Hawaiian Hoary Bat
Tier 1 Mitigation
Habitat Management Plan
for the Poamoho Management Area

Prepared for:
Nā Pua Makani Power Partners, LLC

Prepared by:

TETRA TECH

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1.0 Introduction

The Nā Pua Makani Wind Project (Project) Habitat Conservation Plan (HCP) was approved by the Board of Land and Natural Resources (BLNR) in May 2018, and Nā Pua Makani Power Partners, LLC (NPMPP) was issued an associated federal Incidental Take Permit and state Incidental Take License. As described in the HCP, to mitigate for potential impacts to 34 Hawaiian hoary bats (*Lasiurus semotus*) or ʻōpeʻapeʻa under the Tier 1 take scenario, NPMPP identified a plan consisting of a combination of habitat management and research (Tetra Tech 2016). The habitat management component would be the primary approach to mitigate for potential impacts to bats, and the research component would help regulatory agencies and land managers better understand the impacts of the management actions. The Tier 1 habitat management component in the HCP states that NPMPP would fund eight years of management and monitoring efforts to be conducted by staff of the Koʻolau Mountains Watershed Partnership (KMWP) in the state Poamoho Management Area (PMA) (Figure 1). This Hawaiian Hoary Bat Tier 1 Mitigation Habitat Management Plan (Habitat Management Plan) is consistent with the mitigation commitments described in the HCP, where KMWP is the entity implementing the management actions with financial support from NPMPP.

During the development and approval of the HCP, it was determined that mitigation habitat should be established over an eight-year time period, commensurate with the expected take of Hawaiian hoary bat. The eight-year time period was derived from an estimated need of $198,000 annual budget for habitat management in the PMA and an acknowledgement that the 2015 Hawaiian hoary bat guidelines stated that mitigation should equate to $50,000 per bat, which was the prevailing metric at the time the HCP was approved. To mitigate for 34 bats NPMPP was expected to spend $1,700,000 (34 bats * $50,000/bat = $1.7 million). An expenditure of $1.7 million dollars would cover 8.5 years of vegetation management across the PMA at $198,000 per year. Once the expenditures for the $100,000 research plan and funds spent on baseline mapping were subtracted, the term of Tier 1 mitigation was formalized in the HCP as eight years. As presented, this plan now has a total budget of $2,700,000, or $79,000 per bat, which far exceeds the requirement in the HCP in order to fully mitigate expected take of Hawaiian hoary bat.

The Tier 1 habitat management components are described in this document (Habitat Management Plan); the Habitat Management Plan's goal is to increase bat use in the PMA by supporting the protection of the bat mitigation area from the impacts of invasive species that are expected to negatively affect bat foraging and potentially roosting resources without intervention. The Tier 1 research program is described in a separate document, Hawaiian Hoary Bat Tier 1 Mitigation Research Plan (Research Plan; Tetra Tech 2025). The goal of the Research Plan is to augment our understanding of how the management actions described in this Habitat Management Plan benefits bats. The Research Plan will allow for the study of how habitat degradation influences how arthropod communities change in response to changes in the dominance of invasive species while monitoring within the management plots in the PMA will aim to determine if forest management activities (e.g., invasive plant management and outplanting) have any influence on prey base or bat presence. Combined these efforts will result in a better understand of whether forest management

actions have the potential to change bat prey base and bat use of an area and could inform future forest management actions.

This plan is the culmination of several years of coordination between DOFWA HCP and the USFWS, along with the management partners working in the PMA, including not just KMWP, but also DOFAW Native Ecosystems Protection and Managmement Program (NEPM) and the Oʻahu Invasive Species Committee (OISC). These entitites have provided input into the contents of the plan and will be part of the ongoing coordination that will occur in order to implement it.

1.1 Background

The PMA is located above Wahiawa in the ʻEwa Forest Reserve and contains native, high-elevation forest but invasive plant species are present (Figure 2) and at the time of the HCP approval, feral pigs (*Sus scrofa*) were a significant problem within the PMA (Tetra Tech 2016). The Hawaiʻi Department of Land and Natural Resources (DLNR) is responsible for long-term management of the area but, as noted in the HCP, DLNR identified a need to obtain secure funding for the long-term management and maintenance of the PMA parcels including funding for fence maintenance, pig removal, and invasive species removal to ensure successful forest restoration in the PMA.

As discussed further in this plan, feral pig removal is the first and most crucial step for conservation of native forests in Hawaii, but subsequent management should also include control of non-native invasive plants and outplanting native species of conservation interest that fail to recruit naturally (Cole and Litton 2014). Management of non-native invasive plants is the primary action included in this plan, however this plan includes a commitment to outplanting and flexibility to shift resources to activities that will address supplemental feral pig removal, if and when needed.

Bats have been documented within the PMA via acoustic monitoring efforts initiated by the Project in coordination with KMWP and DLNR in April 2014, and nearby monitoring studies have subsequently documented bats in similar habitats (Tetra Tech 2016, Davidson 2020, Thompson and Starcevich 2022). This habitat has been negatively impacted by feral pigs and invasive plants and will continue to degrade without active and consistent management. As noted in the approved HCP, Division of Forestry and Wildlife (DOFAW) received funding to install ungulate proof fencing around two units in the PMA to protect these areas from ongoing damage by feral pigs. This fencing was completed in 2015 (northern fence unit) and 2016 (southern fence unit). However, ongoing management of these fenced areas is required, including the removal of invasive plants, and continued protection from the impacts of feral pigs (e.g., fence maintenance and pig removal as needed) to interrupt the habitat degradation and increase the quality of the habitat inside the fence.

The restoration and management activities will foster the growth of additional bat roosting and foraging habitat and will support a diverse native species dominated forested corridor connected to the Ahupuaʻa ʻO Kahana State Park and forested habitat managed for conservation in neighboring military reservation areas. Finally, restoration efforts in a native forest that is under pressure from non-native plants and ungulates provide an opportunity to develop a better understanding of the potential benefits of this type of forest restoration project to the Hawaiian hoary bat. This opportunity is leveraged through the Research Plan, which expands on monitoring for the direct

effects of the management actions to pursue a deeper understanding of the mechanisms behind the conservation benefits (Tetra Tech 2025). The result of this improved understanding will help guide the effective allocation of future management resources.

The benefits envisioned include providing on-going protection during the period of performance to reduce the risk of new invasive species gaining a foothold, removal of invasive plants to allow natural restoration processes to reclaim areas impacted by invasive plant species, outplanting trees in areas vulnerable to a new infestation of invasive plants and where bats are most likely to forage or roost, and maintaining the pig proof fence that contributes to protection of this environment. These actions are expected to increase available bat prey and result in an associated increase in bat activity within the managed area, which will be determined via the monitoring program described in this Habitat Management Plan.

1.2 Document Outline

This Habitat Management Plan:

- Describes relevant Hawaiian hoary bat information that provide a theoretical understanding of how bats are expected to benefit from management actions proposed for this mitigation project;
- Describes the baseline condition of the PMA;
- Outlines coordination between the various entities managing resources in the PMA;
- Details the management actions to be carried out for this mitigation project;
- Details the monitoring plan that will measure expected outcomes;
- Details specific measures of success that will be used to evaluate successful implementation of the mitigation project; and
- Identifies potential adaptive management actions to address the identification of conditions that suggest the mitigation project is not providing the expected benefits to bats on the anticipated timeline.

2.0 Hawaiian Hoary Bat Background

The Hawaiian hoary bat, a solitary tree roosting bat, occurs on all the major islands in the Hawaiian Archipelago, Kauaʻi, Oʻahu, Maui, Lānaʻi, Molokai, and Hawaiʻi (Tomich 1986). Recent significant investments in research and preliminary results from management efforts have provided insights into habitat use, tree roost characteristics, diet, population dynamics, seasonal occupancy and foraging ranges on the islands of Oʻahu, Maui, and Hawaiʻi. However, significant knowledge gaps related to the species' life history, survival, sex and distributions, and population size remain. Nonetheless, results from these studies and other research can be leveraged to manage and protect habitat in ways that are likely to enhance habitat suitability for the bat. Below we summarize actionable knowledge about the bat.

2.1 Distribution, and Population Trends

On Hawai‘i Island hoary bats have been shown to migrate along altitudinal gradients in response to changes in temperature, rainfall, and food resources, occupying low elevations during the summer and fall breeding seasons and migrating to the interior highlands during the winter post-lactation period (Menard 2003, Todd 2012, Bonaccorso et al. 2015). On Hawai‘i Island, female bats were found to be more active during the reproductive season (May to September), while male bats were most active during the non-reproductive season (October to April) (Hoeh et al. 2023). Seasonal changes in acoustic activity observed at several locations on O‘ahu (Gorresen et al. 2015, Thompson and Starcevich 2022) and Maui (Todd et al. 2016, H.T. Harvey 2020, Auwahi Wind 2023, Tetra Tech 2023a, Tetra Tech 2023b) suggest similar altitudinal migrations occur on these islands.

An occupancy study conducted on Hawai‘i Island suggest that population is stable and potentially increasing (Gorresen at al. 2013). Similar results were found from an occupancy study on O‘ahu which suggested the population appeared stable to slightly increasing over the study period (Thompson and Starcevich 2022). Estimates of contemporary genetic effective population sizes[1] indicate population sizes are greater on Hawai‘i Island and Kaua‘i than on Maui and O‘ahu and that there has been little to no cotemporary gene flow between islands (Pinzari et al. 2023). Estimates of population size can be extremely difficult for cryptic species like the Hawaiian hoary bat and currently no estimates of population size have been conducted for the species with a high level of confidence.

2.2 Life history information related to habitat management

Bats are highly mobile and capable of flying large distances quickly. This mobility gives them access to a wide range of habitats and can reduce their dependence upon a particular setting. For some bat species there are clear associations with specific habitats (Russo and Jones 2003, Fenton et al. 1992, Racey 1998) while others are more flexible in their use of habitats (Russo and Jones 2003, Rautenbach et al. 1996). Habitat selection by bats can be influenced by a variety of intrinsic (i.e., life history) and extrinsic (i.e., weather) factors. However, the two primary factors that determine habitat selection by bats are availability of adequate roost sites and the abundance or ability to capture prey (Fenton 1997).

The Hawaiian hoary bat is regarded as a generalist species and demonstrates considerable flexibility in its use of native and non-native habitats for foraging and roosting. Radio telemetry studies on Hawai‘i Island have documented the hoary bat traversing greater than 17 kilometers from its roost site to forage among a mosaic of habitat elements such as the edges of cluttered forests and within open spaces including forest gaps, gulches, windrows, roadways , open water, pastures, and above the forest canopy (Whitaker and Tomich 1983; Belwood and Fullard 1984; Jacobs 1996, 1999; Poe 2007; Bonaccorso et al. 2015). These sites provide sheltered foraging grounds on windy nights and facilitate easy capture of prey.

[1] Effective population estimates are not equivalent to the true “census” population size, and all estimates should be interpreted with caution and subject to change with additional data

Hoary bats are known to forage on a variety of insects from 10 orders and 24 different families (Todd 2012, Pinzari et al. 2019, H.T. Harvey 2020). However, Lepidoptera (i.e. moths) represent the most abundant and diverse insect taxa in the diet of hoary bats, followed by Coleoptera—beetles (Todd 2012, Pinzari et al. 2019). Following lactation, a period of high energetic demand, Hawaiian hoary bats have been shown to selectively forage on Coleoptera, which may be easier to catch and satisfy additional nutrient demands (Todd 2012). For many bat species including Hawaiian hoary bats, increased rates in activity are associated with increased abundance of insect prey (Todd 2012, de Oliveira et al. 2015, Gorresen et al. 2018, Halat et al. 2018).

Roost trees species used by Hawaiian Hoary bats include both native and non-native species. Habitat use studies of radio tagged bats indicate that Hawaiian hoary bats select roost trees with a height of 14 to 26 meters, diameter at breast height (DBH) of 32 to 268 centimeters, canopy cover of 4 to 99 percent (Montoya-Aiona et al. 2023), and a mean distance of 29 meters from the forest edge (Montoya-Aiona 2020). These results suggest that structure, not species, is the deciding factor determining use by Hawaiian hoary bats. Montoya-Aiona et al. (2023) found that the top model for predicting tree use was tree height and DBH, but only when tall, larger trees had a relatively open canopy and were situated close to the forest edge. Other studies have found that a varied vegetative structure provides shelter for insect species that are the prey for Hawaiian hoary bats, and Hawaiian hoary bats preferred edge habitat for foraging (H.T. Harvey 2020). In addition, monotypic habitats—like stands of strawberry guava (*Psidium cattleyanum*) are associated with reduced bat foraging quality (Williams et al. 2006).

3.0 Mitigation Framework

As described in Section 1.0, the Project's Tier 1 bat mitigation plan will occur over eight years and is comprised of two elements: the Habitat Management Plan (this document) and the Research Plan (Tetra Tech 2025). The intention of the Habitat Management Plan is to improve habitat for Hawaiian hoary bat through control of invasive species, which will then facilitate the regrowth of a native forest community. That regrowth will generally be accomplished through natural recruitment, but will be supplemented by targeted outplanting, in order to shorten the period between treatment and restoration. Once the vegetation community is transitioned from a monoculture of invasive plant species to a more diverse native forest, the abundance of bat prey species can change quickly. The focus of this plan on treatment of invasive plant species and restoration of native forest, as a mechanism to improve Hawaiian hoary bay habitat, is based on this premise. The Habitat Management Plan monitoring is designed to 1) document the increases in bat acoustic activity within the management area and 2) document increases in availability of prey species associated with changes in the vegetation community achieved through habitat management. The associated Research Plan adds a control study to the Habitat Management monitoring program to increase understanding of how and when the management efforts yield benefits (Tetra Tech 2025). These two elements work in tandem to achieve and document direct benefits to the Hawaiian hoary bat over an eight-year period and to gather additional detail on the

mechanism for those benefits that should help guide the effective allocation of future management resources.

Based on input from U.S. Fish and Wildlife Service (USFWS) and Hawai'i Department of Land and Natural Resources (DLNR) - Division of Forestry and Wildlife (DOFAW) during the development of the HCP, this blended approach is focused primarily on habitat management actions; however, given the novel threats and condition of the PMA, both agencies and the ESRC reinforced the importance of developing a more robust understanding of the effects of these actions than would be achieved through standard evaluative monitoring. This Habitat Management Plan specifically evaluates whether actions to protect and restore habitat and bat prey resources increase acoustic activity (i.e., detection rate) by the Hawaiian hoary bats through an evaluative monitoring program. Increases in acoustic activity may be demonstrated through a variety of lenses such as detecting changes in vocalizations that signify changes in foraging and roosting activity from the baseline. Teixeria et al. (2019) suggests that vocalizations can serve as indicators of behavioral states and contexts that provide insight into populations as it relates to their conservation. Leveraging this observation, the evaluative monitoring plan (Section 9.0) includes evaluation of the types, duration, temporal patterns, and seaonality of calls to reveal changes in these patterns, reflecting changes in the way bats use the PMA over time.

Overall the management and monitoring activities described in this Habitat Managment Plan are expected to complement management and monitoring activities already occurring in the PMA by other entities (see Section 4.3 for more information on other entities activities in the PMA). Mitigation credit will be allocated for management and monitoring activities implemented by NPMPP and all attempts have been made to draw a distinction between NPMPP-activities and those being completed by others. The NPMPP Mitigation Area was delineated based on the identification of future management areas and needs by KMWP and DOFAW. In most cases this separation is demonstrated spatially (Figure 3). In other words, the management and monitoring activities are simply occuring in different locations than those implemented by others. In some cases management activities may overlap spatially, but will employ different management strategies or be targeted towards different resources. Those could include retreatment of areas where new invasions are detected, treatment of other invasive species that were not the focus of previous treatments, or outplanting of native species to avoid establishment of invasive species in the future. This would include outplanting of trees that would create Hawaiian hoary bat habitat over time. Management priorities will be driven by the priorities in any given year, as determined by the PMA mangement partners, but will always be focused on improvements that will benefit Hawaiian hoary bat.

The PMA was selected for several reasons, but the primary reason was so that NPMPP could provide supplemental funding support to the DOFAW and other agencies in order to implement management and monitoring activities that would benefit Hawaiian hoary bat and other native species. Although the DLNR had funding to support the fencing of the area, the DLNR did not have secure funding for long-term forest restoration and management of this parcel including maintenance of the fence constructed by DLNR, on-going feral pig management, if required, and

invasive plant species management; thus, the need exists for secure funds to ensure protection and recovery of bat habitat. Conducting mitigation for Hawaiian hoary bat in the PMA was also agreed to by the USFWS and DOFAW and memorialized in the HCP.

4.0 Poamoho Management Area

The PMA and adjacent ‘Ewa Forest Reserve is primarily DLNR-owned forested habitat extending through mid-elevation habitat to the leeward summit of the central Koʻolau Mountains[2]. The PMA is located above Wahiawa in the ‘Ewa Forest Reserve (Figure 1) and is proposed to be part of the state Natural Area Reserve System. Native, mid-elevation (490 – 730 meters above sea level) forest occurs in the PMA, but habitat-altering invasive plant species are present over significant areas, and prior to fence construction, feral pigs were a significant problem and remain a threat (Figure 2; Tetra Tech 2016). Pigs alter habitat, spread invasive species, and continue to degrade forest in unfenced portions of the ‘Ewa Forest Reserve. Ungulate-proof fencing has been installed on two parcels, one 654 acres and the other 653 acres, for a total of 1,307 acres. DLNR is responsible for long-term management of the area and relies heavily on KMWP to support management of the area.

The ‘Ewa Forest Reserve provides habitat for the Hawaiian hoary bat and use of the area and the vicinity has been documented (Tetra Tech 2016, Davidson 2020, Thompson and Starcevich 2022). The protected PMA includes key Koʻolau Mountains watersheds and key native forest habitat that affords native plants and animals opportunities for protection through active management.

4.1 Baseline Hawaiian hoary bat activity

The results from an island-wide acoustic monitoring research project suggests a generally low occupancy rate at the upper elevation of the PMA (average 0.0164 detections/detector-night June 2017 – October 2021) with detections concentrated in the lactation (mid-June – August) and post-lactation (September – mid-December) seasons (Site-046 in Thompson and Starcevich 2022). Another nearby site at a lower elevation (Site-055) included a higher activity rate (0.0398 detections/detector night) and showed a similar temporal distribution of activity (Thompson and Starcevich 2022). Results from the detectors distributed more broadly within the Koʻolau Mountains suggest that bats are likely present at low levels throughout the year with the lowest occupancy rates occurring during the pregnancy season (April – mid-June). Though no specific data has been collected on bat use in the PMA, these other survey efforts give a reasonable indication of what can be expected in the PMA. Since little is known about bat activity in the PMA, much less the Management Focus Areas (MFAs), baseline activity for the purposes of evaluating mitigation success criteria and triggering adaptive management will be based on Year 1 results from monitoring associated with this Habitat Management Plan (Section 8.0).

[2] The northern fencing unit of the PMA includes 70 acres on Kamehameha Schools’ property within the Kawailoa-Poamoho Training Area.

4.2 Threat assessment

Invasive plants, plant pathogens, and feral pigs all present threats that could impact bats by degrading foraging and roosting habitat. An overview of the current condition of the PMA and the mechanism for how these threats can impact bat foraging and roosting habitat are described below.

4.2.1 Invasive plants

Invasive plants are a serious threat to the ecosystems of Hawai'i due to their capacity to displace native species and disrupt natural cycles that produce freshwater for the island (Loope 1998). The establishment of invasive plants can result in higher rates of erosion, increased sedimentation in streams, and decreased recharge, especially when monotypic vegetation stands are formed (e.g., Kaua'i Invasive Species Committee 2015, Kaiser et al. 2019).

Thirty established invasive plant species have been identified throughout the PMA (Table 1) during recent surveys conducted by KMWP. The five species in Table 1 with an "X" in the Focal Management Column will be the focus of control efforts because each of these species are becoming well-established in the PMA and have the potential to significantly affect habitat quality and diversity if not aggressively managed. The mule's foot fern (*Angiopteris evecta*) is the most prevalent priority weed species in Poamoho (Figure 2). Strawberry guava has also become well established, particularly in the northern section of the management area and in several clusters throughout the eastern and southern portions of the management area (Figure 2). Additionally, patches of manuka (*Leptospermum scoparium*) have become established along the northern border of the PMA along with incipient populations of Moluccan albizia (*Falcataria falcata*) and cane tibouchina (*Chaetogastra herbacea*; Figure 2). Manuka is also a fire prone species, that may present additional risks to native forests if allowed to persist. The remaining twenty-five invasive plant species in Table 1 will be monitored and adaptively managed during implementation of this Habitat Management Plan if they increase in extent and density so that they begin to affect habitat quality and diversity.

The invasive plant species in Table 1 can be aggressive invaders forming dense stands that enable them to outcompete native species for light and soil nutrients, leading to a reduction in the biodiversity of native plant species. (Funk 1987, Wilson 1996, Hughes and Denslow 2005, Allison et al. 2006, Christenhusz and Toivonen 2008, Atwood et al. 2010, Global Invasive Species Database 2020a, Global Invasive Species Database 2020b). Together, competition from these invasive species pose a major threat to the recruitment of many native plant species including 'ōhi'a (*Metrosideros polymorpha*), a keystone species and important roost tree for bats, as well as lama (*Diospyros sandwicensis*), uluhe (*Dicranopteris linearis*), and uluhe lau nui (*Diplopterygium pinnatum*), which are also used by Hawaiian hoary bats for roosting (Montoya-Aiona et al. 2023).

There also is significant potential for new habitat altering invasive species to become established in the PMA in the absence of active management. Incipient invasions that are not identified early and spread unchecked can present significant management challenges for years to come.

Table 1. Focal Management Species and Control Method for Established Invasive Plant Species in the Poamoho Management Area

Scientific Name	Common Name	Method[1]	Herbicide[2]	Focal Management Species
Andropogon virginicus	broomsedge	Foliar	2% GLY in H_2O	
Angiopteris evecta	mule's foot fern	IPA	10 mls of 100% Polaris applied to multiple cuts on "brain"	X
Ardisia elliptica	shoebutton ardisia	IPA	100% Polaris	
Ardisia crenata	Hilo holly	IPA	100% GLY	
Arthrostemma ciliatum	Arthrostemma	Foliar	2% GLY in H_2O	
Buddleja asiatica	Asian butterfly bush	IPA	100% Polaris	
Casuarina equisetifolia	ironwood	Girdle	20% G4, 80% MSO	
Cecropia obtusifolia	trumpet tree	IPA	100% Polaris	
Citharexylum caudatum	juniper berry	Cut stump	30% G4, 70% MSO	
Grevillea robusta	silky oak	IPA	100% Polaris	
Hedychium gardnerianum	Himalayan ginger	Cut	0.2% Escort, 0.5% Crop oil, 96.5% water, 3% MSO	
Heliocarpus americanus	white moho	IPA	100% Polaris	
Lantana camara	Lantana	Cut stump	20% G4, 80% MSO	
Leptospermum scoparium	manuka	Cut	Cut-Stump	X
Melaleuca quinquenervia	paperbark tree	IPA	30% Polaris in H_2O	
Falcataria falcata	Mollucan albizia	IPA	100% AMP	X
Passiflora laurifolia	Jamaican honeysuckle	Cut stump	20% G4, 80% MSO (cut stump)	
		Foliar	2% GLY (foliar)	
Cenchrus setaceus	fountain grass	Foliar	3% GLY in H_2O	
Pluchea carolinensis	sourbush	Basal bark	20% G4, 80% MSO	
Psidium cattleyanum	strawberry guava	IPA	30% G4 with 1% Milestone	X
Psidium guajava	common guava	IPA	30% G4 with 1% Milestone	
Rubus rosifolius	Himalayan blackberry	Basal bark	20% G4, 80% MSO	
Heptapleurum actinophyllum	umbrella tree	IPA	100% GLY or 100% Polaris	
Schinus terebinthifolia	Christmas berry/Brazilian pepper	IPA	100% Polaris	

Scientific Name	Common Name	Method[1]	Herbicide[2]	Focal Management Species
Setaria palmifolia	palmgrass	Foliar	2% GLY in H_2O	
Spathodea campanulata	African tulip tree	IPA	100% Polaris	
Sphaeropteris cooperi	Australian tree fern	Cut	Cut-stump	
Toona ciliata	Australian red cedar	IPA	100% Polaris	
Chaetogastra herbacea	cane tibouchina	Clip and drip	20% G4, 80% MSO	X
Trema orientale	gunpowder tree	IPA or foliar	100% Polaris (adult)	
			2% GLY in H_2O (saplings)	

[1] IPA = incision point application.

[2] GLY = glyphosate; G4 = Garlon 4; MSO = methylated seed oil surfactant.

4.2.2 Feral ungulates

Pigs are currently the only feral ungulates occupying habitat in the vicinity of the PMA. They have been eradicated from the PMA since 2018; however, periodic damage to the existing ungulate fence creates opportunities for feral pigs to enter the PMA and damage habitat. Therefore, regular fence inspections and maintenance are critical to protecting this area. Feral pigs are one of the most destructive invasive species on islands as their behaviors can have impacts across all levels of an ecosystem and are considered to be one of the primary threats to remnant native wet forests (Cole and Litton 2014).

Feral pigs affect native ecosystems directly through herbivory, rooting and trampling. A single feral pig is capable of disturbing up to 200 meters^2/day of forest soil surface (Anderson and Stone 1993). These foraging behaviors substantially increase the area of exposed soil and subsequent soil erosion (Anderson and Stone 1993, Siemann et al. 2009, Cole et al. 2012), facilitate the invasion of non-native plants species, and create sites suitable for vectors of avian disease (Stone and Loope 1987). Furthermore, feral pigs can increase exposure and transmission of rapid ʻōhiʻa death (ROD; Mortenson et al. 2016).

Disturbance from feral pigs strongly suppresses establishment of many native Hawaiian species (Cole and Litton 2014) and can result in long-term consequences for plant regeneration (Lipscomb 1989; Mitchell et al. 2007; Webber et al. 2010), forest structure (Busby et al. 2010; Cole et al. 2012), and ecosystem biogeochemistry (Siemann et al. 2009). Controlling feral pigs through active removal and fencing is therefore considered a critical first step for conserving and restoring native rain forests. Recovery of commonly occurring species can occur relatively quickly (within 6.5 years) following the removal of feral pigs; however, recovery of species of conservation interest can take much longer to recover, in some cases more than 18 years without management (Cole and Litton 2014). The exclusion of feral pigs has been shown to reduce the prevalence and spread of *Ceratocystis*; the pathogen responsible for causing ROD (Fortini et al. 2019). According to Cole and

Litton (2014) feral pig removal is the first and most crucial step for conservation of native forests in Hawaii, but subsequent management should also include control of non-native invasive plants and outplanting native species of conservation interest that fail to recruit naturally.

4.3 Previous and Ongoing Management

There are ongoing efforts to address invasive plant species in the PMA by DOFAW NEPM, OISC, and KMWP (e.g. PMA parternering agencies, see Figure 3). Those entities have previously focused on higher elevation areas within the PMA to benefit the watershed function. These management activities have collectively covered just over 200 acres of the Poamoho Management Area, leaving just under 1,100 acres available for future management. This includes forest restoration specifically designed to benefit the Hawaiian hoary bat. These restoration efforts are anticipated to be targeted to lower elevation areas and riparian corridors where bat roosting and foraging habitat is more likley to occur.

5.0 NPMPP Mitigation Area

As noted in the HCP, DLNR identified a need to obtain secure funding for the long-term management and maintenance of the PMA parcels including funding for invasive species removal, outplanting, and fence repair (as needed) to ensure successful forest restoration in the PMA. Funding provided by NPMPP for that work will generally be focused in areas where previous treatments have not occurred in order to supplement past work and demonstrate discrete mitigation actions that can be attributed to the Project. As shown in Section 13.0 roughly 75 percent of proposed funding will be used for management activities (invasive plant control and outplanting) and 25 percent will be used for monitoring activities over the course of the eight-year management period. Those percentages will shift year-to-year, depending on the annual workplan and the amount of monitoring occurring in any given year.

Figure 3 shows the areas that have been managed by partner agencies. The NPMPP Mitigation Area includes all other areas within the PMA that have not been previously managed, with an emphasis on areas that meet the criteria in Section 5.1. Management activities will not occur evenly across the NPMPP Mitigation Area for a variety of reasons. First, much of the NPMPP Mitigation Area does not need management currently, because there are no documented occurrences of invasive plant species. However, without treatment of invasive plants in locations where they do exist, habitat quality in the remainder of the NPMPP Mitigation Area will degrade over time and become less suitable for native species, including Hawaiian hoary bat. Second, accessibility is an issue in this area and nearly all access must be by helicopter, so the location of landing zones is relevant when considering where work can occur (Figure 3). Finally, some resource issues need to be prioritized over others, either on an annual basis, or as issues arise, highlighting the need for annual planning with partnering agencies (see Section 7.2).

As a result, NPMPP will establish MFAs where work will primarily occur, although changes in management focus may vary year-to-year based on needs, as described above, and through

coordination with partners. For planning purposes MFAs have been generally described here and are shown in Figure 3, but more focused annual planning will occur during implementation.

5.1 Management Focus Area Selection

As described above, there are multiple agencies implementing management activities in the PMA. In order to demonstrate that there is no overlap in management activities and to focus where NPMPP-funded activities will occur, NPMPP has defined the criteria for how MFAs will be selected in this Plan. The MFAs include locations where NPMPP will be conducting management activities intended to increase Hawaiian hoary bat habitat quality, and by extension the Hawaiian hoary bat population. MFAs will be determined on an annual basis through coordination with the management partners at KMWP and DOFAW. The criteria used to determine MFAs will include a combination of biotic and abiotic factors along with logistical factors that will influence management and monitoring activities, all of which result in targeting areas that will have the most benefit for bats.

The following criteria will be used to determine where MFAs are located:

Elevation – the full complement of elevations is present within the NPMPP Mitigation Area, however, where possible, management activities will be targeting lower elevation locations. The intent of this approach is to manage and enhance not just Hawaiian hoary bat foraging habitat, but to also potentially enhance or establish roosting habitat. This is more likely to occur at lower elevations than at higher elevations. Also, lower elevation locations are likely to be more accessible and have more shallow slopes, allowing for more thorough management and repeat management visits, if needed, throughout the year.

Stream Corridors – this coincides with elevation, since the larger streams are generally at lower elevations. Bats use stream corridors as foraging flyways and therefore enhancement along stream corridors that will result in an increase in bat prey species, will inherently benefit bats. MFAs will be preferentially sited along the major waterways shown in Figure 3 in locations that meet one or more of the following criteria.

Locations Suitable for Outplanting – large areas of monoculture stands that could be treated and then outplanted with native vegetation, including trees suitable for foraging and roosting bat habitat.

Slope and Accessibility – the PMA is generally accessible by helicopter, road, trail, and on foot, but the majority of the PMA is less accessible, especially during rainy periods. Management and monitoring activities require consistent and repeat visits throughout the year, so site accessibility is always a consideration when determining where to deploy management activities. MFAs will be located in areas that are within a two-hour overland (off-trail) walk from an existing helicopter landing zone. Existing landing zones are shown in Figure 3. Navigation of the difficult topography is easier along the fence line, so many of the MFAs will also be located along or near fence lines. Slope is a consideration for the same reason. An area may be accessible, but portions of the PMA have steep slopes, which will

limit the ability to deploy management practices, including treatment of invasive plant species and/or outplanting.

Avoiding Overlap With Existing Management Locations – in many locations within the PMA partnering agencies are engaged in management activities. This is primarily focused on invasive plant management and reestablishing native vegetation following the removal of ungulates. All attempts will be made to avoid locations where management activities are ongoing. This will be done so that the NPMPP-funded activities can remain distinct from those activities that are already occurring, and so that NPMPP-funded activities can more fully complement work that is already occurring, allowing for the most complete management footprint within the PMA.

Adjacency to Existing Management Locations – where possible, attempts will be made to identify locations for NPMPP management activities that complement existing and ongoing management activities spatially, meaning that if physically feasible and if there were expected benefits to Hawaiian hoary bat, management activities will be completed in locations that "fill in gaps" in existing management activities. This is particularly true in locations that are either upslope or downslope from existing management areas. This will create a more cohesive management landscape across the PMA and expand benefits for native species, including Hawaiian hoary bat.

Protection of ʻŌhiʻa – It is not possible to discern from existing desktop data where stands of ʻōhiʻa may be located. Stands of ʻŌhiʻa, which could provide Hawaiian hoary bat roosting habitat, will be identified as part of management and monitoring site selection, and during baseline data collection in Year 1. Management activities can then be focused on locations where invasive species, feral ungulates, or plant pathogens threaten to impact this species.

5.2 Management Focus Area 1

Management Focus Area 1 includes locations along the Poamoho Tributary, just inside the ungulate fence, between the fence and the Island LZ (Figure 3). This area is downstream of locations where cane tibouchina has been treated in the past by OISC and KMWP. This location is advantageous because it is accessible and would complete work that has already begun to eradicate cane tibouchina from the northernmost part of Poamoho. This MFA is also at a lower elevation than the areas previously treated and is in a location more likely to support bat habitat in the future, following management activities.

5.3 Management Focus Area 2

Management Focus Area 2 includes locations along the Kaukonahua North Tributary 1, along the stream between The Palms LZ upstream to the locations where DOFAW NEPM aerial spraying has occurred in the past (Figure 3). This includes the confluence of Kaukonahua North Tributary 1 and Kaukonahua North Tributary 2, where KMWP has completed management activities in the past. Management in these areas will supplement work that has been completed by KMWP and take advantage of being downstream of aerial treatment locations by DOFAW NEPM. This general area is

also accessible from the Lower Poamoho LZ and Poamoho Clermontia LZ (Figure 3). This MFA is also at a lower elevation than the areas previously treated and is in a location more likely to support bat habitat in the future, following management activities.

5.4 Management Focus Area 3

Management Focus Area 3 includes locations along the Kaukonahua North Tributary 2, between the confluence of Kaukonahua North Tributary 1 and Kaukonahua North Tributary 2 (Figure 3). This section of the tributary is located just north of the South Line Camp LZ and The Zoo LZ. The MFA is located just downstream of an area of intensive management by KMWP and DOFAW NEPM. The focus of those management efforts were to address invasive plant infestations in the upper watershed so that seeds would not be dispersed downstream into the rest of the watershed and through the PMA. Management in this MFA would continue efforts to address infestations along this tributary to build upon the previous efforts. This MFA is also at a lower elevation than the areas previously treated and is in a location more likely to support bat habitat in the future, following management activities. There may also be opportunities to complete some outplanting of native trees and other species along this tributary in order to further control invasive plant species and create more diverse habitats that will in turn support more diverse bat prey species.

5.5 Management Focus Area 4

Management Focus Area 4 includes locations along the Kaukonahua North Tributary 3, between the fence line and the confluence with Kaukonahua North Tributary 4 (Figure 3). This section of the tributary will be accessed either from the South Line Camp LZ, the Lower Kaukonahua LZ, or the Schofield-Waikane Trail LZ. The MFA is located in an area where KMWP has started to complete management activities and DOFAW NEPM has completed some targeted spraying. Management in this MFA would continue efforts to address infestations along this tributary to build upon the previous efforts. This MFA is at the lowest elevation of all of the MFAs so will have the best opportunity to support bat habitat. There may also be opportunities to complete some outplanting of native trees and other species along this tributary, particularly in some of the previously managed areas near the Lower Kaukonahua LZ, in order to further control invasive plant species and create more diverse habitats that will in turn support more diverse bat prey species.

6.0 Biological Goals and Objectives

The purpose of identifying biological goals and objectives is to establish a framework for developing the mitigation actions and success criteria for this Habitat Management Plan. Biological goals are intended to be broad, guiding principles that clarify purpose and direction. Biological objectives are derived from the goals and provide the basis for determining strategies, monitoring effectiveness, and evaluating the success of actions. The Habitat Management Plan's success criteria (Section 11.0) are then derived from these objectives. Interim time-based metrics are integrated into an adaptive management strategy (Section 12.0); if the interim metrics are met, the mitigation

plan will be on track for meeting the biological goals and objectives. The biological goals and objectives for this Habitat Management Plan are shown in Table 2.

Table 2. Biological Goals and Objectives

Biological Goal: Fully offset the incidental take of 34 Hawaiian hoary bats required for Tier 1 mitigation and provide a net benefit to the species.	
Biological Objective	Enhance, manage, and protect Hawaiian hoary bat foraging and roosting habitat within the PMA in locations where Poamoho Management Partners have not worked in the recent past (see Success Criteria 1 and 2; Section 11.0)
Biological Objective	Document changes in bat prey availability following management (See Success Criteria 4; Section 11.0)
Biological Objective	Demonstrate an increase in bat activity indicative of resource improvement and availability for bats at MFAs. (See Success Criteria 5; Section 11.0)
Biological Goal: Restore structural diversity and prevent further deterioration of Hawaiian hoary bat foraging habitat in the Poamoho Management Area	
Biological Objective	Increase the total area of quality habitat for Hawaiian hoary bat by restoring at least 30 acres but not more than 100 acres of foraging and roosting habitat, through outplantings within the Poamoho Management Area (see Success Criteria 1 and 2; Section 11.0).
Biological Objective	Manage and monitor focal invasive plant species within the NPMPP Mitigation Area for 8 years (see Success Criteria 2; Section 11.0).
Biological Goal: Reduce invasive plant species cover to significantly increase bat prey availability in the Poamoho Management Area for the Hawaiian hoary bat	
Biological Objective	Increase the diversity of native plants within the NPMPP Mitigation Area by Year 8 by reducing invasive plant species (see Success Criteria 1 and 2; Section 11.0).
Biological Objective	Support management partners with the continued eradication of feral ungulates in the NPMPP Mitigation Area for 8 years, if the need arises.
Biological Objective	Monitor bat prey availability in Years 1, 3, 5 ,and 8 and adaptively manage in Years 5 and 8 (if needed).
Biological Goal: Increase native biological diversity to significantly increase Hawaiian hoary bat activity in the Poamoho Management Area	
Biological Objective	Increase native plant recruitment to enhance Hawaiian hoary bat habitat in the NPMPP Mitigation Area by Year 8.
Biological Objective	Monitor bat acoustic activity between sunset and sunrise in Years 1, 3, 5 ,and 8 and adaptively manage in Years 5 and 8 (if needed).

The biological objectives in Table 2 are centered around 1) establishing management and monitoring activities in MFAs within the NPMPP Mitigation Area and, 2) tracking changes in bat

acoustic activity and insect prey as surrogates for the direct number of bats identified in the biological goal.

7.0 Management Program

This section describes the management actions associated with the Habitat Management Plan, the results of which are monitored through the monitoring program (Section 8.0) and measured against the success criteria (Section 11.0).

Management activities include:

- Invasive vegetation management program
    - Management of priority invasive weed species
    - Surveillance and rapid response program to identify and respond to priority incipient invasive species
- Outplantings of at least 30 acres, but no more than 100 acres of trees, to create bat foraging and roosting habitat
- Fence repair on an as needed basis when the need is detected by management partners (feral ungulates have been removed from the PMA but threaten incursion into the PMA if fences are damaged).

7.1 Threat management

This Habitat Management Plan identifies habitat management actions to improve the forest structure and composition of the PMA as a foraging and roosting habitat for the only native bat species in the state. ʻŌhiʻa is the primary native roost tree for Hawaiian hoary bats (Montoya-Aiona et al. 2023) and the dominant canopy tree in the PMA. As such, the loss of this keystone species could result in a cascade of ecological effects. Invasive plants, feral ungulates, and plant pathogens have previously been identified as the major threats to the watershed (KMWP 2002, 2016).

The management actions identified to control the major threats to the PMA and improve and protect the habitat for bats are described below. Together these management strategies aim to protect the existing native canopy species while facilitating the recruitment of native understory species.

7.1.1 Invasive vegetation

Thirty established invasive plants species are currently found within the PMA and identified as target species for control by KMWP (Table 1). KMWP has identified mule's foot fern, strawberry guava, manuka, Moluccan albizia, and cane tibouchina as the highest priority target invasive species in the PMA for management due to their level of establishment or their identified risk for causing significant habitat alteration if their spread is left unchecked.

Mule's foot fern is widespread throughout both the northern and southern management areas, whereas strawberry guava is most prevalent along the northern boundary of the northern

management section and in several patches within the southern. Mule's foot fern and strawberry guava have had the most widespread effects, significantly reduced the diversity of native plant species where they are found, resulting in monotypic habitats.

Manuka, Moluccan albizia, and cane tibouchina are not as abundant as mule's foot fern and strawberry guava, but if left untreated, these invasive species will be increasingly difficult to control and have a broader impact on forest plant diversity. The establishment of these species pose a serious threat to the watershed as they can drastically alter the forest structure by outcompeting native plant species for light and nutrients and change soil and aquatic community composition (Hughes and Denslow 2005, Allison et al. 2006, Atwood et al. 2010, Global Invasive Species Database 2020a, Global Invasive Species Database 2020b).

Management actions that increase the plant and structural diversity of a habitat can be beneficial for bat species as monotypic habitats can precipitate a decrease in foraging quality (Fenton 1997, Williams et al. 2006, Taki et al. 2010). The objective of the management goals and actions below are to restore structural diversity of habitat and prevent further deterioration in the NPMPP Mitigation Area over the next eight years. Invasive plant management will occur in locations that will benefit Hawaiian hoary bat. Those areas were selected based on criteria shown in Section 5.1.

Invasive Plant Species Management Goals and Actions

NPMPP will place primary focus on managing species identified as posing a significant risk for causing habitat alteration through the creation of monotypic stands, as these are most likely to have negative impacts to bat foraging and roosting habitat. KMWP has accumulated a significant geospatial dataset that documents invasive species occurrence within the PMA (Figure 2). Supplemental funding in Year 1 (baseline) and Year 5 (mid-point), and Year 8 (end-point) of the Habitat Management Plan will be used to provide periodic mapping updates of invasive species using sUAS platforms (drones) and other aerial imagery analysis techniques. This location information as supplemented by data collected during field deployments will be used to inform management priorities allowing for targeted invasive vegetation control measures. Goals and associated actions are:

- Statistically significant reduction in target invasive weed species cover within the monitoring plots which indicates that the reduction is not explainable by chance alone (and it can be inferred that it is due to the management actions)[3].
    - Field crews will be deployed at least monthly to manage invasive vegetation within the MFAs. Due to the remote location and regular use of helicopter for deployment, KMWP has found deployment of field crews of three staff to be the most effective use of resources. Three crew is typically max payload for one helicopter flight.
        - Primary target species will be mule's foot fern and cane tibouchina, with a secondary focus on strawberry guava, manuka, and Moluccan albizia. If

[3] A description of how a statistically significant reduction will be measured is provided in Section 8.0 Evaluative monitoring.

other species are identified as a pervasive threat management efforts can be shifted through coordination with KMWP.

- Control methods will vary and will leverage new management techniques as they become available. Approaches are described in Table 1.

- Implement surveillance and response protocols, based on the control methods shown in Table 1, to monitor for and remove priority incipient invasive species as soon as possible following discovery.
    - Field crews are well-trained and knowledgeable with respect to invasive species. During each field visit and at any time when staff are traversing access trails and fence lines, field crews will monitor for the arrival of incipient invasive plant species. The timeline for removal/treatment will vary greatly depending on 1) species; 2) what time of year it is documented (e.g., weather can make access more difficult/unsafe and treatments less effective); and 3) based on #1 and #2, when is the most effective treatment time (e.g., typically before flowering and fruiting but some species can be treated year-round)
- Avoid the spread of invasive plant species to the NPMPP Mitigation Area or to other managed sites within the PMA.
    - Field crews will implement avoidance and minimization measures to avoid transport of invasive species seeds to the NPMPP Mitigation Area or to other managed sites within the PMA, which includes cleaning mud/soil off shoes, gear, and clothing(see Section 7.3).

7.1.2 Outplanting of Trees to Create Habitat

In addition to managing invasive plant species in, particularly in locations where stands of ʻōhiʻa are in danger of being impacted, NPMPP will also seek opportunities to complete outplanting of trees in order to create more forest structure, and by extension, bat foraging and roosting habitat. Ōhiʻa would be the primary tree species outplanted and complemented with plantings of other native tree species of varying stature, which could include māmaki (*Pipturus albidus*), kōpiko (*Psychotria mariniana*), and hame (*Antidesma platyphyllum*). Species selection would be site-specific based on slope, aspect, substrate conditions, propagule availability, and existing native species composition and vegetation structure in the immediate vicinity. Outplantings will be completed in targeted locations within MFAs that have the appropriate slope and accessibility for planting where either NPMPP or management partners have completed invasive plant management that remove dense stands of invasive vegetation, leaving an opening vulnerable to a new infestation of invasive plants that are also in locations where bats are most likely to forage or roost. This includes locations along waterways and in areas that, due to topography, provide natural foraging corridors and protection from high winds. Once invasive plant management is generally successful, overplanting of tree species will benefit the area long-term and reduce the potential for invasive plants to reestablish. Some ongoing invasive plant management will be needed while outplanted species establish, but over time the cost of invasive management should be reduced in those locations. These locations will be determined through coordination with management partners.

By establishing tree cover and vertical structure in locations where it previously did not exist, NPMPP will be creating habitat for use by foraging bats and could be used by roosting bats, if located in the lower elevation portions of the NPMPP Mitigation Area. As such, the locations where outplantings will be done will include those that are previously treated and at lower elevations. Ideally these would be in locations that do not have substantial infestations of invasive plant species upslope, to minimize long term impacts and related management needs in the newly established forested areas. Outplantings will occur along stream corridors in order to increase the abundance and diversity of prey species for foraging bats. Outplanting stock will be selected based on identified areas requiring supplemental planting and sourced from suitable seed collection zones using protocols established in consultation with KMWP, DOFAW Oʻahu Branch, and DOFAW and USFWS HCP staff to ensure the plant stock is appropriate for planting in the area.

Outplanting Management Goals and Actions

- Coordinate with management partners and other entities (e.g., DOFAW) to either secure native seedlings or establish a process to source native seeds and propagate native plants.
- Identify locations where previous management has resulted in the removal of sections of monoculture invasive plants, but no substantially woody/tree species have reestablished.
- Delineate outplanting areas, so that the area is known, and plant native plants at a diversity and density that is similar to native-dominant stands in the PMA or on adjacent lands.
- Monitor survival in years following planting and provide supplemental planting in locations where plant survival falls below success criteria in Section 11.0.

7.2 Roles and Responsibilities

The division of responsibilities shown in Table 3 is based on communication with NPMPP that they will contract with KMWP through the University of Hawaiʻi at Mānoa, Pacific Cooperative Studies Unit (PCSU), to conduct fieldwork with oversight from Tetra Tech. Implementation of management activities will be a dynamic process and will require ongoing communication among all management partners. The frequency of communication will be higher during periods of management activity and will otherwise rely on pre-determined check in meetings. During times of field activities coordination calls will likely occur weekly. Attempts will be made to deploy management and monitoring crews simultaneously in order to manage safety and cost, and to minimize disturbance of the landscape, particularly since most visits will be via helicopter. When field activities are not occurring, coordination meetings will likely be relaxed to bi-weekly or monthly, depending on near-term needs.

NPMPP and the other PMA management partners will collectively work on establishing management and monitoring locations. A set of standard operating procedures will be established regarding vendor selection, best management practices, site access, sanitation protocols, and any other items where a shared understanding or common practices would be beneficial. NPMPP and other PMA management partners will work each year to outline an annual work plan for the NPMPP Mitigation Area. The annual work plan will outline management actions and monitoring activities that will be completed in a 12 consecutive month period, with the funding that is

available. The allocation of NPMPP funding will be clearly articulated so that it can be included in the HCP annual report.

Table 3. Anticipated Responsibilities by Entity

Tetra Tech	KMWP	NPMPP
Implementation management	Responsible for all threat management actions	Coordination with Tetra Tech and KMWP
Lead initial monitoring plot establishment in Year 1	Responsible for all evaluative monitoring	Review annual reports
Lead initial acoustic detector and insect prey trap set up in Year 1	Initial monitoring plot establishment assistance in Year 1	Review of adaptive management actions, if needed
Training on implementation protocols	Assist with initial acoustic detectors and insect prey traps set up in Year 1	
Quarterly check-in site visits during Year 1 to ensure that implementation is proceeding as intended, perform troubleshooting as needed	Lead quarterly bat prey monitoring and yearly vegetation monitoring in Years 1, 3, 5, and 8	
Author annual report	Provide quarterly data summary for annual reporting	
Creation of annual workplan, each year	Creation of annual workplan, each year	Creation of annual workplan, each year
Provide desktop and field support as needed for adaptive management	Complete adaptive management responses	

7.3 Best Management Practices

Management staff will implement the best management practices below to prevent the introduction and spread of alien plants, animals, insects, and forest pathogens within the PMA. Risk will be minimized by regular and thorough cleaning of field gear between deployments and limiting deployments to smaller areas within the PMA. When moving between different parts of the PMA is required in a single deployment, especially if moving from heavily infested areas to more native areas, new field gear will be used to minimize the risk of spreading invasive species.

Footwear - Daily

- Spray down boots or tabis with hose removing excess mud and debris from tread, spikes, laces, and tongue as well as between the toes of tabis
- Scrub outside of boots or tabis with stiff brush to remove finer particles focusing on tread of boot and tabis as well as inner Velcro of tabis
- Spray boots or tabis again to rinse off last of debris as well as spray out inside of footwear
- Repeat if necessary if lingering mud or seeds remain
- Hang to dry and spray with 70 percent isopropyl alcohol

Field Tools - Daily

- Spray heads and body or handle of tools with hose to remove accumulated mud and plant material
- Scrub head until clean
- Spray down once more to rinse
- Hand tools and chainsaws shall be wiped down with 70 percent isopropyl alcohol. The chain shall be removed and soaked in 70 percent isopropyl alcohol for ten minutes.

Backpacks and Clothing – No schedule

- Remove everything from inside of backpack and any side pockets
- Hang from secure location and spray inside and outside of pack with hose making sure to spray out any tucks and folds in the backpack material
- Scrub areas with seams with stiff brush
- Spray with hose once more to rinse
- Clothes will be cleaned, washed, and dried in a dryer.

Trucks – Weekly (or when moving from heavily infested areas to less infested areas)

- Wash exterior of trucks with soap and water
- Spray undercarriage with high pressure hose to remove accumulation of mud and debris
- Remove any floor mats and wash with soap and water
- Vacuum out interior of trucks

More detailed best management practices to prevent the introduction and spread of alien plants, animals, insects, and forest pathogens within the PMA, can be found in Appendix A. These practices will be applied during management and monitoring activities. If best management practices are updated during the eight-year management period, the latest version will be adopted for use. Appendix A specifically includes Invasive Species Biosecurity Protocols from the Pacific Islands Fish and Wildlife Office and Decontamination Protocols for the Prevention of Invasive Species from OISC.

Outplanting efforts will follow standard best practices and phytosanitation protocols throughout the process, from seed collecting to propagation to outplanting, including testing for the invasive little fire ant (*Wasmannia auropunctata*) and as further guided in consultation with OISC. Specific best management practices, customized for planned activities, will be included in the annual work plans. Adherence to biosecurity protocols will be summarized in annual reports.

7.4 Permits and Authorizations

In order to complete the management actions outlined in this section all necessary permits will be obtained by NPMPP in coordination with KMWP and all authorizing agencies, including:

- Native Invertebrate Research Permit (DOFAW)
- Forest Reserve Special Use Permit (DOFAW)

8.0 Evaluative Monitoring

The monitoring plan is designed to monitor changes in vegetation, bat prey, and bat acoustic activity within the NPMPP Mitigation Area during the period of performance (8 years) and provide periodic (Years 1, 3, 5, and 8) measurable results. Monitoring of changes in bat prey species abundance is the primary metric for determining whether habitat has been improved for bat species. It is assumed that through the removal of monotypic stands of invasive species and restoring those areas to native forest it will increase the abundance of bat prey. By monitoring both, there may be potential to draw conclusions about how changes in the vegetation community results in changes in the bat prey community. Monitoring of bat activity, using acoustic detectors, will provide information on whether there are changes in patterns of how bats are using the areas that are being managed and monitored.

Monitoring results can be used to determine if success criteria have been met or provide information to suggest that adaptive management is required to increase the potential that measures of success will be met (Section 11.0). Baseline conditions will be based on monitoring during Year 1 of this Habitat Management Plan and from ongoing monitoring in locations where management actions are not occurring. Table 4 provides a description of activities anticipated to occur in each implementation year.

Table 4. Anticipated Project Implementation Timeline

Time Frame	Mitigation Year	Description of Actions
2025	Year 1	• Determine locations for invasive species management • Evaluation of locations where outplantings could occur • Baseline vegetation monitoring (April to June) • Baseline bat prey monitoring (quarterly) • Baseline bat acoustic activity monitoring (nightly) • Complete Baseline Report • Create annual workplan
2026	Year 2	• Implementation of invasive species management • Implementation of outplanting in areas previously treated by KMWP (e.g., treatment completion areas and seed availability) • Data analysis (3-month period immediately following conclusion of evaluative monitoring annual cycle) • Complete Annual Report • Create annual workplan
2027	Year 3	• Implementation of invasive species management • Implementation of outplanting as opportunities exist (e.g., treatment completion areas and seed availability) • Vegetation monitoring (April to June) • Bat prey monitoring (quarterly) • Bat acoustic activity monitoring (nightly) • Data analysis (3-month period immediately following conclusion of evaluative monitoring annual cycle) • Complete Annual Report • Create annual workplan
2028	Year 4	• Implementation of invasive species management • Implementation of outplanting as opportunities exist (e.g., treatment completion areas and seed availability) • Complete Annual Report • Create annual workplan
2029	Year 5	• Implementation of invasive species management • Implementation of outplanting as opportunities exist (e.g., treatment completion areas and seed availability) • Vegetation monitoring (April to June) • Bat prey monitoring (quarterly) • Bat acoustic activity monitoring (nightly) • Data analysis (3-month period immediately following conclusion of evaluative monitoring annual cycle) • Adaptive management (as needed, based on monitoring data) • Complete Annual Report • Create annual workplan

[1] NPMPP will add monitoring in Years 6 and 7 if Year 5 bat acoustic activity has not increased (see Section 12.0)
[2] If adaptive management is required additional monitoring will be added in Year 6 and possibly Year 7.

Time Frame	Mitigation Year	Description of Actions
2030	Year 6	• Implementation of invasive species management • Implementation of outplanting as opportunities exist (e.g., treatment completion areas and seed availability) • Vegetation bat prey, and bat acoustic activity monitoring (based on Year 5 results)[1] • Data analysis (3-month period immediately following conclusion of evaluative monitoring annual cycle)[2] • Adaptive management (continues as needed, based on Year 5 monitoring data) • Complete Annual Report • Create annual workplan
2031	Year 7	• Implementation of invasive species management • Implementation of outplanting as opportunities exist (e.g., treatment completion areas and seed availability) • Vegetation bat prey, and bat acoustic activity monitoring (based on Year 5 results)[1] • Data analysis (3-month period immediately following conclusion of evaluative monitoring annual cycle)[2] • Adaptive management (continues as needed, based on Year 5 monitoring data) • Complete Annual Report • Create annual workplan
2032	Year 8	• Implementation of invasive species management • Implementation of outplanting as opportunities exist (e.g., treatment completion areas and seed availability) • Vegetation monitoring (April to June) • Bat prey monitoring (quarterly) • Bat acoustic activity monitoring (nightly) • Data analysis (3-month period immediately following conclusion of evaluative monitoring annual cycle) • Complete Annual Report
2033	Post-Mitigation	• Complete Final Annual Report

[1] NPMPP will add monitoring in Years 6 and 7 if Year 5 bat acoustic activity has not increased (see Section 12.0)
[2] If adaptive management is required additional monitoring will be added in Year 6 and possibly Year 7.

8.1 Vegetation and bat prey monitoring

Bat prey and vegetation conditions will be tracked at 15 monitoring plots distributed semi-randomly in MFAs, considering logistical factors and capturing a range of initial conditions relative to level of establishment of target invasive species in the monitoring plots. The Planned Method below summarizes the monitoring framework that will be used to detect changes from three different baseline conditions.

8.1.1 Planned method

Fifteen monitoring plots will be established within the MFAs (Figure 4). Based on the monitoring activities that need to occur inside each plot (e.g. vegetation sampling, insect sampling, and bat acoustic monitoring, the plots are expected to be approximately 0.05-hectare (20-meter x 25 meter). During field siting of monitoring plots, all attempts will be made to minimize the size of the monitoring plots in order to reduce any human related impacts to the surrounding forest, since monitoring plots will be visited routinely over time. If smaller plots can be established while still accommodating all monitoring activities, then the smaller plot size will be used across all monitoring plots. Initial delineation of the monitoring plots will include the establishment of photo points at the plot's corners and the collection of baseline data including GPS location, invasive vegetation cover, slope, and elevation. Plots will be selected and categorized by the degree of invasive vegetation cover to evaluate its effect on arthropod abundance (Emery and Doran 2013). Five monitoring plots will contain no observed presence of mule's foot fern, strawberry guava, manuka, or Mollucan albizia (invasive species deemed likely to form large monotypic habitat altering stands), serving as an initial condition of "native forest." Another five monitoring plots will include areas where one of these invasive species are established but have not yet dominated the vegetation community, representing an initial condition of "established invasive species" (ground or canopy cover< 5 percent[2]). The last five plots will include areas where the selected invasive species is dominant within the vegetation community (ground or canopy cover > 30 percent[4]), serving as an initial condition of "invasive species dominated." The 10 plots that have invasive plants present will receive treatment similar to what is being implemented in MFAs, while the five plots that represent a "native forest" condition, will not. Plot locations meeting the habitat selection criteria above and safety and logistical requirements will be identified within randomly selected grid cells within the MFAs. These monitoring plots are intended to be indicative of changes in bat behavior and use across the NPMPP Mitigation Area. Logistics, including implementation of practices to avoid spreading invasive plant species within the PMA, will require grouping of monitoring plots into clusters to allow monitoring of 3 – 4 individual plots per day. To ensure independence, monitoring plot locations will be at least 200 meters apart.

Arthropod sampling will occur in the monitoring plots four times a year in each monitoring year (Years 1, 3, 5, and 8) (Table 4). Timing of quarterly sampling will be consistent across all sampling years and align with bat reproductive periods as defined by Gorresen et al. (2013): lactation (mid-June to August), post-lactation (September to mid-December), pre-pregnancy (mid-December to March), and pregnancy (April to mid-June). Vegetation sampling will occur once annually each

[4] Percentages are approximate values, subject to adjustment based on identification of ranges found within otherwise suitable monitoring plots. Choice of ground cover or canopy cover as measure of species dominance is dependent on species. For example, strawberry guava stands only come to dominate ground cover through leaf litter, and this is not common at the elevations associated with the PMA. In the vicinity of the PMA canopies dominated by strawberry guava often have associated understories dominated by Koster's curse (*Clidemia hirta*), a species deemed "beyond control" by management agencies. Mollucan albizia's dominance similarly exerts its influence at the canopy level, resulting in the transition of understory to bare earth or invasive groundcover species.

monitoring year in Years 1, 3, 5, and 8, during the peak blooming period for annual vegetation (April to June). Sampling will occur in the monitoring plots. Photos will be taken at the established photo points for each plot, and sampling will include:

- Vegetation
    - Invasive plant species absolute percent cover within plots
    - Plant species richness within plots
- Bat Prey Species
    - Biomass of bat prey species

8.1.2 Alternative method

Should the planned monitoring plot layout prove impractical in the field due to terrain (e.g., plot size/shape not allowing for safe and practicable collection of data on a regular basis) or vegetation density (e.g., dense patches of uluhe which could be damaged through the regular collection of monitoring data), monitoring plots will be modified to be linear transects. Ultimately, all plots will be of the same type (linear or rectangular), including control plots proposed in the Research Plan (Tetra Tech 2025). The decision on which approach to use will be based on a preliminary site visit upon the approval of the Habitat Management Plan and Research Plan.

The alternative linear transect plots would be 100 meters long and allow for the same sampling and data collection protocols. In this case, all work would be performed from a flagged central transect line and sampling would be limited to 2.5 meters on either side of the transect line (5-meter survey buffer). Five photo points would be established along the transect path at regular intervals: 0, 20, 40, 60, and 80 meters.

8.1.3 Vegetation monitoring

This section initially describes how the planned method would be used to monitor vegetation in the MFAs. A second section describes how that sampling approach would be adjusted if the alternative sampling plot approach is used.

8.1.3.1 Planned method

Monitoring plots will be subject to the same habitat management actions as the remainder of the habitat within the MFAs. This differentiates these evaluative monitoring plots from the control plots identified in the Research Plan (Tetra Tech 2025), which occur outside the PMA, will not be actively managed, and which are likely to be impacted by feral ungulates (Figure 5). To measure invasive plant species absolute percent cover, the relative area covered by each invasive species will be estimated in ten 1-meter^2 quadrats located around the boundary of each plot (approximately 9 meters apart; Figure 4). Bonham (2013) and KMWP staff were consulted to determine if the sampling design would be suitable for quantifying invasive species absolute percent cover. Given the relative abundance of mule's foot fern in the PMA and adjacent area, Tetra Tech determined that the sampling design would adequately differentiate and track changes in

amounts of invasive species cover over time. Invasive plant species absolute percent cover will be averaged for each of the individual 15 plots based on the species cover in each of the ten quadrats within each plot.

To measure plant species richness in each plot, all individual species (includes trees, shrubs, grasses, and ferns) will be counted in ten 1 meter^2 quadrats located around the boundary of each plot (same plots used to estimate invasive plant species absolute percent cover, above) (e.g., Keeley and Fotheringham 2005, Young and Johnstone 2011). Plant species richness values from each quadrat will be averaged for each of the 15 plots. A supplemental search will be conducted in each plot, following invasive plant species and plant species richness data collection, to identify any plant species that did not occur within the quadrats and will be added to species richness measurements for each plot. The supplemental search will be a 15-minute to one-hour effort providing meandering survey coverage over the remainder of the plot.[5] This will ensure a consistent level of effort among plots.

In addition to monitoring percent cover of invasive species in the monitoring plots, the total acres of invasive species treated within each MFA will be tracked and reported. This monitoring will be completed in coordination with management partners using a combination of ground-based and drone surveys when possible. Drone surveys are preferred in order to reduce physical impacts on the forest and allow for more survey coverage at lower cost.

8.1.3.2 Alternative method

Under the linear transect monitoring approach sampling quadrats would be positioned adjacent to, but outside, the foot trail forming the transect and located at: 5, 15, 25, 35, 45, 55, 65, 75, 85, and 95 meters from the transect starting point. Sampling outside of the quadrats for other plant species would occur within the 5-meter survey buffer along the 100-meter long transect. In all other respects, vegetation sampling protocols would match those described in section 8.1.3.1.

8.1.4 Bat prey monitoring

This section initially describes how the planned method would be used to monitor bat prey in the MFAs. A second section describes how that sampling approach would be adjusted if the alternative sampling plot approach is used.

8.1.4.1 Planned method

To assess the response of bat prey communities, specifically biomass, to the implementation of management actions, arthropod monitoring will be conducted using standardized collection methods. Biomass was chosen as the primary response variable due to its strong correlation with trophic interactions and its ability to provide insight into community structure dynamics (Saint-Germain et al. 2007).

[5] If no new species are added and coverage of the entire plot is complete within 15 minutes, the supplemental search will end. If new species are added, additional time will be added up to one hour or until the entire plot has been surveyed.

Arthropods will be sampled in each plot using Sea Land and Air Malaise (SLAM) traps equipped with a bottom collection net (Australian Entomological Supplies, South Murwillumbah, NSW, Australia). These traps passively capture flying insects, providing a representative sample of the aerial arthropod community. Insects captured in top and bottom collection vials will be preserved using non – toxic methods.

All flying insects with a body length of 3 mm or greater will be identified to the family level or the most specific taxonomic classification possible. The use of propylene glycol may limit fine-scale taxonomic identification, particularly for taxa such as Lepidoptera, whose scales are critical for species-level identification, therefore biomass will be the primary metric. And diversity will be included if and where possible. All specimens will be counted and measured to the nearest millimeter. To estimate biomass, the size measurements will be used in the weight-length regression equation determined by Gruner (2003):

$$y = a(x)b$$

Where y = dry biomass, x = size measurement, either length or length * width; a and b are coefficients individually chosen for each taxon.

Arthropod sampling will occur quarterly for a duration of one-month during the first year prior to the implementation of mitigation actions to establish a baseline level of biomass and diversity (where possible), and in Years 3, 5, 7 and 8 in accordance with the monitoring plan. The timing of quarterly sampling will remain consistent across all years and will align with key bat reproductive periods: lactation (mid-June to August), post-lactation (September to mid-December), pre-pregnancy (mid-December to March), and pregnancy (April to mid-June), as defined by Gorresen et al. (2013).

8.1.4.2 Alternative method

Under the linear transect monitoring approach SLAM traps would be positioned at approximately the mid-point (50 meters) of the 100-meter long transect. In all other respects, insect sampling protocols would match those described in section 8.1.4.1.

8.2 Bat acoustic activity monitoring

The goal of bat acoustic activity monitoring is to quantify increases in bat acoustic activity at the site in response to the management actions. To measure changes, NPMPP will deploy 15 acoustic monitors within the PMA (one per plot). Nightly monitoring, beginning 1-hour prior to sunset and ending 1-hour after sunrise, will be conducted for a 12-month period in Years 1, 3, 5, and 8. During monitoring years, acoustic monitoring data will be downloaded at least quarterly. Monitoring frequency was established in order to provide enough detail to determine an overall trend in bat activity and enough granularity to potentially associate changes in bat activity with documented changes in vegetation communities and bat prey species, while also being conscious about the number of times researchers need to access locations to retrieve data cards.

Acoustic monitoring will be conducted using Song Meter SM4BAT-FS (SM4) ultrasonic recorders equipped with high frequency microphones (SMM-U2; Wildlife Acoustics, Inc., Maynard, MA). Each

of the SM4 acoustic monitors will be placed within 30 meters of one of the monitoring plots (Section 8.1). The specific location will be identified to maximize the probability of collecting bat detections. These will remain in a constant location during all the monitoring years, including the baseline year. The distribution density of all 15 SM4 acoustic monitors is approximately 1 detector/0.6 kilometers^2.

The following bat use metrics will be reported:

- Detection rate = total nights with bat detections/total active detector-nights (primary measure);
- Number of nightly call files;
- Type of call (i.e., passive or active search phase calls, feeding buzz, and social calls);
- Foraging duration; and
- Timing of nightly activity

8.3 Outplanting Monitoring

Outplantings are likely to be discrete locations where outplanting will establish new forested areas in locations where trees previously did not occur. As such, outplanting monitoring will be focused on percent survival of outplanted species, rather than a broader metric related to vegetation cover or structure. All outplantings will occur in locations where the surrounding vegetation is variable and therefore the outplanted trees may be integrated into, and will be supplementing, an already established vegetative substrate. In other words, unlike other mitigation projects, where outplants are attempting to turn pasture into forest, these outplantings will be aimed at supplementing and improving existing structure and habitat.

9.0 Analysis

For this Habitat Management Plan, analyses target the evaluation of changes of invasive plant species, arthropod communities, and bat acoustic activity within the PMA from baseline conditions. As described in Section 8.0, changes in plant cover and species richness, insect biomass, and bat activity will be tracked at monitoring plots. Changes in these variables will be measured against baseline conditions, and against similar data collected at the control plots, described in the Research Plan (Tetra Tech 2025). The following statistical analyses will be used to determine if changes that occur in response to management actions are statistically significant. An Analysis of Covariance (ANCOVA) will be conducted on data from the 15 plots to compare the effects of that habitat degradation, through invasive species, on arthropod biomass. Sample year and initial status (baseline) will be the main effects while invasive plant species cover, plant species richness, slope, and elevation will be covariates. A PERMANOVA (Anderson 2001) will be used to compare arthropod and invasive plant community composition among site initial conditions over time. Canonical analyses of principal coordinates (CAP; Anderson and Willis 2003) will be used to visualize how arthropod and invasive plant communities shifted.

Bat activity will be summarized during evaluative years and compared to baseline data to evaluate changes over time. Depending on the patterns of observed use, bat activity may be evaluated daily, seasonally, or annually, to highlight changes correlated with management activities.

10.0 Hawaiian Hoary Bat Net Benefit Analysis

The focus of this Habitat Management Plan is to 1) support efforts to halt the degradation of Hawaiian hoary bat habitat in the PMA, 2) increase the biomass of insect for Hawaiian hoary bat in the PMA, and 3) increase the amount of Hawaiian hoary bat habitat in the PMA through outplanting and natural recruitment of native species. These three factors provide a net benefit to the Hawaiian hoary bat. Efforts to restore areas to higher quality foraging and roosting opportunities will result in an increase in bat use of the area. A net benefit will also be realized as the benefits of the forest restoration that occur in the PMA during the ITP/ITL permit term will benefit bats for years after the permit term ends. Finally, the accompanying Research Plan will connect the effects of managing invasive plant species and habitat restoration, which occurs across O'ahu and other Hawaiian Islands, to changes in arthropod communities as it pertains to bat prey. This will provide valuable information on the trophic level effects of habitat restoration efforts. The net benefits expected for Hawaiian hoary bats are further described in the NPM HCP (Tetra Tech 2016).

NPMPP will be conducting management activities in MFAs spread throughout the NPMPP Mitigation Area. The NPMPP Mitigation Area includes areas where no recent management has occurred (Figure 3, see Section 4.3 for more information on recent management activities in the PMA). The activities in the MFAs will benefit bats across the NPMPP Mitigation Area for several reasons. Habitat improvement through removal of invasives in focused areas will benefit other areas in the PMA by reducing the potential for further infestations in areas that have already been treated for invasive plants or areas that are not yet infested. Further, the establishment of larger areas with limited invasive plants will increase the presence of native species and support a greater diversity of bat prey species. This benefits bats not only in the MFAs, but across the NPMPP Mitigation Area and the PMA generally. Over time the entire area will become better habitat for bats. This in turn is expected to increase use of the area by bats. Once bats discover locations where prey abundance and diversity are high, they will return to the areas to forage repeatedly, meaning they will spend more time in the NPMPP Mitigation Area generally, increasing the likelihood of not just foraging, but also for roosting and breeding. The selection of and intended management activity in these MFAs is described in Section 5.1.

11.0 Success Criteria

Baseline measures for success criteria will be established based on results in Year 1 of this Habitat Management Plan to ensure that the effects measured are changes that can be reasonably attributed to the mitigation actions. Using Year 1 as the baseline upon which all other management success is tracked is dependent on Year 1 consisting of typical or average ecological conditions,

such as the amount and timing of precipitation and average temperatures. The control plots will also be used when measuring success criteria. Based on consultation with USFWS and DOFAW, successful implementation of the management portion of the bat mitigation plan will be demonstrated through performance of habitat management actions that improve the environment for bats and demonstration that these changes are correlated with a statistically significant increase in bat acoustic activity (i.e. increase in bat use of the PMA). This is consistent with the Hawaiian hoary bat guidance document (DOFAW 2015), which states that "habitat restoration that enhances or increases forested and foraging areas for bats is an optimum mitigation approach".

Monitoring population trends is challenging as standard methods for estimating population size or densities across the landscape are not yet feasible (Frick 2013, Gorresen et al. 2018). Instead, changes in the magnitude of activity rather than abundance are frequently used as a proxy for population trends (Sugai et al. 2019). Although bat acoustic activity cannot provide direct counts of individual bats[6], over time it does allow us to detect changes in how bats are using an area. Further assessment of the behavioral states from vocalizations identified within recorded acoustic activity can provide additional context on habitat use and insight into a populations' response to conservation actions (Teixeira et al. 2019).

The suite of metrics proposed for monitoring will provide sufficient data to detect changes in seasonality of use and intensity of use. When combined with knowledge on the timing of key life-history stages, vocal behaviors from acoustic data can be used to identify important habitats for reproductive success. Examining the spatial and temporal trends in vocal behaviors through acoustic monitoring can provide a means to assess habitat quality, evaluate the effectiveness of conservation actions, and identify factors in the environment that could be adaptively managed (Teixeira et al. 2019). Therefore, a statistically significant increase in bat acoustic activity (i.e., p-value < 0.05) indicates that the observed change or difference in bat acoustic activity pre- and post-mitigation is unlikely to have occurred due to random chance. As a result, it provides confidence that the observed increase is a real and meaningful effect.

The success criteria that follow provide a lens that connect the dots between the mitigation actions and the benefits to Hawaiian hoary bats. Specifically, habitat management actions, are expected to change the plant communities in the PMA to increase plant richness and reduce invasive species. This change in forest condition is expected to increase the availability of bat prey. Changes in habitat quality, including the amount of bat prey, is expected to increase bat activity. Enhancement of Hawaiian hoary bat habitat in the PMA over this period in combination with the associated $100,000 Research Plan (Tetra Tech 2025) was determined in the Project HCP as sufficient to mitigate for the potential take of 34 bats in Tier 1 (see Tetra Tech [2016] for details).

[6] For example, it is not possible to know if 10 bat passes represent 10 bats or one bat passing 10 times (Frick 2013).

Success Criteria:

Where statistical tests are applicable, all reported changes below will include 95 percent confidence intervals and significance at an alpha value of 0.05 within the monitoring plots described in Section 8.0.

1. Statistically significant increase in plant species richness over baseline by Year 8;
2. Statistically significant reduction in invasive plant species absolute percent cover over baseline by Year 8;
3. Total acres of invasive plant species treated in each MFA;
4. Statistically significant increase in arthropod biomass over baseline by Year 8; and
5. Statistically significant increase in bat acoustic activity (one or both of the primary measures) indicating bat activity has increased (duration or level of activity) over the 8-year implementation period for this Habitat Management Plan.
6. 50% survival of outplanted trees at Year 5 following outplanting.

Section 10.0 describes how achieving the success criteria listed above will benefit bats across the NPMPP Mitigation Area and the PMA. Habitat improvement in focused areas benefits bats not only in the MFAs, but across the NPMPP Mitigation Area and the PMA generally. The expectation is that over time the entire area will become better habitat for bats. This in turn is expected to increase foraging and roosting in the area by bats. This is expected to be most prevalent in the areas that are directly managed by NPMPP, and therefore have the most immediate benefit for bats. However, since bats will be transiting the NPMPP Mitigation Area as they move between MFAs or navigate in and out of the PMA, their use of the NPMPP Mitigation Area, and PMA is expected to increase in general.

12.0 Adaptive Management

Adaptive management will be triggered when the monitoring data suggest the mitigation project is not on track to meet the success criteria (Table 5). NPMPP will analyze data in years 1 (baseline), 3, 5, and 8 to track progress towards meeting goals. Since adaptive management is a response to monitoring outcomes, the soonest that it would occur is in Year 3, following two years of management and monitoring.

12.1 Plant Species and Bat Prey

If plant species richness and arthropod abundance or richness are not trending towards a statistically significant increase over baseline in Year 5, adaptive management would be triggered. Similarly, if bat acoustic activity has not shown an increase in duration or level of activity over baseline by Year 5, adaptive management would be triggered. This would allow for changes in management following Year 5, which would allow for success criteria to be met in Year 8. Adaptive management actions will be responsive to the observed results, and would be developed in

consultation with USFWS, DOFAW, and KMWP. Any identified adaptive management actions would be approved by USFWS and DOFAW prior to implementation.

If by Year 5 plant species richness or arthropod abundance are not trending towards a statistically significant increase in "established invasive species" and "invasive species dominated" plots, or bat acoustic activity has not shown an increase in a primary bat acoustic activity metric (either in duration or in level of activity; this increase does not need to be significant), NPMPP will either increase the intensity of the management, particularly with respect to invasive species, in the NPMPP Mitigation Area or identify additional target areas for increased management. This could include additional focus on larger areas with significant on-going invasive species impacts or areas of potential focal bat use, such as water sources like the pond near the Koʻolau Mountains ridge summit. In addition, if bat acoustic activity has not shown an increase by Year 5, this will trigger additional monitoring in Year 6. If bat acoustic activity in Year 5 shows an increase but that increase is not statistically significant (i.e., the Habitat Management Plan is on track to meeting the success criteria), additional management actions are not triggered but monitoring is required in Year 6.

If by Year 6, bat acoustic activity has not shown a statistically significant increase in bat acoustic activity NPMPP will conduct additional adaptive management actions (Table 5) and add monitoring in Year 7 to continue to track progress towards a statistically significant increase in bat acoustic activity as required by the success criteria. If by Year 6, bat acoustic activity shows a statistically significant increase in bat acoustic activity, the Habitat Management Plan is on a track to meeting the final success criteria and NPMPP can forgo Year 7 monitoring and adaptive management.

Table 5. Adaptive Management Triggers and Responses

Monitoring Year	Plant Species Richness	Arthropods	Bat Acoustic Activity	Outplantings	Potential Adaptive Management Response
Year 1	Baseline Monitoring				
Year 3	No increase in plant species richness within established invasive species and invasive species dominated plots compared to baseline	No arthropod increase within established invasive species and invasive species dominated plots compared to baseline	No trigger, as this is expected to be a lagging indicator	No trigger as it is expected that outplantings would likely only be planted in Year 3 at the earliest.	• Identify additional target areas for increased management • Remove non-priority weed species to increase extent and quality of native habitat • Identify additional target areas for increased management

Monitoring Year	Plant Species Richness	Arthropods	Bat Acoustic Activity	Outplantings	Potential Adaptive Management Response
					• Increase the intensity of management throughout the PMA
Year 5	Not trending towards a statistically significant increase within established invasive species and invasive species dominated plots compared to baseline	Not trending towardsa a statistically significant increase within established invasive species and invasive species dominated plots compared to baseline	No increase in a primary bat activity metric (either duration or level of activity) compared to baseline; this increase does not need to be significant (would trigger adaptive monitoring in Year 6)	Less than 90% survival of outplanted trees.	• Supplemental out-planting of native species • Remove non-priority weed species to increase extent and quality of native habitat • Identify additional target areas for increased management • Increase the intensity of management throughout the MFAs
Year 6	No monitoring or adaptive management will occur unless Year 5 criteria are not met.				
Year 7	No monitoring or adaptive management will occur unless Year 6 criteria are not met.				
Year 8	• Success criteria are not met				• Extend management duration • Identify additional target areas for increased management

12.2 Shifting Funding

Removal and exclusion of feral ungulates through fencing is a common and effective tool for managing invasion and disturbance to critical habitats and is an essential first step in habitat conservation and restoration. Fence construction and removal of ungulates in the PMA was completed by KMWP, Army Natural Resource Program of Oʻahu, and DLNR in 2016. KMWP continues to monitor fence lines to make sure they remain secure and that the PMA remains ungulate free. If a fence breach is identified, typically following a storm, the fence is repaired as

soon as possible. If in that time feral pigs manage to breach the fence, supplemental removal is required. KMWP and DOFAW O'ahu will be completing these action. However, if additional financial or personnel resources are needed to respond to fence breaches funding from NPMPP, that was otherwise intended for the implementation of management actions in Section 7.1, can be shifted to fence repair if requested by KMWP. This shift in funding would be temporary, until the issue had been rectified and will be done in communication with the management partners and DOFAW HCP And USFWS. Any shifting of funds will occur in a way that will not undermine the integrity of the research occurring on the site. A temporary shifting of funds would primarily just result in fewer acres of non-native invasive plants being treated in that year.

13.0 Budget

The mitigation program provided by NPMPP includes funding for 2 full-time staff equivalents, equipment, materials, transportation, and mapping support for 8 years of management activities. Based on USFWS and DOFAW guidance, habitat management in MFAs over this period in combination with an associated $100,000 Research Plan was determined in the Project HCP as sufficient to mitigate for the potential take of 34 bats in Tier 1. This exceeds agency recommendations for habitat mitgation per bat at the time (DOFAW 2015). The estimated annual budget for habitat management and monitoring is shown in Table 6.

Table 6. Estimated Annual Budget for Habitat Management and Monitoring

Year	Estimated Management Budget (2024 Dollars)	Estimated Monitoring Budget (2024 Dollars)[1]	Estimated Total Budget (2024 Dollars)
Year 1	$243,314	$276,321	$519,635
Year 2	$243,314	--	$243,314
Year 3	$243,314	$144,130	$387,444
Year 4	$243,314	--	$243,314
Year 5	$243,314	$144,130	$387,444
Year 6	$243,314	--	$243,314
Year 7	$243,314	--	$243,314
Year 8	$243,314	$144,130	$387,444
Total	**$1,946,512**	**$708,711**	**$2,655,223**

[1]Amount includes monitoring under the management and research plans combined.

A detailed breakdown of the estimated annual budget for habitat management is shown in Table 7.

Table 7. KMWP Estimated Annual Budget for Habitat Management

Description	Total
Salaries and Fringe Benefits (2 FTE equivalent + 1 partial FTE [coordination]	**$129,576**
Helicopter (41 days)	$46,410
Materials and supplies	$8,700
Outplanting materials and supplies	$15,000
Vehicle use, fuel, maintenance	$5,000
Training	$1,300
Travel of Staff for Management	$4,200
Utilities	$1,500
PCSU administration	$10,872
Overhead	$20,756
Subtotal (materials, transport, and administration)	**$113,738**
Grand Total	**$243,314**

A detailed breakdown of the estimated combined budget for habitat monitoring at the PMA and the control site is shown in Table 8. Based on varying levels of effort required to conduct evaluative and research monitoring, Tetra Tech estimates assumes three quarters of staffing, materials, reporting, and analysis costs are attributable to the Habitat Management Plan and one quarter of the costs are attributable to the Research Plan (Tetra Tech 2025). This cost distribution accounts for additional analysis and field work associated with bat acoustic monitoring work in the PMA and the lower number of control plots. This categorization results in an estimate of $177,178 in research funding, exceeding the $100,000 in research funding required by the Project HCP for Tier 1 bat mitigation. Year 1 costs are significantly greater due to one-time only labor costs associated with set up of the monitoring plots and the purchase of monitoring equipment.

Table 8. Estimated Budget for Habitat Monitoring, Analysis, and Reporting

Description	Entity	Year 1 Total[1]	Years 3, 5, 8 Total (Annual)[1]
Salaries and Fringe Benefits (Intermittent)	KMWP	$49,200	$43,200
Salaries and Fringe Benefits (3 Partial FTE)	Tetra Tech	$111,381	$33,851
Subtotal (staffing)		**$160,581**	**$77,051**
Helicopter (41 days Year 1/36 days Years 3, 5, 8)	KMWP	$47,338	$36,067
Bat acoustic detectors (15)	Tetra Tech	$22,500	$3,000
Insect traps (15)	Tetra Tech	$1,500	--
Other materials and supplies	Tetra Tech & KMWP	$1,500	$500
Vehicle use, fuel, maintenance	KMWP	$5,000	$5,000
Training	KMWP	$1,300	$1,300
Travel to Mitigation Area	Tetra Tech & KMWP	$10,538	$3,360
Utilities	KMWP	$1,500	$1,500
PCSU administration	KMWP	$7,261	$5,073
Overhead	KMWP	$11,546	$9,600
Subtotal (materials, transport, and administration)		**$109,983**	**$65,400**
Hawai‘i GET	Tetra Tech	$5,757	$1,679
Grand Total		**$276,321**	**$144,130**

[1] Amount includes management and research plan costs combined

14.0 Reporting

14.1 Baseline Report

A baseline report will be completed at the end of one year of baseline monitoring and will be submitted to DOFAW, the USFWS, and management partners. The baseline report will include the results of evaluative monitoring at locations within the MFAs. Baseline data will be collected as described in Section 8.0. The baseline monitoring report will also include decisions on initial management priorities in the MFAs based on the results of baseline monitoring and discussions with management partners. The baseline report will include at least:

- Period of monitoring
- Monitoring locations
- Surveys completed
- Survey results
- Challenges identified with survey locations or the potential to execute management activities at the location

- Initial management priorities and annual workplan for Year 2.

14.2 Annual Reports

Annual reports will be submitted to DOFAW and USFWS and management partners and will summarize the annual work plan, results of management activities, preliminary data analyses, and adaptive management approaches to habitat management. Annual reports will be submitted within three months following the completion of evaluative monitoring for each year. Annual reports will at least include:

- A summary of management activities completed that year
- Changes in management actions compared to annual workplan, if necessary
- Rationale for changes
- Summary of monitoring activities completed
- Summary of monitoring results for the year and a cumulative analysis of changes in vegetation composition, bat prey abundance and diversity, and bat activity compared to baseline conditions and compared to data collected at monitoring locations outside the PMA
- Narrative describing trends in ecological factors that influence bat activity over time and a discussion of whether the changes being observed are on track to meet success criteria in Year 8
- Any necessary adaptive management activities that are needed in response to monitoring results
- Priorities for the annual workplan for the upcoming year

A final report will be submitted upon the successful implementation of the mitigation program described here, including having achieved the success criteria described in Section 11.

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Figures

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Figure 1: Hawaiian Hoary Bat Mitigation Area Vicinity Map

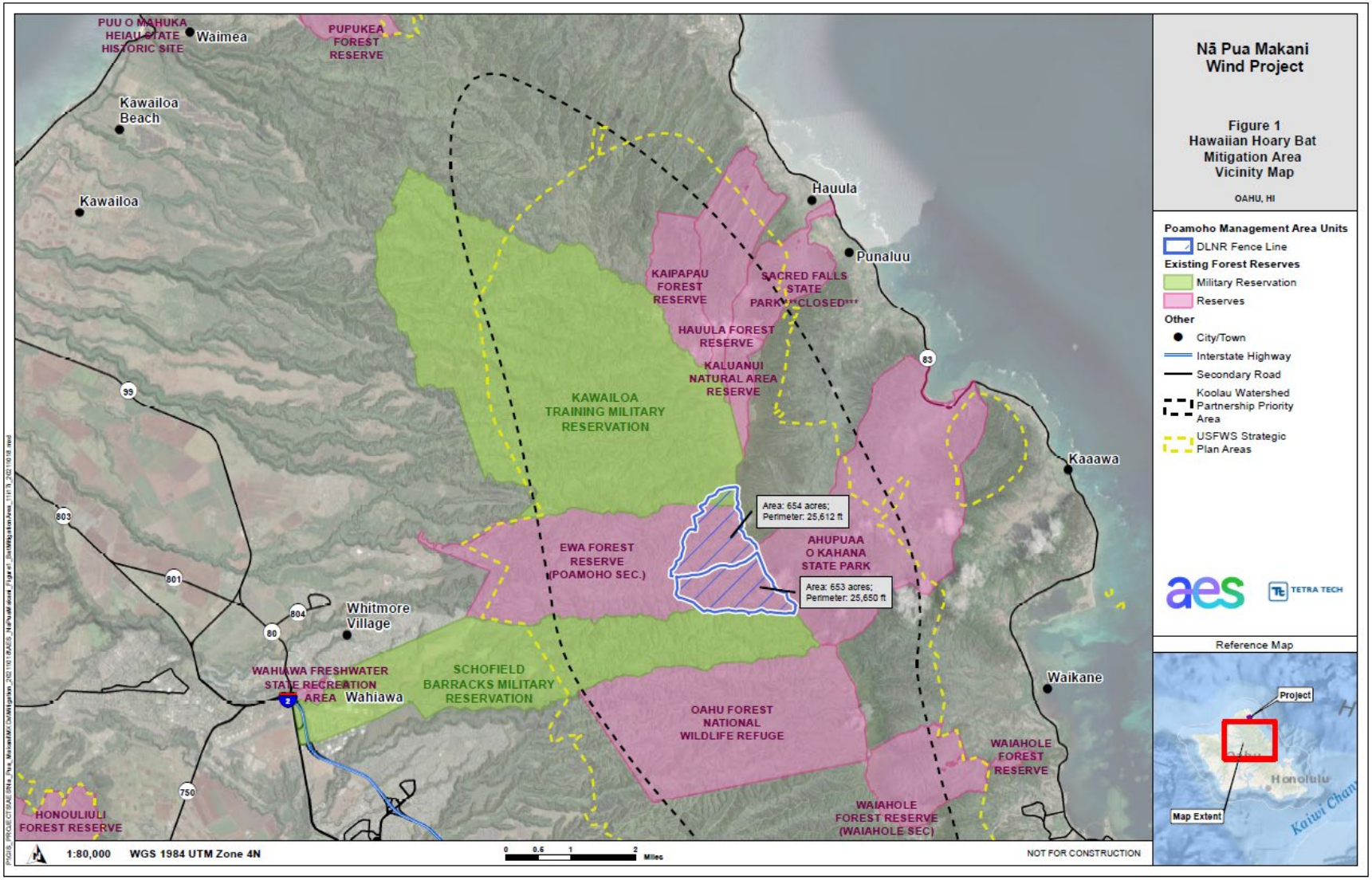


Figure 2: Invasive Plant Species Records for the Poamoho Management Area

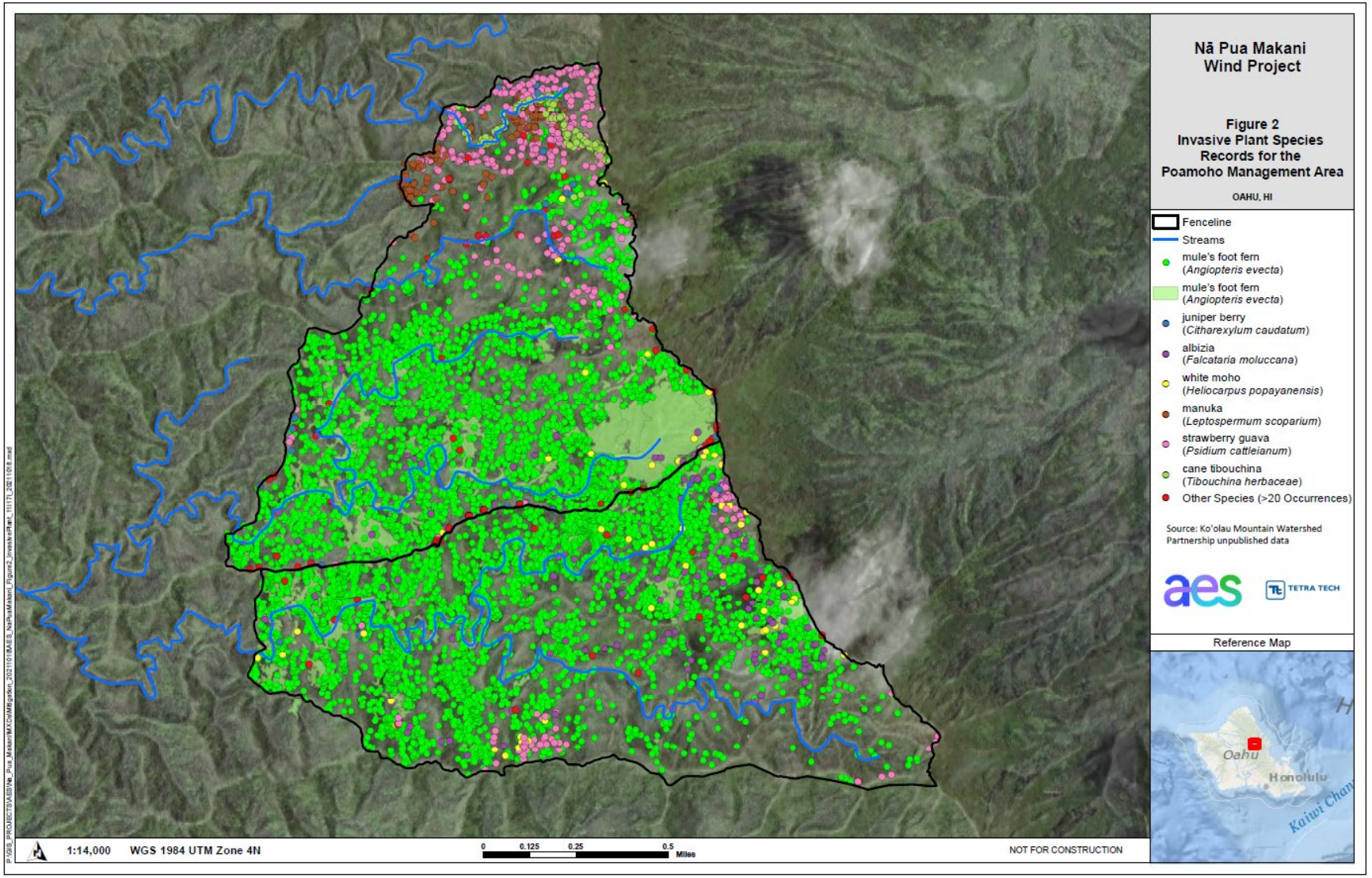


Figure 3. NPMPP Mitigation Area

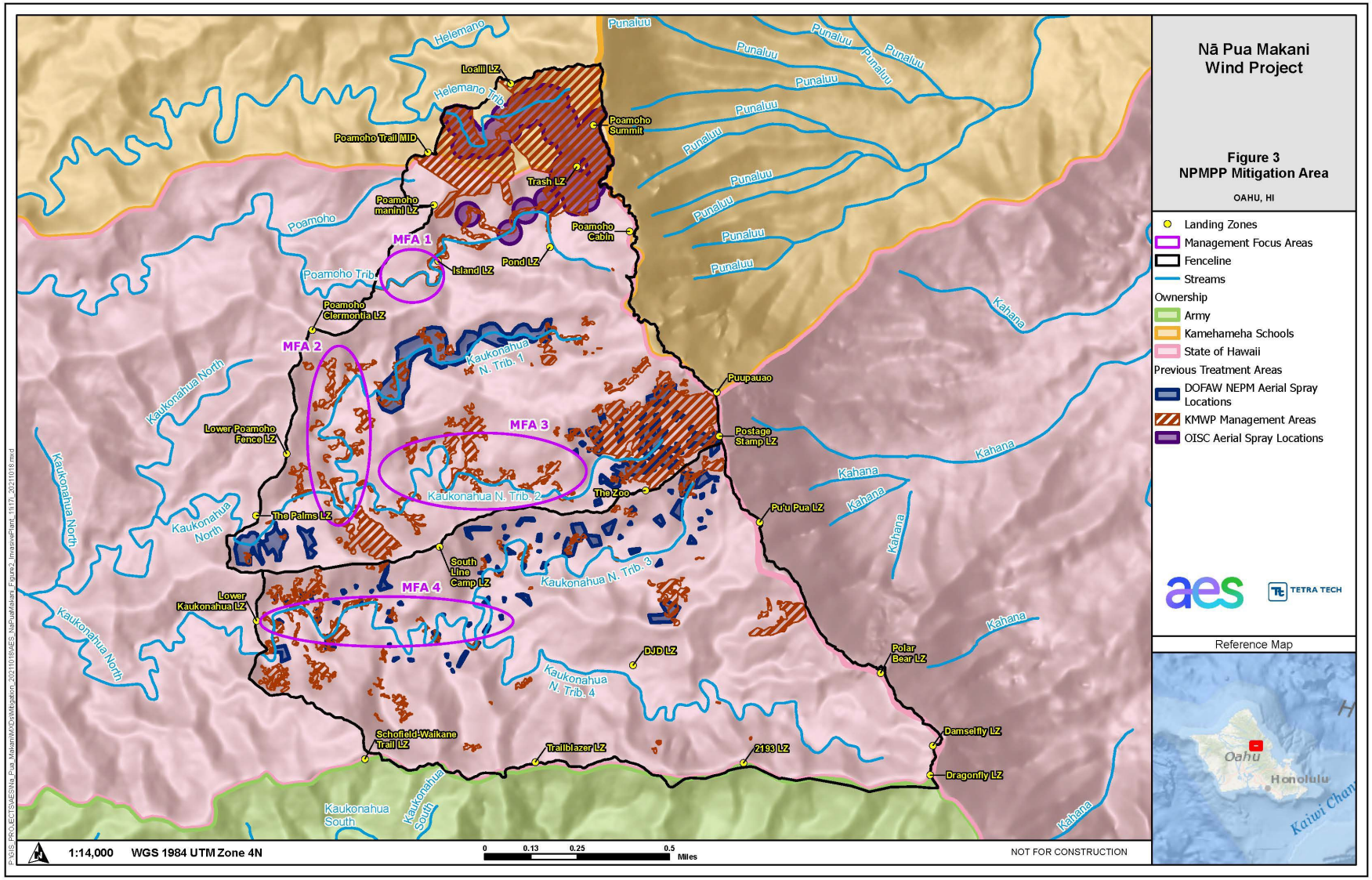


Figure 4. Example Planned Monitoring Plot Layout

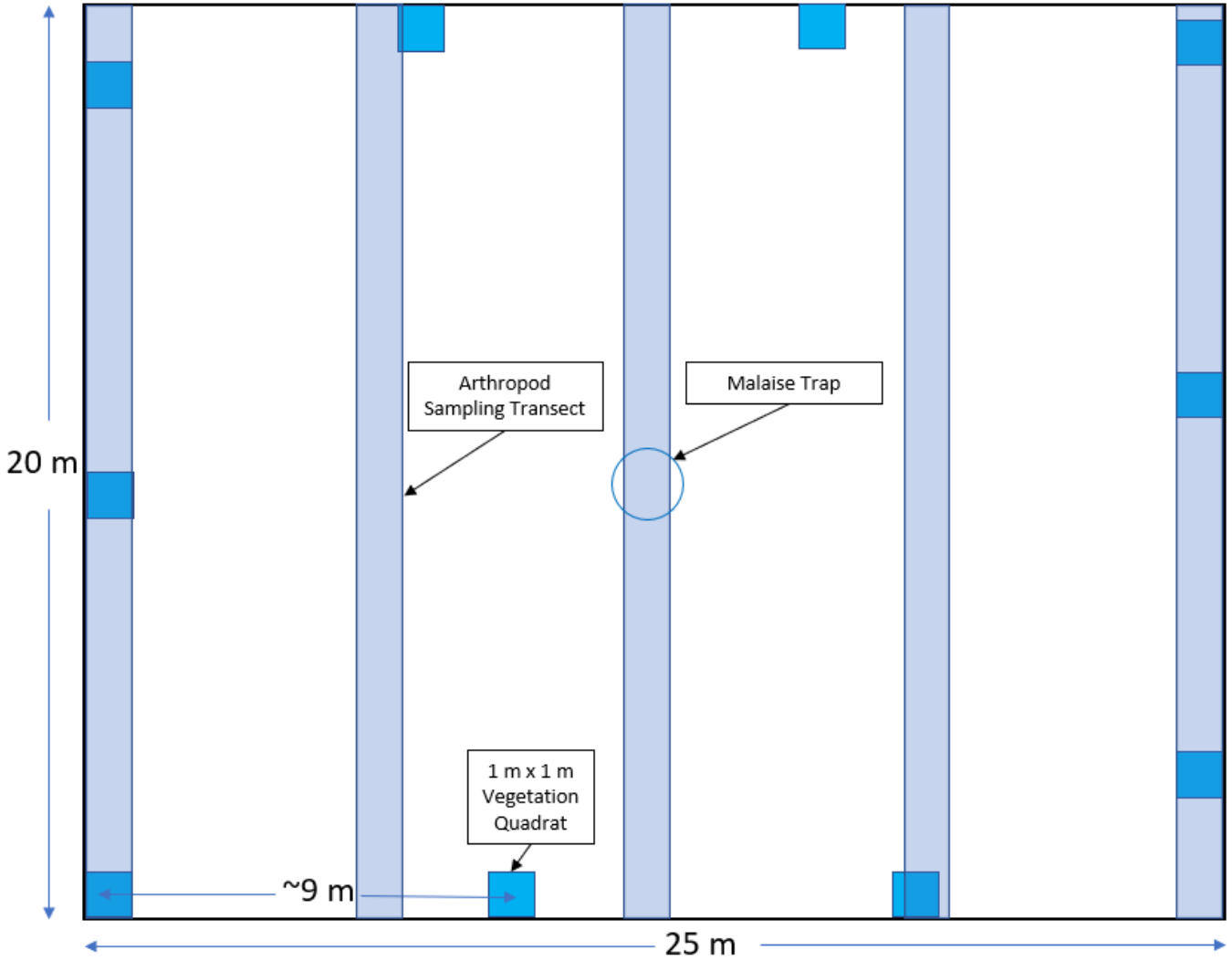
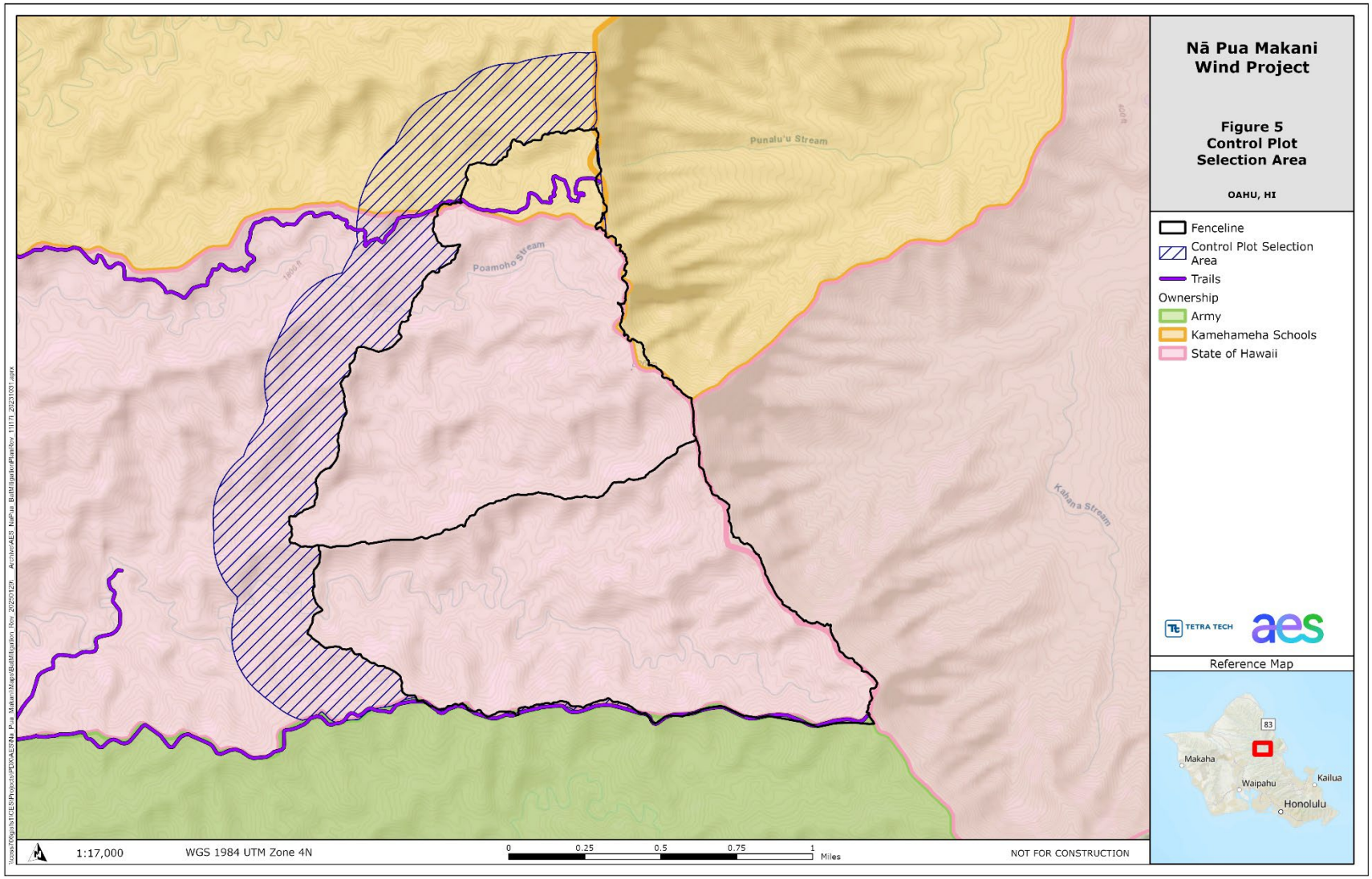


Figure 5. Control Plot Selection Area



Appendix A

Biosecurity Protocols

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PIFWO Invasive Species Biosecurity Protocols

(Updated April 2022)

Project activities may introduce or spread invasive species, causing negative ecological consequences to new areas or islands, resulting in potential impacts to fish, wildlife, and their habitat. For example, seeds of invasive plant species (e.g., *Chromolaena odorata*, *Senecio madagascariensis*, *Cyathea cooperi*, or *Miconia calvescens*) can be inadvertently transported on equipment from a previous work site to a new site where the species are not present. Likewise, equipment used in an area infected with a pathogen or insect pest that can have ecological consequences (e.g., rapid ʻōhiʻa death (*Ceratocystis spp.*), black twig borer (*Xylosandrus compactus*), or naio thrips (*Klambothrips myopori*), if not properly decontaminated, can act as a vector to introduce the pathogen into a new area. Additionally, vehicles must be properly inspected and cleaned to ensure vertebrate or invertebrate pests do not stowaway and spread to other areas. These are just a few examples of how even well-intended project activities may inadvertently introduce or spread invasive species.

To avoid and minimize invasive species potential impacts to fish, wildlife, and their habitat we recommend incorporating the following Invasive Species Biosecurity Protocol into your project planning. We recommend this biosecurity protocol be incorporated when project activities occur within any area containing predominantly native habitat. Project activities involving transportation of a substantial amount of materials (i.e., construction materials or aggregate, etc.), vehicles, machinery, equipment, or personnel between sites should also incorporate the biosecurity protocols. Additional consultation with the Service is recommended if the project involves transportation of materials, equipment, vehicles, etc. between islands or transpacific movement. The Species-Specific Biosecurity Protocols should also be reviewed and implemented depending on the geographic area and/or specific activities of your project.

Invasive Species Biosecurity Protocol

The following biosecurity protocol is recommended to be incorporated into planning for your project to avoid or minimize transportation of invasive species with potential to impact to fish, wildlife, and their habitat. Cleaning, treatment, and/or inspection activities are the responsibility of the equipment or vehicle owner and operator. However, it is ultimately the responsibility of the action agency to ensure that all project materials, vehicles, machinery, equipment, and personnel are free of invasive species before entry into a project site. Please refer to the resources listed below for current removal/treatment recommendations that may be relevant to your project.

1. Cleaning and treatment:
   Project applicants should assume that all project materials (i.e., construction materials, or aggregate such as dirt, sand, gravel, etc.), vehicles, machinery, and equipment contain dirt and mud, debris, plant seeds, and other invasive species, and therefore require thorough cleaning. Treatment for specific pests, for example, trapping and poison baiting for rodents, or baiting and fumigation for insects, should be considered when applicable. For effective cleaning we offer the following recommendations prior to entry into a project site:
   a. Project materials, vehicles, machinery, and equipment must be pressure washed thoroughly (preferably with hot water) in a designated cleaning area. Project materials, vehicles, machinery, and equipment should be visibly free of mud/dirt (excluding aggregate), seeds, plant debris, insects, spiders, frogs (including frog eggs), other vertebrate species (e.g., rodents, mongoose, feral cats, reptiles, etc.), and rubbish. Areas of particular concern include bumpers, grills, hood compartments, wheel wells, undercarriage, cabs, and truck beds. Truck beds with accumulated material are prime sites for hitchhiking invasive species.
   b. The interior and exterior of vehicles, machinery, and equipment must be free of rubbish and food, which can attract pests (i.e., rodents and insects). The interiors of vehicles and the cabs of machinery should be vacuumed clean particularly for any plant material or seeds.

2. Inspection:
   a. Following cleaning and/or treatment, project materials, vehicles, machinery, and equipment, must be visually inspected by its user, and be free of mud/dirt (excluding aggregate), debris, and invasive species prior to entry into a project site. For example, careful visual inspection of a vehicle's tires and undercarriage is recommended for any remaining mud that could contain invasive plant seeds.
   b. Any project materials, vehicles, machinery, or equipment found to contain invasive species (e.g., plant seeds, invertebrates, rodents, mongoose, cats, reptiles, etc.) must not enter the project site until those invasive species are properly removed/treated.

3. For all project site personnel:
   a. Prior to entry into the project site, visually inspect and clean your clothes, boots or other footwear, backpack, radio harness, tools and other personal gear and

equipment for insects, seeds, soil, plant parts, or other debris. We recommend the use of a cleaning brush with sturdy bristles. Seeds found on clothing, footwear, backpacks, etc., should be placed in a secure bag or similar container and discarded in the trash rather than being dropped to ground at the project site or elsewhere.

4. Additional considerations:
    a. Consider implementing a Hazard Analysis and Critical Control Point (HACCP) plan (https://www.fws.gov/policy/A1750fw1.html) to improve project planning around reducing the risk of introducing or spreading invasive species.
    b. When applicable, use pest-free or low-risk sources of plants, mulch, wood, animal feed or other materials to be transported to a project site.
    c. For projects involving plants from nurseries (e.g., outplanting activities, etc.), all plants should be inspected, and if necessary, appropriately cleaned or treated for invasive species prior to being transported to the project site.
    d. Avoid unnecessary exposure to invasive species at a particular site (to the extent practical) to reduce contamination and spread. For example, if your project involves people or equipment moving between multiple locations, plan and organize timelines so that work is completed in native habitat prior to working in a disturbed location to reduce the likelihood of introducing a pest into the native habitat.
    e. Maintain good communication about invasive species risks between project managers and personnel working on the project site (e.g., conduct briefings and training about invasive species). Ensure prevention measures are communicated to the entire project team. Also consider adding language on biosecurity into contracts or permitting mechanisms to provide clarity to all involved in the project. Report any species of concern or possible introduction of invasive species to appropriate land managers.

For current removal/treatment recommendations please refer to the following:
Hawaiian Islands:

- Hawai‘i Island – https://www.biisc.org/
- Maui – https://mauiinvasive.org/
- Moloka‘i - https://www.molokaiisc.org/
- Lāna‘i - https://pulamalanai.com/
- O‘ahu – https://www.oahuisc.org/
- Kaua‘i – https://www.kauaiisc.org/

Mariana Islands:

- Guam – https://biosecurity.guam.gov/
- CNMI – http://www.dfwcnmi.com/

Species-Specific Biosecurity Protocols

The following section contains specific protocols for a few select invasive species of concern in the Pacific Islands highlighted because of their potential to easily spread and cause great harm to native species and habitats. Other invasive species may not have existing specific protocols or may already be minimized by implementing the invasive species biosecurity protocols above (e.g., invasive plants, invertebrates, larger vertebrates). As new threats emerge that require development of species-specific protocols, those may be added to this list.

Table 1. Current island distribution of invasive species with specific biosecurity protocols in the Pacific Islands (PIFWO jurisdiction, as of February 2022).

Island	Invasive Species with Specific Protocols			
	Rapid ʻŌhiʻa Death	**Little Fire Ant**	**Coconut Rhinoceros Beetle**	**Brown Treesnake**
Island of Hawaiʻi	widespread	widespread	not present	not present
Maui	not present	incipient	not present	not present
Oʻahu	incipient	incipient	widespread	not present
Kauaʻi	widespread	not present	not present	not present
Guam	NA	widespread	widespread	widespread
CNMI	NA	not present	Rota only	not present
American Samoa	NA	incipient	widespread	not present

Rapid ʻŌhiʻa Death (ROD)

Rapid ʻŌhiʻa Death (ROD) is a caused by a fungal pathogen (*Ceratocystis* spp.) that attacks and kills ʻōhiʻa trees (*Metrosideros polymorpha*). ʻŌhiʻa is endemic to the Hawaiian Islands and is the most abundant native tree species, comprising approximately 80 percent of Hawaiʻi's remaining native forests.

For more information about ROD including its current distribution, ROD science updates, and the latest on ROD protocol, please visit www.rapidohiadeath.org.

To reduce the risk of spreading ROD, we recommend the following best management practices and decontamination protocol be implemented for projects occurring in any native habitat where ʻōhiʻa is present, on islands where ROD is currently found. If working directly with ʻōhiʻa trees (e.g., sampling suspected trees, clearing an area of ʻōhiʻa, etc.) or in an area(s) known to be highly infested with ROD, additional consultation is recommended.

Best Management Practices for ROD

1. Never transport any part of an ʻōhiʻa tree between different areas of an island or to a different island.

2. Do not use equipment from ROD infected islands on another island unless it is very specialized equipment and follows the decontamination protocol described below.

3. Avoid wounding ʻōhiʻa trees and roots with mowers, chainsaws, weed eaters, and other tools. If an ʻōhiʻa receives a minor injury like a small broken branch, then give the injury a clean, pruning-type cut (close to the main part of the trunk or branch) to promote healing, and then spray the entire wounded area with a pruning seal.

4. Always report suspect ROD ʻōhiʻa trees observed within you project area. ROD is a wilt disease that cuts off the supply of water and nutrients to the tree. The primary symptom to look for is an entire canopy or a large branch with dying leaves or red discolored leaves. Please record the GPS coordinates and location and take a picture of the tree if possible. Please report suspected ROD ʻōhiʻa trees to the following agencies:
    a. Island of Hawaiʻi – BIISC: 808-969-8268 (ohialove@hawaii.edu)
    b. Maui – MISC: 808-573-6472 (miscpr@hawaii.edu)
    c. Molokaʻi – TNC: 808-553-5236 ext. 6585 (lbuchanan@tnc.org)
    d. Oʻahu – OISC: 808-266-7994 (oisc@hawaii.edu)
    e. Kauaʻi – KISC: 808-821-1490 (kisc@hawaii.edu)

ROD Decontamination Protocol

1. Clothes, footwear, backpacks, and other personal equipment
    a. Before leaving the project site, remove as much mud and other contaminants as possible. Use of a brush with soap and water to clean gear is preferred. Footwear, backpacks, and other gear must be sanitized by spraying with a solution of >70 percent isopropyl alcohol or a freshly mixed 10 percent bleach solution.

2. Vehicles, machinery, and other equipment
    a. Vehicles, machinery, and other equipment must be thoroughly hosed down with water (pressure washing preferred) and visibly free of mud and debris, then sprayed with a solution of >70 percent isopropyl alcohol or a freshly mixed 10 percent bleach solution. Use of a "pump-pot" sprayer is recommended for the solution and a hot water wash is preferred. Be sure to thoroughly clean the undercarriage, truck bed, bumpers, and wheel wells.
    b. If non-decontaminated personnel or items enter a vehicle, then the inside of the vehicle (i.e., floor mats, etc.) must be subsequently decontaminated by removing mud and other contaminants and sprayed with the one of the same aforementioned sanitizing solutions.

3. Cutting tools
    a. All cutting tools, including machetes, chainsaws, and loppers must be sanitized to remove visible mud and other contaminants. Tools must be sanitized using a solution of >70 percent isopropyl alcohol or a freshly mixed 10 percent bleach solution. One minute after sanitizing, one may apply an oil-based lubricant to chainsaw chains or other metallic parts to prevent corrosion as bleach is corrosive to metal.

    NOTE: When using a 10 percent bleach solution, surfaces should be cleaned with a minimum contact time of 30 seconds. Bleach must be mixed daily and used within 24

hours, as once mixed it degrades. Bleach will not work to disinfect surfaces that have high levels of organic matter such as sawdust or soil. Because bleach is also corrosive to metal, a water rinse after proper sanitization is recommended to avoid corrosion.

Little Fire Ant (LFA)

The little fire ant (*Wasmannia auropunctata*), or LFA, is an invasive species with a painful sting that can inhabit many different environments. In Hawai‘i, it often infests agricultural fields and farms, damaging crops and stinging unsuspecting workers. Little fire ants are also highly disruptive to native tropical ecosystems and harmful to wildlife. Slow moving, but tiny and capable of foraging 24 hours a day with multiple queens per colony, LFA is a formidable threat to biodiversity, agriculture, and quality of life on tropical islands in the Pacific.

For more information about LFA including helpful guides and workshops for treating or detecting LFA, please visit www.littlefireants.com.

To reduce the risk of spreading LFA, we recommend the following biosecurity protocol be implemented for projects that occur in native habitats on islands where LFA is currently recorded, and in areas known to be infested with LFA (check http://stoptheant.org/lfa-in-hawaii/ for status on each island).

Biosecurity Protocol for LFA

1. For projects involving plants from nurseries (e.g., outplanting activities, etc.), all plants should be inspected for little fire ants and other pests prior to being transported to the project site. If plants are found to be infested by ants of any species, plants should be sourced from an alternative nursery and the infested nursery should follow treatment protocols recommended by the Hawai‘i Ant Lab (https://littlefireants.com/wp-content/uploads/2020-Management-of-Pest-Ants-in-Nurseries-min.pdf).

2. All work vehicles, machinery, and equipment should follow steps 1 and 2 in the “Invasive Species Biosecurity Protocol” for (1) cleaning and treatment and (2) inspection for invasive ants prior to entering a project site.

3. Any machinery, vehicles, equipment, or other supplies found to be infested with ants (or other invasive species) must not enter the project site until it is properly treated (https://littlefireants.com/how-to-treat-for-little-fire-ants-for-homeowners/#recommended-bait-products) and re-tested. Infested vehicles must be treated following recommendations by the Hawai‘i Ant Lab (https://littlefireants.com/resource-center/) or another ant control expert and in accordance with all State and Federal laws. Treatment is the responsibility of the equipment or vehicle owner. Ultimately however, it is the responsibility of the action agency to ensure that all project materials, vehicles, machinery, and equipment follow the appropriate protocol(s).

4. General Vehicle Ant Hygiene: Even the cleanest vehicle can pick up and spread little fire ant. Place MaxForce Complete Brand Granular Insect Bait (1.0 percent Hydramethylnon; https://labelsds.com/images/user_uploads/Maxforce%20Complete%20Label%201-5-18.pdf) into refillable tamper resistant bait stations. An example of a commercially available refillable tamper resistant bait station is the Ant Café Pro (https://www.antcafe.com/). Place a bait station (or stations) in the vehicle and note that larger vehicles, such as trucks, may require multiple stations. Monitor bait stations frequently (every week at a minimum) and replace bait as needed. If the bait station does not have a sticker to identify the contents, apply a sticker listing contents to the station.

5. Gravel, building materials, or other equipment such as portable buildings should be baited using MaxForce Complete Brand Granular Insect Bait (1.0 percent Hydramethylnon; https://labelsds.com/images/user_uploads/Maxforce%20Complete%20Label%201-5-18.pdf) or AmdroPro (0.73 percent Hydramethylnon; https://connpest.com/labels/AMDROPRO.pdf) following label guidance.

6. Storage areas that hold field tools, especially tents, tarps, and clothing should be baited using MaxForce Complete Brand Granular Insect Bait (1.0 percent Hydramethylnon; https://labelsds.com/images/user_uploads/Maxforce%20Complete%20Label%201-5-18.pdf) or AmdroPro (0.73 percent Hydramethylnon; https://connpest.com/labels/AMDROPRO.pdf) following label guidance.

7. Vehicles that have entered a project site known or thought to overlap with areas infested with LFA should subsequently be tested for LFA with baiting in accordance with protocol recommended by the Hawai‘i Ant Lab (https://littlefireants.com/survey-your-home-for-lfa/).

8. If LFA are detected, please report it to 808-643-PEST (Hawai‘i), 671-475-PEST (Guam), or 684-699-1575 (American Samoa). Please visit https://littlefireants.com/identification-of-little-fire-ants/ for assistance in identifying LFA.

Coconut Rhinoceros Beetle (CRB)

The coconut rhinoceros beetle (*Oryctes rhinoceros*), or CRB, is a large, horned scarab beetle native to Southeast Asia. An invasive pest where it occurs outside of its native range, the adult beetles primarily attack coconut palms by boring into the crowns to feed on developing leaves. It is also known to feed on bananas, sugarcane, pineapples, oil palms, and pandanus trees. The larval grub stage burrow into and feed upon decomposing mulch and vegetation. On most Pacific Islands it lacks natural predators, leading to severe declines and extirpations of palm species where it has become established. On Guam, researchers have recently documented a shift of CRB to the island's native and threatened cycad tree (*Cycas micronesica*) (Marler et al. 2020). In the Hawaiian Islands, CRB is a documented threat to archipelago's native *Pritchardia* palm species.

For more information about CRB including the current situation in Guam and high/low-risk areas on O‘ahu, please visit http://cnas-re.uog.edu/crb/ or https://www.crbhawaii.org/.

To reduce the risk of spreading CRB, we recommend the following biosecurity protocol be implemented for projects that involve movement or creation of green waste and occur on islands where CRB is currently found. Please note there are protocols that pertain to specific geographic areas (O‘ahu or Marianas).

Biosecurity Protocol for CRB (O‘ahu)

1. Never transport green waste between islands and minimize the creation, storage, and transport of green waste within O‘ahu, this also includes:
    a. Mulch, bark, compost
    b. Soil of any kind
    c. Potted plants of any kind

    Additional consultation is recommended if the project involves transportation of materials, soil, equipment, vehicles, etc. between islands.

2. If felling or trimming palms, contact CRB Response for a free inspection ((808) 679-5244 or email at info@crbhawaii.org)

3. Keep green waste whole until it is ready to be treated and removed.
    a. Chip green waste on site and transport it on the same day to a secure and managed green waste disposal site/facility.
    b. For chipped green waste in high-risk areas, re-chip prior to movement outside the infested area, treat with pesticide (when applicable), heat treatment (>130 degrees F), spread and dry, or store in sealed durable containers.

4. Minimize accumulations of green waste by regularly treating mulch piles or depositing it in sealed green waste bins. In low-risk areas, we also recommend thinly spreading mulch (less than 2 inches deep) and allowing it to dry (no irrigation).

5. If injured or dying coconut palm trees are observed or if CRB are detected, contact CRB Response at (808) 679-5244 or email at info@crbhawaii.org or online at https://www.crbhawaii.org/report

Biosecurity Protocol for CRB (Marianas)

1. Never transport green waste between islands in the Marianas, this also includes:
    a. Mulch, bark, compost
    b. Soil of any kind
    c. Potted plants of any kind

    Additional consultation is recommended if the project involves transportation of materials, equipment, vehicles, etc. between islands.

2. Designate secure and managed green waste disposal sites to reduce the number of potential oviposition (laying of eggs) sites and larval food.

3. Green waste disposal sites should be monitored with CRB traps. The following control measures should be utilized at green waste sites.
    a. Netting - A gill net with a 1 inch mesh measured knot to knot, made from 0.25 mm nylon monofilament, should be laid over piles of green waste such as palm tree cuttings or decaying organic matter. The netting is helpful for trapping adult beetles emerging from the mulch.
    b. If the green waste site is found within or adjacent to chain link fencing, we recommend use of the DeFence trap. These are simply constructed with a 12 ft piece of tekken netting, folded in half, and secured onto a fence line using zip ties. In the middle of the net, attach a solar powered uvLED light, and a CRB pheromone lure protected in a red Solo cup. This trap design is currently among the most effective methods because it does not require many materials and uses the least amount of space on the property.
        i. For more information on trapping methods, please visit https://cnas-re.uog.edu/wp-content/uploads/2015/09/CRB-Trapping.pdf

4. If CRB are detected contact CNMI Forestry at (670) 256-3321 or Department of Lands and Natural Resources at (670) 322-9834 or Guam's Department of Agriculture Biosecurity Division (671) 477-7822 or email at guament@teleguam.net.

Brown Treesnake (BTS)

The Brown Treesnake (*Boiga irregularis*), or BTS, was accidentally introduced to Guam likely as a stowaway in military cargo shortly after WWII. On Guam, BTS has caused the extinction or extirpation of many native and endemic species of birds and lizards. The loss of native species has furthermore triggered cascading ecological impacts affecting Guam forest regeneration and ecology (Rogers et al. 2017). Preventing the spread of BTS from Guam to other Pacific Islands is the primary goal of the BTS Technical Working Group (TWG) formed by the 2004 BTS Control and Eradication Act. The BTS TWG developed a BTS interdiction program with the goal of 100-percent inspections of outbound cargo using canine inspection teams.

For more information about BTS including links to partnerships and ongoing research, please visit: https://www.fws.gov/pacificislands/articles.cfm?id=%20149489576

The USDA Wildlife Services are responsible for interdiction on Guam and collaborates with the Department of Defense, the Government of Guam, and private industry to remove snakes from outbound aircraft, sea vessels, and cargo. In the CNMI, the Department of Fish and Wildlife conducts redundant canine or visual inspections of inbound air/seacraft and cargo.

The following protocol is required for project activities that involve cargo, baggage, materials, etc. shipped from or through Guam prior to departure and upon arrival to the CNMI:

BTS Inspection Instructions for Guam and the CNMI:

1. Schedule cargo, aircraft, vehicle, and vessel inspections on Guam with the US Department of Agriculture (USDA) Wildlife Services (WS) for any and all vessels, vehicles, aircraft, and cargo that has been stationed or staged on Guam (for contact info, see Contact list on page 2). Inspections are available 24/7.
    a. All cargo staged on Guam must be inspected before transport to other Pacific Islands.
    b. Examples of cargo include vehicles, pallets of goods, loose boxes, containers filled with goods, bundles of construction materials (rolls of metal sheeting, stacks of plywood/boards, PVC pipes, or any material that provides an abundance of small, dark crevices).

2. Before your Guam-outbound cargo arrives on Saipan, Tinian, or Rota, schedule cargo inspections by Commonwealth of the Northern Mariana Islands (CNMI) Department of Fish and Wildlife (DFW).
    a. Rota – contact Jon Mesgnon (670-287-7683) and Manny Pangelinan (670-483-6261)
    b. Tinian – contact Ton Castro (670-287-9453) and Manny Pangelinan (670-483-6261)
    c. Saipan – contact Joe Cruz (670-285-7877) and Manny Pangelinan (670-483-6261)

3. If you see a snake while in cargo staging areas on Guam or anywhere on other islands:
    a. Report it immediately. Take note of where you are, what the snake looked like, and any notable behaviors. Attempt to kill, apprehend, or injure the snake, and take photos if possible. Keep visual contact with the snake until BTS program personnel arrive.
    b. To report a snake in the CNMI (e.g., Saipan, Tinian, Rota) call 670-28-SNAKE (670-287-6253)
    c. To report a snake on any island to the BTS Rapid Response Team on Guam, call 671-777-HISS (671-777-4477)
    d. If the snake is killed, save the carcass, and give to a CNMI, USDA, FWS, or USGS representative.

References Cited

Marler, T.E., Marler, F.C. Matanane, and L.I. Terry. 2020. Burrowing activity of coconut rhinoceros beetle on Guam cycads. Communicative & Integrative Biology, 13:1, 74-83. (https://www.tandfonline.com/doi/full/10.1080/19420889.2020.1774310)

Rogers, H.S., E.R. Buhle, J. Hille Ris Lambers, E.C. Fricke, R.H. Miller, and J.J. Tewksbury. 2017. Effects of an invasive predator cascade to plants via mutualism disruption. Nature Communications. 8:14557. https://www.nature.com/articles/ncomms14557/

DECONTAMINATION PROTOCOLS FOR PREVENTION OF INVASIVE SPECIES

Invasive plants, animals, and pathogens are a concern to public health, the economy, our watersheds, and the services they provide. Preventing the introduction of invasive species to new areas is important to eradication or containment efforts. Ensuring that gear and equipment are clean is a key component to stopping the spread and mitigating the impacts of invasive pests. Reporting newly arrived pests early in the infestation is crucial to eradication and significantly reduces resource spending and negative impacts.

WHAT to inspect & clean

- Gear, equipment, & tools

WHERE to inspect & clean

- Baseyard, site inspections

REPORTING invasive species

- What & how to report

Email: oisc@hawaii.edu

OISC
O'AHU INVASIVE SPECIES COMMITTEE
www.oahuisc.org

Call/Text: 808-286-4616

DECONTAMINATION PROTOCOLS FOR PREVENTION OF INVASIVE SPECIES

WHAT TO INSPECT & CLEAN

Look for seeds, plant material, soil, mud, insects, and other invertebrates.

LARGE EQUIPMENT & VEHICLES | **PERSONAL GEAR** | **SMALL EQUIPMENT & HAND TOOLS**

Large Equipment & Vehicles

(including but not limited to: hydraulic or wheel bulldozers, excavators, dump trucks, backhoes, chippers, bucket trucks, brush cutters, etc.)

Cleaning - Exterior

Manually remove clods of dirt with scraper, stiff brushes, or pry bar. Use compressed air to clean radiators and grills prior to using water. Use high pressure hose to wash from top to bottom.

Cleaning - Interior

Use brushes and/or vacuum to sweep out loose material (special attention to under mats, around seats and gear shifts).

Inspect & Clean Exterior

- Tires, tracks, rims, fender wells
- Spare tire mounting area
- Undercarriage & exhaust system
- Body (plates and panels)
- Light casings and mirrors
- Grills, bumpers and beds
- Chassis and engine bays
- Front and rear axles, brakes and shocks
- Boom, buckets, blade, and other attachments

Inspect & Clean Interior

- Beneath seats
- Beneath floor mats
- Upholstery
- Beneath foot pedals
- Inside folds of gear shift cover

WHAT TO INSPECT & CLEAN

Look for seeds, plant material, soil, mud, insects, and other invertebrates.

LARGE EQUIPMENT & VEHICLES **PERSONAL GEAR**

SMALL EQUIPMENT & HAND TOOLS

Personal Gear

- Clothing
- Hats/Helmets
- Jackets
- Gloves
- Socks
- Boots/shoes
- PPE (chaps, helmets, safety vests, etc.)

Cleaning:
Pockets should be thoroughly inspected for the above-listed materials. Pockets should be turned inside out to remove debris. Shoelaces and shoe tongues should be checked. Upon inspection, pre-clean personal gear by physical removal of dirt and mud with a stiff brush, lint remover, compressed air, or pressurized hot water. Clothing and gear that can be laundered, use soap and water. To kill fungal pathogens such as Rapid ʻŌhiʻa Death, spray footwear with 70% isopropyl alcohol and let sit for 15 seconds, AFTER mud and dirt are removed.

Areas of Concern:
Particular attention must be given to places where foreign material could become accidentally trapped, such as in the cuffs and folds of clothing, treads of boots or waders, or closures such as zippers or ties. Closures include: Zippers, belts, laces or ties, buckles, straps, Velcro grips, buttons and fasteners, and rivets. Attention to fabrics such as: canvas, nylon, cotton, poly blend, wool, fleece, netting, and suede. Other clothing items and accessories that should be checked include: socks and ankle grips, treads of footwear, cuffs and folds, seams, flaps, pockets, collars and hoods, and ventilation openings.

WHAT TO INSPECT & CLEAN

Look for seeds, plant material, soil, mud, insects, and other invertebrates.

LARGE EQUIPMENT & VEHICLES **PERSONAL GEAR**

SMALL EQUIPMENT & HAND TOOLS

Small Equipment & Hand Tools

(including but not limited to: riding mowers, zero-turn mowers, hedge-trimmers, chainsaws, leaf blowers, edgers, backpack sprayers, hand saws, loppers, shovels, machetes, rakes, etc.)

Inspect & Clean

- Mower decks
- Blades
- Undercarriages
- Wheels
- Seats
- Grills
- Safety guards
- Mufflers
- Air vents
- Housing covers
- Handles
- Moving parts
- Grooves
- Joints
- Cracks/Bends

Cleaning:
Manually remove clods of dirt with a scraper, stiff brush, or pry bar. Use compressed air to remove debris from radiators, grills, decks, and covers prior to using water. Wash with high-pressure hose or with water and brush. To kill fungal pathogens such as Rapid ʻŌhiʻa Death, spray footwear with 70% isopropyl alcohol and let sit for 15 seconds, AFTER mud and dirt are removed.

DECONTAMINATION PROTOCOLS FOR PREVENTION OF INVASIVE SPECIES

Where and when to inspect?

BASEYARD:
Before heading out for the day inspect all equipment, vehicles, hand tools, and clothing to ensure it is clean and free of debris. If it is not clean, note it on the daily inspection log (if available), then clean equipment before leaving for the site.

ARRIVAL AT WORK SITE:
Upon arrival, do a quick site assessment for any suspect invasive species of concern. If you find any, take a photo and report it to the O'ahu Invasive Species Committee (OISC) either by email: oisc@hawaii.edu or text: 808-286-4616.

DEPARTURE FROM WORK SITE:
Manually remove mud, dirt, and debris from personal gear and equipment before moving off the work site. Inspect all personal gear, tools, vehicles, and equipment.

RETURNING TO BASEYARD:
All vehicles, equipment, tools and personal gear should be completely free of all mud, dirt and debris. Inspections of equipment are logged daily to make sure it is clean (if available).

Reporting invasive species...

REPORT INVASIVE SPECIES
643-PEST
643pest.org
CALL OR CLICK TO PROTECT HAWAII

Not *every* invasive species in Hawai'i is managed because we simply have too many to tackle. However, some are managed statewide and some are managed island-wide. But not to worry! You don't have to know which species are managed or where. Just remember, **if it's weird report it** to the statewide pest hotline. They will take it from there and, if it is an actionable pest, they will forward the report to the appropriate agency.

DECONTAMINATION PROTOCOLS FOR PREVENTION OF INVASIVE SPECIES

OISC Target Species

OISC concentrates on species that pose the highest threat to the island's ecosystem, economy, and health of residents. We also consider those that have the greatest feasibility of eradication or containment. The following threats are priority species and are actively controlled by OISC. Sightings of these pests should be reported with a photo (if possible) immediately to OISC or www.643pest.org.

Report directly to OISC with location and photo via:
Email: oisc@hawaii.edu or Text: 808-286-4616

Click photo for link to species info or visit: www.oahuisc.org/target-pests/


Cane Tibouchina (Cane Ti)

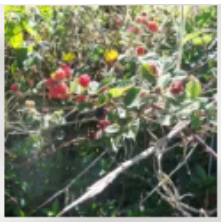

Coqui Frog


Glory Bush


Miconia

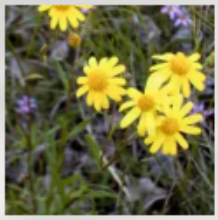

Cape Ivy


Devil Weed


Himalayan Blackberry


Pampas Grass


Coconut Rhinoceros Beetle


Fireweed


Little Fire Ant


Rapid Ohia Death

DECONTAMINATION PROTOCOLS FOR PREVENTION OF INVASIVE SPECIES

OISC Target Species Locations

The maps below represent KNOWN locations under management. Please take extra care to decontaminate gear equipment and tools when working in these areas. These species could be present anywhere on O'ahu. Report ALL suspect targets to OISC or the pest hotline, no matter where you see them.

Report directly to OISC with location and photo via:
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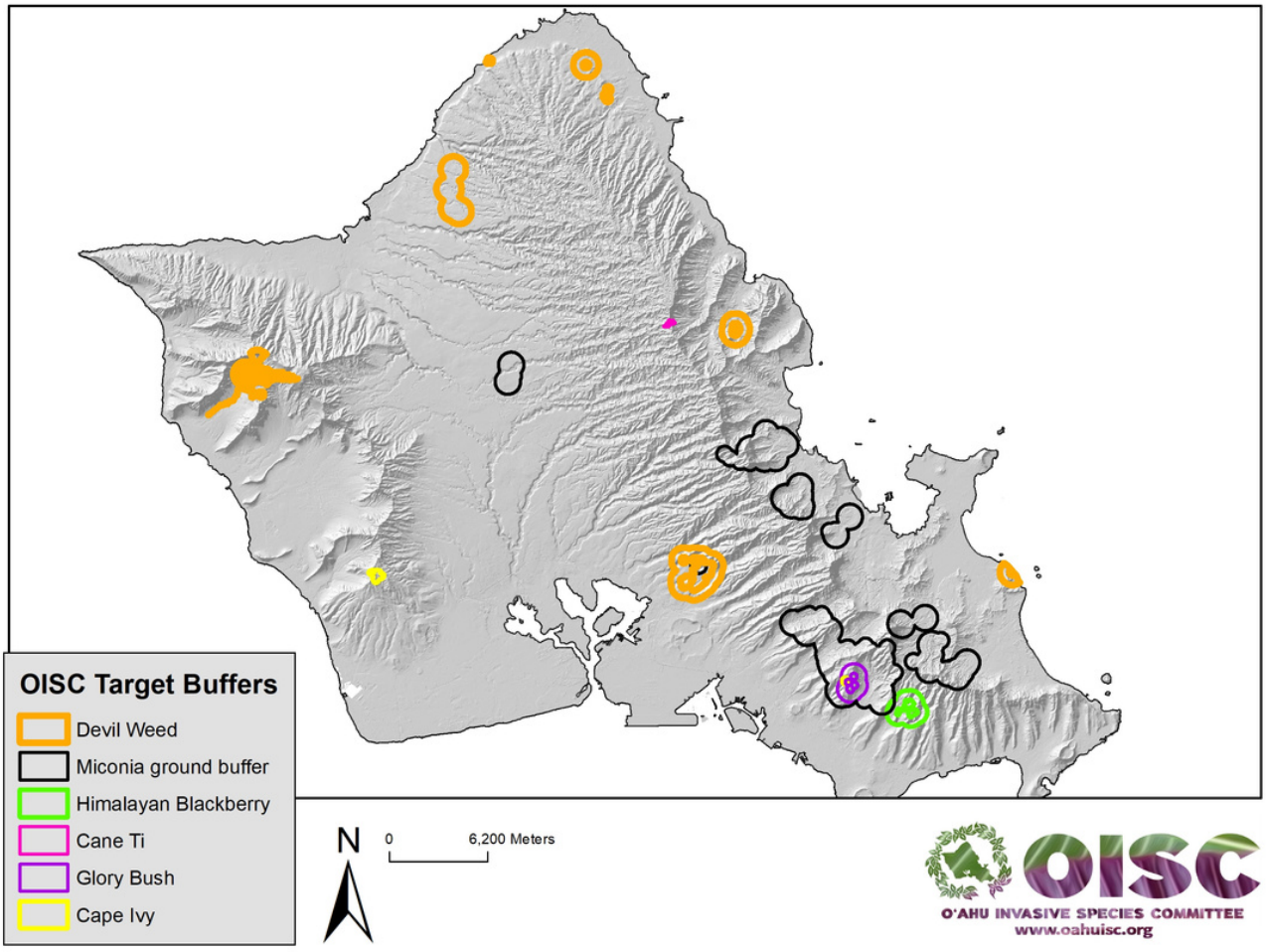

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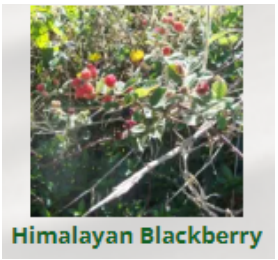
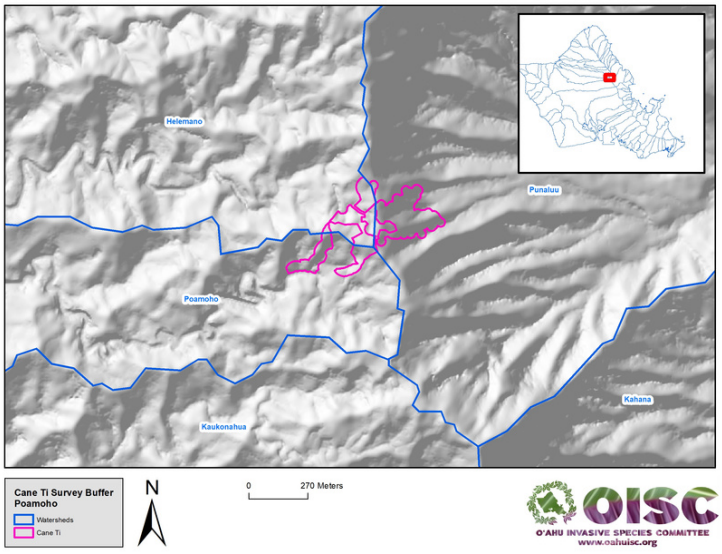
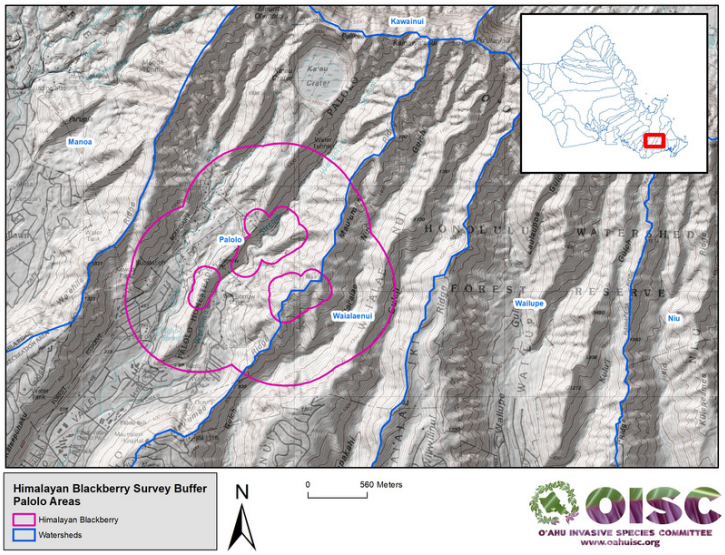
Cane Tibouchina (Cane Ti)



Himalayan Blackberry





DECONTAMINATION PROTOCOLS FOR PREVENTION OF INVASIVE SPECIES

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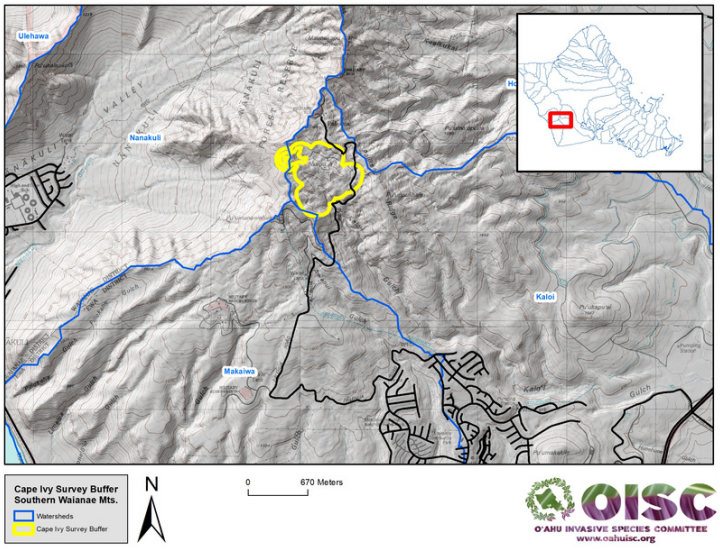
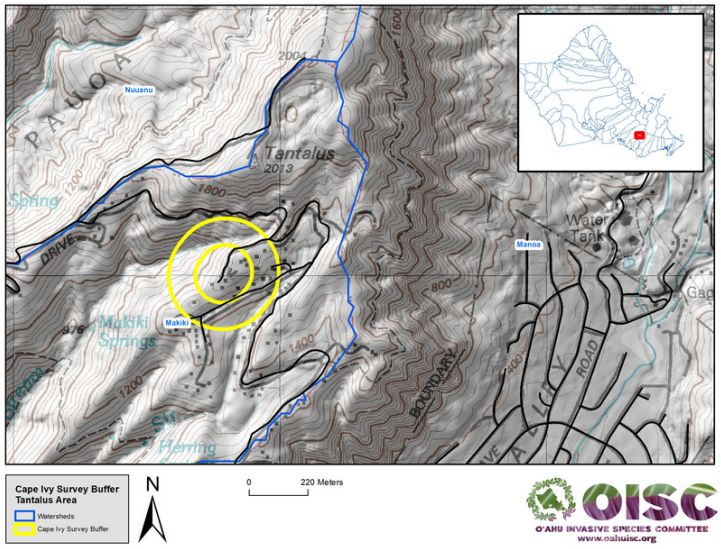
There are only two KNOWN locations on O'ahu that are being managed for Cape Ivy.

Cape Ivy





DECONTAMINATION PROTOCOLS FOR PREVENTION OF INVASIVE SPECIES

OISC Target Species Locations

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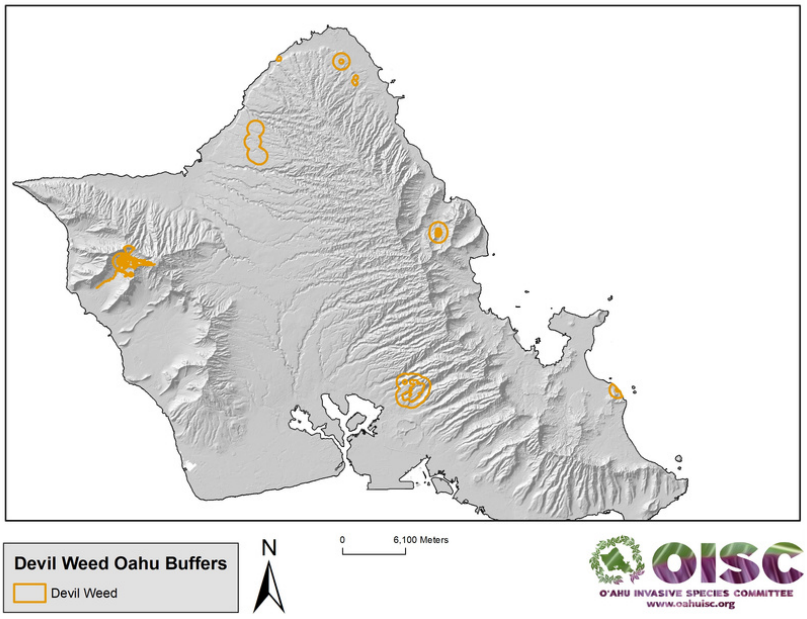
Click photo for link to species info or visit: www.oahuisc.org/target-pests/

Devil Weed has become too widespread for island-wide eradication. It has only been detected on O'ahu and Hawai'i Island. Select locations are being managed by OISC to suppress its spread. OISC is recording all detections and cooperatively managed by private landowners and public volunteers.

Devil Weed



DECONTAMINATION PROTOCOLS FOR PREVENTION OF INVASIVE SPECIES

OISC Target Species Locations

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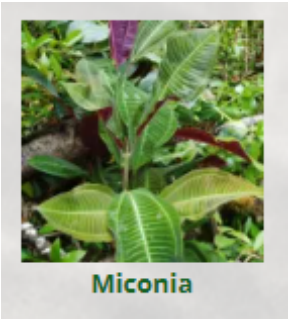
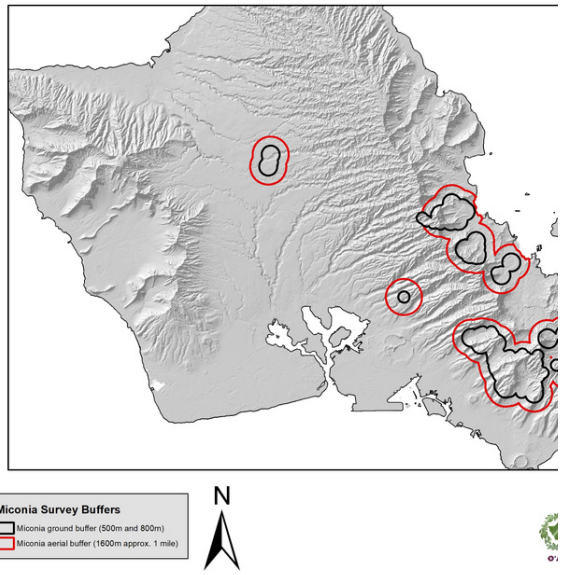
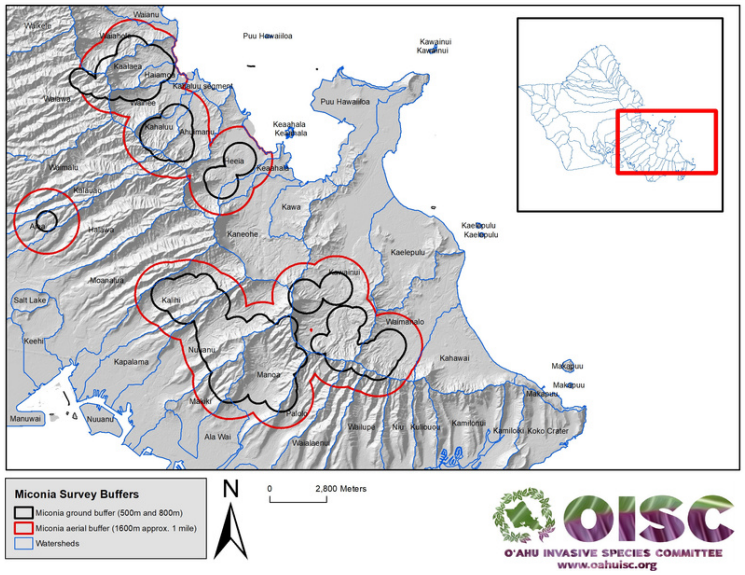
Click photo for link to species info or visit: www.oahuisc.org/target-pests/


Miconia

Miconia is an OISC eradication target. The majority of the infested areas are concentrated in the southern Ko'olau Mountain Range.





OISC
O'AHU INVASIVE SPECIES COMMITTEE
www.oahuisc.org

OISC Target Species Locations

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Click photo for link to species info or visit: www.oahuisc.org/target-pests/

All wild populations of fireweed and pampas grass have been eradicated from O'ahu. Re-introduction is possible anytime/anywhere, as these species are established on other islands. Report ***any*** suspect sighting to OISC.

Fireweed

Pampas Grass

DECONTAMINATION PROTOCOLS FOR PREVENTION OF INVASIVE SPECIES

OISC Target Species Locations

Each of the four species below has been detected in various locations on O'ahu. Little Fire Ants (LFA), Rapid 'Ōhi'a Death (ROD), and Coqui Frogs are being managed at all known locations by either OISC or in partnership with other organizations.

Coconut Rhinoceros Beetles are now established in numerous locations across O'ahu island. Management of CRB on O'ahu has shifted from eradication to containment. The CRB Response can provide guidance for green waste management and Best Management Practices (BMPs) for infested areas: www.crbhawaii.org

You can contact OSIC with any questions. E: oisc@hawaii.ed or call: (808) 286-4616.

Click photo for link to species info or visit: www.oahuisc.org/target-pests/

These four species occur or could occur ***anywhere*** on O'ahu.

Little Fire Ant

Rapid Ohia Death

Coqui Frog

Coconut Rhinoceros Beetle

If restorative planting efforts are taking place, be sure you are not using plants that can become invasive. Not all invasive plants are restricted from sale in Hawai'i. To ensure you are using only native or non-invasive plants, visit www.plantpono.org.

PLANT PONO
plantpono.org

DECONTAMINATION PROTOCOLS FOR PREVENTION OF INVASIVE SPECIES

QUICK TIPS

REPORT ANY SUSPECT INVASIVE SPECIES TO 643PEST.ORG OR YOUR LOCAL INVASIVE SPECIES COMMITTEE.

REPORT INVASIVE SPECIES
643-PEST
643pest.org
CALL OR CLICK TO PROTECT HAWAII

STINGING INSECTS: Most people notice little fire ants (LFA), not because they see them, but because they're getting stung. LFA can nest on the ground and in the trees. Report stinging ants and if possible collect ants for identification by your local Invasive Species Committee.

Check new materials for ants. Plants, planting materials, and building materials should be checked for LFA BEFORE use. Simply place coffee stirrers with a thin smear of peanut butter in and around new materials. Collect them after 1 hour, place any sticks with ants in a ziptop bag and freeze overnight. Mail or drop off ants for identification to your local Invasive Species Committee. For more details on where to submit your ants, visit: ww.stoptheant.org.

PALM DAMAGE & GRUBS: Coconut Rhinoceros Beetles (CRB) are most noticed by the damage to palm leaves and grubs in mulch and compost piles. For the latest information on Best Management Practices for CRB, and images of CRB damage to palm trees and beetle grubs, visit: www.crbhawaii.org

RAPID ʻŌHIʻA DEATH: Rapid ʻŌhiʻa Death (ROD) is a fungal disease that enters wounds of 'ōhiʻa trees. DO NOT INJURE ʻŌHIʻA. If you see an 'ōhiʻa tree with dead leaves attached, report it to your local Invasive Species Committee before pruning/removing. The tree will need to be tested for ROD and if it is infected, special protocols are required to reduce the risk of spreading the fungus. The ROD fungus can be present in the soil. Ensuring mud and debris are removed and spraying gear and tools with 70% alcohol will kill fungal spores.

Click here for a downloadable **ROD Sanitation Checklist**.