

Hawaiian Hoary Bat Tier 1 Mitigation Research Plan

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1.0 Introduction

The Nā Pua Makani Wind Project (Project) Habitat Conservation Plan (HCP) describes a mitigation program to compensate for potential Project take of 34 Hawaiian hoary bat (*Lasiurus semotus*) or ‘ōpe‘ape‘a comprised of: 1) Habitat management efforts and 2) Research. Nā Pua Makani Power Partners, LLC (NPMPP) contracted Tetra Tech, Inc. (Tetra Tech) to develop detailed management and research plans associated with the mitigation components described under HCP Tier 1 Hawaiian hoary bat take levels for review and approval by the regulatory agencies and the Endangered Species Recovery Committee (ESRC). The Nā Pua Makani Hawaiian hoary bat Tier 1 Habitat Management Plan (Habitat Management Plan) describes the corresponding management plan (Tetra Tech 2025). This Research Plan leverages the actions of and habitat changes resulting from the Habitat Management Plan within the Poamoho Management Area (PMA). This Research Plan compares temporal habitat changes within control sites where ungulates are present and no or minimal invasive species management is performed to add depth to the understanding of the effects of the management actions (Tetra Tech 2025).

Based on input from the U.S. Fish and Wildlife Service (USFWS) and the Department of Land and Natural Resources (DLNR)—Division of Forestry and Wildlife (DOFAW) and supported by the recommendation for approval of the Project’s HCP by the ESRC, the PMA of the DLNR ‘Ewa Forest Reserve was selected as the appropriate location to carry out management efforts for the Hawaiian hoary bat. During the HCP approval process, the ESRC, USFWS, and DOFAW emphasized the importance of monitoring and tracking the effectiveness of management actions carried out at the PMA, as bat mitigation activities have not been performed in a largely intact, but simultaneously imminently threatened ecosystem before. As a result, the ESRC and regulatory agencies agreed that it was important to investigate, through supplemental research, the results of mitigation actions at the PMA. The Research Plan is intended to collect data that will help inform future habitat management decisions targeted to benefit the Hawaiian hoary bat. This additional focused research, as part of the mitigation effort described in the HCP, expands on the required basic effectiveness monitoring described in the Habitat Management Plan (Tetra Tech 2025).

2.0 Mitigation Framework

The Project’s Tier 1 bat mitigation plan is comprised of two elements: the Habitat Management Plan (Tetra Tech 2025) and this Research Plan. These two elements work in tandem to achieve and document direct benefits to the Hawaiian hoary bat and to gather additional data 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. The Habitat Management Plan (Tetra Tech 2025) specifically evaluates whether actions to protect and restore habitat and bat prey resources increase acoustic activity by Hawaiian hoary bats through an evaluative monitoring program. 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.

3.0 Research Approach

This Research Plan adds a control study to the Habitat Management evaluative monitoring program to increase understanding of how and when management efforts yield benefits. The primary objective of this study is to better understand in what way and how quickly habitat degradation affects arthropod communities that are important foraging resources for Hawaiian hoary bats. Specifically, this study investigates 1) the pace at which key invasive species modify biomass and presence of arthropod communities once established, 2) how arthropod communities change in response to changes in the dominance of invasive species within a plot, 3) any correlations between documented environmental factors (e.g., elevation, slope) and the rate of establishment of invasive species or the rate of their expansion within plots, and 4) how active management and ungulate exclusion in an area influences observed changes. Importantly this research will allow for the study of how degradation influences these factors while monitoring within the management plots in the PMA will aim to determine if forest management activities (e.g., invasive plant management and outplanting) has any influence on prey base or bat presence. Combined these efforts will result in a better understanding 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 information should also improve our understanding of the scale and timeline of habitat impacts (and associated impacts to bat prey) averted through the habitat management actions. Gaining this understanding should provide land managers information to help prioritize actions related to habitat management in relation to goals of contributing to Hawaiian hoary bat recovery. Finally, a detailed evaluation of site characteristics over time in the vicinity of an observed boundary—marking changes in the level of bat acoustic activity—may help reveal factors associated with these changes (Montoya-Aiona 2020, Montoya-Aiona et al. 2023).

The intention is to have a study that is designed and implemented in a way that could support publication in a peer-reviewed journal.

4.0 Study Area

4.1 Site Description

The study area included in this Research Plan consists of two distinct areas: the NPMPP Mitigation Area, a portion of the PMA, which serves as the experiment site where habitat management will

occur, and is included in the Habitat Management Plan (Tetra Tech 2025) and portions of the adjacent 'Ewa Forest Reserve and adjacent properties, which encompass the control site where habitat management will not occur. Both areas are primarily DLNR-owned forested habitat along the leeward summit of the central Ko'olau Mountains¹. The PMA is located above Wahiawā 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 (*Sus scrofa*) 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. The 'Ewa Forest Reserve provides habitat for the Hawaiian hoary bat and use of the PMA and the vicinity has been documented (Tetra Tech 2016, Thompson and Starceovich 2022). Ungulate-proof fences have been installed on two parcels, one 654 acres and the other 653 acres; combined these comprise the PMA. The protected PMA includes protection priority 1 watershed areas (DLNR 2011) and key native forest habitat that afford native plants and animals opportunities for protection through active management. DLNR is responsible for long-term management of the PMA and relies heavily on the Ko'olau Mountains Watershed Partnership (KMWP) to support management of the area.

Generally the NPMPP Mitigation Area extends across the majority of the PMA. It includes some areas where management activities are currently underway by partner agencies. Those areas are not counted towards the total area where NPMPP is requesting mitigation credit for Hawaiian hoary bat. Management activities will not occur evenly across the NPMPP Mitigation Area for a variety of reasons. There will be areas of Management Focus Areas that are derived from resource issues, the need for threat abatement, and opportunities for habitat enhancement for Hawaiian hoary bat.

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 parameters for the selection of MFAs 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. The criteria used to determine MFAs included a combination of biotic and abiotic factors along with logistical factors that will influence management and monitoring activities (these details are outlined in the Bat Management Plan).

Due to insecure funding and a high need for habitat protection and management throughout the Ko'olau Mountains, consistent financial commitments are necessary. Habitat management funding from the Project will ensure management of habitat and maintenance of fences for the PMA over the next eight years. This associated Research Plan will improve managers' understanding of the

¹ The northern fencing unit of the PMA includes 70 acres on Kamehameha Schools' property within the Kawaihoa-Poamoho Training Area.

effects of management actions and management inaction on resources important to the conservation of the Hawaiian hoary bat.

4.2 Habitat Management Actions within the Poamoho Management Area

Habitat management actions that will be carried out as part of NMPP's Hawaiian hoary bat mitigation program include fencing repair and maintenance, ungulate removal (as required²), and habitat restoration through invasive plant species control and outplanting of native species. Outplanting of native plant species is planned to reduce the risk of erosion or otherwise accelerate benefits beyond those achievable through natural recruitment processes. Outplanted tree species will also result in the creation of bat habitat over time. Overall, the goals of these actions are to restore natural gap dynamics, open natural waterways, increase ecosystem diversity, and protect the PMA against on-going habitat degradation that would be anticipated without a long-term, stable, and secure funding source. By achieving these goals, NPMPP expects to observe increases in bat prey species abundance and diversity (e.g., Haddad et al. 2001, Taki et al. 2010). Changes in prey species are expected to coincide with increases in bat acoustic activity (Coleman and Barclay 2013, Frick et al. 2023). Habitat management actions will not occur outside of the PMA.

4.3 Vegetation Status

Habitat within the PMA and adjacent portions of the 'Ewa Forest Reserve are dominated by an intact, but imminently threatened, mesic to wet native 'ōhi'a (*Metrosideros polymorpha*) forest. The area hosts the diverse array of native plants expected in mid-elevation mesic and wet forests on O'ahu (e.g., koa [*Acacia koa*], uluhe [*Dicranopteris linearis*] 'ōlapa [*Cheirodendron* spp.]), as well as significant populations of invasive plant species (e.g., mule's foot fern [*Angiopteris evecta*], strawberry guava [*Psidium cattleianum*], and manuka [*Leptospermum scoparium*]). Incipient populations of other habitat-modifying weeds such as Moluccan albizia (*Falcataria falcata*) and cane tibouchina (*Chaetogastra herbacea*) also occur in the area. Though these numbers are currently low, active management is needed to ensure that populations do not grow beyond controllable levels.

5.0 Materials and Methods

Bat prey and vegetation conditions will be tracked in up to nine monitoring plots (control plots) distributed randomly but considering logistical factors (e.g., accessibility) and capturing a range of initial conditions relative to level of establishment of target invasive species in the control plots.

² The fenced units within the PMA are ungulate free; however, periodic damage to the fence could allow pigs to access the area. Regular fence inspections and monitoring for ungulate activity will ensure that any incursions are identified promptly and the pigs are removed before causing significant damage.

5.1 Planned method

Up to nine 0.05-hectare (20 meter x 25 meter) control plots will be established outside but proximate to the PMA (Figure 3). The number of actual plots will be dependent on the space available on adjacent lands (Figure 3) and consideration of impacts that could occur from the establishment of monitoring plots and repeated presence of researchers accessing the locations. Both the number and size of plots may be adjusted in order to maximize the information collected, for research purposes, while minimizing the impact on the land and native forest community.

Initial delineation of the 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. Control plots will be delineated by the degree of invasive vegetation cover to evaluate its effect on arthropod abundance (Emery and Doran 2013). There will be three types of control plots and an equal number of each type for comparison purposes. The first type will include control plots that contain no observed presence of mule's foot fern, strawberry guava, manuka, or Moluccan albizia (invasive species deemed likely to form large monotypic habitat altering stands), serving as an initial condition of "native forest." The second type will include control plots 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 percent³). The third type of control plots will include areas where the selected invasive species is dominant within the vegetation community (ground or canopy cover > 30 percent³), serving as an initial condition of "invasive species dominated." Plot locations meeting the habitat selection criteria above and safety and logistical requirements will be identified within randomly selected grid cells covering the PMA control plot buffer (Figure 3). Logistics, including implementation of practices to avoid spreading invasive plant species, will require grouping of control plots into clusters to allow monitoring of 3 – 4 individual plots per day. To ensure independence, control plot locations will be at least 200 meters apart.

5.2 Alternative method

Should the proposed control 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), control plots will be modified to be linear transects. Ultimately, all plots will be of the same type (linear or rectangular), including evaluative monitoring plots proposed in the

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 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. Moluccan albizia's dominance similarly exerts its influence at the canopy level, resulting in the transition of understory to bare earth or invasive groundcover species.

Management Plan (Tetra Tech 2025). The decision on which approach to use will be based on a preliminary site visit upon the approval of the 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.

5.3 Plot locations and sampling schedule

Control plots will be distributed outside the southern, western, and northern boundaries of the PMA (habitat east of the PMA abruptly changes to sheer cliffs and is substantially different than within the PMA so has been excluded). These sites may be located on the 'Ewa Forest Reserve or other within areas managed and owned by other cooperating entities (i.e., Army Natural Resources Program of O'ahu and Kamehameha Schools) (Figure 3). The specific locations will be selected within a 400-meter buffer of the perimeter fence (Figure 3), but potential sites may be excluded based on accessibility⁴, logistical considerations, landowner restrictions, habitat selection criteria, and similarity in forest structure and elevation to evaluative monitoring plots selected in the PMA (Tetra Tech 2025). Control plot locations meeting the criteria above will be identified within randomly selected grid cells. The goal is to identify a distributed set of control plots where invasive species management levels are reduced from those within the PMA and feral ungulates have access but where forest conditions are otherwise like the evaluative monitoring plots identified for the Habitat Management Plan (Tetra Tech 2025). Based on available data from KMWP (Figure 2), the primary invasive species present in these control plots is expected to be mule's foot fern; however, the overall presence of a range of invasive species cover values within control plots will be measured.

Arthropod sampling will occur four times a year in each monitoring year (Years 1, 3, 5, and 8), matching the timing of arthropod sampling within the evaluative monitoring plots (Tetra Tech 2025). 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, 3, 5, and 8 during the peak blooming period for annual vegetation (April to June), matching the timing of the vegetation sampling within the evaluative monitoring plots (Tetra Tech 2025). Photos will be taken at the established photo points for each control plot, and sampling will include:

⁴ Proximity to landing zones or trails and allowing safe and regular access to perform required monitoring.

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

5.4 Vegetation monitoring

This section initially describes how the planned method (see Section 5.1) would be used to monitor vegetation in control plots in the vicinity of the PMA. A second section describes how that sampling approach would be adjusted if the alternative sampling plot approach (see Section 5.2) is used.

5.4.1 Planned method

Plant species richness and invasive plant species absolute cover will be evaluated within control plots using the methods described within this section and consistent with the methods and timing described in the Habitat Management Plan (see Section 5.0 and Tetra Tech 2025). Control plots differ from evaluative monitoring plots within the PMA. Control plots will not undergo habitat management whereas evaluative monitoring plots within the PMA will be managed consistent with habitat management practices deployed throughout the PMA.

To measure invasive plant species absolute percent cover, the relative area covered by each invasive species will be estimated in ten 1-meter² quadrats located around the boundary of each control 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 control plots based on the species cover in each of the ten quadrats within each control plot.

To measure plant species richness in each control plot, all individual species (includes trees, shrubs, grasses, and ferns) will be counted in ten 1-meter² quadrats located around the boundary of each control 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 control plots. A supplemental search will be conducted in each control 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 control plot. The supplemental search will be a 15-minute to one-hour effort providing meandering survey coverage over the remainder of the control plot

(Huebner 2007, Young and Johnstone 2011, Bourdaghs 2014).⁵ This will ensure a consistent level of effort among control plots.

5.4.2 *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 5.4.1.

5.5 Bat prey monitoring

This section initially describes how the planned method (see Section 5.1) would be used to monitor bat prey in control plots in the vicinity of the PMA. A second section describes how that sampling approach would be adjusted if the alternative sampling plot approach (see Section 5.2) is used.

5.5.1 *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).

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):

$$y = a(x)b$$

⁵ If no new species are added and coverage of the entire control 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 control plot has been surveyed.

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). Alternative method

Under the linear transect monitoring approach sweep net or vacuum aspirator sampling would occur along the entire 100-meter long transect. The Malaise trap or light trap would be positioned at approximately at the mid-point (50 meters) of the 100-meter long transect. In all other respects, insect sampling protocols would match those described in section 5.5.1.

5.6 Roles and Responsibilities

The division of responsibilities shown in Table 1 is based on NPMPP's intent to contract with KMWP to conduct fieldwork with assistance from Tetra Tech.

Table 1. Anticipated Responsibilities by Entity

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

5.7 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 information on best management practices is included as Appendix A in the associated Hawaiian Hoary Bat Tier 1 Mitigation Habitat Management Plan for the Poamoho Management Area. These practices will be applied during 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.

6.0 Analysis

This Research Plan uses data from the Habitat Management Plan (Tetra Tech 2025), supplemented by the addition of control plots to compare the changes in invasive plant and arthropod communities within and outside the PMA over time. These analyses should help inform how areas where management levels are reduced and feral ungulates are present evolve in comparison to areas with more intensive management and no ungulates.

An Analysis of Covariance (ANCOVA) will be conducted on data from up to nine plots outside of the PMA described here (control plots) and the 15 plots within the PMA and subject to the beneficial actions described in the Habitat Management Plan (evaluative monitoring plots; Tetra Tech 2025). This analysis will compare the effects of that habitat degradation, through the impacts of invasive species, on arthropod biomass and richness within the PMA versus outside the PMA. Year, initial status, inside PMA/outside PMA treatments 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 and inside PMA/outside PMA treatments over time. Canonical analyses of principal coordinates (CAP; Anderson and Willis 2003) will be used to visualize how arthropod and invasive plant communities shifted.

7.0 Benefit to bats

Understanding how plant communities and associated Hawaiian hoary bat prey evolve in the absence of intensive management (e.g., removal of invasive plants and exclusion of ungulates) will provide information relevant to habitat management decision-making associated with the goals of protection and recovery of the Hawaiian hoary bat. This information in combination with results from the Habitat Management Plan monitoring (Tetra Tech 2025) should help land managers prioritize actions to benefit the Hawaiian hoary bat and better understand how to prioritize actions in native forest that is significantly impacted by invasive species. The granularity of detailed field studies such as this can illuminate important aspects of life history and related ecological processes that are important to identifying effective habitat management tools for specific sites. This study specifically provides an opportunity to improve our understanding of how habitat and bat prey interact with and without management actions, as well as the role invasive species management can have on improving the availability of bat prey in a native-dominated, but imminently threatened forest environment.

8.0 Adaptive Management

The Research Plan is subject to field conditions that may affect specific field protocols (e.g., the planned quadrat size), the comparability of data over time, or significantly change conditions at one or more of the evaluative monitoring or control plots. NPMPP will coordinate closely with KMWP throughout the implementation of the Research Plan (and the associated Habitat Management Plan) to ensure potential issues are minimized, and monitoring and data collection methodologies are consistent in areas with and without ungulates. However, if conditions within the evaluative monitoring or control plots change such that they significantly impact the ability of NPMPP to collect data, or the potential analysis or interpretation of research results, NPMPP will work with the USFWS and DOW to identify a suitable approach to adjust the research study design. In addition, if adaptive management triggers additional monitoring in the management area due to not meeting the success criteria, additional monitoring would also occur in the control site.

Such adjustments could include the incorporation of alternative analysis procedures, the addition, elimination, or substitution of evaluative monitoring or control plots, or other adjustments identified based on the specific conditions being addressed.

9.0 Budget

The estimated combined budget for habitat monitoring at the PMA and the control site is shown in Table 2. Based on varying levels of effort required to conduct evaluative and research monitoring, Tetra Tech estimates three quarters of monitoring (staffing, materials, reporting, and analysis costs) are attributable to the 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. If adaptive management is required, additional costs may result.

Table 2. Estimated Budget for Habitat Monitoring, Analysis, and Reporting

Description	Entity	Year 1 Total¹	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	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			

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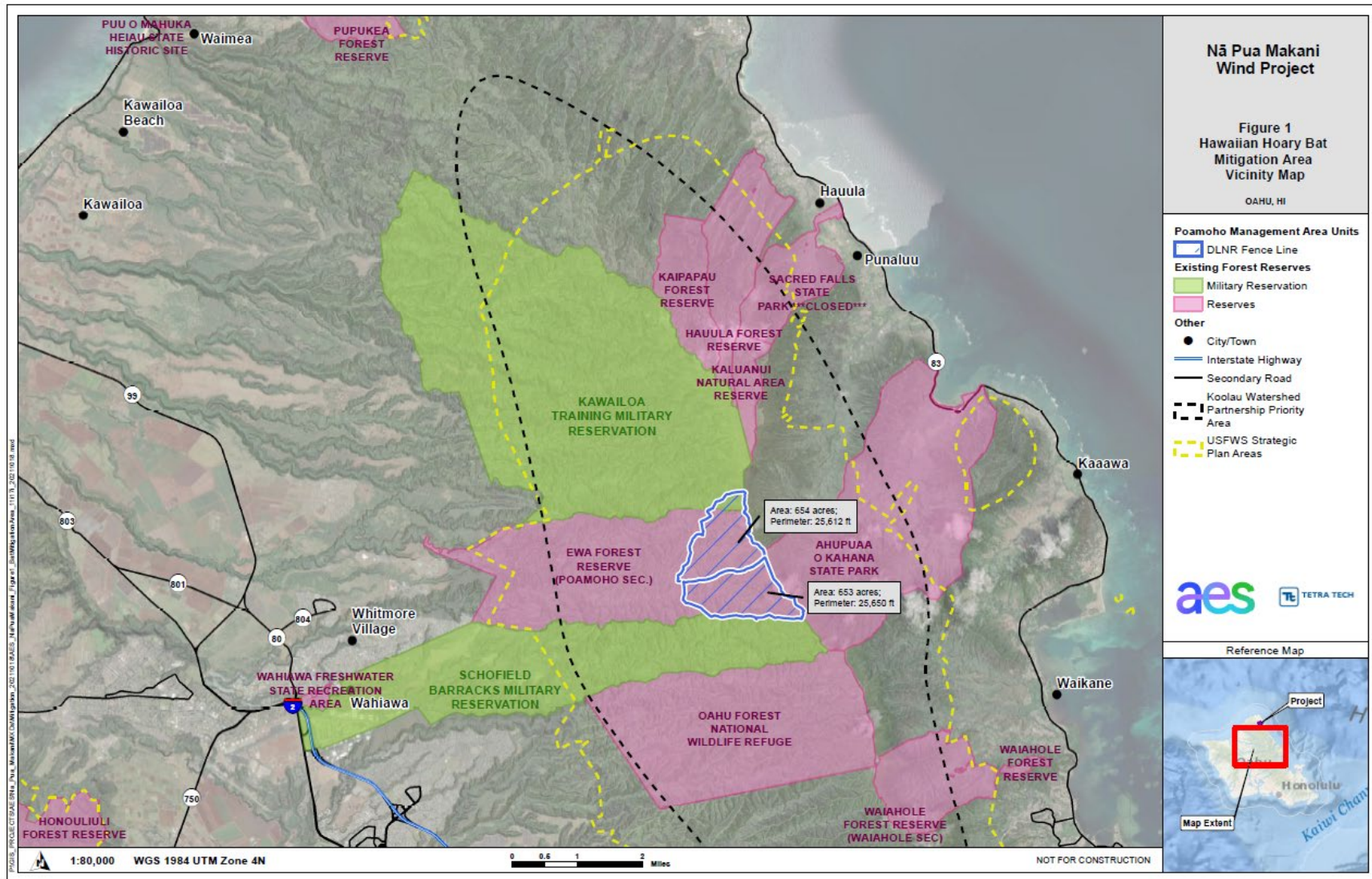
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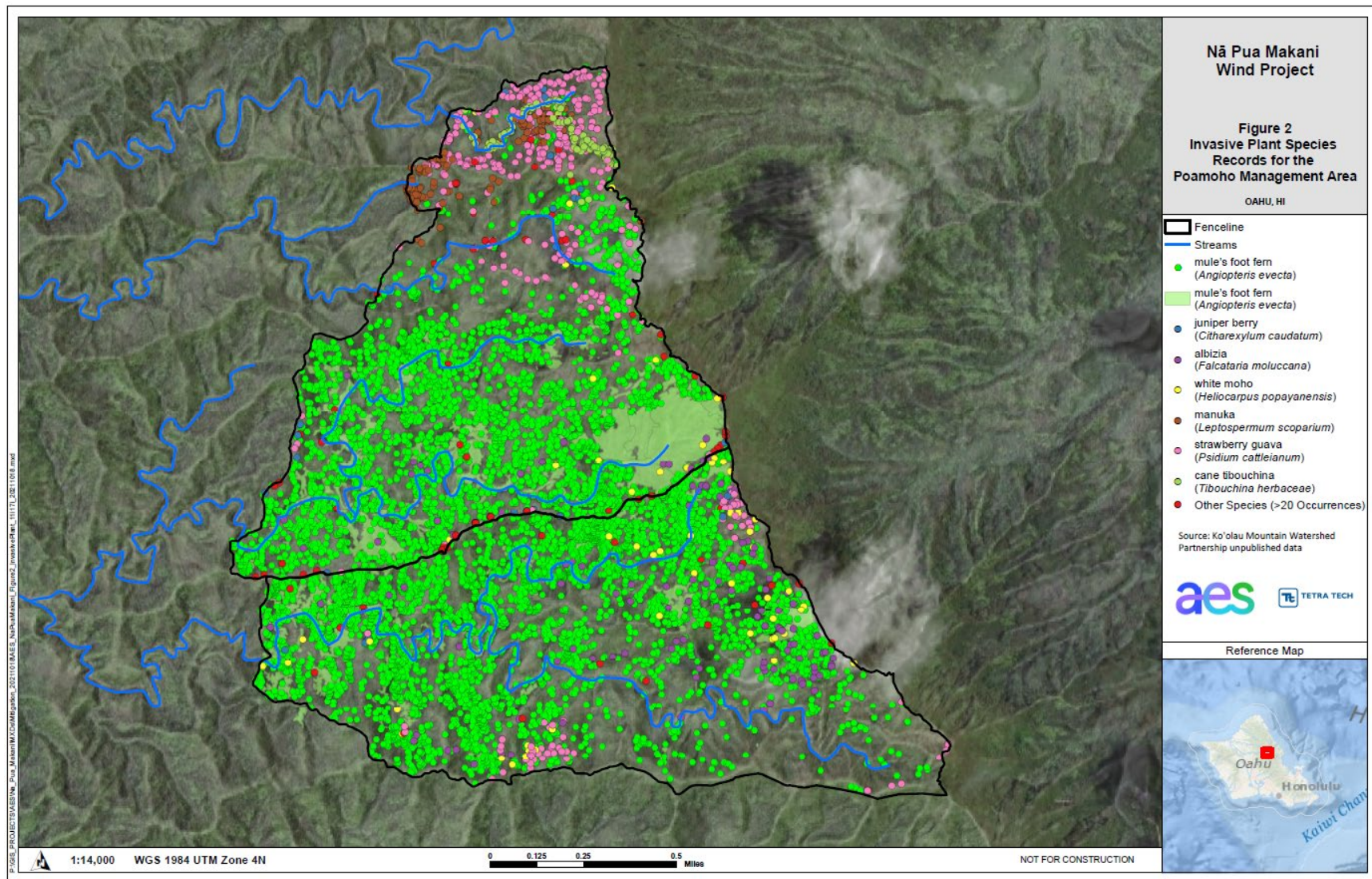
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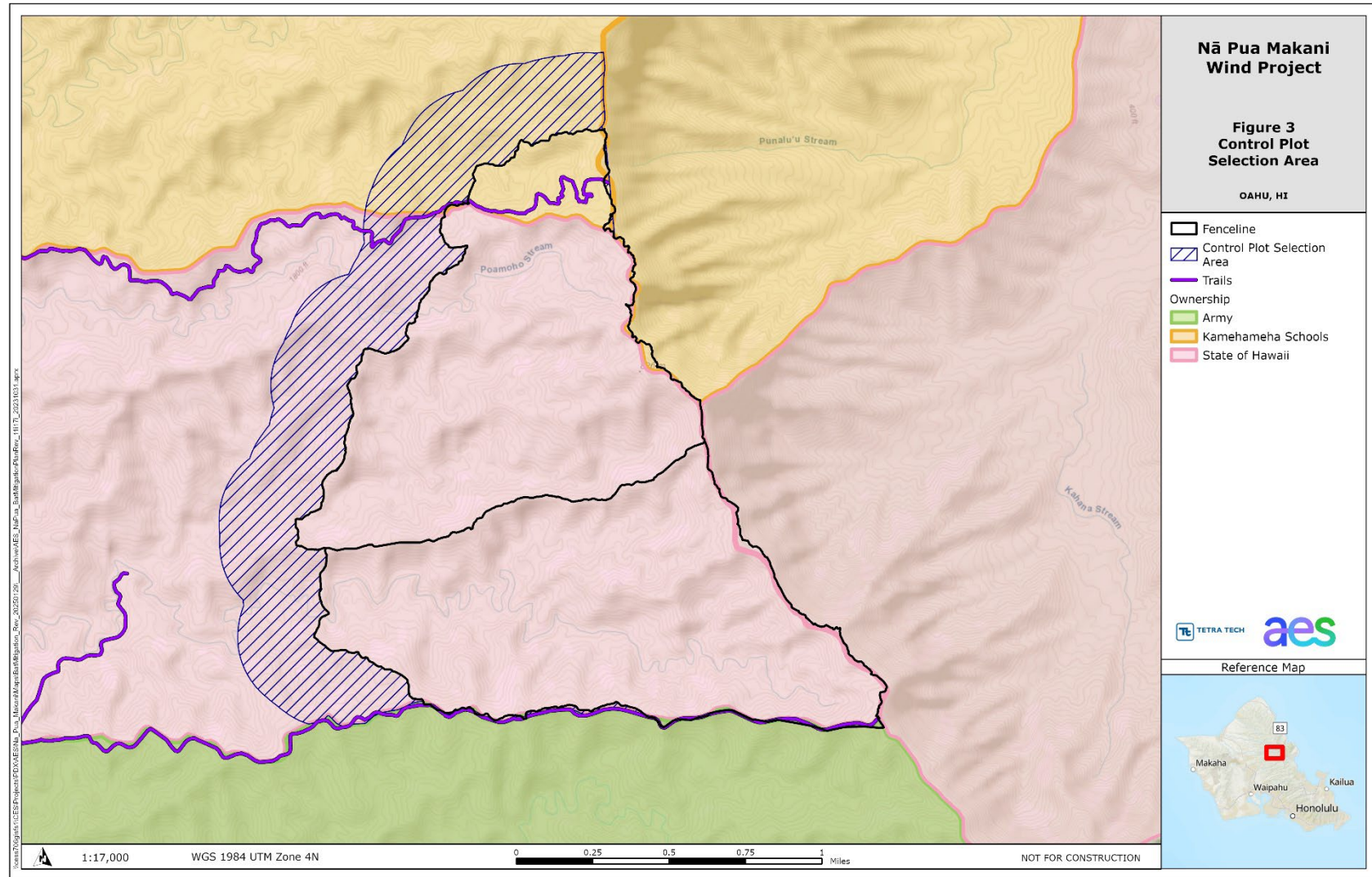


Figure 4. Example Planned Monitoring Plot Layout

