seen a commensurate increase in presence where we promote *R. pilosum* within the WEA.

Incidental sightings of geese continue at low frequencies at locations outside our core monitoring areas. However, we have not continued to observe geese at these reported locations; therefore, we believe these incidental sightings represent temporary visitations and not undiscovered or new high-frequency-use sites.

Monitoring goose presence helps us to better manage potential conflicts between geese and military activities in a timely and efficient manner and to minimize disruptions to training. Because Hawaiian Geese are highly mobile animals, we 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.

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. In addition, for FY 2021 we placed 3 Hawaiian Goose educational signs around cantonment to further educate and minimize impacts to Hawaiian Geese when people are at PTA. These signs were placed near areas frequented by personnel training and working at PTA.

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 61). Within the Pua ʻĀkala management area, we manage habitat only within the formerly proposed predator-proof fence (Pua ʻĀkala habitat enhancement in Figure 61).

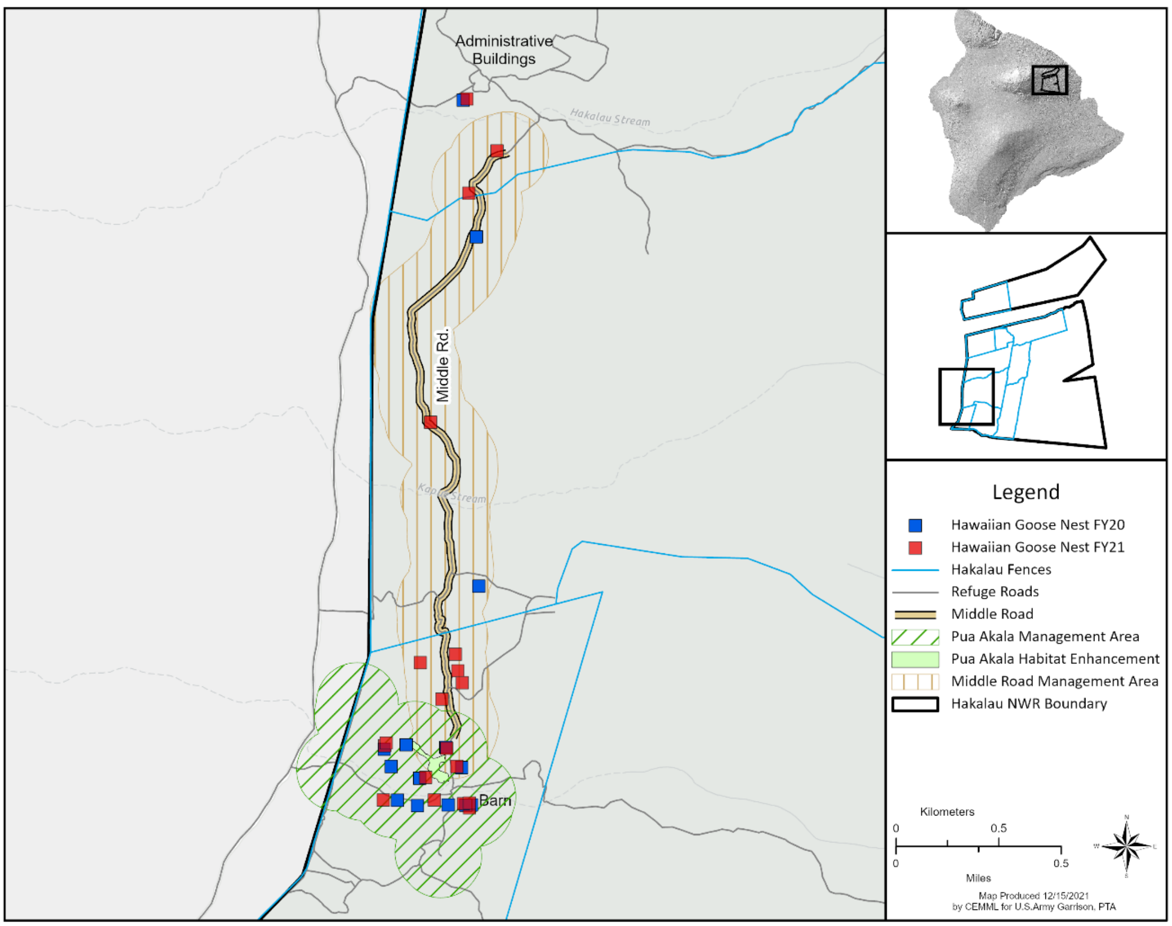

Figure 61. Army supported management areas during FY 2020 and FY 2021 and Hawaiian Goose nest locations at Hakalau Forest National Wildlife Refuge.

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 2019/2020 and the 2020/2021 Hawaiian Goose breeding seasons (CEMML 2020a; CEMML 2021b). 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 61). Inadequate nutritional quality is a limiting factor for the reproduction of Hawaiian Geese and gosling survival at high elevation sites (USFWS 2004). Although the effects of habitat management (e.g., mowing grass or planting food plants) on geese productivity have not been well studied at high elevations, forage quality and availability is increased when habitat is managed in this way.

In FY 2020–FY 2021, we cut ~1.2 ha of kikuyu grass (*Cenchrus clandestinus*) with weed whackers and a large deck mower within the Pua ʻĀkala management area 6 times. We also spot-sprayed blackberry (*Rubus discolor*), bull thistle (*Cirsium vulgare*), and gorse (*Ulex europaeus*). Six small wooden shelters were placed around the mowed area to provide additional protection for geese.

Hawaiian Goose Monitoring

In FY 2020–FY 2021, we monitored geese inside the Army-managed areas at HFNWR during the breeding season between September and April (Figure 61). 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 times geese forage inside the management areas. Documenting the use of managed areas (areas with improved forage and/or reduced predators) by family groups with goslings helps determine the numbers of goslings that are supported to fledging through our management efforts. Fledglings that were consistently observed in management areas, regardless of whether or not they hatched from a nest outside the predator control area, are counted towards our goal of producing 26 fledglings per year.

Geese are also sighted and recorded while staff scan the management areas and/or perform other management actions. When possible, geese are identified by their leg-bands. Total numbers of geese using the management areas are recorded and family groups with goslings are noted.

Over the report period, we observed cumulative totals of 142 geese with unique leg bands and 30 fledglings identified by one or more banded parent (Table 54). 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 2020/2021 (Table 54). Since we began managing the habitat at HFNWR in 2017, geese have been observed regularly using the Army-managed areas.

Table 54. Hawaiian Goose sightings from Army-managed areas during breeding seasons (September to April) at Hakalau Forest National Wildlife Refuge.

Breeding Season	Total Goose Sightings	Banded Adults	Unbanded Adults[a]	Unbanded Fledglings[a]
2017/2018[b]	78	68	5	5
2018/2019	89	67	6	16
2019/2020[b]	74	54	8	12
2020/2021	123	88	17	18

[a] Unbanded adults and juveniles that were identifiable by 1 or more banded partner/parent.

[b] Monitoring began in October these years due various delays.

Since we began managing the habitat at HFNWR in 2017, geese have regularly been observed using the Army-managed areas. On 24 February 2021, the carcass of a female Hawaiian Goose (Green/White 726) was found on the grass inside the Pua ʻĀkala management area. The cause of death is unknown. On 25 February 2021, HFNWR staff collected and removed the body. For more information regarding the incidental sighting please refer to Appendix D.

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 12 nests in Army-managed areas between October 2019 and April 2020, and 18 nests between September 2020 and April 2021 for a total of 30 nests over the report period (Figure 61).

To include fledglings toward our fledging production goals, we established 2 criteria:

- For nests within Army-managed areas, we count goslings if they are banded, seen flying, or seen alive more than 10 weeks since hatching (when they may be capable of flight).
- For nests with unknown locations or with locations outside of the Army-managed areas, we count goslings if they are observed using the management areas on more than 25% of days staff are present/monitoring within the first 10 weeks of hatching, and are banded, seen flying, or seen alive after those 10 weeks.

Using these criteria, we counted a total of 30 fledglings produced over the report period: 12 between October 2019 and April 2020, and 18 between September 2020 and April 2021. The 2-year average fledgling production for the report period is 15 fledglings per year, which falls short of our annual goal of supporting 26 goslings to fledging. We discuss the overall, 4-year progress toward the goal of producing 26 fledglings on average annually below in the discussion.

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 62).

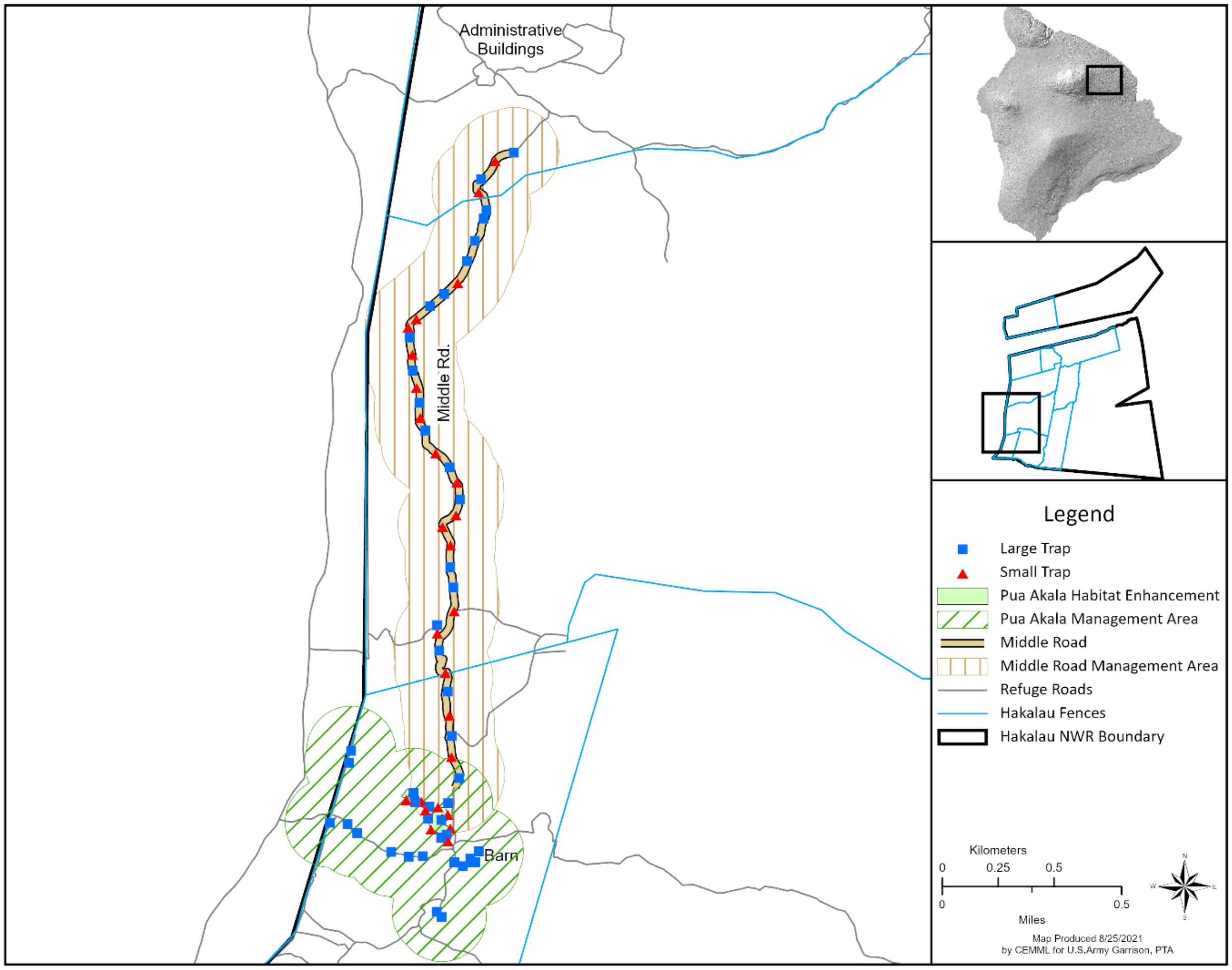

Figure 62. Predator trap layout during FY 2020–FY 2021 Hawaiian Goose breeding season at Hakalau Forest National Wildlife Refuge.

Live Trapping Results

In FY 2020 (October 2019 and April 2020), we deployed 55 live traps and removed 12 predators (2 feral cats, 9 mongooses, and 1 rat). In FY 2021 (September 2020 and April 2021), we deployed 71 traps and removed 15 predators (5 feral cats, 8 mongooses, and 2 rats) (Table 55).

Table 55. Predators captured in live traps during the FY 2020–FY2021 Hawaiian Goose breeding season on Army-managed areas at Hakalau Forest National Wildlife Refuge.

Breeding Season	Traps Deployed	Total Captures	Cats	Mongoose	Rats
FY 2020	55	12	2	9	1
FY 2021	71	15	5	8	2

Lethal Trapping Results

In FY 2020 (October 2019 and April 2020), we studied whether Hawaiian Geese interact with deactivated self-resetting traps (Goodnature® A24 rat + stoat traps, Goodnature Limited, Wellington, New Zealand, hereafter referred to as A24 traps) traps in a way that poses a risk to the geese. Out of 306 recorded interaction events, geese showed interest in the A24 traps during 83 (27%) events and geese made contact with the shroud entrance of the A24 traps during 3 (1%) events. After reporting these findings, HFNWR approved the use of A24 to protect Hawaiian Goose nests for the 2020/2021 Hawaiian Goose breeding season.

In FY 2021 (September 2020 and April 2021), we deployed up to four A24 traps, spaced approximately 25 m away from each Hawaiian Goose nest. We removed 31 predators (2 mongooses, 4 rats, and 25 mice). 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 Hawaiʻi and mitigates impacts to the Hawaiian Goose due to military training activities at PTA. 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 30 geese. With 18 goslings successfully fledging in FY 2021, we reached 69% of the target production of 26 fledglings per year. This was the second-highest number of goslings to fledge since FY 2019 when 20 goslings fledged (Table 56).

Since FY 2018, management activities in the Army-managed areas have supported goslings to fledgling age across 4 breeding seasons (Table 56). On average, these efforts have supported about 14 fledglings per year, which is short of the target established in the 2013 BO of producing an average of 26 fledglings per year by year 10 of the project. The target set in the 2013 BO 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 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.

Table 56. Hawaiian Goose nests and fledglings on Army-managed areas during breeding seasons (September to April) 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%
4-year Mean	12.25	14.25	55%

[a] Sightings for the 2017/2018 breeding season began in October.

To sustain high fledgling success and to achieve the annual requirement of 26 fledglings, we recommend continuing management activities in the 2021/2022 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)(a) and to address INRMP objectives and conservation measures and terms and conditions from the 2003 and 2008 BOs and associated Incidental Take Statements. Our goal was to determine occupancy and seasonal activity patterns throughout the installation between 2014 and 2021. The project was aimed to identify habitat association based on 5 vegetation classes, and bat prevalence in potential treeland roosting habitats more generally. Between 2014-2017 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. We resumed occupancy data collection in 2019 and 2020 for 9 weeks starting in September, rather than centering data collection across the 4 months when adults mate and juveniles fledge (September-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. Similarly, the activity dataset now spans June 2014 through August 2021 which helps clarify our assumptions about seasonal activity patterns. Occupancy estimates of peak of activity (September-December) 2014-2017, 2019, and 2020 were also analyzed. We present methods and results of bat activity and of occupancy estimates during the peak of activity for each of the 5 years of data collected

<u>Seasonal Activity Methods</u>

We conducted acoustic sampling at 5 established monitoring locations across PTA since 2014 (Figure 63). Anabat SD2 (Titley Scientific, Ballina, Australia) detectors and microphones recorded bat calls from sunset to sunrise each night throughout the study. Each detector was powered by a 12 V battery connected to a solar panel. All calls were recorded using zero-crossings analysis which produced individual files of spectrograms for each acoustic event. Spectrograms were viewed in AnalookW (version 4.2n, Titley Electronics) to prevent misidentification. We created an activity index based on the number of 1-minute intervals per night in which bat echolocation calls were recorded (Miller 2001). We refer to this call frequency as bat-call minutes, and use "minutes" to describe overall estimates of nightly bat activity. Furthermore, we calculated the average number of calls specific to feeding activity and refer to them as feeding buzzes (Griffin et al. 1960). Refer to the FY 2014 Annual Report for the Natural Resources Program, Pōhakuloa Training Area, Island of Hawaiʻi (Peshut et al. 2015) for more detailed information regarding overall project design, goals and methods.

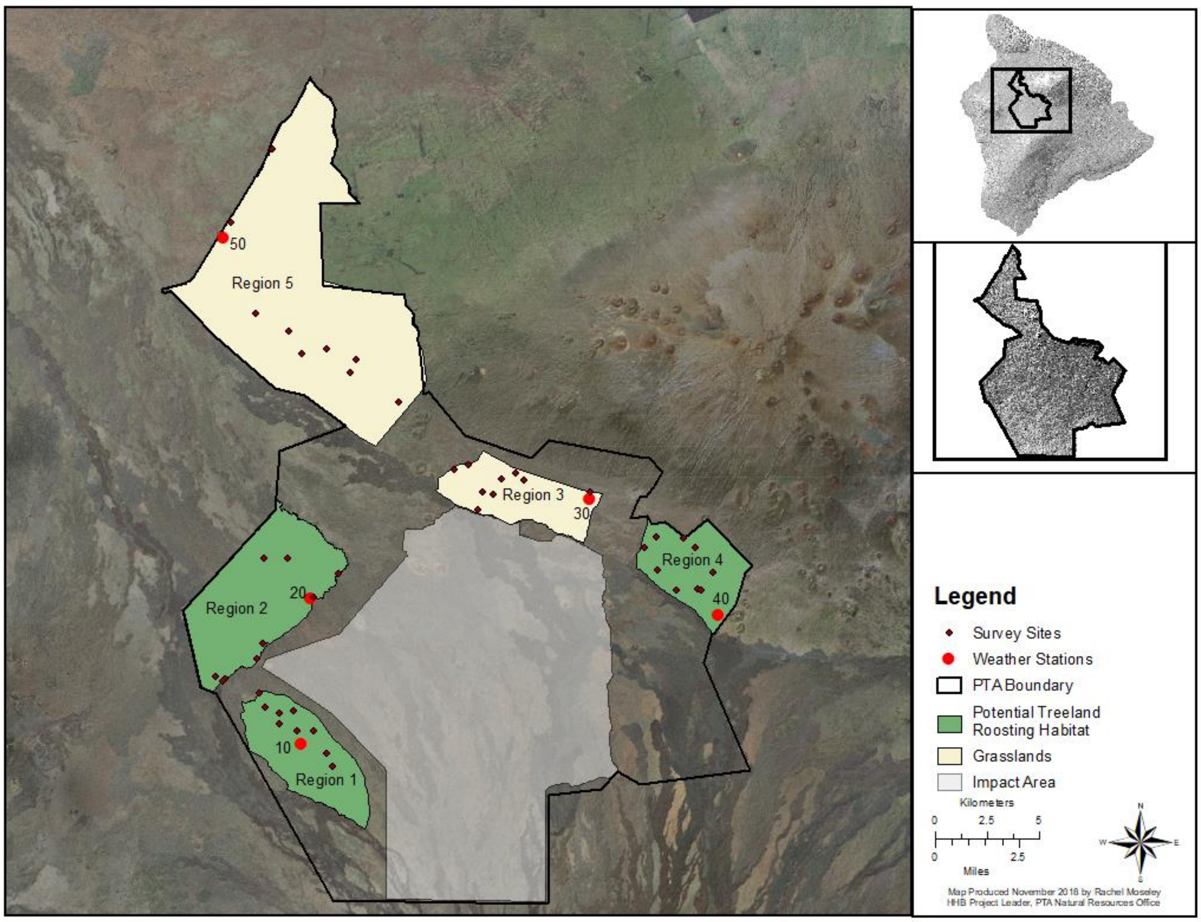

Figure 63. Survey sites and weather station locations for Hawaiian hoary bat monitoring at Pōhakuloa Training Area.

Seasonal sampling has biological significance outside of the traditional seasons in a year. The possibility of change in bat activity and occupancy between seasons can be driven by changing weather patterns or energetic requirements related to the bat's life cycle traits (Gorresen et al. 2013; Menard 2001). For this reason, quarterly sampling occurred as follows:

- Mid-June–August (lactation)
- September–December (mating/fledging)
- January–March (pre-pregnancy)
- April–mid-June (pregnancy)

Seasonal Activity Analysis

We accounted for temporal and spatial pseudoreplication using general linear mixed models (GLMMs) in lieu of the previous ANOVA analysis. The generalized linear model (GLM) describes the relationship between covariates and the conditional mean of a response variable and handles non-normal data by employing exponential distribution families (Bolker et al. 2009). The GLMM, however allows for the inclusion of both fixed effects and random effects—effects which model the cause of correlation by defining the structure of the variance/covariance matrix (Millar and Anderson 2004, Bolker et al. 2009). Mixed models allow for more than one source of variability. For example, there is most likely random variability across locations not captured by seasonal changes alone.

Due to overdispersion (a measure of variance in the response variable) we used a negative binomial distribution to model the counts of call minutes. Using a GLMM allowed us to avoid log-transforming the counts to fit a normal distribution imposed by standard tests such as ANOVA (O'Hara and Kotze 2010, Frick 2013).

Analyses were conducted in program R (R Core Team 2021) version 4.0.4 using the package glmmTMB (Brooks et al. 2017).

Seasonal Activity Results

The best model showed a significant effect of reproductive cycle on call minutes and included the random effects year, month, and location (Table 57). Activity means were highest during mating and fledging September–December, followed by lactation June–August, and finally by pre-pregnancy and pregnancy (January–mid-June) which were not different from each other (Table 58). Inclusion of the lagged predictor "lagMin" improved the model significantly.

Table 57. Set of ranked models for the generalized linear mixed model on bat call minutes[a].

Model	AICc	ΔAICc	Df	AICcWt
cycle + lagMin + (1|studyYr/month/loc)	44691.1	0	9	1
cycle + lagMin + (1|cycle/loc)	46689.9	1998.7	8	<0.001
cycle + (1|studyYr/loc)	47569.4	2878.2	7	<0.001
studyYr + (1|cycle/loc)	47574.4	2883.2	10	<0.001
cycle + (1|loc)	48363.2	3672.1	6	<0.001
null	53316.7	8625.6	2	<0.001

[a] Models were ranked based on the degrees of freedom (Df), bias corrected Akaike information criterion (AICc), the change in AICc from the top ranked model (ΔAICc), and the model weight (AICcWt) which represents the relative likelihood. Variables were included as nested random effects if listed inside parentheses, and as fixed effects otherwise. Data set is from July 2014 through August 2021.

Table 58. Mean number of bat call minutes for each reproductive cycle period from the top-ranked generalized linear mixed model[a].

Parameter	Estimate	SE	Lower CI	Upper CI
Lactation	0.58	0.12	0.35	0.81
Mating/Fledging	0.81	0.12	0.58	1.05
Pre-pregnancy	0.38	0.15	0.09	0.67
Pregnancy	0.24	0.14	-0.04	0.51
Sigma	0.97	*	0.93	1.02

[a] Estimates, standard error (SE), and lower and upper confidence intervals of the odds ratios are presented using a means parameterization of the model. Sigma is the estimated overdispersion parameter. Data set is from July 2014 through August 2021. *Values not calculated for sigma.

Pooled data of mean monthly bat call minutes showed a distinct peak in activity during August and September (between lactation and mating/fledging) and a dip in activity during March and April (between pre-pregnancy and pregnancy) (Figure 64). When we subset mean monthly bat call minutes by year, there was a similar pattern in activity levels.

Occupancy Study Design

To model bat occupancy seasonally and spatially we designed a multiple season occupancy study, based on MacKenzie et al. (2003). We collected data using this design from 2013 to 2017. Following the initial data analysis and a brief pause data in collection (2018), we implemented a modified approach in 2019 and 2020. Based on results from the activity study (Table 57), we limited data collection during the reproductive cycle with the highest activity (September to December) at PTA. We then modified the analytical approach for modeling to evaluate occupancy during this peak in activity over a 5-year period.

Occupancy (ψ) is defined as the probability that a randomly selected area of interest is occupied by a species (MacKenzie et al. 2006). MacKenzie et al. (2006) also demonstrated the importance of estimating the probability of detecting the species given it is truly present during sampling (*p*) because detection is often imperfect. For example, a species may be present but less detectable at a site due to weather conditions or habitat characteristics at the time of sampling. We designed the study to capture the most information possible about the underlying dynamics governing ψ and *p*.

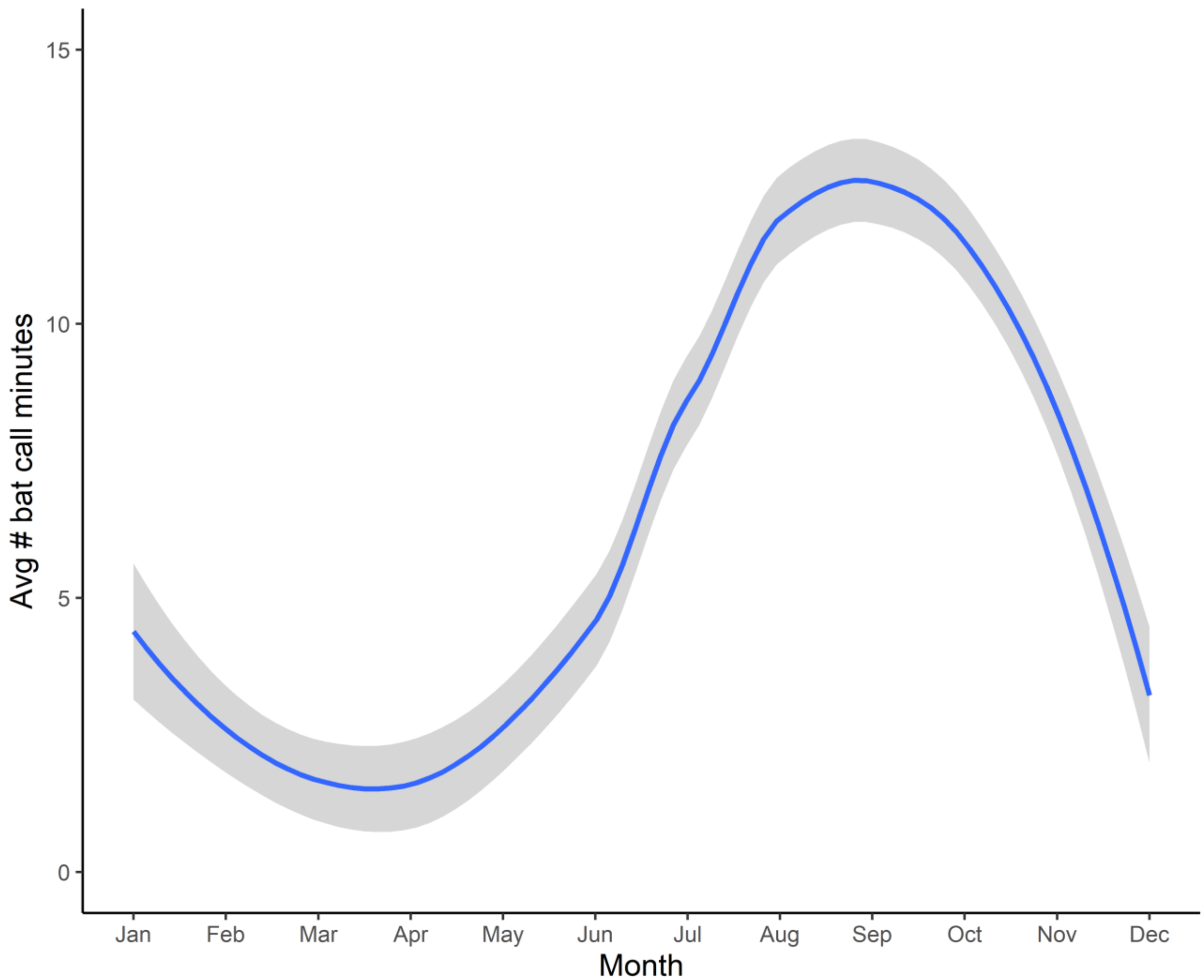

Figure 64. Mean nightly bat call minutes by month July 2014–August 2021[a].

[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.

We used a stratified random design and within each region established 9 sites to serve as spatial replicates (Figure 63). We deployed 1 detector at a site in each region for 7 consecutive nights and repeated sampling at the remaining ones until we sampled all 45 sites in a season. Each season we newly randomized site sampling order which generated 84 nights per site. This binary presence/absence data, also known as encounter history, was coded [1] if we detected bats or [0] if no detections occurred, for each night/site combination. The 7 observation nights serve as the secondary sampling period - a timeframe during which the dynamic model assumes there are no changes in occupancy at the site. The site is either occupied or not. Since sampling occurred during 12 distinct seasons, there were 12 primary sampling periods and 11 transitional stages during which the model assumes the occupancy of a site may change. In the model these transitions are represented by the parameters (γ) local colonization and (ε) local extinction, thus the term "dynamic" occupancy model. Parameter γ_{ti} represents the probability that a site *i* that is unoccupied at time *t* may become occupied during time *t* + 1, while parameter ε_{ti} represents the probability that a site that is occupied at time *t* may become occupied during time *t* + 1. Due to the highly mobile nature of the species, we will refer to colonization as “arrival” and extinction as “departure” as described in Gorresen et al. (2013). This is a better interpretation of how bats used sites across the study period.

We chose several site covariates to model occupancy spatially. The covariate “region” characterized the general vegetation class of a site while “tree habitat” was a binary covariate describing presence or absence of trees within a 100 m buffer of the site. Additionally, we used average nightly temperature and wind, and total rainfall values over the entire study period as measures of the overall quality or suitability of each region, and by extension, each site. In the absence of historical regional insect abundance data, the windiness of a region was used as a potential indicator of regional food availability (Gorresen et al. 2013).

Temporally variable sampling covariates temperature, wind, rainfall, and humidity were also evaluated nightly to model the likelihood of detecting bats. In general, we expected that detection probability would be negatively associated with humidity or rain. High-frequency sound attenuates faster in humid air than dry air which may decrease microphone detection (Griffin 1971). We used monthly temperature, wind, and rainfall values to help distinguish inter-seasonal effects on arrival or departure separate from the overall meteorological attributes of the site. Based on the literature we expected that there would be a consistent seasonal pattern in the probability of detecting the species at PTA, so we used both Julian date and cycle to model parameters as a function of time of year. We also converted Julian date to a sine function as described in Gorresen et al. (2013) to reduce the number of days from 365 to 1, thereby reducing the number of parameters and improving model performance.

<u>Occupancy Analysis Methods</u>

Occupancy Models for Seasonal and Spatial Occupancy – 2014 to 2017

We fit a dynamic occupancy model (MacKenzie et al. 2003) with program R (R Core Team 2019) version 3.5.1 and the package unmarked (version 0.12-2; Fiske and Chandler 2011). We used the colext function to fit the model and estimated all parameters using a logit link function. To facilitate model-fitting, we standardized all continuous covariates with a mean of zero and standard deviation of one. Prior to model-fitting, we performed a multicollinearity test to ensure covariates with strong correlations were not included in the same model.

We modeled all 4 parameters (ψ, *p,* γ, and ε) either as a function of covariates or as constant “(•)” across site or time intervals. The null model ψ(•) *p*(•) γ(•) ε(•) represented constants for all parameters and provided mean estimates for all sites across the study. We first developed a set of single-parameter models to assess covariate effects on each parameter from which we later built more complex models. In each model set we fit alternatives to the null model by varying the covariate on the parameter of interest while holding all other parameters constant. We then used Akaike’s information criterion (AIC) to assess the relative support for the candidate set of models, with lower

AIC scores indicating better-approximating models (Burnham and Anderson 2002). We used the R package AICcmodavg (version 2.1-1; Mazerolle 2020) to calculate biased-corrected AIC scores (AICc) values and assessed goodness of fit of the best-approximating model based on 1000 bootstrapped samples following MacKenzie and Bailey (2004). Overdispersion is a measurement of unmodeled heterogeneity and variance structure represented by the equation c-hat = X^2 /*df*. Values between 1 and 1.5 are generally acceptable.

To estimate the probability of detecting bats on at least one occasion we calculated the cumulative detection probability (p*) as $p^* = 1-(1-p)^N$, where p is the per-occasion detection probability and N is the number of replicate surveys (7 in this case). We used the back-transformed estimate of p using the inverse logit link function. We also derived projected and smoothed estimates of occupancy and standard errors for each season from the best-approximating model based on 1000 bootstrap samples using the "nonparboot" function in unmarked (Kéry and Chandler 2012). The projection method estimates latent occupancy rates for an entire hypothetical infinite population, from which the samples are taken (Weir et al. 2009). Conversely, smoothing limits inference to the proportion of the sites sampled and the estimates are more precise, particularly when visiting the same sample sites annually (Weir et al. 2009). We present both smoothed and projected estimates for comparison.

Finally, we developed a Bayesian version of the best-approximating dynamic occupancy model to calculate as derived parameters the number of sites occupied in each season (similar to those derived using the 'nonparboot' function), in addition to estimates of total number of occupied sites in each region x season combination. We implemented the Bayesian dynamic occupancy model using JAGS software (version 4.3.0; Plummer 2003) and the R package jagsUI (version 1.4.9; Kellner 2017). We used uninformative priors for all model parameters. We estimated all parameters from 50,000 Markov Chain Monte Carlo (MCMC) iterations using 3 chains, and the first 10,000 samples discarded as the burn-in period, yielding a total of 120,000 samples from which to calculate the posterior distributions.

Occupancy Modeling for Periods of Peak Activity – 2014-2017, 2019, and 2020

Based on model outputs from our original analysis, bat activity at PTA peaks during mating/fledging season (Table 57). We modeled presence/absence data gathered during the peak of activity (September-December) 2014-2017, 2019, and 2020. Because our original dataset showed that occupancy is high during this time of year and because none of the predictors helped explain occupancy, we did not include any predictors on occupancy in our models, and instead focused on maximizing the likelihood of the probability of detection. Similarly, we did not include predictors on local colonization or local extinction because previous results showed that none of the predictors were associated with bat movement in to or out of a particular region. For this dataset we retain the 2 parameters to describe the mean probabilities over the study period. We performed model comparisons based on Akaike Information Criterion (AIC) for preliminary detection-only models first to ensure weather predictors previously ruled out for lack of model fit were not associated with detection in this dataset. The final candidate set included predictors on detection probability associated with the region/vegetation classification and timing of the sample.

Occupancy Results

Occupancy Models for Seasonal and Spatial Occupancy – 2014 to 2017

Mean occupancy of the study was 8.48 on the logit scale, corresponding to an initial occupancy probability of ~1.0 meaning all sites were occupied. This was anticipated given bats were detected at all 45 sites in the first season of sampling (Table 60, null model). The preliminary occupancy model set showed that the constant model had the lowest AICc score and an AICc weight of 0.41, suggesting site attributes were not strongly associated with occupancy (Table 59). The model including mean average nightly temperature as a site attribute had a delta AIC value of less than 2 and AICc weight of 0.22, however, and may be weakly associated with occupancy because of the significant difference in means of the 5 regions. The projected seasonal estimates of occupancy are high ranging 0.84–0.99, whereas the smoothed estimates are more variable and range 0.69–0.99 (Figure 65). Projected values are generalized estimates of the hypothetical super-population, and smoothed values are those of the proportion of sites that were sampled each year.

Table 59. Preliminary single-parameter models ranked individually[a].

Occupancy Model Rankings				
ψ covariates	**K**	**AICc**	**ΔAICc**	**w**
null/constant	4	4039.40	0.00	0.41
ψ(mean annual temp)	5	4040.63	1.24	0.22
ψ(mean annual windspeed)	5	4041.76	2.37	0.13
ψ(treehab)	5	4041.91	2.51	0.12
ψ(mstudyr)	5	4041.94	2.54	0.12
ψ(region)	8	4050.41	11.01	0.00
Detection Model Rankings				
***p* covariates**	**K**	**AICc**	**ΔAICc**	**w**
p(cycle+region)	11	3856.80	0.00	0.99
p(cycle*region)	23	3865.48	8.68	0.01
p(region)	8	3923.45	66.65	0.00
p(mean annual temp)	5	3948.91	92.10	0.00
p(mean annual windspeed)	5	3960.39	103.59	0.00
p(treehab*cycle)	11	3968.46	111.66	0.00
p(treehab+cycle)	8	3972.53	115.72	0.00
p(mean annual rainfall)	5	3973.47	116.67	0.00
p(cycle)	7	3991.53	134.72	0.00
p(julian)	5	4003.62	146.82	0.00
p(windspeed)	5	4006.04	149.24	0.00
p(season)	5	4011.42	154.62	0.00
p(month)	15	4017.15	160.35	0.00
p(temp)	5	4023.15	166.35	0.00
p(treehab)	5	4024.20	167.40	0.00
p(jdate)	5	4032.50	175.70	0.00

Table 59. Preliminary single-parameter models ranked individually[a] (cont.).

Detection Model Rankings				
***p* covariates**	**K**	**AICc**	**ΔAICc**	**w**
null	4	4039.40	182.60	0.00
p(rain)	5	4039.44	182.64	0.00

Arrival/Departure Model Rankings				
γ and ε covariates	**K**	**AICc**	**ΔAICc**	**w**
γ(.)ε(region+cycle)	11	4230.39	0.00	1.00
γ(cycle+treehab)ε(cycle+treehab)	12	4249.01	18.62	0.00
γ(region+cycle)ε(region+cycle)	18	4252.64	22.25	0.00
γ(cycle)ε(cycle)	10	4253.04	22.65	0.00
γ(mean annual rainfall)ε(mean annual rainfall)	6	4258.76	28.37	0.00
γ(region)ε(region)	12	4265.23	34.84	0.00
γ(treehab)ε(treehab)	6	4266.66	36.27	0.00
γ(mStudyt)ε(mStudyt)	6	4266.80	36.41	0.00
γ(.)ε(mmStudyw)	5	4268.22	37.83	0.00
γ(mean annual windspeed)ε(mean annual windspeed)	6	4269.66	39.27	0.00
null (intercept only)	4	4272.14	41.75	0.00
γ(.)ε(mmStudyt)	5	4274.70	44.30	0.00
γ(monthly rainfall)ε(monthly rainfall)	6	4276.96	46.57	0.00
γ(monthly temp)ε(monthly temp)	6	4277.25	46.86	0.00
γ(region+cycle)ε(.)	11	4279.45	49.06	0.00
γ(region*cycle)ε(region*cycle)	42	6069.13	1838.74	0.00

[a] Column K represents number of model parameters. AICc lists Akaike's information criterion values for model ranking. Delta AICc is the relative difference in values from the best model with the smallest value and w represents the model weight. Rows ordered by best model/strongest weight from top to bottom.

Mean detection probability across all sites and seasons was -0.43 on the logit scale, corresponding to a probability of 0.39, where a p-hat (estimate of p) value of 1 means we detected bats on all nights (Table 60, null model). The preliminary detection model set showed that the additive effect of region and cycle had the lowest AICc score as well as an AICc weight of 0.99 indicating strong model certainty and suggesting that p was associated with the time of year effects and regional characteristics. All models incorporating region as a covariate maximized the likelihood better than either cycle or tree habitat in the candidate model sets, suggesting that regional site characteristics as described by vegetation composition provided a better fit to the data than did the proximity of trees (Table 59).

Arrival and departure models had no associations with meteorological covariates and were also only associated with cycle and region (Table 59). Mean colonization probability was 0.73 (logit scale) or 0.67, while mean extinction probability was -1.29 (logit scale) or 0.22, showing that bats were more likely to arrive at a previously un-occupied site than to depart from a previously occupied site (Table 60, null model).

Table 60. Estimates from null and best-approximating single parameter models[a].

Null model					
ψ(•)γ(•)ε(•)p(•)					
Parameter	**Estimate**	**SE**	**OR**	**Lower**	**Upper**
ψ(Int)	8.48	19.67	*	*	*
γ(Int)	0.73	0.23	*	*	*
ε(Int)	-1.29	0.14	*	*	*
p(Int)	-0.43	0.04	*	*	*

Best Detection model					
ψ(•)γ(•)ε(•)p(cycle+region)					
Parameter	**Estimate**	**SE**	**OR**	**Lower**	**Upper**
ψ(Int)	9.35	18.4	*	*	*
γ(Int)	1.12	0.42	*	*	*
ε (Int)	-1.8	0.21	*	*	*
p(Int)	-0.15	0.11	*	*	*
p(mate)	0.33	0.11	1.40	1.20	1.50
p(preg)	-0.61	0.13	0.54	0.38	0.71
p(prepreg)	-0.51	0.12	0.60	0.45	0.76
p(region2)	-0.76	0.14	0.47	0.30	0.63
p(region3)	-0.47	0.13	0.62	0.45	0.80
p(region4)	0.50	0.12	1.70	1.50	1.80
p(region5)	-0.94	0.14	0.39	0.23	0.55

Best Arrival/Departure model					
ψ(•)γ(•)ε(region+cycle)p(•)					
Parameter	**Estimate**	**SE**	**OR**	**Lower**	**Upper**
ψ(Int)	8.87	20.35	*	*	*
γ(Int)	0.76	0.235	*	*	*
ε(Int)	-3.7	0.63	*	*	*
ε(region2)	1.31	0.48	3.70	3.24	4.18
ε(region3)	1.37	0.48	3.90	3.47	4.39
ε(region4)	-1.00	0.69	0.37	-0.4	1.13
ε(region5)	1.34	0.49	3.80	3.33	4.27
ε(mate)	2.07	0.55	8.00	7.58	8.34
ε(preg)	1.46	0.65	4.30	3.7	4.9
ε(prepreg)	2.55	0.57	13.00	12.44	13.06
p(Int)	-0.43	0.04	*	*	*

[a] Intercept (null) model estimates for occupancy (ψ), local arrival (γ), local departure (ε), and probability of detection (p) for bats at all 45 sites during mating/fledging 2014–2017. Coefficients (on the logit scale), standard error, odds ratios (OR) and lower and upper confidence intervals of the odds ratios are presented. *Values not calculated for the intercept.

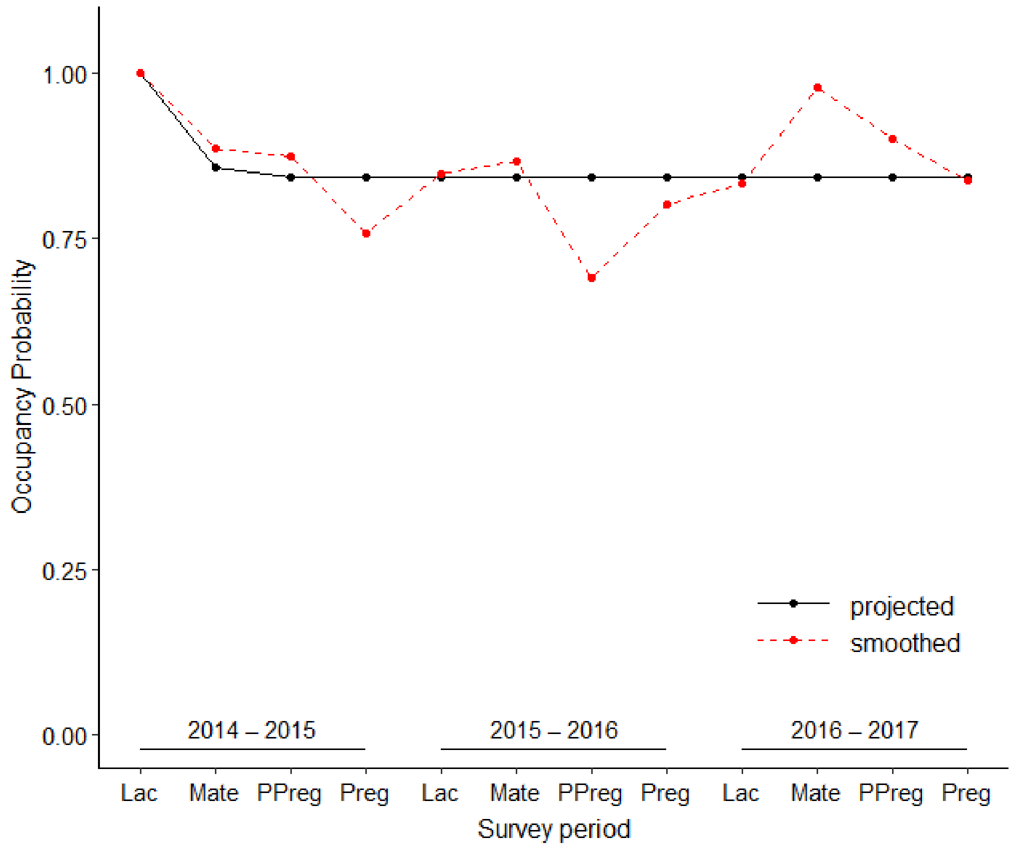

Figure 65. Smoothed and projected estimates of occupancy across the study (12 seasons) based on 1000 bootstraps[a].

[a] Derived estimates are based on 1000 bootstraps on the probability scale. An estimate of 1.0 means that all sites are occupied. Projected values are generalized estimates of the hypothetical super-population, and smoothed values are those of the proportion of sites that were sampled each season.

The best-approximating model overall was also the top-ranking p-only model ψ(•)γ(•)ε(•)*p*(cycle+region) with an AICc weight of 0.89. A goodness of fit test showed that the observed frequency in encounter histories was reasonable as described in Mackenzie and Bailey (2004). There was an acceptable amount of overdispersion in the global model (c-hat = 1.24). Cumulative detection probability, based on this model, was highest in region 4 (*Myoporum sandwicense* and *Sophora chrysophylla* woodland) during mating ($p^* = 0.99$) and lowest in region 5 (*Cenchrus clandestinus* grassland) during pregnancy ($p^* = 0.75$). Bayesian parameter estimates produced in JAGS were similar to those produced in unmarked and showed the same temporal patterns in detection probability and occupancy probability. Figure 66 shows that the derived number of sites occupied varied seasonally with higher numbers of sites during mating and lactation cycles and the lowest in pre-pregnancy and pregnancy cycles.

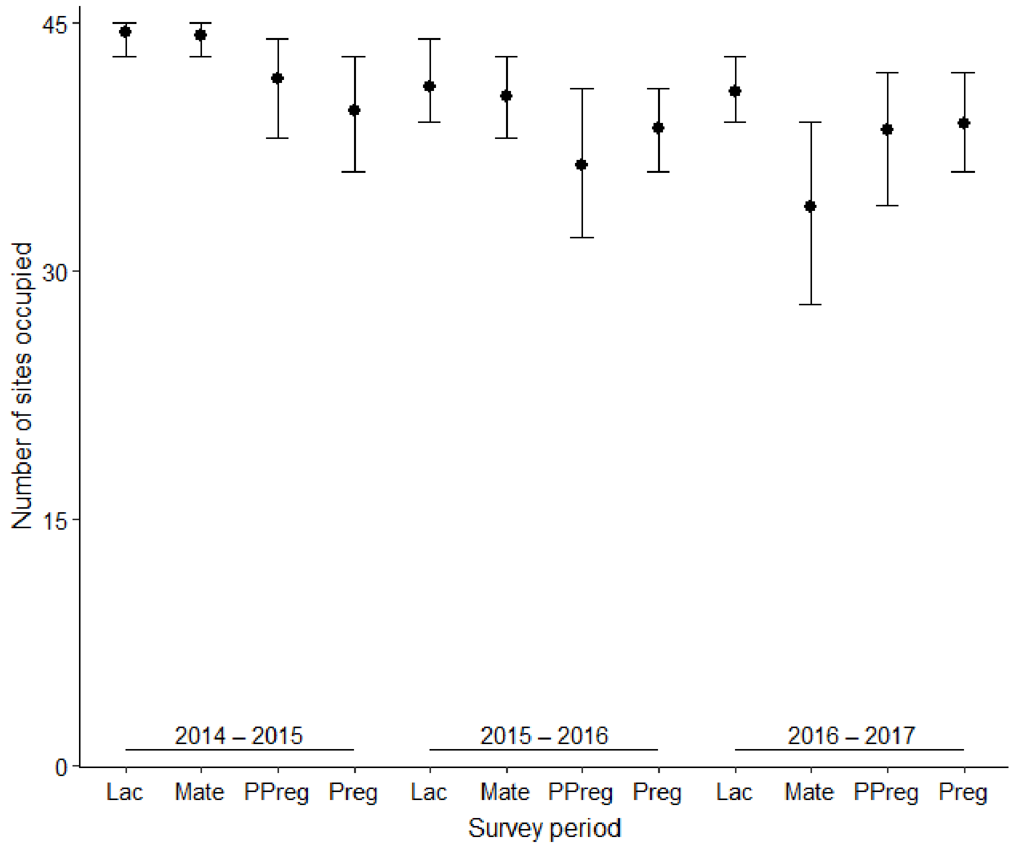

Figure 66. Number of sites occupied in each of the 12 seasons[a].

[a] Mean number of sites occupied by Hawaiian hoary bats during each of the 12 survey periods from 2014 to 2017. Error bars represent standard deviation. Derived estimates and 95% confidence intervals are based on the best-approximating model fit using a Bayesian framework (50,000 iterations of 3 chains with a burn-in period of 10,000 samples).

Occupancy Models for Periods of Peak Activity – 2014 to 2017, 2019, and 2020

The best-approximating model overall was $\psi(\bullet)\gamma(\bullet)\varepsilon(\bullet)p$(year+region) with an AICc weight of 0.52 (Table 61). Mean occupancy of the study was 1.93 on the logit scale, corresponding to an initial occupancy probability of 0.86, where a value of 1.0 indicates bats were present at all 45 sites (Table 62). There is some support for the model including julian date (jdate) as a predictor of detection probability because it has a delta AIC value of less than 2 and an AICc weight of 0.32.

Table 61. Final model set ranked individually[a].

Model	K	AICc	ΔAICc	w
ψ(.)γ(.)ε(.)p(year+region)	9	1935.02	0.00	0.52
ψ(.)γ(.)ε(.)p(jdate+region)	9	1936.00	0.99	0.32
ψ(.)γ(.)ε(.)p(year*month+region)	15	1937.49	2.47	0.15
ψ(.)γ(.)ε(.)p(month+region)	11	1942.79	7.77	0.01
ψ(.)γ(.)ε(.)p(year*region)	13	1948.14	13.13	0
ψ(.)γ(.)ε(.)p(year+treehab)	6	1998.44	63.43	0
ψ(.)γ(.)ε(.)p(.)	4	2000.08	65.06	0
ψ(.)γ(.)ε(.)p(jdate+treehab)	6	2001.71	66.70	0
ψ(.)γ(.)ε(.)p(month+treehab)	8	2007.13	72.11	0

[a] Models used to explain occupancy (ψ), local arrival (γ), local departure (ε), and probability of detection (p) for bats at all 45 sites during mating/fledging 2014–2017 and 2019-2020. Column K represents the number of model parameters. AICc lists Akaike's information criterion values adjusted for small sample size for model ranking. ΔAICc is the relative difference in values from the best model with the smallest value and w represents the model weight.

Table 62. Null model estimates[a].

Null model Parameter	Estimate	SE	OR	Lower	Upper
ψ(Intercept)	1.93	0.49	*	*	*
γ(Intercept)	1.34	0.78	*	*	*
ε(Intercept)	-3.03	0.42	*	*	*
p(Intercept)	0.04	0.06	*	*	*

[a] Intercept (null) model estimates for occupancy (ψ), local arrival (γ), local departure (ε), and probability of detection (p) for bats at all 45 sites during mating/fledging 2014–2017 and 2019-2020. Estimates (on the logit scale), standard error, odds ratios (OR) and lower and upper confidence intervals of the odds ratios are presented. *Values are not calculated for the intercept.

A goodness of fit test showed that the observed frequency in encounter histories was reasonable as described in Mackenzie and Bailey (2004). There was an acceptable amount of overdispersion in the global model (c-hat = 1.03). Both the projected and smoothed estimates of occupancy were high, ranging from 0.90-0.99 (Figure 67). Projected values are generalized estimates of the hypothetical super-population, and smoothed values are those of the proportion of sites that were sampled each year. Cumulative detection probability based on this model was lowest in region 5 (*Cenchrus clandestinus* grassland) during 2015 (p* = 0.54), and highest in region 4 (*Myoporum sandwicense* and *Sophora chrysophylla* woodland) during 2016 (p* = 0.99)(Table 63).

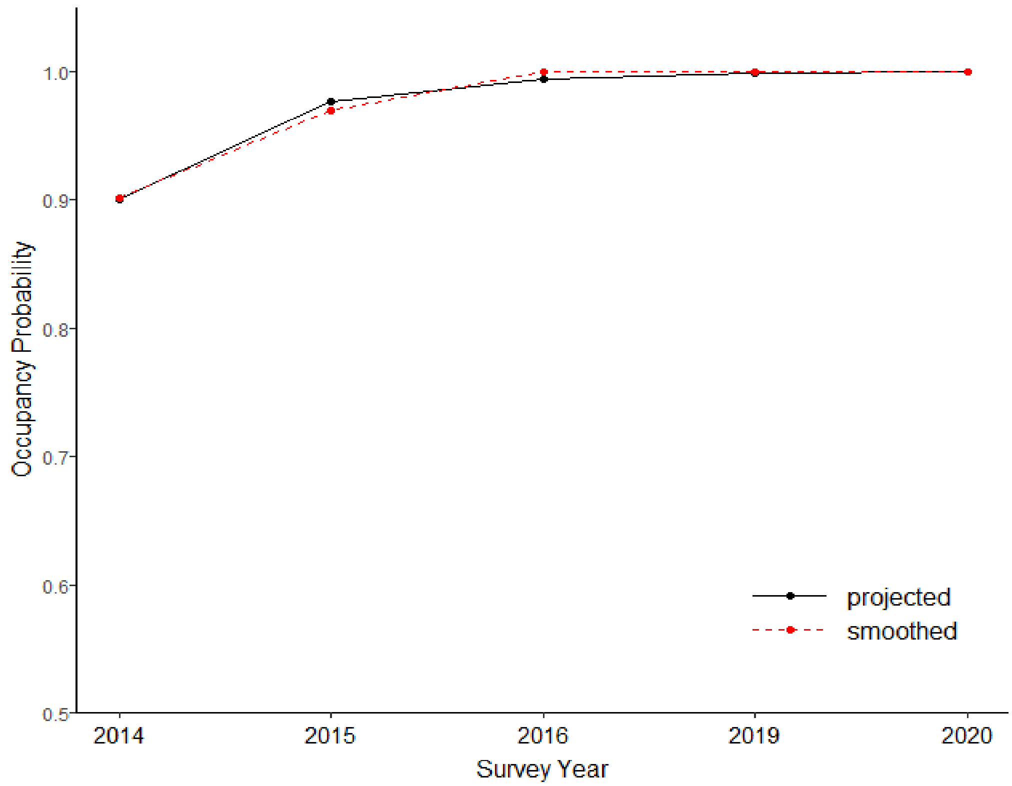

Figure 67. Smoothed and projected occupancy estimates during mating/fledging[a].

[a] Derived estimates are based on 1000 bootstraps on the probability scale. An estimate of 1.0 means that all sites are occupied in that survey year. Projected values are generalized estimates of the hypothetical super-population, and smoothed values are those of the proportion of sites that were sampled each year.

Table 63. Best-approximating occupancy model[a].

Parameter	Estimate	SE	OR	Lower	Upper
ψ(Intercept)	2.203	0.61	*	*	*
γ(Intercept)	1.213	1.23	*	*	*
ε(Intercept)	-8.818	16.47	*	*	*
p(Intercept)	0.163	0.19	*	*	*
p(2015)	-0.480	0.2	0.6185	0.358	0.88
p(2016)	1.055	0.19	2.87241	2.664	3.08
p(2019)	0.601	0.19	1.82379	1.587	2.06
p(2020)	0.175	0.19	1.19126	0.935	1.45
p(region2)	-0.808	0.18	0.44594	0.227	0.67
p(region3)	-0.561	0.18	0.57038	0.339	0.80
p(region4)	0.055	0.17	1.05620	0.815	1.30
p(region5)	-1.457	0.19	0.23295	0.061	0.40

[a] Estimates from the best-approximating model used to describe mean occupancy (ψ), local arrival (γ), local departure (ε), and probability of detection (p) for bats during mating/fledging 2014–2017 and 2019-2020. Estimates (on the logit scale), standard error, odds ratios (OR) and lower and upper confidence intervals of the odds ratios are presented. *Values are not calculated for the intercept.

Mean detection probability across all sites and seasons was 0.35 on the logit scale, corresponding to a probability of 0.52, where a value of 1.0 means we detected bats every night (Table 61). This is a 28% increase from the detection probability of the 3-year dataset which was 0.39. All models incorporating region as a covariate maximized the likelihood better than tree habitat (treehab) in the candidate model sets (Table 63). Mean colonization probability was 0.79, while mean extinction probability was 0.05, showing that on average, bats were 15 times more likely to arrive at a previously unoccupied site than to depart from a previously occupied site, across the study period.

Discussion for Hawaiian Hoary Bat Survey, Monitoring, and Management

Acoustic occupancy and activity analyses show that bats are present across the installation throughout the year and that activity peaks during the autumn months. Both analyses complement each other by emphasizing time of year effects on bat prevalence. 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. However, the substantial increase in bat activity between August and September, suggests that females are present from August to September with newly fledged young. 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 during summer months, they may be at higher risk from fire, military training or construction at PTA 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 be feeding, roosting, or traversing the installation in a way that may not be adequately modeled with the variables collected. The 2014–2021 activity dataset shows consistent peaks during September although there is interannual variability in the magnitude. Additionally, although previous studies on Hawaiʻi Island show that bats migrate to interior highlands (between 1000 and 3000 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 and 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 2000 and 3600 m (Bonacocorso 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.

The decision to focus occupancy sampling on the peak of activity has strengthened our assumptions of bat presence at PTA. For example, analysis of the 5-year mating/fledging season reflects an increase in the mean probability of detection to 0.52, up from 0.39 during the 3-year study. Similarly, the new analysis reflects an increase in the mean colonization probability to 0.79, up from 0.67 during the 3-year study. The initial occupancy estimate for the new dataset is slightly lower than that of the 3-year study because bats were not present at every site during the mating/fledging season in 2014, although they were present at all sites during the prior (initial) season (lactation) in 2014. Model comparisons still support the previous assumption that regional site characteristics as described by general vegetation composition provided a better fit to the data than did the proximity of trees.

Focusing sampling on the peak of activity also reduced the variability in the sample, which will increase the power to detect a decline in occupancy over time. Further analysis is required to determine the power to detect a specific trend in either direction (increasing or decreasing) over a given number of years. Western EcoSystems Technology (WEST) conducted a power simulation using pilot data collected June–December during the Gorresen et al. (2013) Hawaiʻi Island study. Based on the parameter estimates of the pilot data ($\psi = 0.66$, $\gamma = 0.64$, $\varepsilon = 0.069$, $p = 0.63$), their analysis evaluated the number of sites required to detect occupancy trends of various magnitudes and study duration (WEST 2015). For example, the simulation found that the power to detect a 40% decreasing trend over 10 years at 50 sites over 7 nights was 0.97. However, using the same number of samples to detect a 20% decreasing trend would take 20 years achieve a power of 0.82. Whereas a 40% decreasing trend over 5 years requires a sample size between 50 and 75 sites to achieve power between 0.72 and 0.86. 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). Though the 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. We note that 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.

Despite limitations of acoustic monitoring, results from this work will contribute to a better understanding of the natural history and ecology of the Hawaiian hoary bat, particularly in high elevation interior habitats on Hawaiʻi Island not previously studied. Results also provide a baseline estimation of occupancy with which to compare future estimates over the years. In FY 2022, 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. A *Hawaiian Hoary Bat Conservation Management Plan at PTA* has been drafted and 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.

Hawaiian Hoary Bat Management

We delivered 18 briefings 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 briefings as necessary when new employees were hired. In addition, we advised construction contractors and military units regarding tree removals or trimming during bat's birthing and pup rearing seasons (June 1 through September 15) to avoid impact. No trees greater than 5 m tall were trimmed or removed any year between June 1 and September 15. For trees shorter than 5 m, we inspected the trees for bats before approving any action. No bats were observed during the inspections during the reporting period.

Incidental Take

The Army must document and report any 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 entanglement 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 for incidental indirect take of bats as the amount of treeland habitat destroyed outside the Impact Area annually. The Army is authorized for take associated with the loss of no more than 48 ha per year of potential available treeland roosting habitat outside the Impact Area and cumulative losses of no more than 1,345 ha outside the Impact Area. Treeland loss primarily occurs from wildland fire, but other military actions, such as maneuvers, live-fire, and construction also influence losses.

No wildland fires occurred in FY 2020 and no additional treeland habitat was lost due to military actions, such as maneuvers, live-fire, and construction.

In FY 2021, 5 wildland fires occurred. The first wildland fire ignited in Training Area 16 on 15 July 2021. The second wildland fire ignited in KMA on 17 July 2021. The third wildland fire ignited off-PTA near Mana Road in the town of Waimea on 30 July 2021; on 31 July 2021, the fire jumped Old Saddle Road and burned onto KMA. The fourth and fifth fires ignited along the Daniel K. Inouye Highway near the 48-mile marker on 11 August 2021 and 13 August 2021, respectively. Combined, the fires burned approximately 1,925 ha, of which 15 ha are considered potential treeland roosting habitat. The fires resulted in indirect incidental take of Hawaiian hoary bats, consuming approximately 31% of the allowable 48 ha per year. No bat carcasses were reported in the burned areas and impacts to the Hawaiian hoary bat 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 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 likely 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:

1) The geographic extent of the BSTP colony to better analyze potential effects to the birds from military activities.
2) The behavior of adults and chicks to minimize effects or risks to the birds where feasible.
3) BSTP life history to add information to the scientific community.
4) The impact of predators to BSTP to minimize depredation.

In May 2020, the Army completed an informal consultation with USFWS for predator control within the Band-rumped Storm Petrel 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 is not likely to adversely affect the Band-rumped Storm Petrel (USFWS 2020a).

In December 2020, the Army received the amended recovery permit (TE40123A-3) to authorize the management actives described in the PTA *Band-rumped Storm Petrel* (*Hydrobates castro*) *Management Plan*, which was submitted to the USFWS with the amendment request (CEMML 2020c). Two additional permits are required to manage BSTP at PTA. The USFWS Migratory Birds Program, issued USAG-P a Scientific Collection Permit (Number MB95880B-0, 1) to authorize salvage, transport, and possession of BSTP, which is a species 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-P a Protected Wildlife Permit (Number WL19-42) to authorize salvage, transport, and collect up to 25 BSTP specimens per year. To comply with reporting requirements for permit WL19-42, in January 2021, we submitted to DOFAW a technical report, *"2020 Breeding Season Report for the Band-rump Storm Petrel at Pōhakuloa Training Area, Hawaii Island, Hawaiʻi, Protected Wildlife Permit WL 1-42"* (CEMML 2021a).

In September 2021, we designated the area around the BSTP colony as an Area of Species Recovery (ASR) and assigned the administrative number 501 (ASR 501). To better understand the extent of the BSTP colony, breeding phenology and pertinent behavioral characteristics, we survey for potential BSTP nests with a search dog and monitor potential nests via video surveillance. We also control predators within and around the colony.

In this biennial report, we summarize major highlights from the 2020 and 2021 BSTP breeding seasons. Because the BSTP chicks fledge between October and November, we report fledging events that occurred between October and November in 2019 and 2020. Any fledging that occurs between October and November 2021 will be reported in subsequent fiscal year reports.

In addition, the Army is in the process of 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.

<u>Determining the Geographic Extent of the Known Colony</u>

Burrow Surveys with Search Dog Methods

Due to the cryptic burrowing habits of BSTP, we used a trained search dog ("Makalani") and his handler to detect petrel burrows. Makalani was chosen because of his ability to work at high elevations, his demonstrated ability to leave the target species unharmed, his lineage of working bird dogs, and his previous success at detecting BSTP specimens and potential burrows at PTA.

An Astro Garmin 320 GPS device was used to record Makalani's search track. The Astro GPS device consists of 2 components: a hand-held GPS device (Garmin Astro 320) and a dog collar GPS device (Astro T-5). GPS points and photos were taken when any bird specimen or potential burrow spot was found. A spot was deemed a "potential burrow" (PB) when Makalani demonstrated behavior indicating the presence of a target ("pointing"). A spot was deemed an area of "significant interest" when Makalani showed keen interest in the area but could not pinpoint a specific spot to point on. When an area is deemed a potential burrow, we also conducted an intensive search around the burrow and checked for other openings within a 50 m buffer to ensure the safe deployment of predator traps. Each location deemed to be an active or potential burrow is marked with a unique identification tag (aluminum tags with engraved numbering) and its location recorded with a GPS device.

Burrow Survey with Search Dog Results

We conducted a total of 3 searches with Makalani, 3 August 2020, 23 August 2021, and 20 September 2021. Each search lasted about 6.5 hours. A total of approximately 34 linear km was surveyed by Makalani, 12 km in FY 2020 and 22 km in FY 2021 (Figure 68). In FY 2020, we revisited 21 locations and Makalani only showed interest at N01, N05, and PB706 (Table 64). In FY 2021, we revisited 17 locations and Makalani only showed interest at N01, N05, and PB19 (Table 64). We did not find any BSTP carcasses or feathers during any of the 3 searches.

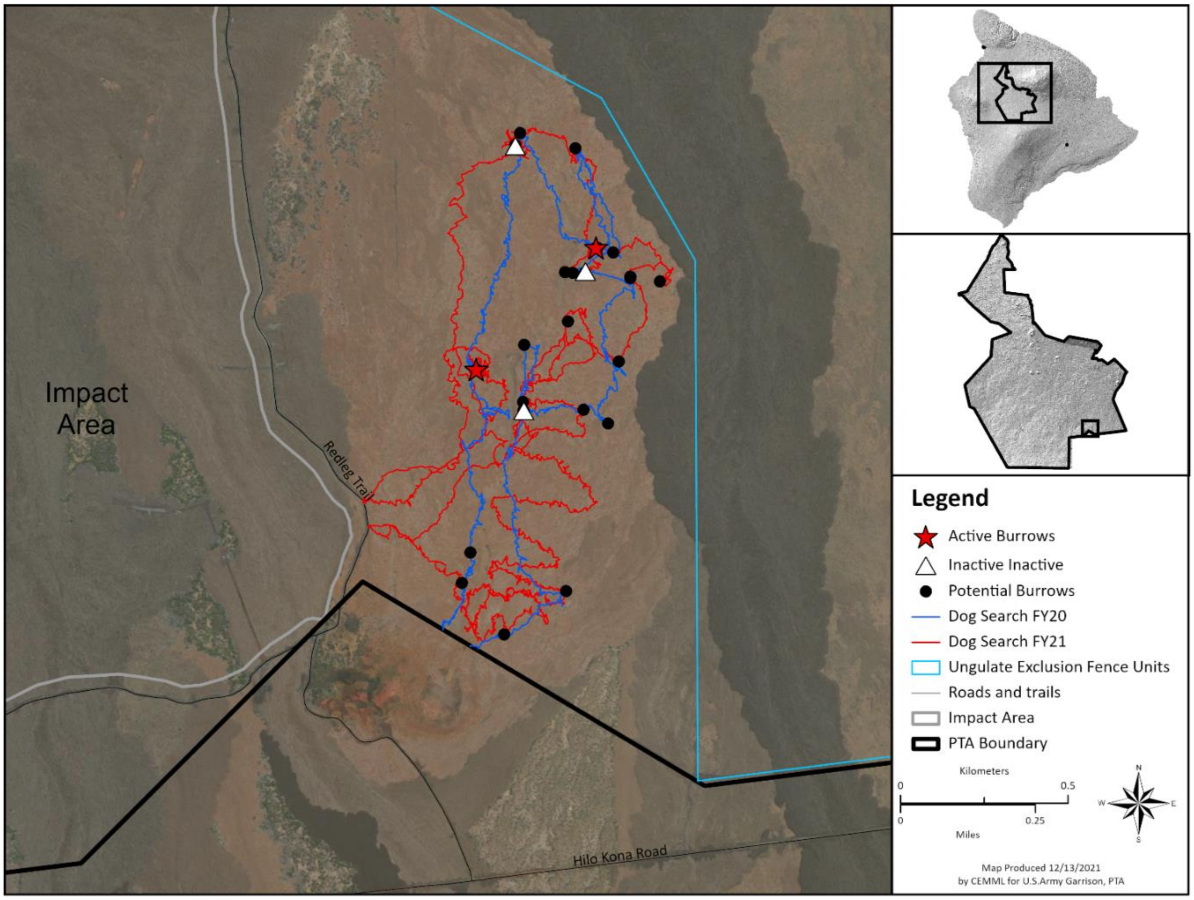

Figure 68. Dog search tracks (34 km) for Band-rumped Storm Petrel nests in FY 2020–FY 2021 in Training Area 21 at Pōhakuloa Training Area[a].

[a] White triangles show previously active burrows where the detector dog showed no interest. Red stars show active burrows confirmed by the by detector dog and camera traps independently.

Characterizing BSTP Behavior

Burrow Monitoring Methods

The BSTP breeding biology in Hawaiʻi is not well known, but individuals are assumed to nest in burrows or natural cavities at high-elevation, inland habitats. BSTP calls have been previously recorded in late May at PTA (Galase 2019). The species is highly faithful to burrow sites, typically returning to the same site each year.

Each year after conducting burrow surveys with a search dog, any location where the dog showed interested that was deemed an active or potential burrow was monitored with a video surveillance camera (Reconyx XP-9 ultrafire professional covert camera traps™). All the cameras were mounted on a camera bracket and secured on the ground or on top of nearby rocks. Each camera was positioned at least 2 m away from the burrow entrance, with the camera pointed directly at the burrow's opening. Each camera was set to take a photograph and a video when triggered by motion and simultaneously to take a photograph every 30 seconds (i.e., time-lapse) during periods of high BSTP activity (8:00 pm–10:00 pm and 3:00 am–5:00 am, 480 photographs per time-lapse per period). Before arming a camera, a "walk test" was performed to ensure that the camera would take a picture or video when something moved in front of the burrow's opening.

Table 64. Dog search survey scent detection and video surveillance results for FY 2020 and FY 2021.

Active or Potential Burrow ID	Dog Search Year	Scent Detected[a] (Yes/No)	Burrow Monitored with Video Surveillance (Yes/No)
N01	FY 2020	Yes	Yes
	FY 2021	Yes	Yes
N02	FY 2020	No	No
	FY 2021	No	No
N03	FY 2020	No	No
	FY 2021	No	No
PB706	FY 2020	Yes	Yes
	FY 2021	No	No
N04	FY 2020	No	No
	FY 2021	No	No
N05	FY 2020	Yes	Yes
	FY 2021	Yes	Yes
PB19	FY 2021	Yes	Yes

[a] Band-rumped Storm Petrel scent or potential scent detected by search dog.

We used 32 GB SD cards to record photographs and videos. Cards were switched out each visit, approximately every 2 weeks, and lithium batteries were replaced as needed to ensure continuous coverage over the season. The photographs and videos were reviewed in the office to assess BSTP activity and presence/absence of predators at the burrows. BSTP activities around the burrows were categorized into 4 behaviors. "Inside the burrow" was defined as still images or videos of BSTP within the interior of burrow based on distinct markers of the burrow's features. "Outside the burrow" was defined as activity or images of BSTP outside of the burrow. "Entering the burrow" was defined as a series of images or video of BSTP entering the burrow from outside. "Exiting the burrow" was defined as a series of images or video of BSTP movements from the interior of the burrow toward the edge or outside of the burrow.

At the end of each breeding season each burrow was assigned a final status:

- Active Burrow
    - Active breeding – individuals regularly enter the burrow for more than a month.
        - Successful: evidence of a chick fledging, to include when a chick or down feathers are observed outside the burrow and no depredation is observed.
        - Failed: no chick or down was observed, or depredation was detected.
    - Prospecting – if individuals visit the burrow for a short period of time but no activity is detected in the last 2 months of breeding.

- Inactive Burrow – a previously active burrow with no activity in the current breeding season.
- Potential Burrow – a burrow identified by the detector dog with possible bird activity, but no observed BSTP activity detected by the camera traps.

Videos and photos were processed with Timelapse Image Analyzer (Greenberg Consulting Inc. 2021) and the files were organized by the collection date or by the burrow site. We developed a custom data entry interface for Timelapse Image Analyzer Template to document the following: personnel performing the analysis, quality of the imagery, presence of BSTP, presence of rodent species, BSTP behavior, and notes. This information regarding imagery analysis is exported from Image Analyzer and saved as .csv files accessible via Excel.

Burrow Monitoring Results

In 2020, we deployed cameras at 9 burrows from May through November and detected BSTP activity at 2 burrows (Table 65). We detected adults at N01 and N05, but we did not detect a chick or fledging event at either burrow. However, in November 2020, we found 1 down feather outside the burrow of N05 indicating a chick may have fledged. No BSTP depredation was detected; however, multiple black rats and mice were seen entering and exiting the burrow.

During the 2021 BSTP breeding season, we deployed cameras at 6 burrows from May through November. For this reporting period we detected only adult BSTP activity at 2 burrows (Table 65). In previous years most of the BSTP chicks were detected at the burrows between October and November. If detect BSTP chicks are detected the results will be reported in subsequent reports.

Burrow N01

In FY 2019, we placed a camera at N01 on 2 May and observed an adult entering the burrow on 6 June. An adult last visited on 26 June 2019. We did not detect depredation, a chick, or a fledgling at the burrow. No other activity was detected at the burrow after 26 June 2019, and the fate of the adult is inconclusive.

In FY 2020, we placed a camera at N01 on 4 May and observed the first adult entering the burrow on 8 June. The last BSTP adult visit was detected 9 October 2020. Between May and October 2020, the camera recorded for approximately 211 days and a total of 111,301 photographs and 683 videos were recorded. On video, an adult BSTP engaged in 1 of 4 behavior categories during 78 detections: inside the burrow 37 times, outside the burrow 10 times, entering 10 times, and exiting 21 times (Table 66). During the 211 days of burrow monitoring, no depredation of a BSTP adult, egg or chick was detected; however, we did detect black rats on 16 days, and mice on 2 days at the burrow.

Table 65. Band-rumped Storm Petrel active and potential burrow monitoring results via video surveillance in FY 2020–2021.

Burrow ID	Surveillance (Year)	Burrow Status	Adult Detected (Yes/No)	Chick Detected (Yes/No)	Fledging Detected (Yes/No)	Depredation Detected (Yes/No)
N01	2019	Active	Yes	No	No	No
	2020	Active	Yes	No	No	No
	2021	Active	Yes	Unknown[a]	Unknown[a]	No
N02	2019	Inactive	No	No	No	No
	2020	Inactive	No	No	No	No
	2021	Inactive	No	No	No	No
N03	2019	Inactive	No	No	No	No
	2020	Inactive	No	No	No	No
	2021	Inactive	No	No	No	No
N04	2019	Inactive	Yes	No	No	No
	2020	Inactive	No	No	No	No
	2021	Inactive	No	No	No	No
N05	2019	Active	Yes	Yes	Yes	No
	2020	Active	Yes	No	No[a]	No
	2021	Active	Yes	Unknown[b]	Unknown[b]	No
PB03	2019	Inactive	No	No	No	No
	2020[c]	-	-	-	-	-
	2021[c]	-	-	-	-	-
PB601	2019	Inactive	No	No	No	No
	2020[c]	-	-	-	-	-
	2021[c]	-	-	-	-	-
PB702	2019	Inactive	No	No	No	No
	2020[c]	-	-	-	-	-
	2021[c]	-	-	-	-	-
PB706	2020	Inactive	No	No	No	No
	2021[c]	-	-	-	-	-
PB900	2019	Inactive	No	No	No	No
	2020	Inactive	No	No	No	No
	2021[c]	-	-	-	-	-
PB901	2019	Inactive	No	No	No	No
	2020	Inactive	No	No	No	No
	2021[c]	-	-	-	-	-
PB902	2019	Inactive	No	No	No	No
	2020	Inactive	No	No	No	No
	2021[c]	-	-	-	-	-
PB19	2021	Inactive	No	No	No	No

[a] No BSTP chick was detected by the surveillance camera, but 1 down feather was found to possibly suggest a fledge event.

[b] Band-rump Storm Petrel chick did not emerge from the burrow by 30 September 2021.

[c] No video surveillance camera was deployed at the burrow (dog showed no interest to the burrow during the burrow search).

In FY 2021, we placed a camera at N01 on 20 May and observed the first adult entering the burrow on 12 June. Between May–September2021, the camera recorded for approximately 133 days and 10 of those days BSTP were detected. On video, an adult BSTP engaged in 1 of 4 behavior categories during 146 detections: inside the burrow 65 times, outside the burrow 31 times, entering 4 times, and exiting 46 times (Table 66). During the 133 days of burrow monitoring black rats were detected on 15 days, and mice on 7 days at the burrow.

Table 66. Number of Adult Band-rumped Storm Petrel behaviors detected at each active burrow in FY 2020–2021.

	Band-rumped Storm Petrel Behaviors at the Burrow			
Burrow ID	Inside	Outside	Entering	Exiting
N01[a]	102	41	14	67
N02	0	0	0	0
N03	0	0	0	0
N04	0	0	0	0
N05[b]	12	18	0	33

[a] BSTP adult was detected 10 days within the 133-day monitoring period.
[b] BSTP adult was detected 14 days within the 133-day monitoring period.

Burrow N02

In FY 2019, we placed a camera at N02 on 2 May and no activity was detected during the breeding season. This burrow was categorized as inactive.

In FY 2020, we placed a camera at N02 on 5 May and no BSTP activity was detected during the breeding season; the burrow was categorized as inactive. During the 210 days of burrow monitoring black rats were detected on 7 days and a mouse was detected on 2 days at the burrow. A total of 93,564 photographs and 95 videos were recorded.

In FY 2021, we placed a camera at N02 on 20 May and no BSTP activity was detected; the burrow was categorized as inactive. During the 133 days of burrow monitoring black rats were detected on 2 days and no mice were detected at the burrow.

Burrow N03

In FY 2019, we placed a camera at N03 on 2 May and no activity was detected during the breeding season. This burrow was categorized as inactive.

In FY 2020, we placed a camera at N03 on 4 May and no BSTP activity was detected during this breeding season; the burrow was categorized as inactive. During the 211 days of burrow monitoring black rats were detected on 1 day and mice were detected on 3 days at the burrow. A total of 79,069 photographs and 69 videos were recorded.

In FY 2021, we placed a camera at N03 on 20 May and no BSTP activity was detected; the burrow was categorized as inactive. During the 133 days of burrow monitoring black rats were detected on 2 days and mice were detected on 3 days at the burrow.

Burrow N04

In FY 2019, we placed a camera at N04 on 2 May and observed the first adult entering the burrow on 9 June. The last adult visit was detected on 3 September 2019. We did not detect depredation, a chick, or a fledgling at the burrow. No other activity was detected at the burrow after 3 September 2019, and the fate of the adult is inconclusive.

In FY 2020, we placed a camera on N04 on 4 May and no BSTP activity was detected during this breeding season; the burrow was categorized as inactive. During the 211 days of burrow monitoring black rats were detected on 9 days and a mouse was detected on 1 day at the burrow. A total of 92,546 photographs and 47 videos were recorded.

FY 2021, we placed a camera on N04 on 20 May and no BSTP activity was detected; the burrow was categorized as inactive. During the 133 days of burrow monitoring black rats were detected on 2 days and mice were detected on 7 days at the burrow.

Burrow N05

In FY 2020, we placed a camera at N05 on 4 May and observed the first adult entering the burrow on 27 May. The last adult visit was detected on 25 October 2020. On video, an adult BSTP engaged in 1 of 4 behavior categories during 22 detections: inside the burrow 1 time and exiting 21 times (Table 66). No chick was detected on camera; however, we observed a down feather outside the burrow on 02 November 2020. The timing of finding the down is consistent with known periods of BSTP fledging and the down's presence suggests that a chick was present and may have fledged.

In FY 2021, we placed a camera at N05 on 20 May and observed the first adult entering the burrow on 28 May. Between May–September 2021, the camera recorded for approximately 133 days and 14 of those days BSTP were detected. On Video, an adult BSTP engaged in 1 of 4 behavior categories during 41 detections: inside the burrow 11 times, outside the burrow 18 times, and exiting 12 times (Table 66). During the 133 days of burrow monitoring black rats were detected for 4 days, and no mice were detected at the burrow.

PB03

In FY 2019, we placed a camera on PB03 on 20 June and no activity was detected during this breeding season. This burrow was categorized as inactive.

PB601

In FY 2019, we placed a camera on PB601 on 6 June and no activity was detected during this breeding season. This burrow was categorized as inactive.

PB702

In FY 2019, we placed a camera on PB702 on 20 June and no activity was detected during this breeding season. This burrow was categorized as inactive.

PB706

This burrow was categorized as inactive.

In FY 2020, we placed a camera on PB706 on 11 August and no activity was detected during this breeding season; the burrow was categorized as inactive. During the 113 days of burrow monitoring a black rat was detected on 6 days and no mice were detected at the burrow. A total of 27,682 photographs and 16 videos were recorded.

In FY 2021, Makalani did not detect any BSTP activity in the burrow, therefore it was not monitored; the burrow was categorized as inactive.

PB900

In FY 2019, we placed a camera at PB900 on 28 August and no activity was detected during the breeding season. This burrow was categorized as inactive.

In FY 2020, we placed a camera on PB900 on 4 May and no activity was detected during this breeding season; the burrow was categorized as inactive. During the 211 days of burrow monitoring a black rat was detected on 4 days and a mouse was detected on 1 day at the burrow. A total of 62,085 photographs and 26 videos were recorded.

In FY 2021, Makalani did not detect any BSTP activity in the burrow, therefore it was not monitored; the burrow was categorized as inactive.

PB901

In FY 2019, we placed a camera at PB901 on 29 August and no activity was detected during the breeding season. This burrow was categorized as inactive.

In FY 2020, we placed a camera on PB901 on 4 May and no activity was detected during this breeding season; the burrow was categorized as inactive. During the 211 days of burrow monitoring a black rat was detected on 4 days and a mouse was detected on 1 day at the burrow. A total of 74,335 photographs and 838 videos were recorded. This camera took many videos because of multiple grass clumps growing in and at the front of the burrow.

In FY 2021, Makalani did not detect any BSTP activity in the burrow, therefore it was not monitored; the burrow was categorized as inactive.

PB902

In FY 2019, we placed a camera at PB902 on 14 August and no activity was detected during the breeding season. This burrow was categorized as inactive.

In FY 2020, we placed a camera on PB902 on 5 May and no activity was detected during this breeding season; the burrow was categorized as inactive. During the 210 days of burrow monitoring a black rat was detected on 1 day and a mouse was detected on 3 days at the burrow. A total of 73,028 photographs and 33 videos were recorded.

In FY 2021, Makalani did not detect any BSTP activity in the burrow, therefore it was not monitored; the burrow was categorized as inactive.

PB19

In FY 2021, we placed a camera on PB19 on 20 September. We will assign a category at the end of the breeding season. No BSTP or rodent activity has been detected at the burrow by the end of September. The burrow was categorized as inactive.

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 69). A combination of live and lethal traps was used to remove small mammals.

Live Trapping

We deployed up to 40 Tomahawk® (30"x10"x12") live traps within the BSTP colony (ASR 501) in TA 21 (Figure 69). Live traps were spaced 200 m apart, and they were monitored daily using SkyHawk® (PICA Production Development), an electronic cellular connectivity device that alerts the user when a trap has been triggered (trap door closes, or trap vibrates). These trap sensors are a new tool and eliminated the need to physically check traps every 24 hours (Animal Care Use Committee requirement). All the live traps were baited with a single can of sardines (Beach Cliff Sardines in soybean oil) with scent holes punctured in the top and the traps were rebaited every month. All live traps with Skyhawks sensors are set/open 7 days a week.

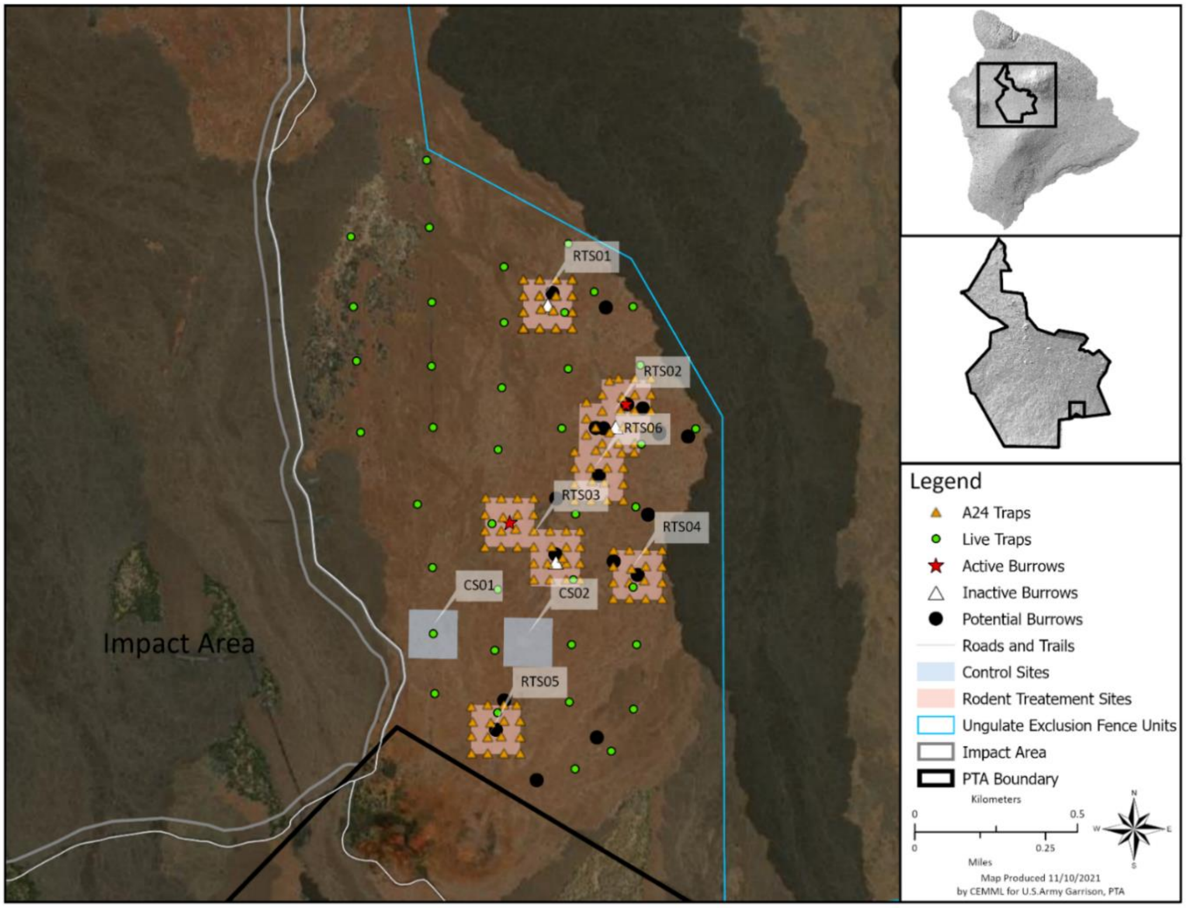

Figure 69. Predator trap layout in the Band-rumped Storm Petrel colony in Training Area 21 at Pōhakuloa Training Area[a].

[a] Goodnature® A24 traps (orange triangles) were spaced about 50 m in a grid within the rodent treatment sites. Live traps (green dots) were spaced 200 m apart.

Lethal Trapping

To protect nesting BSTP from rodents, in May 2020 we established 5 rodent treatment sites (RTS) that encompassed all potential, inactive, and active burrows (Figure 69). 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 three months, the Goodnature® chocolate formula bait lure and each 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 taps 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.

Between May 2020 and September 2021, we monitored 106 A24 traps within 5 RTS. After discovering PB19 in September 2021, we established a new RTS (RTS06) around the potential burrow. Only 13 A24 traps were deployed due to terrain considerations, bringing the combined total of A24 traps in all RTS to 119.

In addition, 7 surveillance cameras (Browning Dark Ops HD Pro®) were deployed to monitor 7 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 (*Branta sandvicensis)*, the Hawaiian Short-eared Owl (*Asio flammeus sandwichensis)*, and the ʻŌmaʻo (*Myadestes obscurus*). In addition, the Barn Owl (*Tyto alba*), a documented BSTP predator, also occurs in TA 21.

Live and Lethal Trapping Results

In FY 2020, (April–September 2020), we deployed 40 live traps and removed 4 predators (Table 67). In FY 2021, (October 2020–September 2021), we deployed 40 live traps and removed 9 predators (Table 67). In FY 2021, 2 Chukars (*Alectoris chukar)* non-native game birds were also captured in the live traps and subsequently released unharmed. No native or endangered animals were captured in the live traps.

Table 67. Predators captured in live traps around the petrel breeding colony site (ASR 501) at Pōhakuloa Training Area in FY 2020–FY 2021.

Breeding Season	Traps Deployed	Total Captures	Cats	Mongoose	Rats
FY 2020[a]	40	4	3	0	1
FY 2021[b]	40	9	8	0	1

ASR, Area of Species Recovery
[a] Live trapping occurred April–September 2020.
[b] Live trapping occurred October 2020–September 2021.

In FY 2020, we found and removed 63 rodent carcasses (25 black rats and 38 mice) from the A24 traps and snap traps (Table 68). In FY 2021, we found and removed 132 rodent carcasses (47 black rats and 85 mice) from the A24 traps and snap traps (Table 68). 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 birds (BSTP, Hawaiian Goose, Hawaiian Short-eared owl, ʻŌmaʻo) were detected at the 7 monitored A24 traps. In addition, no Barn Owls were detected at the A24 traps. The cameras detected 3 other birds: Chukar (*Alectoris chukar,* non-native, game bird), Skylark (*Alauda arvensis,* non-native), and Pacific Golden Plover (*Pluvialis fulva,* indigenous). However, the birds in the photographs did not appear to interact with the trap. We detected 2 instances of a feral cat scavenging a rat carcass from an A24 trap. A feral cat was captured within 24 hours near the A24 trap where one of the scavenging events occurred.

Table 68. Total number of A24 traps and snap traps deployed and the total number of rodents collected and removed from each rodent treatment sites at ASR 501 in FY 2020[a]–FY2021.

Rodent Treatment Site	A24 Traps		Snap Traps		Black Rats Removed		Mice Removed	
	FY 2020	FY 2021	FY 2020	FY 2021	FY 2020	FY 2021	FY 2020	FY 2021
RTS01	16	16	2	2	8	11	2	22
RTS02	27	27	8	12	3	2	11	13
RTS03	31	31	8	10	6	7	13	24
RTS04	16	16	2	2	4	10	6	17
RTS05	16	16	2	2	4	17	6	9
RTS06	0	13	0	2	0	0	0	0
Total	**106**	**119**	**22**	**30**	**25**	**47**	**38**	**85**

[a] FY 2020 lethal trapping occurred June 2020 –September 2020.

Tracking Tunnels

We used tracking tunnels to monitor changes in rodent activity in response to trap deployment, because tracking tunnels present an index of 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. Following trapping, we deployed 152 tracking tunnels at the same sites quarterly between August 2020 and November 2021 (Figure 70). In November, we added 16 tracking tunnels to RTS06.

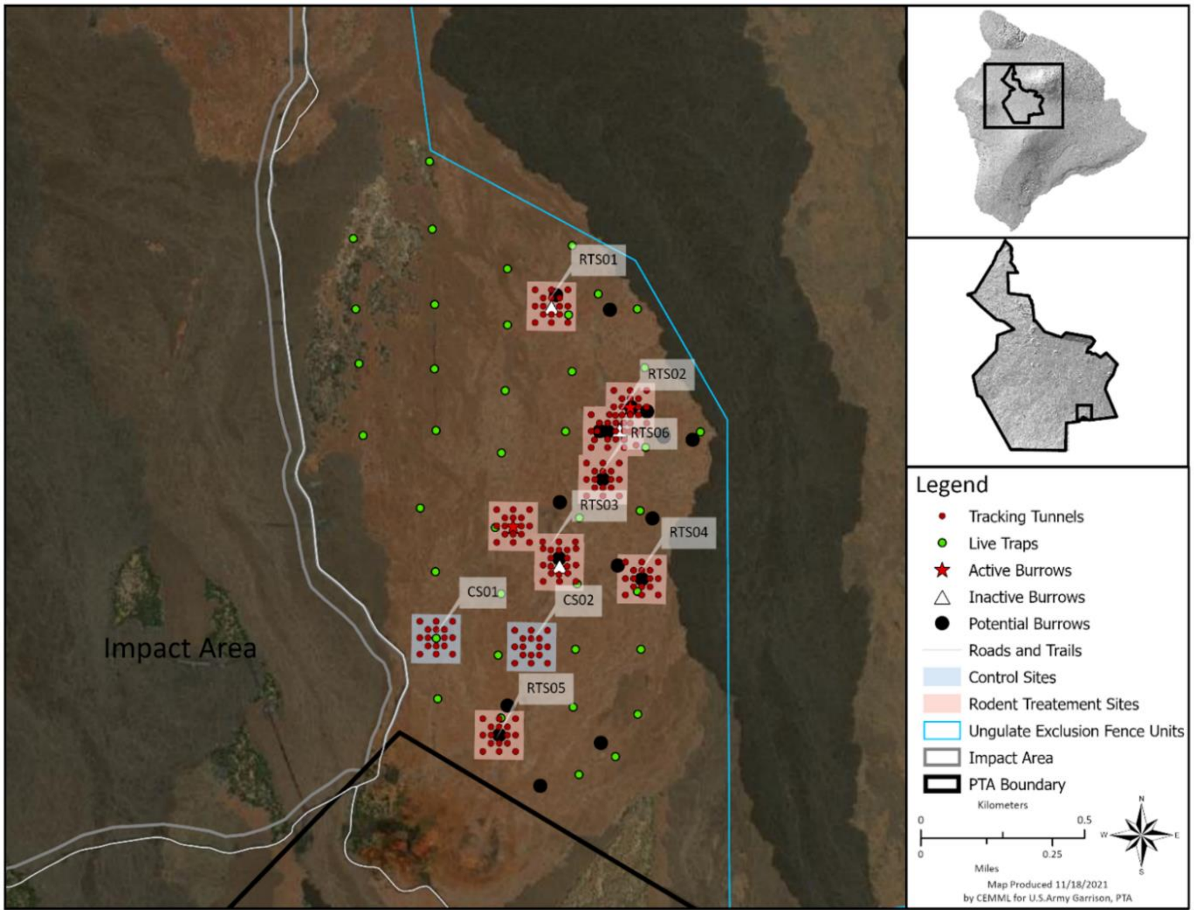

Figure 70. Tracking tunnel layout around the Band-rumped Storm petrel colony in Training Area 21 at Pōhakuloa Training Area[a].

[a] Tracking tunnel locations (red dots) spaced approximately 25 m apart within each rodent treatment and control site.

Tracking Tunnel Results

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 0-11%). 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 69. Tracking tunnel results, which indicate rodent activity in the rodent treatment sites and control site in ASR 501 from May 2020 to August 2021.

Site ID	Species	May 2020[a]	Aug 2020	Nov 2020	Feb 2021	May 2021	Aug 2021
CS01	Black Rat	**38%**	6%	88%	50%	0%	0%
	Mouse	**50%**	0%	25%	0%	38%	0%
CS02	Black Rat	**44%**	0%	0%	6%	0%	0%
	Mouse	**6%**	63%	6%	0%	0%	13%
RTS01	Black Rat	**31%**	0%	0%	0%	0%	0%
	Mouse	**69%**	69%	31%	81%	63%	81%
RTS02	Black Rat	**17%**	8%	0%	0%	0%	0%
	Mouse	**6%**	25%	11%	8%	53%	0%
RTS03	Black Rat	**44%**	0%	19%	0%	0%	0%
	Mouse	**36%**	17%	50%	33%	58%	78%
RTS04	Black Rat	**44%**	0%	38%	0%	0%	0%
	Mouse	**44%**	69%	19%	81%	63%	94%
RTS05	Black Rat	**69%**	0%	56%	0%	0%	0%
	Mouse	**25%**	75%	0%	19%	0%	6%
RTS06[b]	Black Rat	-	-	-	-	-	-
	Mouse	-	-	-	-	-	-

CS, Control Site (no rodent trapping), RT, Rodent Treatment Site (rodent trapping).

[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 (RTS). Data reported to the right of the vertical solid line are post-rodent trapping in the RTS.

[b] Trapping began in September 2021 followed by tracking tunnel deployment in November.

Discussion Seabirds

Since the first BSTP active burrow (N01) was discovered in 2015, we have successfully confirmed 4 more active burrows (N02, N03, N04, and N05). In FY 2020 and FY 2021 we detected only adult BSTP in N01 and N05. We hope the adjusted camera settings - increased time-lapse frequency and recoding time duration - and additional cameras will detect a chick in FY 2022.

Improvements for monitoring the BSTP burrows were made in FY 2021. In 2020, the camera detected 1 single event where an adult BSTP was inside burrow N05 and 21 times an adult was also detected exiting the burrow. But the camera never detected an adult outside the burrow or entering the burrow. This led us to believe that there might be another burrow entrance at N05. Therefore, in FY 2021, we placed an additional camera at another burrow entrances near the initial burrow entrance approximately 1 m away. With this adjustment we were able to detect an adult BSTP inside the burrow 11 times and an adult outside the burrow 18 times. But we still did not detect an adult entering the burrow. In FY 2022, we need to investigate why we are having low BSTP detections at N05 and how we can increase detection rates.

Trapping for predators year-round has increased feral cat captures throughout the year and 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. And, 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 RTS likely contributed to low black rat activity levels. Since February 2021, black rat activity ranged from 0% to 11% at 5 RTS (Table 69). Based on information from other rodent control efforts in Hawaiʻi, keeping black rat activity below 20% likely confers a positive conservation benefit to a 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. Therefore, keeping the black rat activity below 20% will likely benefit BSTP nest success.

Patterns in mouse activity at the RTS were variable but appeared to increase when rat activity was lower. Other biological studies have documented the influence of rat activity on mouse activity (Brown et al. 1996, RCUH 1998). Another study found that after rats were removed from an area, the mouse population increased due to competitive release (Ruscoe et al. 2011). Moreover, when rats have been removed from a system, mice can have similar negative effects on nesting sea birds (Angel et al. 2009). Therefore, monitoring the mouse population within the colony is critical as we continue to remove rats. If mouse activity remains high, we may consider spacing traps per recommendations for controlling mice (12.5–25 m). At PTA we have documented a decline in mouse activity when changing the spacing of A24 traps from 50 m to 25 m in ASR 41 for the endangered plant *Schiedea hawaiiensis*.

Tracking tunnel data from the CS showed that rat and mouse activity naturally varied over time. We do not know what drives the natural activity cycles for these species, but these fluctuations likely influence the activity patterns within the RTS. For example, the black rat activity was 0% on both CS grids from May through November 2021, suggesting that rat activity was low across the region regardless of trapping effort. Therefore, the low black rat activity observed on all the RTS for the same period cannot be attributed solely to our trapping efforts. However, through a combination of natural activity cycles and our trapping efforts, black rat activity generally decreased, and mouse activity was variable, in all RTS from May 2020 (pre-trapping) to November 2021.

In 2022, we plan to continue trapping year-round and expand the RTS with additional A24 traps as needed. In addition, we will be collaborating with the SkyHawk® company to improve on the sensor notifications and increase the sensors' cellular connectivity. These improvements for managing predators will continue to help minimize the number of predators in and near the colony and help reduce depredation pressure on the birds.

Collecting pertinent information regarding BSTP breeding at the colony remains challenging. Finding and confirming new active nests has been time consuming and we still do not know the extent of the area that BSTP use for breeding at PTA. With only 5 active nests documented within the past 5 years, knowledge of breeding activity and behavior remains rudimentary.

In addition to breeding activity, BSTP call activity from previous years suggests that many non-breeding birds 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 there is a substantial non-breeding component to the colony. However, we have even less information about the non-breeding component of the colony at PTA. Because of the challenges in monitoring unmarked populations, we are exploring acoustic monitoring options coupled with new developments in occupancy modeling to evaluate changes in call activity over time. Additional acoustic information will also help bolster knowledge of seasonal and nightly colony attendance patterns of non-breeders.

We recommend continuing to investigate the colony extent, colony attendance patterns, non-breeding behaviors, and breeding activity to accurately assess potential effects from military activities on the birds. We recommend updating the INRMP to address conservation activities for this species and to reduce the need to designate critical habitat on the installation for this species.

4.2.6 Avian Monitoring

We monitor birds annually and this project addresses SOO task 3.2(2), INRMP objectives, conservation measures from the 2003 BO, and obligations under the MBTA to monitor protected birds. We have annually monitored birds at PTA since 1998.

Our sampling design is based on variable circular-plot and distance sampling methods (Reynolds et al. 1980), which can be used to obtain relatively unbiased, regional information on bird abundance, and to track changes in population trends through time. Point-transect sampling enables us to monitor a wide range of bird species, each of which possesses a different singing style, and each of which may occur in a variety of acoustically different habitats (BCRIB 1999).

For most situations, distance sampling is the best method currently available for determining abundance and monitoring trends for land birds. Without a measure of the detection probability, counts of birds are an unreliable measure of differences in the actual number of birds present (Burnham 1981; Barker and Sauer 1995; Nelson and Fancy 1999). For distance sampling, we assign an exact distance measurement to each bird detected. Recording distance to each detected bird enables us to derive a species-specific density estimate adjusted by a species' detection probability (Ralph et al. 1995), allowing us to estimate the number of individuals missed. Thus, to obtain relatively unbiased long-term trend data the sampling design incorporates distance measures.

In addition, we can apply several qualitative (e.g., number of birds detected per station) and quantitative analytical methods to investigate changes in species composition and density of native and non-native birds relative to management actions (i.e., alien plant and animal control) including BACI (before-after-control-impact) analyses to investigate changes in bird composition and density due to changes in vegetation or other habitat characteristics.

Methods

Fifteen monitoring transects ranging between 2 to 3.5 km in length cover 3 study areas: TA 1–4 (4 transects), TA 22 (4 transects), and TA 23 (7 transects). Between 14 and 24 monitoring stations are spaced every 150 m along each transect (Figure 71). Transect and station spacing was selected to minimize the likelihood of counting the same bird at 2 or more stations and was adapted from methods used to monitor for Palila on Mauna Kea (Scott et al. 1984). We monitor each station for 6 minutes between 0630 and 1100 during selected days between December and 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.

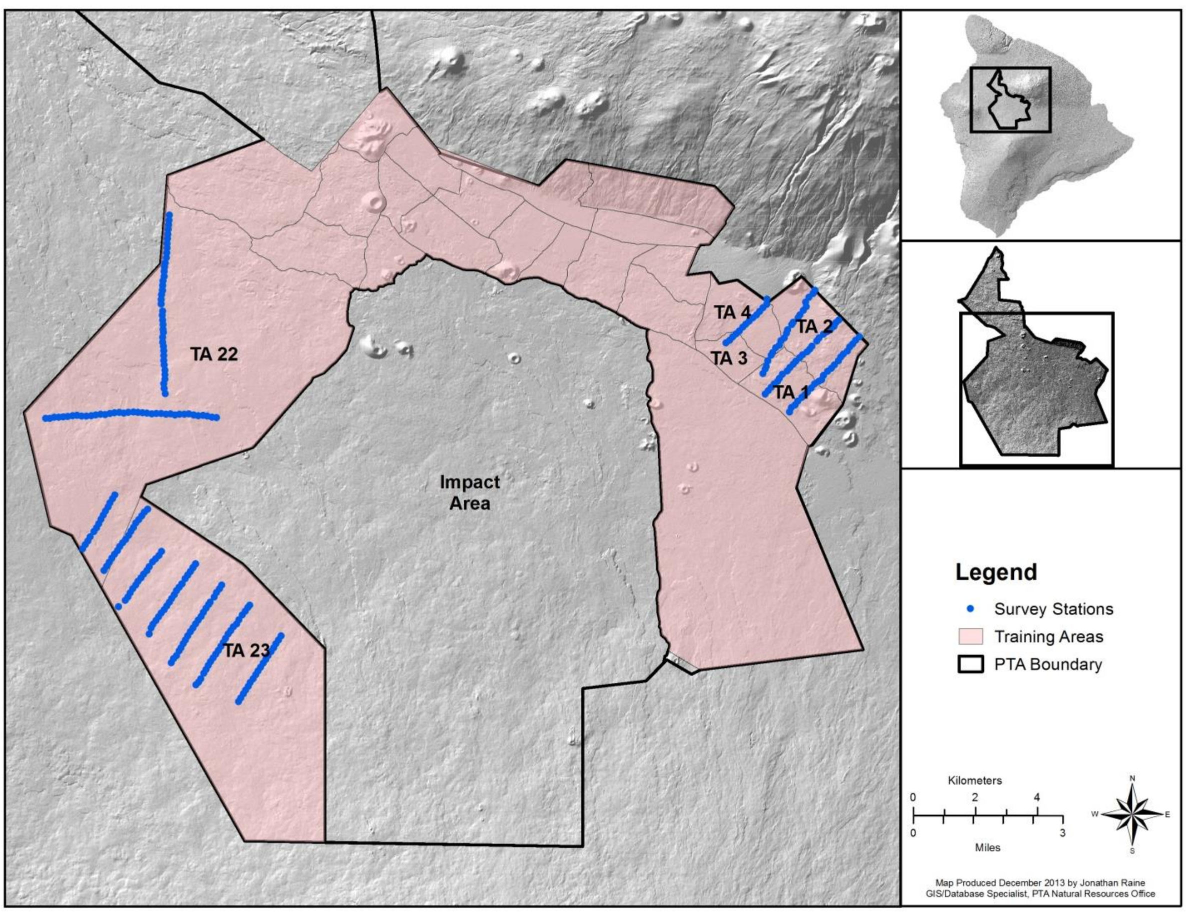

Figure 71. Avian monitoring transects at Pōhakuloa Training Area.

Detection frequency (mean number of bird calls detected per station) is estimated by taking the ratio of the total number of bird detections, by species, to the total number of monitoring stations.

Results

Birds detected in FY 2020 and FY 2021 are summarized in Table 70. Of the 26 birds detected, 3 were native species, 15 were non-native non-game species, 7 were non-native game species, and 1 is indigenous (Pacific Golden Plover). Eight species detected (native and non-native) are protected under the MBTA. Similar to previous years, Hawaiian Amakihi (*Hemignathus virens*) was the most frequently detected bird per station. We also frequently detected Japanese White-eye (*Zosterops japonicas*), House Finch (*Haemorhous mexicanus*), Yellow Fronted Canary (*Serinus mozambicus*), and Erckel's Francolin (*Pternistis erckelii*).

We did not detect the endangered Palila (*Loxioides bailleui*).

Discussion Avian Monitoring

Annual bird surveys address SOO task 3.2(2), several INRMP stewardship objectives that pertain to monitoring species protected under the MBTA, and 2003 BO conservation measures to monitor Palila.

We did not detect Palila, but we did detect 8 native and non-native bird species protected under the MTBA (Table 70). Since 1998, Hawaiian Amakihi, Japanese White-eye, House Finch, and Yellow Fronted Canary are often the most frequently detected species as reported in previous annual and biennial reports.

In FY 2022, we plan to issue a technical report analyzing the bird monitoring dataset from 1998 through 2021. We plan to model the data set using the DISTANCE framework to estimate population densities and abundances. We will investigate data trends and assess the feasibility of additional analyses, such as BACI, to investigate changes in bird community composition and population densities following significant management actions (e.g., ungulate removal) or catastrophic events (e.g., wildland fire).

Avian monitoring provides baseline information for ‘Amakihi and ‘Apapane, species the Department of Defense (DoD) has designated as “mission-sensitive priority bird species”[12]. Monitoring baseline and assessing population trends for these species can help us understand whether ecosystem management actions, such as fencing and ungulate removal and fire risk reduction, affect populations for these 2 species at PTA. We plan to use the pending data and trend analysis to develop management plans for these species per INRMP objectives and in accordance with the DoD Natural Resource Program’s *Strategic Plan for Bird Conservation and Management on Department of Defense Lands* (DoD Partners in Flight, 2014).

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[12] Mission-sensitive priority bird species are bird species that occur on DoD lands and are at risk of becoming listed as threatened or endangered under the federal Endangered Species Act if current populations trends continue (Department of Defense Partners in Flight, 2015)

Table 70. Avian monitoring species counts and bird per station mean results for FY 2020 and FY 2021.

Common Name	Species	FY 2020		FY 2021	
		Species counted	Mean birds/ station	Species counted	Mean birds/ station
African Silverbill[c]	*Lonchura cantans*	170	0.59	98	0.34
ʻApapane[ab]	*Himatione sanguinea*	31	0.11	30	0.10
Barn Owl[ac]	*Tyto alba*	1	0	0	0
Black Francolin[d]	*Francolinus*	82	0.29	23	0.08
California Quail[d]	*Callipepla californica*	31	0.11	7	0.02
Chinese Hwamei[c]	*Garrulax canorus*	0	0	3	0.01
Chukar[d]	*Alectoris chukar*	5	0.02	4	0.01
Common Myna[c]	*Acridotheres tristis*	4	0.01	4	0.01
Erckel's Francolin[d]	*Pternistis erckelii*	380	1.33	150	0.52
Hawaiian ʻAmakihi[ab]	*Chlorodrepanis virens*	1319	4.61	1039	3.63
Hawaiian Short-eared Owl[ab]	*Asio flammeus*	0	0	6	0.02
House Finch[ac]	*Haemorhous mexicanus*	320	1.12	128	0.45
Japanese Bush-Warbler[c]	*Cettia diphone*	23	0.08	0	0
Japanese Quail[d]	*Coturnix japonica*	1	0	0	0
Japanese White-eye[c]	*Zosterops japonicus*	662	2.31	694	2.43
Kalij Pheasant[d]	*Lophura leucomelanos*	0	0	3	0.01
Lavender Waxbill[c]	*Estrilda caerulescens*	3	0.01	0	0
Northern Cardinal[ac]	*Cardinalis*	12	0.04	8	0.03
Northern Mockingbird[ac]	*Mimus polyglottos*	109	0.38	73	0.26
Nutmeg Mannikin[c]	*Lonchura punctulata*	1	0	0	0
Pacific Golden Plover[a]	*Pluvialis fulva*	11	0.04	12	0.04
Red-billed Leiothrix[c]	*Leiothrix lutea*	1	0	1	0
Saffron Finch[c]	*Sicalis flaveola*	1	0	8	0.03
Sky Lark[ac]	*Alauda arvensis*	134	0.47	81	0.28
Wild Turkey[d]	*Meleagris gallopavo*	11	0.04	0	0
Yellow Fronted Canary[c]	*Serinus mozambicus*	258	0.90	225	0.79

[a] Migratory Bird Treaty Act listed species
[b] Native species
[c] Non-native, non-game species
[d] Non-native, game species

In addition, distance sampling techniques are not well-suited for 2 other mission-sensitive bird species that occur at PTA: Pacific Golden Plover (*Pluvialis fulva*) and Hawaiian Short-eared Owl (*Asio flammeus sandwichensis*). Another mission-sensitive species, the Hawaiian Thrush (ʻŌmaʻo, *Myadestes* *obscurus*), is known to occupy sub-alpine habitats on the installation that are not currently included in our annual monitoring.

Avian monitoring addresses several compliance issues simultaneously. Understanding population trends for mission-sensitive species can aid in developing population change thresholds to trigger management actions that may help to minimize population declines and may help avert the potential listing of these bird species as threatened or endangered. Managing for species before they become listed under the ESA benefits the Army because it is likely to be more cost effective and can help to reduce or prevent constraints on mission activities.

MBTA Incidental Take

Incidental take of migratory birds was not reported or observed at PTA during the reporting period.

4.2.7 Anthricinan Yellow-Faced Bee

We implemented projects for the anthricinan yellow-faced bee under 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 from military activities to the bee and its habitat.

Actions to Survey and Monitor Anthricinan Yellow-Faced Bee

A single anthricinan yellow-faced bee was collected at PTA in 2004, possibly a vagrant (USFWS 2013b, USFWS 2015). We do not know the precise location of the collection, but the bee was found resting in a fruit capsule of the endangered plant, *Kadua coriacea*, which typically occurs in open *Metrosideros* treeland, a generally poor habitat for *Hylaeus* (Magnacca and King 2013). The anthricinan yellow-faced bee is typically a coastal species. While other typically coastal species occur at PTA, namely *Hylaeus flavipes* and *Hylaeus ombrias*, no additional anthricinan yellow-faced bees have been found, and a permanent breeding population at the installation is questionable (Magnacca and King 2013).

From 25–28 June 2018, a *Hylaeus* specialist, Dr. Karl Magnacca, surveyed for *Hylaeus* spp. at the installation. He did not detect the anthricinan yellow-faced bee and we are uncertain if this species is present at PTA. However, this and past survey efforts have documented at least 10 *Hylaeus* species at the installation.

For this reporting period we did not conduct any *Hylaeus* surveys, but we did control for invasive ants in ASR 40 for the protection of *Solanum incompletum*.

Discussion for Anthricinan Yellow-Faced Bee management

For FY 2022, we are preparing information about this species for a formal consultation under section 7 of the ESA. In addition are planning to conduct future *Hylaeus* surveys to help us prepare a Biological

Assessment that describes the status of the bee at PTA and evaluates the potential effects from military activities to the bee and its habitat.

4.2.8 Blackburn's Sphinx Month

We implemented projects for Blackburn's sphinx moth (BSM, *Manduca blackburni*) under 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 from military activities to the species and its habitat. In FY 2021, we trained our staff to recognize and report BSM.

Actions to Survey and Monitor Blackburn's Sphinx Month at PTA

The BSM is one of the largest native insects in Hawaiʻi. The moth is currently known to occur in Maui, Kahoʻolawe and Hawaiʻi Island. We first documented 6 BSM caterpillar (5th instar) on 1 July 2019 and 1 caterpillar (5th instar) 3 July 2019 on a tree tobacco (*Nicotiana glauca*) at KMA.

In FY 2020, 2 additional BSM incidental sighting reports were recorded at PTA; 2 caterpillars (5th instar) were found on *S. incompletum* at ASR 24 on 4 November 2019 and 2 caterpillars (5th instar) were found on *S. incompletum* at ASR 24 on 6 November 2019 (Table 71) (Figure 72). For more information regarding the incidental sightings please refer to Appendix D.

No incidental reports of BSM larvae were reported in FY 2021.

Table 71. Blackburn's Sphinx Moth incidental sightings at Pōhakuloa Training Area.

Observation Date	Location	Host Plant	Number of BSM caterpillars
7/1/2019	Ke'āmuku Maneuver Area	*Nicotiana glauca*	6
7/3/2019	Ke'āmuku Maneuver Area	*Nicotiana glauca*	1
11/4/2019	Training Area 22 (ASR 24)	*Solanum incompletum*	2
11/6/2019	Training Area 22 (ASR 24)	*Solanum incompletum*	2

Discussion for Blackburn's Sphinx Month Management at PTA

Since 2019, we have discovered BSM caterpillars 4 times at PTA. Two sightings occurred in KMA on *N. glauca* and 2 occurred in TA 22 on *S. incompletum* in ASR 24. In the past, we documented BSM along the Daniel K. Inouye Highway through KMA, but we did not detect BSM within PTA until July 2019. The 2 BSM sightings in TA 22 (ASR 24) were unexpected since there are few *N. glauca* plants in the area, and we did not think there was sufficient density of *S. incompletum* plants to attract and support BSM.

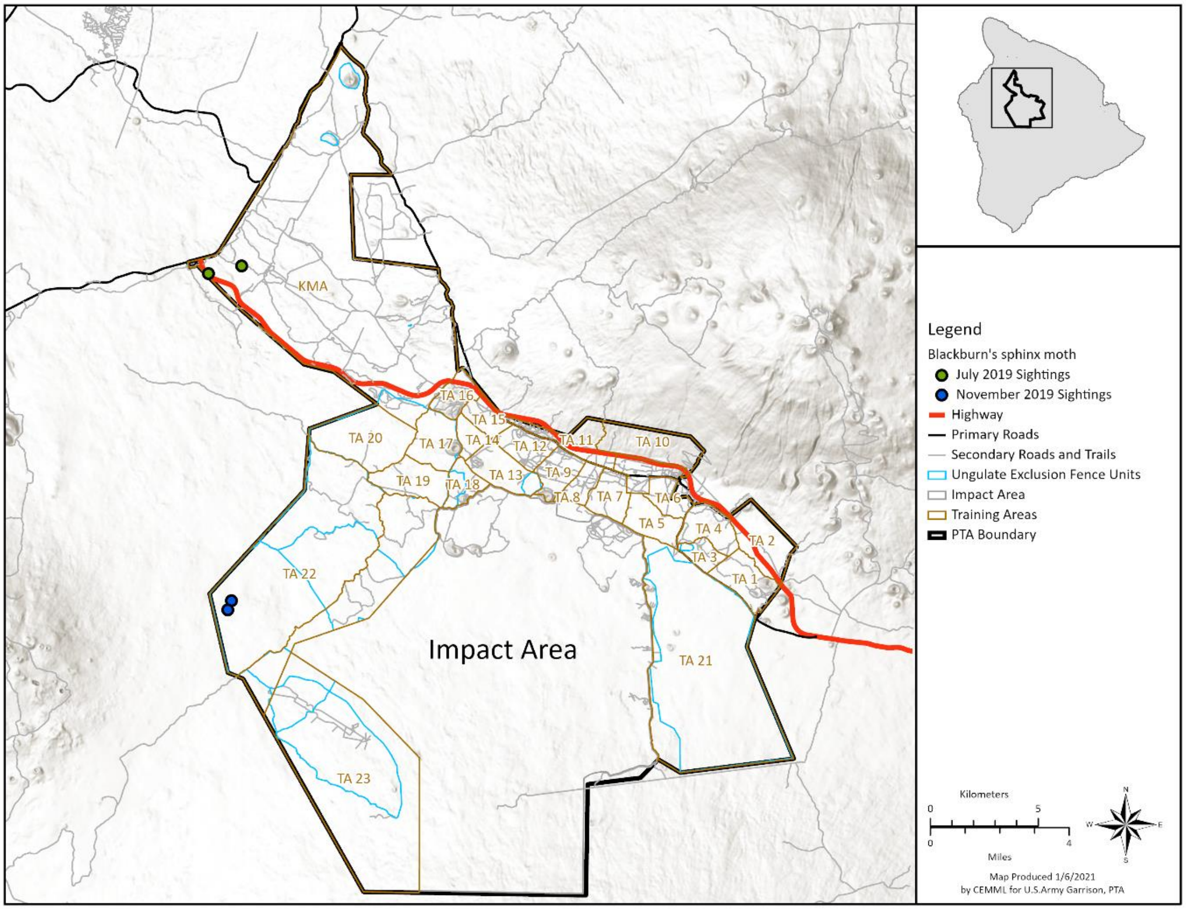

Figure 72. Blackburn's sphinx moth sightings since 2019 at Pōhakuloa Training Area.

Because we recently discovered BSM at PTA, we do not know much about its potential distribution or other possible *Solanaceae* host plants on the installation. However, the presence of BSM on *N. glauca* may be a challenge for natural resources management and military operations in KMA. *N. glauca* continues to invade PTA and as it becomes established, especially in KMA and along the western PTA boundary, BSM numbers are also likely to increase. In addition, *N. glauca* grows quickly in open areas, such as fire and fuel breaks, and forms dense thickets if not controlled. As BSM presence increases along with this invasive plant in KMA, military training and operations may be constrained.

In TA 22, the BSM poses a different management challenge- how to manage an ESA-listed animal species feeding on an ESA-listed plant species. Staff members at Puʻu Waʻawaʻa also observed BSM feeding on *S. incompletum* plants (Edith Adkins, personal communication, 23 October 2020, unreferenced). In FY 2022, 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 30 goslings between FY 2020 and FY 2021, which is substantial progress toward our goal of supporting 26 goslings to fledgling age annually in Army-managed areas at HFNWR. Our analysis of the Hawaiian hoary bat monitoring data has given us a better understanding of seasonal activity patterns and the likelihood of occupancy across the installation. Similarly, we continue to improve our knowledge about the Band-rumped Storm Petrel and patterns of colony attendance and breeding activity and success. This reporting period we successful detected 2 active burrows (N01 and N05).

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

Wildlife management projects directly support Army readiness by minimizing and compensating for military-related impacts to TES and their habitats. Many of our projects implement the non-discretionary terms and conditions identified in the 2003, 2008 and 2013 Incidental Take Statements that must be met to authorize the incidental take provisions associated with Army actions. Thus, continued and consistent funding to manage wildlife species is critical to ensure compliance with the ESA while maintaining training capacity, efficiency, and effectiveness. Through our efforts, we continue to strive to attain our goals for wildlife management and to minimize potential disruptions to military activities at PTA due to conflicts with protected wildlife.

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 (i.e., protocols) to align project purpose, goals, and objectives to 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 2022, 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 wild goats (*Capra hircus*), sheep (feral hybrids of *Ovis aries l.*), black rats (*Rattus rattus*), mice (*Mus musculus*), mongoose (*Herpestes auropunctatus*), cats (*Felis catus*), dogs (*Canis familiaris*), and various invertebrate species (e.g., ants, aphids, and scales). Depending on the target species, we implement several methods to control or deter invasive species: physical (live traps, lethal traps, shooting and fences), and chemical (pesticides).

The overall operational goals of the Threat Management Section are to:

- Maintain the ungulate exclusion fence integrity to prevent ingress by ungulates.
- Maintain ungulate-free status in all ungulate exclusion fence units.
- Survey, control, and minimize impacts from small mammals, 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)(c), 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.

Ingress Monitoring Methods

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 dens) of ungulates. If ungulates are sighted, then the following information is recorded: location, date and time, and information about the animals (species, number, gender, and fur coloration). Reported sightings are tracked and stored in an ArcGIS online geodatabase.

To monitor for ungulate ingress into the fences at high-use entry points, we placed 19 Reconyx HyperFire™ HC600 and 3 Browning Dark Ops Pro HD surveillance cameras at selected gates (Figure 73). Camera locations were selected based on road traffic patterns, military and construction contractor use, sizes of fence units, and areas where ungulate sightings have been observed outside of the fence unit gates. These infrared-equipped cameras remain active 24 hours a day.

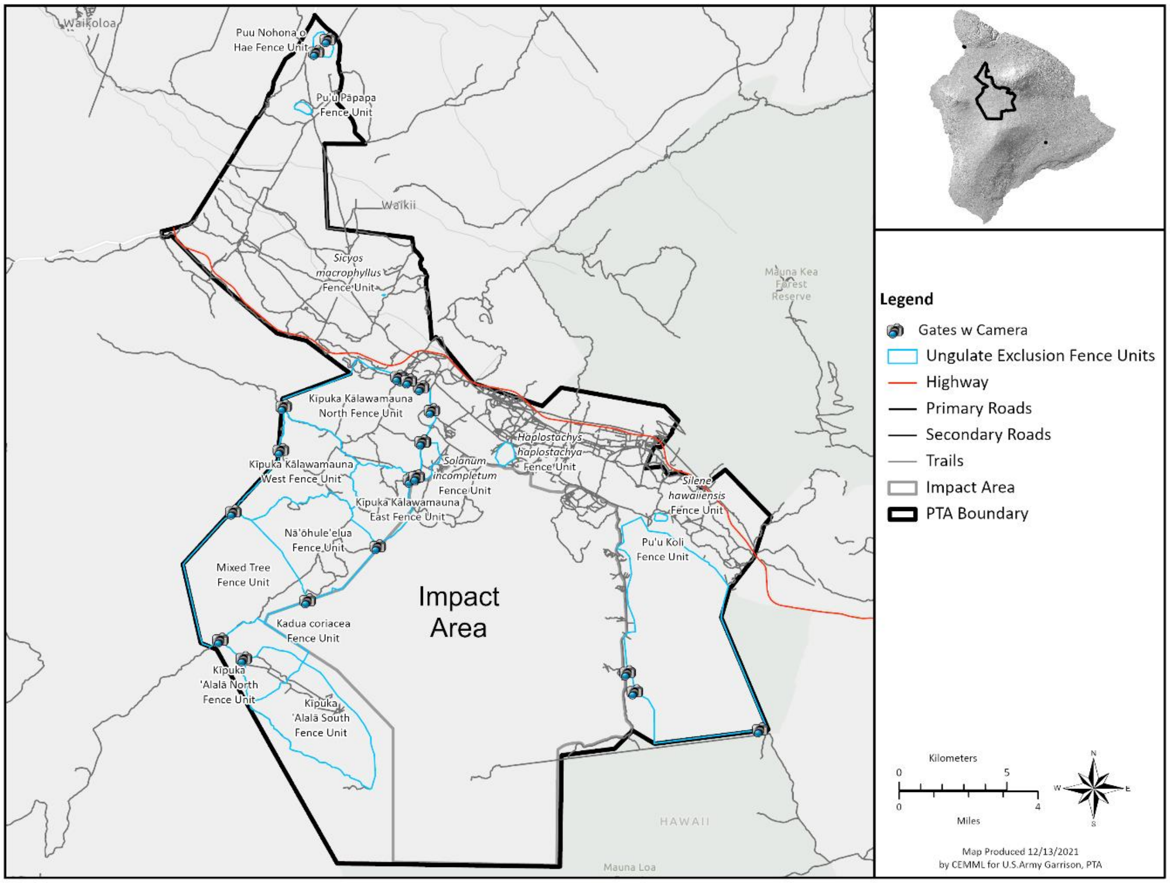

Figure 73. Ungulate exclusion fence units and surveillance camera locations at Pōhakuloa Training Area.

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 is reviewed monthly for organization and to guide management activities.

When we suspect that animals may be present inside a fence unit, we may deploy animals fitted with VHF radio collars inside the same fence. We use collared animals when the herd location is unknown, if camera monitoring is unsuccessful at confirming animal presence, and in large fence units with dense vegetation and limited visibility. Since most ungulates prefer to herd together, the collared animal locates uncollared animals of the same species within the fence. After the collared animal joins the uncollared ungulates, we track herd movements with a VHF receiver and implement a control method (live trapping, ungulate drive, or shooting) to remove the uncollared ungulates. Once we remove all the uncollared ungulates, we then remove the collared animals. We aerial survey for ungulates within the ungulate exclusion fence units to address 2003 BO conservation measures. By helicopter we survey transects approximately 500 m apart within a fence unit, using GPS and ArcGIS maps to record the flight path. Any ungulate sighting is recorded and stored in the incidental sighting database.

For small fence units (<100 ha), we typically survey on foot since ungulates are easily tracked inside these units.

Ungulate Removal Methods

We remove any ungulates confirmed within the exclusion fences, usually by using several methods in conjunction. Methods include live trapping, drives, and shooting with or without aerial support.

To trap the animals, we use corral traps (3 to 4 interlocked panels of 12’ x 6’ galvanized welded wire) to capture ungulates. Water, plant material, or salt blocks are used to lure ungulates into the trap. We monitor traps daily and we safely release all captured ungulates outside the ungulate exclusion units. We typically use live traps when we know an animal is frequenting an area or location.

We will drive animals out of fence units if the unit is small or if the animals frequent a specific area or location. Ungulate drives are also practical in fence units with good visibility. We drive ungulates by forming a line with minimal spacing between personnel and walking toward an open gate, flushing and herding the ungulates ahead of the line and through the open gate.

We contract Hawaiʻi Game Management, LLC (HGM) to remove ungulates with lethal force. Shooters use live-fire weapons (shotgun or rifle) to kill the ungulates. All shooting operations are conducted on the ground (i.e., no aerial hunting is permitted), but shooters can use helicopter assistance to find the ungulates. Shooting is the most efficient method for removing ungulates from large fence units and is often coupled with the use of radio-collared animals.

Ungulate Management Results

Aerial Survey Results

In FY 2020, HGM conducted aerial surveys over the ungulate exclusion fence units on 03 and 10 June 2020 for a total of 9.8 hours over the 2 days (Figure 74). In FY 2021, HGM conducted aerial surveys over the ungulate exclusion fence units on 25 and 27 June 2021 for a total of 8.0 hours over 2 days (Figure 74). No ungulates were detected during the 4 days of aerial surveys.

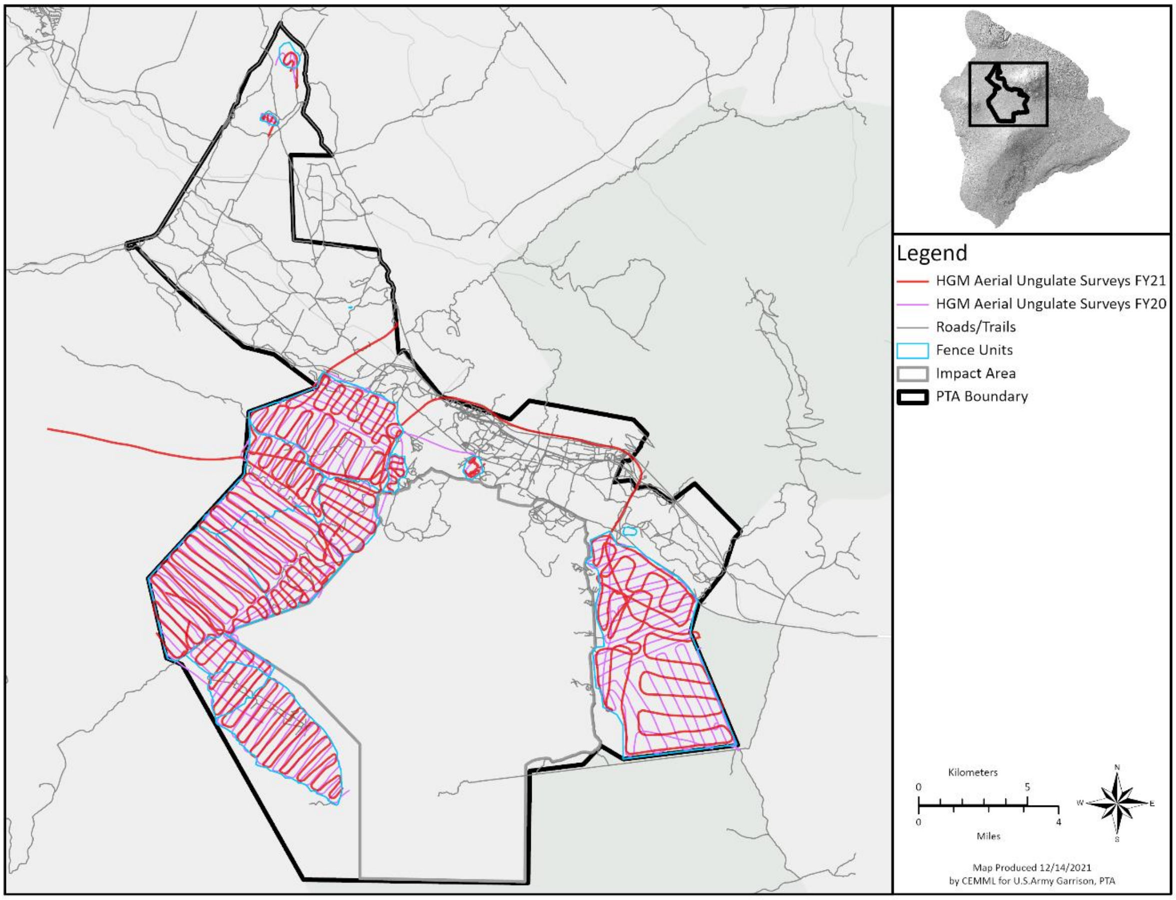

Figure 74. Hawai'i Game Management aerial survey transects conducted at Pōhakuloa Training Area during FY 2020–FY 2021.

Incidental Reports and Camera Surveillance Monitoring and Ungulate Removal Results

We initiated monitoring to detect possible ungulate ingress into the exclusion fences based on 9 reports (6 incidental sightings and 3 camera detections). For 5 of the 9 reports, we confirmed ungulates in the fence units (Table 72). A total of 14 ungulates were detected and 13 removed. We are still monitoring 1 ingress in the Kīpuka Kālawamauna North Fence Unit and in FY 2022, we plan to remove the collared ram in the Puʻu Koli Fence Unit. Actions taken over the report period are summarized for each fence unit below.

Table 72. Ungulate ingress detections in the ungulate exclusion fence units at Pōhakuloa Training Area during FY 2020–FY 2021.

Fence Unit	Report Date	No. of Ungulates Detected	Initial Detection Method		Method to confirm detection		No. of Ungulates Removed
			Incidental Sighting	Camera	Camera	Judas Animal	
Puʻu Koli	April 2020	2		X	X	X	2[a]
Haplostachys Haplostachya	Sept 2020	2	X			X	2[a]
Puʻu Nohona O Hae	March 2021	3	X				3
Puʻu Koli	July 2021	6		X	X	X	6[b]
Kīpuka Kālawamauna North	July 2021	1		X	X		0

[a] Collared ungulate removed from fence unit at the same time as the uncollared ungulates.

[b] A camera detected 4 ungulates entering and 6 ungulates exiting the fence unit through an open gate and a collared ram remains in the Pu'u Koli Fence Unit.

Through our camera surveillance, we documented 76 times that vehicle gates were left open and unattended. Most of 607,322 photos recorded at the vehicle gates showed personnel entering and exiting the fence units. In addition, some photos detected mongoose, feral cats, dogs, game birds and ungulates (outside of the fence unit).

Based on the camera surveillance and aerial survey data, we implemented removal operations as needed. We successfully removed the 7 uncollared ungulates that we confirmed, via our monitoring efforts, inside the fence units (Table 72 and Table 73). During the reporting period, a total of 4 ungulate removal operations were conducted: 1 in the Puʻu Koli Fence Unit, 1 in the Puʻu Nohona o Hae Fence Unit, and 2 in the *Haplostachys haplostachya* Fence Unit. An additional 6 ungulates were removed from the Puʻu Koli Fence Unit, but those removals were attributed to the animals themselves exiting through the same open gate they used to enter the unit (Table 73).

Table 73. Number of ungulates removed per fence unit at Pōhakuloa Training Area during FY 2020–FY 2021.

Fence Unit	Sighting Report Date	No. of Ungulates Detected	No. of Ungulates Removed	Date(s) ungulate removed	Removal Methods		
					Live Trapping	Ungulate Drive	Shooting
Puʻu Koli[a]	July 2021	2	2	Nov 2020		2	
Haplostachys haplostachya[a]	Sep 2020	2	2	Sep 2020 Aug 2021	1	1	
Puʻu Nohona o Hae	March 2021	3	3	March 2021		3	

[a] Collared ungulate removed from fence unit at the same time as the uncollared ungulates.

Puʻu Koli Fence Unit

In April 2020, a surveillance camera at a vehicle gate detected 2 sheep inside the fence as they walked the fence line. We deployed additional cameras within the fence and confirmed the presence of the sheep. During the subsequent fence inspection, we found openings under the fence caused by substrate erosion, which were repaired (see Section 4.3.5). In September 2020, we deployed a collared ram to facilitate the removal of 2 sheep from Puʻu Koli Fence Unit. In November 2020, HGM assisted us in conducting an ungulate drive to remove all 3 sheep (including the collared ram) from the Puʻu Koli Fence Unit.

In July 2021, a vehicle gate was not locked properly, and 4 sheep were detected entering the Puʻu Koli Fence Unit (Figure 75). However, 6 sheep were detected via camera exiting the gate. Because we are uncertain if additional ungulates entered, but were not detected on the camera, in August 2021, we deployed a collared ram to confirm if there were other uncollared sheep in the from Puʻu Koli Fence Unit. As of 30 September 2021, this collared ram remains within the fence unit.

Haplostachys haplostachya Fence Unit

In April 2020, 2 goats were reported inside the *H. haplostachya* fence unit. We deployed additional cameras within the fence and confirmed the presence of the goats. In September 2020, we successfully drove one of the goats from inside the fence and deployed a collared billy to facilitate the removal of remaining goat. In August 2021, we captured and removed the uncollared and collared goat via live trap. The unit is again ungulate-free as of 30 September 2021.

Puʻu Nohona o Hae Fence Unit

In March 2021, 3 goats were sighted in the Puʻu Nohona o Hae Fence Unit the during fence inspection and we found a breach along the fence line caused by soil erosion. We deployed additional cameras within the fence and confirmed the presence of the goats. We successfully drove the animals from the fence unit within days of their discovery. As of 30 September 2021, the fence is again ungulate-free.

Figure 75. A photo of sheep entering the Puʻu Koli Fence Unit through an unattended open vehicle gate.

Kīpuka Kālawamauna North Fence Unit

In July 2021, a surveillance camera at a vehicle gate detected 1 sheep inside the fence as it walked along the fence line. We deployed additional cameras within the fence and confirmed the presence of the sheep. During the subsequent fence inspection, we found openings under the fence caused by substrate erosion, which were repaired (see Section 4.3.5). As 30 September 2021, the sheep was still inside the fence.

Mixed Tree Fence Unit

During the previous report period in February 2019, we released a collared ram in the Mixed Tree Fence Unit to investigate a possible ingress report. Because the ram did not herd with other collared sheep, we concluded that there were no other sheep in the unit. Therefore, on November 2019, the ram was captured and released outside the PTA fence units and following its removal the fence unit is considered ungulate free.

Discussion for Ungulate Management

We successfully removed 7 ungulates from the PTA ungulate exclusion fence units, and we continue to meet regulatory obligations for sustaining ungulate-free fence areas. As demonstrated by the numerous incursions, our monitoring and removal efforts are essential to maintaining the fences ungulate-free. Constant pressure from ungulates outside the fence units, the need for civilian contractors and military personnel to travel into the fence units, and reoccurring fence damage from weather events, unstable substrates, and human activity increase the likelihood of future ungulate incursions. By maintaining a system to monitor for incursions and quickly remove ungulates, we meet our INRMP objectives and 2003 BO conservation measures to reduce the negative effects associated with ungulates to TES habitats and ESA-listed plants. Maintaining the fenced habitats ungulate-free demonstrates effective ecosystem management that confers benefits to a wide range of native species including the 20 ESA-listed plants and 27 additional SAR plants.

4.3.2 Small Mammal Management

Projects implemented for small mammal management address SOO task 3.2(2)(c), INRMP objectives, and conservation measures identified in the 2003 BO. We control small mammals (rodents, mongoose, feral cats, and feral dogs) to minimize potential impacts to TES at PTA. Because small mammal control is resource intensive, we apply targeted control under specific conditions. For example, although rodent control for 3 ESA-listed plants[13] is described as on-going conservation actions and conservation measures in the 2003 BO, we typically apply rodent control only when we observe rodent damage to plants.

Rodents damage a wide variety of plants in Hawaiʻi, and they severely reduce reproduction of certain plants by consuming many fruits or seeds (Sugihara 1997; Cole et al. 2000; Gillies and William 2013; Pender et al. 2013). For ESA-listed plants at PTA, we typically control rodents to minimize their damage to vegetative and reproductive parts of the plants. When rodent damage to plants warrants a management response, we monitor with surveillance cameras and tracking tunnels to assess rodent activity near the plants. Rodent control may include live trapping and lethal trapping.

We monitor the Tier 1 species quarterly and record any plant damage caused by rodents (see Section 2.4). If damage is detected, we control rodents to minimize rodent populations around the plants.

We continue to implement rodent control at ASR 41/213 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 for predatory small mammals, we deploy surveillance cameras to monitor for presence/absence of

[13] *Neraudia ovata*, *Solanum incompletum*, and *Zanthoxylum hawaiiense.*

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® (36"X11.5"X13.5") and larger Tomahawk® (16"X5"X5") traps primarily for cats but these traps were also capable of capturing mongooses and rodents. We spaced these traps between 50 m and 100 m apart for mongoose and cats, respectively. We used a smaller Tomahawk® (30"X10"X12") trap spaced between 25 m and 50 m apart to capture rodents and mongooses, respectively. All the traps were baited with a single can of sardines (Beach Cliff Sardines in soybean oil) with scent holes punctured in the top and were checked daily.

For lethal trapping of rodents, we used snap traps (Victor® or Kress™ Snap-E traps) and 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 place 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 41/213*

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 2019–September 2021. The percent of boards tracked by black rats and mice ranged from 0%–100% and 0%–33%, respectively (Table 74). From December 2019 – September 2020 we maintained 9 A24 traps and observed evidence of kills at ASR41/213. Due to increased rodent activity in September 2020, we increased the number of A24 traps from 9 to 16 in October 2020. From December 2020-June 2021 both the rat and mouse activity dropped to 0%. Then in September 2021 the percent rat activity increased to 100% and mouse activity increased to 33%. These increases in activity were likely the result of not replacing the bait at 3-month intervals. We attempted to leave the bait lures for a 6-month period as recommended by the vendor. When we checked the A24 traps after the 6-month period (March to September 2021), we noticed many of the A24 traps had zero bait in the trap and some CO_2 canisters were totally expended. Based on this outcome, we plan to return to replace bait every 3 months instead of 6 months.

Table 74. Tracking tunnel results as percent of tracking tunnels with activity (i.e., percent activity) by rodent species at Area of Species Recovery 41/213 from FY 2020–FY 2021.

Species	May 2017[a]	Dec 2019	Mar 2020	Jun 2020	Sep 2020	Dec 2020	Mar 2021	Jun 2021	Sep 2021
Black rat	77%	77%	44%	0%	77%	0%	0%	0%	100%
House mouse	0%	0%	0%	0%	22%	0%	0%	0%	33%

[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 (RTS). 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 Strom Petrel Colony (ASR 501) to decrease depredation pressure.

In FY 2020, using live traps we removed 4 predators (3 feral cat and 1 rat) and in FY 2021, we removed 9 predators (8 feral cat and 1 rat).

In FY 2020, using lethal traps we removed 63 rodent carcasses (25 black rats and 38 mice) from the A24 traps and snap traps. In FY 2021, we removed 132 rodent carcasses (47 black rats and 85 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 Hakalau Forest National Wildlife Refuge (HFNWR), with the goal of increasing nest success and gosling survivorship

We did not control predators at PTA for Hawaiian Geese because we did not observe any molting or breeding activity.

In FY 2020, using live traps we removed 12 predators (2 feral cat, 9 mongooses, and 1 rat) and in FY 2021, we removed 15 predators (5 feral cats, 8 mongooses, and 2 rats).

In FY 2020, no lethal trapping was conducted. In FY 2021, using lethal traps we removed 31 predators (2 mongooses, 4 rats, and 25 mice).

Refer to Section 4.2.3 for a detailed description of the predator control at HFNWR for Hawaiian Goose management.

Discussion for Small Mammal Management

Since 2017, *S. hawaiiensis* and *N. ovata* have been documented to have high levels of rodent damage (i.e., bite marks on leaves and stems, broken stems) at ASR 41/213. Following deployment of the A24 traps in May 2017, we initially recorded a large decrease in black rat activity and for the 3 quarters preceding this report period (March to September 2019), black rat activity was zero (CEMML 2020b). However, activity jumped to 77% between September and December 2019 and then showed no clear pattern through September 2020 (Table 74 and Figure 76). After September 2020, black rat activity dropped to zero for another 3 quarters (December 2020 to August 2021) but increased to 100% in September 2021. Although we attribute the dramatic increase in black rat activity in September 2021 to running out of bait lures in most of the traps, there may be natural cycles that influence periodic increases in the rat population that swamp our control grid. Research has found that black rat densities are high from June through January in Hawaiian forests and factors such as food availability and predator density (i.e., cats and mongoose) influence black rat population densities (Shiels et al. 2014). Mouse activity was generally low from 2017 through 2021, except for a peak in activity between June and September 2018.

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 2021, we deployed tracking tunnels 15 times. During this period, black rat activity was below or near 20% for 11 of the deployments (73%) and mouse activity was below or near 20% for 12 deployments (80%, Figure 76). In addition, we recorded a decrease in rodent damage to *S. hawaiiensis* and *N. ovata* plants during quarterly plant monitoring over the same time period.

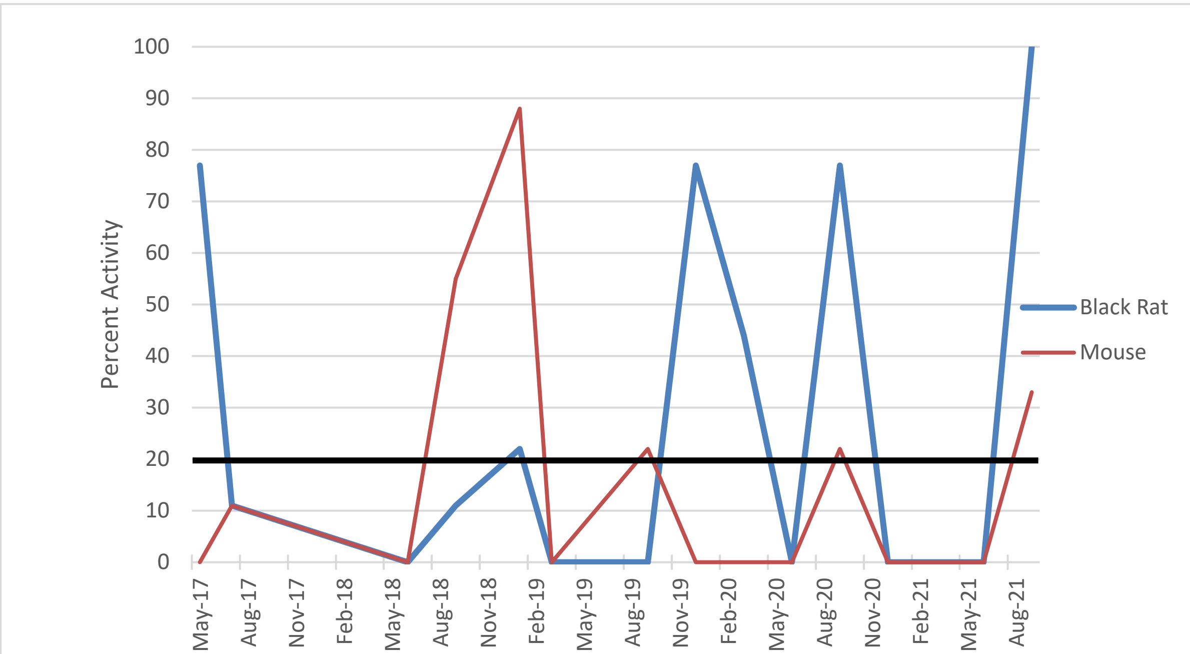

Figure 76. Tracking tunnel results as percent of tracking tunnels with activity (i.e., percent activity) by rodent species at Area of Species Recovery 41/213 from May 2017 through September 2021. Rodent control began following May 2017. The dark horizontal line marks 20% activity.

By not replacing the A24 traps CO_2 canisters and bait within 3 months and waiting for 6 months, we saw a significant jump in rodent activity in ASR 41/213. For FY 2022, we plan to maintain the traps every 3 months.

Although it is difficult to make a direct connection between small mammal control activities and survivorship of Hawaiian Geese and Band-rumped Storm Petrels, we assume that the removal of predators benefits these species. For example, the removal of 7 feral cats, 19 mongooses, and numerous rodents HFNWR is likely to have a positive effect by decreasing predator pressure on the Hawaiian Goose during breeding season. In addition, removing 11 feral cats and numerous rodents at the seabird colony likely decreased predator pressure on breeding Band-rumped Storm Petrels. In FY 2022, we plan to expand our trap efforts in ASR 501.

Control of small mammals that depredate ESA-listed plants and animals is critical for minimizing the negative effects from 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(1)(b) 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 on 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 reevaluated after invertebrate control efforts. The 2003 BO identifies 2 invertebrate taxa to control: aphids and ants. As required per the 2003 BO, NRP 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 poses 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 attributed to the decline of these plants (i.e., drought, invertebrate infestations, and invasive plants). To control for invertebrates, we removed aphids and scale with insecticidal soaps, and we applied insecticide to control for invasive ants.

Invertebrate Management Methods at ASR 40

Ant Monitoring with Vials

We used a systematic design to investigate the presence of ants at 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 77). 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 from each other. 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.

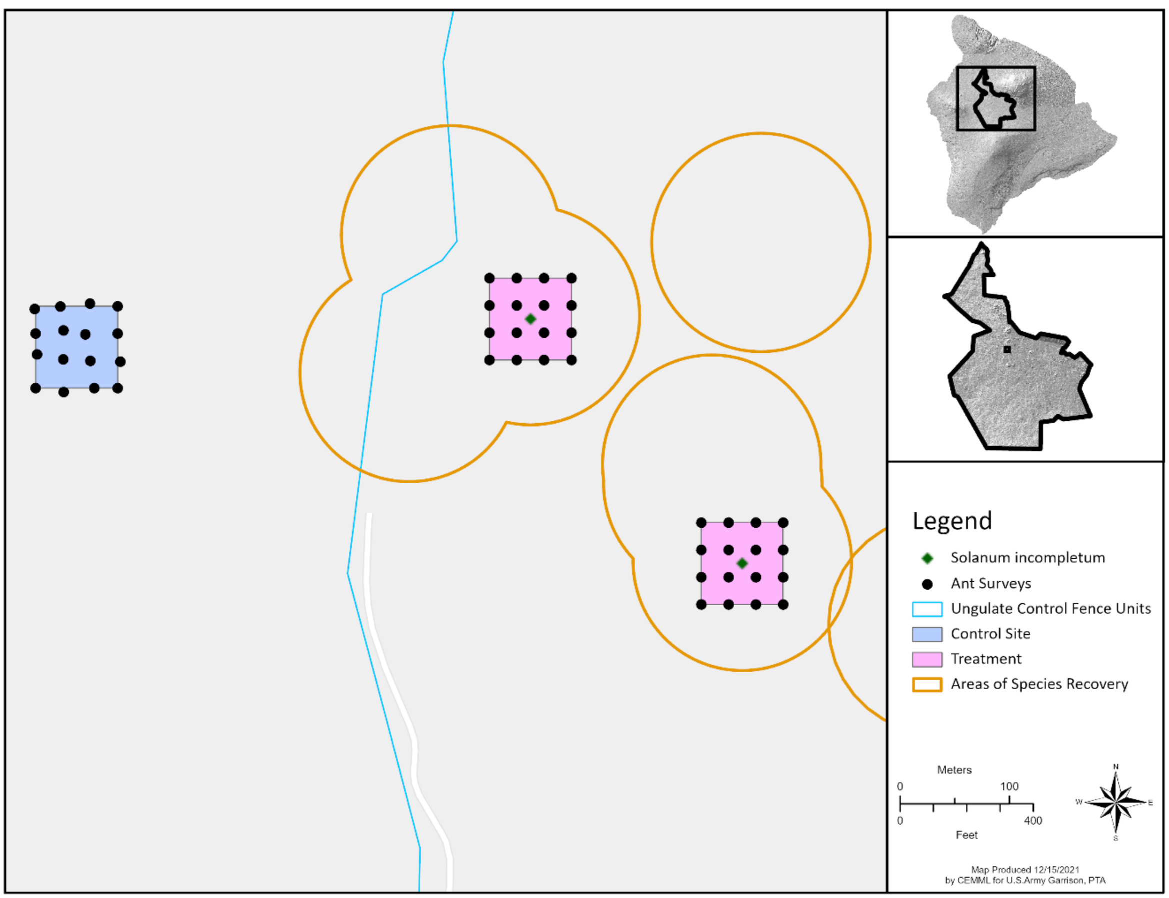

Figure 77. Ant management site in Area of Species Recovery 40 at Pōhakuloa Training Area.

Invertebrate Infestation Monitoring

At each ATS we opportunistically searched each *S. incompletum* plant for a total of 4 minutes per plant (Figure 78). 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 un-treated areas.

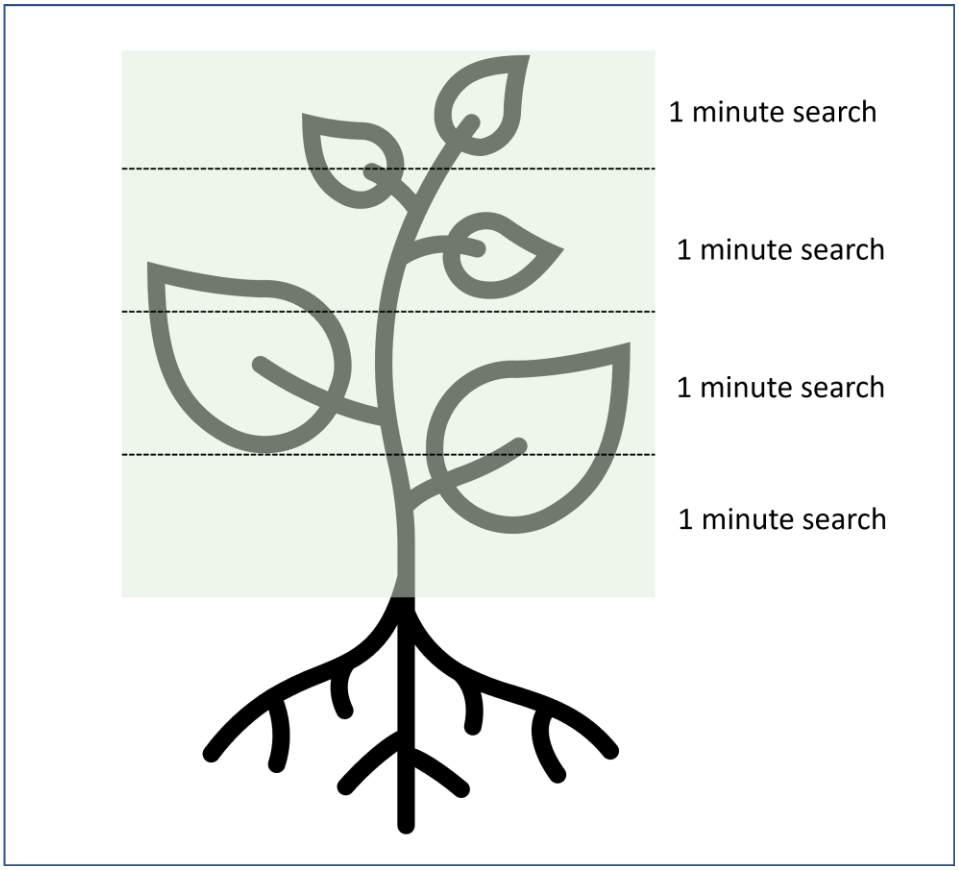

Figure 78. Invertebrate infestation monitoring design for visually counting the total number of invertebrates found on each plan during a 4-minute count.

Ant Treatment

We applied Maxforce® Complete Granular Insect Bait (active ingredient Hydramethylnon 1%) using granular hand spreaders at each ATS. We applied approximately 2.08 lbs of Maxforce across each ATS on 02 June 2021 and 09 September 2021. Applicators walked 5 m wide transects applying an even distribution of insecticide at each location.

Ant Vials Monitoring Results

On 26 May 2021 (pre-treatment), 2 September and 22 September 2021 (post-treatment) we collected ant vials from the 3 ant management sites (16 vials C01, 16 vials ATS01 and 16 ATS02). The only ant species found in all 3 ant management sites was Argentine ants. Ant presence was measured as number of ants per collection vial. The average number of ants per vial in ATS01 and ATS02 were significantly lower after the treatment (~4 months) (Table 75). In addition, C01 ant numbers also decreased (mean 0.7 ants per vial) on 2 September, but the ant numbers increased (mean 59.2 ants per vial) when ant vials were collected on 22 September. CS01 is approximately 350 m from the outer treatment boundary from ATS01 and was not likely affected by the treatments. The observed decline in the number of ants in CS01 may have been caused by a natural cycle.

Table 75. The mean number of ants per vial collected in the ant management areas in Area of Species Recovery 40 pre- and post-treatment.

Site	26 May 2021[a]	02 September 2021	22 September 2021
CS01	60.3 (± SE 24.9)	0.7 (± SE 0.4)	59.2 (± SE 15.3)
ATS01	14.4 (± SE 11.6)	5.1 (± SE 4.2)	0.4 (± SE 0.3)
ATS02	2.2 (± SE 1.4)	1.7 (± SE 1.1)	0 (± SE 0)

CS, Control Site; ATS, Ant Treatment Site
[a] Data reported for 26 May 2021 is prior to treatment. Data right of the vertical line are data taken post treatment.

Invertebrate Infestation Monitoring

During pre-treatment monitoring on 26 May 2021, at AST01 and AST02, respectively, we found 0 aphids and 1 dead scale and 0 aphids and 0 scales on *S. incompletum* plants. During post-treatment monitoring on 2 September 2021, at AST01 and AST02, respectively, we found 0 aphids and 1 dead scale and 0 aphids and 11 living scales on *S. incompletum* plants. No monitoring occurred on 22 September 2021 following treatment in ATS01 and ATS02. We plan to monitor these sites in November 2021. Because no *S. incompletum* plants are established in CS01, we cannot compare the results in treatment vs. non-treatment areas.

<u>Discussion for Invertebrate Management</u>

Results from the post-treatment showed a reduction of Argentine ant activity at the all the ATS, but ant activity also declined in the control after the first treatment. However, on 22 September the ant activity returned back to a level similar to pre-treatment numbers. The cause of the decline in ant activity in the control site in September is unknown. 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 on 2 September 2021 we observed 11 living scales on the *S. incompletum* plants. We are assuming a direct relationship between ants and the 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 2020b). 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 2022, we plan to continue to monitor this site and possibly use chemical or mechanical removal of the scales from the *S. incompletum* plants. Also, we plan to expand and 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)(c) and 3.2(2)(d) and to address INRMP objectives and conservation measures from the 2003 and 2013 BOs. The goals for early detection are to detect new introductions of invasive animal species before they become established and to contain or eradicate the species when possible. These goals are met by conducting surveys within the Bradshaw Army Airfield (BAAF) environs, at construction and auxiliary sites, on plant or plant products brought to PTA, and on incoming machinery, vehicles, and construction equipment.

Early Detection Survey and Monitoring Methods

To fulfill conservation measures from the 2003 BO, we systematically survey and monitor for invasive animals and track incidental sightings.

Systematic Survey and Monitoring Methods

We use baited traps to systematically survey or monitor for invasive invertebrate species (e.g., invasive ant species) at construction sites, off-site quarries, auxiliary sites, on plants or plant products brought to PTA, and on incoming machinery, vehicles, and construction equipment. 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, and jelly or jam) and deployed between 5-m or 100-m intervals depending on the location or equipment/vehicle being inspected. We collect traps 45 minutes after deploying. All invertebrates found in or around the trap are collected or photographed and collected invertebrates are brought back to PTA for identification to the lowest taxon possible.

In addition, we implement visual encounter surveys along established transects within the BAAF environs and at construction and auxiliary sites. We search for basking reptiles and uncommon or new animals within 5 m of each transect line. Surveys are conducted primarily during mid-morning when reptiles or invertebrates are most likely to be active and visible. We search under rocks, branches, human-made structures; items that are moved are replaced in their original position to minimize disturbance to habitat. We collect or photograph any new or uncommon invertebrate and identify the animal to the lowest taxon possible. In addition, we inspect the security fences surrounding the perimeter of BAAF for brown tree snakes (e.g., skins or snakes coiled on fence) during the quarterly Hawaiian hoary bat barbed wire fence inspections.

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 would remain in place for more than several days (e.g., temporary office buildings, storage containers). All incoming contractors are provided the PTA Invasive Pest Prevention SOP and other invasive species materials.

Incidental Observations Methods

We report incidental detections of all newly introduced 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 6 of 8 quarters (2 quarters were skipped due to heavy military training on the airfield). No newly introduced invasive animal species nor evidence of brown tree snakes (e.g., skins or snakes coiled on the perimeter BAAF fence) were detected.

Off-Site Quarries

We inspected 6 off-site aggregate piles for invertebrate invasive species. During an inspection at 1 quarry, we found an Argentine ant 50 m away from the cinder stockpile. Argentine ants are well established on cantonment at PTA, therefore delivery of the cinder to PTA was of minimal concern.

Equipment and Materials

We completed 6 invasive invertebrate inspections on incoming equipment and materials and detected a target invasive invertebrate during a single inspection. On 21 August 2021, while a PTA team member was inspecting a pull-along trailer that contained boxes of Red Cross supplies, he detected LFA in the container. The trailer was approved to be parked inside 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%).

To follow up on the initial detection and treatment of the infested trailer interior, on 25 August 2021 we deployed 6 baited vials inside the infested trailer and 6 vials in each of 4 other trailers that were brought to PTA at the same time from the same location as the infested trailer. We also deployed 25 baited vials in a 33m x 33 m area surrounding the 5 containers. On 24 August 2021, we observed 1 LFA crawling inside the infested trailer and numerous ~50–100 dead LFAs on the floor and boxes. The 1 living LFA was not captured. We used the survey data collected on 24 August 2021 as baseline information to evaluate the effectiveness of reducing ant presence/numbers following treatment of the area with Amdro Ant Block® (A.I. hydramethylon 0.88%).

On 25 August 2021, we treated all areas and the containers with a fire ant insecticide, Amdro Ant Block® (A.I. hydramethylon 0.88%). We applied 2 more treatments on 1 September 2021 and 29 September 2021. The application rate was 7 oz per 180 linear ft per the insecticide label instructions.

During post-treatment monitoring of the interiors and area surrounding the trailers, no other LFA were detected in September and October. Argentine ants were the only other ant species detected inside and outside the containers (Table 76). No LFA were found in the vials (pre- or post-treatment) and we observed a decrease in Argentine activity. The number of vials with Argentine ants dropped inside the containers from 77% (pre-treatment) to 0%–4% (post-treatment) and a similar decrease of Argentine ants were observed outside of the containers 96% (pre-treatment) to 8%–24% (post-treatment).

Table 76. Survey and monitoring results for invasive ants (percent vials occupied) in and around an invertebrate-infested container delivered and staged in 2021 within cantonment at Pōhakuloa Training Area.

Treatment Site [a]/Ant Species	24 August 2021 [b]	25 August 2021	1 September 2021	28 October 2021
Inside Containers (26 vials)				
Little Red Fire Ants	0%[c]	0%	0%	0%
Argentine Ants	77%	4%	0%	0%
Outside Containers (25 Vials)				
Little Red Fire Ants	0%	0%	0%	0%
Argentine Ants	96%	8%	8%	24%

[a] The area surveyed and monitored for ants included the infested trailer, 4 additional trailers that were relocated to PTA at the same time from the same location as the infested trailer, and a 33 m x 33 m area encompassing the 5 trailers.

[b] The initial survey for ants was completed on 24 August 2021. This survey was completed after the initial infestation in the trailer was treated with a general insecticide but before the trailer and surrounding area was treated with fire ant specific insecticide. We use the data from this survey to evaluate the change in ant presence during subsequent monitoring of the areas.

[c] One living Little Red Fire Ant (LFA) was seen crawling inside the container and many dead LFA were seen in the container.

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 appears 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. We will continue to monitor this location for LFA in FY 2022.

Although the immediate benefit of early detection programs may not be readily apparent, adequately funding and staffing such programs can help minimize potential future costs to control or manage new infestations of highly invasive species that degrade training lands and impact the mission (Boice et al. 2010). Supporting and implementing early detection and invasive control projects is aligned with Department of Defense Pest Management Program objectives (DoD 2008) and Army Regulation 200-1. Implementing actions to prevent the establishment of new invasive species (e.g., LFA, rabbits, and African killer bees) typically requires less time, effort, and funding than responding to and managing infestations of new invasive species.

4.3.5 Fence Maintenance

Fence maintenance meets SOO task 3.2.(2)(e) and addresses INRMP objectives to protect TES habitats and several conservation measures in the 2003 and 2008 BOs. We regularly inspect 138 km of ungulate exclusion fence (15 fence units) and 107 gates to ensure continued functionality.

Fence Maintenance Methods

To maintain the 15 ungulate exclusion fence units 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 for status and condition at 22 gates. Refer to the Ungulate Control Management Section 4.3.1 for additional information of 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 2020–FY 2021, we repeatedly inspected the fence lines, covering a combined distance of approximately 1,023 km, and completed 35 major fence repairs (damage severe enough to possibly allow an ungulate breach). We removed 13 fallen trees from fence lines, fixed 18 locations damaged by erosion below the fence, and replaced fence damaged by vehicle strikes 4 times. In addition, 39 damaged gates were discovered and repaired. Gate repairs included replacing bent door frames and broken hinges, lubricating or replacing rusted locks, straightening or replacing bent drop rods, welding fence skirts, and replacing faded or cracked signs.

Numerous minor repairs were also completed during fence inspections and were not considered serious fence integrity issues. Therefore, these small maintenance repairs were not individually documented. Minor repairs during this reporting period included stretching fence wire in areas where fence had become loose, replacing fence clips, replacing fence anchors and t-posts, closing small gaps between fences and substrate, and replacing locks and latches on gates.

We spent over 388 hours clearing vegetation (approximately 313 hours applying herbicides, approximately 75 hours cutting brush) along the fence corridors. We applied 1,457 gallons of herbicides on invasive plants covering about 28.2 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 2 instances of gate damage via camera. For the first event, a HUMVEE was used to nudge open the gate and the other instance a person was seen kicking the gate forcibly open. The gate was repaired, and no ungulates were detected entering the fence unit through the damaged gate.

Military personnel, contractors, and our staff submitted 3 incidental fence damage reports (3 gates). All damages were repaired, and no ungulates were detected entering the fences through the damaged gates.

Fence Maintenance Discussion

Maintaining fence and gate integrity is essential to preventing animals from accessing the fences and the habitats inside. Through these activities, we continue to meet INRMP objectives and conservation measures in BOs. We have successfully maintained the 15 ungulate exclusion fences ungulate-free for the last 2 years. 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.

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, are more cost effective and result in less impacts than the alternatives of no or delayed action. Thus, continued and consistent funding to manage invasive species is critical to ensure we can cost effectively address our goals of detecting, controlling, and/or eradicating invasive animals to prevent impacts to TES and high value resources.

We will continue to fine-tune our planning process to identify needs and establish priorities in FY 2022. 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 tasks 3.2(2)(f) and 3.2(2)(g) 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 1-4, 10, 11) and to minimize potential ungulate ingress into the PTA ungulate exclusion fence units. The secondary benefit of the Game Management Program is to provide outdoor recreation and public access to military lands for hunting game mammals and upland game birds on approximately 156 km^2 at USAG-P (Figure 79). 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.

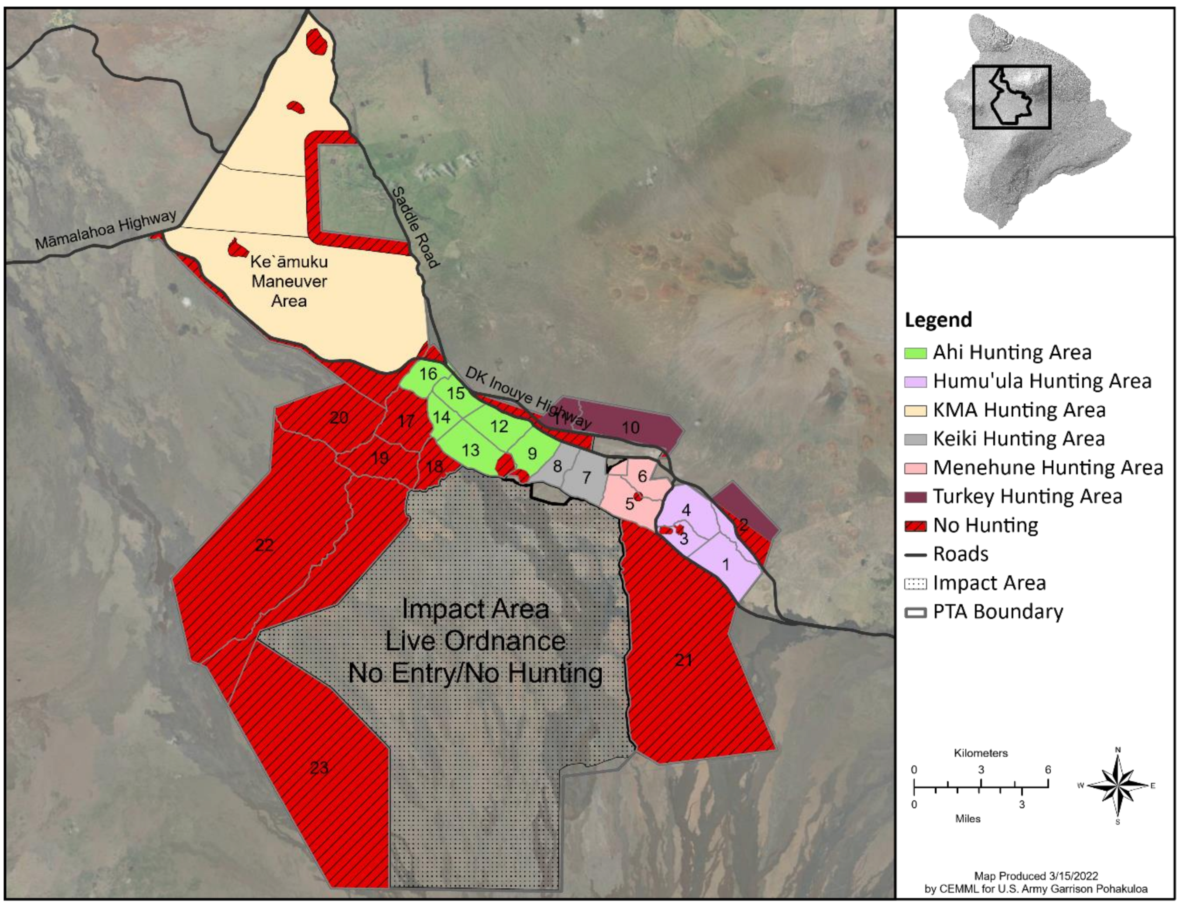

Figure 79. Public hunting unit locations at Pōhakuloa Training Area.

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 one 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; there are also 2 units designated specifically for spring turkey season (Figure 79). Game mammal species available for archery hunting include mouflon-domesticated hybrid sheep (*Ovis aries*), feral goats (*Capra hircus*), and feral pigs (*Sus scrofa*). Archery is the primary hunting activity and is offered during most months of the year. The upland game bird season is from November through January each year. Spring turkey season is from March to mid-April; however, wild turkeys can be hunted during the normal game bird season. Upland game birds may be hunted with shotguns at PTA. There are 12 species of game birds available to harvest (Table 77). Rifles, muzzleloaders, and handguns are not approved for use at PTA. Disabled hunters with valid medical documentation are permitted to use crossbows.

Table 77. Upland game bird species present at Pōhakuloa Training Area.

Common Name	Species	Origin
Black Francolin	*Francolinus francolinus*	Introduced
California Quail	*Callipela californica*	Introduced
Chestnut-bellied Sandgrouse	*Pterocles exustus*	Introduced
Chukar	*Alectoris chukar*	Introduced
Erckel's Francolin	*Francolinus erckelli*	Introduced
Gray Francolin	*Francolinus pondicerianus*	Introduced
Japanese Quail	*Coturnix japonica*	Introduced
Kalij Pheasant	*Lophura leucomelana*	Introduced
Ring-necked Pheasant	*Phasianus colchicus*	Introduced
Spotted Dove	*Streptopelia chinensis*	Introduced
Wild Turkey	*Meleagris gallopavo*	Introduced
Zebra Dove	*Geopelia striata*	Introduced

To coordinate access to hunting, 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 annually and addresses access requirements, permits and associated fees, prohibited activities, restricted areas, safety zones, transport of firearms, and general hunting information.

In 2015, the Army purchased a web-based service, iSportsman, to manage public hunting activities. The PTA iSportsman portal became operational in 2016 and we have continued to use it since then. It is an easy-to-use, interactive service developed to assist natural resource managers with the coordination of hunting-related activities. The web-based program facilitates the issuance of hunting permits, provides information related to the hunting program, and can generate automated, customizable reports for hunter effort and harvest for analysis and reporting. Hunters use iSportsman to check in and out of the hunting units and to report their harvest from a smart phone or cell phone. In addition, the iSportsman portal allows the Conservation Law Enforcement Officer access to real time information on hunter participation and location on the installation, enhancing his effectiveness in enforcing USAG-P hunting regulations and facilitating hunter safety.

There are 9 different hunting permits that can be purchased through iSportsman: combo hunting permit (mammal and bird), $40.00; game mammal hunting permit, $25.00; game bird hunting permit, $25.00. 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 July 1st through June 30th.

During the reporting period, a total of 2,232 permits were sold or distributed. A total of $28,400.00 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 5.2.1 below).

The majority of the funds collected from permit fees will be spent on a home range/space use study of Erckel's francolin, and to renew the iSportsman web service contract in FY 2022. 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 take place to ensure their proper function and appearance to the hunting public. Vegetation control and maintenance of water storage/delivery systems are part of regular maintenance. Brush cutting and spot-spraying of 1.5% Roundup PowerMax herbicide (active ingredient glyphosate) was used to reduce fuel loads and to decrease the potential of fire in these parking areas.

5.2.2 Hunter Effort and Harvest

Game Mammal Harvest

During the reporting period, 29 days were available for mammal hunting with a total of 1,883 check-ins. Hunters harvested 809 mammals (Table 78).

Table 78. Game mammals harvested in the public hunting units at Pōhakuloa Training Area.

Game Mammal	Ahi	Humuʻula	KMA	Total
Feral pig	0	2	40	42
Wild sheep	304	124	247	675
Feral goat	27	1	64	92
Total				809

KMA, Keʻāmuku Maneuver Area

Game Bird Harvest

During the reporting period, 22 days were open for upland game bird hunting and there were 495 hunter check-ins. Hunters harvested 744 game birds representing 10 game species (Table 79).

Table 79. Game birds harvested in the public hunting units Pōhakuloa Training Area.

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 Francolin	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 distributions, abundance, and activity can help select areas to open for hunting and determine the amount of hunting pressure resources can support. However, animal populations and detectability vary over space and time and direct estimation of population numbers is often difficult and costly (Stephens et al. 2015). To address these concerns, we developed and tested new methods to estimate abundance of game species.

5.3.2 Mammals

Space to Event and Instantaneous Sampling

In practice, the best abundance estimator is one that generates sufficiently accurate and precise estimates to achieve project goals while optimizing for cost, time, and model complexity. Here, we focus on two recently developed remote camera analytical approaches that stand to satisfy those optimization criteria for abundance estimation. The space to event (STE) model and instantaneous sampling (IS) methods use time lapse photographs to estimate density and abundance of unmarked populations (Moeller et al. 2018). 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.

The use of time lapse photography in the STE and IS models carries two major benefits. The first is that it eliminates the need to collect data on - or calculate estimates of – animal movement rate because the time-lapse sampling methodology is entirely independent of these variables. This is beneficial because simulations have showed that incorrectly estimating movement (speed) causes linear bias in estimates derived using similar models (Loonam et al. 2021). The second is that it eliminates reliance on motion sensors, which introduce additional sources of uncertainty around detection probability and camera field of view (McIntyre et al. 2020). Essentially, timelapse photography gives practitioners more control over photographic data collection and reduces model complexity by removing an estimated parameter (movement). A trade-off is that perfect detection must be assumed. This is reasonable if the camera viewshed is properly measured and unobstructed, but it might come at the cost of using only pictures with animals a short distance away from the camera (Moeller et al. 2018). It is important to note that both methods are not equally at risk of violating perfect detection. Since the STE data collection is dictated by binomial (detection or non-detection) data and the IS method relies on counts, the perfect detection assumption is more likely to be violated for IS. For instance, if 4 animals are within a camera's normal field of view on a foggy day and only 2 individuals are visible to the camera, the data gathered from a photograph would be unbiased with respect to the STE model because presence is recorded regardless of the number of individuals. Conversely, bias would be introduced to the IS estimate because group size would be misrepresented as 2 instead of the true size, 4. Given the additional sources of variation and error, a more accurate and precise estimate is expected for the STE model than for IS.

The STE and IS methods assume independent animal movement, that camera placement is random and has no influence on animal behavior, and population closure (geographic and demographic). An additional assumption of the STE model is that animals follow a Poisson distribution at the spatial scale of the camera. Recent studies have demonstrated mixed outcomes for STE model and IS when assumptions are violated. (Loonam et al. 2021) applied the STE model to a low-density species and found that it was inconsistent from survey to survey and less accurate and precise compared to other camera sampling estimators that require movement data. The authors attributed the relative underperformance of the STE model to low sample sizes and non-random camera placement. Similarly, in a field application of the STE model and IS to a cryptic species, Amburgery et al. (2021) found that the use of lures influenced animal behavior to a degree that resulted in poor performance of both models. Conversely, a simulation study suggested that the STE model should be robust to the violation of independent movement and closure assumptions if cameras are randomly placed (Loonam et al. 2021).

The STE and IS methods showed encouraging results when applied to an elk (*Cervus canadensis*) population, but additional field testing was recommended in a scenario where true abundance is known (Moeller et al. 2018). Other studies have also highlighted the benefits of comparing empirical estimates from multiple estimators (Lonsinger et al. 2019; Gilbert et al. 2020; Palencia et al. 2021). We compared the STE model and IS to an independent estimate derived from aerial distance sampling conducted concurrently with camera sampling. The aerial estimate was used as a proxy for true abundance and was assumed to be reliable because distance sampling assumptions were met, and because a large portion (73%) of the study area was sampled.

Methods were applied to mouflon-domesticated hybrid sheep (*Ovis aries*, hereafter, sheep). The objectives of this study are to 1) provide empirical comparisons of mostly untested unmarked abundance estimators using remote cameras, and 2) identify a practical method for estimating sheep abundance to inform management at PTA.

Methods

Aerial Distance Sampling

Helicopter line transect distance sampling was conducted on 21 September 2020, following published methods (Buckland et al. 2001; Marques et al. 2006). A random location was used as a starting point to draw a linear transect. Nine systematic parallel transects were subsequently drawn at 1 km intervals, totaling 72 km in length (Figure 80). Two of the transects were bisected; one by the study area boundary and the other by an unfenced, culturally sensitive area where hunting is not allowed. The split lines were treated as independent transects to achieve the recommended number of at least 10 replicates (Buckland et al. 2001). The systematic design was adequate because the spacing did not coincide with a regular spatial feature that might be unrepresentative of the entire area (e.g., ridges, power lines, streams bottoms) (Buckland et al. 2001). The pilot followed transects traveling approximately 40 knots at 60–90 m elevation, while 2 observers watched for sheep on either side. Once sheep were spotted, the helicopter was flown to the location of initial sighting, and the location was recorded using GPS. If sheep were grouped, the location was recorded at the center of the group. One major assumption of distance sampling is that detections are independent, which is violated for grouped populations. To account for this, we defined the group as the object of interest and recorded group size to be included in modeling (Buckland et al. 2001). See below for further discussion of distance sampling assumptions. After sheep location, group size, and time were recorded, the helicopter returned to the transect and the process continued. The perpendicular distance from the transect to sheep location was retroactively calculated using GIS (2018 ArcGIS Desktop Release 10.6.1 ESRI, Redlands, CA).

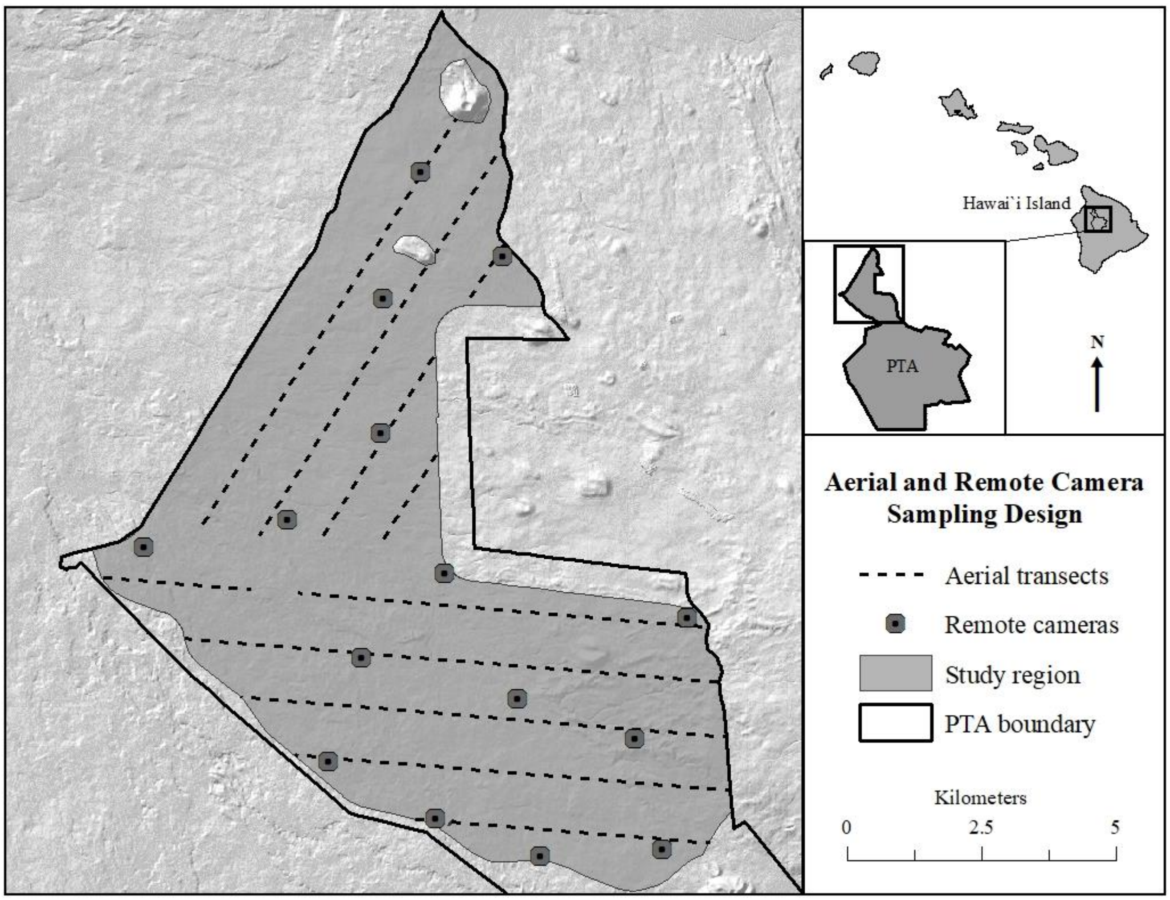

Figure 80. Sampling design for aerial and camera sampling. Dots indicate camera locations and dotted lines indicate aerial transects.

We used a common approach for detection function selection, where either the half normal or hazard rate key function is first selected using Akaike's information criterion (AIC) (Buckland et al. 2001; Miller et al. 2017a). A subsequent AIC selection process was completed with a model that included group size as a covariate. Detection function model fitting, goodness of fit tests, and AIC model selections were completed using the *dsm* (Miller et al. 2020) and *dplyr* (Wickham et al. 2021) packages in R (R Version 3.6.2, www.r-project.org, accessed 10 Jan 2021). To account for GPS observation error and error associated with sheep movement in response to the helicopter, all distances were pooled into

50 m bins for detection function model fitting. Such binning of data can lead to more robust density estimates. It is recommended to right truncate 5% of distance data to remove outliers and facilitate modeling (Buckland et al. 2001). A 450 m truncation distance was used, which amounted to a removal of 3.8% of the distance data.

There are 3 core assumptions that must be met to obtain reliable density estimates from line-transect distance sampling: 1) objects on the line are detected with certainty, 2) objects are detected at their initial location, and 3) measurements are exact (Buckland et al. 2001). Violation of assumption 1 was unlikely here because the study area was mostly open with few trees and dense cover, offering unobstructed views for the preponderance of the survey. As a further precaution, helicopter doors were detached so that observers could easily see areas directly below.

Assumption 2 was at risk of violation because sheep were aware of the helicopter and at times exhibited avoidance behavior, but the 50 m pooled distance histogram showed no distinct modes away from the origin, indicating that the binning of data was adequate to account for error that might have stemmed from avoidance behavior. In general, random movement of objects before detection generates positive bias in estimates of object density, but bias is small if object movement is slow relative to that of the observer (Hiby 1986; Buckland et al. 2001). Indeed, helicopter movement rate was many times that of sheep, and the direction of helicopter avoidance by sheep appeared random. Therefore, bias was likely minimal but positive if present in the aerial estimate.

Locations recorded with GPS have inherent error correlated with the number of satellites acquired to triangulate position, which is a potential violation of assumption 3. A helicopter distance sampling study (after which the present aerial survey was designed) reported that the assumption of no measurement error was reasonably well met when recording locations with GPS (Marques et al. 2006). The authors did note that any results obtained under a field trial should be carefully examined to ensure no erroneous generalizations are made. In the present study, observers took care to record GPS locations where sheep were initially seen and not their subsequent location if they fled.

There were 5 suspected occurrences where the same sheep were observed from 2 adjacent transects, and observers were vigilant to note those occurrences; however, the possibility of some unnoticed double counting of sheep is acknowledged. Double counting is not itself a cause of bias if such counts correspond to different units of counting effort (Buckland et al. 2001). Bias is likely to be small unless repeated counting is common during a survey, which was unlikely here because of the speed of the helicopter relative to sheep movement rate.

Camera Sampling

We followed the formulae and analytical methodology detailed in (Moeller et al. 2018). The STE and IS analyses were completed using the same set of photographs compiled from 15 cameras (Hyperfire2 (10), HC-600 (5), Reconyx, Holmen, Wisconsin, USA), deployed 12 September 2020–14 October 2020. The month-long sampling period was chosen based on a study that showed 4 weeks to be the optimal camera deployment time for IS, conducted in a region adjacent to the study area (Adams 2019). Cameras were placed randomly at least 2 km from one another to avoid spatial correlation of observations. Cameras were mounted on fence T-posts approximately 0.9 m high and were faced north to avoid sun glare, except for when topography was not conducive to sampling, in which case cameras were faced south.

Camera viewshed is defined as a circular sector of viewable area for each camera, calculated using camera lens angle and radius. It is important to accurately measure camera viewshed since it is used to estimate density and extrapolate to abundance. Natural landmarks can be used to demarcate camera viewshed radii, but we were hesitant to use that demarcation method because of the potential difficulty to accurately distinguish naturally occurring objects in pictures. Given the importance of camera viewshed measurement, we standardized the radius at 40 m for each camera and manually secured brightly painted PVC pipe reference markers at approximately 0° and 40 m relative to camera lenses. Camera lens angle differed between the Hyperfire2 and HC-600 models (37.7° and 42° respectively). The camera viewshed was significantly diminished and highly variable during nocturnal hours; therefore, pictures taken from 18:00 to 06:00 were not included in the analysis. Cameras were programmed to take a photograph every 30 minutes regardless of sheep presence. Based on manual review of the pictures, the 30-minute interval was an adequate period between sampling occasions to allow animals to redistribute across the landscape; however, there were rare instances where it was difficult to determine whether an individual appeared in sequential photographs. Frequent double counting of animals would result in a high-biased estimate, but there was no evidence for that here, and all sheep pictured in the camera viewsheds were used in analyses.

For the STE analysis, Timelapse software was used to record whether a sheep was detected or not detected at each camera for each sampling occasion (Timelapse version 2.2.3.6, Greenburg 2020). Cameras were randomly compiled into a list, which was used to determine the first camera that detected sheep for each 30-minute interval. The encounter history, sampling occasions, camera viewsheds, and number of cameras were used to estimate density, which was extrapolated to an abundance estimate by multiplying by the size of the study area. For IS, Timelapse software was also used to tally and record the number of sheep detected at each camera for each sampling occasion. A mean count over temporal and spatial replicates was used to estimate density, which was extrapolated to an abundance estimate by multiplying by the size of the study area. Space to event and IS estimates were both calculated using the *spaceNtime* package (Moeller 2021) in R.

To test for statistical differences, we compared 95% lognormal confidence intervals (CI) for each population estimate and determined whether they overlapped. Estimates were considered significantly different if there was no overlap of CIs. Lognormal CIs were used to eliminate the possibility of negative lower bounds. The CI for the aerial estimate was calculated using the *dsm* (Miller et al. 2020) package in R via the delta method (Marques and Buckland 2004). The CIs for the camera estimates were computed using the *spaceNtime* (Moeller 2021) package in R. The variance calculations needed to derive these CIs also rely on likelihood theory and the delta method (Moeller et al. 2018).

Population Closure Assumptions

The assumption of demographic and geographic closure was well met for aerial distance sampling because of the short sampling period. The risk of violating closure assumptions was higher for the STE and IS methods because of the longer sampling period, though it is important to note that since these models estimate average abundance through time, they should be less sensitive to changes in density during prolonged sampling periods (Loonam et al. 2021). No hunting occurred during the sampling period and the risk of predation was very low. Feral dogs have been known to depredate sheep on the island; however, there was no photographic evidence of dogs, nor were any directly observed. A study of sheep in an abutting area showed annual survival to be high with 92% (*n* = 41) in 2017 and 93% (*n* = 48) in 2018 (Adams 2019), suggesting a low probability of mortality during the sampling period for the present study. There are no data for the seasonality of sheep reproduction at PTA, but it likely takes place all year (I.A. Cole, Hawaiʻi Department of Land and Natural Resources Division of Forestry and Wildlife, personal communication).

Geographic closure was at risk of violation because there were no barriers to the boundary of the study area. However, sheep mean home range was shown to be relatively small in the abutting area mentioned above, 9.81 km^2 (SE=1, *n* = 47) (Adams 2019). Closure assumptions are less likely to be violated with a population that has a small mean home range relative to the study area, and evidence suggests that mean home range for this population is relatively small, about 10% of the study area. The issue of failing to meet geographic closure lies with individuals that traverse study area boundaries. It has been shown that completely random movement in and out of a study area does not introduce bias to some capture-recapture estimators from closed-population methods (Kendall 1999). Considering the lack of predators and general aseasonality of the region, there is no compelling reason to assume non-random movement across study area boundaries. Potential sources of bias from minor violations in closure assumptions are acknowledged but unlikely to be of consequence here.

Results

Observed sheep included in the aerial analysis totaled 802, spotted mostly in groups ($\bar{x}$ = 10, SE = 1.17, *n* = 78). The half normal key function was selected in the initial half normal vs. hazard rate AIC analysis. The subsequent AIC analysis included the half normal model and a half normal model with group size added as a covariate; the latter model was top ranked, while the former had an AIC of 4.9. The top-ranked model showed no evidence of lack of fit (Cramer-von Mises test, test statistic = 0.09, P-value = 0.63) and estimated sheep abundance to be 1156 (SE = 153.8, 95% CI = 873–1533).

The STE and IS estimators are valid under the assumption that animals move independently. Though it is known that sheep at PTA are social and move in groups, most pictures with animals had 1 or 2 per group, suggesting independence. A total of 156 sheep were pictured in 66 of 825 sampling occasions. The STE model estimated abundance to be 916 (SE = 112.8, 95% CI = 721–1166) and IS estimated abundance to be 2065 (SE = 606.1, 95% CI = 1175–3627). Overlapping CIs provided insufficient evidence for statistical differences among the 3 estimates (Figure 81).

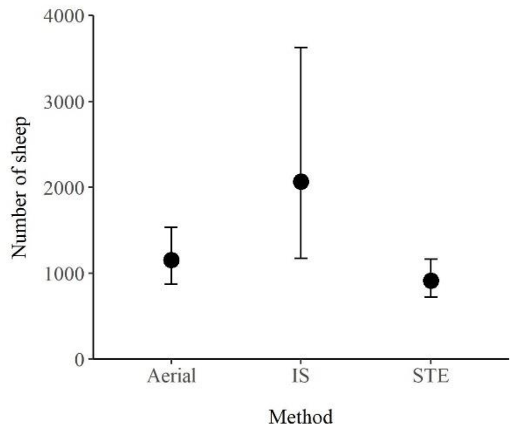

Figure 81. Comparison of estimates derived from aerial distance sampling, instantaneous sampling (IS), and the space to event model (STE). Error bars indicate 95% confidence intervals.

<u>**Discussion**</u>

Diagnostics of the aerial distance sampling analysis were favorable. The adequate model fit, low degree of assumption violation, and large sampling area relative to study area all contributed to the credibility of that estimate as a proxy for true abundance and standard of comparison for the camera estimates. Despite the lack of significant difference among estimates, the IS point estimate was well outside the CI for the aerial estimate and was considerably imprecise. Conversely, the STE point estimate fell within the CI for the aerial estimate and was relatively precise, suggesting the STE model to be more reliable than IS.

Two core assumptions of the STE model are that animals are Poission-distributed at the camera level and that animals within camera viewsheds are detected perfectly when photographed. It is still unclear how robust the STE model is to violation of the former, though simulations showed the model to be robust to variations in movement and density (Moeller et al. 2018). The STE estimate was contained by the CI of the aerial estimate suggesting that the model is robust to violation or that the assumption was not violated in this study. It is likely that the latter assumption was well met because only clear, well-lit daytime photos were used in the analysis. In most photographs, animals were clearly either inside or outside of the camera viewshed because of the precautions taken to eliminate error associated with camera viewshed measurement. However, this determination was difficult for a few photographs that pictured sheep in the corners of the camera viewshed, at the 40 m boundary on the outer edges. It is recommended that markers be placed at the edges of the viewshed in addition to the marker at 0° to better meet the perfect detection assumption. For example, in the case of a camera with a 42° viewshed, 40 m markers should be placed near 0°, 21°, and 339°. The open terrain of the study area contributed to perfect detection because there were limited obstructions that might conceal sheep within camera viewsheds.

The STE results are consistent with the elk case study; the estimate was lower than that of the aerial (Moeller et al. 2018). This could be in part because the STE model does not integrate group size information into the estimate. Though a histogram of group size from picture data showed most groups to contain 1 or 2 sheep, the group sizes recorded during aerial sampling averaged 10. Elk are also known to be a social species and it is possible that the assumption of independent movement was violated to a degree that resulted in underestimation in both studies. Careful consideration should be taken by managers who attempt to apply the STE method to social species.

Despite the lack of significant difference, the potential positive bias in the aerial estimate and the relatively wide CI of the IS estimate make the similarity of estimates ambiguous. The IS estimator would likely be an unreliable tool for management at PTA because high uncertainty is not conducive to measuring population trends. Further, underestimation carries less risk than overestimation in the context of adaptive management of harvested populations because overestimation could lead to overharvest. We recognize that overharvest would not necessarily be an issue at first given that one management goal is to relieve browsing pressure on sensitive plant species, but overharvest might become a concern if sheep populations are controlled at lower levels. These results partly align with the elk case study that showed the estimate from IS to have the widest CI but the lowest point estimate of the 4 compared (Moeller et al. 2018).

Management Implications

Camera sampling was approximately 3 times as expensive as aerial sampling because of the up-front cost of the cameras. Further analysis showed that camera sampling would be less expensive if the area were resurveyed 3 or more times. Given that sheep abundance must be estimated annually and in 2 additional hunting units at PTA, camera sampling quickly becomes the more affordable option. Sampling with cameras has the added benefit of improved safety for observers.

Another practical benefit of camera sampling (STE method), although perhaps not for very large areas, was that the entire estimation process could be completed by 1 person. The field work is straightforward and the associated R package (Moeller 2021) facilitates a streamlined, reproducible analytical process, making STE estimation ideal for integration into Standard Operating Procedures (SOPs). Such SOPs are very useful for project continuity, which results in a higher probability of consistently estimating abundance and thus successful management. It is recommended that the STE method continue to be implemented by the game management program at PTA with the specific goal of measuring sheep population response to adaptive management, thereby promoting controlled harvest of sheep and the conservation of ESA-listed plant species endemic to Hawaiʻi.

5.3.3 Game Birds

Introduction

The sustainable management of game species requires the monitoring of survival and population density, but managers should also understand how environmental factors influence those parameters. Though there are many nuances to the study of habitat loss, it is well understood that on balance, the degradation of habitat can pose a major threat to animal communities (Johnson 2007; Buchmann et al. 2013). Therefore, it is in the best interest of managers to determine factors that impact habitat, and to understand how those impacts correlate to population density. Here, we utilize unpublished information gathered by CEMML over the course of 17 years and across several different projects to estimate game bird population trends and to investigate whether habitat degradation from ungulate overbrowsing negatively correlates with those trends.

PTA harbors 20 ESA-listed plant species that are primarily threatened by wildland fire and non-native ungulate browsing. In a 2003 BO delivered by the USFWS, the Army was federally mandated to build ungulate proof fencing units around areas with TES and to eradicate ungulates inside of the fence units. Prior to the fence construction in 2003, a bird monitoring project was initiated in 3 regions of the installation; 2 of the regions were fenced and eradicated of ungulates in 2013 and 2017, and 1 region was not fenced. Ungulate density in the unfenced region is high (B.T. Leo, unpublished data).

Preliminary analysis of the bird point count data revealed that there was sufficient data to warrant analysis for only 1 game bird species, Erckel's francolin, a non-native partridge introduced to Hawaiʻi in the late 1950s and early 1960s (Duff and Lepczyk 2021). This dataset was used to estimate population trends within a Bayesian framework for each region. We compared long-term and short-term population trends within and among study regions and speculated on the effect of ungulate browsing on bird density.

In addition to ungulate presence, we considered the effect of precipitation on game bird density. A drought occurred in Hawaiʻi in the years leading up to 2012, which likely had an impact on Erckel's francolin food and cover resources. If a correlation is observed, precipitation data could be used as an indicator for population health and therefore be useful when making management decisions.

The objectives of this section are as follows: 1) estimate annual density indices, long-term (2003–2020) population trends, and short-term (2011-2020) population trends of Erckel's francolin in 3 separate regions; 2) compare trends found in fenced vs. non-fenced regions to infer effect of ungulate presence on bird density; 3) determine whether there is a correlation in precipitation and bird density. This information will be useful in a management context at PTA because ungulate species are also a game species managed by PTA; if these objectives are met, the information can be used to adjust the harvest of ungulates in unfenced regions to optimize the densities of bird and ungulate game species.

Methods

The 3 study regions were classified into 6 cover types by CEMML with data collected in 2011 and 2012, using the sampling methodology of the National Park Service in its vegetation mapping program on Hawaiʻi (Cogan and Kudray 2009; Lea 2011; Block et al. 2013). We refer to the regions as M, P and T; the P and T regions consist mostly of woodlands and the M region mostly shrubland (Figure 82, Table 80). Common species in woodland include *Metrosideros polymorpha*, *Myoporum sandwicense* and *Sophora chrysophylla.* In shrublands, common woody species associates include *Chenopodium oahuense*, *Styphelia tameiameiae*, *Vaccinium reticulatum*, *Sida fallax*, *Coprosma montana*, *Osteomeles anthyllidifolia, Coprosma ernodeoides* and shrub-stature and tree-stature *Myoporum* *sandwicense* and *Sophora chrysophylla*. Dominant herbaceous species include *Cenchrus setaceus*, *Senecio madagascariensis*, *Eragrostis atropioides*, *Lepidium africanum*, *Melinis repens*, and *Eragrostis leptophylla*.

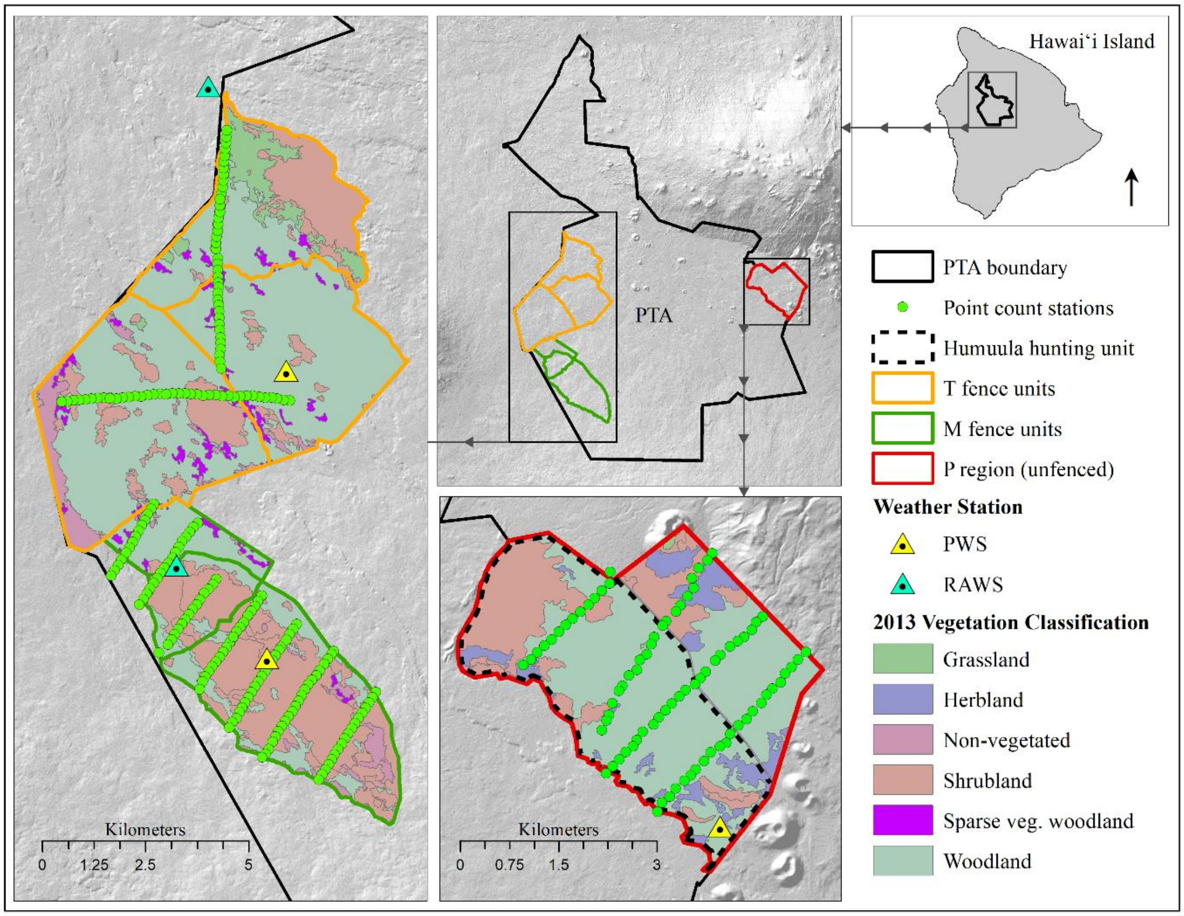

Figure 82. Layout of variable circular plot transects at Pōhakuloa Training Area, 2003–2020. Dots indicate survey locations, triangles indicate weather stations, and colored lines indicate study regions.

Precipitation data from 2003–2012 were obtained from Western Regional Climate Center's Wildland Fire Remote Automated Weather Stations (RAWS) in the M and T regions. One RAWS was located within the M region, and one RAWS was located approximately 1.1 km north of the northernmost T region point count survey location (Figure 82). No RAWS data were available in the P region during the 2003-2012 period, and no data were available in any region in 2013. In 2014, CEMML installed permanent weather stations (PWS) inside the three regions; precipitation data collected from those weather stations were used for analysis in years 2014–2020.

Table 80. Percent vegetation classification in study regions M, P, and T, as determined by the Center for Environmental Management of Military Lands at Pōhakuloa Training Area, November 2013.

	Region		
Vegetation Classification	**M**	**P**	**T**
Woodland	32.40%	63.24%	67.96%
Shrubland	60.33%	24.72%	17.96%
Sparsely vegetated herbland areas	5.43%	0.29%	4.82%
Sparsely vegetated woodland	1.83%	0.00%	3.39%
Grassland	0.00%	0.31%	5.87%
Herbland	0.00%	10.84%	0.00%
Saddle Road	0.00%	0.55%	0.00%
Unknown	0.00%	0.05%	0.00%

Ungulate Removal

In 1999–2010, 314 ungulates were removed from the M region and that region was declared ungulate free in 2011. In Region T, 1,970 ungulates were removed from 2010–2016 and that region was declared ungulate free in 2017. Fence units were regularly monitored for ungulate ingress after eradication. Region P was not fenced and a recent study using camera sampling and space to event modeling showed that ungulate density is high there (Table 81) (Moeller et al. 2018) (B.T. Leo, unpublished data).

Table 81. Sheep density (per km^2) ($\widehat{D}$) and abundance ($\widehat{N}$) calculated using camera sampling and space to event models in the P study region at Pōhakuloa Training Area in 2019 and 2020.

Year	$\widehat{D}$	$\widehat{N}$	SE	LCL	UCL
2019	28	327	46	237	417
2020	40	471	55	363	579

Game Bird Hunting

One major difference between the regions is that the P region was subject to the public hunting of game birds during and prior to the study period, while the M region has never been hunted, and the T region had moderate levels of hunting until about 2010 when fence construction began (L.D. Schnell, personal communication). The P region is located on land that is leased by the Army from the State of Hawaiʻi. As such, any hunting activity conducted in that region is regulated by the State of Hawaiʻi, including a limited hunting season (November–January) and daily bag limits. Potential effects of hunting on the analyses are discussed below.

Bird Sampling

Point count distance sampling can be problematic when applied to game bird species. Erckel's francolin are cryptic and often hidden, which precludes visual survey. Counting based on vocalization also presents challenges. If males disproportionately emit territorial calls and the sex ratio is unknown, it must be assumed to be 1:1. Further, determining observer-to-bird distance based on call alone is difficult because calls are emitted at relatively high volumes and can travel long distances. Here, analytical measures are applied to partially account for observer-to-bird error; but due to these potential biases, the estimates reported are considered density indices, not point estimates. Despite these shortcomings, the calculated index should be useful for trend analysis because the survey methodology was consistent across years. As such, annual estimates should not be biased relative to one another.

Annual bird surveys were conducted during the non-breeding season in December and January, 2003–2020 (CEMML 2020b). The variable circular plot method was used with a 6 minute window, following published methodology for Hawaiian forest birds (Reynolds et al. 1980; Scott et al. 1984). The M, P, and T regions were surveyed (Figure 82). The M survey locations are arranged in 7 parallel transects consisting of 126 counting stations. The T survey locations are arranged in two perpendicular transects consisting of 78 stations. The P survey locations are arranged in 4 parallel transects consisting of 84 stations that partially overlap a game bird and ungulate hunting unit, called Humuʻula (Figure 82).

Detection function model fitting, goodness of fit tests, and AIC model selections were completed using the *dsm* (Miller et al. 2020) and *dplyr* (Wickham et al. 2021) packages in R (R Version 3.6.2, www.r-project.org, accessed 10 Jan 2021). It is recommended to right truncate 5% of distance data to remove outliers and facilitate modeling (Buckland et al. 2001). Distance data were right truncated at 300 m, leaving 2,479 observations, amounting to a data truncation of 9.2%. To reduce bias associated with imperfect observer to bird distances measurements, distances were binned into six distance class groups, bounded at 0, 25, 50, 100, 150, 200, and 300 m. Data binning relaxes the distance accuracy assumption, as long as observations are placed in the correct interval (Buckland et al. 2001; Rosenstock et al. 2002)

To facilitate model robustness, data were pooled across years and an AIC model selection process was conducted to select the key detection function, which was used to fit 3 additional models to the data: a null model and 2 others that included covariates (minutes after sunrise and observer)(Buckland et al. 2001; Miller et al. 2017b). A final AIC model selection analysis was completed, and the top-ranked model was used to calculate annual density. It is not recommended to attempt detection function model fitting with sparse data, therefore, we did not calculate density for years with < 50 observations (Buckland et al. 2001).

Trend Estimation and Assessment

We estimated trend within a Bayesian framework, following previously published methods used to estimate trends of Hawaiian forest bird species using point count data on the Big Island (Camp et al. 2010). We fitted log link regression models in JAGS using the *rjags* package within R (Plummer 2019; R Core Team 2020). Uninformative normal priors were used for α (intercept) and β (slope) parameters; and an uninformative gamma prior was given for τ ($variance^{-1}$). Long term trends were centered on 2011 (2003–2020) and short-term trends were centered on 2016 (2011–2020). A burn in period of

10,000 iterations was used for 3 chains consisting of 50,000 iterations each, totaling 150,000 pooled samples.

The benefit of a Bayesian approach in this context is that it allows for the detection of ecologically relevant trends when variability is high (Wade 2000). Here, an ecologically relevant trend is defined as a 50% change over the examined period (17 years long term or 9 years short term). With this criterion, long (β_l) and short (β_s) term trends were classified as the following: an ecologically meaningful decrease if $\beta_l < -0.0433$ and $\beta_s < -0.07702$; ecologically negligible if $-0.0433 < \beta_l < 0.02385$ and $-0.07702 < \beta_s < 0.0451$; and an ecologically meaningful increase if $\beta_l > 0.02385$, and $\beta_s < 0.0451$. (Camp et al. 2008).

To classify the strength of the observed trends, β's were assigned a posterior probability (*P*), by integrating the posterior distribution over the composite hypothetical β's, limited at the thresholds listed above. The resulting probabilities were classified into four classes based on the ratio of the posterior odds to the prior odds, also known as the Bayes factor: very weak if $P < 0.1$, weak if $0.1 \le P < 0.7$, strong if $0.7 \le P < 0.9$, and very strong if $P \ge 0.9$. (Wade 2000; Camp et al. 2010).

The relationship between precipitation and annual bird density was modeled using linear regression in R. Precipitation data were unavailable in the P region from 2003 to 2013 and was therefore not included in that analysis.

Results

Density indices were estimated for 14 years within the period of 2003–2020 because there were 3 years with insufficient data for detection function model fitting (Buckland et al. 2001). The preponderance of detections were auditory (99%) but 1% of detections were visual. The initial AIC analysis showed hazard rate to out-rank the half normal with a difference in AIC score of 358. In the second AIC analysis, hazard rate with observer added as a covariate was top ranked. Goodness of fit could not be calculated because the modeling of binned distances with a categorical covariate limited the availability of degrees of freedom; however, visual inspections of the model showed adequate fit. For an additional check for lack of fit, we ran a goodness of fit test without binning the data, and the test showed no evidence for lack of fit (Cramer-von Mises test statistic = 0.26, p-value = 0.18) therefore, each year was modeled with hazard rate detection function and observer added as a covariate.

In the M region, Bayes factors showed strong evidence for an ecologically negligible long-term trend, and very strong evidence for an ecologically meaningful increase in short term trend. In the P region, Bayes factors showed very strong evidence for an ecologically meaningful decrease for both long- and short-term time periods. There was weak evidence for ecologically negligible and meaningful increasing trends during both periods in the T region (Figure 83, Table 82).

Annual density estimates and annual precipitation showed positive linear correlations in the M (F = 14.61, p-value = 0.002, df = 12, $R^2 = 0.55$) and T (F = 11.05, p-value < 0.001, df = 12, $R^2 = 0.47$) regions.

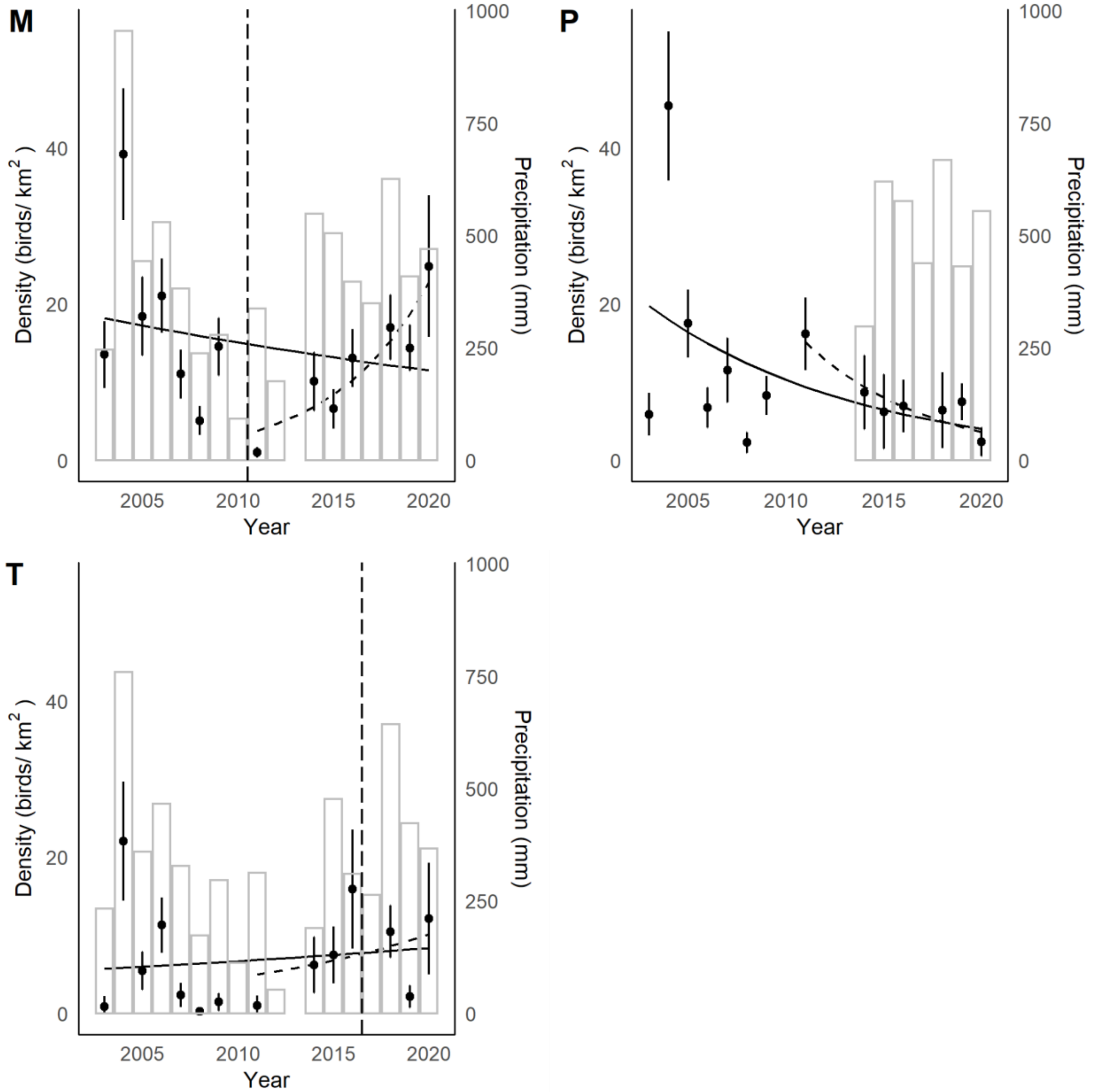

Figure 83. Density estimates of Erckel's francolin in three regions of Pōhakuloa Training Area, 2003–2020. The bold letter in the upper left of each plot indicates region[a].

[a] Black points indicate annual density estimates with standard error bars. Solid black line is the long-term density trend (2003–2020), dashed trendline is the short-term density trend (2011–2020), and the vertical dashed line in the M and T plots indicate when the region was declared ungulate free. Grey bars indicate annual precipitation.

Table 82. Erckel's francolin density trends estimated within a Bayesian framework using a log-link linear regression[a].

				Posterior probability		
Region	**Time period**	**β**	**95% Credible Interval**	**$\beta < \phi_l$**	**$\phi_l < \beta < \phi_u$**	**$\beta > \phi_u$**
M	03-20	-0.025	(-0.05, -0.01)	0.05	**0.95**	0
	11-20	0.200	(0.14, 0.27)	0	0	**1**
P	03-20	-0.093	(-0.12, -0.066)	**1**	0	0
	11-20	-0.159	(-0.234, -0.091)	0**.99**	0.01	0
T	03-20	0.022	(-0.01, 0.056)	0	0.54	0.46
	11-20	0.043	(-0.025 0.118)	0	0.52	0.48

[a] β is slope and ϕ's are thresholds for ecological meaningfulness: $\beta < \phi_l$ is ecologically meaningful decrease, $\phi_l < \beta < \phi_u$ is ecologically negligible, and $\beta > \phi_u$ is ecologically meaningful increase. Posterior probabilities were calculated by integrating composite β's limited at ϕ's. Bolded values indicate very strong trends, as determined using Bayes factors.

Discussion

Examination of the point count distance histogram revealed that common detection functions fit auditory data well, despite the previously discussed problems with auditory data for game birds. Likewise, sampling diagnostics of the Bayesian model were favorable, suggesting that auditory data could be continued to be used as an index for monitoring Erckel's francolin population trend.

A notable result of the trend analysis was the difference in short term trends between the fenced and non-fenced regions. Trends were either increasing or ecologically negligible in the fenced regions and decreasing in the non-fenced region. The difference in short term trends between the M and P regions is particularly remarkable given the strong probability (1 and .99, respectively) of those estimates.

A major difference between regions that must be considered is that the P region has been subject to annual bird hunting pressure since at least 1998, while the M region has never been hunted. This factor no doubt contributed to the observed differences in trend between the M and P regions, but to what degree is uncertain. The hunting conducted in that region is regulated by the State of Hawaiʻi, including a limited 3-month hunting season and daily bag limits, but it is unknown whether those limitations are sustainable for the bird populations at PTA. The regulations for the region are in line with other state managed hunting areas that maintain sustainably harvested game bird populations, suggesting that hunting in the P region is not solely responsible for the sustained decline of Erckel's francolin density. It is also worth mentioning that only a portion of the P region has been open for hunting since 2018, covering 69% of the area, leaving the other 31% to effectively act as a hunting refuge (Figure 82). In addition, a portion of the non-hunted area was also fenced circa 2015 and ungulate density is considerably lower in the fenced region.

The correlation between density and rainfall suggests that drier conditions in the years leading up to 2013 could in part explain the lower bird densities around that period. Erckel's francolin forage on seeds, leaves, and flower heads, and game birds require vegetative cover for protection from harsh environmental conditions and predators (USAG-P Natural Resources Program, unpublished data)

(Schwarz and Schwarz 1949). Fewer foraging opportunities and increased environmental exposure could have resulted in higher mortality or immigration to higher quality habitat.

It is interesting that bird density declined in all three regions during the same drought period, but it was only in the regions where ungulates were removed (or in the case of the T region, in the process of being removed) that showed signs of recovery. One explanation could be that during the post drought period food and cover resources could regenerate in the ungulate free regions, while ungulate browsing in the unfenced region prohibited regeneration, preventing bird densities from rebounding there.

The browsing pressure in the P region is obvious, with denuded vegetation below a distinct browse line. The visible destruction of vegetation offers reasonable evidence to speculate that ungulate browsing negatively affects game bird habitat, but a recent study of game bird diet offered compelling data suggesting that browsing had a direct effect on Erckel's francolin foraging habits. The study showed that in the P region, seed from *Urtica urens* (a nettle) made up the highest percentage (34%, n = 40) of food type (by wet mass) in Erckel's francolin crops, with the second highest being a grass seed (12.8 %) (USAG-P Natural Resources Program, unpublished data). *Urtica urens* is one of the few food plants that ungulates might avoid because of their stinging defense. Stinging hairs found on nettles act as an effective herbivore deterrent, which is why they are frequently observed as pasture weeds across different taxa and geographical zones (Ensikat et al. 2021). Though it is not known whether Erckel's francolin would select *Urtica urens* seed as a primary food source regardless of availability, it could be possible that nettle seeds were found to be the primary food component in Erckel's francolin crops because that is what is most available, but not necessarily because it is the most nutritious. Indeed, in the same unpublished study *Urtica urens* appeared in 0 out of 23 Erckel's francolin crops that were collected in another region with a 75% lower ungulate density; however, further inquiry is needed to support any claim that a change in Erckel's francolin forage food availability affects survival.

Other factors besides precipitation and over-browsing are no doubt at play. The P region is relatively near the installation cantonment area, which supports a feral cat population. It is possible that cantonment area acts as a source population, contributing to a higher cat density relative to the M and T regions. It is known from game camera photos that cats are present in the P region. It is not known to what extent feral cats predate Erckel's francolin, however it should not be overlooked as a contributing factor to bird density decline.

Though it is difficult to definitively identify the reason for the difference in observed population trends between the regions, the data give little doubt that a difference exists. Therefore, it is in the best interest of the game management program to take action that will increase Erckel's francolin density in the P region. The results presented here suggest that ungulate harvest should be increased in the P region while simultaneously monitoring the density of both ungulates and game birds. Precipitation should also be monitored, and more conservative harvest limits should be considered in drought years. It is recommended that a bird hunting moratorium be placed in the P region until densities recover. The simultaneous moratorium of bird hunting and increase in ungulate removal could make it difficult to determine the degree to which each influences bird density; however, if bird density positively responds to the proposed management action, it would provide further evidence for the existence of each factor's influence and warrant further effort to disentangle their effects.

5.3.4 Game Bird Diet and Toxicology

The impacts of game birds to native plants, especially ESA-listed plants, is not well-understood and is poorly documented. Some researchers suggest that game birds are beneficial to native plants as seed dispersers (Cole et al. 1995). However, recent field-based observations suggest that game birds may negative affect native plants through physical disturbance (Dr. Christina Liang, personal communication, 2018) and selective feeding (Dr. Susan Cordell, personal communication, 2018). We documented an Erckel's francolin positioned near the endangered *Schiedea hawaiiensis* proximate to what appear to be clipped branches. To address the knowledge gap of whether game birds have a positive or negative impact on native fauna, we conducted a game bird diet study in November 2019. We sought to determine whether game birds facilitate the spread of exotic seeds to contribute to the INRMP objective of preserving ESA-listed plant species. This information could then be used to manage game bird densities in TES-sensitive areas, or to manage game bird habitat in a way that could enhance their availability as a game species if it is deemed appropriate to do so.

Another aspect we investigated was whether game birds ingest toxic plants on Hawaiʻi. The invasive fireweed (*Senecio madagascariensis*) has been implicated in poisoning livestock on Hawaiʻi (Gardner et al. 2006). Alkaloids like those found in fireweed have been shown to be toxic to California white chicks; therefore we hypothesize that fireweed might be toxic to game birds if ingested (Brown et al. 2016). A diet analysis would help us take the first step towards understanding if toxic plants are regularly consumed by game species, and whether they have negative impact on birds.

The objectives of this study aim to investigate the ecological implications of game bird foraging habits at PTA. Specifically, we aimed to 1) identify preferred food types of 4 species of game bird and determine if preferred food type varies by season or bird species, 2) determine germination viability of seeds from game bird fecal samples, and 3) calculate a game bird Body Condition Index (BCI) and compare with liver toxicity levels to determine if toxic plants have a negative impact on bird health.

<u>Methods</u>

Birds were opportunistically sampled in three regions that vary by vegetation and elevation: Humuʻula, Ahi, and KMA hunting units (Figure 84). Specimens were collected in two phases. The first phase involved the collection of birds with the help of public hunter volunteers. Hunter-submitted specimens were collected by setting up collection stations during the hunting season (November–January). As hunters checked out of the hunting areas, they had the option to submit their harvested birds for data collection, which involved taking the measurements detailed below. The second was the scientific collection phase, which is covered under Hawaiʻi State issued permits WL19-43 and WL20-12 and occurred during the public hunting off-season. Specimens obtained from both volunteer hunter birds and collected under permits were pooled into a single dataset for analysis.

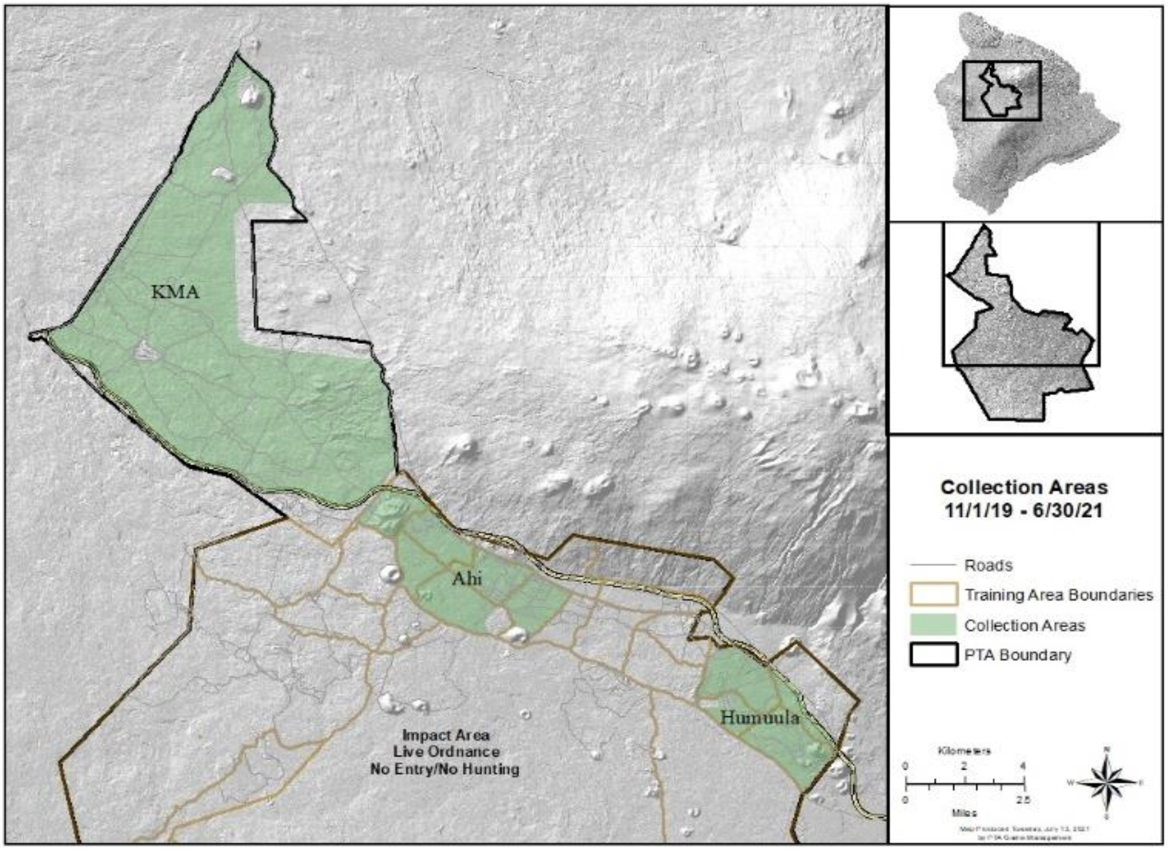

Figure 84. Scientific collection areas at Pōhakuloa Training Area, 2019-2021.

Under permits, game birds were collected lethally with a 12 ga. shotgun (Benelli, Model# 10861) in designated hunting areas at PTA. The PTA Game Manager, coordinated with PTA Command and Range Control to secure approval for use of a firearm in this capacity. This type of sampling was chosen because it is a direct collection technique that can be replicated, free of cost, when public hunters volunteer to donate birds harvested as part of the normal public hunting process. Also, lethal collection must occur to obtain liver samples, which are necessary for the histological analysis. For each specimen collected under this permit, crops and livers were removed, measurements taken, and carcasses were subsequently returned to the area of harvest.

Bird livers and crops were extracted after harvest. Crop contents were removed, identified to lowest possible taxonomic rank, and wet mass was measured using a digital scale (NEWACALOX, 8068-series). Relative percent wet mass was also calculated for each food item (Barnett and Crawford 1994). Overall frequency of occurrence was obtained by dividing the number of crops in which each food type was present by the total number of crops examined. Measurements were recoded for culmen, tarsus (150mm SPI plastic dial calipers, Avinet, model 31-415-3) and wing chord (60cm wing ruler, Avinet, WING60UW). A variety of different scales were used to measure mass (1000g, 2500g, 5kg Pensola, 50kg Electric EBalance) depending on species.

Liver samples were frozen and sent to Dale Gardner and Bryan Stegelmeier at the USDA Poisonous Plant Research Laboratory (PPRL) for chemical and histological analysis. In addition to frozen liver samples, a portion of the liver was stored and sent in 10% Neutral Buffered Formalin. Upon arrival at PPRL, crop samples were freeze dried, ground, and analyzed for toxins using procedures previous published for toxin detection (Gardner et al. 2006). Liver samples were also freeze dried and analyzed for PA metabolites using previously published procedures (Brown et al. 2016).

Fecal samples were extracted from collected birds by applying ventral pressure above the cloaca. Species and area harvested were recorded, and samples were placed in 100 cm^2 gardening pots no deeper than 1 cm from the surface of sterile, evenly mixed perlite (Expanded perlite #3, Wilkin Mining and Trucking Inc.) and professional growing mix (Sunshine aggregate plus # 4, Sun Gro Horticulture). We used 1 pot per species per area and placed them in the RPPF. An automatic sprinkler system watered the pots 3 times a week for approximately 5 minutes. Pots were monitored weekly, and plants were removed once identified.

Crop content and diet preference were analyzed using a baseline-category logit model. Baseline-category logit models can investigate the effects of multiple variables on primary food type (Agresti 2013). The nominal response variable was primary food type, determined by wet mass found in crop contents. Since the data were sparse, we only considered two predictor variables: bird species and season. Food categories included seed, vegetation, flower head, fruit, and invertebrate.

To determine whether there is a correlation between toxic plant consumption and liver toxicity levels, a negative binomial or logistic regression will be used with a binomial response variable (yes/no if fireweed was found in the crop), and continuous independent variable (liver toxin levels measured as micro grams of Pyrrolizidine alkaloids). This portion of the study is not yet complete and will commence once the histological analysis is completed by USDA.

To determine if toxicity level is correlated with bird health, a regression analysis (linear, polynomial, etc.) will be calculated using a morphometric Body Condition Index (BCI). It is common practice to use percent body fat as a direct index for body condition; however, percent body fat is very difficult to measure. Here, several morphometric measurements were used to determine a BCI. We chose not to use body mass alone as a proxy because body mass is often not just a measure of body fat, but also one of many possible measures of size. We ran a principal components analysis using culmen length, tarsus length, and wing chord for each species and calculated a regression on body mass and the first principal component. The BCI was then calculated as the standardized residual of actual body mass from the value predicted by the regression equation (Labocha and Hayes 2012). The resulting BCI should theoretically be unbiased regardless of average adult species body size. Birds with low BCIs will be identified to determine whether BCIs showed any correlation with toxic plant density, crop content, or liver toxin levels.

Results

We collected 126 birds from public hunters from November 2019–January 2020 and November 2020–January 2021 (Table 83). We collected 99 birds under scientific collection permits from March 2020–July 2020 and April 2021–June 2021. Eight birds were collected that did not have crop contents; therefore, 217 bird crops were available for crop content analysis.

Table 83. Fifteen most common diet items for California quail, Erckel's francolin, ring-necked pheasant, and wild turkey, ranked mean percentage of total crop contents by mass for each species. Frequency indicates the percent occurrence of total crops sampled for that species.

Francolin (n = 90)				Pheasant (n = 45)			
Species	**Type**	**Percentage of Diet**	**Frequency**	**Species**	**Type**	**Percentage of Diet**	**Frequency**
Urtica urens	seed	13.72	11.70	*Neonotonia wightii*	vegetation	54.38	41.67
Bromus catharticus	grass seed	8.17	13.83	*Vicia sativa*	seed	16.08	22.92
Dubautia linearis	vegetation	7.97	8.51	*Medicago lupulina*	vegetation	9.20	22.92
Vicia sativa	seed	6.96	6.38	*Vicia sativa*	vegetation	6.76	27.08
Medicago lupulina	vegetation	5.58	25.53	*Medicago lupulina*	seed	5.48	8.33
Vicia hirsuta	seed	4.63	3.19	*solanum americanum*	fruit	1.90	2.08
Dubautia?	seed	4.48	1.06	*Neonotonia wightii*	seed	1.52	12.50
invert	invert	3.70	10.64	*Vicia hirsuta*	seed	0.91	2.08
Solanum americanum	fruit	3.57	5.32	*Wahlenbergia gracilis*	flower head	0.54	4.17
Wahlenbergia gracilis	flower head	3.51	5.32	grit	grit	0.52	4.17
Unk	seed	3.20	5.32	invert	invert	0.36	8.33
*Chenopodium oahuense**	flower head	2.29	1.06	Unk	vegetation	0.31	8.33
Senecio madagascariensis	flower head	2.22	3.19	*Carex wahuensis**	vegetation	0.26	2.08
Invert	invert	2.21	18.09	*Vicia sativa*	flower head	0.26	2.08
unk seed	seed	2.18	4.26	*Bromus catharticus*	grass seed	0.21	2.08
Quail (n = 59)				**Turkey (n = 23)**			
Species	**Type**	**Percentage of Diet**	**Frequency**	**Species**	**Type**	**Percentage of Diet**	**Frequency**
Medicago lupulina	seed	24.34	33.33	*Neonotonia wightii*	vegetation	65.15	52.17
Urtica urens	seed	18.25	16.67	Unk	grass seed	7.49	21.74
Unk	grass seed	9.94	20.00	*Verbecina enceloides*	seed	4.50	21.74
Medicago lupulina	vegetation	9.70	30.00	*Medicago lupulina*	vegetation	3.28	21.74
Erodium cicutarium	vegetation	6.76	21.67	*Carex wahuensis**	vegetation	2.52	8.70
*Sophora chrysophylla**	seed	4.23	11.67	grit	grit	2.27	26.09
Erodium cicutarium	seed	3.45	20.00	unk	grass seed	1.82	13.04
Invert	invert	3.12	10.00	*Vicia sativa*	vegetation	1.19	13.04
Holcus lanata	grass seed	2.65	23.33	*Cenchrus clandestinum*	vegetation	1.13	8.70
Wahlenbergia gracilis	flower head	2.63	3.33	*Melinis repens*	grass seed	1.08	4.35
Senecio madagascariensis	flower head	2.03	3.33	Invert	invert	0.85	30.43
Unk	vegetation	1.86	15.00	unk	grass seed	0.78	4.35
Medicago lupulina	flower head	1.70	1.67	*Wahlenbergia gracilis*	flower head	0.74	8.70
Malva parviflora	vegetation	1.32	1.67	*Conyza canadensis*	flower head	0.70	8.70
Salsoa kali	seed	1.10	1.67	*Bromus catharticus*	seed	0.70	8.70

* Native species

There were many common diet components among the 4 species of game birds including *Vicia sativa, Medicago lupulina, Neonotonia wightii,* and *Urtica urens* (Table 83). Diet items were dominated by non-natives with relatively few native species. Identification of plant species is still underway, and more work needs to be done to confirm the identity of some species.

Across species, seeds were the most common food type of the chosen categories as measured by wet mass (Table 84). The data were sparse (217 observations across 40 cells); therefore, test statistics cannot be used to evaluate goodness of fit and are only valid for comparing nested models differing by relatively few terms (Agresti 2014). The test statistics (G^2 and X^2 values) generated using baseline category logit models indicated that both season and species had effects on primary food choice (Table 85). Absolute values of standardized residuals comparing observed and fitted values indicate that the model adequately fit the data; 2 of the residuals exceeded 3 but the rest of the residuals did not exceed 2.

A comparison of estimated parameters showed that that bird species had the most effect on primary food choice. All species preferred either seeds or vegetation to flower heads, fruits, or invertebrates. Francolin and quail had a higher probability of selecting seeds than vegetation in both the hunting season and off season (Figure 85, Table 86). Pheasant and turkey showed the opposite pattern; the probability of pheasant selecting vegetation was 4 times that of seeds in the hunting season and 3 times that of seeds in the off season. Turkeys showed the same pattern but to a smaller degree (Figure 85, Table 86).

Table 84. Primary food type by wet mass for Erckel's francolin, ring-necked pheasant, California quail and wild turkey at Pōhakuloa Training Area. Numbers in parenthesis indicate fitted values from the model with predictors bird species and season.

		Primary food choice					
Species	**Season**	**Seed**	**Vegetation**	**Flower head**	**Fruit**	**Invert.**	**Total**
Francolin	Hunting	28	23	7	0	2	60
		(31.4)	(21.5)	(5.1)	(0.0)	(2.0)	
	Off	17	4	3	3	3	30
		(13.6)	(5.5)	(4.9)	(3.0)	(3.0)	
Pheasant	Hunting	4	11	0	0	0	15
		(2.1)	(12.6)	(0.3)	(0.0)	(0.0)	
	Off	4	22	2	2	0	30
		(5.9)	(20.4)	(1.7)	(2.0)	(0.0)	
Quail	Hunting	23	14	0	0	0	37
		(22.3)	(13.0)	(1.6)	(0.0)	(0.0)	
	Off	14	4	4	0	0	22
		(14.7)	(5.0)	(2.4)	(0.0)	(0.0)	
Turkey	Hunting	3	5	0	0	0	8
		(2.2)	(5.8)	(0.0)	(0.0)	(0.0)	
	Off	5	10	0	0	0	15
		(5.8)	(9.2)	(0.0)	(0.0)	(0.0)	
	Total	98	93	16	5	5	217

Table 85. Goodness of fit values for baseline category logit models of game bird primary food choice.

Model	G^2	df	No. parameters
Saturated	-	0	32
~1	77.38	28	4
(S)	67.29	24	8
(B)	27.35	16	16
(S+B)	11.23	12	20

S, season; B, bird species

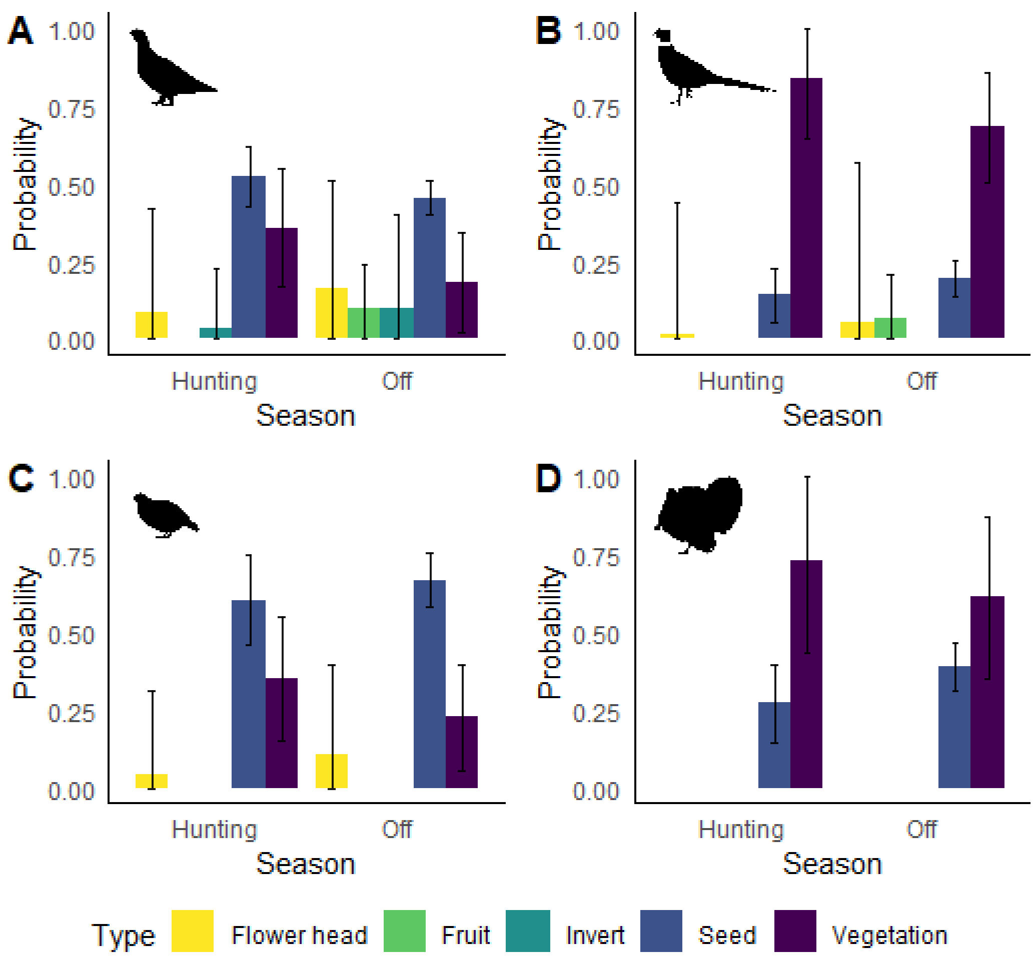

Figure 85. Baseline category logit model predicted probabilities of primary food choice for A) Erckel's francolin, B) ring-necked pheasant, C) California quail, and D) wild turkey at Pōhakuloa Training Area.

Table 86. Predicted probabilities from the baseline category logit model. Numbers in parentheses indicate standard error.

		Primary food choice				
Species	Season	Seed	Vegetation	Flower head	Fruit	Invert.
Francolin	Hunting	0.52 (0.09)	0.36 (0.19)	0.08 (0.33)	0.00 (0.19)	0.03 (0.20)
	Off	0.45 (0.05)	0.18 (0.16)	0.16 (0.35)	0.10 (0.14)	0.10 (0.30)
Pheasant	Hunting	0.14 (0.09)	0.84 (0.19)	0.02 (0.42)	0.00 (0.18)	0.00 (0.19)
	Off	0.20 (0.09)	0.68 (0.19)	0.06 (0.41)	0.07 (0.17)	0.00 (0.12)
Quail	Hunting	0.60 (0.15)	0.35 (0.20)	0.04 (0.30)	0.00 (0.18)	0.00 (0.21)
	Off	0.67 (0.09)	0.23 (0.17)	0.11 (0.29)	0.00 (0.13)	0.00 (0.33)
Turkey	Hunting	0.27 (0.13)	0.73 (0.30)	0.00 (0.23)	0.00 (0.16)	0.00 (0.18)
	Off	0.39 0.08)	0.61 (0.26)	0.00 (0.26)	0.00 (0.12)	0.00 (0.30)

Body condition models adequately fit the data for Erckel's francolin, ring-necked pheasant, and wild turkey, but not for California quail (Figure 86). The histological analysis has not yet been completed by the USDA and are not included in this report.

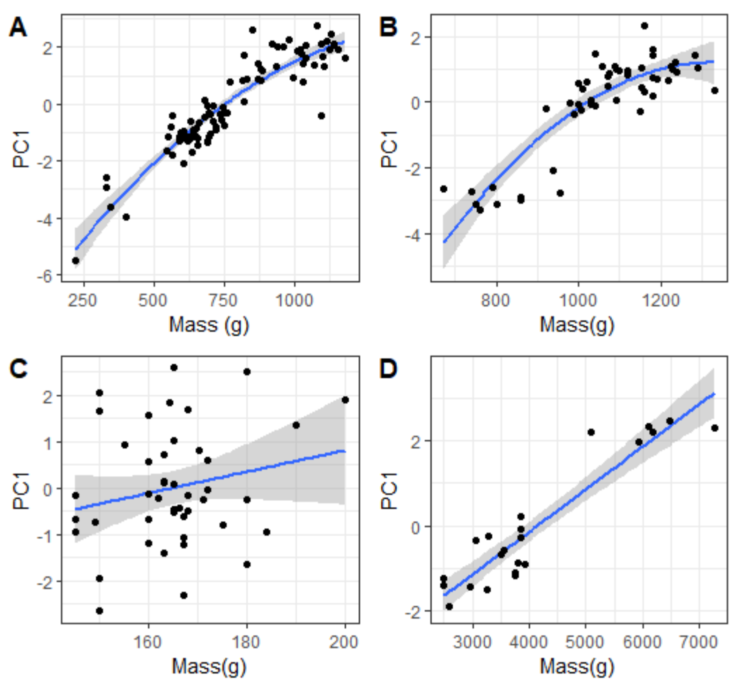

Figure 86. Body Condition Index models (A, Erckel's francolin; B, ring-necked pheasant; C, California quail; D, wild turkey)[a].

[a] The y axis, PC1 indicates the result of a principal components analysis using culmen, tarsus, and wing chord length. Models will be used in conjunction with histological analysis to determine whether toxic plants impact bird health. If many birds that had fireweed in crops and had high levels of liver toxin also fell consistently below the index mean, this would provide evidence that a fireweed can negatively affect game bird health.

Germination trials began in April 2020 with samples taken from birds collected under the permit. Of those samples, 9 plants germinated from 4 bird species (Table 87).

Table 87. Plants germinated from California quail, Erckel's francolin, ring-necked pheasant, and wild turkey fecal samples.

	Hunting Unit		
Species	**Humuʻula**	**Ahi**	**Keʻāmuku Maneuver Area**
Quail	-	-	*Conyza sp.*
Francolin	-	-	*Solanum (nigrescens or americanum)*
	-	-	*Vicia sativa*
	-	-	*Conyza sp.*
Pheasant	-	-	*Medicago lupulina*
	-	-	*Verbascum thapsus*
	-	-	*Wahlenbergia gracilis*
Turkey	*Bromus catharticus*	-	*Sporobolus indicus*
	Cenchrus clandestinus	-	*Cenchrus clandestinus*

Discussion

The baseline category logit model showed that primary food choice did vary by season and species, and the goodness of fit test indicated that bird species has the most effect on primary food choice. Erckel's francolin and California quail preferred seeds whereas ring-necked pheasant and wild turkey preferred vegetation. The diet of the latter 2 species consisted in part of seeds, and the probability of seed consumption increased from winter (hunting season) to summer (off-season). Erckel's francolin diet data suggested that species to be a more of a generalist forager. This might account for the high sample size of that species (more birds available to be harvested and submitted by hunters) in all 3 collection areas.

Trials in the RPPF showed non-native seeds to be viable after gut passage for each game bird species examined, indicating that game birds likely play a role in non-native seed dispersal at PTA. Data showed that wild turkeys are more likely to distribute monocot non-native grasses, whereas the other 3 game bird species are more likely to result in germination of dicots. Some native seeds were found in crops, but none germinated during RPPF trials. As of November 2021, there are 2–3 plants that germinated as part of the RPPF trials that are too early in development to identify. We hope to identify these plants in the coming months.

Game birds did consume fireweed, but it is unclear whether the plant has a negative impact on their health. We hope to receive results from the USDA histological analysis soon so that the fireweed analysis can be completed.

5.4 Overall Discussion for the Game Management Program

One of the primary goals of the Game Management Program is to understand the dynamics of resident game populations and how they relate back to natural resource protection and conservation.

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

In addition to contributing to resource management, 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.

6.0 ECOLOGICAL DATA PROGRAM

6.1 INTRODUCTION

The purpose of the Ecological Data Program (EDP) is to facilitate the planning, implementation, analysis, and reporting for 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, management, and analysis. Specifically, the EDP provides guidance and support to technical programs to ensure that ecological data collection methodologies, data/GIS management, analysis, and reporting are aligned with overarching programmatic goals and objectives. This function is essential for the efficient fulfillment of PTA NRP obligations and to effectively utilize all available data to streamline natural resource management strategies. In addition, the EDP develops, implements, and maintains the necessary information technology (IT) infrastructure supporting management planning, scheduling, implementation, tracking, and reporting. We also facilitate the coordination and incorporation of research results from external agencies toward the effective fulfillment of NRP goals and objectives.

More recently, we have also begun to take on a greater role in project development to ensure protocols can most efficiently address pre-established questions pertinent to the project purpose and intents, including assessments of management efficacy, strategy optimization, 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.

The EDP supports SOO tasks 3.2.4(a) through 3.2.4(e) as follows.

6.2 DEVELOP AND MAINTAIN ESA-LISTED AND RARE PLANT AND ANIMAL MANAGEMENT ACTIONS DATABASES FOR THE PURPOSES OF MONITORING, COLLECTION, EVALUATION, AND DISSEMINATION OF ECOLOGICAL DATA.

The EDP provided 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 (Table 88) to meet project objectives. This work seeks to ensure project strategies, goals, and methods for implementation, execution, data analysis, and reporting are fully described, documented, and approved by senior CEMML and Army staff prior to project implementation. Data management systems were built primarily using Microsoft Access and ESRI ArcGIS platforms and align with state and federal standards for ecological data management.

Specific support functions provided by the EDP included the development and maintenance of data collection and management frameworks for game bird and ungulate surveys and monitoring, seabird monitoring, Hawaiian Goose work both at PTA and HFNWR, fence inspection and maintenance, IPP weed and fuels control efforts, and all rare plant monitoring and survey work. Additionally, we also provided support for the development of the Programmatic Biological Assessment (PBA) including data development, processing, curation, management, analysis, and distribution.

Another important component of our program that receives a high priority and visibility involves facilitating the transfer of knowledge and information derived from data managed and analyzed into technical reports and documents. With a dedicated Technical Documentation Specialist on staff, we are often called upon by both internal technical programs and by other Army directorates to develop technical documents to meet specific reporting and communications requirements. Table 88 provides some recent highlights from these types of projects undertaken by EDP. For a 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 A.

Table 88. Highlights of technical writing support provided by Ecological Data Program.

Document / Deliverable Title	Description	EDP Role	Status
Biennial Report FY 2020–2021	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 2022
Managing Species at Risk at PTA	Article published in Army's Ecosystem Management Bulletin	Primary author	2020 Issue
Annual Report FY 2020	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 Feb. 2021
Waimea Library Display	Informational display to educate the public about the PTA NRP, TES, installation background, CEMML management activities	Primary author, installation/take down	Display setup during Sep. 2021
End of Agreement Report	Final progress report to document CEMML accomplishments towards SOO tasks and maintain compliance with the PTA INRMP	Document management, primary author for select sections, data/map/graphic support, formatting, review/edits	Delivered to CEMML and Army leadership in Jan. 2022
SAR Technical Report	Report documenting the distributions and abundances of several plant SAR at PTA	Primary author	Draft
Recovery Permit TE4123A-2 Report 2019	Annual report required by conditions of the permit. Report covered genetic conservation actions for 20 T&E species	Data support, technical review	Delivered to USFWS in Feb. 2020

Table 88. Highlights of technical writing support provided by Ecological Data Program (cont.).

Document / Deliverable Title	Description	EDP Role	Status
Recovery Permit TE4123A-3 Report 2020	Annual report required by conditions of the permit. Report covered genetic conservation actions for 20 T&E plant species and the Band-rumped Storm Petrel	Data support, technical review	Delivered to USFWS in Jan. 2021
Zanthoxylum hawaiiense Technical Report	Report to document the latest status of *Z. hawaiiense* at PTA, including plant locations, abundances, and sex	Primary author	Draft
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, technical review	Ongoing
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	Ongoing
Research Support Letters	Produced letters of support for requests from outside agencies to conduct ecological research on the installation.	Primary author, coordination for Commander signature	Ongoing

CEMML, Center for Environmental Management of Military Lands; EDP, Ecological Data Program; HFNWR, Hakalau Forest National Wildlife Refuge; INRMP, Integrated Natural Resources Management Plan; NEPA, National Environmental Policy Act; NRP, Natural Resources Program; PBA, Programmatic Biological Assessment; PTA, Pōhakuloa Training Area; SAR, Species At Risk; SOO, Statement of Objectives; TES, Threatened and Endangered Species

6.3 Develop Algorithms to Support Queries for Planning, Monitoring, and Reporting Purposes.

Using relational databases, we designed targeted queries to organize and extract data from complex data sets for analysis. We used our expertise in ecology, experimental design, and data management as needed to assist technical programs to develop project-specific strategies to collect and manage complex ecological data for all facets of work done at PTA. This support included but was not limited to aerial surveys for ungulate presence, seabird presence and activity patterns, Hawaiian Goose nesting behaviors and success, predator tracking and control, Hawaiian hoary bat occupancy, rare plant surveys and monitoring, ungulate exclusion fence inspection and maintenance, and fuels monitoring and control. For these projects, we worked directly with technical program managers and staff to develop data dashboards, queries, and other data views to facilitate interaction with and use of data to meet project goals and objectives.

EDP also continued our work maintaining and managing the Management Actions Tracking System (MATS). The MATS stores and organizes information on the effort expended toward the fulfillment of statutory regulatory obligations. Specifically, MATS is designed for technical programs to enter data on the number of personnel hours and other costs spent toward executing the variety of management actions taking place in the field on a day-to-day basis. Management actions are linked to itemized statutory requirements so that all expenditures toward the fulfillment of obligations can be explicitly tracked and reported. This is an essential function for reporting, budgeting, accountability, and strategic planning. Given recent changes to the program, including the establishment of a new SOO, as well as lessons learned from interactions with the system to date (i.e., successes and failures), we believe now is an opportune time to update and upgrade MATS to ensure its optimal value to the organization. To this end, EDP and CEMML senior leadership have begun discussions to establish a new vision, goals, and objectives for a "MATS 2.0". This new system 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 MAINTAIN ALL SPATIAL DATA RELATED TO NATURAL RESOURCES MANAGEMENT ACTIVITIES IN GEODATABASE FORMAT.

The primary focus of the EDP regarding programmatic-level spatial data support continues to be the development and improvement of mobile GIS frameworks that streamline the collection, organization, analysis, and use of geospatial data collected in the field to facilitate operations of technical programs. The data frameworks we develop allow for data to be collected quickly and efficiently in the field using navigation tools and drop-down menus. To this end, we use ESRI's ArcGIS mapping and analytics platform. Using mobile and desktop applications such as Collector, Field Maps, Survey123, Operations Dashboard, Insights, ArcGIS Online, ArcGIS Pro, and now ArcGIS Enterprise, we develop custom data collection, management, and analysis solutions for a range of projects including incipient weed detection, plant survey and monitoring, fence inspection and maintenance, and Hawaiian hoary bat, Hawaiian Goose, and Band-rumped Storm Petrel surveys and monitoring (Table 89). These solutions include strategies for complete and automated field-to-report workflows eliminating or minimizing the time needed for data entry and streamlining data quality assurance and control processes. The data collection systems are also designed to facilitate analysis and generation of maps and figures. Data collected in the field are automatically synced with geodatabases designed to facilitate these workflows. Incorporation of these technologies provides significant cost and time savings from project implementation through completion, allowing us to accomplish more of our important conservation goals with limited funds. The systems are also designed to facilitate data analysis and generation of maps and figures for reporting.

Table 89. List of major projects supported by the Ecological Data Program.

Program	Project	Date Implemented
Botanical	Plant Surveys in Training Area 23	5/1/2021
Botanical	Species at Risk (SAR) surveys	6/3/2020
Botanical	*Zanthoxylum hawaiiense* monitoring	6/3/2020
Wildlife	Band-rumped Storm-Petrel monitoring and tracking	2/2/2016
Wildlife	On- and off-site Hawaiian Goose monitoring and management	7/31/2016
Wildlife	Fence Inspection and Maintenance	11/2/2015
Invasive Plants	Invasive plant survey and monitoring	2/8/2017

6.5 PREPARE GRAPHICS AND MAPS THAT SUPPORT NATURAL RESOURCES MANAGEMENT AND OVERALL PROGRAM ACTIVITIES.

EDP continues to provide high-end cartographic/GIS/spatial analysis support for all natural resource related facets 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. We use the ESRI ArcGIS platform to create high accuracy, high precision maps, both print and digital. All spatial data are managed to easily share and collaborate with Army and conservation partners (i.e., using appropriate metadata and data transfer protocols). All projects described in this report requiring the creation of spatially explicit data products (graphics, maps, spatial analysis) have been supported with assistance and expertise from the EDP. Recently, we have shifted our geospatial data management framework from an ArcGIS Desktop/Online foundation to an ArcGIS Enterprise foundation. This shift will further enhance our ability to manage complex data sets in a way that ensures optimal effectiveness, quality control, and opportunity for collaboration.

One major initiative recently undertaken was to bring all spatial data into compliance with Federal metadata standards. This also directly benefits our ability to share data among the Army and agency partners as described above. In more specific terms, quarterly we are requested to provide Spatial Data Standards for Facilities, Infrastructure, and Environment (SDSFIE) compliant data to the Army. The Army requests data to be in this format to be added to their Enterprise geodatabases so that they can be disseminated to other directorates and agencies. Compiling our data is beneficial to the Army and to CEMML, because it would give us master datasets that we can share and eliminates the need to compile data each time we receive a request.

This effort consists of 2 primary components: 1) compiling data from our variety of sources and 2) ensuring data is in SDSFIE compliant format, which entails adding fields and data descriptions which are clearly laid out in Army guidance documents. Because the vast majority of our data does not fall neatly into existing SDSFIE containers, this effort will be done in phases. Layers that we use and share most frequently would be addressed during the first phase. This would entail some major work to compile the data, as well as to formulate SOPs to ensure a consistent procedure to keep data current for quarterly data calls.

6.6 INVESTIGATE, DEVELOP, AND IMPLEMENT SYSTEMS FOR EFFICIENT DATA COLLECTION AND ANALYSIS FOR EFFECTIVE OPERATIONAL AND RESOURCES PLANNING.

We are fortunate to have on-staff experts in the fields of remote data acquisition, utilization, and management. EDP staff include small aircraft and unmanned aircraft systems (UAS) pilots with expertise in planning and implementing UAS flight missions to collect environmental data. We also have been able to leverage our in-house capacity to access and utilize publicly available remotely sensed data including satellite imagery, LiDAR, and other multi-spectral datasets toward the effective accomplishment of SOO tasks. For example, our program is regularly called upon to provide situational awareness support to other directorates in the event of wildland fire. EDP provided support during a recent fire event by accessing and processing Sentinel-2 satellite imagery to provide near real-time situational updates regarding the advancement of the fire and how it relates to natural, cultural, civilian and DoD assets on the ground to personnel fighting the fire as well as to our command structure. These datasets are multispectral and allow our group to produce true color RGB imagery in addition to several vegetation indices including NDVI, IR, and VARI. When deemed safe to enter the area, we also use these data to provide delineated burn footprints and acreage estimates to support the planning of direct on-the-ground assessments of impacts to natural resources from the fire.

Prior to the stand-down regarding the use of commercial off-the-shelf UAS systems on DoD installations, we used CSU funds (outside of this cooperative agreement) to develop a fleet of UAS and appropriate sensors to collect pertinent ecological data to support several projects including rare and invasive plant surveys, ungulate surveys, and fuels monitoring. During this reporting period, we made no further advancements in the development or use of UAS resources. However, these resources and the expertise to use them remain available to apply when it is again authorized to do so. For the time being, the future application of these technologies is out of our hands and will rely on decisions made at the DoD level.

6.7 OVERALL SUMMARY DISCUSSION FOR THE ECOLOGICAL DATA PROGRAM

The EDP continues to be an essential program within the PTA NRP, supporting the efficient and effective accomplishment of project goals and objectives. Over the past 2 years, we have significantly increased our contributions to this end. This is largely due to increased authority and responsibility within the program to guide technical programs in the development of project protocols to ensure alignment between project goals and effort expended, as well as intra-program improvements in workflows and technical capacity. Access to technical trainings and conferences, primarily related to the use of ArcGIS products, as been essential to this growth. Also, our considerable in-house technical knowledge of ecology, information systems, programming, and analysis provided fertile ground from which to develop processes and procedures that have significantly aided in the efficient fulfillment of SOO tasks across all programs.

Over the past 2 years, we have also taken on a significantly greater role in project development to ensure protocols can most efficiently address pre-established questions pertinent to the project purpose and intents, including assessments of management efficacy, strategy optimization, and budget tracking and accounting. However, there is much work left to be done on that front. For the NRP to function as efficiently as possible, EDP will have to play a more clearly defined role with respect to project development and management in the future. We will be working with the project PI and Senior Cooperator Program Manager in the coming months and years to achieve this goal.

We continue to develop and implement digital data collection and management approaches that have been in use with all technical programs for field data collection efforts. New technologies continue to be assessed for use in optimizing field-to-office data flow using 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.

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AREA 2: TECHNICAL ASSISTANCE FOR MILITARY INITIATIVES

7.0 PROJECTS THAT RECEIVED TECHNICAL SUPPORT

We provide technical services to the Army in the form of personnel expertise, data acquisition and evaluation, graphics support, and document preparation, for military initiatives for training capacity, for cooperative initiatives with state and federal resource agencies, and to provide for a defense in litigation proceedings. We also review proposed military actions to assess potential effects to TES and other species of concern. Technical assistance is provided under CEMML's Statement of Objectives (SOO) task 3.4.

During the reporting period, we assisted with the following military training, operations, and maintenance projects as well as public outreach and education initiatives. For a list of completed document deliverables produced to support military initiatives and compliance-related regulatory obligations during this reporting period, please refer to Appendix A.

7.1 ENDANGERED SPECIES ACT AND NATIONAL ENVIRONMENTAL POLICY ACT

7.1.1 Programmatic Biological Assessment

We assisted the PTA Army Biologist with preparing for the development of the installation's upcoming Programmatic Biological Assessment (PBA). 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. The PTA PBA was modeled after the Oʻahu PBA, currently under formal consultation with the USFWS. Actions considered within the PTA PBA include current routine military training, current non-military actions, and planned or proposed military and management-related activities. A variety of avoidance and minimization measures are ongoing at PTA to reduce potential impacts of military activities to TES, including wildland fire management, non-native species control, and integrated training management. The action area considered within the PBA, is delineated based on the furthest likely extent of wildfire and weed spread that would be a result of military activities at PTA.

An effects analysis has been completed for the TES and the Palila Critical Habitat present within the action area. Direct effects may include risk of wildfire and trampling, based on probabilities of impacts as a function of the described actions. Indirect effects may include risk of non-native plant (weed) spread to ESA-listed populations. Cumulative effects of non-military actions are also included. Ongoing avoidance and mitigation measures are accounted for within these impact analyses. For those species where analyses indicate that military activities are likely to adversely affect the populations, additional on- and off-site conservation measures are proposed. Specific management strategies will include population monitoring, invasive species control, and outplanting.

During the reporting period, we coordinated with, met with, and provided natural resources information to USAG-P, 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 bi-weekly conference calls, drafted sections of the project description, reviewed and commented on draft threats analysis methods, and provided substantial technical support and guidance to develop conservation measures to off-set unavoidable impacts to TES. Additional support included map production, summaries of potential impacts from proposed projects to TES, and document review.

Technical assistance for information/data requests, reports, and supporting documents included:

- Noise Assessment for Proposed Reactivation of Artillery Firing Points at PTA (May 2020).
- PTA PBA Draft Training Descriptions for USFWS Review (June 2020).
- PTA Threat Analyses Methods (June 2020).
- PTA BA Species List and Critical Habitat Units in Action Area (July 2020).
- Effects to Seabirds from Artificial Lights (August 2020).
- Revised PTA PBA Project Schedule (November 2020).
- Invasive Species Checklist for Public Access to PTA (February 2021).
- 5-Year Outplanting Plan for PTA (July 2021).
- PTA PBA Conservation Measures Cost Estimates (September 2021).

7.1.2 Records of Environmental Consideration

During the reporting period, we regularly assisted the PTA Army Biologist with reviewing Records of Environmental Consideration (RECs). RECs are submitted with project documentation under the National Environmental Policy Act (NEPA), and briefly document that an Army action has received environmental review. We provided technical reviews, comments, and recommendations. We concurred with RECs for military initiatives that did not have adverse effects on TES, or if the project's effects to natural resources were covered under previous consultations with USFWS.

In FY 2020 and FY 2021, we reviewed and commented on the following RECs:

- 4534 Establish Firing Points 713, 714, and 715 (Outplanting and 700 FP in TA 22)
- 4693 Site Prep for ARMAG
- 4699 Replace Freezers
- 4700 Curation Container
- 4763 Waikiʻi Grazing Lease
- 4767 Infantry Platoon Battle Complex Ground Softening

7.1.3 Predator Control for Band-rumped Storm Petrel

On 22 May 2020 we submitted a request for informal consultation with the USFWS for predator control at the Band-rumped storm petrel (BSTP) colony during the breeding season. We requested concurrence with the determination that proposed small mammal control activities, in accordance with the BSTP Management Plan may affect, but is not likely to adversely affect listed species or their designated critical habitat. Small mammal control activities in a portion of TA 21 have the potential to affect the endangered Hawaiʻi Distinct Population Segment (DPS) of the BSTP, and the threatened Hawaiian Goose.

The project entails implementation of small mammal control and nest surveys within the BSTP colony at PTA. A combination of live and lethal traps will be used to remove small mammal predators (feral cats, mongooses, and rodents), and tracking tunnels and camera traps will be employed to monitor predator activity and evaluate trapping efficacy. Small mammal control is being conducted to minimize the risk of predation to BSTP adults and chicks. In addition, surveys for BSTP nests will be conducted with the assistance of a trained detector dog under the direction of a qualified handler. Project activities will be conducted from March through November.

The Army proposed avoidance and minimization measures for live and lethal traps, and for surveys using detector dogs. Because the project's negative impacts to BSTP are insignificant or discountable, while providing the potential for increased survivorship, USFWS concluded that the overall project effects are beneficial. Additionally, they concluded that any negative effects from the project to the Hawaiian Goose are insignificant or discountable. The USFWS concurred with the Army's determination that the proposed action may affect, but is not likely to adversely affect, the endangered BSTP Hawaiʻi DPS and the threatened Hawaiian Goose.

7.1.4 Army Training Land Retention EIS

On the Army's behalf, we provided information, data, and technical reviews and support to develop an Environmental Impact Statement (EIS), and its support documents, for Army Training Lands Retention. During the reporting period, we reviewed the *Army Training Land Retention at Pōhakuloa Training Area Preliminary Draft Environmental Impact Statement* (USACE 2021). Technical assistance included providing data/information reviews, GIS data, and providing program and other reports pertaining to natural resources found on state-owned lands at PTA. We identified data gaps for the project delivery team and provided responses to questions on topics including bird and mammal species observed on state-owned lands, invasive plant species management, ASRs and fence units, NatureServe Global ranks tracked in the INRMP, and hunting management at PTA.

We provided additional technical support/assistance to the PTA Army Biologist by loading maps onto mobile devices and loaning tablet devices for field visits. We clarified questions about PTA collaborations with the Mauna Kea Watershed Alliance and Three Mountain Alliance (Dark Sky Initiative) for the EIS team working on scoping comment responses. We provided feedback regarding comments on the Revised Draft Description of the Proposed Action and Alternatives (DOPAA) for the

EIS. We also provided map packs, geodatabases, and GIS data layers for TES and natural resources assets to the Army and partnering agencies upon request.

7.2 Integrated Natural Resources Management Plan

During the reporting period, we coordinated annual INRMP review meetings between the Army, federal and state regulators/conservation partners, and relevant stakeholders. We facilitated discussions with regulatory partners regarding annual accomplishments toward INRMP goals, the review process, stakeholder responsibilities, and PTA NRP areas. We coordinated agency review of document updates and assisted with tracking the INRMP review by partner agencies (e.g., USFWS, Hawaiʻi DoFAW). We coordinated agency responses and ensured comments were incorporated into the INRMP. The INRMP was submitted to the Army to route to agencies for signature in March 2018; the final INRMP was signed in February 2020.

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).

On 13-14 November 2019, we hosted the INRMP review meeting on-site at PTA and coordinated field visits for attendees to see natural resource management areas at the installation. Locations visited included Puʻu Leilani, ASR 18 (*Kadua coriacea*), a Hawaiian hoary bat monitoring station, ASR 41 (*Schiedea hawaiiensis*), the Infantry Platoon Battle Course, ASR 40 (*Solanum incompletum*), Landing Zone (LZ) Turkey, Puʻu Nohona o Hae, the Range 1 Complex, and the Band-rumped Storm Petrel colony. On 17-18 November 2020, we hosted the meeting virtually due to the COVID-19 pandemic.

7.3 Conservation Reimbursable Programs

7.3.1 Fish and Wildlife Conservation Fund

The Fish and Wildlife Conservation Fund is an installation-level program where proceeds obtained from the sale of hunting permits are used for wildlife management projects to protect, conserve, and manage wildlife. During the reporting period, the PTA Army Biologist worked with Army Environmental Command and the US Army Garrison Resources Management team (fiscal) to establish proper procedures to deposit permit-sale revenue and to withdraw funds to reimburse approved expenditures for wildlife-related projects at the installation. We developed 2020 and 2021 Annual Work Plans and budgets, including annual projected revenue and requested reimbursements. We provided monthly accounting of permit sales to the Army.

7.3.2 Agricultural and Grazing Outlease Program

The Army's agriculture and grazing outlease program involves the leasing of Army lands to non-Army entities for agricultural and grazing purposes. This program is a reimbursable program because lease payments are used to cover the administrative costs of outleasing and the financing of multiple land use management. During the reporting period, we provided assistance to the PTA Army Biologist by reviewing program requirements, the current lease, and providing technical and natural resources information about the area under the current grazing lease in the Keʻāmuku Maneuver Area.

7.4 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.

7.4.1 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.

Hawaiʻi Wildfire Management Organization Island-wide Vegetation Mapping

We continued to participate in a collaborative vegetative fuels management mapping project as part of a statewide effort by Hawaiʻi Wildfire Management Organization and other stakeholders to identify fuels management priorities, improve access to funding for fuels treatment projects, enhance communication opportunities and clarity among stakeholders, and maximize fire protection by using resources for the highest shared priorities. We provided geospatial data delineating the locations of our fuel breaks with current fuels management activities including details on management actions and frequency, as well as locations of Fuels Management Corridors at PTA for the purpose of collaboratively reducing wildfire risk on Hawaiʻi Island.

7.4.2 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 nearly 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 in Hilo, but most members call in from around the state or the mainland for monthly updates. The Hawaiʻi Island ROD Working Group meets every other month 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.

7.4.3 Mauna Kea Watershed Alliance

During the reporting period, we participated in meetings of the Mauna Kea Watershed Alliance (MKWA). The MKWA partnership boundaries span over 500,000 acres across the upper elevation Mauna Kea landscape, with partnership lands representing around 2/3 of the total acreage. The alliance is composed of several landholders including federal and state of Hawaiʻi agencies, land trusts, non-profits, and ranches. The MKWA vision is to protect and enhance watershed ecosystems, biodiversity, and resources through responsible management while promoting economic sustainability and providing recreational, subsistence, educational and research opportunities.

The MKWA seeks to manage critical watersheds on a landscape-level by initiating planning for priority areas with the goal of implementing management actions for threats such as feral ungulates, fire, and invasive alien weeds. Coordinated management of these watershed lands is critical to sustain adequate quality and quantity of water and provide important habitat for a wide diversity of native plants and animals, including many that are endangered.

During the reporting period, 1–2 CEMML staff assisted Mauna Kea Forest Restoration (MKFRP) Project staff in conducting predator control in areas at PTA buffering Palila Critical Habitat. We coordinated access with the Army to allow the people to control predators at PTA and we ensured MKFRP received all required safety briefs from PTA Range Control.

7.4.4 Endangered Palila Management

Annual Statewide Palila Population Counts

During the reporting period, 1–4 CEMML staff participated in the annual statewide Palila population counts. We coordinated access with the Army to allow the people participating in the counts to exit survey areas on Mauna Kea though PTA. We ensured all survey participants accessing PTA received all required safety briefs from PTA Range Control. We have participated with this project since 1997.

7.4.5 Hawaiian Goose Management

Annual Statewide Hawaiian Goose Counts

During the reporting period, 1 CEMML staff participated in the annual statewide Hawaiian Goose Survey. We have participated with this project since 2016.

Banding of Hawaiian Geese at Hakalau Forest National Wildlife Refuge

During the reporting period, 4 CEMML staff assisted State of Hawaiʻi, Department of Natural Resources-Division of Forestry and Wildlife staff in banding Hawaiian Geese at Hakalau Forest National Wildlife Refuge.

7.4.6 Seabird Management

Nest surveys with Assistance from a Detector Dog

During the reporting period, 1–2 CEMML staff assisted State of Hawaiʻi, Department of Natural Resources-Division of Forestry and Wildlife staff in using a detector dog to survey for seabirds (Hawaiian Petrel and Band-rump Storm Petrel) on Mauna Loa.

7.5 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, reviewing and providing comments on draft manuscripts. During the reporting period, we provided support for the following external research efforts.

7.5.1 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 is often prohibitive for installation managers and hampers 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 to 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 reporting and verification of species occurrences in near-real-time. 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 in near-real-time is particularly critical when such species are highly mobile (e.g., birds) and have the potential to conflict with military operations without warning.

7.5.2 Readiness and Environmental Protection Integration Program

Title: Increasing Military Installation Resilience and Mitigating Rare Plant Impacts in the Hawaiʻi U.S. Army Garrison
Principal Investigator: Ms. Emma Yuen
Abstract: 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 are key capabilities that support the National Defense Strategy at PTA. Management actions proposed include reducing wildfire risk through fire risk reduction planning and fire 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 state-wide 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 26 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 Napuu). Napuu 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 of the species is a critical component of the actions identified by the USFWS for the recovery of the species.

7.5.3 Strategic Environmental Research and Development Program

Title: Population Models to Predict Threatened and Endangered Plant Responses to Multiple Stressors
Principal Investigator: Dr. Clare Aslan

Abstract: The research team will use an interdisciplinary approach combining terrestrial ecology, population biology, and statistical and mathematical modeling to examine population trajectories in response to multiple environmental stressors for 20 listed T&E plant species at PTA. The aims are to identify: (a) for each species the impact of multiple stressors on populations, (b) the link between impacts and plant functional types, and (c) plant population parameters that can efficiently be measured to guide conservation management as stressors grow and change. This work builds on multiple years of field research on T&E plants at PTA. The project goals are to: 1) collect demographic data on response to multiple stressors of 20 T&E plant species at PTA; 2) employ Integral Projection Model-based demographic modeling techniques to evaluate population trajectories and responses to multiple stressors for all 20 T&E plant species; 3) develop, trial, and ground-truth streamlined demographic data collection protocols that target mechanisms of decline by plant functional traits and can be implemented over the long-term to collect data on stressor responses and project population trajectories for each target species and functional type; and transfer protocols to installation managers, inclusive of time and human resource investment and tradeoffs, to assist manager prioritization and decision-making for long-term monitoring and conservation of the full suite of listed species. The diverse T&E plant species at PTA offers a unique opportunity to examine known stressors and their cumulative population impacts for multiple DoD-relevant T&E species, thus developing fundamental knowledge at the level of plant functional types that can be applied toward management of functionally similar at-risk species across DoD installations

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 on-line materials and conduct workshops to transfer these techniques to managers, in a way that could be scaled to bases around the world.

Title: The Impact of Non-Native Predators on Pollinators and Native Plant Reproduction in a Hawaiian Dryland Ecosystem

Principal Investigator: Dr. Christina Liang

Abstract: Oceanic islands are well known for their high endemism and unique biological diversity, which make them particularly susceptible to disturbances such as non-native species invasions. Such invasions can disrupt pollination services and result in strong negative impacts on native plant reproduction and genetic diversity. Non-native invasive predators (NIP) consume animal pollinators and, by doing so, reduce pollinator populations and possibly eliminate entire pollinator guilds. Loss of pollination services due to NIP is likely an important, although poorly understood, factor in both native plant conservation and management of long-term sustainability of native island ecosystems. Here we propose to determine the impacts of NIP on native and non-native pollinators and pollinator services for at-risk as well as common native plant species in an invaded Hawaiian tropical dryland ecosystem. We will 1) identify current pollinators and pollination effectiveness for focal plant species, 2) examine diets of study site NIP (rodents, ants, and yellowjackets), and 3) apply common NIP control techniques to experimentally determine their effectiveness at both reducing NIP populations and NIP impacts on pollination and native plant reproduction.

Title: Recovery of Native Plant Communities and Ecological Processes Following Removal of Nonnative, Invasive Ungulates from Pacific Island Forests.

Principal Investigator: Dr. Creighton Litton

Abstract: Non-native ungulates exert a large effect on native biodiversity and the structure and function of native ecosystems on islands throughout the Pacific region. In Hawai‘i, removal of ungulates is broadly recognized as a crucial first step in conserving native ecosystems, especially threatened, endangered, and at-risk species. To this end, land managers, including those on DoD installations, fence and remove non-native ungulates where conservation of native biodiversity is a priority. However, these actions are labor and cost intensive, and the long-term outcomes are not well quantified. Surprisingly little information is available on the magnitude and time frame of native plant recovery, the potential for non-native plant invasions, and the response of critical, underlying ecological processes. The objectives of the proposed research are to quantify the impacts of non-native ungulate removal on the biodiversity, structure, and function of 2 major ecosystem types, tropical wet forest and tropical dry forest, found on DoD installations throughout the Pacific Island region, and to test if nutrient manipulation is a viable management strategy for promoting native plants. Specifically, we will explore pathways and mechanisms through which ungulate removal impacts long-term patterns of native and non-native plant dynamics. In addition, to understand how ungulate removal affects key underlying ecological processes we will quantify changes in ecosystem carbon (C), nitrogen (N) and phosphorus (P) cycling, availability, and storage following removal. Finally, we will test whether manipulation of soil N and P availability can be used as a management tool to favor native plants over non-native, invasive plants.

7.5.4 Legacy Resource Management Program

Title: Post-Wildfire Plant Regeneration in Arid Ecosystems: Overcoming Biotic and Abiotic Soil Limitations

Principal Investigator: Dr. Rebecca Ostertag

Abstract: Increased wildfire frequency and severity due to climate change threatens dryland ecosystems throughout the country and Pacific Islands. Severe wildfires destroy vegetation and alter soil properties, leading to soil erosion and degraded habitat value for important species. To maintain optimal training conditions and military readiness and to meet standards of environmental stewardship, DoD land managers must employ effective science-based strategies to restore vegetation post-wildfire at the landscape scale. This project will develop and test methods to overcome limiting factors to natural tree regeneration caused by fire damage to soil properties in a dryland forest ecosystem using burned and unburned plots established following a 2010 wildfire. Developing and testing effective procedures to improve post-fire regeneration will provide DoD land managers with critical tools needed to adapt to increasing aridity from climate change and to optimize training conditions and military readiness into the future.

7.5.5 National Science Foundation

Title: Collaborative Research: Unlocking the evolutionary history of a rapid Hawaiian Islands radiation with extraordinary breeding system diversity

Principal Investigator: Dr. Stephen Weller

Abstract: Our research objectives are first to obtain a more highly resolved phylogeny of *Schiedea hawaiiensis* using next generation sequencing, and large numbers of single nucleotide polymorphisms for detecting hybridization between species. Using this more highly resolved phylogeny we have 2 major goals. The first is to understand the evolution of breeding systems and determine how many transitions to breeding systems with separate sexes have occurred. We will also determine how many transitions to selfing breeding systems have taken place. Genetic markers from next generation sequencing will be used to determine whether hybridization between species has been important in breeding system evolution through transfer of male sterility genes associated with the evolution of separate sexes. We believe that most cases of lateral gene transfer occur between recently evolved species lacking sterility barriers. More distantly related species appear to produce largely sterile offspring, based on preliminary studies. We are uncertain whether native pollinators transfer genes between species; at present we have pollination data for 2 hermaphroditic species. We hope to determine whether the same or different native moths pollinate hermaphroditic species of *Schiedea*, some of which we know are highly outcrossed. An additional factor is the evolution of wind pollination, which is associated with the evolution of separate sexes. Exchange of genes between species pairs where one or both species is wind pollinated may be more common than for species with biotic pollination. In summary, whether hybridization occurs in *Schiedea* may depend on whether sympatric species are distantly or more closely related, and the nature of the reproductive systems. The greatest gene exchange is predicted for recently evolved, closely related species with separate sexes and wind pollination.

7.5.6 Smithsonian Institution

Title: Genetic relationship between native plants in the daisy family as part of the Smithsonian's Global Genome Initiative

Principal Investigator: Dr. Matthew Knope

Abstract: This research project is funded through the Smithsonian Institution and implemented by researchers at the University of Hawaiʻi at Hilo. The project will investigate the familial relationships between several members of the aster or sunflower family. The researchers received a grant to collect samples of each native species of the Asteraceae (Daisy) Family on Hawaiʻi Island. PTA either cultivates or encompasses land where at least 7 of these species grow. The collections will lead to a physical herbarium specimen tied to a high-quality DNA extraction and DNA sequences used for species recognition. These genetic data can lead to better management and conservation decisions, and has the potential for other broader implications, as is elaborated on at the Smithsonian Institution's Global Genome Initiative website (https://ggi.si.edu/). For this study, the researchers are requesting access to PTA to take 2 small cuttings from each taxon. The cuttings will consist of a single branch or stem of the plant but will not kill the plant or remove a substantial portion of the organism. Specimens and DNA extractions will ultimately be deposited at the Smithsonian Institution Herbarium and information from these collections will be made publicly available. This project would likely involve 2 days of collection in KMA and western training areas.

7.5.7 University of Hawaiʻi at Mānoa

Title: Indigenous Knowledge and Factors Influencing the Detectability of Pueo (Hawaiian Short-eared Owl, *Asio flammeus sandwichensis*)

Principal Investigator: Ms. Kaleiheana-a-Pōhaku Stormcrow

Abstract: The proponent is requesting permission to establish survey sites on PTA for the Hawaiian Short-eared Owl (Pueo) as part of a statewide monitoring effort. Pueo occur on PTA, but we do not know much about their numbers at PTA or island-wide. Pueo are protected under the Migratory Bird Treaty Act and meet the DoD definition of a SAR. Participation in this project will help the Natural Resources Program develop tools to monitor/manage these birds to help reduce the chances of future listing under the ESA. Ms. Stormcrow is a graduate student at the University of Hawaiʻi at Mānoa. She is requesting access to the PTA road network to establish survey/monitoring sites; access monthly from July 2021 through December 2022. Schedule will be coordinated with Range Division through the NRP. Surveys will be done during early mornings (before sunrise) and evening/night hours when owls are active. This project will help develop tools to effectively monitor this species at PTA for regulatory and NRP requirements.

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 ʻ*ihi* 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 wide spread 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 defines 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.

7.5.8 US Fish and Wildlife Service

Title: The Rise and Fall of the Endemic Hawaiian Mint, *Haplostachys haplostachya*.
Author: Ms. Narrissa Brown
Abstract: Endemic Hawaiian mints in the family Lamiaceae are one of the largest plant lineages in the Hawaiian archipelago, with 3 diversified genera. Among these are the genera *Phyllostegia, Stenogyne*, and *Haplostachys*, which contain 59 extant members and at least 13 extinct species. *Haplostachys haplostachya* is the only remaining species in its genus and is federally listed as endangered. Once found on multiple Hawaiian Islands, its current range is constricted to a few remnant areas on the island of Hawaiʻi. There are many factors that contribute to its viability and this plant is subject to a large number of threats which imperil its continued existence. These threats include habitat destruction by non-native ungulates, fires, and military training; herbivory by ungulates, reduced reproductive success, competition by invasive species, loss of genetic diversity, and climate change. Conservation measures are being implemented to prevent the extinction of this plant species. Here, we assess the viability of *H. haplostachya* using the conservation biology principles of resiliency, redundancy, and representation. We evaluated the viability of this species based on its current condition and ability to persist into the future. We determined that this species has low to moderate resiliency, low redundancy, and low to moderate representation in its current condition, and that the overall viability of this species is low to moderate.

The PTA NRP assisted the lead author of this research by escorting her team to wild populations of *H. haplostachya* at PTA to be photographed for the publication.

7.5.9 US Forest Service

Title: Forest Inventory and Analysis Program
Principle Investigator: Jonathan Marshall
Abstract: The Forest Inventory and Analysis (FIA) program is a nationwide forest census managed by the USDA Forest Service. Data is collected from randomly distributed sample plots across Hawaiʻi,

with roughly one plot every 3 miles, including at PTA. The FIA protocol is a standardized, reliable, and repeatable method for collecting forest inventory data. FIA plots in Hawaiʻi are part of a nationwide permanent plot network that extends throughout all 50 states and associated territories from the Caribbean to the southern and western Pacific. Funding for FIA is appropriated by Congress and is supported by local partnerships. Our partners are an integral part of FIA and their contributions of personnel, funding, and continued support make this endeavor possible.

7.6 Specialized Services

7.6.1 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. In FY 2020, we shifted from retaining helicopter services directly with a vendor to retaining helicopter services via an Office of Aviation Safety service contract. This ensures helicopter pilots, and their craft are certified via the program.

7.6.2 Technical Support for Audio Recording Equipment and Audio Data Interpretation

We retained the services of the Listening Observatory of Hawaiian Ecosystems at the University of Hawaiʻi at Hilo to develop software to identify segments of audio recordings with Band-rumped Storm Petrel calls to aid in data analysis and population monitoring/modeling.

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.

7.6.3 Wildland Fire Pre-suppression Management Actions for Established Conservation Areas

We coordinated pre-suppression management actions with the CEMML Wildfire Program Manager. Specific actions included updating the survey methods used to monitor the Fuels Monitoring Corridors. The Wildfire Program Manager also reviewed video and photographs taken during the FMC survey of areas with a buildup of fuels and provided recommendations for management.

7.6.4 Technical Support for Humane Treatment of Nuisance Animals

Staff that 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.

7.6.5 Training for Use and Maintenance of Specialized Equipment

Staff completed training for the safe use and maintenance of several power tools needed for management operations. During the reporting period, we coordinated 2 trainings/certifications for the safe operation of all-terrain vehicles for 4 staff members. Staff that use chainsaws were trained/certified on safe use of the tool as well as safe felling operations.

7.7 Army Biologist and PTA Command

7.7.1 Installation Status Report Metrics

During the reporting period, we provided the Army Biologist the number of natural resources projects planned and accomplished for each quarter of the calendar years.

7.7.2 Installation Management Command Environmental Reporting System Data Support

During the reporting period, we assisted the PTA Army Biologist by gathering and summarizing information regarding natural resources at PTA as well as projects and accomplishments towards INRMP objectives. We assisted with developing written summaries of actions for upload to the national database by the Army Biologist.

7.7.3 Change of Command

During the reporting period, we provided updates to the PTA NRP Continuity Book to document the responsibilities of the Army Biologist, a Department of the Army Civilian who directs a full-time cooperative staff. The Continuity Book also highlights the function and layout of the NRP for the PTA command group, Installation Management Command G4, and applicable external agencies. Additionally, it is intended to provide a central and usable resource for NRP program managers and technical staff. The Continuity Book is updated biennially prior to the PTA Change of Command, or as necessary.

In May 2021, we provided an orientation (i.e., Commander In-Brief) to the NRP for the incoming PTA Commander LTC Kevin Cronin, summarizing regulatory background, ecosystem management, CEMML support of the Army, PTA environment, threatened and endangered species, and the NRP program areas. We also hosted LTC Cronin for a field visit to several locations to showcase natural resource management activities at the installation. The purpose of the field trips was to educate the new Commander about our TES, the work that we do to support the Army, answer questions/facilitate discussion, promote camaraderie and improved relations between CEMML staff and the Army, and visit native ecosystems in the tropical sub-alpine dryland forests at PTA. At each stop, we briefed the Commander about the history of the location, TES present, and management activities conducted in the vicinity. A folder containing hard copies of all educational materials was provided to each participant, along with maps and photos. The agenda for the field trip is provided below.

1) **Puʻu Leilani**
   - Summary of conservation fence project at PTA
   - Ungulate control and ingress monitoring, fence inspections
   - Fuels management system – fuel breaks, firebreaks, fuel monitoring corridors

2) **ASR 18**
   - *Kadua coriacea*
   - Hawaiian hoary bat survey and monitoring
   - Rapid ʻŌhiʻa Death

3) **ASR 8**
   - Fence gate with camera
   - *Tetramolopium arenarium*
   - Management efforts – weed control, outplanting, weed control buffers
   - July 2018 fire in Training Areas 18, 19, 22

4) **ASR 40**
   - *Solanum incompletum*
   - Management challenges – clonal groups, fine fuels, high costs

5) **Puʻu Kapele**
   - Invasive species prevention
   - Public access issues, new challenges for prevention
   - Hunter education

7.7.4 Rare Plant Propagation Facility Tours for VIP Groups

Throughout the reporting period, we supported numerous Army Command and VIP Tours at PTA. We led groups 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.

Additionally, management staff provided presentations highlighting the goals and objectives of each section of the PTA NRP. To manage natural resources at the installation, we implement CEMML Statement of Objectives tasks to comply with INRMP objectives, ESA consultation requirements, regulatory outcomes from NEPA documents, the IWFMP, the MBTA, as well as various compliance-related documents and permits to work with TES. After the presentations, managers were available to answer questions and facilitate discussion about NRP goals and how they relate to the military mission at PTA.

7.8 PERMITS

To work with TES on federal and state lands, we are required to obtain multiple permits to comply with several state and federal statutes and regulations. We prepare permit applications and coordinate with Army and regulatory agency officials to obtain valid permits. We perform management actions in accordance with permit terms and conditions and prepare annual reports as required by such permit conditions. Following is short description of each permit necessary to meet our SOO tasks and INRMP objectives.

7.8.1 Federal Permits Issued by the US Fish and Wildlife Service

Native Endangered & Threatened Species Recovery Endangered & Threatened Plants (TE40123A-2 and TE40123A-3)

This permit is issued by the USFWS, Endangered Species Program to USAG-P under section 10(a)(1)(A) of the ESA to assist in the recovery of 20 threatened and endangered plants at PTA. The recovery permit allows us to engage in activities that are normally prohibited by section 9 of the ESA, such as seed collection from endangered plants, for scientific purposes or to enhance propagation or survival of the species listed in the permit. The permit establishes operational terms and conditions as well as data collection and reporting requirements. The USAG-P Deputy Garrison Commander is the permit holder and CEMML staff listed on the permit are authorized to perform specified tasks in accordance with permit terms and conditions. The permit is typically renewed every 5 years. In December 2020, permit TE40123A-2 was amended to included activities to manage the Band-rumped Storm Petrel, which was listed as endangered in 2016. The amended permit (TE40123A-3) authorizes management activities in accordance with the information consultation to implement predator control (see Section 7.1.3) and with the 2020 management plan submitted as part of the permit amendment application.

Federal Fish and Wildlife Permit – Scientific Collection with Import / Export (MB95880B-0)

This permit is issued to USAG-P by the USWFS, Migratory Birds Program under the Migratory Bird Treaty Act (MBTA) to authorize the collection and possession of remains of Band-rumped Storm Petrels (*Hydrobates castro*). Normally, possession of remains of birds protected under MBTA is unlawful, but with the permit we are able to use these remains for scientific purposes. The USAG-P Commander is the permit holder and CEMML staff listed on the permit are authorized to perform the work. The permit is typically renewed every 5 years.

National Wildlife Refuge System Research and Monitoring Special Use Permit (12516-19006-G and 12516-20019-G)

This permit is issued by the USFWS, National Wildlife Refuge System to USAG-P to authorize management activities for the Hawaiian Goose (*Branta sandvicensis*) at Hakalau Forest National Wildlife Refuge on Hawaiʻi Island. The Special Use Permit specifies terms and conditions for working on refuge lands with the endangered goose. The permit is typically renewed annually, and 2 permits were issued over the report period: 12516-19006-G and 12516-20019-G. The USAG-P Deputy Garrison

Commander is the current permit holder and CEMML staff listed on the permit are authorized to implement actions prescribed on the permit.

7.8.2 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 (I1347 and I2689)

This permit authorizes us to collect, possess, propagate and outplant state-listed and ESA-listed threatened and endangered plant species. This permit is necessary to maintain the species we outplanted on State lands and to collect propagules from those plantings. The permit is renewed annually, and 2 permits were issued over the report period: I1347 and I2689. The USAG-P 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.

Mauna Loa Forest Reserve Permit for Access and Research, Puʻu Huluhulu Native Plant Sanctuary – Pending Approval

This permit is necessary to maintain the species we outplanted on state lands and to collect propagules from those plantings. The permit is renewed annually. A permit was issued for 20 August 2020 through 20 August 2021. We applied to renew the permit in August 2021; however, due to delay at the state and the expiration of other required permits, the application has not been approved. 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); 2) State of Hawaiʻi Permit for Threatened and Endangered Plant Species (I2689); and State of Hawaiʻi Department of Hawaiian Homelands, Limited Right of Entry. We anticipate gaining approval for all permits in early 2022. The renewal request names the USAG-P Commander as the permit holder and CEMML staff will be listed on the permit for authorization to perform the work in accordance with the permit's terms and conditions.

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); 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 June 2020 through 30 June 2021 (amended) and 30 November 2021 through 30 November 2022. The USAG-P 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.

Protected Wildlife Permit - Scientific Collection (WL19-42) – 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-0). The USAG-P Commander is the permit holder and CEMML staff are listed as the sub-permittees responsible to perform activities in accordance with permit terms and conditions. The permit is renewed every 2 years.

Protected Wildlife Permit–Scientific Collection (Upland Gamebirds: WL19-43 and WL20-12)

This permit authorizes the collection and possession of upland game birds to better understand the role gamebirds play in exotic seed dispersal by examining diet and movement patterns within PTA. Outside of the upland gamebird hunting season, we are authorized to take 15 Erckel's francolin (*Pternists erckelii*), 15 California quail (*Callipepla californica*), 15 ring-necked pheasant (*Phasianus colchicus*), and 8 wild turkeys (*Melegaris gallopavo intermedia*). During the report period 2 permits were issued: WL19-43 and WL20-12. The USAG-P Commander is the current permit holder and a CEMML staff member is listed as the sub-permittee responsible to perform activities in accordance with permit terms and conditions. Permit WL20-12 is valid through 1 July 2021.

7.8.3 Permit Issued by the Hawaiʻi State Department of Hawaiian Home Lands

Limited Right of Entry - Outplanting & Maintenance of Native Indigenous at Puʻu Huluhulu, Hawaiʻi Island (18:061)

This permit is issued by the Hawaiʻi State Department of Hawaiian Home Lands (DHHL) under Hawaiʻi Administrative Rules Title 10, Chapter 4. This permit is needed to access Hawaiian Home Lands at Puʻu Huluhulu to facilitate access with vehicles to our worksite. The USAG-P Commander is the permit signatory and CEMML staff listed on the permit are authorized to access the Hawaiian Home Lands at Puʻu Huluhulu for up to 30 entry events. We contacted DHHL to renew the permit in August and are waiting for a response to initiate the renewal process.

7.9 Public Outreach

Public outreach and educational initiatives regarding the Army's stewardship efforts to conserve natural resources at PTA, including TES management, are consistent with DoD guidance to the installation commander to develop and foster positive community involvement and relationships (DoD 2012). In addition, community involvement is 1 of the 3 lines of effort established by the PTA Commander (LTC Borce, 2018–2021). To support these outreach and education efforts and to meet SOO tasks 3.2(5)(g) and INRMP objectives, we engage in various events, provide presentations, and publish information about natural resources projects that highlight the Army's natural resources program and stewardship efforts.

Due to the COVID-19 pandemic, we did not host or participate in many public outreach events over the reporting period. Events that we normally participate in but were canceled include: Earth Day events at PTA and off-site, community events and festivals, hosting school groups at PTA, local meetings and symposia, conservation events/meetings. As communities begin to host more public events as the pandemic recedes, we anticipate once again hosting and participating in public outreach events.

7.9.1 Waimea Library Display

We set up an annual informational 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:

- A *Hydrobates castro* Colony at Pōhakuloa Training Area, by Nicole Galase, Lena Schnell, and Rogelio Doratt.
- Seasonal Activity Patterns of the Hawaiian Hoary Bat (*Lasiurus cinereus semotus*) at Pōhakuloa Training Area, by Rachel Moseley, Lena Schnell, and Rogelio Doratt.
- A Phased Approach to Improving Habitat for a Critically Endangered Species, by CEMML staff.
- How the Army Combats Rapid ʻŌhiʻa Death, by CEMML staff.
- PTA Natural Resources Office Overview.
- Natural Resources Infrastructure at PTA (map).

Each display is up for 1 month, facilitating positive feedback from library staff and members of the public. Due to the COVID-19 pandemic, we did not set up a display in 2020, but the display was up during September 2021.

7.10 PUBLICATIONS AND PRESENTATIONS

7.10.1 National Military Fish and Wildlife Association

The National Military Fish and Wildlife Association connects, educates, supports, and advocates for natural resources professionals across the DoD to protect and enhance the military mission through sustainable resource conservation. In March 2020, we attended the NMFWA annual meeting and presented 3 posters about natural resources management activities at PTA:

- Ungulate-free Status – 3 Years and Counting at US Army Garrison, Pōhakuloa Training Area.
- First Confirmed Band-rumped Storm Petrel Colony in the Hawaiian Islands at US Army Garrison, Pōhakuloa Training Area.
- Wild Sheep Abundance and Population Trends at US Army Garrison, Pōhakuloa Training Area, Hawaiʻi.

7.10.2 Hawaiʻi Conservation Conference

The Hawaiʻi Conservation Conference allows a diverse group of scientists, policymakers, conservation practitioners, educators, students and community members from Hawaiʻi and the Pacific to converge and discuss conservation. It's a time to connect, share and inspire, all with the common goal of caring for our natural resources. We did not provide any presentations at the conference during the reporting period.

7.10.3 ESRI User Conference

We attended the annual ESRI User Conference (in person prior to 2019, virtually in 2020 and 2021 due to COVID-19). The conference provided a venue for training, support, and information that cannot be attained anywhere else, especially given our remote location. During the reporting period, we revamped our data management pipeline to provide efficiency gains from faster and more informed data collection methods in the field and streamlined pipelines from access and analysis to archiving and reporting. Since we moved into phase 2 of our buildout, attending the ESRI User Conference provided our staff the opportunity to learn how to manage our resources most effectively and disseminate the flow of data most efficiently to our subject matter experts.

7.10.4 Pacific Seabird Group

In 2020, the Pacific Seabird Group and Endangered Species Recovery Committee held a statewide virtual meeting to allow scientists, researchers, and students to share emerging science and management techniques and to provide opportunities for collaboration. We presented "*First Confirmed Band-rumped Storm Petrel Colony in the Hawaiian Islands at the US Army Garrison, Pōhakuloa Training Area".* The presentation focused on camera surveillance and predator control monitoring and efficacy.

7.10.5 Ecosystem Management Program Bulletin

During the reporting period, we submitted 2 articles for the annual Ecosystem Management Program (EMP) Bulletin produced by the Oʻahu Army Natural Resources Program. The bulletin is designed to educate the public and the military community about the unique resources on Army-managed lands and the Army's efforts to conserve them. The goal is to encourage a collective conservation ethic, foster innovation and inspire and expand opportunities for collaboration and partnership with academia, industry, and beyond.

Title: Species At Risk: A Story of the Native Hōʻawa
Date: September 2020 (published in the 2020 Issue)
Type: Article
Publication: EMP Bulletin, US Army Garrison-Hawaiʻi
Author(s): Tiana Lackey

Summary: At PTA, one of the rare species the Army is working to protect is the hōʻawa tree species (*Pittosporum terminalioides*). Numbers on Hawaiʻi Island are extremely low and NRP staff are working hard to determine just how many remain. The endemic hōʻawa is both naturally and culturally significant in Hawaiʻi and was one of the main food sources for the ʻalalā or Hawaiian Crow. While some species of native hōʻawa are still common enough to be used in landscaping on some Hawaiian Islands, *P. terminalioides* is considered a species at risk (SAR). The DoD classifies a plant as a SAR if the plant is not federally listed as threatened or endangered under the ESA but is designated as a candidate for federal listing or is regarded as critically imperiled or imperiled throughout its range. The Army recognizes the importance of managing for SARs at PTA. By proactively monitoring and managing for SARs and their habitat, the Army can help preclude the need for federal listing under the ESA, protect significant biological diversity and reduce recovery costs, while maintaining military training capacity. Additionally, managing for SARs before they become federally listed reduces the Army's obligations under the ESA and helps to ensure no net loss of training capacity at the installation. The Army plans to continue its efforts to proactively manage for all SARs at the installation as part of its comprehensive Natural Resources Program.

Title: Controlling Fuels Protects Endangered Plants at Pōhakuloa Training Area
Date: September 2021 (to be published in the 2021 Issue)
Type: Article
Publication: EMP Bulletin, US Army Garrison-Hawaiʻi
Author(s): Pamela Sullivan
Summary: Wildland fires in Hawaiʻi present serious risks to people, homes, communities, and infrastructure, but also to valuable natural resources, particularly rare native species. Like other areas in the nation, the incidence of wildfires in Hawaiʻi has increased severalfold over the last century, and particularly in the last decades with the effects of climate change worsening the threat. Hawaiian ecosystems are not adapted to fire as most native plant species do not exhibit specific fire adaptations. Due to a combination of poorly adapted native species and the introduction of highly invasive pyrophytic species over the past century or more, wildfire has altered and degraded native Hawaiian ecosystems. The invasion and establishment of nonnative, drought tolerant grasses can change the fire regime, altering the ecosystem to promote more frequent fires. This issue is evident at PTA where invasive grasses occur in habitat for TES and rare species. To that end, the NRP implements conservation measures (e.g., fuel breaks, firebreaks, weed control buffers, fuel monitoring corridors) to avoid and minimize potential effects to TES from ongoing military training activities. This combination of fuels management can reduce fire spread, large fire probability, and ignition probability, thereby reducing or preventing impacts to TES. Case studies are provided from wildland fire events in 2012, 2018, and 2021.

7.10.6 Posters

During the reporting period, we produced 3 scientific posters that NRP staff presented at various conferences, meetings, proceedings, and outreach events:

Title: First Confirmed Band-Rumped Storm Petrel Colony in the Hawaiian Islands at the US Army Garrison Pōhakuloa Training Area, Hawaiʻi Island
Date: March 2020
Author(s): Lena Schnell
Summary: The Band-rumped Storm Petrel (BSTP, *Hydrobates castro*) is an endangered subtropical pelagic seabird of the Atlantic and Pacific Oceans. Its breeding behavior and distribution are poorly understood, and potential breeding sites expand across some of the main Hawaiian Islands. Prior to this study, no active breeding sites had ever been confirmed. Since 2015, we used a combination of acoustic monitoring, night vision surveys, dog searches, remote camera surveillance to search for occupied BSTP nests. We discovered a breeding colony of BSTP at 2,113 m elevation on the northern slope of Mauna Loa within PTA. Camera surveillance confirmed 5 active breeding nests. Since this is the first confirmed location of a colony in Hawaiʻi, further investigations are being conducted to better understand the BSTP distribution and breeding behavior at the installation.

Title: Ungulate-free Status – 3 Years and Counting at US Army Garrison, Pōhakuloa Training Area
Date: March 2020
Author(s): Rogelio Doratt, Den Jensen
Summary: Non-native ungulates (sheep, goats, and pigs) are a serious threat to native species and ecosystems in Hawaiʻi. At PTA on Hawaiʻi Island dryland habitats support 26 threatened and endangered species, some exceedingly rare and most of which are negatively affected by non-native ungulates. There are 15 ungulate exclusion fence units at PTA totaling 138 km in length and they protect 15,092 ha of native habitat. Since 2017, all 15 fence units have been ungulate-free. To maintain the ungulate-free status of the fence units we developed an ungulate-free management action plan: 1) incidental sighting reporting, 2) camera surveillance monitoring, 3) fence line inspections, 4) Judas animal monitoring (telemetry tracking collar), and 5) aerial surveys. If any of these 5 actions provide evidence of an ungulate ingress, then removal operations are implemented. Ungulate removal operations include live trapping, ungulate drives, and ungulate shooting. Since 2017, monitoring efforts detected have 8 ingress events and 17 ungulates have been removed.

Title: Wild Sheep Abundance and Population Trends at US Army Garrison, Pōhakuloa Training Area, Hawaiʻi
Date: March 2020
Author(s): Brian Leo
Summary: PTA is a large military installation on the Big Island of Hawaiʻi and an organized hunting program has been implemented there since 2016. The most popular game animals are wild sheep, including feral (*Ovis aries*) and mouflon (*Ovis musimon*); however, most are a hybrid of the 2 species. Harvest of these species at PTA has occurred without any information on the population trends or density estimates since the start of the program. To achieve management objectives and inform our ongoing programmatic Section 7 consultation, USAG-P funded Colorado State University, CEMML staff to develop a population model that will be used to estimate population parameters, identify abundance trends, and help determine the effect of the hunting program on sheep abundance. We characterized the sheep population using a discrete form of the Schaefer model; after optimization,

the initial population was estimated to be 233 in 2017 and abundance increased on a general trend to 320 by 2019. The model suggested a relatively high carrying capacity (725) compared to the abundance estimates. The model showed that the sheep population is stable but would increase in the absence of hunting pressure. We suggest that another population estimate from an independent method (e.g., aerial surveys), would be very useful because it would provide a datapoint with which to compare the estimate derived from Instantaneous Sampling.

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-P 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.

During the reporting period, we provided assessments following 5 wildland fire events in July and August 2021. In this section, we summarize the key findings from the post-disturbance assessments that were submitted to the Army.

8.1 FIRING POINT 519 (TRAINING AREA 16) FIRE

On 15 July 2021, at approximately 1520 hours, a wildland fire ignited at Firing Point 519 in Training Area 16 at PTA. The fire was started during military training exercises (smoke grenade) by the 1st Platoon, Echo Company, 100th Battalion, 442nd Infantry Regiment. The fire was declared 100% contained that same evening. The fire burned approximately 4 ha in the *Eragrostis atropioides* Herbaceous Alliance (Block et al. 2013). There were no effects to ESA-listed plant species or Hawaiian hoary bat habitat.

For more details on the 15 July 2021 wildland fire at Firing Point 519 refer to the "*Technical Report and Post-Disturbance Assessment for the July 2021 Wildland Fires: Keʻāmuku Maneuver Area (LZ Dove)/Palila Critical Habitat, Firing Point 519 (Training Area 16), Pōhakuloa Training Area, Island of Hawaiʻi*" (CEMML 2021d).

8.2 KEʻĀMUKU MANEUVER AREA (LZ DOVE)/PALILA CRITICAL HABITAT FIRE

On 17 July 2021, at approximately 1330 hours, a wildland fire ignited near LZ Dove in KMA. The fire was started during military training exercises (blank ammunition) by the 1-299 Calvary Regiment, Hawaiʻi Army National Guard. The fire spread quickly and jumped Fuel Break 313 (Scout Trail) which runs from Keʻekeʻe Road to the northern edge of the Kilohana Girl Scout Camp. Firefighters used Fuel

Break 313 to fight the fire. The fire wrapped around the north end of the fuel break where fuels control ends but did not jump Old Saddle Road at that location. The fire burned approximately 508 ha in KMA in the following vegetation communities: *Dodonaea viscosa* Shrubland Alliance, *Eragrostis atropioides* Herbaceous Alliance, *Myoporum sandwicense–Sophora chrysophylla* Shrubland Alliance, *Pennisetum* (*ciliare*, *setaceum*)–Mixed Medium-Tall Ruderal Grassland Alliance, *Pennisetum clandestinum* Semi-natural Grassland Alliance, and Semi-natural Herbland Alliance (Block et al. 2013).

Effects to ESA-listed Plant Species and Palila Critical Habitat

There were no known locations of ESA-listed plant species within the burn footprint; however, a single location of *Sicyos macrophyllus* was within the vicinity of the fire. An emergency firebreak that was bulldozed during fire response operations successfully stopped the fire approximately 200 m from the *S. macrophyllus* location. On 1 September 2021, we surveyed the *S. macrophyllus* location and confirmed that 5 plants (4 adults and 1 juvenile) were healthy and showed no fire impacts. Vegetation at the site was recorded at 75-90% native cover and 5-10% non-native cover. There were no effects to ESA-listed plant species.

On the evening of 17 July 2021, the fire jumped Old Saddle Road near the Kilohana Hunter Station and spread into Palila Critical Habitat (PCH). The fire burned approximately 99 ha of PCH on adjacent state land, increasing the total footprint of the fire to 657 ha. The PTA Fire Department, Hawaiʻi County Fire Department, and State of Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife personnel conducted joint fire response operations in PCH. The fire was declared 90% contained on 19 July 2021.

Incidental Take of Hawaiian Hoary Bat Habitat

The 17 July 2021 fire burned 3 ha of vegetation considered potential available Hawaiian hoary bat roosting habitat, approximately 6% of the allowable 48 ha per year. No bat carcasses were reported in the burned area and impacts to the Hawaiian hoary bat are assumed to be negligible.

For more details on the 17 July 2021 wildland fire in KMA (LZ Dove) and PCH refer to the "*Technical Report and Post-Disturbance Assessment for the July 2021 Wildland Fires: Keʻāmuku Maneuver Area (LZ Dove)/Palila Critical Habitat, Firing Point 519 (Training Area 16), Pōhakuloa Training Area, Island of Hawaiʻi*" (CEMML 2021d).

8.3 MANA ROAD/MAUNA KEA/ KEʻĀMUKU MANEUVER AREA FIRE

On 30 July 2021, at approximately 1100 hours, a wildland fire ignited off-PTA near Mana Road in the town of Waimea. Fueled by high winds, the fire spread quickly and burned significant acreage on Parker Ranch and state lands on Mauna Kea. On 31 July 2021, the fire jumped Old Saddle Road and burned onto KMA near Puʻu Nohona o Hae and Puʻu Pāpapa. One of the largest wildland fires in recorded Hawaiʻi history, the fire burned approximately 1,273 ha in KMA and more than 17,000 ha overall. The fire was declared 100% contained on 6 August 2021. The following vegetation communities were within the KMA burn footprint: *Dodonaea viscosa* Shrubland Alliance, *Eragrostis* spp. Semi-natural Woodland Alliance, *Myoporum sandwicense–Sophora chrysophylla* Shrubland Alliance, *Pennisetum* (*ciliare*, *setaceum*)–Mixed Medium-Tall Ruderal Grassland Alliance, *Pennisetum clandestinum* Semi-natural Grassland Alliance, and Semi-natural Herbland Alliance (Block et al. 2013).

Effects to ESA-listed Plant Species

We assessed impacts to ESA-listed plant species by comparing direct counts of *Isodendrion hosakae, Lipochaeta venosa,* and *Vigna o-wahuensis* from July–September 2020 (CEMML 2021c) to counts made during our post-fire survey. All known monitoring plots were visited during the post-fire surveys. The following data were collected: 1) counts of seedlings, juveniles, and adults present, 2) health/vigor status of plants, 3) observations of particulate impacts to plants, 4) observations of direct heat impacts to plants. Post-fire assessment data also included total ground cover of native and non-native species using cover classes of 0%, <1%, 5–10%, 10–25%, 25–50%, 50–75%, 75–90%, >90%.

Puʻu Nohona o Hae Survey Results

There were no known locations of ESA-listed plant species within the burn footprint near Puʻu Nohona o Hae in KMA; however, several locations of *Lipochaeta venosa* and *Vigna o-wahuensis* were in the general vicinity of the fire. An emergency firebreak that was bulldozed around the puʻu during fire response operations, combined with a conservation fuel break that encircles the puʻu, successfully stopped the fire approximately 115 m from the nearest plant locations. On 30 August 2021, we surveyed all known locations of *L. venosa* and *V. o-wahuensis* to assess potential fire impacts.

There were approximately 17 locations of *L. venosa* within proximity of the burn footprint containing a pre-fire estimate of 50 individuals (CEMML 2021c). We recorded 37 individuals (5 juveniles and 32 adults) of *L. venosa* during post-fire surveys. Vigor data shows 3% healthy, 21% moderate, and 76% poor individuals. The cover of non-native plants species ranged from 1–90% total cover in the vicinity of the plants. No direct or indirect fire impacts were observed.

There were approximately 44 locations of *V. o-wahuensis* within proximity of the burn footprint containing a pre-fire estimate of 102 individuals (CEMML 2021c). We recorded 0 individuals of *V. o-wahuensis* during post-fire surveys, but as the locations of the plants were not within the burn footprint the loss of plants cannot be attributed to the fire. Non-native species cover ranged from 5–25% in the vicinity of the previously recorded plant locations. No direct or indirect fire impacts were observed.

Puʻu Pāpapa Survey Results

There were no known locations of ESA-listed plant species within the burn footprint near Puʻu Pāpapa in KMA; however, several locations of *Isodendrion hosakae* were in the general vicinity of the fire. Emergency firebreaks that were bulldozed in KMA during fire response operations, combined with a conservation fuel break that encircles the puʻu, successfully stopped the fire approximately 113 m from the nearest plant locations. On 1 September 2021, we surveyed all known locations of *I. hosakae* to assess potential fire impacts.

There were approximately 20 locations of *I. hosakae* within proximity of the burn footprint containing a pre-fire estimate of 637 individuals (CEMML 2021c). We recorded 326 individuals (287 juveniles and 39 adults) of *I. hosakae* during post-fire surveys. Vigor data shows 92% healthy, 7% moderate, and 1% poor individuals. The cover of non-native plants species ranged from 1–90% total cover in the vicinity of the plants. No direct or indirect fire impacts were observed.

Incidental Take of Hawaiian Hoary Bat Habitat

The 30 July 2021 fire burned 12 ha of vegetation considered potential available Hawaiian hoary bat roosting habitat, approximately 25% of the allowable 48 ha per year. No bat carcasses were reported in the burned area and impacts to the Hawaiian hoary bat are assumed to be negligible.

For more details on the 30 July 2021 wildland fire in KMA near Puʻu Nohona o Hae and Puʻu Pāpapa refer to the "*Technical Report and Post-Disturbance Assessment for the July 2021 Wildland Fire: Mana Road/Mauna Kea/Keʻāmuku Maneuver Area, Pōhakuloa Training Area, Island of Hawaiʻi*" (CEMML 2021e).

8.4 Daniel K. Inouye Highway (MM48) Fires

On 11 and 13 August 2021, 2 fires occurred south of the DKI Highway near MM 48 in KMA. Mop up operations continued until the morning of 15 August 2021. The fires burned approximately 100 ha: 33 ha in KMA and 67 ha on adjacent state land. The fires burned the following vegetation types in KMA: *Dodonaea viscosa* Shrubland Alliance, *Pennisetum* (*ciliare*, *setaceum*)–Mixed Medium-Tall Ruderal Grassland Alliance, and Semi-natural Herbland Alliance (Block et al. 2013). The cause of both fires was suspected arson. Because the fires were not training related, any loss of treeland roosting habitat is not considered incidental take of the Hawaiian hoary bat and the Army was not required to produce a technical report for USFWS. We produced a memorandum to document the post-disturbance assessment.

Based on rare plant survey data, no known locations of ESA-listed plant species were within the burn footprint (Arnett 2002). KMA is former ranchland and thus a highly degraded landscape dominated by invasive grasses. Due to the continued presence of feral ungulates, we determined it was highly unlikely that any ESA-listed plant species occur in the area; therefore, we did not conduct post-fire surveys. The fires did not have any known impacts on ESA-listed plant species.

To assess impacts to Hawaiian hoary bat habitat, we overlaid vegetation types that may provide treeland roosting habitat with the burn footprint using ArcGIS. No potential available treeland roosting habitat was within the burned area; therefore, no incidental take of Hawaiian hoary bats occurred from the fires.

For more details on the August 2021 wildland fires in KMA near DKI Highway refer to the MFR "*Post-disturbance assessment for the fires that occurred near the DK Inouye Highway (MM 48) in the Keʻāmuku Maneuver Area in August 2021*" (CEMML 2022).

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 Agreements W9126G-16-2-0014 and 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

FY 2020–FY 2021 COMPLETED DOCUMENT DELIVERABLES FOR THE ARMY'S NATURAL RESOURCES PROGRAM AT PŌHAKULOA TRAINING AREA

We produced the following document deliverables during the FY 2020–FY 2021 reporting period (01 October 2019 through 30 September 2021). This list includes technical reports, published articles, protocols, standard operating procedures, survey summaries, professional presentations, 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).

- **Results of DeLuz Quarry Inspection on 12 November 2019 (2019 11 19):** this memorandum summarizes the invasive species survey results for the aggregate inspection conducted at DeLuz quarry. 7 p.

- **2020 Breeding Season Report for the Band-rumped Storm Petrel at Pōhakuloa Training Area, Hawai'i Island, Hawai'i Protected Wildlife Permit WL 19-42 (2020 01 28):** this technical report summaries the management activities conducted for the Band-rumped Storm Petrel (burrow survey with search dog, burrow monitoring, and predator control) at PTA. This report was submitted to comply with the State of Hawaiʻi Protected Wildlife Scientific Collecting Permit annual report requirement. 19 p.

- **MBTA Scientific collecting for BSTP 2019 Annual Report (2020 01 28):** 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.

- **Results of Ant Survey on Pōhakuloa Training Area Cantonment Area between Quonset Huts Inspection (2020 03 03):** this email summarizes the invasive ant species survey results for the cantonment area between PTA Quonset huts on 3 March 2020. 1 p.

- **Results of West Hawaiʻi Concrete Quarry Inspection (2020 03 19):** this email corresponds summarizes the invasive species survey results for the aggregate inspection conducted at West Hawaiʻi Concrete on 19 March 2020. 1 p.

- **Results of West Hawaiʻi Concrete Quarry Inspection (2020 04 14):** this email summarizes the invasive species survey results for the aggregate inspection conducted at West Hawaiʻi Concrete on 10 April 2020. 1 p.

- **Band-rumped Storm Petrel (*Hydrobates castro*) Management Plan (2020 05 07):** document summarizing management actions conducted for the BSTP at PTA. Management objectives include determining the geographic extent of the known colony, behavior characterization, and predator control. Methods include acoustic monitoring, nest surveys, video surveillance, and small mammal control. 10 p.

- **2016–2020 Annual Reports for the State of Hawaiʻi Access and Research Permit and Hawaiʻi Experimental Tropical Forest Research Permit for Pōhakuloa Training Area, Hawaiʻi Island, Hawaiʻi (2020 05 20)**: permit report produced to update NRP reporting status with the State of Hawaiʻi, DLNR DoFAW to outplant TES plants on State lands. 6 p.

- **2019/2020 Hawaiian Goose Conservation Project Plan, Hakalau (2020 06 11):** 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. 4 p.

- **2019/2020 Breeding Season Report for Hawaiian Goose Conservation Project Hakalau Forest National Wildlife Refuge Hakalau, Hawaiʻi Island, Hawaiʻi (2020 07 30):** this technical report summaries the management activities (Hawaiian Goose habitat management, goose monitoring, nest monitoring, and predator control) we conducted for the 2019/2020 Hawaiian Goose breeding season. This report was submitted to comply with the Hakalau SUP annual report requirement. 12 p.

- **Army Natural Resources Program at Pōhakuloa Training Area, Biennial Report, 01 October 2017–30 September 2019 (2020 09 08):** report documenting the work performed jointly by CEMML and USAG-P regarding the management of natural resources at PTA during the 2-year period of FY 2018–FY 2019. 440 p.

- **Site Assessment for Vegetation Control in Weed Control Buffers and Fuel Breaks (2020 09 22)**: SOP produced to ensure standardized and objective methods of assessing vegetation growth (weeds and fuels) to effectively plan vegetation control within weed control buffers and fuel breaks). 5 p.

- **Vegetation Control in Areas of Species Recovery (2020 09 22)**: SOP produced to manage invasive plant species effectively and efficiently within prescribed weed control buffers around federally listed threatened and endangered plant species in Areas of Species Recovery using herbicide applied with a backpack sprayer. 5 p.

- **IPSM Site-specific Survey and Control (2020 09 23)**: SOP produced to provide instructions for consistent execution of site-specific survey and control operations for secondary target weeds. The SOP will be updated as needed when we develop a new IPSM protocol. The new protocol will include details on prioritizing weed species and sites, decision criteria, and approaches to monitoring and management. 11 p.

- **US Army Garrison, Pōhakuloa Training Area, Natural Resource Program, Ungulate Exclusion Fence and Gate Damage Incident Report (2020 10 28**): this report summarizes the damage discovered at one of the ungulate exclusion fence units at PTA. This gate damage occurred in the Nāʻōhuleʻelua Fence Unit. 4 p.

- **COVID-19 Safety Practices for Camping Operations (2020 11 25)**: SOP produced to provide mitigation measures unique to the COVID-19 pandemic during required overnight camping operations at remote field sites. 4 p.

- **MBTA Scientific Collecting for Band-rumped Storm Petrel 2020 Annual Report (2021 01 13):** 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.

- **Results of West Hawaiʻi Concrete Quarry Inspection (2021 01 19):** this memorandum summarizes the invasive species survey results for the aggregate inspection conducted at West Hawaiʻi Concrete on 11 January 2021. 6 p.

- **2020 Annual Report for Pōhakuloa Training Area, Hawaiʻi Island, Hawaiʻi, Recovery Permit TE-40123A-2 (2021 01 30):** technical report documenting activities performed collectively by the Army and CEMML staff during 2020 and to satisfy annual recovery permit reporting requirements. Includes activities authorized under the USFWS recovery permit TE-40123A-2. 110 p.

- **2020 Breeding Season Report for the Band-rumped Storm Petrel, Pōhakuloa Training Area, Hawaiʻi Island, Hawaiʻi (2021 01 14):** technical report documenting activities performed at PTA under the State of Hawaiʻi Protected Wildlife Permit Number WL19-42 for the purpose of scientific collecting. Permit grants us permission to salvage, transport, and collect up to BSTP specimens per year at PTA. 29 p.

- **Fuel Monitoring Corridor (FMC) Assessment Report for 2020 Assessment (2021 01 21)**: memorandum documenting results of FMC monitoring conducted on 14 December 2020. FMCs were assessed by ocular estimation via helicopter flyover. We confirmed that a minimum of 100 m separated any contiguous fuels on one side of each FMC from contiguous fuels on the opposite side of each FMC. Based on results of the assessment, no management of surface fuels was required at the time but 2 areas where invasive grasses were invading were identified for potential future management. 2 p.

- **FY 2020 Annual Report for the Army Natural Resources Program at Pōhakuloa Training Area (2021 02 11)**: report produced to satisfy annual reporting requirements mandated in regulatory and guiding documents. The report covers the period of FY 2018 (01 October 2019 through 30 September 2020). 64 p.

- **Technical Report for 2019 Outplanting Activity at Pōhakuloa Training Area and Recommendations for Maintaining or Removing Outplantings (2021 02 09):** technical report to document outplanting activities from February–April 2019 at PTA including a map of the planting sites and detailed planting records with founder information. The report also provides regulatory context, impacts to and from military training, biological context, implications for management, and recommendations for each site. 54 p.

- **Results of West Hawaiʻi Concrete Quarry Inspection (2021 02 17):** this memorandum summarizes the invasive species survey results for the aggregate inspection conducted at West Hawaiʻi Concrete on 8 February 2021. 4 p.

- **US Army Garrison, Pōhakuloa Training Area, Natural Resource Program, Ungulate Exclusion Fence Incident Report (2021 02 24**): this report summarizes the detection of an unknown person trespassing onto PTA property and climbing over a vehicle gate at the Puʻu Nohona o Hae ungulate exclusion fence. 2 p.

- **US Army Garrison, Pōhakuloa Training Area, Natural Resource Program, Rare, Federally listed Species and Migratory Bird Species Incidental Report Hawaiian Goose (2021 03 03):** 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 25 February 2021 Hakalau staff collected the carcass. Cause of death is unknown. 6 p.

- **History and Status of the Puʻu Waʻawaʻa Forest Reserve Cone Unit (2021 04 21):** 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 (2021 05 12):** 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.

- **Information Papers for LTC Cronin In-Brief (2021 05 20):** series of information papers prepared to brief the incoming Commander on important natural resources issues. Topics included external research, collaborations, Hakalau, the Natural Resources Program, outreach, Programmatic Biological Assessment, publications and presentations. Each 1-2 p.

- **US Army Garrison, Pōhakuloa Training Area, Natural Resource Program, Ungulate Exclusion Fence and Gate Damage Incident Report (2021 05 27**): this report summarizes the damage discovered at one of the ungulate exclusion fence units at PTA. This gate damage occurred in the Nāʻōhuleʻelua Fence Unit. 8 p.

- **Determination of Compliance/non-compliance with the 2003 Biological Opinion Requirement to Develop a Dust Study at Pōhakuloa Training Area (2021 06 15):** memorandum comparing the Gleason (2007) and Potetti (2009) dust studies to the 2003 BO to determine if the Army is in compliance with the requirement to develop a dust accumulation and deposition study at PTA to identify whether there are adverse effects of dust on a variety of native plant species. 9 p.

- **2020/2021 Hawaiian Goose Conservation Project Plan, Hakalau (2021 07 06):** this project plan proposes the 2021/2022 management activities (Hawaiian Goose habitat management, goose monitoring, nest monitoring, and predator control) that we plan for the Hawaiian Goose breeding season. 4 p.

- **Results of West Hawaiʻi Concrete Quarry Inspection (2021 07 08):** this memorandum summarizes the invasive species survey results for the aggregate inspection conducted at West Hawaiʻi Concrete on 8 July 2021. 4 p.

- **Equipment Inspection, Red Cross Containers at Pōhakuloa Training Area (2021 08 19):** this email describes the invasive species inspection request for inspecting equipment being brought to PTA from the Red Cross. 1 p.

- **US Army Garrison, Pōhakuloa Training Area, Natural Resource Program, Ungulate Exclusion Fence and Gate Damage Incident Report (2021 09 30):** this report summarizes the damage discovered at one of the ungulate exclusion fence units at PTA. This gate damage occurred in the Kipuka Kālawamauna North Fence Unit. 3 p.

- **2020/2021 Breeding Season Report for Hawaiian Goose Conservation Project Hakalau Forest National Wildlife Refuge Hakalau, Hawaii Island, Hawaii (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 2020/2021 Hawaiian Goose breeding season. This report was submitted to comply with the Hakalau SUP annual report requirement. 26 p.

- **Hawaiian Hoary Bat (*Lasiurus cinereus semotus*) Conservation Management Plan at Pōhakuloa Training Area, Hawaiʻi (Draft, expected publication 2021):** this conservation plan describes how to help conserve the Hawaiian hoary bat at PTA, minimize long-term constraints to military training, and satisfy requirements to develop and coordinate such a plan with agency partners.

- **2021 Breeding Season Report for the Band-rumped Storm Petrel at Pōhakuloa Training Area, Hawai'i Island, Hawai'i Protected Wildlife Permit WL 19-42 (Draft, expected publication 2021):** this technical report summaries the management activities conducted for the Band-rumped Storm Petrel (burrow survey with search dog, burrow monitoring, and predator control) at PTA. This report was submitted to comply with the State of Hawaiʻi Protected Wildlife Scientific Collecting Permit annual report requirement.

Technical Assistance for Military Initiatives

We produced the following documents to provide technical assistance for military training, operations, and maintenance projects to maintain or increase training capacity at the installation, for cooperative initiatives with state and federal resources agencies, and to provide for a defense in litigation proceedings.

- **Outplanting and 700 FP in TA 22 - REC 4534 Establish Firing Points 713, 714, and 715 (2020 02 25)**: memorandum provided in support of REC 4534. Summarizes background regarding the outplanting of endangered plants near the proposed construction sites for Firing Points 713, 714, and 715 in TA 22; the regulatory implications and potential effects to training; and recommended and alternative courses of actions with justifications. 3 p.

- **Informal Consultation for Predator Control at Band-rumped Storm Petrel Colony during Breeding Season (2020 05 22):** informal consultation letter requesting USFWS concurrence the determination that proposed small mammal control activities at the BSTP colony during breeding season may affect, but is not likely to adversely affect, BSTP and the Hawaiian Goose. Concurrence received in a letter dated 2020 05 27. 6 p.

- **PTA Nat Res Comments for REC 4693, 4699, 4700 (2020 10 05):** consolidated comments on 3 RECs – REC 4693 Site Prep for ARMAG (NR Issues were Hawaiian hoary bat entanglements, light effects to bats and seabirds, invasive species); REC 4699 Replace Freezers (no anticipated issues to TES); REC 4700 Curation Container (no anticipated issues to TES). 2 p.

- **PTA Nat Res Comments for REC 4763 Waikiʻi Grazing Lease (2021 03 15):** comments regarding proposed grazing lease around Waikiʻi Ranch buffer. Potential NR issues were impacts to listed bird species, Hawaiian hoary bat, and invasive species. 1 p.

- **PTA Nat Res Comments on REC 4767 IPBA Ground Softening (2021 04 28):** comments regarding proposed ground softening activities at the IPBC to allow soldiers to conduct dismounted maneuvers while training on the range. NR issues included potential impacts to *Kadua coriacea*, other location of TES plants in the action area, invasive species, dust, and the transmission of Rapid ʻŌhiʻa Death. 3 p.

Assessments After Disturbance Events

We produced the following documents to assess effects to natural resources, threatened and endangered species (TES), and their habitat after disturbance events (e.g., wildland fire, drought, flooding).

- **Technical Report and Post-Disturbance Assessment July 2021 Wildland Fire: Mana Road/Mauna Kea/Keʻāmuku Maneuver Area (2021 09 22)**: report prepared to fulfill the Army's wildland fire reporting requirements per the 2003 BO. Summarizes effects to TES from a July 2021 fire that burned 1,273 ha in KMA. No ESA-listed plant species were affected by the fire; 12 ha of potential habitat for the Hawaiian hoary bat were burned. 7 p.

- **Technical Report and Post-Disturbance Assessment July 2021 Wildland Fires: Keʻāmuku Maneuver Area (LZ Dove)/Palila Critical Habitat and Firing Point 519 (Training Area 16) (2021 10 18)**: report prepared to fulfill the Army's wildland fire reporting requirements per the 2003 BO. Summarizes effects to TES from 2 July 2021 fires that burned 657 ha in KMA/PCH and 4 ha in TA 16. No ESA-listed plant species were affected by the fires; 3 ha of potential habitat for the Hawaiian hoary bat were burned. 5 p.

Outreach, Presentations, and Publications

- **A Landscape Approach to Managing Multiple Stressors for Multiple Federally Listed Species, Pōhakuloa Training Area, Hawaiʻi (2020 10 01):** article written for the publication "Conserving Biodiversity on Military Lands: A Guide for Natural Resources Managers". Summarizes how the NRP minimizes regulatory burdens resulting from ESA consultations by managing multiple stressors to support stable baseline populations of rare plants while minimizing constraints on military training and operations. 8 p.

- **Species At Risk: A Story of the Native Hōʻawa (2021 02 22):** article published in the 2020 issue of the Oʻahu Army Natural Resources Program Ecosystem Management Program Bulletin. Summarizes Army management of species at risk (SAR) at PTA and highlights the native hōʻawa (*Pittosporum terminalioides*). By proactively monitoring and managing for SARs and their habitat, the Army can help preclude the need for federal listing under the ESA, protect significant biological diversity and reduce recovery costs, while maintaining military training capacity. 3 p.

- **Information Paper - Overview of U.S. Army Garrison-Pōhakuloa Training Area Natural Resources Program (2020 09 02)**: paper to provide information to USAG-P Command regarding an overview of the Army NRP at PTA. 2 p.

- **Information Paper - Public Outreach Conducted by the U.S. Army Garrison, Pōhakuloa Training Area Natural Resources Program (2021 05 12)**: paper to provide information to

USAG-P Command regarding the public outreach and educational initiatives conducted by the Army NRP at PTA. 1 p.

- **Information Paper - Collaborations between Partner Agencies and the US Army Garrison, Pōhakuloa Training Area Natural Resources Program (2021 05 13)**: paper to provide information to USAG-P Command regarding the mutual initiatives and collaborations between partner agencies and the Army NRP at PTA. 1 p.

- **Information Paper - Publications and Presentations Produced by the U.S. Army Garrison, Pōhakuloa Training Area Natural Resources Program (2021 05 13)**: paper to provide information to USAG-P Command regarding the publications and scientific presentations produced by the Army NRP at PTA. 2 p.

- **Information Paper - External Research Facilitated by the U.S. Army Garrison, Pōhakuloa Training Area Natural Resources Program (2021 05 18)**: paper to provide information to USAG-P Command regarding the research projects conducted by external agencies and coordinated through the Army NRP at PTA. 2 p.

- **Information Paper - Programmatic Biological Assessment for the U.S. Army Garrison, Pōhakuloa Training Area, Island of Hawaiʻi (2021 05 19)**: paper to provide summary information to USAG-P Command regarding the Biological Assessment "*Mission and Mission Sustainment on Army Lands on Pōhakuloa Training Area*" prepared for the Army by the Engineer Research and Development Center, Construction Engineering Research Laboratory, USACE. 1 p.

- **Information Paper - Off-site Hawaiian Goose Management Conducted by the U.S. Army Garrison, Pōhakuloa Training Area Natural Resources Program (2021 05 20**): paper to provided information to USAG-P Command regarding the Hawaiian Goose management conducted at Hakalau Forest National Wildlife Refuge by the Army NRP at PTA. 1 p.

- **Information Paper - Band-rumped Storm Petrel Management (2021 07 15):** paper to provide information to USAG-P Command regarding the management of an active BSTP colony by the Army NRP at PTA. 2 p.

- **First Confirmed Band-Rumped Storm Petrel Colony in the Hawaiian Islands at the US Army Garrison Pōhakuloa Training Area, Hawaiʻi Island (2020 03 05)**: poster summarizing BSTP management at PTA after discovery of an active breeding site in 2015. Management includes a combination of acoustic monitoring, night vision surveys, dog searches, remote camera surveillance to search for occupied BSTP nests. Camera surveillance confirmed 5 active breeding nests. 1 p.

- **Ungulate-free Status – 3 Years and Counting at US Army Garrison, Pōhakuloa Training Area (2020 03 05)**: poster summarizing management of 15 fence units at PTA after they were declared ungulate-free in 2017. The ungulate management action plan includes incidental sighting reporting, camera surveillance monitoring, fence line inspections, Judas animal monitoring, and aerial surveys. In the case of ingress, ungulate removal operations include live trapping, ungulate drives, and ungulate shooting. 1 p.

- **Wild Sheep Abundance and Population Trends at US Army Garrison, Pōhakuloa Training Area, Hawaiʻi (2020 03 05)**: poster summarizing development a population model used to estimate population parameters, identify abundance trends, and help determine the effect of the hunting program on sheep abundance at PTA. The model showed that the sheep population is stable but would increase in the absence of hunting pressure. 1 p.

- **First Confirmed Band-rump Storm Petrel Colony in the Hawaiian Islands at U.S. Army Garrison, Pōhakuloa Training Area, Hawaiʻi (2021 06 03):** 20-minute virtual presentation by Rogelio E. Doratt for the Hawaiʻi Division of Forestry and Wildlife, Seabird Workshop, Endangered Species Recovery Committee (ESRC).

- **Evaluation of Unmarked Abundance Estimators using Game Cameras and Aerial Surveys (2021 09 16)**: article submitted to Wildlife Society Bulletin, expected publication in FY 2022. Summarizes a case study of feral sheep at PTA that tested 2 camera methods that use the same set of timelapse photographic data: a space to event model (STE) and instantaneous sampling (IS). The study showed the STE to be a cost effective, practical abundance estimator of feral sheep when compared to well-established aerial distance sampling techniques. 20 p.

- **Controlling Fuels Protects Endangered Plants at Pōhakuloa Training Area (2021 09 23)**: article submitted for the 2021 issue of the Oʻahu Army Natural Resources Program Ecosystem Management Program Bulletin. Summarizes fuels management (e.g., fuel breaks, firebreaks, weed control buffers, fuel monitoring corridors) implemented by the PTA NRP to avoid and minimize potential effects to TES from ongoing military training activities. Case studies are provided from wildland fire events in 2012, 2018, and 2021. 3 p.

State and Federal Permits

- **Native Endangered and Threatened Species Recovery Endangered and Threatened Plants, USFWS Recovery Permit TE-40123A-2**: ESA section 10(a)(1)(A) recovery permit issued to the Army by the USFWS authorizing activities for threatened and endangered plant species prohibited under Section 9. Expires 6 Nov 2022.

- **Authorization to Possess Hawaiian Goose for Conservation Education**: authorizes the Army to possess taxidermied remains of a Hawaiian Goose for education purposes. Required under USFWS (MBTA) and DLNR DoFAW (HRS-HAR) statutes. No expiration.

- **Protected Wildlife Permit for the Purpose of Scientific Collecting MB95880B-0**: permit issued to the Army by the USFWS Migratory Bird Permit Office allowing for the collection (salvage, transport, and possession) of the Band-rumped Storm Petrel at PTA for scientific purposes. Expires 31 March 2022.

- **Protected Wildlife Permit Scientific Collecting Band-rumped Storm Petrel WL19-42**: permit issued to the Army by the State of Hawaiʻi Department of Land and Natural Resources allowing for the salvage, transport, and possession of BSTP at PTA for the purpose of scientific collecting. Renewal in progress, application submitted Aug 2021.

- **Hawaiʻi Experimental Tropical Forest Research Permit:** permit issued to the Army by the US Forest Service and the State of Hawaiʻi Department of Land and Natural Resources authorizing management of threatened and endangered plantings and propagule collections for research. Renewal in progress, application submitted Aug 2021.

- **Natural Area Reserve, Rare Plant, and Native Invertebrate Research Permit (I2689):** permit issued to the Army by the State of Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife, authorizing monitoring, collection of propagules, maintenance and threat control around outplanting sites of threatened and endangered plant species established by PTA at Kīpuka ʻOwēʻowē, Puʻu Huluhulu, and Puʻu Waʻawaʻa. Renewal in progress, application submitted Aug 2021.

- **Outplanting and Maintenance of Native Indigenous Plants at Puʻu Huluhulu Permit 18-061**: Limited Right of Entry permit issued to the Army by the State of Hawaiʻi Department of Hawaiian Home Lands authorizing outplanting and maintenance of native indigenous plant species at Puʻu Huluhulu. Expires after 30 entries, about 2025.

- **Outplanting and Maintenance of Native Indigenous Plants at Puʻu Huluhulu Permit**: permit issued to the Army by the State of Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife, authorizing access to Puʻu Huluhulu Native Plant Sanctuary quarterly to maintain outplanting sites using only mechanical means and to monitor and collect seeds and cuttings from endangered plant species. Renewal in progress, application submitted Aug 2021.

- **Hakalau Forest National Wildlife Refuge Special Use Permit 12516-19006-G**: special use permit issued to the Army by the USFWS providing access to and allowing activities to be conducted at HFNWR for the Hawaiian Goose (e.g., nest searches, predator control, nest monitoring, habitat management). Renewal in progress, application submitted Aug 2021.

- **Protected Wildlife Permit Scientific Collecting Game Birds WL20-12**: permit issued to the Army by the State of Hawaiʻi Department of Land and Natural Resources allowing for the salvage, transport, and possession of game birds at PTA for the purpose of scientific collecting. Expired on 01 July 2021.

APPENDIX B

THREATENED AND ENDANGERED SPECIES AT PŌHAKULOA TRAINING AREA

Hawaiʻi is the most isolated island chain in the world, located approximately 4,000 miles from the nearest continent. The small islands of the central and western Pacific are hundreds to thousands of miles downstream of prevailing oceanic and atmospheric currents. This isolation has significant implications for the biological resources of these islands. Many of the species at Pōhakuloa Training Area (PTA) are endemic to the Hawaiian Islands and species assemblages generally are limited in their distribution. Additionally, when native plants, insects and birds crossed the Pacific to get here, most of their natural predators did not travel with them. In many cases, the plants and insects of Hawaiʻi lost their thorns and chemical defenses. Due to these decreased defenses, introduced feral ungulates have decimated plant populations at PTA. Other threats to ecosystem health at the installation come from changes to the landscape as a result of invasive plants and wildland fire.

PTA includes a portion of the last remaining sub-alpine tropical dryland ecosystem in the world. Parts of the installation (Training Area 2 and parts of Training Areas 1, 4, 10 and 11) are also in critical habitat for the Palila (*Loxioides bailleui*) which is listed as endangered under the Endangered Species Act (ESA). Natural resources at PTA have been managed since 1995 through a series of cooperative agreements between the Center for Environmental Management of Military Lands and the Army. The installation provides potential habitat for a total 27 ESA-listed species.

There are 20 ESA-listed plant species at the installation and 1 plant species that is undescribed and not ESA-listed but is managed due to its rarity and limited distribution (Figure B1). Several of these plant species occur exclusively on the installation. For species-specific maps, refer to Sections 2.4 and 2.5 of this biennial report.

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

17. *Stenogyne angustifolia* var. *angustifolia*
18. *Tetramolopium arenarium* ssp. *arenarium* var. *arenarium*
19. *Tetramolopium* sp.1 (not ESA-listed)
20. *Vigna o-wahuensis*
21. *Zanthoxylum hawaiiense*

One mammal species, 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 (*Lasiurus cinereus semotus*)
2. Hawaiian Goose (*Branta sandvicensis*)
3. Band-rumped Storm Petrel (*Oceanodroma castro*)
4. Hawaiian Petrel (*Pterodroma sandwichensis*)
5. Anthricinan yellow-faced bee (*Hylaeus anthracinus*)
6. Blackburn’s sphinx moth (*Manduca blackburni*)

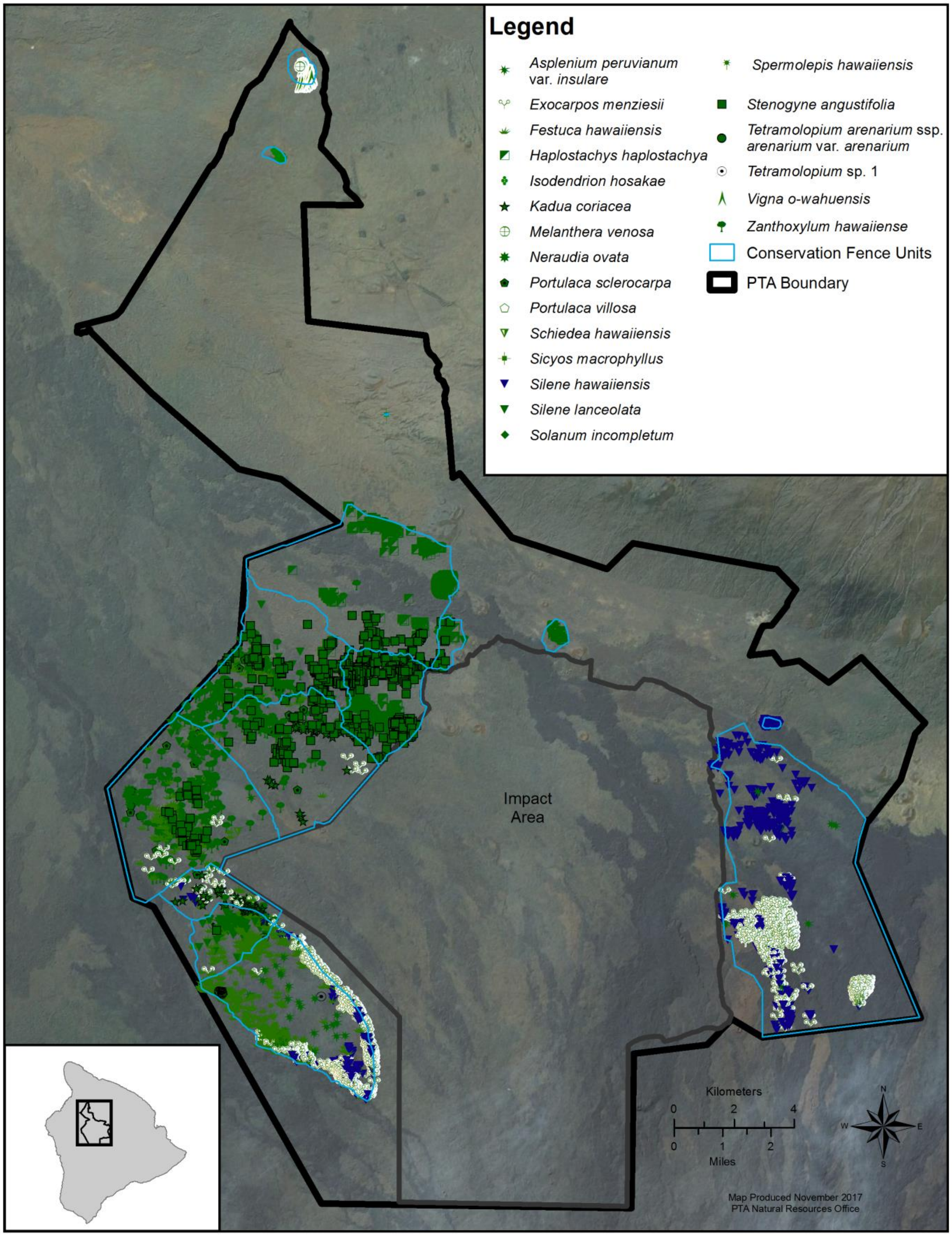

Figure B1. Current known distribution of threatened and endangered plant species at Pōhakuloa Training Area.

Asplenium peruvianum var. *insulare* (Fragile Fern)

This endangered fern is a real cave dweller. At PTA, *A. peruvianum* var. *insulare* grows in moist and dark areas such as large lava tubes, pits, and deep cracks. It reproduces by spores located on the underside of the leaflets.

Description: *A. peruvianum* var. *insulare* is a terrestrial, delicate, small to medium-sized perennial fern with underground stems. Each plant has about 1 to 20 fronds, which are 15 to 46 cm long and 1 to 3 cm wide. The fronds are often proliferous with one-to-many proliferations on the upper stipes and lower rachises. Fronds are also narrow, long-linear, and pale green. The rhizomes are decumbent and 3 to 12 mm in diameter. Stipes are dull gray or brown with 2 greenish ridges on the upper surface. This species has occasional one-to-many plantlets on the upper stipes and lower rachises.

Habitat: On Maui *A. peruvianum* var. *insulare* is found in streamside hollows and grottoes that occur in mesic to dry subalpine shrubland dominated by *Leptecophylla tameiameiae* and *Sadleria cyatheoides* with scattered *Metrosideros polymorpha.* The species has also been observed in montane wet ʻōhiʻa forest in rocky gulches in association with other fern species. *A. peruvianum* var. *insulare* has been observed at elevations between 1,680 and 2,410 m. On the island of Hawaiʻi *A. peruvianum* var. *insulare* grows in moist and dark areas in large lava tubes, pits, and deep cracks on varying ages of lava that have moderate soil or ash accumulation, often in association with mosses and liverworts. This species can occasionally be found growing in the interface between young ʻaʻā and older pāhoehoe lava flow deposits. At PTA, the species is found in the *Metrosideros polymorpha* Woodland Alliance, *Myoporum sandwicense - Sophora chrysophylla* Shrubland Alliance, and *Dodonaea viscosa* Shrubland Alliance vegetation types. Plants are frequently found growing in white mineral deposits of caves without any soil or ash accumulation.

Life History: Little is known about the reproductive cycles, longevity, specific environmental requirements, and limiting factors for *A. peruvianum* var. *insulare*. Reproduction is by spores located on the underside of the pinnae.

Distribution: *A. peruvianum* var. *insulare* was known historically from east Maui and from the island of Hawaiʻi and currently remains on both islands. At PTA, this species is known to occur in TAs 21, 22, and 23. Prior to ungulate control the species was commonly found within skylights or in caves near the entrance. Plants have been recorded outside of caves now that ungulates have been controlled. As September 2020, there are 714 adults and juveniles and 192 gametophytes in 67 locations at the installation.

Exocarpos menziesii (Menzie's Ballart, Heau)

This broom-like shrub belongs to the sandalwood family. The species gets its name from the Greek word *exo*, out of or without, and *karpos*, fruit, in reference to the fruit being partially embedded within a fleshy receptacle.

Description: *E. menziesii* is a shrub or small tree 0.5 to 2 m tall. Stems are densely branched toward the ends, the tips conspicuously maroon-tinged. Stems are stiff, upright, and conspicuously striate. Leaves are usually only scale-like with occasional foliaceous ones present, these elliptic to oblanceolate, 10-14 mm long. Flowers are perfect with 5 red petals that are 3 mm long. Fruits are reddish brown to red at maturity, ellipsoid to narrowly ovoid, 7-10 mm long. The exposed portion above the receptacle is 3-6 mm long, apex rounded with a small terminal beak partially embedded in a yellow, fleshy, receptacle.

Habitat: *E. menziesii* occupies the driest habitats of the 3 Hawaiian *Exocarpos* species. The 2 collections from Lānaʻi suggest a wider range in the past for this species. *E. menziesii* occurs in open *Metrosideros polymorpha* shrubland or on lava flows with sparse vegetation at elevations of 1,400 to 2,100 m in the montane dry ecosystem on the island of Hawaiʻi.

Life History: Three endemic *Exocarpus* species are found in Hawaiʻi. Both unisexual and perfect flowers have been reported in *E. gaudichaudii*; the breeding systems of all 3 species should be carefully studied.

Distribution: *E. menziesii* is historically known from the islands of Lānaʻi (Kaiholena Gulch) and Hawaiʻi (from Kahuku Ranch in the south up through Hualālai and Puʻu ka Pele on the leeward slopes of the island). Currently there is 1 scattered occurrence of *E. menziesii* of fewer than 20 individuals on the slopes of Hualālai; there are no known remaining occurrences of the species on Lānaʻi. At PTA, the species is widely distributed in TAs 21, 22, and 23. We estimate that there are 2,068 individuals in 4,388 locations at the installation (within and outside the fence units).

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 9,905 individuals in approximately 1,238 locations at the installation (within and outside the fence units). Prior to ungulate control *F. hawaiiensis* was almost exclusively found growing within *L. tameiameiae*, whose dense and stiff, pointed leaves provided shelter for *F. hawaiiensis* from ungulates. After conservation fencing and ungulate control, *F. hawaiiensis* is now growing in the open and multiple individuals are often recorded at a location.

Haplostachys haplostachya (Hawaiian Mint, Honohono)

This endangered mint appears to be fire resistant. The success of *H. haplostachya* following fire events may be due to its ability to resprout and its frequent location on rocky slopes. Fires in rocky areas tend to occur at low and moderate intensities because of low fuel loads.

Description: *H. haplostachya* is a perennial, erect short-lived shrub that grows to 30 to 60 cm tall. The leaves are fleshy, heart-shaped, and narrowly cordate. The upper surface of the leaves is light green, densely 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 24,010 individuals in approximately 3,110 locations at the installation. This is the most abundant ESA-listed plant species found at PTA, accounting for more than half the known individuals of all species combined. *H. haplostachya* is distributed over more than 2,430 ha within several fence units.

Isodendrion hosakae (Aupaka)

This endangered shrub in the violet family is found on steep puʻu in the South Kohala District on the island of Hawaiʻi. Its habitat is surrounded by converted pasture lands. In the absence of grazing pressures from cattle and feral ungulates, *I. hosakae* would presumably be more widely distributed.

Description: *I. hosakae* is a branched, upright, short-lived evergreen shrub. Plants range from 8 to 82 cm tall. Flowers and fruits occur on woody stems. Leaves are leathery and lance-shaped, measuring 3 to 7 cm long and 0.6 to 2.0 cm wide. Stipules are persistent and conspicuously cover stem ends. Flowers are bilaterally symmetrical, yellowish-green to white, and up to 18 mm long. The fruit is a red-tinged, green elliptical capsule measuring 12 to 16 mm long, and contains up to 9 obovoid seeds. *I. hosakae* is most similar to *I. pyrifolium* differing in leaf shape and size of lower flower petal.

Habitat: *I. hosakae* occurs in areas that have been converted to pasture lands for more than a century. The species is now only found on puʻu, possibly due to less frequent access by cattle and feral herbivores. The species occurs in dry montane shrublands dominated by *Dodonaea viscosa*, *Sophora chrysophylla*, *Wikstroemia* sp., and *Santalum* sp. Currently, much of the habitat is dominated by non-native grass species (e.g., *Cenchrus setaceus*). *I. hosakae* has been observed at elevations from 900 to 1,030 m.

Life History: Little life history information is known for *I. hosakae.* Flowering and fruiting has been reported during all months when monitoring has been conducted. Sexual reproduction mechanisms are not known, including pollination agents. Flowers are white and produce a sweet scent in late afternoon and evening, suggesting moths may be a pollination vector. There is no evidence of vegetative reproduction occurring in nature. Seedlings have been observed in the field in the vicinity of natural plants. Recruitment rates in the field appear to be low, but data are limited.

Distribution: *I. hosakae* is limited in distribution to the South Kohala District on the island of Hawaiʻi. The historical distribution of the taxon is not known since the species was only described about 50 years ago. The species is historically known from Puʻu Pāpapa and Puʻu Nohona o Hae in KMA, as well as 1 other puʻu in the vicinity on private lands. Currently, *I. hosakae* is only found on Puʻu Pāpapa, no plants remain on Puʻu Nohona o Hae. As of September 2020, there are 610 adults and juveniles and 27 seedlings in 30 locations at the installation. The possible and estimated elevation range of *I. hosakae* range is 915–1,040 m.

Kadua coriacea (Leather-leaf Sweet Ear, Kioʻele)

Due to its extreme rarity, the reproductive biology for this endangered plant in the coffee family is poorly understood. In past years, an unexplained lack of regeneration has been observed for *K. coriacea* despite the fact that the majority of adults were reproductively active. However, several seedlings were located in the last few years at PTA.

Description: *K. coriacea* is a small, many-branched, erect shrub. Leaves are leathery and more or less oval-shaped. The leaves are opposite, hairless above, hairless or downy below, and 3 to 8 cm long with 5 to 10 mm sheath-like petioles. Stipules are reduced and attached to the petiole base. Flowers are small, clustered, trumpet-shaped, cream-colored, and fleshy. The flowers have calyx lobes that do not enlarge when the fruit develops. Fruits are cup or top-shaped, containing dark-brown, irregularly angled seeds. The fruits are longer than wide and flower buds are square in cross-section.

Habitat: On the island of Hawaiʻi, the species occurs on pāhoehoe lava flows in the *Metrosideros polymorpha* Woodland Alliance vegetation type. It is found at elevations from 1,500 to 1,700 m. Associated species include *Dodonaea viscosa*, *Leptecophylla tameiameiae*, *Metrosideros polymorpha*, *Myoporum sandwicense*, *Myrsine lanaiensis*, and *Osteomeles anthyllidifolia*.

Life History: Life history information for *K. coriacea* is poorly understood, including flowering cycles, pollination vectors, seed dispersal agents, longevity, and environmental requirements. Immature and mature fruits have been observed in August, flowers in September, vegetative growth in December, and immature fruits and flowers in January. Despite the common perception that this is a short-lived species, we have observed many individuals for more than 10 years and some for 20 years or more.

Distribution: Historically, *K. coriacea* was present on the islands of Hawaiʻi, Maui, and Oʻahu but is currently only found on Hawaiʻi Island at PTA. This species tends to grow as single to a few individuals at locations in TAs 22 and 23. Plants in ASRs 11, 13, 18, 21, and 22 in the north may have been part of a more continuous distribution prior to ungulate impacts and other disturbances. Plants in ASRs 29 and 30 are likely a continuous distribution that is separated from the northern *K. coriacea* ASRs by a younger lava flow. Recruitment at natural plant locations was unconfirmed until recently. As of September 2020, there are 150 adults and juveniles in 128 locations at the installation.

Lipochaeta venosa (Nehe)

This endangered flowering plant in the sunflower family is known only from the island of Hawaiʻi, where it grows on puʻu within dry shrublands. The main threat to the species is loss and degradation of its habitat; much of the area is ranchland grazed by cattle and roamed by feral pigs and goats. Non-native plants and fire also threaten *L. venosa* habitat.

Description: *L. venosa* is a low-growing, perennial herb with curved, spreading stems that are 50 cm long. The species is partly deciduous and loses leaves during periods of drought. The leaves are triangular with 2 basal lobes, pinnately dissected throughout, and 2.1 to 2.8 cm long and 1.5 to 2.2 cm wide. The upper surface of the leaves has minute, straight, appressed hairs. On the lower surface, the hairs are denser. Flower heads are solitary or in clusters of 2. Ray floret achenes are 2 to 2.4 mm long and 1.5 to 1.8 mm wide with minute wings. The disk floret achenes are about the same size but wingless.

Habitat: *L. venosa* is restricted to puʻu in montane dry shrublands, dominated by non-native grasses (e.g., *Cenchrus setaceus*) with some native shrubs (e.g., *Dodonaea viscosa*, *Chenopodium oahuense*, and *Osteomeles anthyllidifolia*), typically at elevations from 725 to 1,140 m. In the absence of grazing pressures this species most likely would be more widespread. In KMA, the species occurs on the very stony soils of a puʻu. *L. venosa* is known to root sprout and can recolonize areas following fire events.

Life History: Life history information is poorly known for *L. venosa*. This species flowers between March and July, but flowering periods may extend beyond this period. Flowers do not appear to be specialized. The species roots readily 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 September 2020, there are 50 adults and juveniles in 17 locations 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 2003-2004 and 2013-2014

Distribution: *N. ovata* is known currently and historically only from the island of Hawaiʻi. It has been found in wet forests in the northern part of the island in Laupāhoehoe, in drier portions of the island at PTA, north Kona in Kaloko, and in the southern part of the island in Manukā. At PTA, this species is found in a small portion of TA 22 along the western boundary. The *N. ovata* at PTA may represent the upper limit of the species range. As of September 2020, there are 56 adults and juveniles in 24 locations at the installation.

Portulaca sclerocarpa (Hard Fruit Purslane, Poʻe)

This endangered flowering herb in the purslane family is only found on the island of Hawaiʻi and an islet off Lānaʻi. On Hawaiʻi Island, *P. sclerocarpa* grows on cinders and lava substrates in dry habitats at Hawaiʻi Volcanoes National Park and PTA. Unfortunately, 90% of known individuals were lost in 2008 after a major decline in the national park population.

Description: *P. sclerocarpa* is a short, generally herbaceous perennial that has a fleshy tuberous taproot that becomes woody. Its stems are up to 20 cm long. The species has stalkless, succulent, grayish-green leaves that are almost circular in cross-section. Dense tufts of hairs are located in each leaf axial and underneath the tight clusters of 3 to 6 stalkless flowers. The flowers are grouped at the end of the stem and petals are white, pink, or pink with a white base. The sepals are 5 mm long with membranous edges. The hardened capsules are 5 mm long, and have thick walls that open late or not at all.

Habitat: *P. sclerocarpa* is found on weathered Mauna Kea soils, puʻu, or geologically young lavas in montane dry shrublands, and in open *Metrosideros polymorpha* woodlands from 1,030 to 1,630 m in elevation. At PTA, the species is found on barren lava and in the *Metrosideros polymorpha* Woodland Alliance and *Myoporum sandwicense - Sophora chrysophylla* Shrubland Alliance vegetation types. Associated taxa are *Sophora chrysophylla, Dodonaea viscosa*, and *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 September 2020, there are 271 adults and juveniles and 3 seedlings in 60 locations 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 September 2020, there are 11 adults and juveniles in 2 locations 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 to 7.8 cm long and 1.7 to 2.8 cm wide, they are thin and leathery. The leaves are ovate to elliptic with only the midvein evident. The flowers are small, dull yellowish green, purple-tinged or purple, and arranged in clusters of 15–20 on an elongated and branched stem. The fruit is a small capsule with 9–20 seeds.

Habitat: At PTA, *S. hawaiiensis* is found in the *Metrosideros polymorpha* Woodland Alliance vegetation type. Associated species include *Myrsine lanaiensis*, *Dodonaea viscosa*, and *Leptecophylla tameiameiae* on the interface between ʻaʻā and pāhoehoe lava flows.

Life History: *S. hawaiiensis* has an autogamous breeding system. Self-pollination is facilitated by wind; when pollen is shaken from the anthers it is deposited on the stigma. The species is apparently not adapted to cross-pollination via wind, because there are so few pollen grains per flower. Most *Schiedea* species occurring in dry habitats have evolved sexual dimorphism rather than autogamy. Mutations to male sterility may not have occurred in *S. hawaiiensis*; sexual dimorphism does not occur in any closely related species.

Distribution: *S. hawaiiensis* is endemic to the island of Hawaiʻi. It was known from only 1 collection in Waimea prior to being recorded at PTA. As of September 2020, there are 18 adults and juveniles in 2 locations 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 individuals (4 adults, 1 juvenile) 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 to 40 cm long that arise from an enlarged root, and are generally covered with short, sticky hairs. Leaves are slender, often recurved, and stalkless. The stems are 6 to 15 mm long and 0.5 to 0.8 mm wide. Flowers are borne in loosely arranged, elongate, sticky clusters. The calyx is fused, 5-toothed, purple-tinged, and 11 to 14 mm long. Petals are green-white above and sometimes maroon or maroon-streaked below. Each petal is divided into 2 parts, a 2-lobed expanded blade and a long narrow, stalk-like base.

Habitat: *S. hawaiiensis* typically grows in montane and subalpine dry shrublands on weathered lava and ash, as well as on all ages of lava and cinder substrates at elevations from 900 to 1,300 m. At PTA, this species is found on barren lava, on disturbed sites, and in the *Metrosideros polymorpha* Woodland Alliance, *Chenopodium oahuense* Shrubland Alliance, *Dodonaea viscosa* Shrubland Alliance, *Myoporum sandwicense - Sophora chrysophylla* Shrubland Alliance, and *Eragrostis atropioides* Herbaceous Alliance vegetation types. Associated species include *Dodonaea viscosa*, *Leptecophylla tameiameiae*, *Metrosideros polymorpha*, *Rumex giganteus*, *Sophora chrysophylla,* and *Vaccinium reticulatum*.

Life History: Life history information for *S. hawaiiensis* is limited. This species has been observed to be in a vegetative state through the winter and spring with flowers and fruit present in summer and fall. *S. hawaiiensis* is considered short-lived; however, the plant may be longer lived than originally thought because it can resprout from the large, woody taproot (e.g., it has been documented to resprout from its large taproot following a fire). Seeds germinate readily and seedlings are easy to establish under greenhouse conditions.

Distribution: *S. hawaiiensis* is endemic to the island of Hawaiʻi. At PTA, the species is found in TAs 3, 21, 22, and 23. *S. hawaiiensis* has responded to conservation fencing and ungulate removal with an increased abundance and broader distribution. We estimate there are 9,093 individuals in approximately 1,581 locations 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 to 80 mm long and 2 to 11 mm wide. Flowers are small and arranged in open clusters with stalks 8 to 23 mm long. This species has stamens that are shorter than its sepals. The calyx is 5-toothed, 10-veined, and approximately 6 mm in length. Capsules are approximately 8 to 9 mm long and open at the top.

Habitat: On the island of Molokaʻi, *S. lanceolata* is restricted to cliff faces and ledges of gullies in dry to mesic shrublands due to ungulate impacts. On Oʻahu, this species is restricted to a steep cliff at the Mākua Military Reservation. On the island of Hawaiʻi, *S. lanceolata* grows on rocky tumuli or outcrops, on ʻaʻā lava, in deep ash deposits over pāhoehoe lava, and in Mauna Kea substrate in dry montane shrubland at elevations between 1,250 and 1,320 m. At PTA, *S. lanceolata* is found in the *Metrosideros polymorpha* Woodland Alliance, *Myoporum sandwicense – Sophora chrysophylla* Woodland Alliance, *Myoporum sandwicense – Sophora chrysophylla* Shrubland Alliance, and *Dodonaea viscosa* Shrubland Alliance vegetation types. Associated species include *Chenopodium oahuense, Dodonaea viscosa, Dubautia linearis*, *Eragrostis* sp., *Euphorbia* sp., *Leptecophylla tameiameiae, Metrosideros polymorpha*, *Myoporum sandwicense,* and *Sophora chrysophylla*.

Life History: Life history information for *S. lanceolata* is limited. Plants have been observed to be in flower and fruit during the winter and spring months and in vegetative form during the rest of the year. This species is propagated easily under greenhouse conditions.

Distribution: Historically, *S. lanceolata* was known from the islands of Hawaiʻi, Kauaʻi, Lānaʻi, Molokaʻi, and Oʻahu, but this species is currently only found on Hawaiʻi, Molokaʻi, and Oʻahu. At PTA, *S. lanceolata* is found in TAs 17, 19, 22, and 23. *S. lanceolata* has responded to conservation fencing and ungulate removal with an increase in abundance and a broader distribution. We estimate there are 11,772 individuals in approximately 650 locations at the installation. The species has a clumped and scattered distribution over approximately 2,835 ha at PTA.

Solanum incompletum (Hawaiian Prickle Leaf, Pōpolo Kū Mai)

For over half a century, this endangered nightshade was thought to be extinct until it was rediscovered at PTA in 1996. It is currently found in 3 locations at the installation. *S. incompletum* is one of the few native Hawaiian plant species that has developed or retained spiny reddish-orange prickles as a defense mechanism.

Description: *S. incompletum* is a woody shrub that reaches heights of up to 3 m. The stems and lower leaf surfaces are covered with prominent reddish prickles. Leaf margins are 1 to 4-lobed on each side. Leaves are oval to elliptic, 10 to 15 cm long and 7 cm wide and found on petioles of up to 7 cm in length. There are prominent veins on the lower leaf surface. Inflorescences are loose clusters of single-stalked flowers. The white petals form a star that is approximately 2 cm in diameter. Fruits are round berries, yellow-orange to black in color and approximately 1.5 cm in diameter.

Habitat: Historically, *S. incompletum* occurred in dry to mesic forests, diverse mesic forests, and subalpine forests. At PTA, this species is found on lava flows of various ages in the *Metrosideros polymorpha* Woodland Alliance, *Myoporum sandwicense – Sophora chrysophylla* Shrubland Alliance, and *Dodonaea viscosa* Shrubland Alliance vegetation types. Associated species include *Dodonaea viscosa*, *Sophora chrysophylla,* and *Myoporum sandwicense*.

Life History: Detailed life history information is not available for this species. However, *S. incompletum* is reproducing, based on the various age-classes represented in the natural population. The species is known to fruit in late summer and fall. Field-collected seeds have been successfully propagated under greenhouse conditions. *S. incompletum* appears to reproduce vegetatively as well as sexually. One or more rings of stems appear to sprout from the root of the main plant, so the number of individuals does not take into account this life history aspect of the species.

Distribution: Historically, *S. incompletum* was known from the islands of Hawaiʻi, Lānaʻi, and Maui. It is thought that the distribution of *S*. *incompletum* may also have included the islands of Kauaʻi and Molokaʻi. Currently, the species is only known from the island of Hawaiʻi. At PTA there are 3 main locations in TAs 18, 19, and 22 and a 4th extirpated location in TA 22. As of September 2020, there are 99 adults and juveniles in 21 locations at the installation. The species is also found in an adjacent kīpuka on state lands.

Spermolepis hawaiiensis (Hawaiian Parsley)

***Spermolepis* is a genus of 5 species from North America, Argentina, and the Hawaiian Islands in the parsley family with some 3,000 species worldwide. *S. hawaiiensis* is distinguished from other native members of the family by being a non-succulent annual with umbrella-shaped inflorescence. The feathery foliage is similar to some other members of the parsley family, such as dill, cilantro, carrot, and fennel.**

Description: *S. hawaiiensis* is a slender annual herb, has few branches, and grows to a height of 5 to 20 cm. Leaves are dissected into narrow, lance-shaped divisions; are oblong to somewhat oval; and grow on stalks about 2.5 cm long. Flowers are arranged in a loosely compound umbrella shape, with each inflorescence arising from the stem and opposite the leaves. Each inflorescence consists of 2 to 6 flowers with white elliptic to ovate petals. Fruits are oval, laterally compressed, and constricted at the line where the two halves meet. The fruits are 4 mm long and 3 mm wide and are covered with curved bristles.

Habitat: *S. hawaiiensis* is known from a variety of plant communities throughout its range, including *Metrosideros* forests, *Dodonaea* lowland dry shrublands, cultivated fields, and pastures. It occurs at an elevation range of 300 to 600 m. Associated plant species include *Doryopteris* sp., *Gouania hillebrandii*, *Leucaena leucocephala*, and *Sida fallax*. On Hawaiʻi Island, *S. hawaiiensis* is known from shady spots in *Dodonaea viscosa* dry shrubland which occurs on pāhoehoe lava at elevations between 1,135 and 2,140 m. Associated native plant species include *Myoporum sandwicense*, *Osteomeles anthyllidifolia*, and *Sophora chrysophylla*. At PTA, this species occurs on lava, in ash, and in soil pockets where moisture accumulates, typically in the *Metrosideros polymorpha* Woodland Alliance and *Myoporum sandwicense* - *Sophora chrysophylla* Shrubland Alliance vegetation types.

Life History: At PTA, this species is heavily dependent upon rainfall to carry out its life cycle. Large recruitment events have been observed after periods of above average rainfall. Based on observations, it is likely that *S. hawaiiensis* does not germinate at all during long periods of inadequate rainfall.

Distribution: Historically, *S. hawaiiensis* was found on Hawaiʻi, Kauaʻi, Lānaʻi, Maui, Molokaʻi, and Oʻahu and is still extant on all of these islands. At PTA, this species is found in TAs 22 and 23. We estimate there are at least 595 individuals in approximately 372 locations 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 and 6 cm long and 6 and 12 mm wide. Flowers are tubular, smooth, and distinctly veined with a lip, 8 to 13 mm long. The upper lip of the flower is twice as long as the lower. Petals are yellow to dull brownish-pink and finely pubescent.

Habitat: *S. angustifolia* grows on relatively flat, ash-veneered lava and shallow soils in semi-arid shrublands and woodlands. This species has been described as abundant on various-aged lava or rock outcrops that support the following diversity of vegetation types: *Metrosideros polymorpha* Woodland Alliance, *Myoporum sandwicense – Sophora chrysophylla* Woodland Alliance, *Myoporum sandwicense – Sophora chrysophylla* Shrubland Alliance, *Dodonaea viscosa* Shrubland Alliance, *Chenopodium oahuense* Shrubland Alliance, and *Eragrostis atropioides* Herbaceous Alliance.

Life History: *S. angustifolia* vegetatively reproduces along by rhizomes, stolons and aerial shoots. Shoots root at leaf nodes and form ramets (genetically identical, potentially independent plants). The exact means of sexual reproduction are unknown although plants have been observed flowering during most months and flowers are bisexual. Although little is known about seed viability, dormancy, and longevity, it is believed that seed coat removal increases germination rates. The degree of pollinator specificity is currently unknown. The lack of odor, flower shape and color, stamen position and quantity of nectar suggested that this species may be pollinated by native birds; however, numerous insects have been observed crawling on the stems, leaves and flowers and may also serve as pollination vectors.

Distribution: Historically, *S. angustifolia* was known from the islands of Hawaiʻi, Maui, and Molokaʻi but currently occurs only on the island of Hawaiʻi. At PTA, this species is found in TAs 18, 19, 22, and 23. We estimate there are 14,044 individuals in approximately 1,268 locations at the installation. *S. angustifolia* is one of the more abundant ESA-listed plant species at PTA, with a nearly continuous distribution over 2,310 ha.

Tetramolopium arenarium var. *arenarium* (Mauna Kea Pāmakani)

This endangered plant in the sunflower family is extremely rare and only occurs in 3 clusters distributed over fewer than 2 ha at PTA. Following severe drought conditions, the *T. arenarium* var. *arenarium* population declined to just 12 individuals in 2010. We implemented emergency watering until weather conditions improved, and the species population was successfully sustained.

Description: *T. arenarium* var. *arenarium* is an erect tufted shrub 0.8 to 1.3 m tall. Plants are covered with tiny glands and straight hairs. Leaves are alternate, toothless or shallowly toothed, and more or less lance-shaped. The leaves range in length from 15 to 35 mm and in width from 3 to 9 mm. Flower clusters are at the end of each stem and have 5 to 10 heads. Each head has 20 to 34 bracts beneath a single series of white florets (male ray florets) on the outside and fewer than 15 inner bisexual maroon petalled florets (disk florets). The fruits are compressed achenes.

Habitat: *T. arenarium* var. *arenarium* occurs on very old Mauna Kea flows (greater than 10,000 years old) in *Dodonaea viscosa*-dominated lowlands and montane dry shrublands at elevations from 800 and 1,500 m. At PTA, the species is found in the *Dodonaea viscosa* Shrubland Alliance at elevations between 1,300 m and 1,700 m. Associated native plants include *Leptecophylla tameiameiae, Dubautia linearis, Euphorbia olowaluana, Sida fallax, Chenopodium oahuense*, *Haplostachys haplostachya*, and *Stenogyne angustifolia*.

Life History: This species flowers in January, April, and August and in the fall and early winter. Seed production has been observed in late winter and spring. *T. arenarium* var. *arenarium* is easy to germinate and establish under greenhouse conditions.

Distribution: Historically, *T. arenarium* var. *arenarium* was known from the islands of Hawaiʻi and Maui. The species is extremely rare and currently occurs only on the island of Hawaiʻi at a few locations at PTA in TA 19. As of September 2020, there are 307 adults and juveniles in 27 locations at the installation. Individual counts vary with precipitation and can fluctuate widely.

Tetramolopium sp. 1 (Tooth-leaf Pāmakani)

The plant in the sunflower family is undescribed and not ESA-listed but is managed at PTA due to its rarity and limited distribution. It is related to *T. arenarium*, *T. consanguineum*, and *T. humile*. Extremely small numbers make this species vulnerable to catastrophic disturbance.

Description: *T.* sp. 1 is a perennial shrub, up to 2 m in height, initiating from a single stem and branching with each flowering. The leaf edges are continuous or may be toothed, are 7–9 cm in length and 1.5–2.0 cm wide. The surface of the leaves have glands and straight, stiff hairs. The flower heads form a flat or round-topped open inflorescence. Bracts below the flower heads are maroon along the mid-rib. There are numerous ray flowers with white petals, which recurve as they mature. The disk flowers are fewer typically yellow and occasionally maroon. The fruit is a dry achene that does not open at maturity.

Habitat: *T.* sp. 1 occurs within the *Dodonaea viscosa* Shrubland Alliance, *Myoporum sandwicense* – *Sophora chrysophylla* Shrubland Alliance, and *Metrosideros polymorpha* Woodland Alliance. Associated native species include *Alyxia stellata, Chenopodium oahuense, Coprosma montana, Leptecophylla tameiameiae*, *Osteomeles anthyllidifolia*, *Myrsine lanaiensis, Santalum paniculatum,* and *Sida falax.* Non-native species present in these alliances include *Cenchrus setaceus, Ehrharta calycina, Melinis repens, Microlaena stipoides, Nassella ceruna, Passiflora tarminiana, and Senecio madagascariensis.* Elevation range for this species is from 1,525–1,725 m.

Life History: Little is known about the life history of *T.* sp. 1. Precipitation levels appear to drive much of the reproductive cycle for this species. Flowering tends to occur in the late winter and spring with fruiting in the late spring and summer. The plant can be readily propagated under greenhouse conditions.

Distribution: At PTA, *T*. sp. 1 occurs in TAs 22 and 23. As of September 2020, there are 174 adults and juveniles and 106 seedlings in 70 locations at the installation. 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 will receive a name more than 30 years after its discovery – *Tetramolopium stemmermanniae*.

Vigna o-wahuensis (Oʻahu Cowpea)

This endangered legume is endemic to Hawaiʻi. Though *V. o-wahuensis* was described from a specimen collected on Oʻahu, it is now extirpated from that island. Unknown factors are driving an apparent decline in known locations of this species. Because of the highly ephemeral nature of *V. o-wahuensis,* definitively documenting declines in distribution and/or abundance is extremely difficult.

Description: *V. o-wahuensis* is a slender, short-lived, twining perennial herb with fuzzy stems that grow to 0.4 m. Leaves are compound, with three leaflets that are 1.2 to 8 cm long and 0.1 to 2.5 cm wide. Coarse hairs sparsely to moderately cover the leaflets. Flowers occur in clusters of 1 to 4 and have thin, translucent, pale yellow or greenish-yellow petals 2 to 2.5 cm long. The calyx is sparsely hairy and 4 to 8.0 mm long with asymmetrical lobes. Fruits are slender pods of 4 to 9 cm in length and 5 mm in width. Pods may be slightly inflated and contain between 7 and 15 gray or black seeds less than 6 mm long.

Habitat: *V. o-wahuensis* occurs in lowland dry to mesic grassland and shrubland at elevations from 10 m to 1,370 m. Associated plant species include *Sida fallax*, *Chenopodium* sp., *Dubautia menziesii,* and *Osteomeles anthyllidifolia*.

Life History: Life history information for *V. o-wahuensis* is currently unknown. The taxon has been observed flowering in March, April and July, with fruits present in July. *V. o-wahuensis* is an ephemeral species sensitive to drought conditions.

Distribution: *V. o-wahuensis* is currently known from the islands of Hawaiʻi, Kahoʻolawe, Lānaʻi, Maui, and Molokaʻi. At PTA, this species is found on Puʻu Nohona o Hae in KMA. *V. o-wahuensis* is an ephemeral species that tends to die back during drier periods. In addition, plants can senesce or emerge in a short period of time. As a result, monitoring can be challenging for this species. Also, distinguishing individual plants can be challenging if the plants are doing well as they will spread out over other plants making it difficult to distinguish individuals. As of September 2020, there are 100 adults and juveniles and 2 seedlings in 45 locations 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 to 8 m tall with a trunk up to 25 cm in diameter. Leaves are alternate and are comprised of 3 leathery lance-shaped, lemon-scented, toothed leaflets. These leaflets are 3.4 to 10 cm long and 1.5 to 5 cm wide. The stalk of the opposite leaflets has 1 joint and the central, terminal leaflet has 2. Trees are dioecious, having either male or female flowers. Inflorescences contain 15 to 20 flowers with 4 triangular sepals each. Fruits are sickle-shaped follicles that range in length from 8 to 10 mm. The fruits contain a single black seed 6 to 8 mm in diameter.

Habitat: *Z. hawaiiense* typically grows in *Metrosideros*-dominated lowland dry or mesic forests, in montane dry forests, and on lava at elevations that range from 550 to 1,740 m. It is typically found in low areas where pockets of deeper soils accumulate within or at the edge of ʻaʻā lava flows. The species is associated with *Antidesma platyphyllum* and *Streblus pendulinus* on the island of Maui and with *Myrsine lanaiensis, Myoporum sandwicense*, and *Sophora chrysophylla* on the island of Hawaiʻi. Individuals of this species are widely scattered, and rarely will more than a few plants be found in close proximity to one another. At PTA, *Z. hawaiiense* is found on lava and in a variety of vegetation types including the *Metrosideros polymorpha* Woodland Alliance and *Myoporum sandwicense* – *Sophora chrysophylla* Shrubland Alliance.

Life History: Life history information for *Z. hawaiiense* is limited. Observations suggest that this species is susceptible to browse and bark stripping by ungulates and some seed predation by rodents. Seeds readily germinate under greenhouse conditions. 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 individuals in approximately 575 locations at the installation. The bulk of the distribution is in TA 22 (3,075 ha), but including the most remotely located individuals, the total distribution of *Z. hawaiiense* covers 4,050 ha at PTA.

Hawaiian Hoary Bat, ʻŌpeʻapeʻa (*Lasiurus cinereus semotus*)

This endangered bat is the only native land mammal in Hawaiʻi. This bat's common name was inspired by the hoary or "frosty" appearance of its fur, which is brown but frosted white on its back. The Hawaiian hoary bat is a nocturnal insectivore. It finds food through echolocation, meaning it emits calls and listens for their echoes.

Description: Hawaiian hoary bats are medium-sized, nocturnal and insectivorous bats weighing 14 to 22 grams with a wingspan of 27 to 35 cm. This species is heavily furred with a mixture of grayish brown or reddish-brown fur tinged with white, giving it a frosted or "hoary" appearance. Ears are short, thick, rounded and edged in black and the tail is furry. Although females are slightly larger than males, forearm lengths are similar in both genders. The Hawaiian hoary bat is about 45% smaller than the North American hoary bat, which it is believed to be related to. Flight is efficient and rapid in both open and closed habitats.

Habitat: The Hawaiian hoary bat has been detected in a wide variety of habitat types, from barren lava to open forests. Bats have been observed in a variety of native tree and shrub species, including *Metrosideros polymorpha* and *Leptecophylla tameiameiae*. Treeland, shrubland, and grassland communities at PTA provide sufficient available roosting and foraging habitat. Roosting (treeland) and foraging (shrubland) habitats are not mutually exclusive, as bats have been observed roosting in shrub vegetation and often forage in relatively closed forest. Roosts are typically located in dense canopy foliage or sub-canopy when canopy is sparse, with open access for launching into flight.

Life History: Hawaiian hoary bats are known to leave roost sites before sunset and return before midnight. Long-distance migration is unlikely due to the isolation of the Hawaiian Islands and the tropical climate. This species is not colonial and roosts solitarily in tree foliage. Breeding takes place in the lowlands during spring and summer with bats moving to higher elevations in fall and winter. Females typically give birth to twins between May and August and rear pups between May and September. Pups fledge from July through September, a critical time in the reproductive cycle.

Distribution: The Hawaiian hoary bat is endemic to Hawaiʻi where it is the only existing native terrestrial mammal. This species has been documented historically on the islands of Hawaiʻi, Kauaʻi, Maui, Molokaʻi, Oʻahu, and possibly Kahoʻolawe but is now resident only on Hawaiʻi, Kauaʻi, and Maui. Hawaiian hoary bat presence at PTA was first documented in 1992. Bats are thought to be present throughout the installation, but distribution and activity levels are currently unknown.

Hawaiian Goose, Nēnē (*Branta sandvicensis*)

This 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 (*Oceanodroma castro*)

This elusive petrel is strictly nocturnal at its breeding sites to avoid predation by gulls and diurnal raptors and will even avoid coming to land on clear moonlit nights. Like most petrels, the walking ability of the Band-rumped Storm Petrel is limited to a short shuffle from/to the burrow. This species spends the non-breeding period out at sea.

Description: Band-rumped Storm Petrels are medium-sized, highly pelagic petrel with an estimated life span of 15–20 years. This species is 19–21 cm in length with a 43–46 cm wingspan and weighs 44-49 g. Beaks are sharply hooked with distinct tubular nostrils foreheads are steep. Adults are blackish-brown and have a sharply defined narrow white band across the rump area that extends slightly onto the under-tail coverts. This species also has a slightly paler, brownish-gray wing bar across the upper wing coverts, forming a V-shape on the back. The tail is vaguely forked, the wings are pointed, and the legs are short.

Habitat: Band-rumped Storm Petrel colonies exist on rough, inaccessible terrain such as steep, heavily vegetated cliffs and high-elevation barren lava flows, where predation pressure is presumably relaxed. Habitat is thought to be similar to the Hawaiian Petrel. The Band-rumped Storm Petrel is known to visit puʻu to swoop and call. The species' breeding biology in Hawaiʻi is not well known, but individuals are assumed to nest in burrows, crevices, or cracks in lava tubes at high-elevation, inland habitats.

Life History: The Band-rumped Storm Petrel feeds far from shore by hovering close to the water surface and scooping up minute food, often contacting the water with their feet. Breeding seasonality is assumed similar to the Hawaiian Petrel. Adults access inland colonies from February to November with a small period of absence around March and April. Females lay a single egg per season between May and June and young petrels fledge in October. The Band-rumped Storm Petrel is highly faithful to nesting sites, typically returning to the same site each year. Although little is known about courtship behaviors, birds, probably unpaired juveniles, swoop and call over the colony.

Distribution: Archaeological and subfossil evidence suggests Band-rumped Storm Petrels previously inhabited all of the main Hawaiian Islands. Currently, populations are extant on the islands of Kauaʻi, Maui, and Hawaiʻi. The species has been recorded at PTA between 2008–2015 (May–August) in TAs 21 and 23. Call activity suggests the Band-rumped Storm Petrel is present in portions of these training areas seasonally; however, at this time it is unclear how the petrels are using habitat at PTA. In 2015, a colony was discovered at PTA with confirmed activity at a burrow, which is significant because no active nesting burrows had been previously documented in the Hawaiian Islands.

Hawaiian Petrel, ʻUaʻu (*Pterodroma sandwichensis*)

This endangered petrel nests on land in burrows or rock crevices but feeds out at sea. Scientists previously thought that this species remained close to shore, but new research shows they travel as far as Alaska and Japan during 2-week long feeding trips. The Hawaiian Petrel's diet consists of squid, fish, and crustaceans.

Description: Hawaiian Petrels are large, nocturnal gadfly petrels that are endemic to the Hawaiian Islands. This species averages 40 cm long with a wingspan of 90 cm. The top of the body is dark gray, and the forehead and underside are white. The lower wing surface is white with conspicuous black margins. This species has a tail that is short and wedge-shaped. The legs and the upper part of the feet are pink to flesh colored. The webbing is black tipped. The bill is grayish-black, short, stout, and with a sharp decurved tip. The wings and tail are long and pointed compared to other taxa of *Pterodroma.*

Habitat: Hawaiian Petrel colonies are typically located at high elevation, xeric habitats or wet, dense forests. Nests are located in burrows, crevices, or cracks in lava tubes. Due to pressure from introduced predators and habitat degradation, modern Hawaiian Petrel colonies and nesting activity in Hawaiʻi typically takes place above 2,500 m.

Life History: Hawaiian Petrels nest in colonies and form long-term pair bonds. The adults arrive and depart colonies at night during the breeding season (March-October). Pairs return to the same nest site year after year, where females lay a single white egg. As the chicks mature, the parental care diminishes, and the adults leave the nest about 2 to 3 weeks before the chicks. Hawaiian Petrels often feed hundreds of kilometers from colonies, usually foraging with mixed-species feeding flocks, typically over schools of predatory fishes.

Distribution: Subfossil evidence indicates the Hawaiian Petrel was once common on all of the main Hawaiian Islands, but distribution is now limited to Hawaiʻi, Kauaʻi, and Maui. Additional populations may exist on Molokaʻi and Lānaʻi, and off the shores of Kahoʻolawe and Niʻihau, but there is limited survey data for these areas. Pelagic distribution during the non-breeding season is largely unknown but petrels remain near the islands during the nesting season. Extant breeding colonies are located in Hawaiʻi Volcanoes National Park on Mauna Loa and possibly on the windward side of Mauna Kea, but no colonies have been confirmed there to date. Archaeological evidence suggests that Hawaiian Petrels were once common at PTA. Currently, the species is believed to transit the area, but no active nesting colonies have been detected at the installation.

Anthricinan Yellow-faced Bee (*Hylaeus anthracinus*)

The genus *Hylaeus* is represented by about 60 species in Hawaiʻi. On Hawaiʻi Island there are 28 species, 18 of which are endemic to the island. Many species are morphologically similar but can be distinguished by microscopic examination of physical characteristics, with males having more distinguishable features than females. *Hylaeus* are known as yellow-faced bees or masked bees for their yellow to white facial markings.

Description: Anthricinan yellow-faced bees have 3 main body parts – a head, thorax, and abdomen. One pair of antennae arises from the front of the head, between the eyes. Two pairs of wings and 3 pairs of legs are attached to the thorax, the abdomen is composed of multiple segments. All *Hylaeus* bees roughly resemble small wasps in appearance. The anthricinan yellow-faced bee has clear to smoky wings and black legs. The male has a single large yellow spot on the face, and below the antennal sockets the face is yellow. The female is entirely black and can be distinguished by black hairs on the end of the abdomen and an unusual mandible with 3 teeth.

Habitat: Anthricinan yellow-faced bees occupy virtually all native habitats from the wettest to driest locales from the coastal strand to 3,000 m elevation. They typically are associated with native plant species even in a matrix of native and alien vegetation in which alien plants are abundant and flowering. It is not known whether this selectivity is exclusive, or whether it is caused by preference or by inability to recognize or handle alien plant flowers.

Life History: Anthricinan yellow-faced bees are solitary, without the caste system and associated genetics characteristic of social *Hymenoptera* found in Hawaiʻi such as honeybees, western yellow jacket wasps, and Argentine ants. Both females and males forage for nectar, and males search for females on the wing. They lay eggs in multi-chambered burrows in the ground or appropriate media (e.g., rotting wood) and provision the nests with pollen and nectar.

Distribution: Small populations of anthricinan yellow-faced bees are currently known from the islands of Maui, Kahoʻolawe, Molokaʻi, Oʻahu, and Hawaiʻi, but the number of individual bees is unknown. This bee is considered a coastal species, but there is evidence that it occurs in montane dryland forest habitat as well. One anthricinan yellow-faced bee was collected at PTA in 2004, possibly a vagrant. The precise locality is not known, but it was found resting in a fruit capsule of the endangered *Kadua coriacea*, which typically occurs in open *Metrosideros* treeland, a generally poor habitat for this species. No additional anthricinan yellow-faced bees have been found at PTA, and it is questionable whether a breeding population exists at the installation.

Blackburn’s Sphinx Moth (*Manduca blackburni*)

This moth in the Sphingidae family is endemic to 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 ranging 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 C

REGULATORY DRIVERS FOR SECTIONS AND PROJECTS OF THE ARMY'S NATURAL RESOURCES PROGRAM AT PŌHAKULOA TRAINING AREA

Table C1. Regulatory drivers for the Army's natural resources program at Pōhakuloa Training Area

Program	Section	Project	Program Plan Requirement Wording (2017)	Regulatory Document(s)	W9126G-16-2-0014 SOO Task	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)	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)(a)	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)(a)	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)(d)	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)(d)	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)(d)	3.2.1.2

Table C1. 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-16-2-0014 SOO Task	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)(d)	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)(d)	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)	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)	3.2.1
Botanical	Plant Survey and Monitoring	Vegetation Monitoring	Evaluate reasons for lack of mamane recruitment in Palila Critical Habitat Area B.	Biological Opinion 2003	N/A	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	N/A
Botanical	Plant Survey and Monitoring	Vegetation Monitoring	Determine dust effects on mamane/naio woodland and to assess the efficacy of the Palila Critical Habitat buffer.	Biological Opinion 2003	N/A	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	N/A

Table C1. 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-16-2-0014 SOO Task	W9126G-21-2-0027 SOO Task
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	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)(e)	3.2.1.4
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)(e)	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 impacted by the construction of the BAX.	Biological Opinion 2003	3.2(1)(e)	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)(e)	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)(e)	3.2.1.4

Table C1. 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-16-2-0014 SOO Task	W9126G-21-2-0027 SOO Task
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)(e)	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)(e)	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)(e)	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)(f)	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)(f)	3.2.1.5 / 3.2.5.3
Botanical	Genetic Conservation and Outplanting	RPPF Activities	Propagate and grow *Hap hap* from the BAX propagules to adequately replace individuals impacted by BAX construction.	Biological Opinion 2003	3.2(1)(f)	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)(f)	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)(f)	3.2.1.5 / 3.2.5.3

Table C1. 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-16-2-0014 SOO Task	W9126G-21-2-0027 SOO Task
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)(f)	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)(b) / 3.2(1)(c) / 3.2(3)(a)	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)(b) / 3.2(1)(c) / 3.2(3)(a)	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)(b) / 3.2(1)(c) / 3.2(3)(a)	3.2.1.3 / 3.2.4.1
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)(b) / 3.2(1)(c) / 3.2(3)(a)	3.2.1.3 / 3.2.4.1

Table C1. 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-16-2-0014 SOO Task	W9126G-21-2-0027 SOO Task
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(3)(a)	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(3)(a)	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(3)(a)	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(3)(a)	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(3)(a)	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(3)(a)	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(3)(a)	3.2.4.1

Table C1. 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-16-2-0014 SOO Task	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(3)(a)	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(3)(a)	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(3)(a)	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(3)(b)	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(3)(b)	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(3)(b)	3.2.4.2

Table C1. 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-16-2-0014 SOO Task	W9126G-21-2-0027 SOO Task
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(3)(b)	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(3)(b)	3.2.4.2
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(3)(b)	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(3)(c)	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(3)(c)	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)	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)(a)	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 three (3) business days of the incident.	Biological Opinions 2003 & 2013	3.2(2)(b)	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)(b)	3.2.2.2 / 3.2.8.1

Table C1. 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-16-2-0014 SOO Task	W9126G-21-2-0027 SOO Task
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)(b)	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)(b)	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)(b)	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)(b)	3.2.2.2
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)(b)	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)(b)	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)(b)	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)(b)	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)(b)	3.2.2.2 / 3.2.8.1
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Notify the in 24 hours Service if a nest being monitored for translocation fails.	Biological Opinions 2003 & 2013	3.2(2)(b)	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)(b)	3.2.2.2 / 3.2.8.1

Table C1. 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-16-2-0014 SOO Task	W9126G-21-2-0027 SOO Task
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)(b)	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)(b)	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)(b)	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)(b)	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)(b)	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)(b)	3.2.2.2
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose Off-site	Fund, construct, maintain, and repair two, 20-acre predator-proof fences.	Biological Opinion 2013	3.2(2)(b)	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)(b)	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)(b)	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)(b)	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)(b)	3.2.2.2

Table C1. 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-16-2-0014 SOO Task	W9126G-21-2-0027 SOO Task
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose Off-site	Construct a shade structure inside each predator-proof fence.	Biological Opinion 2013	3.2(2)(b)	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)(a)	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)	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)	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)(a)	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)	3.2.2
Wildlife	Wildlife Survey and Monitoring	Hawaiian hoary bat	Notify the Service within three working days if any take of Hawaiian hoary bats occurs, or upon finding a dead, injured, or sick bat. Provide written reports to the Service.	Biological Opinion 2003	3.2(2)	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)	3.2.2

Table C1. 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-16-2-0014 SOO Task	W9126G-21-2-0027 SOO Task
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)	3.2.2 / 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)	3.2.2 / 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)	3.2.2 / 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)	3.2.2 / 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)(a)	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)(a)	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)(a)	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)	3.2.2 / 3.2.8.1

Table C1. 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-16-2-0014 SOO Task	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)	3.2.2 / 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)	3.2.2 / 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)	3.2.2 / 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)	3.2.2 / 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)	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)(a)	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)(a)	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)	3.2.2 / 3.2.8.1

Table C1. 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-16-2-0014 SOO Task	W9126G-21-2-0027 SOO Task
Wildlife	Wildlife Survey and Monitoring	Seabirds	Coordinate with Range Control to implement minimization measures for UCAS.	Informal Consultation UCAS, 2013	3.2(2)	3.2.2 / 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)(a)	3.2.2.1
Wildlife Program - continued Management Section – Avian Project						
Wildlife	Wildlife Survey and Monitoring	Avian Survey	Conduct periodic surveys for Palila and MBTA-protected species within PTA.	INRMP	3.2(2)	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)	3.2.2 / 3.2.8.1
Wildlife	Wildlife Survey and Monitoring	Avian Survey	Document and report birds "taken" during military readiness activities.	INRMP	3.2(2)	3.2.2 / 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)	3.2.2 / 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)	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)(c)	3.2.2.3

Table C1. 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-16-2-0014 SOO Task	W9126G-21-2-0027 SOO Task
Wildlife	Wildlife Threat Management	Small Mammal Control	Control predators for Band-rumped Storm Petrels in the colony in TA 21	INRMP	3.2(2)(c)	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)(c)	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)(c)	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	3.4	3.2.8
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	3.4	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)(d)	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)(d)	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)(d)	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)(d)	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)(e)	3.2.2.5

Table C1. 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-16-2-0014 SOO Task	W9126G-21-2-0027 SOO Task
Wildlife	Wildlife Threat Management	Fence Maintenance	Inspect barbed wire on security fences, quarterly, for entangled bats.	Biological Opinion 2003	3.2(2)(e)	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)(e)	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)(e)	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)(e)	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)(e)	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)	3.2.2
Wildlife	Game Management	Game Mammal Surveys	Survey for game mammals and game birds in the hunting units.	INRMP	3.2(2)	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(2)(f)	3.2.3.1
Wildlife	Game Management	Physical Resources for Hunting Management	Repair and maintain facilities to support the hunting project.	INRMP	3.2(2)(f)	3.2.3.1
Wildlife	Game Management	Project Coordination Outreach	Attend public meeting and outreach activities.	N/A	3.4	3.2.8.2
Ecological Data Program – INRMP (2019) Objective 4.1.5						

Table C1. 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-16-2-0014 SOO Task	W9126G-21-2-0027 SOO Task
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 to efficient reporting. Increase efficiency and effectiveness of data collection.	N/A	3.2(4)(a) / 3.2(4)(b) / 3.2(4)(e)	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(4)(c)	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(4)(d)	3.2.7.4
Technical and Administrative Support						
General	Technical Support	General	Respond to requests for information in matters of environmental concern or T&E issues.	N/A	3.4	3.2.8.1
General	Technical Support	Consultations and Coordination	Participate in meeting with partners.	N/A	3.4	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	3.4	3.2.8.3

Table C1. 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-16-2-0014 SOO Task	W9126G-21-2-0027 SOO Task
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	3.4	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	3.4	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	3.4	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	3.4	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	3.4	3.2.8.1 / 3.2.8.2
General	Technical Support	Consultations and Coordination	Report dead nēnē to the Service within 48 hours.	Biological Opinion 2008	3.4	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	3.4	3.2.8.1 / 3.2.8.2

Table C1. 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-16-2-0014 SOO Task	W9126G-21-2-0027 SOO Task
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	3.4	3.2.5.2 / 3.2.8.1
General	Technical Support	Planning	Develop and update Natural Resources Program Plan.	Biological Opinion 2003	3.4	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	3.4	3.2.5.2 / 3.2.8.4
General	Technical Support	Planning	Management Team identifies dust abetment measures.	Biological Opinion 2003	3.4	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 mamane.	Biological Opinion 2003	3.4	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	3.4	3.2.4.4
General	Technical Support	Training Coordination	Support updates to PTA SOPs and INRMP	N/A	3.4	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	3.4	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	3.4	3.2.5.2 / 3.2.8.4

Table C1. 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-16-2-0014 SOO Task	W9126G-21-2-0027 SOO Task
General	Technical Support	Training Coordination	Coordinate with military units to train in Training Area 21.	Biological Opinion 2008	3.4	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	3.4	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	3.4	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	3.4	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	3.4	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	3.4	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(2)(f)	3.2.3.1
General	Program Administration	Program Execution	Provide public outreach regarding natural resources management at USAG-PTA.	N/A	3.2(5)(g)	3.2.9.7
General	Program Administration	Program Execution	Prepare and track budgets for program execution.	N/A	3.2(5)(a)	3.2.9.1

Table C1. 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-16-2-0014 SOO Task	W9126G-21-2-0027 SOO Task
General	Program Administration	Program Execution	Provide support purchasing.	N/A	3.2(5)(b)	3.2.9.2
General	Program Administration	Program Execution	Develop and implement a safety program	N/A	3.2(5)(c)	3.2.9.3
General	Program Administration	Program Execution	Provide training to staff to meet safety program and OSHA requirements	N/A	3.2(5)(c)	3.2.9.4
General	Program Administration	Program Execution	Provide HR support to hire and manage staff.	N/A	3.2(5)(d)	3.2.9.5
General	Program Administration	Program Execution	Comply with IACU requirements	N/A	N/A	3.2.9.6

APPENDIX D

WILDLIFE ENCLOSURE 1

ARMY NATURAL RESOURCES PROGRAM AT PŌHAKULOA TRAINING AREA RARE AND FEDERALLY LISTED SPECIES AND MIGRATORY BIRD SPECIES INCIDENT REPORT FORM

HAWAIIAN GOOSE INCIDENTAL FIND

24 FEBRUARY 2021

Army Natural Resources Program at Pōhakuloa Training Area (PTA)
Rare and Federally-listed Species and Migratory Bird Species Incident Report Form

DISCOVERY INFORMATION

Date Discovered: 2/24/2021 **Time Discovered:** 10:17am **Observer(s):** Jennifer Navarra

Type of Discovery (circle): (Scheduled Search) Incidental Find Reported

Species Scientific Name: *Branta sandvicensis* **Species Common Name:** Hawaiian Goose

Special Status (e.g. ESA, MBTA, etc.): Threatened and MBTA **Number of animals:** One

Incident Type (e.g. individual animal, nest, etc): Carcass of a single goose was discovered.

General Location (e.g. Range 01, BAAF, etc.): Pua Akala tract, Hakalau Forest National Wildlife Refuge

GPS Location (UTM Easting/Northing): 255826, 2190074

Weather at Time of Discovery (if known):

Temperature	Precipitation	Wind Speed/Direction	Cloud Cover (%)
22 °C	Light Rain	5mph/West	100

CASUALTY INCIDENT INFORMATION

Band Identification (for Hawaiian Geese) or other (if available): HAGO Green/White 726, FWS 1138-94405 (species code_State leg band ID_ USFWS leg band ID (if known) (Hawaiian Goose species code HAGO). Example: HAGO_Black LL_788-26089, UNB for unbanded, UNK for unknown identification)

Sex (circle): male (female) unknown **Age (circle):** (adult) juvenile unknown

Condition (circle): injured (intact) scavenged dismembered (other) (describe): body was intact, but decomposed

Estimated Date and Time of Incident: unknown

Probable Cause of Death or Injury: The goose may have been attacked by a predator.

Storage Location of Specimen: The goose carcass was collected on 25 February 2021 by Mr. Mackey Bishop, Hakalau Forest National Wildlife Refuge employee.

CASUALTY INCIDENT INFORMATION (continued)

Notes: On 24 February 2021, the carcass of the female Hawaiian Goose Green/White 726 was found on the grass inside the Pua Akala Management Area by Ms. Navarra (Figure 1 and Figure 2). The carcass was discovered approximately 66.5 m away from the nest site (PA-20-2) where G/W 726 and her mate G/W 764 had successfully nested in 2020 and produced 4 goose hatchlings.

After the G/W 726 carcass was reported, we reviewed the nest monitoring camera photos to determine the last time G/W 726 was detected (Table 1). G/W 726 appeared to have been injured on 19 December 2020 (Figure 3) and 2 of the 4 hatchlings were no longer observed. G/W 726 was last detected or observed on 21 December 2020. Unfortunately, the camera malfunctioned during 21-28 December 2020, therefore no geese recordings were taken. The last time the male G/W 764 was seen with the 2 remaining goslings was on 30 December 2020.

Table 1. Camera nest monitoring detections of the Hawaiian Geese at the nest PA-20-2 site.

Date	Time	Nest Camera Detection	Notes
11/24/2020	12:36 pm	G/W 726 and 4 eggs	Camera deployed to monitor nest
12/17/2020	9:16 pm	G/W 726 , 1 hatchling and 3 eggs	–
12/18/2020	5:38 pm	G/W 726 and 4 hatchlings	–
12/19/2020	9:06 am	G/W 726, 764 and 4 hatchlings	
12/19/2020	1:08 pm	No geese	G/W 726, 764 and 4 hatchlings not in the nest
12/19/2020	1:22 pm	G/W 726 and 2 hatchlings	G/W 726 (bleeding from the posterior end)
12/20/2020	12:22 am	2 hatchlings	Last time hatchlings detected via the camera
12/21/2020	8:08 am	Goose	Could not read leg band, assume its G/W 726
12/21/2020-12/28/2020	–	–	SD camera card malfunction, no pictures taken
12/29/2020	–	–	Camera removed from nest site

Notes: Recoynx® XP-9 ultrafire cameras were positioned approximately 1-2 meter away from the nest and they were programmed to take 1 picture every 2 minutes within a 24 hour period.

INCIDENT REPORTING NOTIFICATION

PTA- Natural Resource Program: Date: 2/24/21 **Time:** 2:36 pm

Contact Person(s): Rogelio Doratt

Comments: Ms. Navarra emailed Mr. Doratt and notified him that the carcass of the Hawaiian Goose female Green/ White 726 was discovered during a scheduled goose survey.

Hakalau Forest National Wildlife Refuge and PTA- Natural Resource Program: Date: 2/24/21 **Time:** 4:17 pm

Contact Person(s): Thomas Cady, Donna Ball, Joy Anamizu, Lena Schnell, Dan Jensen

Comments: Mr. Doratt emailed Hakalau Forest National Wildlife Refuge staff and PTA Natural Resource Program staff and notified them that the carcass of the Hawaiian Goose female Green/White 726 was discovered during a scheduled goose survey.

Figure 1. Carcass of the Hawaiian Goose (*Branta sandvicensis*) found within the Pua Akala Habitat Enhancement Area at Hakalau Forest National Wildlife Refuge. State leg band and USFWS leg band on the Hawaiian Goose, Green/White 726*,* 1138-94405.

Figure 2. Location of the carcass of the Hawaiian Goose (*Branta sandvicensis*), state leg band Green/White 726 which was found 66.5 m away from the female's 2020 nesting location at the Pua Akala Management Area of Hakalau Forest National Wildlife Refuge on 24 February 2021.

Figure 3. Injured Hawaiian Goose (*Branta sandvicensis*), state leg band Green/White 726 with 2 hatchlings on the nest site (PA-20-2) at Hakalau Forest National Wildlife Refuge.

Please contact Lena Schnell at (808) 315-0300 or email lena.schnell@colostate.edu for further information regarding this wildlife incident report.

Report generated by (name, date): Jennifer Navarra and Rogelio Doratt, 3/3/2021

WILDLIFE ENCLOSURE 2

ARMY'S NATURAL RESOURCES PROGRAM AT PŌHAKULOA TRAINING AREA RARE AND FEDERALLY LISTED SPECIES AND MIGRATORY BIRD SPECIES INCIDENT REPORT FORM

BLACKBURN'S SPHINX MOTH INCIDENTAL FINDS

4 AND 6 NOVEMBER 2019

Army's Natural Resources Program at Pohakuloa Training Area (PTA),
Rare and Federally- listed Species and Migratory Bird Species Incident Report Form

DISCOVERY INFORMATION

Date Discovered: 11/4/2019 **Time Discovered:** 12:00 pm **Observer(s):** Lena Schnell and Mona Tatum

Type of Discovery (circle): Scheduled Search ~~(~~Incidental Find~~)~~ Reported

Species Scientific Name:
Manduca blackburni

Species Common Name:
Blackburn's sphinx moth

Special Status (e.g. ESA, MBTA, etc.): Endangered

Number of animals: 2, 5th instar caterpillars

Incident Type (e.g. individual animal, nest, etc) Individual animals

General Location (e.g. Range 01, BAAX, etc.): ASR 24 , SolInc Plant 014

GPS Location (UTM Easting/Northing): GPS 213447, 2180272

Weather at Time of Discovery (if known):

Temperature Precipitation Wind Speed/Direction Cloud Cover (%)




2

Army's Natural Resources Program at Pohakuloa Training Area (PTA), Rare and Federally- listed Species and Migratory Bird Species Incident Report Form

DISCOVERY INFORMATION

Date Discovered: 11/6/2019 **Time Discovered:** 12:00 pm **Observer(s):** Mona Tatum

Type of Discovery (circle): Scheduled Search (Incidental Find) Reported

Species Scientific Name: Manduca blackburni

Species Common Name: Blackburn's sphinx moth

Special Status (e.g. ESA, MBTA, etc.): Endangered

Number of animals: 2, 5th instar caterpillars

Incident Type (e.g. individual animal, nest, etc) Individual animals

General Location (e.g. Range 01, BAAX, etc.): ASR 24 , SolInc Plant 003

GPS Location (UTM Easting/Northing): GPS 213616, 2,180724

Weather at Time of Discovery (if known):

Temperature Precipitation Wind Speed/Direction Cloud Cover (%)

1

APPENDIX E

FY 2021 ANNUAL REPORT FOR THE ARMY'S NATURAL RESOURCES PROGRAM AT PŌHAKULOA TRAINING AREA, ISLAND OF HAWAIʻI

We produce a full programmatic report biennially (every 2 years). Each biennial report includes an appendix that satisfies annual reporting requirements identified in the Statement of Objectives for work conducted by the Center for Environmental Management of Military Lands at Pōhakuloa Training Area (PTA), as well as regulatory and guiding documents including the 2003, 2008, and 2013 Biological Opinions (BOs) issued to PTA by the US Fish and Wildlife Service (USFWS). The report is also produced to maintain compliance with the installation's Integrated Natural Resources Management Plan (INRMP) and regulatory obligations under the Endangered Species Act (ESA), National Environmental Policy Act (NEPA), and Migratory Bird Treaty Act (MBTA).

This appendix covers the reporting period of FY 2021 (01 October 2020 through 30 September 2021). A report covering FY 2020 (01 October 2019 through 30 September 2020) 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.

12.0 BOTANICAL PROGRAM

12.1 INTRODUCTION

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

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* sp. 1, which is undescribed and 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 E1):

- Tier 1 – Plant species with fewer than 500 individuals at PTA.
- 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 E1. Management tiers for of plant species listed under the Endangered Species Act at Pōhakuloa Training Area.

Tier 1	Tier 2
Asplenium peruvianum var. *insulare*	***Exocarpos menziesii***
<u>Isodendrion hosakae</u>	***<u>Festuca hawaiiensis</u>***
<u>Kadua coriacea</u>	***Haplostachys haplostachya***
Lipochaeta venosa	***Silene hawaiiensis***[b]
Neraudia ovata	***Silene lanceolata***
Portulaca sclerocarpa	*Spermolepis hawaiiensis*
Portulaca villosa	*Stenogyne angustifolia*
<u>Schiedea hawaiiensis</u>	
Sicyos macrophyllus	
Solanum incompletum	
<u>Tetramolopium arenarium</u>	
<u>Tetramolopium sp. 1</u>[a]	
Vigna o-wahuensis	
Zanthoxylum hawaiiense	

[a] Undescribed, not listed under the Endangered Species Act.
[b] *Silene hawaiiensis* is threatened; all other species are endangered.
Bold = species found only at Pōhakuloa Training Area; Underline = most of the statewide population is found at Pōhakuloa Training Area.

In previous reports we assigned each rare plant species to 1 of 3 management priority levels based on each species' distribution and abundance. The species assigned to each level were referred to as Priority Species (PS) 1 to 3. After review of the PS ranking system, we decided that the 2-tiered classification better suited the management objectives for the species at PTA.

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 *2021 Annual Recovery Permit Report for Pōhakuloa Training Area, Hawaiʻi Island, Hawaiʻi, Recovery Permit TE-40123A-3* (CEMML 2022).

12.2 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.

12.2.1 Plant Surveys

The purpose of plant surveys was to document the distribution and quantify abundance of ESA-listed plant species at PTA. The plant surveys meet SOO task 3.2(1)(a) and INRMP and Army Regulation-100 requirements for Planning Level Surveys.

Plant Surveys in Training Area (TA) 23 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 from outside the ungulate exclusion fence in TA 23.

For a complete description of the plant survey methodology see Section 2.2.2 of this biennial report.

In FY 2021, we surveyed a total of 453.6 linear kilometers. Endangered plant species found during the surveys include *Asplenium peruvianum* var. *insulare*, *Exocarpos menziesii*, and *Festuca hawaiiensis* as well as the threatened species *Silene hawaiiensis* (Table E2).

Table E2. Count of listed plant species found during surveys in the unfenced area of Training Area 23 June through August 2021.

Species	Seedlings	Juveniles	Adults	Total to September 2021[a]
Asplenium peruvianum var. *insulare*	0	3	1	4
Exocarpos menziesii	0	0	2,267	2,267
Festuca hawaiiensis	0	1	4	5
Silene hawaiiensis	0	0	17	17

[a] Totals represent the cumulative number of adults and juveniles found June 2021 through September 2021.

We found 2,267 *E. menziesii* outside the fence unit during surveys since June 2021, which is more than double the estimated abundance of the species at PTA (2,068, 90% CI 1,844–2,292). Moreover, we have only surveyed a fraction of the potential suitable habitat in the unfenced portion of TA 23. Based on this preliminary information, the abundance estimates from within the fence units underrepresents the *E. menziesii* population at PTA. The plants found outside the fence appeared to be well-established adults and no young plants were observed. Fruit was present, but there is ample evidence of rodent depredation throughout the surveyed area.

We also encountered *Silene hawaiiensis* during surveys since June 2021, but at a low frequency. The numbers of individuals encountered is not expected to change to overall abundance estimate for this species at PTA. Because feral ungulates selectively browse *Silene hawaiiensis,* we did not expect to find large numbers of individuals in unfenced areas.

Plant Surveys at the Infantry Platoon Battle Course

We surveyed approximately 12 ha within in the Infantry Platoon Battle Course for rare plant species to support range development proposed to conduct ground softening (selective ripping and crushing of lava) to allow soldiers to conduct dismounted maneuvers while training. This project will ground soften up to 12 ha.

For a complete description of the plant survey methodology see Section 2.2.2 of this biennial report.

We verified that 1 individual of the endangered plant species *Kadua coriacea* was still present in the proposed project footprint, but no other threatened and endangered species were found. To avoid potential impacts, the *Kadua coriacea* location will be avoided during ground softening operations.

Surveys for *Tetramolopium* sp. 2 in Training Area 22

In December 2019, an unknown plant was found in TA 22. Based on plant growth and structure, the plant was thought to be a member of the *Tetramolopium* genus.

For a complete description of the plant survey methodology see Section 2.2.2 of this biennial report.

In April 2021, we surveyed an approximately 75-ha buffer around the *Tetramolopium* sp. location. Seven surveyors walked about 23 km to cover the area during a 2-day period. No new locations of the *Tetramolopium* sp. were discovered.

Surveys for *Portulaca* Species at Sites Previously Occupied

To support the genetic investigation and to confirm the current distribution of *Portulaca* species at PTA, we surveyed locations that were formerly occupied by *Portulaca* species at Puʻu Keʻekeʻe and Puʻu Nohona o Hae.

For a complete description of the plant survey methodology see Section 2.2.2 of this biennial report.

We did not locate any *Portulaca* during the surveys at Puʻu Keʻekeʻe and Puʻu Nohona o Hae. The presence of ungulates at Puʻu Keʻekeʻe is the likely cause for the extirpation of those individuals. The plants were last seen in 1998 and the likelihood is low of plants regenerating at this site due the density of ungulates.

12.2.2 Monitoring in FY 2021

Sicyos macrophyllus

In February 2021, during a routine visit to the *Sicyos macrophyllus* fence unit, we discovered 3 young *S. macrophyllus* growing inside. *S. macrophyllus* was last recorded growing inside the fence in 2017. For more details see the species summary in Section 2.4.9.

Zanthoxylum hawaiiense

To update the distribution an abundance of *Z. hawaiiense,* in March 2020 we revisited 575 previously documented locations and counted all individuals present. *Z. hawaiiense* individuals were tagged with a preprinted metal tag attached with copper wire around the base of the tree. We found 492 living trees and 140 recruits or seedlings. For more details see the species summary in Section 2.4.14.

Annual Monitoring for Tier 1 Plant Species

In FY 2021, we began developing a new monitoring protocol for Tier 1 species and articulated new conservation management and monitoring objectives. We anticipate implementing the new Tier 1 monitoring protocol in early FY 2022. By implementing the new monitoring protocol, we will be better able to track population trends and distribution over time for Tier 1 species, which are extremely rare. Knowing their locations, numbers, population structure, habitat quality, and stressors affecting the survival of mature plants, and plant recruitment is important for designing management actions to meet NEPA and ESA commitments and requirements.

12.3 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, 5 wildland fires occurred at PTA:

Firing Point 519 Fire in Training Area 16

On 15 July 2021, at approximately 1520 hours, a wildland fire ignited at Firing Point 519 in Training Area 16 at PTA. The fire started during military training exercises (smoke grenade) by the 1st Platoon, Echo Company, 100th Battalion, 442nd Infantry Regiment. The 4-ha fire was declared 100% contained that same evening. No TES or critical habitat were impacted by this wildfire.

Landing Zone Dove Fire in Keʻāmuku Maneuver Area

On 17 July 2021, at approximately 1330 hours, a wildland fire ignited near Landing Zone Dove in the Keʻāmuku Maneuver Area (KMA). The fire started during military training exercises (blank ammunition) by the 1-299 Calvary Regiment, Hawaiʻi Army National Guard. The fire burned approximately 508 hectares in KMA. On the evening of 17 July 2021, the fire spread to adjacent state lands and burned approximately 99 hectares of Palila Critical Habitat, making the total footprint of the fire 657 hectares. On PTA, no TES were impacted by the fire (see Objective 3.2(1)(d) for post-fire plant monitoring results).

Mana Road Fire – Mauna Kea and Keʻāmuku Maneuver Area

On 30 July 2021, at approximately 1100 hours, a wildland fire ignited off-PTA near Mana Road in the town of Waimea. Fueled by high winds, the fire spread quickly and burned significant acreage on Parker Ranch and state lands on Mauna Kea. On 31 July 2021, the fire jumped Old Saddle Road and burned onto the KMA near Puʻu Nohona o Hae. One of the largest wildland fires in recorded Hawaiʻi history, the fire burned more than 17,000 hectares overall and about 1,273 hectares in KMA. The fire was declared 100% contained on 6 August 2021. On PTA, no TES or critical habitat were impacted by the fire (see Objective 3.2(1)(d) for post-fire plant monitoring results).

Daniel K. Inouye Highway Fires

On 11 August 2021, in the afternoon, a wildfire ignited south of the Daniel K. Inouye (DKI) Highway near the 48-mile marker in KMA. The fire burned an area of about 150–200 yds^2 and was 100% contained on the same evening. On 13 August 2021, at approximately 1400 hours, a second wildfire ignited at the same approximate location along the DKI Highway. The fire was mostly contained and extinguished by 15 August 2021. The second fire burned approximately 100 ha: 33 ha in KMA and 67 ha on adjacent state land. Both fires were suspected arson. On PTA, no TES or critical habitat were impacted by the wildland fires.

Refer to Section 8.0 of this report for additional information regarding the wildland fires.

13.0 WILDLIFE PROGRAM

13.1 INTRODUCTION

To manage wildlife resources at PTA, we implement Statement of Objective (SOO) tasks 3.2(2)(a) through 3.2(2)(e) to comply with INRMP objectives (Sikes Act Improvement Act), ESA consultation requirements, the Migratory Bird Treaty Act (MBTA), regulatory outcomes from NEPA documents, and the conditions of federal and state TES permits. The 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 ESA-listed plants.

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 (*Lasiurus cinereus semotus*), Hawaiian Goose (*Branta sandvicensis*), and Hawaiian Petrel (*Pterodroma sandwichensis*).

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). Despite down-listing of the Hawaiian Goose, 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 2020a). We implement management for the Hawaiian Hawk under the INRMP and in accordance with the MBTA. In addition, since 2006 12 additional bird species protected under the MBTA have been observed at PTA (USAG-P 2020).

In 2016, the Band-rumped Storm Petrel (*Hydrobates castro*) and the anthricinan yellow-faced bee (*Hylaeus anthracinus*) were listed as endangered by the USFWS under the ESA (USFWS 2016). 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 USFWS and the Army agreed that the Army's proposed action (burrow surveys with a detector dog and predator management) may affect but is not likely to adversely affect the Band-rumped Storm Petrel (USFWS 2020b). In November 2020, the Band-rumped Storm-Petrel was added to the federal recovery permit issued under section 10(a)(1)(A) of the ESA. The permit authorizes activities consistent with the May 2020 informal consultation and with activities identified in an action plan that was submitted to the USFWS as part of the permit amendment application. In July 2019, the ESA-listed Blackburn's sphinx moth (*Manduca blackburni*) was discovered at PTA, and 2 additional occurrences of the moth are documented at PTA since then. Reporting requirements for anthricinan yellow-faced bee and the Blackburn's sphinx moth will be addressed in future reports.

The wildlife section of this report is divided into 6 sub-sections:

1) Hawaiian Goose
2) Hawaiian Hoary Bat
3) Band-rumped Storm Petrel
4) Blackburn's Sphinx Moth
5) Wildland Fire Impacts to Wildlife
6) Migratory Bird Incidental Take Summary

The information contained herein satisfies annual reporting requirements identified in regulatory and guiding documents for PTA.

13.2 HAWAIIAN GOOSE

13.2.1 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 Section 4.2.3.

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 Wildlife Enhancement Area (WEA), a 5.3-ha safe area for geese to occupy at the Range 1 Complex.

Hawaiian Goose Monitoring

The Army is required to report and monitor all Hawaiian Goose nesting, breeding, and molting activity and incidental take that occurs at PTA. To meet this requirement, we systematically monitor for geese and track incidental sightings.

Systematic Monitoring Methods

Hawaiian Goose presence, both on the ground and in flight, is systematically monitored with foot surveys and/or vehicle surveys within core areas of PTA where geese have been consistently observed and in areas where geese have nested. Core monitoring areas at PTA include the Range 1 Complex, the Forward Operating Base (FOB) Warrior Search Area (Training Areas 1, 3, and 4), Training Areas 6 and 7, and Bradshaw Army Airfield (BAAF). Observation data are reported by survey date and core area.

Foot surveys consist of 1–2 biologists traversing the area and recording the presence of Hawaiian Geese. Vehicle surveys consist of 1–2 biologists driving on 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., have 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.

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.

Targeted Monitoring Methods

We initiate targeted monitoring when breeding or molting activity is observed during systematic surveys or to follow up on incidental sighting reports. Targeted monitoring typically involves multiple visits to the same location to monitor the same individuals for as long as the individuals are present at the location. Targeted monitoring may involve nest monitoring as well.

Systematic Monitoring Results

In the core management areas, we detected a total of 4 geese during 2 of 191 surveys (Figure E1). Four individual geese were identified by their leg-bands (Table E3). We observed geese at 2 of the 4 core areas.

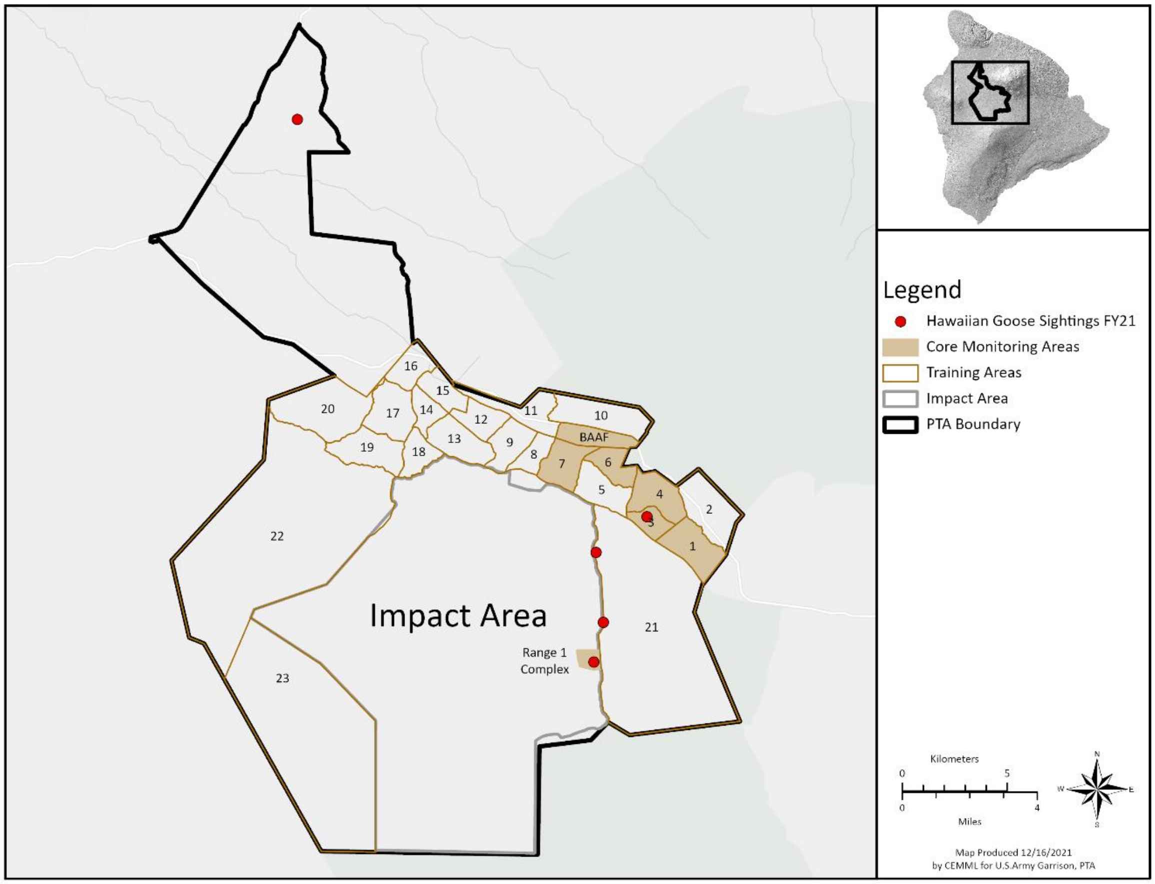

Figure E1. Hawaiian Goose sightings in FY 2021 and core monitoring areas at Pōhakuloa Training Area.

Table E3. Hawaiian Goose systematic monitoring data.

Survey Areas	No. of Surveys	No. of Surveys with Goose Presence	Total Goose Observations[a]	With Bands	W/out Bands	Band not Identified
Range 1 Complex	35	1	2	2	0	0
FOB[b] Warrior Search Area	53	1	2	2	0	0
Bradshaw Army Airfield	51	0	0	0	0	0
Training Areas 6 and 7	52	0	0	0	0	0

[a] Total goose observations included repeated visits of geese with leg-bands and repeat visits of birds without bands or when the bands could not be identified.

[b] FOB, Forward Operating Base

Incidental Sightings Results

No geese were sighted in the core monitoring areas (Table E4). In non-core areas, 4 goose observations were reported from 3 incidental sighting events. We were unable to identify leg-bands for all 4 geese.

Table E4. Hawaiian Goose incidental sightings by location and geese leg-band information.

Survey Areas	Incidental Sighting Events	Total Goose Observations[a]	With Bands	W/out Bands	Band not Identified
Core Area					
Range 1 Complex	0	0	0	0	0
FOB[b] Warrior Search Area	0	0	0	0	0
Bradshaw Army Airfield	0	0	0	0	0
Training Areas 6 and 7	0	0	0	0	0
Non-Core Areas	3	4	0	0	4

[a] Total goose observations included repeated visits of geese with leg-bands and repeat visits of birds without bands or when the bands could not be identified.
[b] FOB, Forward Operating Base

Targeted Monitoring Results

No Hawaiian Goose molting or breeding occurred at PTA during the reporting period.

Management Activities

Actions to Monitor and Manage Hawaiian Goose Breeding Activity

No Hawaiian Goose breeding activity occurred at PTA during the reporting period.

Actions to Minimize Conflicts between Training and Hawaiian Geese

The 2013 BO requires the Army to 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 E2).

Hawaiian Goose habitat enhancement occurs within the WEA fence unit proximate to the Range 1 Complex (Figure E2). Habitat enhancement includes promoting habitat and food availability by selectively cutting and applying herbicide to unwanted weed species such as fireweed (*Senecio madagascariensis*), fountain grass (*Cenchrus setaceus*), and other non-native plants that outcompete plants preferred by geese. The Army's goal for habitat enhancement is to attract geese to the WEA and away from live-fire training areas at the Range 1 Complex.

We selectively applied 66 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.

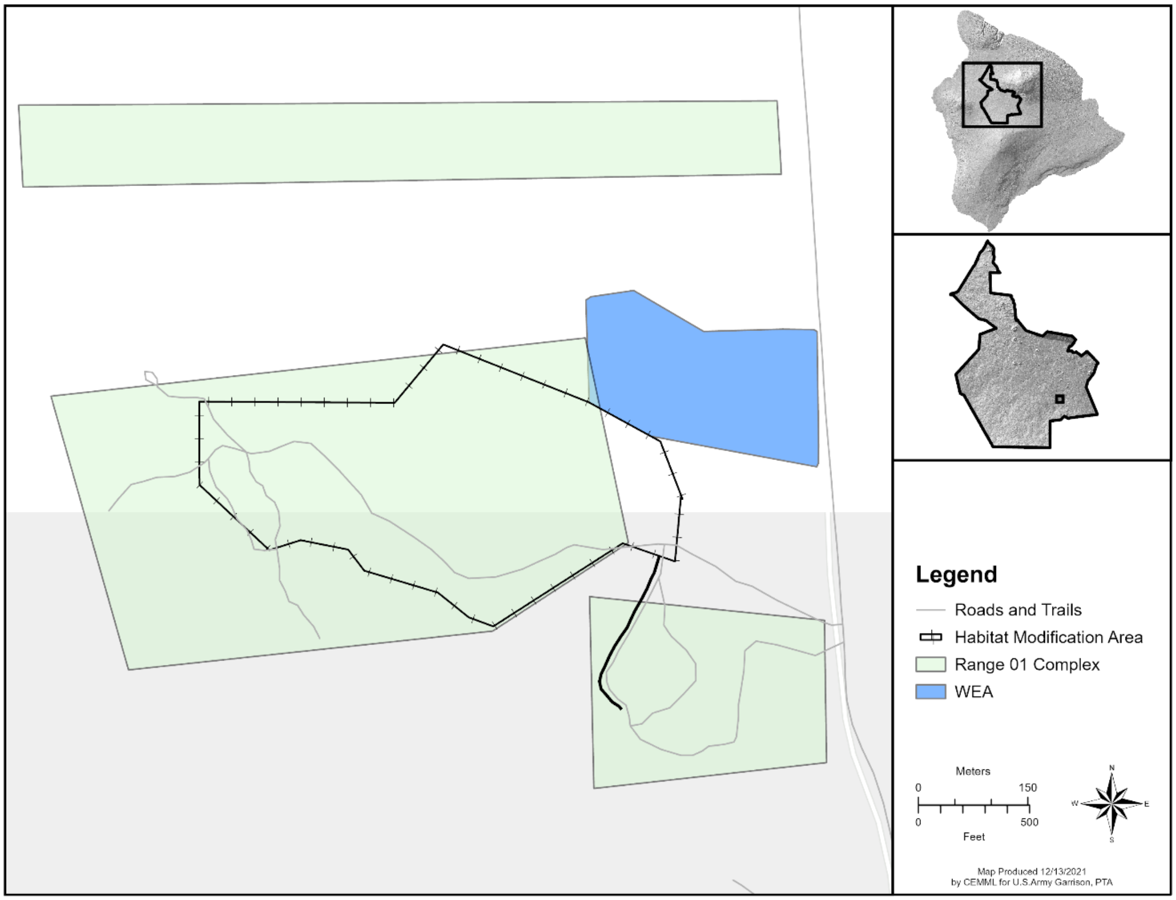

Figure E2. Hawaiian Goose habitat modification area and the Wildlife Enhancement Area at Range 1 Complex, Pōhakuloa Training Area.

__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 8 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 E5). 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 E5. Hawaiian Goose systematic survey days and survey days with geese presence at core area between FY 2017–FY 2020. 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.

Years	No. of Surveys with Goose Presence	Total No. of Surveys
FY 2017	8	77
FY 2018	3	84
FY 2019	8	140
FY 2020	3	145
FY 2021	2	191

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 2021 we received 3 incidental sighting reports (1 military and 2 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. In addition, for FY 2021 we placed 3 Hawaiian Goose educational signs around cantonment to further educate people at PTA about Hawaiian Geese. These signs were placed near high-foot traffic areas for soldiers and others to see.

13.2.2 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 E3). Habitat management activities within the Pua ʻĀkala management area only occur within the formerly proposed predator-proof fence.

To be consistent with refuge goals, we developed a management action plan with HFNWR to include: (1) habitat management, (2) goose monitoring, (3) nest monitoring, and (4) predator control.

On 1 October 2021, we submitted the *2020/2021 Breeding Season Report for Hawaiian Goose Conservation Project, Hakalau Forest National Wildlife Refuge* to HFNWR and USFWS (CEMML 2021b). This report presents only major highlights from the report for Hawaiian Goose habitat management, goose monitoring, nest monitoring, and predator control.

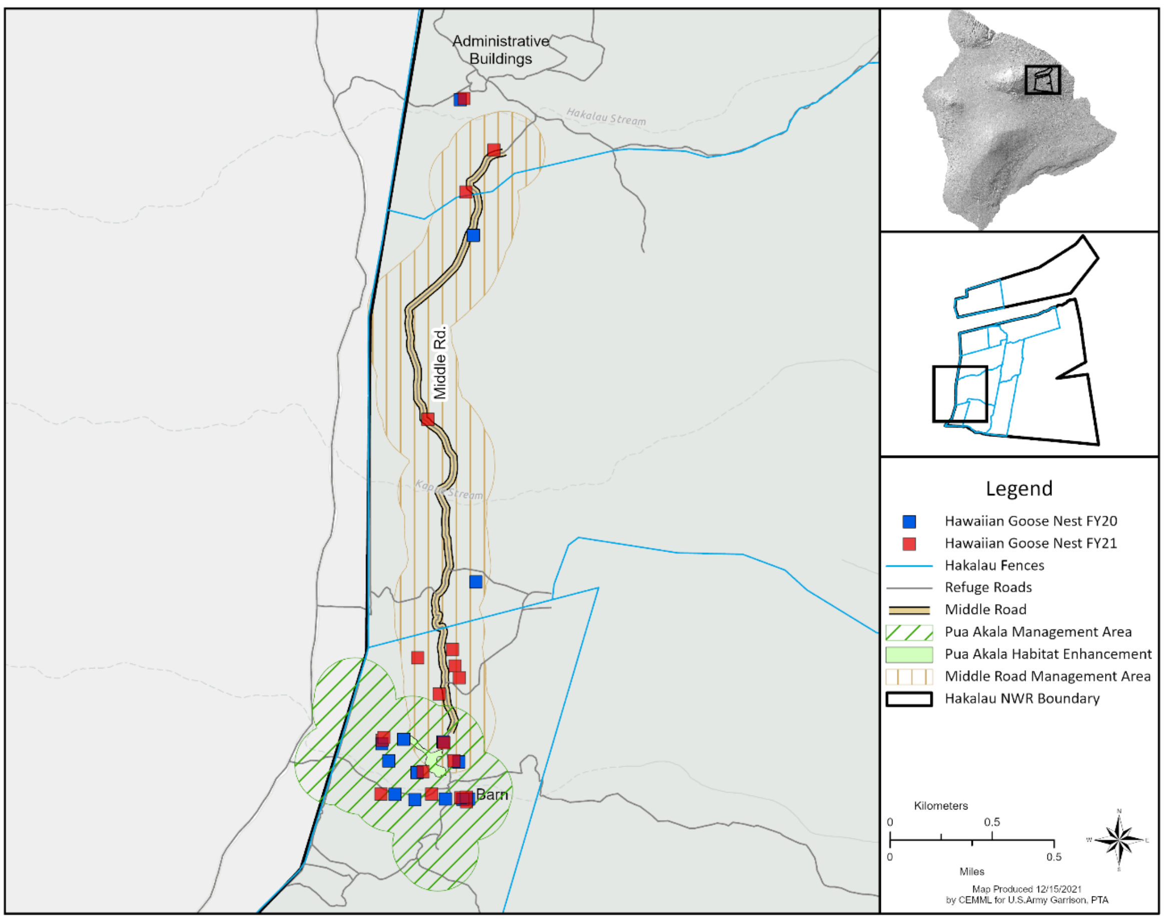

Figure E3. Hawaiian Goose sightings, nest locations, and Army-supported management areas at Hakalau Forest National Wildlife Refuge.

Habitat Management

The Army manages habitat within the Pua ʻĀkala management area by cutting grass and removing invasive plant species to enhance goose foraging grounds. Inadequate nutritional quality is a limiting factor for the reproduction of Hawaiian Geese and gosling survival at high elevation sites (USFWS 2004). Although the effects of habitat management (e.g., mowing grass or planting food plants) on geese productivity have not been well studied at high elevations, forage quality and availability is increased when managed.

In FY 2021, 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 E3). 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 September 2020 and April 2021, we observed a total of 88 geese with unique leg bands, 18 fledglings (identified by one or more banded parents) and multiple unbanded or unknown geese in the Army-supported management areas. In addition, a total of 18 pairs of geese (36 individuals) nested during this year's breeding season, 17 nests in the Army- managed areas and 1 nest in the administration building area (Figure E3). Of the 36 individuals, 25 of them (69%) had previously nested (2017-2020) in the Army-managed areas and 32 geese (89%) had unique leg bands.

Hawaiian Goose Nest Searching and Monitoring

Between September 2020 and January 2021, we found and monitored 18 nests (Figure E3). Nine of the nests were in the Pua ʻĀkala Management Area, 8 nests were in the Middle Road Management Area, and 1 nest was outside the HFNWR administrative site. Seventeen of the 18 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, 18 goslings fledged from the Army-managed areas. This was 69% 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 2022, we plan to continue to refine management and monitoring techniques to improve nesting success and fledging rates.

Predator Control at Hakalau Forest National Wildlife Refuge

We implement cat, mongoose, and rodent control in the Army-managed areas and wherever geese are likely to nest, with the goal of increasing nest success and gosling survivorship. A total of 71 live-traps (45 large and 26 small) were deployed and most were left open for 3 consecutive nights each week over a 33-week period and totaled 4,643 trap nights. We adjust trap nights to standardize trapping effort and capture rates. 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. Overall, a total of 5 feral cats, 8 mongooses, and 2 rats were removed from the management areas.

Between September 2020 and April 2021, we deployed up to four A24 traps (Goodnature® rodent kill traps), spaced approximately 25 m away from each Hawaiian Goose nest. We removed 31 predators (2 mongooses, 4 rats, and 25 mice). 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 Hawaiʻi and mitigates impacts to the Hawaiian Goose due to military training activities at PTA. Our actions within the Army-managed areas, and the administration building area contributed to the successful fledgling of 18 goslings in FY 2021 (69% of the target production of 26 fledglings per year). This was the second-highest percentage for producing fledging's per year since FY 2018 (Table E6). In the FY 2019 breeding season 20 fledglings (77%) was the highest number we had previously produced.

Table E6. Hawaiian Goose nests and fledglings on Army-managed areas during breeding seasons (September to April) 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%
4-year Mean	12.25	14.25	55%

[a] Sightings for the 2017/2018 breeding season began in October.

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 towards the overall success of goose conservation at the refuge.

13.3 Hawaiian Hoary Bat

13.3.1 Introduction

We implement management for the Hawaiian hoary bat to meet SOO tasks and objectives in the INRMP and regulatory documents. The 2003 and 2008 USFWS BOs and associated Incidental Take Statements require the Army to implement a bat monitoring program to determine Hawaiian hoary bat presence and habitat use at PTA. Elements from the BOs and Incidental Take Statements require annual reporting to USFWS. The goal of the Hawaiian hoary bat monitoring project was to determine occupancy and seasonal activity patterns throughout the installation. The study was also meant to identify habitat association based on 5 vegetation classes, and bat prevalence in potential treeland roosting habitats more generally.

13.3.2 Monitoring for the Hawaiian Hoary Bat at PTA

For a detailed description of the methods, results, and discussion of the modeled presence/absence data gathered during the peak of activity (September—December) from 2014—2017, 2019, and 2020, and seasonal activity from July 2014-August 2021, refer to the Hawaiian hoary bat Section 4.2.4 of this report.

In FY 2021, we collect occupancy data during the peak of activity (September 2019–December 2020) at the same 45 sites previously sampled. We also collected nightly bat activity data at 5 locations continuously monitored throughout FY 2021 for seasonal activity analysis.

Overall, acoustic occupancy and activity analyses showed that bats are present across the installation throughout the year and that activity is highest between August and September (between lactation and mating/fledging) and lowest during March and April (between pre-pregnancy and pregnancy).

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 4.2.4 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

Acoustic occupancy and activity analyses show that bats are present across the installation throughout the year and that activity peaks during the autumn months. Both analyses complement each other by emphasizing time of year effects on bat prevalence. 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 understood. However, the substantial increase in bat activity between August and September, suggests that females are present from August to September with newly fledged young. 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 during summer months, they may be at higher risk from fire, military training or construction at PTA 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.

In FY 2022 we plan to continue to monitor bats and to improve knowledge of seasonal activity and occupancy estimates at PTA to help the military anticipate and evaluate the impact of potential hazards to bats such as fire, military training, or construction. A Hawaiian Hoary Bat Conservation Management Plan at PTA has been drafted and 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.

13.4 HAWAIIAN BAND-RUMP STORM PETREL

13.4.1 Introduction

We implement management for Band-rumped Storm Petrel (BSTP) to meet SOO tasks and objectives in the INRMP and regulatory documents. In May 2020, the Army completed an informal consultation with the USFWS for predator control at a BSTP colony during the breeding season at PTA. The Army received concurrence from USFWS with the determination that the Army's proposed actions (burrow surveys with a detector dog and predator management) may affect but is not likely to adversely affect the BSTP (USFWS 2020b).

In December 2020, the Army received the amended recovery permit (TE40123A-3) to authorize the management actives described in the PTA *Band-rumped Storm Petrel* (*Hydrobates castro*) *Management Plan*, which was submitted to the USFWS with the amendment request (CEMML 2020). Two additional permits are required to manage BSTP at PTA. The USFWS Migratory Birds Program, issued USAG-P a Scientific Collection Permit (Number MB95880B-0, 1) to authorize salvage, transport, and possession of BSTP, which is a species protected under the Migratory Bird Treaty Act. The State of Hawaiʻi Board of Land and Natural Resources, Division of Forestry and Wildlife (DOFAW) issued 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 2021, we submitted to DOFAW a technical report, *"2020 Breeding season report for the Band-rump Storm Petrel at Pōhakuloa Training Area, Hawaii Island, Hawaii, Protected Wildlife Permit WL19-42"* (CEMML 2021a). The Army is in the process of drafting a Programmatic Biological Assessment for formal consultation under Section 7 (2)(a) of the ESA with the USFWS for the BSTP, as well as other ESA-listed animals and 20 species of ESA-listed plants. Until then, the informal consultation provides the Army avoidance and minimization measures to help reduce effects from our BSTP management activities.

Petrel management activities at PTA include: (1) determining the geographic extent of the known colony, (2) characterizing behavior, and (3) predator control.

In January 2021, we submitted the annual report for Permit No. MB95880B-0 to USFWS stating zero BSTP specimens were collected. We also submitted the *2020 Breeding Season Report for the Band-rumped Storm Petrel at Pōhakuloa Training Area, Hawaiʻi Island, Hawaiʻi* to the State of Hawaii DLNR for Permit No. WL 19-42 (CEMML 2021a). The state annual report summarizes the management activities for the 2020 BSTP breeding season at PTA.

This report presents major highlights from the 2021 breeding season: determining the geographic extent of the known colony, characterizing behavior, and predator control.

13.4.2 Determination of the Geographic Extent of the Known Colony

Due to the cryptic burrowing habits of BSTP, we used a trained search dog (“Makalani”) and his handler to detect petrel burrows. Makalani was chosen because of his ability to work at high elevations, his demonstrated ability to leave the target species unharmed, his lineage of working bird dogs, and his previous success at detecting BSTP specimens and potential burrows at PTA.

Search Dog Methods

An Astro Garmin 320 GPS device was used to record Makalani’s search track. The Astro GPS device consists of 2 components: a hand-held GPS device (Garmin Astro 320) and a dog collar GPS device (Astro T-5). GPS points and photos were taken when any bird specimen or potential burrow spot was found. A spot was deemed a “potential burrow” when Makalani demonstrated behavior indicating the presence of a target (i.e., “pointing”). A spot was deemed an area of “significant interest” when Makalani showed keen interest in the area but could not pinpoint a specific spot to point on.

Search Dog Results

We conducted 2 searches covering a total of 22 km with Makalani on 23 August 2021 and 20 September 2021 (Figure E4). Each search lasted about 6.5 hours and we did not find any BSTP carcasses or feathers. We revisited 17 spots and Makalani only showed interest at N01, N05, and a new potential burrow, PB19. Prior to Makalani indicating activity at N01 and N05, we had already confirmed BSTP activity via cameras. We added a camera to monitor PB19.

13.4.3 Characterizing BSTP Behavior

Burrow Monitoring Methods

The BSTP breeding biology in Hawaiʻi is not well known, but individuals are assumed to nest in burrows or natural cavities at high-elevation, inland habitats. BSTP calls have been previously recorded in late May at PTA (Galase 2019). The species is highly faithful to burrow sites, typically returning to the same site each year.

Each year after conducting burrow survey with a search dog, we placed cameras (Reconyx XP-9 ultrafire professional covert camera traps™) at all locations where the search dog showed interest and the spot was deemed an active or potential burrow. All the cameras were mounted on a bracket and secured on the ground or on top of nearby rocks. Each camera was positioned at least 2 m away from the burrow entrance, with the camera pointed directly at the burrow’s opening. Each camera was set to take a photograph and a video when triggered by motion and, simultaneously, to take a photograph every 30 seconds (i.e., time-lapse) during periods of high BSTP activity (8:00 pm–10:00 pm and 3:00 am–5:00 am, 480 photographs per time-lapse per period). Before arming a camera, a “walk test” was performed to ensure that the camera would take a picture or video when something moved in front of the burrow’s opening.

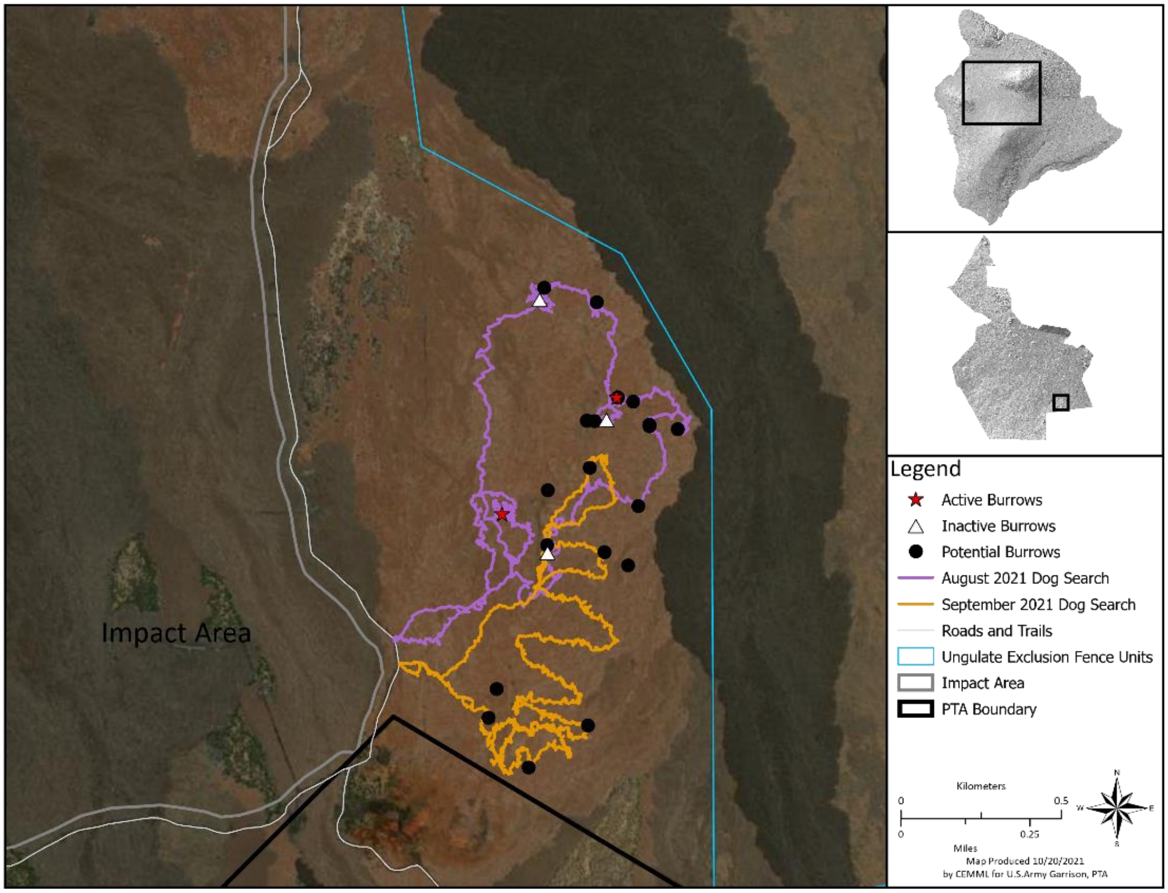

Figure E4. Dog search tracks (22 km) for Band-rumped Storm Petrel nests in FY 2021 in Training Area 21 at Pōhakuloa Training Area[a].

[a] White triangles show previously active burrows where the detector dog showed no interest. Red stars show active burrows confirmed by the by detector dog and camera traps independently.

We used 32 GB SD cards to record photographs and videos. Cards were switched out each visit, approximately every 2 weeks, and lithium batteries were replaced as needed to ensure continuous coverage over the season. The photographs and videos were reviewed in the office to assess BSTP activity and presence/absence of predators at the burrows. BSTP activities around the burrows were categorized into 4 behaviors. “Inside the burrow” was defined as still images or videos of BSTP within the interior of burrow based on distinct markers of the burrow’s features. “Outside the burrow” was defined as activity or images of BSTP outside of the burrow. “Entering the burrow” was defined as a series of images or video of BSTP entering the burrow from outside. “Exiting the burrow” was defined as a series of images or video of BSTP movements from the interior of the burrow toward the edge or outside of the burrow.

At the end of each breeding season each burrow was assigned a final status:

- Active Burrow
    - Active breeding – individuals regularly enter the burrow for more than a month.
        - Successful: evidence of a chick fledging, to include when a chick or down feathers are observed outside the burrow and no depredation is observed.
        - Failed: no chick or down was observed, or depredation was detected.
    - Prospecting – if individuals visit the burrow for a short period of time but no activity is detected in the last 2 months of breeding.
- Inactive Burrow – a previously active burrow with no activity in the current breeding season.
- Potential Burrow – a burrow identified by the detector dog with possible bird activity, but no observed BSTP activity detected by the camera traps.

Videos and photos were processed with Timelapse Image Analyzer (Greenberg Consulting Inc.) and the files were organized by the collection date or by the burrow site. We developed a custom data entry interface for Timelapse Image Analyzer Template to document the following: personnel performing the analysis, quality of the imagery, presence of BSTP, presence of rodent species, BSTP behavior, and notes. This information regarding imagery analysis is exported from Image Analyzer and saved as .csv files accessible via Excel.

Burrow Monitoring Results

In FY 2021, we deployed cameras at 6 burrows from May through September (they will be retrieved in November 2021) and detected BSTP activity at 2 burrows (Table E7). In 2020, the cameras did not detect BSTP chicks at the burrows. In FY 2021, we deployed additional cameras and increased the frequency in the timelapse settings to maximize the chances of detecting BSTP at the burrows. In past years, chicks have been only detected between October and November, which are in the subsequent fiscal year reporting period. Therefore, chicks detected in 2021 will be reported in the FY2022 report.

In FY 2021, no BSTP depredation was detected, and multiple black rats and mice were seen entering and exiting the burrows. Burrow video surveillance results for FY 2021 are summarized below (Table E7).

Table E7. Band-rumped Storm Petrel active and potential burrow monitoring results via video surveillance FY 2021.

Burrow ID	Burrow Status	Adult Detected (Yes/No)	Chick Detected (Yes/No)	Fledging Detected (Yes/No)	Depredation Detected (Yes/No)
N01	Active	Yes	Unknown[a]	Unknown[a]	No
N02	Inactive	No	No	No	No
N03	Inactive	No	No	No	No
N04	Inactive	No	No	No	No
N05	Active	Yes	Unknown[a]	Unknown[a]	No
PB19	Inactive	No	No	No	No

[a] Band-rump Storm Petrel chick do not emerge from the burrows until October and November.

Burrow N01

In FY 2021, we placed a camera at N01 on 20 May and observed the first adult entering the burrow on 12 June. Between May–September 2021, the camera recorded for approximately 133 days and 10 of those days BSTP were detected. On video, an adult BSTP engaged in 1 of 4 behavior categories during 146 detections: inside the burrow 65 times, outside the burrow 31 times, entering 4 times, and exiting 46 times (Table E8). During the 133 days of burrow monitoring black rats were detected for 15 days, and mice for 7 days at the burrow.

Table E8. Number of adult Band-rumped Storm Petrel behaviors detected at each burrow in FY 2021.

	Band-rumped Storm Petrel Behaviors at the Burrow			
Burrow ID	**Inside**	**Outside**	**Entering**	**Exiting**
N01[a]	65	31	4	46
N02	0	0	0	0
N03	0	0	0	0
N04	0	0	0	0
N05[b]	11	18	0	12

[a] BSTP adult was detected 10 days within the 133-day monitoring period.
[b] BSTP adult was detected 14 days within the 133-day monitoring period.

Burrow N02

In FY 2021, we placed a camera at N02 on 20 May and no BSTP activity was detected. This burrow is inactive. During the 133 days of burrow monitoring black rats were detected on 2 days and no mice were detected at the burrow.

Burrow N03

In FY 2021, we placed a camera at N03 on 20 May and no BSTP activity was detected. This burrow is inactive. During the 133 days of burrow monitoring black rats were detected on 2 days and mice were detected on 3 days at the burrow.

Burrow N04

FY 2021, we placed a camera on N04 on 20 May and no BSTP activity was detected. This burrow is inactive. During the 133 days of burrow monitoring black rats were detected on 2 days and mice were detected on 7 days at the burrow.

Burrow N05

In FY 2021, we placed a camera at N05 on 20 May and observed the first adult entering the burrow on 28 May. Between May–September 2021, the camera recorded for approximately 133 days and 14 of those days BSTP were detected. On video, an adult BSTP engaged in 1 of 4 behavior categories during 41 detections: inside the burrow 11 times, outside the burrow 18 times, and exiting 12 times (Table E8). No adult was detected entering the burrow. During the 133 days of burrow monitoring black rats were detected for 4 days, and no mice were detected at the burrow.

PB19

In FY 2021, we placed a camera on PB19 on 20 September. No BSTP or rodent activity has been detected at the burrow.

13.4.4 Predator Control Management

Live and Lethal Trap

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 E5). A combination of live and lethal traps was used to remove small mammals.

<u>Live Trapping</u>

We deployed up to 40 Tomahawk® (30"x10"x12") live traps within ARS 501 in TA 21 (Figure E5). Live traps were spaced 200 m apart, and they were monitored daily using SkyHawk® (PICA Production Development), an electronic cellular connectivity device that alerts the user when a trap has been triggered (trap door closes, or trap vibrates). These trap sensors are a new tool and eliminated the need to physically check traps every 24 hours (Animal Care Use Committee requirement). All the live traps were baited with a single can of sardines (Beach Cliff Sardines in soybean oil) with scent holes punctured in the top and the traps were rebaited every month. All live traps with Skyhawks sensors are set/open 7 days a week.

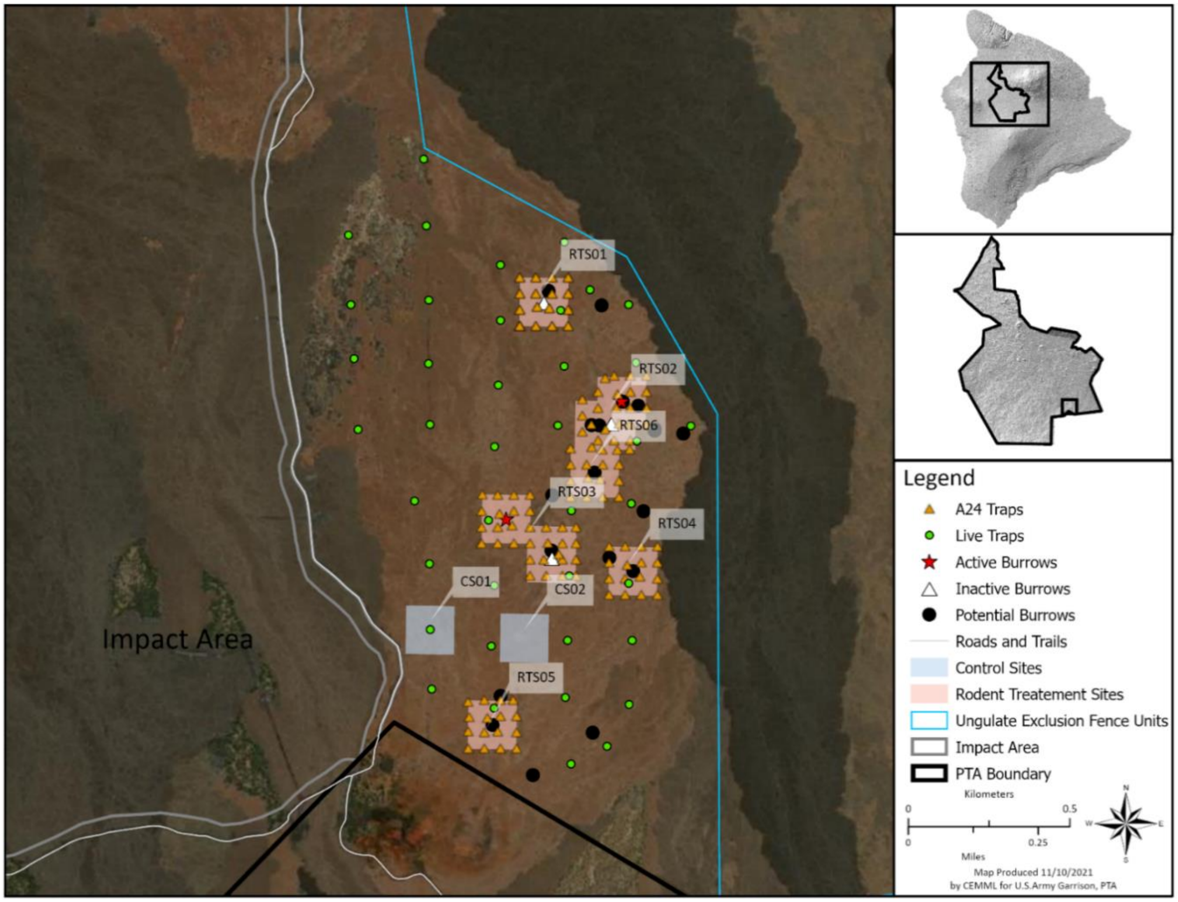

Figure E5. Predator trap layout in the Band-rumped Storm Petrel colony in Training Area 21 at Pōhakuloa Training Area[a].

[a] Goodnature® A24 traps (orange triangles) were spaced about 50 m in a grid within the rodent treatment sites. Live traps (green dots) were spaced 200 m apart.

<u>Lethal Trapping</u>

To protect nesting BSTP from rodents, in May 2020 we established 5 rodent treatment sites (RTS) that encompassed all potential, inactive, and active burrows (Figure E5). 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 three months, the Goodnature® chocolate formula bait lure and each CO_2 canister were replaced. Also, for each RTS, up to 2 snap traps (Kress™ Snap-E traps), 1 rat and 1 mouse, were deployed inside protective boxes and set at least 2 m from the burrow openings. We rebaited snap taps 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.

During the reporting period between October 2020 and September 2021, we monitored 106 A24 traps within 5 RTS. After discovering PB19 in September 2021, we established a new RTS (RTS06) around the potential burrow. Only 13 A24 traps were deployed due to terrain considerations, bringing the combined total of A24 traps in all RTS to 119.

In addition, 7 surveillance cameras (Browning Dark Ops HD Pro®) were deployed to monitor 7 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 (*Branta sandvicensis)*, the Hawaiian Short-eared Owl (*Asio flammeus sandwichensis)*, and the ʻŌmaʻo (*Myadestes obscurus*). In addition, the Barn Owl (*Tyto alba*), a documented BSTP predator, also occurs in TA 21.

Live and Lethal Trapping Results

In FY 2021 we deployed 40 live traps and removed 9 predators (8 feral cat and 1 rat). In addition, 2 Chukars (*Alectoris chukar)* non-native game birds were also captured in the live traps and subsequently released unharmed. No native or endangered animals were captured in the live traps.

In FY 2021, we found and removed 132 rodent carcasses (47 black rats and 85 mice) from the A24 traps and snap traps (Table E9). Because carcasses may be on the ground under the A24 traps 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.

Table E9. Number of lethal traps deployed by type and number of rodents removed from rodent treatment sites at the Band-rumped Storm Petrel colony (ASR 501) FY 2021.

Rodent Treatment Site	A24 Traps	Snap Traps	Black Rats Removed	Mice Removed
RTS01	16	2	11	22
RTS02	27	12	2	13
RTS03	31	10	7	24
RTS04	16	2	10	17
RTS05	16	2	17	9
RTS06	13	2	0	0
Total	**119**	**30**	**47**	**85**

[a] FY 2020 lethal trapping occurred June 2020 -September 2020.
ASR, Area of Species Recovery

We monitored 7 A24 traps with cameras and no native or endangered birds (BSTP, Hawaiian Goose, Hawaiian Short-eared owl, ʻŌmaʻo) were detected. In addition, no Barn Owls were detected. However, the cameras detected 3 birds (2 non-native and 1 indigenous): Chukar (*Alectoris chukar)*, Skylark (*Alauda arvensis*), and Pacific Golden Plover (*Pluvialis fulva*). However, the birds in the photographs did not appear to interact with the trap. We detected 2 instances of a feral cat scavenging a rat carcass from an A24 trap. A feral cat was captured within 24 hours near the A24 trap where one of the scavenging events occurred.

Tracking Tunnels

We used tracking tunnels to monitor changes in rodent activity in response to trap deployment, because tracking tunnels present an index of 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. Following trapping, we deployed 152 tracking tunnels at the same sites quarterly between August 2020 and November 2021 (Figure E6). In November, we added 16 tracking tunnels to RTS06.

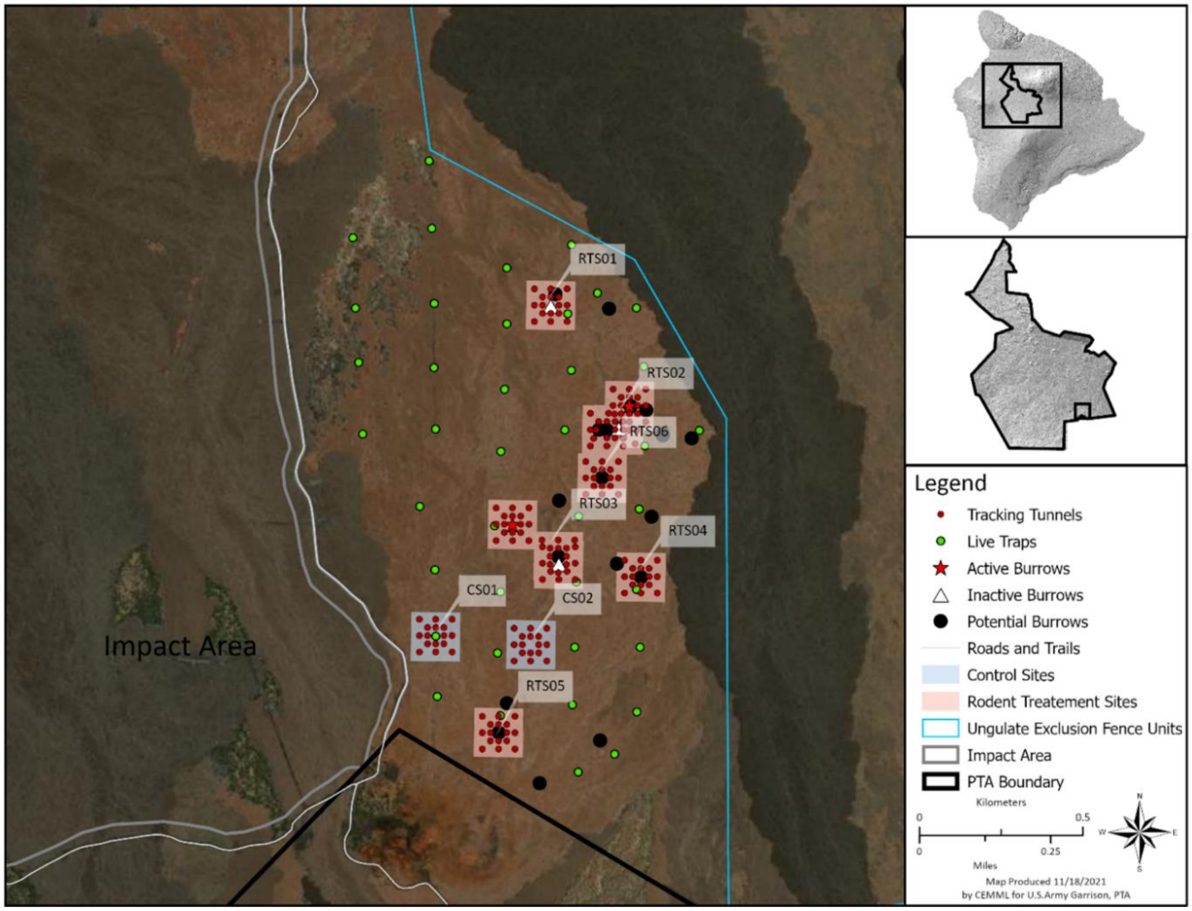

Figure E6. Tracking tunnel layout around the Band-rumped Storm petrel colony in Training Area 21 at Pōhakuloa Training Area[a].

[a] Tracking tunnel locations (red dots) spaced approximately 25 m apart within each rodent treatment and control site.

Tracking Tunnel Results

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 E10). Overall, rat activity decreased in each RTS following trapping. Since February 2021, black rat activity for all RTS has been below 11% (range 0-11%). 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 E10). 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-P NRP unpublished data) and TA 23 (RCUH 1998).

Table E10. Tracking tunnel results, which indicate rodent activity in the rodent treatment sites and control site in ASR 501 from May 2020 to August 2021.

Site ID	Species	May 2020[a]	Aug 2020	Nov 2020	Feb 2021	May 2021	Aug 2021
CS01	Black Rat	**38%**	6%	88%	50%	0%	0%
	Mouse	**50%**	0%	25%	0%	38%	0%
CS02	Black Rat	**44%**	0%	0%	6%	0%	0%
	Mouse	**6%**	63%	6%	0%	0%	13%
RTS01	Black Rat	**31%**	0%	0%	0%	0%	0%
	Mouse	**69%**	69%	31%	81%	63%	81%
RTS02	Black Rat	**17%**	8%	0%	0%	0%	0%
	Mouse	**6%**	25%	11%	8%	53%	0%
RTS03	Black Rat	**44%**	0%	19%	0%	0%	0%
	Mouse	**36%**	17%	50%	33%	58%	78%
RTS04	Black Rat	**44%**	0%	38%	0%	0%	0%
	Mouse	**44%**	69%	19%	81%	63%	94%
RTS05	Black Rat	**69%**	0%	56%	0%	0%	0%
	Mouse	**25%**	75%	0%	19%	0%	6%
RTS06[b]	Black Rat	-	-	-	-	-	-
	Mouse	-	-	-	-	-	-

ASR, Area of Species Recovery; CS, Control Site (no rodent trapping); RT, Rodent Treatment Site (rodent trapping).
[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 (RTS). Data reported to the right of the vertical solid line are post-rodent trapping in the RTS.
[b] Trapping began in September 2021 followed by tracking tunnel deployment in November.

Federal and State of Hawaiʻi Permits

In December 2020, we received an amended federal recovery permit (TE40123A-3) to authorize BSTP management activities such as surveys for BSTP burrows with a detector dog, burrow monitoring with cameras, acoustic recordings, and predator control. In FY 2021, we applied to renew our State of Hawaiʻi Protected Wildlife Permit Number WL19-42.

Salvage and or Incidental Take

No BSTP specimens were collected in FY 2021.

Discussion for Band-rumped Storm Petrel Management

Since the first BSTP active burrow (N01) was discovered in 2015, we have successfully confirmed 4 more active burrows (N02, N03, N04, and N05). In FY 2021 we detected adult BSTP in N01 and N05, but the report period ended before chicks are typically detected (October or November 2021). We believe that increasing the number of cameras and adjustments to the camera settings will maximize the chances of detecting a chick as it emerges from the burrow.

In FY 2021, we improved camera monitor at the BSTP burrows. For burrow N05, an adult BSTP was seen inside only 1 time but was seen exiting 21 times. This led us to believe that there might be another burrow entrance at N05. Therefore, in FY 2021, we placed an additional camera at another burrow entrance near the initial burrow entrance approximately 1 m away. With this adjustment we were able to increase detections of adult BSTP, but how the birds are entering the burrow remains elusive. In FY 2022, we will continue to adjust camera placement and settings to maximize the chances of capturing chicks emerging from the burrow and fledging.

By continuing to trap for predators year-round we are seeing an increase in feral cat captures and a decrease in black rat activity around the RTS. Since implementing limited predator control trapping (only during pre-BSTP arrival, April–June), in 2018 and 2019 and year-round trapping since 2020, zero BSTP carcasses have been discovered during the breeding season. In 2022, we plan to continue trapping between breeding seasons to minimize the number of predators in and near the colony and reduce depredation pressure on the birds.

In addition to breeding activity, BSTP call activity from previous years suggests that many non-breeding birds 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 there is a substantial non-breeding component to the colony. However, we have even less information about the non-breeding component of the colony at PTA. Because of the challenges in monitoring unmarked populations, we are exploring acoustic monitoring options coupled with new developments in occupancy modeling to evaluate changes in call activity over time. Additional acoustic information will also help bolster knowledge of seasonal and nightly colony attendance patterns of non-breeders.

We faced many challenges collecting additional BSTP information at the colony site. Finding and confirming new active nests was time consuming and knowledge of the area that BSTP use for breeding remains limited. With only 5 active nests documented within the past 5 years, knowledge of breeding activity and behavior remains rudimentary.

We will continue to investigate the colony extent, colony attendance patterns, non-breeding behaviors, and breeding activity to accurately assess potential effects from military activities on the birds and to guide the development of conservation measures commensurate with anticipated effects. To offset potential impacts to the species that are not military activity-related, we will update the INRMP to address conservation activities for this species and to reduce the need to designate critical habitat on the installation for this species.

13.5 BLACKBURN'S SPHINX MOTH

13.5.1 Introduction

In 2000, the USFWS listed the Blackburn's sphinx moth (BSM, *Manduca blackburni*) as an endangered species, making it the first Hawaiian insect to receive such a status. Historically BSM 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, BSM population numbers are small; however, no reasonably accurate estimates of population sizes have been determinable due to the adult moths' wide-ranging behavior and its overall rarity.

In July 2019, the moth was discovered for the first time at PTA (7 caterpillars – 5th instar – on tree tobacco, *Nicotiana glauca*). In FY 2020, we found four 5th instar caterpillars on *Solanum incompletum* at ASR 24 (Table E11 and Figure E7).

13.5.2 Incidental Sightings

Staff are trained to report any BSM sighting while performing their other duties. For incidental sightings 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.

In FY 2021, no incidental reports of BSM larvae were reported.

Table E11. Blackburn's Sphinx Moth incidental sightings at Pōhakuloa Training Area since 2019.

Observation Date	Location	Host Plant	BSM caterpillars
7/1/2019	Keʻāmuku Maneuver Area	*Nicotiana glauca*	6
7/3/2019	Keʻāmuku Maneuver Area	*Nicotiana glauca*	1
11/4/2019	Training Area 22 (ASR 24)	*Solanum incompletum*	2
11/6/2019	Training Area 22 (ASR 24)	*Solanum incompletum*	2

ASR, Area of Species Recovery; BSM, Blackburn Sphinx moth (*Manduca blackburni*)

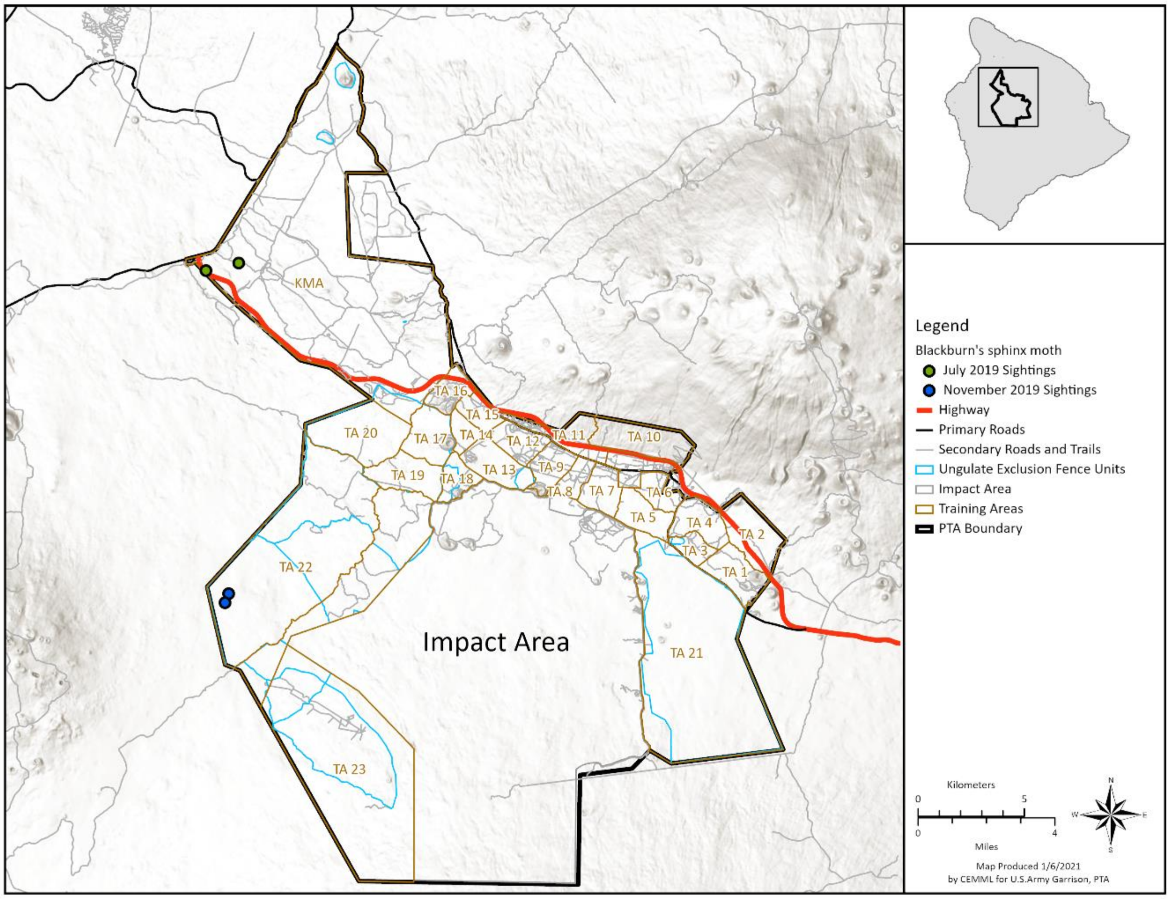

Figure E7. Blackburn's sphinx moth sightings at Pōhakuloa Training Area since 2019.

Discussion for Blackburn's Sphinx Moth Management

Prior to 2019, we documented BSM along the Daniel K. Inouye Highway in KMA, but we did not detect BSM within the rest of PTA until July 2019. Since 2019, we have confirmed a total of 11 individual BSM caterpillars at PTA. Two reported sightings were discovered in KMA (7 caterpillars) on *N. glauca* plants and 2 reported sightings (4 caterpillars) were discovered on *S. incompletum* in ASR 24 in TA 22. The 2 BSM sightings in TA 22 (ASR 24) were unexpected since there are few *N. glauca* plants in the area, and we did not think there was sufficient density of *S. incompletum* plants to attract and support BSM.

Because we recently discovered BSM at PTA, we do not know much about its potential distribution or other possible *Solanaceae* host plants on the installation. The presence of BSM on *N. glauca* may be a challenge for natural resources management and military operations in KMA. *N. glauca* continues to invade PTA and as it becomes established, especially in KMA and along the western PTA boundary, BSM numbers are also likely to increase. In addition, *N. glauca* grows quickly in open areas, such as fire and fuel breaks, and forms dense thickets if not controlled. As BSM presence increases along with this invasive plant in KMA, military training and operations may be constrained.

In TA 22, the BSM poses a different management challenge – how to manage an ESA-listed animal species feeding on an ESA-listed plant species. Staff members at Puʻu Waʻawaʻa also observed BSM feeding on *S. incompletum* plants (Edith Adkins, personal communication, 23 October 2020). In FY 2022, we plan to have NRP staff attend a BSM monitoring workshop sponsored by Hawaiʻi Department of Forestry and Wildlife staff working at Puʻu Waʻawaʻa.

13.6 WILDLAND FIRE IMPACTS TO WILDLIFE

The 2003 BO (USFWS 2003) requires the Army to indirectly monitor Hawaiian hoary bat incidental take as the amount of treeland habitat destroyed outside the Impact Area annually. The Army is covered for take associated with the loss of no more than 48 ha per year of potential available treeland roosting habitat outside the Impact Area and cumulative losses of no more than 1,345 ha outside the Impact Area. Treeland loss primarily occurs from wildland fire, but other military actions, such as maneuvers, live-fire, and construction also influence losses.

During the reporting period, 5 wildland fires occurred at PTA:

Firing Point 519 Fire in Training Area 16

On 15 July 2021, at approximately 1520 hours, a wildland fire ignited at Firing Point 519 in Training Area 16 at PTA. The fire started during military training exercises (smoke grenade) by the 1st Platoon, Echo Company, 100th Battalion, 442nd Infantry Regiment. The 4-ha fire was declared 100% contained that same evening. There were no effects to Hawaiian hoary bat habitat from this wildfire.

Landing Zone Dove Fire in Keʻāmuku Maneuver Area

On 17 July 2021, at approximately 1330 hours, a wildland fire ignited near Landing Zone Dove in the Keʻāmuku Maneuver Area (KMA). The fire started during military training exercises (blank ammunition) by the 1-299 Calvary Regiment, Hawaiʻi Army National Guard. The fire burned approximately 508 hectares in KMA. On the evening of 17 July 2021, the fire spread to adjacent state lands and burned approximately 99 hectares of Palila Critical Habitat, making the total footprint of the fire 657 hectares. On PTA, the fire burned approximately 3 ha of vegetation considered potential available Hawaiian hoary bat roosting habitat.

Mana Road Fire – Mauna Kea and Keʻāmuku Maneuver Area

On 30 July 2021, at approximately 1100 hours, a wildland fire ignited off-PTA near Mana Road in the town of Waimea. Fueled by high winds, the fire spread quickly and burned significant acreage on Parker Ranch and state lands on Mauna Kea. On 31 July 2021, the fire jumped Old Saddle Road and burned onto the KMA near Puʻu Nohona o Hae. One of the largest wildland fires in recorded Hawaiʻi history, the fire burned more than 17,000 hectares overall and about 1,273 hectares in KMA. The fire was declared 100% contained on 6 August 2021. On PTA, the fire burned approximately 12 ha of vegetation considered potential available Hawaiian hoary bat roosting habitat.

Daniel K. Inouye Highway Fires

On 11 August 2021, in the afternoon, a wildfire ignited south of the Daniel K. Inouye (DKI) Highway near the 48-mile marker in KMA. The fire burned an area of about 150–200 yds^2 and was 100% contained on the same evening. On 13 August 2021, at approximately 1400 hours, a second wildfire ignited at the same approximate location along the DKI Highway. The fire was mostly contained and extinguished by 15 August 2021. The second fire burned approximately 100 ha: 33 ha in KMA and 67 ha on adjacent state land. Both fires were suspected arson. On PTA, there were no effects to Hawaiian hoary bat habitat from this wildfire.

Combined, the fires burned approximately 1,925 ha of which 15 ha are considered potential treeland roosting habitat. The fires resulted in indirect incidental take of Hawaiian hoary bats, consuming approximately 31% of the allowable 48 ha per year. No bat carcasses were reported in the burned areas and impacts to the Hawaiian hoary bat are assumed to be negligible.

Refer to Section 8.0 of this report for additional information regarding the wildland fires.

13.7 Migratory Bird Incidental Take Summary

The Army is required to protect migratory birds and their habitats. The USFWS has authorized incidental take of MBTA-protected species for Department of Defense projects that are deemed military readiness activities. NEPA documents for military activities and the PTA INRMP (USAG-P 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 2021.

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