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

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November 2023

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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 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 cinereus semotus*) or ʻōpeʻapeʻa under the Tier 1 take scenario, NPMPP identified a plan consisting of a combination of habitat management and research. 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 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) to support protection of the area from the impacts of invasive species that are expected to negatively affect bat foraging and potentially roosting resources without intervention (Habitat Management Plan). The Tier 1 research program is described in a separate document, Hawaiian Hoary Bat Tier 1 Mitigation Research Plan (Research Plan; Tetra Tech 2023). The Research Plan is designed to investigate how the management actions described in this plan benefit bats.

The PMA was selected for several reasons. Although the Hawaii Department of Land and Natural Resources (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 fence maintenance (of the fence constructed by DLNR), feral pig (*Sus scrofa*) removal, and invasive species removal; thus, the need exists for funds to ensure protection and recovery of bat habitat. The specific quantification of the area to be managed and its relationship to the number of bats benefited through the mitigation actions is described in the Project HCP and was based on guidance from the U.S. Fish and Wildlife Service (USFWS) and DLNR- Division of Forestry and Wildlife (DOFAW; Tetra Tech 2016). The U.S. Fish and Wildlife Service issued an Incidental Take Permit for the Project based on their review and approval of the HCP and the proposed bat mitigation program, and DLNR – Division of Forestry and Wildlife similarly reviewed and approved the HCP and issued an Incidental Take License.

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 documented bats in similar habitats (Tetra Tech 2016, Starcevich et al. 2020). Given the on-going threats from feral pigs and invasive plants, this habitat has been negatively impacted and will continue to degrade without active and consistent management. Protection from impacts of feral pigs and invasive plant removal will 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 forested corridor connected to the Ahupua ʻ a O 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 2023). 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, and support for infrastructure maintenance such as the pig proof fence that contribute to protection of this environment. These actions are expected to increase available bat prey and result in an associated increase in bat acoustic activity within the managed area, which will be determined via the monitoring program described in this Habitat Management Plan.

This Habitat Management Plan:

- Describes relevant Hawaiian hoary bat information that provide a theoretical understanding of how bats will benefit from management actions proposed for this mitigation project;
- Describes the baseline condition of 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.

2.0 Mitigation Framework

As described in Section 1.0, the Project's Tier 1 bat mitigation plan is comprised of two elements: the Habitat Management Plan (this document) and the Research Plan (Tetra Tech 2023). 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 2023). These two elements work in tandem to achieve and document direct benefits to the Hawaiian hoary bat 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 USFWS and 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 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. An increase in acoustic activity will also be measured by detecting vocalizations that signify changes in foraging and roosting activity. 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.

3.0 Hawaiian Hoary Bat Background

The Hawaiian hoary bat, a solitary tree roosting bat, occurs on all the major Islands in the Hawaiian Archipelago, Kauaiʻi, Oʻahu, Maui, Lānaʻi, Molokaʻi, and Hawaiʻi (Tomich 1986). Recent significant investments in research and preliminary results from management efforts have provided significant insights into habitat use, tree roost characteristics, diet, population dynamics, seasonal occupancy and foraging ranges on the islands of Oʻahu, Maui, and Hawaiʻi. Significant knowledge gaps related to the species' life history, survival, sex and distributions, and population size, remain, but findings 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.

3.1 Distribution, and Population Trends

On Hawaii 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). Seasonal changes in acoustic activity observed at several locations on Oʻahu (Gorresen et al. 2015, Starcevich et al. 2020) and Maui (Todd et al. 2016, Auwahi Wind 2020, Tetra Tech 2020a, Tetra Tech 2020b) suggest similar altitudinal migrations occur on these islands.

Occupancy studies conducted on Hawaiʻi Island suggest that population is stable and potentially increasing (Gorresen at al. 2013). Similar studies are currently ongoing to monitor population trends on Oʻahu. 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.

3.2 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 Hawaiʻi Island have documented the hoary bat traversing greater that 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 (Bonaccorso et al. 2015; Whitaker and Tomich 1983; Belwood and Fullard 1984; Jacobs 1996, 1999; Poe 2007). These sites provide sheltered foraging grounds on windy night and facilitate easy capture of prey.

Hoary bats are known to forage on a variety of insects from 10 orders and 24 different families (Todd 2012, HT Harvey 2019, Pinzari et al. 2019). However, Lepidoptera—butterflies and 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 H=hoary bats have been shown to selectively forage on Coleoptera, which may be easier to catch and provide additional nutrients demands (Todd 2012). For many bat species including Hawaiian hoary bats, increased rates in activity are associated with increased abundance of insect prey (Gorresen et al. 2018, Todd 2012, Haddad et al. 2001, Knops et al. 1999).

Roost trees species used by Hawaiian Hoary bats include both native and non-native species. The diversity in roost trees used by Hawaiian hoary bats exists only among non-native species, as the only native trees species confirmed as a roost tree by hoary bats is ʻōhiʻa (*Metrosideros polymorpha*). Habitat use studies of radio tagged bats indicate that Hawaiian hoary bats select roost trees with a mean height of 21 meters, a mean diameter at breast height of 75 centimeters, a mean canopy cover of 43 percent, and a mean distance of 29 meters from the forest edge (Montoya-Aiona 2020). These results suggest that structure, not species, are the deciding factors of use by Hawaiian hoary bats. Other studies have found that a varied vegetative structure provides shelter for insect species that are the prey for Hawaiian hoary bats, and preferred edge habitat for Hawaiian hoary bat foraging (Jantzen 2012, HT Harvey 2019). In addition, monotypic habitats—like stands of strawberry guava (*Psidium cattleyanum*) are associated with reduced bat foraging quality (Fenton 1997, Williams et al. 2006).

4.0 Poamoho Management Area

The PMA and adjacent ʻEwa Forest Reserve is primarily DLNR-owned forested habitat along the leeward summit of the central Koʻolau Mountains[1]. The PMA is located above Wahiawa in the ʻEwa

[1] The northern fencing unit of the PMA includes 70 acres on Kamehameha Schools' property within the Kawailoa Training Military Reservation.

Forest Reserve (Figure 1) and is proposed to be part of the state Natural Area Reserve System. Native, high-elevation 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 ʻEwa Forest Reserve. Ungulate proof fence has been installed on two parcels, one 654 acres and the other 653 acres. DLNR is responsible for long-term management of the area and relies heavily on KMWP to support management of the area.

The ʻEwa Forest Reserve provides habitat for the Hawaiian hoary bat and use of the area and the vicinity has been documented (Tetra Tech 2016, Starcevich et al. 2020). 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 bat activity

With limited data collection, Hawaiian hoary bat acoustic activity has been documented within the PMA at relatively low rates. During a 30-day deployment of one acoustic monitor (April 14, 2014 – May 13, 2014) one bat was detected (April 22, [pregnancy reproductive period]) (Tetra Tech 2016)[2]. Preliminary results from an island-wide acoustic monitoring research project suggests a generally low occupancy rate in the vicinity of the PMA (average 0.0153 detections/detector-night June 2017 – October 2019) with detections limited to the lactation (mid-June – August) and post-lactation (September – mid-December) seasons (Starcevich et al. 2020). 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). 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 6.2).

4.2 Threat assessment

Invasive plants, plant pathogens, and feral ungulates 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 Hawaiʻidue 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., Kauaʻi Invasive Species Committee 2015, Kaiser et al. 2019).

[2] Summary data only in Tetra Tech (2016).

Thirty established invasive plant species have been identified throughout the PMA (Table 1) during recent surveys conducted by KMWP. 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 east 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 Moluccanalbizia (*Falcataria falcata*) and cane tibouchina (*Chaetogastra herbacea*; Figure 2). Each of these species are becoming well-established and have the potential to significantly affect habitat quality and diversity if not aggressively managed.

The aforementioned invasive species 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 ʻōhiʻa, a keystone species and important roost tree for bats.

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	

Scientific Name	Common Name	Method[1]	Herbicide[2]	Focal Management Species
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	Christmasberry/Brazilian pepper	IPA	100% Polaris	
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 Plant pathogens

In Hawaiʻi, the most notorious plant pathogens to date are vascular wilt fungus (*Ceratocystis lukuohia*) and the canker pathogen (*Ceratocystis huliohia*). These two newly described species are responsible for causing Rapid ʻŌhiʻa Death (ROD), resulting in the devastating mortality of ʻōhiʻa forests (Barnes et al. 2018).

ʻŌhiʻa is an iconic keystone canopy tree species endemic to Hawaiʻi. It is the most common and widespread native tree species throughout Hawaiʻi, occurring from sea level to 2,500 meters elevation and is a pioneer and foundation species in both mesic and wet montane forests and on substrates ranging from 50 to 4 million years in age (Friday and Herbert 2006, Loope 2016, Pratt and Jacobi 2009). It is the most ecologically important native tree in Hawaiʻi, defining native forest succession and ecosystem function over broad areas, providing critical habitat for rare and endangered native bird, bat, and insect species, and exemplifying the strong links between native Hawaiian culture and the islands' environment (Dawson and Stemmermann 1990, Gruner 2004, Peck et al. 2014).

The fungal pathogens that trigger ROD cause browning of canopy leaves in weeks to months following infection by the pathogens. Inoculation trials conducted on seedlings indicate that both *Ceratocystis* species are aggressive on ʻōhiʻa. However, field observations on the progression of symptoms in naturally infected trees suggest that *C. huliohia* is less aggressive than *C. lukuohia* (Barnes et al. 2018). *Ceratocystis lukuohia* has now been identified as the main cause of stand-level mortality events, whereas *C. huliohia* is thought to be associated with smaller, more localized mortality events. (Fortini et al. 2019).

First detected in 2010 in the Puna district of Hawaiʻi Island, ROD has since spread to an estimated 40,469 hectares across Hawaii Island, resulting in the death of hundreds of thousands of native ʻōhiʻa (Keith et al. 2015, Mortenson et al. 2016). In 2018 *C. lukuohia* was confirmed on the Island of Kauaʻi (DLNR 2018) and in July of 2019 a single case of *C. huliohia* was confirmed on Maui and five cases of *C. huliohia* were confirmed on Oʻahu (CTAHR 2022), including in the PMA.

The rapid spread of *C. lukuohia* and *C. huliohia* in Hawaiʻi presents a great threat to the diversity, structure, and function of ʻōhiʻa forests and the services they provide. If the disease is not contained, much of the landscape is likely to be replaced by non-native species (Mortenson et al. 2016).

The use of ʻōhiʻa as the only native roost tree species used by hoary bats in Hawaiʻi further highlights its importance as a keystone species. The loss of ʻōhiʻa in the PMA due to ROD would reduce the availability and quality of Hawaiian hoary bat roost trees and could be anticipated to degrade foraging habitat by facilitating further establishment of monotypic invasive species forest stands.

4.2.3 Feral ungulates

Pigs are currently the only feral ungulates occupying habitat in the vicinity of the PMA. They have been extirpated from the PMA; 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 (Scowcroft and Hobdy 1987, Anderson and Stone 1993, Siemann et al. 2009, Cole et al. 2012), facilitates the invasion of non-native plants species (Ickes et al. 2001, Spear and Chown 2009), and creates sites suitable for vectors of avian and disease (Stone and Loope 1987, Wehr et al. 2018). Furthermore, feral pigs can increase exposure and transmission of ROD (Mortenson et al. 2016).

Disturbances from feral pigs strongly suppresses establishment of many native Hawaiian species (Cole and Litton 2014) and can result 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 common native species can occur relatively quickly (within 6.5 years) following the removal of feral pigs (Cole and Litton 2014) and 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).

5.0 Management Program

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 of the 1,307 acres of habitat in the PMA 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 (see Tetra Tech [2016] for details). This section describes the management actions associated with the Management Plan, the results of which are monitored through the monitoring program (Section 6.0) and measured against the success criteria (Section 8.0). 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
- Plant pathogen surveillance and management
- Feral ungulate surveillance and management (feral ungulates have been removed from the PMA but threaten incursion into the PMA if fences are damaged [sections 4.2.3, 5.1.3]).
  - Regular fence inspections and maintenance activities
  - Rapid response program to inspect and repair fence as required following storm events
  - Monitoring program to identify and respond to presence of feral ungulates within the management area

It is assumed that the existing native seed bank will reestablish over time in areas where invasive species are removed and managed. Supplemental outplantings will be added in response to the monitoring as part of adaptive management, as needed (see Section 9.0).

5.1 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 (USFWS 1998, Mitchell et al. 2005, Gorresen et al. 2013) 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 recommendations for management and control of the major threats are described below. Together these management strategies aim to protect the existing native canopy species while facilitating the recruitment of native understory species.

5.1.1 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 ti 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.

Mauka, Moluccan albizia, and cane ti 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 over the next eight years.

<u>Invasive Plant Species Management Goals and Actions</u>

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. Supplemental funding in Year 1 and Year 5 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 target invasive vegetation control measures. Goals and associated actions are:

- Significant reduction in target invasive weed species cover within the PMA.
    - Field crews will be deployed at least monthly to manage invasive vegetation within the PMA. Due to the remote location and regular use of helicopter for deployment, KMWP has found deployment of field crews of four to six staff to be the most effective use of resources.
        - Primary target species will be mule's foot fern, strawberry guava, manuka, Moluccan albizia, and cane ti, as well as any incipient arrivals determined to pose a similar threat.
        - 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 to monitor for and respond to priority incipient invasive species
    - Field crews are well-trained and knowledgeable with respect to invasive species. Through the course of field work and regular traversing of access trails and fence lines, field crews will monitor for the arrival of incipient invasive plant species.
- Avoid the spread of invasive plant species to the PMA or to other managed sites from the PMA.
    - Field crews will implement avoidance and minimization measures to avoid transport of invasive species seeds to the PMA or to other managed sites from the PMA, which includes cleaning mud/soil off of shoes, gear, clothing, and vehicles and following the ROD guidelines (see Section 5.1.2).

5.1.2 Plant pathogens

Early detection and management of infected trees is critical to stop the spread of ROD. As of April 2023, there were 12 locations with positive ROD detections on Oʻahu; six on residential properties and six in forested, wildland areas (DOFAW 2023). One of these 12 locations is the PMA, where in 2020, ROD was identified in five ōhiʻa trees(University of Hawai'i 2023). . Of the two *Ceratocystis* species responsible for causing ROD, only *C. huliohia* has been identified within the management area. Although *C. huliohia* is less aggressive than *C. lukuohia* (University of Hawai'i 2023), it still poses a serious threat. The objective of the ROD management goal is to minimize the spread and impact of ROD within the PMA over the next eight years.

ROD Management Goals and Actions

Management actions will aim to identify and regress the spread of ROD while stopping further introductions of the pathogen throughout the PMA. Best use sampling practices are periodically updated by the University of Hawaiʻi College of Tropical Agriculture and Human Resources (CTAHR: ROD Sampling) and will be implemented as suggested. Goals and associated actions are:

- Identify and record trees suspected to be infected with *Ceratocystis* fungus. Observations will occur incidentally during implementation of management activities in PMA.
    - Field crews will be trained in the identification of trees suspected to be infected by ROD.
    - Suspected trees will be reported and, if appropriate, tested based on current guidance.
    - Where suspected or confirmed ROD is present, these areas will be avoided to the extent possible to minimize physical damage from staff and vehicles.
- Stop further introductions of ROD pathogen into the PMA.
    - All staff working in the PMA will be trained on proper procedures to minimize the risk of spreading ROD.
    - If not already established, an information sign will be set up at the entrance of the Poamoho Trail to educate trail users of the risk of ROD and necessary steps to stop it spread.
    - The information sign will be accompanied by a boot cleaning station.
    - Vehicles the travel off-road is areas where suspected or confirmed ROD is present, will wash the tires and undercarriage with detergent to remove all soil and mud prior to entering uninfected areas.

5.1.3 Feral ungulates

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. Ungulate removal is also critical in minimizing the impact of ROD.

Fence construction and removal of ungulates in the PMA was completed by KMWP, Oʻahu Army Natural Resources Program, and DLNR in 2016. However, continued financial support is required to ensure the integrity of the fence-line and exclusion of ungulates from the area. The objective of the feral ungulate management goal is to exclude pigs from the PMA and avoid associated potential impacts.

Feral Ungulate Management Goals and Actions

Currently feral pigs are the only ungulate of concern for the PMA. The following is an outline of goals and strategies to ensure the exclusion of feral ungulates from the PMA over the next eight years. Goals and associated actions are:

- Maintain fence integrity

    - Visual inspection of the entire fence-line will be conducted quarterly throughout the 8-year implementation of the Management Plan to ensure the integrity of the exclosure.

    - Additional fence inspections will be conducted following storm events along with increased surveillance for potential incursion if a breach in the fence is observed.
    - Repair of any holes or fasteners and replacement of panels or posts will be conducted as needed to maintain the integrity of the exclosure.
- Maintain feral pig exclusion from the PMA
    - Passive trapping and monitoring methods and visually check monitoring locations quarterly. Conduct opportunistic monitoring for pig sign in conjunction with weed removal and other management efforts.
    - Hunting and trapping, and increased monitoring will be implemented following identification of pig activity within the PMA.

6.0 Evaluative Monitoring

The monitoring plan is designed to monitor changes in vegetation, bat prey, and bat acoustic activity within the PMA during the period of performance (8 years) and provide periodic (Years 1, 3, 5, and 8) measurable results that can be used to identify successful mitigation or provide information to suggest that adaptive management is required to meet the Habitat Management Plan's measures of success (Table 2). Additional monitoring components discussed above (sections 4.2.1 – 4.2.3) include monitoring for incipient invasive species, ROD, fence integrity, and feral ungulate intrusion to the PMA. However, although these measures are considered beneficial and will contribute to the overall success of the project, they will not directly show changes at the PMA associated with improvements to bat foraging habitat, bat prey, nor bat use. Baseline conditions will be based on monitoring during Year 1 of this Habitat Management Plan (Section 6.1).

Table 2. Anticipated Project Implementation Timeline

Time Frame	**Mitigation Year**	**Description of Actions**
2024	Year 1	• Initiation of management actions • Baseline vegetation monitoring (April to June) • Baseline bat prey monitoring (quarterly) • Baseline bat acoustic activity monitoring (nightly) • Data analysis (3-month period immediately following conclusion of evaluative monitoring annual cycle)
2025	Year 2	• Implementation of management actions • Annual report (by June 1)

Time Frame	Mitigation Year	Description of Actions
2026	Year 3	• Implementation of management actions • 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) • Annual report (by June 1)
2027	Year 4	• Implementation of management actions • Annual report (by June 1)
2028	Year 5	• Implementation of management actions • 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) • Annual report (by June 1)
2029	Year 6	• Implementation of management actions • 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) • Annual report (by June 1)
2030	Year 7	• Implementation of management actions • 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) • Annual report (by June 1)
2031	Year 8	• Implementation of management actions • 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) • Annual report (by June 1)
[1] NPMPP will add monitoring in Years 6 and 7 if Year 5 bat acoustic activity has not increased (see Section 9.0) [2] If adaptive management is required additional monitoring will be added in Year 6 and possibly Year 7.		

6.1 Vegetation and bat prey monitoring

Fifteen 0.5-hectare (20 meter x 25 meter) monitoring plots will be established within the PMA (Figure 3). 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 delineated 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 and 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[3]), serving as an initial condition of "invasive species dominated." The invasive species that contributes most significantly to monitoring plot invasive species cover within individual plots will be based on the monitoring plot selection. Plot locations meeting the habitat selection criteria above and safety requirements will be identified within randomly selected grid cells covering the PMA.

Arthropod sampling will occur in the monitoring plots four times a year in each monitoring year (Years 1, 3, 5, and 8) (Table 2). 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 monitoring year in Years 1, during the peak blooming period for annual vegetation (April to June). Photos will be taken at the established photo points for each plot, and sampling will include:

- Vegetation
    - Invasive plant species absolute percent cover
    - Plant species richness
- Arthropods
    - Diversity
    - Abundance (i.e., biomass)

[3] 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 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.

6.1.1 Vegetation monitoring

Monitoring plots will be subject to the same habitat management actions as the remainder of the habitat within the PMA. This differentiates these evaluative monitoring plots from the control plots identified in the Research Plan (Tetra Tech 2023), which occur outside the PMA, will not be actively managed, and which are likely to be impacted by feral ungulates (Figure 4).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 3). 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.[4] This will ensure a consistent level of effort among plots.

6.1.2 Bat prey monitoring

Arthropods will be sampled in each plot using two methods: sweep nets or a vacuum aspirator and a light trap or malaise trap. Each sampling method is best suited for certain taxa, and the use of multiple sampling methods may give more complete results than the use of a single method (McCravy 2018). Light traps are an extremely common and efficient trapping method, attracting insects towards the light where they are funneled into a collection container. Malaise traps are large tent like structures made of netting that funnel insects into a common area (Montgomery et al. 2021) Both light traps and malaise traps target flying insects, such flies (Diptera), wasps, flying ants, bees (Hymenoptera), true bugs (Hemiptera), moths (Lepidoptera) (Montgomery et al. 2021). The malaise trap would be modified to include a collection reservoir (e.g., a pan with collecting liquid) at the bottom as well as the top to ensure beetles are collected (DOFAW pers. comm May 25, 2023). Spatial placement is extremely important for both of these trap types given that light traps

[4] 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.

are only effective at a distance of less than 30 meters (Truxa and Fiedler 2012) and malaise traps must be within the flight path of the insect (Montgomery et al. 2021).

Vacuum aspirators and sweep nets collect insects directly from vegetation, capturing both flying and non-flying insects, and can also be used to collect epigeic (i.e., live on the soil surface) arthropods (McCravy 2018). Both sweep nets and vacuum aspirators have been found to result in similar species richness, however the mean size of invertebrate biomass was greater for sweep netting than vacuum sampling. Vacuum sampling was more effective at collecting small (less than 5 cm) invertebrates, whereas sweep netting captured large (greater than 5 cm) Orthoptera and Lepidoptera larvae at higher rates (Doxon et al. 2010).

Collection using sweep nets or vacuum aspirators will be conducted along five parallel 20 meter transects, approximately 1 meter wide, spaced 5 meters apart (Figure 3) over the course of one day. Malaise traps or light traps will be placed at the center of each of the plots (Figure 3). Malaise traps would operate for one to two weeks per quarterly sampling period and light traps would operate two to three nights per quarterly sampling period. All samples collected will be combined for each plot. Arthropods collected during each sampling period with a body length ≥ 5 millimeters will be sorted to order, size, and oven-dried for 48 hours at 65°C (Gorresen et al. 2018). Size classifications with include ≥ 5 to 10 millimeters, >10 to 20 millimeters, and > 20 millimeters. Biomass was chosen as it has shown to be a better response variable when investigating trophic interactions and can provide a more accurate picture of the processes driving changes in community structure (Saint Germain et al. 2007).

6.2 Bat acoustic activity monitoring

The goal of bat acoustic activity monitoring is to quantify increases in bat acoustic activity at the site as a function of changes to foraging and roosting activity in response to the management actions. To measure changes, NPMPP will deploy 15 acoustic monitors within the PMA. 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.

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). Nine of the SM4 acoustic monitors will be randomly distributed throughout the PMA. The six additional SM4 acoustic monitors will be associated with randomly selected sampling plots described in Section 6.1—two “native forest” plots, two “established invasive species” plots, and two “invasive species dominated” plots. 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 calls/total active detector-nights (primary measure);
- Number of nightly call files;

- Number of echolocation pulses;
- Type of call (i.e., passive or active search call, and feeding buzz);
- Foraging duration; and
- Timing of nightly activity

7.0 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. The Research Plan (Tetra Tech 2023) integrates and compares the changes in invasive plant and arthropod communities to help understand how areas where management levels are reduced and feral ungulates evolve over time.

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 and richness. Year and initial status 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 use metrics will be summarized during evaluative years and compared to baseline data to evaluate changes in the use metrics. Depending on the patterns of observed use, bat use metrics may be evaluated seasonally to highlight changes correlated with management activities.

8.0 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 reasonably attributed to the mitigation actions. Based on consultation with USFWS and DOFAW, successful implementation of the management portion of the bat mitigation plan will perform habitat management actions that improve the environment for bats and that these changes are correlated with a statistically significant increase in bat acoustic activity. This is consistent with the Hawaiian hoary bat guidance document (DOFAW 2021), which states that core use area “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, Cornman 2021, Kotila 2023). 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[5], 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 diversity or abundance of bat prey. Changes in habitat quality, including the amount of bat prey, is expected to increase bat acoustic activity. Enhancement of 1,307 acres of Hawaiian hoary bat habitat in the PMA over this period in combination with the associated $100,000 Research Plan (Tetra Tech 2023) 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).

Success Criteria:

1. Statistically significant increase in plant species richness over baseline;
2. Statistically significant reduction in invasive plant species absolute percent cover over baseline;
3. Statistically significant increase in arthropod abundance or richness increase over baseline; and
4. 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 Management Plan.

9.0 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 3). NPMPP will analyze data in years 1 (baseline), 3,

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

5, and 8 to track progress towards meeting goals. If plant species richness and arthropod abundance or richness have not resulted in 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 (this increase does not need to be significant), adaptive management would be triggered. 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 or richness have not resulted in a statistically significant increase in "established invasive species" and "invasive species dominated" plots, NPMPP will initiate supplemental out-planting of native species within the PMA to promote recovery of areas impacted by invasive plant species (Table 3). Out-planting stock will be selected based on identified areas requiring supplemental planting and sourced 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.

If by Year 5 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 PMA or identify additional target areas for increased management (Table 3). 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 Management Plan is on track to meeting the success criteria), adaptive 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 3) 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 Management Plan is on a track to meeting the final success criteria and NPMPP can forgo Year 7 monitoring and adaptive management.

Table 3. Adaptive Management Triggers and Responses

Monitoring Year	Plant Species Richness	Arthropods	Bat Acoustic Activity	Potential Adaptive Management Response
Year 1	Baseline Monitoring			
Year 5	No statistically significant increase within established invasive species and	No statistically significant increase in established invasive species and invasive	No increase in a primary bat activity metric (either duration or level of	• Supplemental out-planting of native species

Monitoring Year	Plant Species Richness	Arthropods	Bat Acoustic Activity	Potential Adaptive Management Response
	invasive species dominated plots compared to baseline	species dominated plots compared to baseline	activity) compared to baseline; this increase does not need to be significant	• Identify additional target areas for increased management • Increase the intensity of management throughout the PMA
Year 6[1]	No statistically significant increase in established invasive species and invasive species dominated plots compared to baseline	No statistically significant increase in established invasive species and invasive species dominated plots compared to baseline	No statistically significant increase in a primary bat activity metric (either duration or level of activity) compared to baseline	• Supplemental out-planting of native species • Identify additional target areas for increased management • Increase the intensity of management throughout the PMA
Year 7[2]	No statistically significant increase in established invasive species and invasive species dominated plots compared to baseline	No statistically significant increase in established invasive species and invasive species dominated plots compared to baseline	No statistically significant increase in a primary bat activity metric (either duration or level of activity) compared to baseline	• Supplemental out-planting of native species • Identify additional target areas for increased management • Increase the intensity of management throughout the PMA
Year 8	Success criteria are not met			• Extend management duration • Identify additional target areas for increased management

[1]Only applicable if Year 5 success criteria are not met.
[1]Only applicable if Year 6 success criteria are not met.

10.0 Reporting

Annual reports will be submitted to the cooperating agencies and stakeholders that summarize the results of restoration activities, preliminary analysis results, and adaptive management approaches to habitat management and restoration.

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Figures

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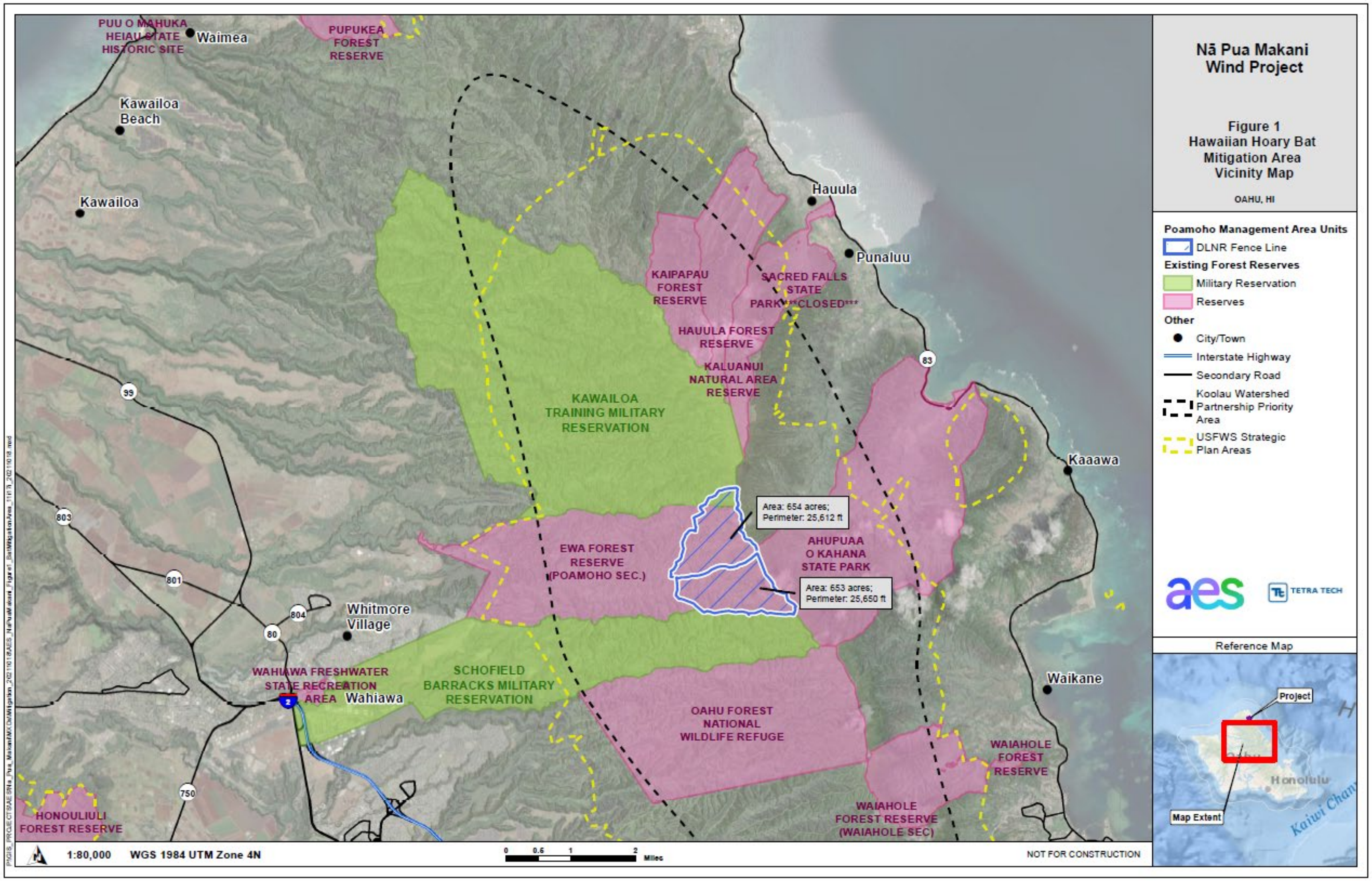
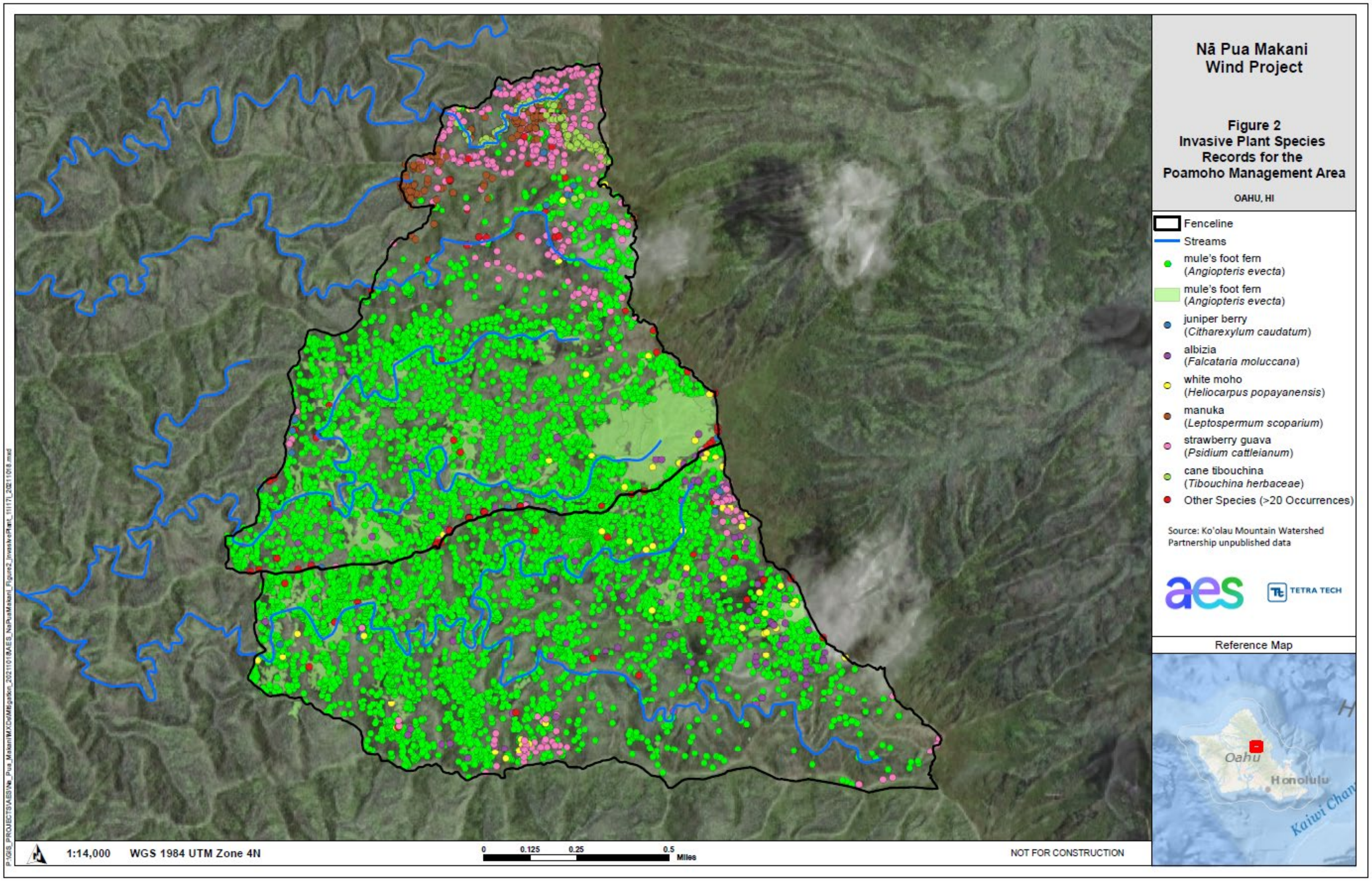
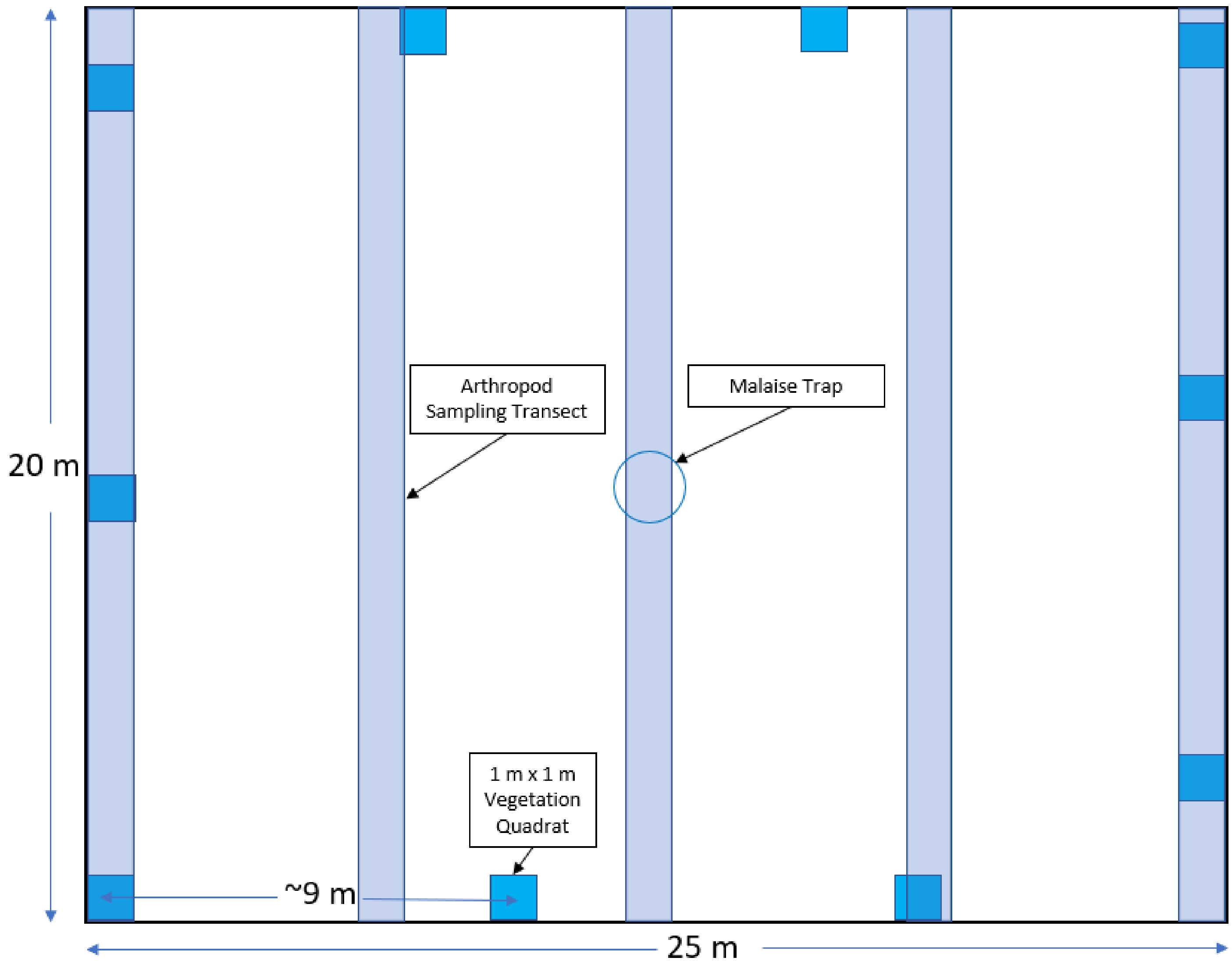
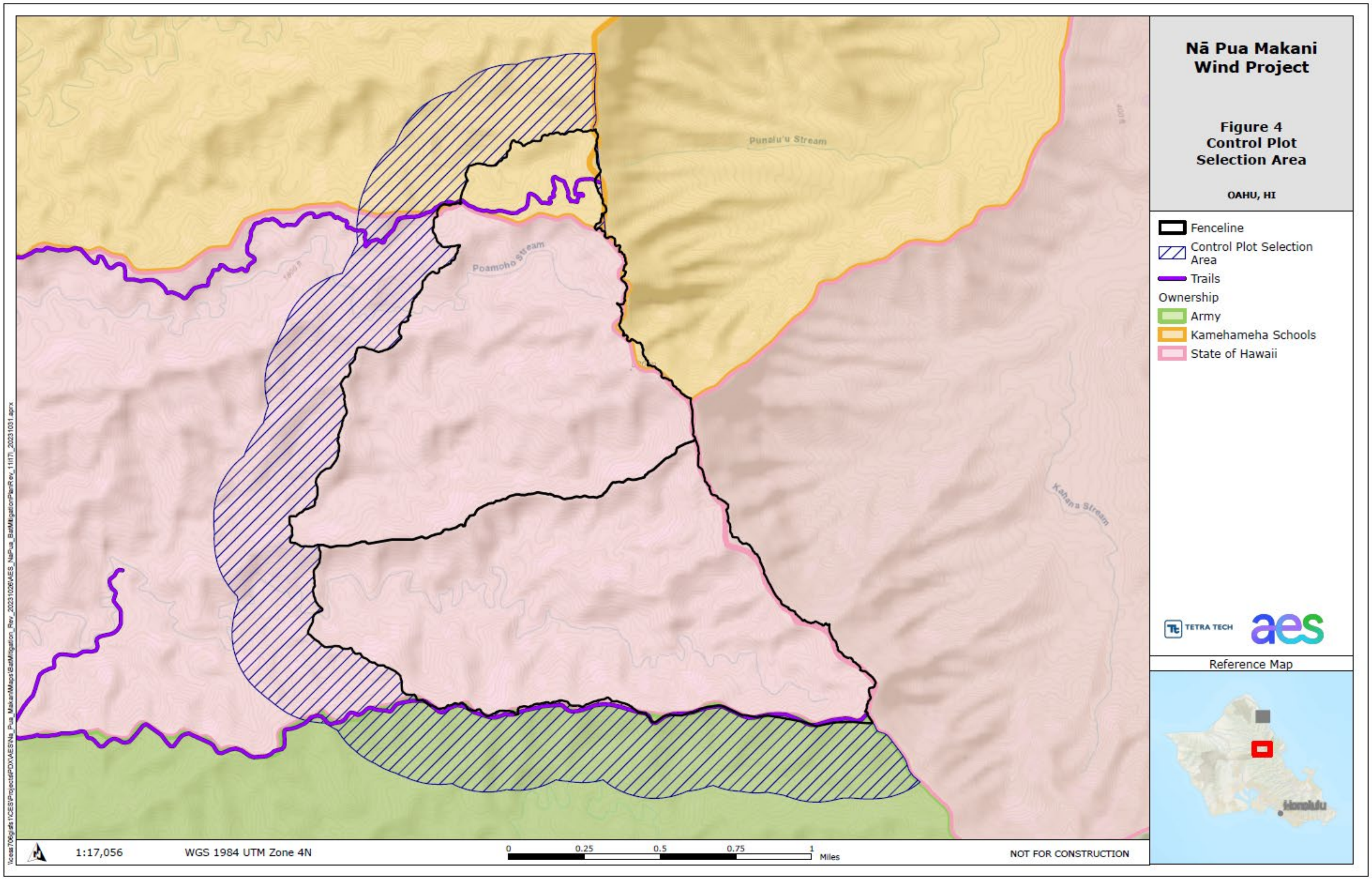

Nā Pua Makani Wind Project
Figure 1
Hawaiian Hoary Bat Mitigation Area Vicinity Map
OAHU, HI
Poamoho Management Area Units
DLNR Fence Line
Existing Forest Reserves
Military Reservation
Reserves
Other
City/Town
Interstate Highway
Secondary Road
Koolau Watershed Partnership Priority Area
USFWS Strategic Plan Areas
Reference Map
Project
Map Extent
Honolulu
PUU O MAHUKA HEIAU STATE HISTORIC SITE
Waimea
PUPUKEA FOREST RESERVE
Kawailoa Beach
Kawailoa
Hauula
Punaluu
KAIPAPAU FOREST RESERVE
SACRED FALLS STATE PARK***CLOSED***
HAUULA FOREST RESERVE
KALUANUI NATURAL AREA RESERVE
KAWAILOA TRAINING MILITARY RESERVATION
Kaaawa
Area: 654 acres; Perimeter: 25,612 ft
EWA FOREST RESERVE (POAMOHO SEC.)
AHUPUAA O KAHANA STATE PARK
Area: 653 acres; Perimeter: 25,650 ft
Whitmore Village
WAHIAWA FRESHWATER STATE RECREATION AREA
Wahiawa
SCHOFIELD BARRACKS MILITARY RESERVATION
OAHU FOREST NATIONAL WILDLIFE REFUGE
Waikane
WAIAHOLE FOREST RESERVE
WAIAHOLE FOREST RESERVE (WAIAHOLE SEC)
HONOULIULI FOREST RESERVE
1:80,000
WGS 1984 UTM Zone 4N
Miles
NOT FOR CONSTRUCTION



Nā Pua Makani Wind Project
Figure 2
Invasive Plant Species Records for the Poamoho Management Area
OAHU, HI
Fenceline
Streams
mule's foot fern (*Angiopteris evecta*)
mule's foot fern (*Angiopteris evecta*)
juniper berry (*Citharexylum caudatum*)
albizia (*Falcataria moluccana*)
white moho (*Heliocarpus popayanensis*)
manuka (*Leptospermum scoparium*)
strawberry guava (*Psidium cattleianum*)
cane tibouchina (*Tibouchina herbaceae*)
Other Species (>20 Occurrences)
Source: Ko'olau Mountain Watershed Partnership unpublished data
TETRA TECH
Reference Map
Oahu
Honolulu
1:14,000
WGS 1984 UTM Zone 4N
0 0.125 0.25 0.5 Miles
NOT FOR CONSTRUCTION

Figure 3. Example Monitoring Plot Layout




Nā Pua Makani
Wind Project
Figure 4
Control Plot
Selection Area
OAHU, HI
Fenceline
Control Plot Selection Area
Trails
Ownership
Army
Kamehameha Schools
State of Hawaii
Reference Map
Honolulu
Punalu'u Stream
Poamoho Stream
Kahana Stream
1:17,056
WGS 1984 UTM Zone 4N
0
0.25
0.5
0.75
1
Miles
NOT FOR CONSTRUCTION