

Hawaiian Hoary Bat Tier 6 Auwahi Site-Specific Mitigation Implementation Plan

**Prepared for
Auwahi Energy Center**

Prepared by



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Appendices

Appendix 1. Ulupalakua Ranch Agricultural Easement

Acronyms and Abbreviations

DOFAW	Division of Forestry and Wildlife
HCP	Habitat Conservation Plan
Mitigation Area	Tier 6 Mitigation Area
Project	Auwahi Energy Center
SSMIP	Site-Specific Mitigation Implementation Plan
USFWS	U. S. Fish and Wildlife Service

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1.0 Introduction

This Tier 6 Site-Specific Mitigation Implementation Plan (SSMIP) follows the mitigation planning for the 'ōpe'ape'a (*Lasiurus semotus*; hereafter Hawaiian hoary bat), as outlined in the Auwahi Energy Center (Project) Habitat Conservation Plan (HCP) and as amended in 2019 (HCP Amendment; Auwahi Wind 2012, Tetra Tech 2019). The SSMIP identifies specific mitigation actions for review and approval by the U.S. Fish and Wildlife Service (USFWS) and Hawai'i Division of Forestry and Wildlife (DOFAW) at the time mitigation is triggered. Tier 6 mitigation must offset the take of 25 bats. The proposed Tier 6 bat Mitigation Area is located within Ulupalakua Ranch (private land) on Maui (Figure 1) and is in close proximity to the Auwahi Tier 1 and 4 mitigation areas (Figure 1). Pu'u 'Io Mitigation Area (also referred to as Mitigation Area) is the Tier 6 Mitigation Area within Ulupalakua Ranch. To develop this SSMIP, Auwahi consulted with Ulupalakua Ranch, and USFWS and DOFAW HCP staff for input and approval of mitigation actions within the proposed Mitigation Area that would be beneficial to the Hawaiian hoary bat.

The mitigation strategies outlined in the approved HCP Amendment are designed to enhance Hawaiian hoary bat roosting and foraging habitat, as well as increase prey availability within the associated Mitigation Area and were used as the basis for assessing potential mitigation opportunities. The following mitigation components are expected to improve bat roosting and foraging conditions and support movement across the landscape by creating a patchwork of open, edge, and closed-canopy habitats. These components are excerpted from the approved HCP Amendment (p. 6-43), with Tier 6 mitigation intended to offset the take of 25 bats:

- **Primary Mitigation Type:** Implement land restoration and management activities to enhance bat foraging and roosting habitat.
- **Design Criteria:** Incorporate elements similar to Tier 4 mitigation, such as water feature installation and outplanting forest corridors.
- **Acreage:** Improve 511 acres and reforest to a minimum density of 20 percent forest cover.
- **Success Monitoring:** Conduct acoustic monitoring at a minimum of six locations, along with insect monitoring using malaise traps.

2.0 Hawaiian Hoary Bat Biology

Data of Hawaiian hoary bat observations (1874 – 2023; Figure 2) demonstrate activity within the elevation gradient and near the Tier 6 mitigation area (Hawaii Natural Heritage Program 1996, Todd et al. 2016, H.T. Harvey. 2020, Pinzari et al. 2019, Thompson and Hammond-Rendon 2024, Kaheawa Wind I 2024, Kaheawa Wind II 2024, Auwahi Wind 2024) . Mitigation Actions have been designed to have the greatest potential to increase and enhance roosting habitat availability and foraging opportunities. Mitigation Actions were informed by the best available science around Hawaiian hoary bat biology as summarized below.

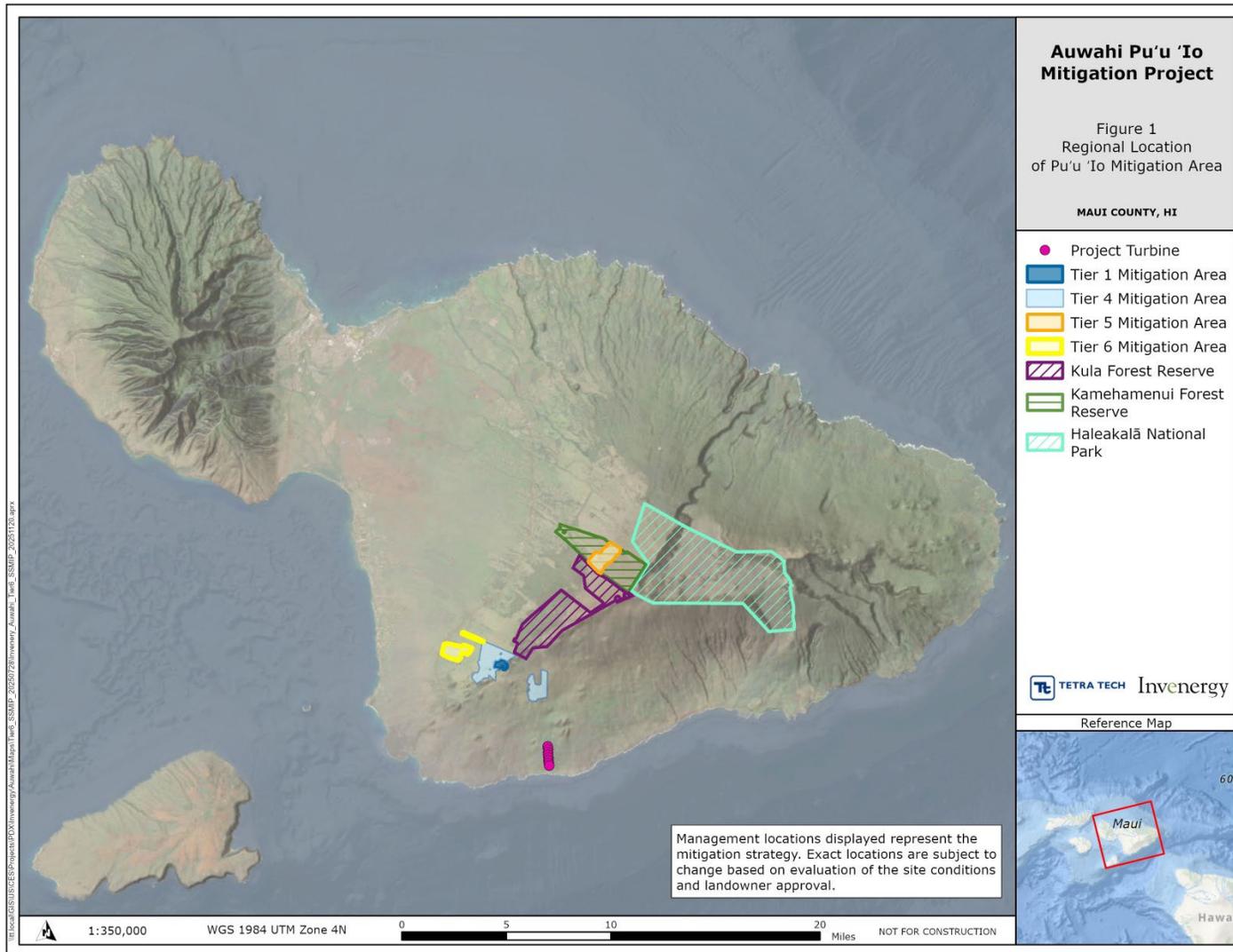


Figure 1. Regional Location of Pu'u 'Io Mitigation Area

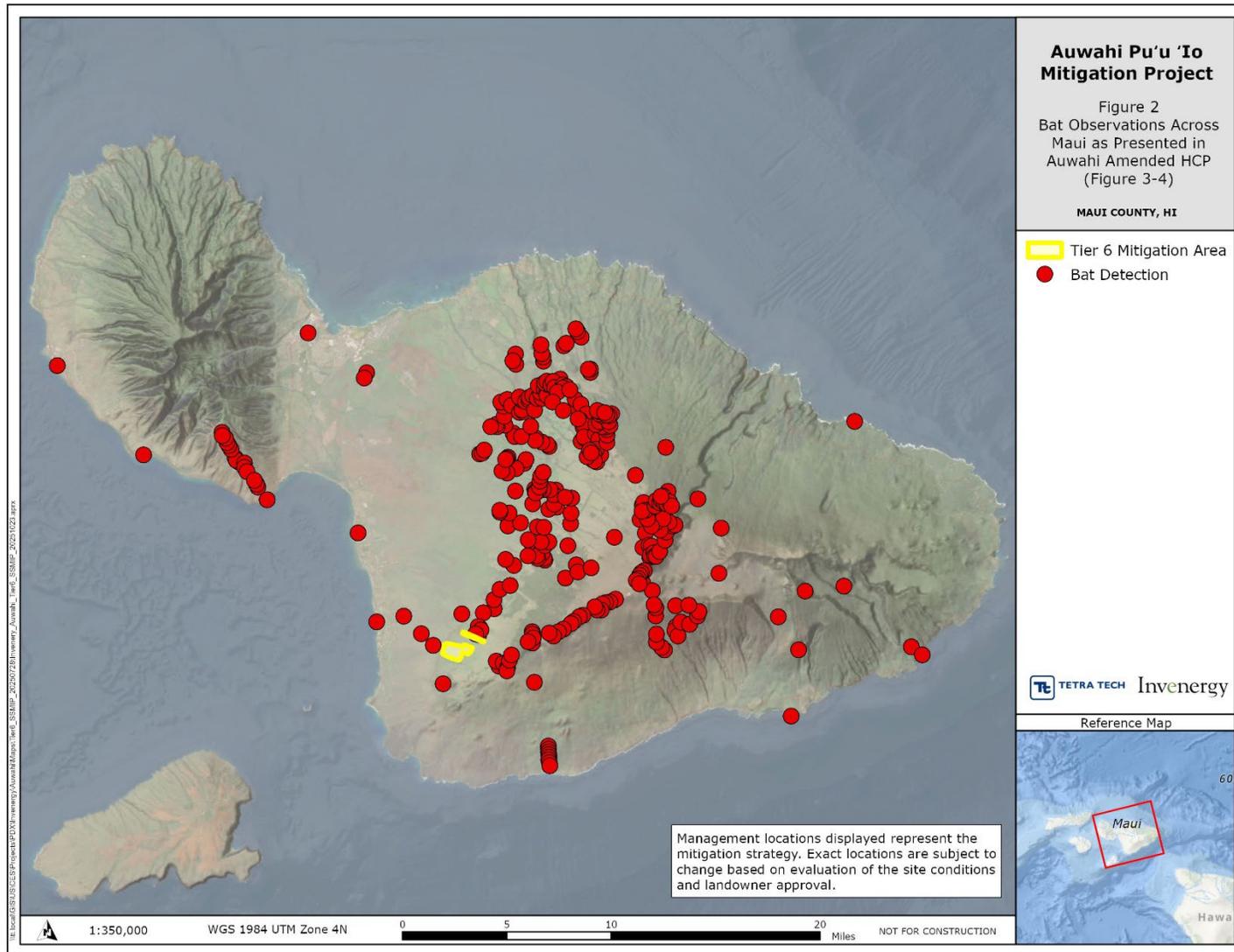


Figure 2. Bat Observations Across Maui as Presented in Auwahi Amended HCP

2.1 Roosting

Hawaiian hoary bats are a solitary, foliage-roosting species distributed across a wide range of habitats and elevations found on all the main Hawaiian Islands (Bonaccorso et al. 2015). Foliage roosting for this bat is documented primarily in non-native plantation species and fruit trees, although native trees are also used (Montoya-Aiona et al. 2023a). Maternity roosts (adult female with pup) have been observed in ‘ōhi‘a (*Metrosideros polymorpha*), paperbark (*Melaleuca quinquenervia*), litchi (*Litchi chinensis*), mango (*Mangifera indica*), African tulip (*Spathodea campanulata*), eucalyptus (*Eucalyptus robusta*) and ironwood (*Casuarina equisetifolia*; Kawaiiloa Wind Power 2013, Montoya-Aiona et al. 2023a). A study on Hawai‘i Island found tree stands used during reproduction (i.e., by juveniles or adult females classified as pregnant or lactating) ranged in elevation from 12.7 to 1,007 meters (Figure 3; Montoya-Aiona et al. 2023a, Montoya-Aiona et al. 2023b). This study represents the first detailed assessment of roost selection by ‘ōpe‘ape‘a, and as indicated by the authors, sampling bias due to the trail and road network in lowland settings may have affected the results and the use of roosts outside of this elevation range for reproductive benefit may be discovered as the field develops. In general, individuals also chose roosts closer to forest edge than randomly available options (Figure 4; Montoya-Aiona et al. 2023a).

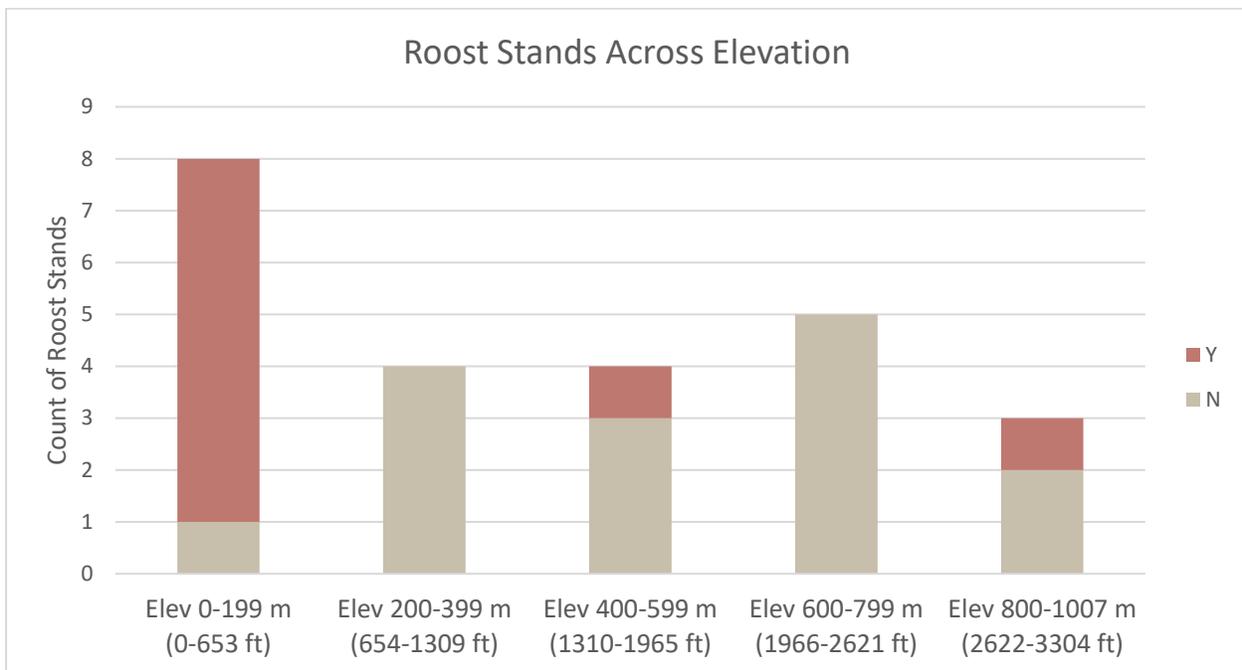


Figure 3. Roost Stands Documented by Montoya-Aiona et al. (2023a, 2023b) on Hawai‘i Island Used by Hawaiian Hoary Bats During Reproduction¹

¹ “Y” indicates visual confirmation of the perch in the roost and at least one pup present, classified as maternity roosts in Montoya-Aiona et al. (2023b). This graph represents an independent analysis of data provided in Montoya-Aiona et al. 2023a.

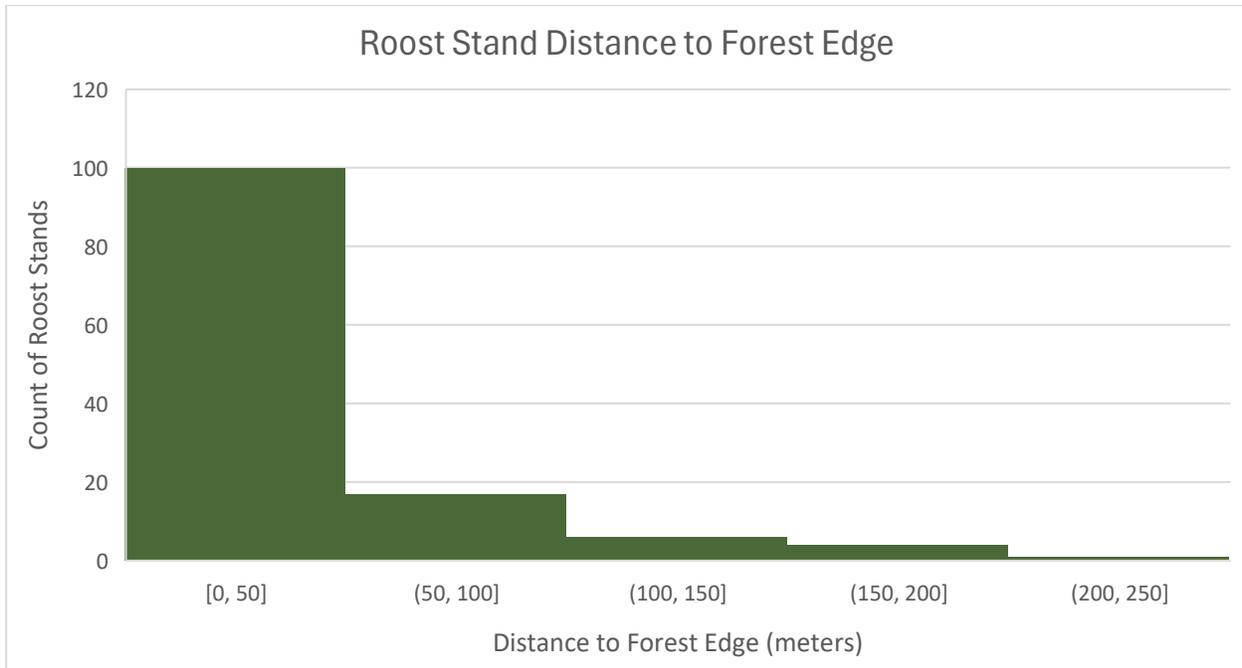


Figure 4. Distance to Forest Edge From Hawaiian Hoary Bat Roost Stands Documented on Hawai'i Island²

2.2 Foraging

The Hawaiian hoary bat is an insectivorous bat species. The bat feeds on a variety of native and non-native night-flying insects including moths, beetles, crickets, mosquitoes, and termites (Whitaker and Tomich 1983). Fecal pellet analysis and insect sampling have shown that 99 percent of the Hawaiian hoary bat diet consists of moth and beetle prey (Todd 2012). Above 2,000 feet, Hawaiian hoary bats selectively ate beetles (43 percent of diet) relative to their abundance at study sites (less than 4 percent of insects sampled), although species such as moths and beetles may be overestimated in fecal pellet analysis due to sampling bias. Additionally, bat activity is correlated with insect activity, meaning as insect abundance increased so did bat activity (Todd 2012, Gorresen et al. 2018). Bats are documented to travel up to 7 miles per night on Hawai'i Island to reach foraging grounds (Bonaccorso et al. 2015).

Forest edges can support foraging by the Hawaiian hoary bat. This species typically forages along forest edges, in open areas, within canopy gaps, and over open water bodies such as streams, ponds, and coastal ocean zones (Whitaker and Tomich 1983, Bonaccorso et al. 2015, Pinzari et al. 2019). In general, the creation of edge habitats supports bat movement and enhances foraging opportunities (Entwistle et al. 2001, Jantzen and Fenton 2013). Edge environments are particularly valuable because they reduce energy costs associated with commuting and increase access to a diversity of

² This graph represents an independent analysis of data provided in Montoya-Aiona et al. 2023a. One outlier not included in chart for an adult male tracked in January 2020 to an approximate roost tree location with a centroid 624 meters from a forest edge.

prey including lepidoptera and coleoptera (Grindal and Brigham 1999, Langhans and Tockner 2014). Acoustic monitoring on Maui, particularly in the Kula region, revealed that Hawaiian hoary bats foraged in gulches, low-density developed areas, and grasslands among the nine habitat types studied (H.T. Harvey 2020).

2.3 Water Use

Documented use of water by bats for drinking and foraging is well established (Brooks and Ford 2005, Jackrel and Matlack 2010, Tuttle et al. 2006, Vindigni et al. 2009). In Hawai'i, the full extent of water resource use by Hawaiian hoary bats (*Lasiurus semotus*) is not fully understood. Hawaiian hoary bats have been observed foraging and have been captured over artificial ponds (Pinzari et al. 2019). Dietary analysis has identified insect taxa associated with ponds, indicating that bats consume insects incidentally while drinking (Pinzari et al. 2019). More recently, bats have been documented foraging over artificial ponds installed as part of mitigation strategy under Auwahi's Tier 4 Mitigation Plan using acoustic (Thompson and Hammond 2021, Thompson and Hammond 2022) and thermal videography surveys (Auwahi Wind 2022).

While data specific to Hawaiian hoary bats are lacking, research on species in western North America show surface area and accessibility of water sources determine whether bats are able to drink from it (Tuttle et al. 2006). One study documented 16 individuals regularly using a 1.5 m-diameter artificial water source (Adams and Hayes 2008), demonstrating that even small, accessible bodies of water can provide consistent drinking opportunities for bats. A thermal imagery study at the Tier 4 mitigation area documented drinking behavior at water features (Auwahi Wind 2022).

Water availability and access also appear to play a key role in reproduction. In the same study, Adams and Hayes (2008) found that lactating females made more frequent visits to the water source than non-reproductive females, suggesting increased water demand during lactation. Additional research supports this link, indicating that access to reliable water sources may influence both lactating females and the first-year survival of pups (Korine et al. 2016).

In wetter regions of Hawai'i, or above the cloud inversion layer where frequent rainfall or moisture provide abundant surface water and dew accumulation on vegetation, bats may rely less on discrete water bodies. Conversely, in drier, leeward regions or areas with limited vegetative cover, artificial or natural water sources may represent critical resources that influence local bat activity. However, the overall extent, frequency, and ecological importance of water resource use by Hawaiian hoary bats remain poorly characterized and warrant further investigation.

3.0 Mitigation Area

3.1 Site Description and Regional Importance

The Mitigation Area consists of 511 acres within the larger parcel of TMK 2-2-1:009:001, owned by Ulupalakua Ranch. The site is located 6.3 miles southwest of Kamehamenui Forest Reserve, is located makai and adjacent to the current Tier 4 and Tier 1 mitigation areas and consists primarily

of pastureland and ephemeral streams. Elevations within the parcel range from 600 to 1,000 meters. Infrastructure within the Mitigation Area consists of ranch roads, fences, and small water troughs. Water resources are generally limited in Leeward Haleakalā (USGS 2013), and there are no named perennial streams located within the Mitigation Area.

The Tier 6 Mitigation Area is connected to a series of regional conservation efforts for native species management, and Hawaiian hoary bat mitigation specifically (Figure 1). The Tier 6 mitigation is within a continuous corridor of mitigation and conservation areas, notably the Kula Forest Reserve, Kamehamehū Forest Reserve, and the Tier 1, 4, and 5 Auwahi mitigation areas. The Tier 6 Mitigation Area is adjacent to the Tier 4 mitigation area, and the planned mitigation actions further expand the connection to the Tier 4 mitigation area and benefit for Hawaiian hoary bats.

3.2 Existing Protections

The land within the Mitigation Area owned by Ulupalakua Ranch is subject to an existing agricultural conservation easement that limits its use; however, this easement does not offer specific benefits or protections for the Hawaiian hoary bat.

3.3 Existing Land Cover and Land Use

The existing (baseline) habitat conditions within the Mitigation Area include pastureland currently grazed by cattle, which is also used by feral pigs and deer. The vegetation is predominantly a mix of kikuyu grass (*Pennisetum clandestinum*) and scattered non-native trees, such as silky oak (*Grevillea robusta*), *Eucalyptus* spp., *Jacaranda* spp., and Christmas berry (*Schinus terebinthifolia*). Little forest cover exists within the Mitigation Area. Table 1 shows land cover estimates from the National Oceanic and Atmospheric Administration’s Coastal Change Analysis Program (Figure 5).

Table 1. Baseline Land Cover in the Proposed Mitigation Area

Land Cover	Tier 6 Mitigation Area	
	Acres	Percentage
Pasture/Hay	487	95
Evergreen Forest	17	3
Shrub/scrub	6	1
Developed/Low Intensity	1	< 1
Total	511	100¹

¹ Numbers do not add up to 100 due to rounding.

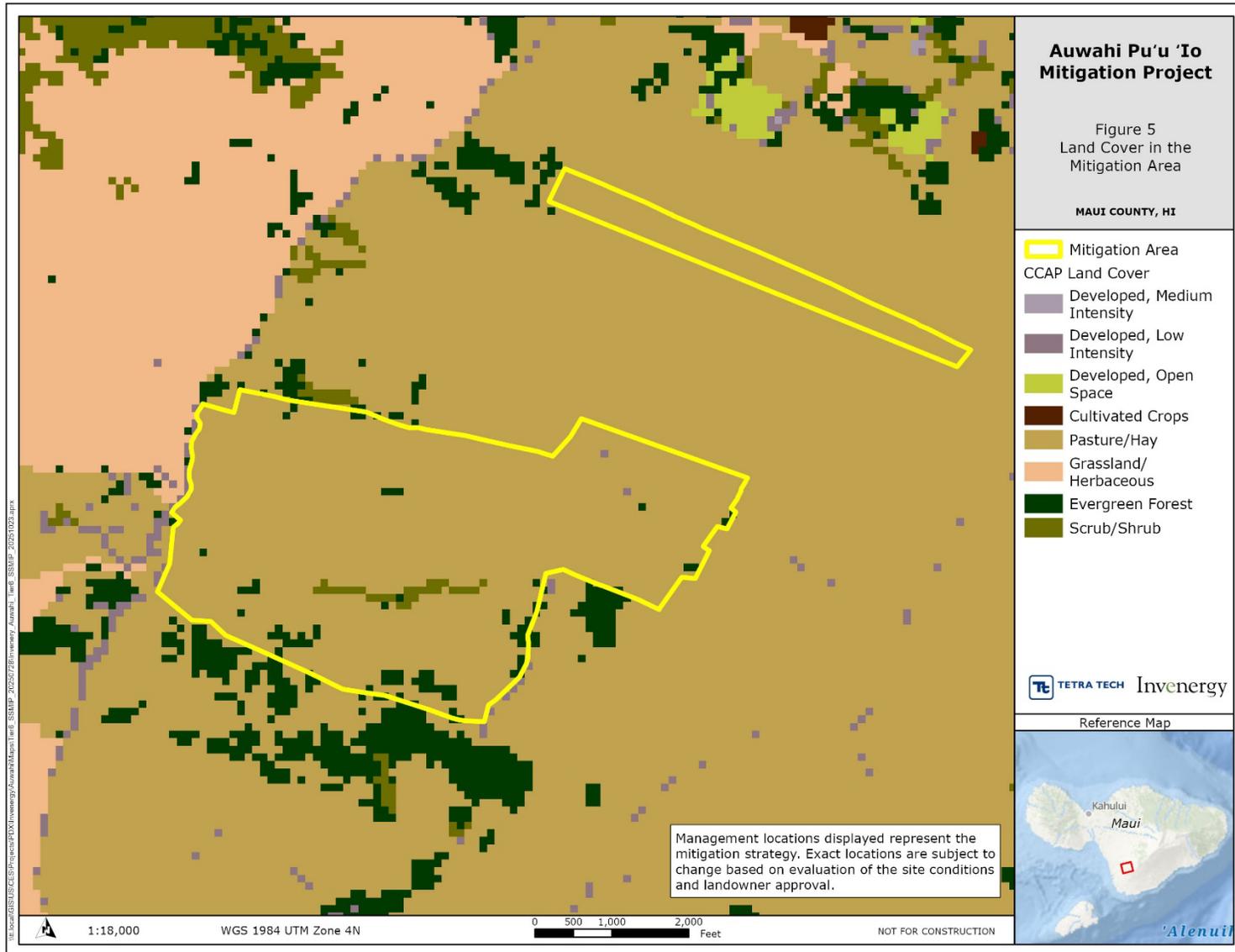


Figure 5. Land Cover in the Mitigation Area

4.0 Goals and Objectives

The HCP Amendment identifies broad biological goals and objectives that describe the guiding principles and specific strategies required to define and implement a successful land-based mitigation plan (Tetra Tech 2019). The SSMIP refines these goals and objectives to address the specifics of mitigation offset requirements and Mitigation Area conditions. The overall goal of the Tier 6 SSMIP is to define mitigation actions to offset the incidental take of 25 bats at the Project, enhance both roosting and foraging opportunities for the Hawaiian hoary bat during all reproductive stages, while also supporting long-term landscape-level habitat resilience. The objectives of the SSMIP define specific protections, enhancements, threat minimization, and management actions connected to the natural landscape features used by the Hawaiian hoary bat at the Mitigation Area. These objectives provide the basis for specific mitigation actions (Section 5.0), effective monitoring approaches (Section 7.0), and success criteria (Section 8.0).

Auwahi has leveraged results of the research, bat habitat restoration, and management efforts conducted in Tiers 1 – 4 (Figure 1), as well as discussions with USFWS and DOFAW during the completion of the Tier 5 SSMIP, data from other applicable studies, and USFWS and DOFAW mitigation guidance, to identify appropriate Tier 6 mitigation actions that will offset the incidental take of 25 bats for Tier 6 (Tetra Tech 2019). To provide the framework for the SSMIP, the goal, objective, and associated mitigation actions are outlined below. Figure 6 shows the Pu'u 'Io Mitigation Area at Ulupalakua Ranch.

Goal: To offset the incidental take of 25 bats at the Auwahi Energy Center, increase the quantity and quality of Hawaiian hoary bat roosting and foraging habitat within two portions of Ulupalakua Ranch land totaling 511 acres (Mitigation Area) through long-term protection, threat minimization, and habitat creation and enhancement.

Objective 1: Enhance long-term protection for the Mitigation Area.

- *Action 1- Enhance Long-term Protection:* The acreage is in a perpetual agricultural conservation easement (Attachment A). Auwahi will develop an additional agreement with Ulupalakua Ranch that memorializes restrictions and responsibilities under this document to ensure protection of the lands for conservation purposes and to guarantee no other activities could occur that would harm bats or reduce conservation benefits for the length of the mitigation project (approx. 10 years).

Objective 2: Minimize threat and increase in the quantity and quality of roosting and foraging habitat within the Mitigation Area to support a stable or increasing Hawaiian hoary bat population.

- *Minimization Action 1 – Barbed Wire Removal:* As a threat minimization measure, 17,000 linear feet of barbed wire fence existing within the Mitigation Area would be removed.
- *Mitigation Action 1 – Fence Installation and Maintenance:* To protect young outplanted trees from ungulates, 19,100 linear feet of new smooth wire fences would be constructed around

forest corridor plantings to exclude ungulates. Fencing would be installed around individual trees/clusters in the case of silvopastoral plantings.

- *Mitigation Action 2 – Ungulate Removal:* In areas fenced for forest corridor outplanting, all ungulates would be removed from the fenced area to increase the survivorship of outplantings as well as encourage passive regrowth of native species.
- *Mitigation Action 3 – Forest Corridor Outplantings:* Complete forest corridor outplantings with native tree species within two years following fence installation and ungulate removal that equate to at least 20 percent forest cover in the Mitigation Area.
- *Mitigation Action 4 – Silvopastoral Outplantings:* Plant the remainder of the Mitigation Area, the areas not included in the forest corridor plantings, in a silvopastoral style including tree species known to provide maternity roosts for Hawaiian hoary bat.
- *Mitigation Action 5 – Invasive Vegetation Control:* Enhance growth and survival of native vegetation through quarterly invasive plant management throughout the Mitigation Area to decrease the competition on native species reforestation from invasive, non-native woody vegetation.
- *Mitigation Action 6 – Water Source:* Within one year of landowner agreements being completed, a water feature would be installed to increase and diversify foraging habitat/substrate for bats and bat prey (i.e., insects), and support fire suppression efforts.

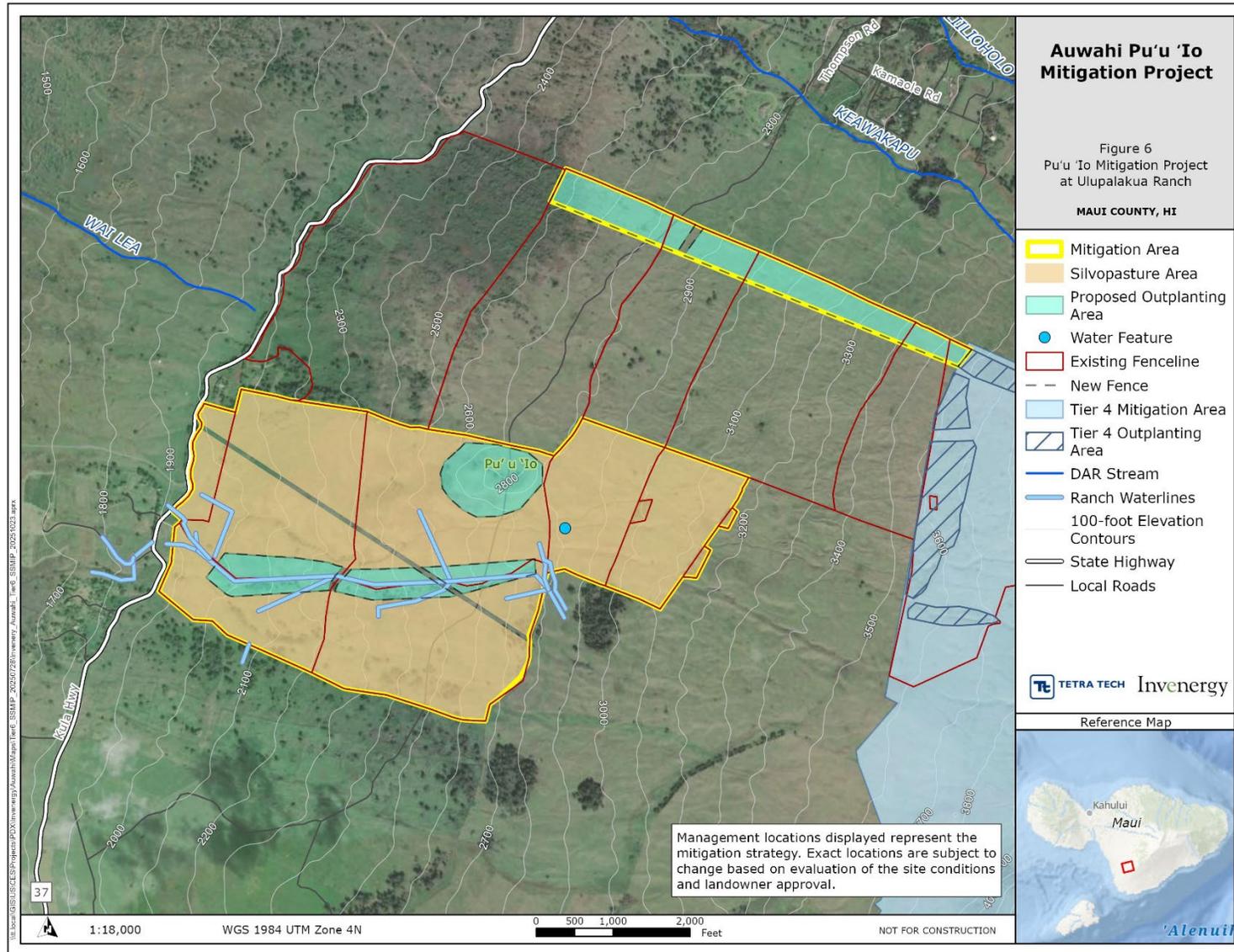


Figure 6. Pu'u 'Io Mitigation Area at Ulupalakua Ranch

5.0 Minimization and Mitigation Actions

Mitigation measures include both threat minimization and habitat improvement actions. Combined, these actions would result in a net benefit for Hawaiian hoary bats in the Mitigation Area. The mitigation actions described below include:

1. Protection of area;
2. Barbed wire removal (minimization action);
3. Ungulate exclusion fence installation;
4. Ungulate removal;
5. Forest corridor outplantings;
6. Silvopastoral outplantings;
7. Invasive vegetation control; and
8. Water source.

5.1 Protections to Benefit Hawaiian Hoary Bats

Following its approval, the SSMIP would be implemented and include placement of protections over the Mitigation Area for 10 years from the time the agreement is executed. The agreement with Ulupalakua Ranch would cover the duration of the mitigation actions and monitoring activities. This area would be managed for the benefit of Hawaiian hoary bat through cooperation with the landowner, based on terms outlined in an agreement between Auwahi and Ulupalakua Ranch. The agreement would enable implementation of the actions in this SSMIP. The agreement will not supersede the existing agricultural conservation easement (Attachment A) but will impose additional servitudes which are necessary and appropriate for carrying out the Mitigation Area bat-focused conservation measures as identified in the SSMIP including any restrictions for fruit harvesting in the silvopastoral areas. Where the agreement differs from the agricultural easement the more restrictive protections shall apply.

5.2 Minimization Action 1: Barbed Wire Removal

As a threat minimization measure, barbed wire existing within the Mitigation Area would be removed or replaced with smooth wire or other alternatives. Barbed wire is a known mortality source for Hawaiian hoary bat, and its removal has been included in other approved mitigation plans. Currently there is approximately 17,000 linear feet of top strand barbed wire within the Mitigation Area which would be replaced with smooth wire to reduce threats of collision by Hawaiian hoary bats.

5.3 Mitigation Action 1: Installation of Ungulate Exclusion Fences

To protect young trees being outplanted from ungulates, smooth wire fences would be constructed around forest corridor plantings to exclude ungulates. For forest corridor outplantings, fences would be installed to encircle the outplanting and tied into existing ranch-maintained fences where it is feasible. The ungulate-proof fence around the forest corridor along the northern parcel border would create an additional barrier and facilitate feral ungulate removal efforts that are on-going at Ulupalakua Ranch. The ungulate exclusion fence installation would result in 21,650 linear feet of new fencing within the Mitigation Area (Figure 6). Outside of the fenced forest corridor areas, in the silvopastoral planting areas, cattle grazing would continue, so individual trees or small groups of trees would be fenced.

5.4 Mitigation Action 2: Ungulate Removal

In areas fenced for forest corridor outplanting, all ungulates would be removed from the fenced area to increase the survivorship of outplantings as well as encourage passive regrowth of native species. Ungulates would be removed within 1 year following fence completion. Ranch-wide ungulate removal outside of the mitigation area will be occurring in parallel to Auwahi's efforts inside the mitigation area, which will reduce overall ungulate pressure on the area.

5.5 Mitigation Action 3: Forest Corridor Outplantings

Auwahi would outplant and maintain the land within the Mitigation Area to create areas of forest edge habitat (forest corridors) (Figure 6). Overall, the plantings would achieve at least 20 percent forest cover within the 511-acre Mitigation Area, which corresponds to the first statistically significant peak in *Lasiurus cinereus* use of a forested area (Jantzen 2012). In addition, Montoya-Aiona et al. (2023a, 2023b) found that Hawaiian hoary bat roost locations were predominantly within 50 meters of forest edge, understanding that there could be some sampling bias due to accessibility of forested tracts. Forest corridor outplantings will support foraging bats and may also provide potential roosting opportunities.

Fast growing, native or indigenous species such as koa (*Acacia koa*), 'ohe mauka (*Polyscias oahuensis*), and neneleau (*Rhus sandwicensis*) would be used for forest corridor outplantings to establish canopy cover, and be interspersed with at least 10 percent of the outplanted stems incorporating known native roost tree species such as 'ōhi'a (*Metrosideros polymorpha*), lama (*Diospyros sandwicensis*), and wiliwili (*Erythrina sandwicensis*). Additional native canopy and mid-story species may include 'iliahi (*Santalum spp.*), and koai'a (*Acacia koaia*), and. As part of the overall planting palette, native understory species will also be included to increase structural complexity and support bat prey availability; examples include 'a'ali'i (*Dodonaea viscosa*), naio (*Myoporum sandwicense*), and māmane (*Sophora chrysophylla*), as well as other native species identified in Madeiros et al. (1998). Consultation with species experts will occur to refine and finalize the plant species list as additional information becomes available. Other non-invasive tree species could be considered if preferred native species were unavailable to achieve mitigation objectives; however, the use of such species would require the approval of the USFWS and DOFAW.

Trees would be outplanted in the forest corridors at 100 trees per acre and those plantings would be oriented along gulches and interspersed with any existing trees on the landscape in order to take advantage of existing movement corridors for Hawaiian hoary bat. Trees would be spaced approximately 20 feet apart in order to achieve this density. Once trees reach maturity, this planting density would ensure there is enough space for the plants to survive while also creating a vegetated edge that bats will recognize as such during echolocation. Forest corridor outplantings would be fenced to exclude ungulates, to increase the speed at which trees establish and to avoid damage to plantings from ungulates in the future.

Outplantings would be installed within two years of fence completion and ungulate removal in the forest corridor area. Outplanting timing would depend on plant availability. If seed collection and propagation is required, then those activities would begin as soon as seasonally possible following SSMIP approval and execution of all agreements necessary to facilitate site access and mitigation activity. It may be that some readily available plants are outplanted initially and then other species, which require seed collection and propagation, would be added by Year 5, to increase plant diversity and to ultimately achieve the stems per acre and forest cover desired.

5.6 Mitigation Action 4: Silvopastoral Outplantings

Outside of the forest corridors, Auwahi would outplant areas with more dispersed silvopastoral plantings (Figure 6). These areas would be in addition to the 20 percent forest cover achieved by the forest corridor outplantings. Hawaiian hoary bats have been observed using areas with similar style dispersed tree cover (Montoya-Aiona et al. 2023a). Trees would be planted at a density of one tree per acre as individuals or small clusters of fruit trees (e.g., ulu, litchi, and mango) some of which are known to provide maternity roosts for Hawaiian hoary bat. As defined by U.S. Forest Service, silvopastoral practices are the deliberate integration of trees and grazing livestock operation on the same land and include trees spacing such that enough light can penetrate the canopy to allow for an understory that can support grazing. Trees would be individually fenced or fences in small clusters to avoid damage from ungulates. Silvopastoral plantings may occur sooner than forest corridor outplantings since outplanted trees can be fenced individually. Silvopastoral outplanting timing would also depend on plant availability.

5.7 Mitigation Action 5: Invasive Vegetation Control

To help decrease the competition on native species reforestation, invasive non-native woody vegetation would be controlled to enhance growth and survival of native vegetation through invasive plant management within the Mitigation Area. Invasive non-native woody vegetation management would be primarily focused in the forest corridor areas, though the entire Mitigation Area will be routinely monitored for newly established non-native woody vegetation so it can be removed within 1 year of detection. At least one annual inspection of the Mitigation Area would occur to identify locations where non-native invasive vegetation control is needed, though anytime non-native invasive woody vegetation is detected during other routine management or monitoring activities, they would be documented. The primary means of woody vegetation control would be manual or mechanized removal, and this work would occur annually, as needed.

5.8 Mitigation Action 6: Water Source

A water feature would be installed in the Mitigation Area to provide a drinking source, augment foraging areas, provide flood mitigation for downslope area, and aid in fire suppression to protect the other components of the mitigation. Water resources are limited on the leeward slopes of Haleakalā with no perennial named streams located in the Mitigation Area. Water features have been shown to be used by bats for drinking and foraging at the Tier 4 mitigation ponds. Installing a water feature could increase and diversify foraging habitat for bats and bat prey (i.e., insects). Drinking water is also an essential resource for bats and successful reproduction is directly related to water availability (Adams and Hayes 2008). Increasing availability to water resources during the maternity period would reduce stress on pregnant females and increase reproductive success. A water feature which can support fire suppression benefits Ulupalakua Ranch and reduces bat habitat destruction from fire. It also retains water onsite from rain events, which reduces flood risk for communities downslope.

Table 2 provides a summary of the mitigation actions described above and by year of implementation.

Table 2. Summary of Minimization and Mitigation Actions by Year

Action	Year ^{1,2}									
	1	2	3	4	5	6	7	8	9	10
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Barbed wire fence removal	X									
Complete ungulate exclusion fencing around forest corridors	X									
Annual fence inspection and as-needed maintenance		X	X	X	X	X	X	X	X	X
Complete feral ungulate removal in forest corridors	X	X								
As needed ungulate removal			X	X	X	X	X	X	X	X
Complete plantings in Outplanting Areas	X ³	X ³	X ³							
Non-native invasive woody vegetation removal		X	X	X	X	X	X	X	X	X
Install water source	X									

1. The timeline for the associated actions described are Auwahi’s best estimate based on current information; however, timing of approvals, logistical challenges, or other factors may affect the precise scheduling of actions. Changes in the timing of a mitigation action are also likely to affect the timing of the associated monitoring.

2. Seven-year timeline presented aligns with the remaining planned operational life of the Project, through 2032 (Section 1.1 in Tetra Tech 2019).

3. Outplantings in 2026 would be in the silvopastoral portion of the Mitigation Area. In 2027 outplanting in the forest corridors could occur, once fencing and ungulate removal is complete. Outplantings in Year 3 may include supplemental plantings of species that were not readily available by 2027 and needed to be propagated.

6.0 Net Benefit for Hawaiian Hoary Bat

Ulupalakua Ranch contains sufficient land to accommodate the 511-acre Mitigation Area, and the proposed location is low enough in elevation to support maternity roosting, as documented in studies on Hawai’i Island (see Section 2). With its proximity to Tier 1 and 4 mitigation areas, the Mitigation Area would also support local connectivity through enhancement of forest corridors from low-density developed areas up slope towards the Waihou mitigation area (Auwahi Tier 1) which was shown to be used by reproductive females (Pinzari et al. 2019).

Tier 6 SSMIP actions will increase Hawaiian hoary bat roosting and foraging habitat, and prey availability within the Mitigation Area. The size of the Mitigation Area is based on the acreage offset calculation of 20.3 acres per bat, memorialized in the Amended HCP (Tetra Tech 2019; pg. 6-43). Mitigation actions are anticipated to offset the take of 25 bats. Auwahi will include a bat monitoring program to document an increase in bat activity at the site as a result of mitigation actions. If success criteria outlined in Section 8.0 are reached, then the mitigation actions will be considered to offset bat take and provide a net benefit.

Further, the Mitigation Area is located in a part of Maui that has benefited from other land protection and management, including other Hawaiian hoary bat mitigation activities. The addition of this Mitigation Area to the larger network of ongoing management for the species, including the other mitigation areas developed by Auwahi, will create additional bat habitat connectivity and overall resiliency within the region. Finally, the use of silvopastoral planting alongside forest corridor plantings may allow for documentation, and potentially comparisons between the two outplanting styles with respect to changes in bat prey and bat use.

7.0 Monitoring

Monitoring would occur to determine whether the mitigation actions are resulting in an increase in the quantity and quality of Hawaiian hoary bat habitat in the Mitigation Area (Table 3). Monitoring would occur in two phases, baseline monitoring and implementation monitoring. Baseline monitoring would occur during the first year following the execution of all agreements necessary for site access and mitigation activity. Implementation monitoring would begin in Year 3, following completion of fencing (Mitigation Action 2), ungulate removal (Mitigation Action 3), and outplanting (Mitigation Actions 4 and 5). Implementation monitoring would occur every other year for the duration of the permit term.

Table 3. Summary of Monitoring Actions by Year

Action	Year ^{1,2}									
	1	2	3	4	5	6	7	8	9	10
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Acoustic bat monitoring in Mitigation Area	B	B	I		I		I			I
Bat prey (insect) monitoring	B	B	I		I		I			I
Assess percent forest cover of Mitigation Area	B				I		I			I

B = Baseline monitoring; I = Implementation monitoring.

1. The timeline for the associated actions described are Auwahi’s best estimate based on current information; however, timing of approvals, logistical challenges, or other factors may affect the precise scheduling of actions. Changes in the timing of a mitigation action are also likely to affect the timing of the associated monitoring.

2. Ten-year timeline presented aligns with the remaining planned operational life of the Project, through 2035 (Section 1.1 in Tetra Tech 2019).

7.1 Acoustic Bat Monitoring and Analysis

Increasing bat activity at the site as measured through acoustic monitoring is identified in the Amended HCP as the primary success criteria for the mitigation actions. Acoustic monitoring at the site would begin approximately 3 months after management actions have started and continue through a baseline monitoring period then every other year for the remaining permit term. The acoustic baseline monitoring will be used to assess increases in bat activity in the Mitigation Area. Six monitoring locations will be established and provide a ratio of one or more detectors for approximately every 85 acres, which is three to seven times greater density than similar studies (Gorresen et al. 2015, Todd et al. 2016). This level of monitoring and type of analysis is similar to what is currently being completed at the adjacent Tier 4 mitigation project (Thompson and Hammond-Rendon 2024).

7.1.1 Assessment Metrics

Changes in bat foraging activity will be assessed using several metrics obtained from acoustic data recorded throughout the Mitigation Area. The use of animal vocalizations accompanied by an applied knowledge of associated behaviors can be a useful tool for monitoring a populations’ response to conservation actions within the Mitigation Area (Teixeria et al. 2019). Together these metrics will be used as a proxy for bat activity to provide a better understanding of the response of bat use at the Mitigation Area following the implementation of mitigation actions, with the idea that if it can be demonstrated that there is a concentration of bat activity in the Mitigation Area, it could be deduced that the site is at least providing foraging habitat and could potentially support bat roosting and even maternity roosts. However, follow-up targeted monitoring would be required to confirm the presence of roosting bats including females with pups. . Details on metrics that will be tracked and how success will be determined are included in Section 7.1.2.

7.1.2 Analysis

Linear mixed model regression analysis will be conducted to test correlations between bat acoustic activity and environmental variables that will be influenced by the mitigation actions among years. This model framework treats monitoring locations as spatially independent. Acoustic monitors will be distributed widely to minimize the spatial autocorrelation among adjacent monitors. If large spatial correlation is suspected, analysis methods to take this into account can be considered (Dormann et al. 2007).

The primary variable used as indices of bat activity will be detection probability; however, other acoustic metrics including the number of nightly call files, call type and timing of activity, may also be included in the modeling procedures. Reported changes in bat activity metrics will include 95 percent confidence intervals and significance at an alpha value of 0.05. The assumption is that following implementation of mitigation actions, namely forest outplantings and removal of ungulates, bat activity will have increased by the end of the permit term.

The regression analysis will illustrate the strength of the relationships between changes in bat foraging activity and other measured variables, such as percent forest cover. Fixed parameters in the models may include but are not limited to year, proximity to outplanting area or water feature, elevation, temperature, and rainfall. Sampling location will be included as a random parameter.

Among highly correlated bat activity metrics the use of Principal Component Analysis (PCA) will be explored to reduce the number of inputs for the linear mixed model analysis, while maintaining interpretability of changes in bat acoustic activity. For example, the number of nightly call files may be highly correlated with number of echolocation pulses. In that case, PCA results would indicate that combining those variables into a single input is statistically justified and would improve the linear mixed model regression. Using PCA prior to regression analysis, especially in the presence of multiple environmental variables, is common because it enhances the regression model's interpretability.

Information gained by the number of nightly call files and number of echolocation pulses will be supplemented by the type of call (i.e., passive or active search call, or feeding call), and time of nightly activity. These variables will be tracked to provide greater context for what bats are doing at the Mitigation Area while they are there, how long they stay, and when they arrive; these variables may be used in the linear mixed model regression analysis as well.

7.2 Bat Prey Monitoring

Insect sampling with a malaise trap as identified in the Amended HCP would occur in the years in which acoustic monitoring is conducted. Bat prey monitoring will be conducted to determine the response of bat prey communities, specifically overall biomass, to the implementation of management actions. Biomass was chosen as a response variable as it has shown to be a strong 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). Arthropods will be sampled in the Mitigation Area during each monitoring year using one malaise trap,

deployed within the Mitigation Area for one week at a time, eight times during the monitoring year (Table 3). The eight one-week monitoring sessions will occur as follows: one week in April, one week in May, and six weeks August – October (generally every other week). This includes more intensive monitoring during the reproductive period, August – October, when bat prey resources are most critical. Monitoring locations will remain consistent throughout all sampling years. Samples will be collected at most, weekly, during each sampling period, and more frequently if it appears the samples are degrading in a way that will influence identification. Sample collection, storage, and transport will use best practices and will be coordinated with the Bishop Museum.

Auwahi will quantify baseline insect biomass in the Mitigation Area using these methods, during Year 1. Auwahi will then conduct follow up monitoring in Years 3, 5, 7, and 10 to determine if changes in insect biomass occurred in response to mitigation actions (Table 3). Bat prey monitoring is a tool to assess the impact of mitigation actions and identify appropriate changes to management, if necessary, through adaptive management. If at any point bat prey species are not being detected in expected numbers, additional monitoring methods may be used during focused sampling events for those species. Following the sampling, insect biomass will be reported in the annual report.

7.3 Percent Forest Cover

Jantzen (2012) documented an initial peak of use by hoary bat once forest cover reached 20 to 25 percent. Forest cover will be primarily achieved through the outplanting of forest corridors within the Mitigation Area. However, the additional silvopastoral outplanting of the remainder of the Mitigation Area will add forest cover to the Mitigation Area, and when taken as a whole, the total percent forest cover will exceed 20 percent. The percent forest cover of the Mitigation Area will be assessed through GIS analysis using aerial imagery; either imagery taken by satellites, if less than 1 year old, or taken by an unmanned aerial system. Percent forest cover will be assessed during Year 1 of the Baseline Monitoring period. Percent forest cover will then be resampled in Year 5 and Year 7.

Percent forest cover is assumed to increase each year and that the goal of at least 20 percent forest cover will be reached by Year 5 after outplanting is completed. As long as forest cover is increasing, no additional actions are necessary. If, in Year 5 forest cover has not reached the goal of 20 percent, then Auwahi will replant native plants necessary to bring the native plant cover up to 20 percent, if it is apparent that 20 percent will not be achieved by Year 10, based on the trajectory of forest cover from baseline.

8.0 Success Criteria and Adaptive Management

To evaluate whether the proposed mitigation actions effectively enhance foraging and roosting habitat for the Hawaiian hoary bat, a weight-of-evidence approach will be adopted that uses several monitoring metrics as a measure of success. This approach evaluates changes in bat activity and habitat use by integrating multiple converging indicators of behavior, timing and spatial distribution throughout the year with an emphasis on the maternity season.

Success is defined as meeting two or more of the following conditions:

1. Seasonal Increase in Bat Activity Rates

- **Definition:** A statistically significant increase from baseline in the rate of nightly bat acoustic detections including call files or feeding buzzes (the number of bat calls or feeding buzzes/total active detector nights), with a particular focus on the maternity season (typically mid-June to late September), following monitoring in Year 5.
- **Rationale:** Increases in bat activity during the maternity period would indicate improved foraging opportunities and habitat suitability during a time when the energetic requirements of pregnant or lactating females and newly volant juveniles are at their peak.
- **Supporting Evidence:** Growth and reproduction, particularly lactation and weaning, represent the most energetically demanding periods for most mammals, including bats (Heideman 1988, Migula 1969, Millar 1975, Studier et al. 1973, Wunder 1985). During this period, females experience elevated energetic requirements to support gestation, milk production, and the development of young. The availability of sufficient foraging resources is among the most critical factors influencing the timing and success of reproduction, directly affecting maternal condition and the number and quality of surviving offspring (Bronson 1985, Bronson 2009, Boutin 1990). Seasonal patterns of reproduction in bats are strongly associated with fluctuations in the availability of foraging resources across both temperate and tropical regions (Racey and Entwistle 2000, Rautenbach et al. 1988). Accordingly, increasing access to suitable foraging opportunities and high-quality foraging areas during the reproductive season is essential to meeting the heightened energetic demands of females and supporting successful reproduction.

2. Timing of Nightly Acoustic Activity Relative to Sunset

- **Definition:** A statistically significant decrease in the time interval between sunset and first acoustic detection or peak in acoustic activity by the end of Year 5.
- **Rationale:** A reduction in the time interval between sunset and first acoustic detection may indicate that bats are either roosting at the Mitigation Area or are arriving shortly after roost emergence to forage.

Supporting Evidence: Hawaiian Hoary bats usually emerge to forage approximately at sunset (Bonaccorso et al. 2015). A decrease in the time between sunset and first acoustic detection at the Mitigation Area may reflect enhanced availability or quality of resources that supports bats roosting on site or arriving shortly after emergence to exploit nearby foraging opportunities.

3. Increased Nightly Foraging Duration

- **Definition:** A statistically significant increase from baseline in the duration of nightly acoustic activity by the end of Year 5.
- **Rationale:** An increase in the duration of nightly acoustic activity may reflect improved foraging habitat quality capable of supporting sustained use by multiple individuals throughout the night

Supporting Evidence: The relationship between habitat quality and foraging and activity of bats are good indicators of ecosystem health (Scott et al. 2010). Sustained or extended nightly use may suggest that the habitat improvements implemented at the Mitigation Area are supporting longer periods of activity by bats throughout the night, aligning with expected outcomes for enhanced foraging habitat quality.

4. Use of New Water Feature

- **Definition:** A statistically significant increase from baseline in the rate of nightly bat acoustic detections including call files or feeding buzzes (the number of bat calls or feeding buzzes/total active detector nights), at the newly installed water feature by the end of Year 5.
- **Rationale:** Elevated activity reflects increased foraging at the new feature, suggesting the presence of a valuable resource.
- **Supporting Evidence:** Insectivorous bats are documented to use water for drinking and as a preferred feeding area (Brooks and Ford 2005, Jackrel and Matlack 2010, Tuttle et al. 2006, Vindigni et al. 2009). The Hawaiian hoary bat has been documented using ponds installed as part of Auwahi's Tier 4 Mitigation Area (Thompson and Hammond 2021, Thompson and Hammond 2022).

5. Documented Roost Use within the Mitigation Area

- **Definition:** Confirmation of roost use within the mitigation, defined as at least one individual documented roosting in vegetation during the day at any point during the period of implementation. Activity would initially be documented using acoustic data with confirmation of roosting using additional techniques, as determined through coordination with DOFAW, USFWS, and other species experts.
- **Rational:** Documented evidence of a bat roosting within the mitigation parcel demonstrates the site's suitability for roosting, and a potential for maternity roosting. This indicates that the mitigation is likely to confer future reproductive advantages by increasing access to appropriate roosting habitat.
- **Supporting Evidence:** Hawaiian hoary bats are documented to use the same roost tree in subsequent years, and multiple bats will use the same tree at the same time (Montoya-Aiona et al. 2023a). While known roosts on Maui Island are very limited (H.T.

Harvey 2020), acoustic indicators could lead to the identification of periods of activity indicative of potential roosts within the mitigation area.

Table 4 summarizes the success criteria for the Tier 6 Mitigation Area, including linking the objectives and success criteria to adaptive management triggers and actions. The mitigation objectives are ultimately what will be used to measure success. Adaptive management triggers have been identified that determine when adaptive management needs to be considered, based on monitoring results. Table 4 also outlines the timeline for when adaptive management triggers will be assessed and includes examples of responses that could be used, through adaptive management, to address any deficiencies detected in the effectiveness of mitigation actions, based on monitoring data. These actions are labeled as examples because adaptive management actions would be coordinated with DOFAW, USFWS, and other species experts.

Table 4. Summary of Success Criteria, Monitoring, and Adaptive Management Program

Objectives	Success Criteria	Adaptive Management Trigger	Considerations for Adaptive Management Response	Example Adaptive Management Reponses
<p>Objective 1: Secure protection for the Mitigation Area.</p>	<p>Execution of agreement</p>	<p>N/A</p>	<p>N/A</p>	<p>N/A</p>
<p>Objective 2: Increase in the quantity and quality of Hawaiian hoary bat roosting and foraging habitat within the Mitigation Area.</p>	<p>Bat activity will meet 2 or more of the conditions defined in the Success Criteria, demonstrating in this weight-of-evidence approach that the actions effectively enhanced the Mitigation Area by the end of the permit term.</p>	<p>Hawaiian hoary bat activity does not meet 2 or more of the conditions defined in the Success Criteria for the Mitigation Area at the end of Year 5.</p>	<p>If bat activity is decreasing across the Mitigation Area after Year 5, but at least one condition defined in the Success Criteria are met, or bat activity is neutral or trending in the positive direction in the forest corridor or silvopastoral outplanting areas, then the adaptive management response shown in the last column would be employed.</p> <p>If bat activity is decreasing across the Mitigation Area, including in outplanting area, after Year 5, and none of the conditions defined in the Success Criteria are met then the adaptive management response shown in the last column would be employed.</p>	<p>Conduct acoustic monitoring during the following year (Year 6) and rerun analysis. Additional data collection strengthens regression models by enhancing its ability to detect significant effects.</p> <p>Investigate trends in forest cover and insect biomass, and determine if any adaptive management actions shown below could be employed to increase the chance of meeting success criteria by the end of the permit term. Deploy actions as needed.</p> <ul style="list-style-type: none"> • Auwahi would install a second water feature near the Mitigation Area, or • If forest cover is not at least 15 percent in Year 5 above baseline condition, Auwahi would complete supplemental plantings to get forest cover to at least 20 percent by the end of an agreed upon timeframe with USFWS and DOFAW, or • Auwahi would outplant additional species that are likely to attract bat prey species.

9.0 Reporting

Quantitative measures identified for each monitoring variable described in Section 7.0, along with the success criteria summarized in Section 8.0, will be the primary metrics for analysis. Auwahi will include in the annual report a summary of the data by year, including the Baseline Monitoring Years. These measures will include some items that require one-time reporting, once they are completed, and others that are recurring including:

One-time Reporting Requirements

- Affirmation of the binding agreement with the Ranch is fully executed;
- Completion of fence around forest corridors outplanting locations;
- Number of trees planted, or acreage planted;
- Length of edge habitat created;
- Size in gallons and surface area of new water source;
- Photos of water source;

Annual Reporting Requirements

- Status of outplantings;
- Results and changes from the baseline, including the statistical power with which any change is documented for each parameter in the years acoustic monitoring conducted;
- Assessment of bat activity (i.e., detection rates, call type, timing of activity);
- Relationship between changes in bat foraging behavior and changes in quality and quantity of bat foraging habitat; and
- A summary of insect biomass in years when adaptive management is needed;
- Any adaptive mitigation actions taken; and
- Any additional pertinent summary information needed to provide a full picture of mitigation actions.

10.0 Timeline

Table 5 includes a timeline for implementation of mitigation actions and monitoring activities by year.

Table 5. Approximate Implementation Timeline

Timeline ^{1, 2}	Monitoring Period	Mitigation	Description of Actions
2026	Baseline Monitoring	Year 1	<ul style="list-style-type: none"> • Install ungulate exclusion fence around forest corridor planting locations. • Remove ungulates from forest corridor planting locations. • Begin seed collection and plant propagation for outplanting, if necessary. • Outplant silvopastoral plantings and install protection fences. • Conduct baseline acoustic monitoring in the Mitigation Area including in the location of the planned water feature. • Conduct baseline insect monitoring eight times per year. • Measure percent forest cover of Mitigation Area. • Complete assessment of non-native invasive vegetation to inform management.
2027	Baseline Monitoring	Year 2	<ul style="list-style-type: none"> • Complete ungulate exclusion fence around forest corridor planting locations. • Complete removal of ungulates from forest corridor planting locations. • Initiate outplantings in forest corridor planting locations. • Complete silvopastoral outplanting and fencing if not completed in Year 1. • Complete annual non-native invasive vegetation management. • Conduct baseline acoustic monitoring in the Mitigation Area including the location of the planned water feature.
2028	Implementation Monitoring	Year 3	<ul style="list-style-type: none"> • Complete outplantings in forest corridor planting locations. • Conduct implementation acoustic monitoring across the Mitigation Area, including at the water source. • Conduct insect monitoring eight times per year. • Complete ungulate exclusion fence inspections. • Complete annual non-native invasive vegetation management.
2029	Implementation Monitoring	Year 4	<ul style="list-style-type: none"> • Complete ungulate exclusion fence inspections. • Complete annual non-native invasive vegetation management.
2030	Implementation Monitoring	Year 5	<ul style="list-style-type: none"> • Complete ungulate exclusion fence inspections. • Complete annual non-native invasive vegetation management. • Conduct implementation acoustic monitoring across the Mitigation Area, including at the water source.

Tier 6 Site-Specific Mitigation Implementation Plan

Timeline ^{1, 2}	Monitoring Period	Mitigation	Description of Actions
			<ul style="list-style-type: none"> • Conduct insect monitoring eight times per year. • Measure percent forest cover of Mitigation Area.
2031	Implementation Monitoring	Year 6	<ul style="list-style-type: none"> • Complete ungulate exclusion fence inspections. • Complete annual non-native invasive vegetation management.
2032	Implementation Monitoring	Year 7	<ul style="list-style-type: none"> • Complete ungulate exclusion fence inspections. • Complete annual non-native invasive vegetation management. • Conduct implementation acoustic monitoring across the Mitigation Area, including at the water source. • Conduct insect monitoring eight times per year. • Measure percent forest cover of Mitigation Area.
2033		Year 8	<ul style="list-style-type: none"> • Complete ungulate exclusion fence inspections. • Complete annual non-native invasive vegetation management.
2034		Year 9	<ul style="list-style-type: none"> • Complete ungulate exclusion fence inspections. • Complete annual non-native invasive vegetation management.
2035		Year 10	<ul style="list-style-type: none"> • Complete ungulate exclusion fence inspections. • Complete annual non-native invasive vegetation management. • Conduct implementation acoustic monitoring across the Mitigation Area, including at the water source. • Conduct insect monitoring eight times per year. • Measure percent forest cover of Mitigation Area.
<p>1. The timeline for the associated actions described are Auwahi’s best estimate based on current information; however, timing of approvals, logistical challenges, or other factors may affect the precise scheduling of actions (e.g., the installation of the new basin(s)). Changes in the timing of a mitigation action are also likely to affect the associated monitoring. The commitments to the timing of mitigation actions and associated monitoring are described in sections 5.0, 7.0, and their respective subsections.</p> <p>2. Timeline presented aligns with the remaining planned operational life of the Project, through 2035 (Section 1.1 in Tetra Tech 2019).</p>			

11.0 Cost Estimate

Table 6 includes an estimate of costs to implement the mitigation and monitoring actions described in the SSMIP.

Table 6. Cost Estimate

Mitigation Action	Total
Full or partial replacement of 18,300 linear feet of barbed wire (@ \$55/linear foot)	\$1,006,500,
Forest corridor outplanting (materials and labor)	\$280,000
Forest corridor fence installation – 21,650 linear feet, @\$50/linear foot (materials and labor)	\$1,082,500
Silvopastoral fencing installation (406 trees @\$500/tree)	\$203,000
Fence monitoring and maintenance (on average \$15,000 annually for 6 years)	\$90,000
Ungulate removal from fenced forest corridors	\$15,000
Ongoing ungulate monitoring and removal (on average 2.5 hours per year for 6 years)	\$75,000
Water source installation and maintenance	\$100,000
Invasive vegetation control	\$300,000
Acoustic monitoring	\$200,000
Insect monitoring	\$120,000
Total	\$3,472,000

12.0 Literature Cited

- Adams, R. A., and Hayes, M. A. 2008. Water availability and successful lactation by bats as related to climate change in arid regions of western North America. *Journal of Animal Ecology*, 1115-1121.
- Auwahi Wind (Auwahi Wind Energy LLC). 2012. Final Auwahi Wind Farm Project Habitat Conservation Plan. Prepared for Auwahi Wind Energy LLC by Tetra Tech EC, Inc. January 2012.
- Auwahi Wind (Auwahi Wind Energy LLC). 2022. Auwahi Wind Habitat Conservation Plan FY 2022 Annual Report. Prepared for Auwahi Wind by Tetra Tech. August 2022.
- Auwahi Wind (Auwahi Wind Energy LLC). 2024. Habitat Conservation Plan FY 2024 Annual Report. Prepared for Auwahi Wind, LLC. by Tetra Tech. August 2024.
- Bonaccorso, F.J., C.M. Todd, A.C. Miles, and P.M. Gorresen. 2015. Foraging Range Movements of the Endangered Hawaiian Hoary Bat, *Lasiurus cinereus semotus*. *Journal of Mammalogy* 96(1):64-71.
- Boutin, S. 1990. Food supplementation experiments with terrestrial vertebrates: patterns, problems, and the future. *Canadian Journal of Zoology*. Volume 68, Number 2. February.

- Bronson, F. H. 1985. Mammalian reproduction: an ecological perspective. *Biol. Reprod.* **32**: 1–26. Bronson 2009;
- Brooks, R. T. and M. T. Ford. 2005. Bat activity in a forest landscape of central Massachusetts. *Northeastern Naturalist* 12(4):447-462.
- Dormann, C.F., J.M. McPherson, M.B. Araújo, R. Bivand, J. Bolliger, G. Carl, R.G. Davies, A. Hirzel, W. Jetz, W.D. Kissling, I. Kühn, R. Ohlemüller, P.R. Peres-Neto, B. Reineking, B. Schröder, F.M. Schurr, and R. Wilson. 2007. Methods to account for spatial autocorrelation in the analysis of species distributional data: a review. *Ecography* 30: 609–628.
- Entwistle, A.C., S. Harris, A.M. Hutson, P.A. Racey, A. Walsh, S.D. Gibson, I. Hepburn, and J. Johnston. 2001. Habitat management for bats A guide for land managers, landowners and their advisors. Joint Nature Conservation Committee.
- Gorresen, P.M., P.M. Cryan, M.M. Huso, C.D. Hein, M.R. Schirmacher, J.A. Johnson, K.M. Montoya-Aiona, K.W. Brinck, and F.J. Bonaccorso. 2015. Behavior of the Hawaiian Hoary Bat (*Lasiurus cinereus semotus*) at wind turbines and its distribution across the North Koʻolau Mountains, Oʻahu. Hawaiʻi Cooperative Studies Unit, University of Hawaiʻi at Hilo, Technical Report HCSU-064.
- Gorresen PM, Brinck KW, DeLisle MA, Montoya-Aiona K, Pinzari CA, Bonaccorso FJ. Multi-state occupancy models of foraging habitat use by the Hawaiian hoary bat (*Lasiurus cinereus semotus*). *PLoS One*. 2018; 13: 1–14. <https://doi.org/10.1371/journal.pone.0205150> PMID: 30379835.
- Grindal, S.D, and R.M. Brigham. 1999. Impacts of forest harvesting on habitat use by foraging insectivorous bats at different spatial scales. *Ecoscience* 6(1):25 – 34.
- Hawaii Natural Heritage Program. 1996. Natural Diversity Database. December, 1996. The Nature Conservancy of Hawaii, Honolulu, Hawaii.
- Heideman, P.D. 1988. The timing of reproduction in the fruit bat *Haplonycteris fischeri* (Pteropodidae): geographic variation and delayed development. *Journal of Zoology*. Volume 215, Issue 4. Pp 577-595. August.
- H.T. Harvey. 2020. Hawaiian Hoary Bat Research, Maui. Final Report 2019. Project #3978-01. Prepared for TerraForm Power. February 2020.
- Jackrel, S.L., and R. S. Matlack. 2010. Influence of surface area, water level and adjacent vegetation on bat use of artificial water sources. *American Midland Naturalist*, 164, 74 – 79.
- Jantzen, M.K. 2012. Bats and the landscape: The influence of edge effects and forest cover on bat activity. Electronic Thesis and Dissertation Repository. 439. <https://ir.lib.uwo.ca/etd/439>.

- Jantzen, M.K. and M. B. Fenton. 2013. "The depth of edge influence among insectivorous bats at forest–field interfaces." NRC Research Press. 11 March 2013.
<https://cdnsiencepub.com/doi/pdf/10.1139/cjz-2012-0282>
- Kawailoa Wind Power (Kawailoa Wind Power, LLC). 2013. Kawailoa Habitat Conservation Plan—ITL 14: FY 2013 Annual Report—Year 1. Haleiwa, HI.
- Kaheawa Wind Project I. 2024 Habitat Conservation Plan FY 2024 Annual Report. Prepared for Kaheawa Wind Power, LLC.
- Kaheawa Wind Project II. 2024. Habitat Conservation Plan FY 2024 Annual Report. Prepared for Kaheawa Wind Power, LLC.
- Korine, C., Adams, R., Russo, D., Fisher-Phelps, M., and Jacobs, D. 2016. Bats and water: anthropogenic alterations threaten global bat populations. *Bats in the Anthropocene: Conservation of bats in a changing world*, 8, 215-241. Langhans, S.D., and K. Tockner. 2014. Edge effects are important in supporting beetle biodiversity in a gravel-bed river floodplain. *PLoS ONE* 9(12): 1-19.
- Langhans, S.D., and K. Tockner. 2014. Edge effects are important in supporting beetle biodiversity in a gravel-bed river floodplain. *PLoS ONE* 9(12): 1-19.
- Madeiras, A.C., C.F. Davenport, and C.G. Chimera. 1998. Auwahi: Ethnobotany of a Hawaiian Dryland Forest. [Cooperative National Park Resources Studies Unit, University of Hawai'i. Technical Report 117.](#)
- Migula, P. 1969. Bioenergetics of pregnancy and lactation in European common vole. *Acta Theriologica*. Volume XIV, Issue 3. Pp. 167-179.
- Millar, J. S. 1975. Tactics of energy partitioning in breeding *Peromyscus*. *Can. J. Zool.* **53**: 967–976.
- Montoya-Aiona, K., Gorresen, P. M., Courtot, K. N., Aguirre, A., Calderon, F., Casler, S., Ciarrachi, S., Hoeh, J., Tupu, J. L., & Zinn, T. 2023a. Multi-scale assessment of roost selection by 'ōpe'ape'a, the Hawaiian hoary bat (*Lasiurus semotus*). *PloS One*, 18(8), e0288280.
- Montoya-Aiona, K., Gorresen, P.M., and Courtot, K.N. 2023b. Hawai'i Island 'ōpe'ape'a (Hawaiian hoary bat) roost data, 2018–2021: U.S. Geological Survey data release, <https://doi.org/10.5066/P9X6G081>.
- Pinzari, C., R. Peck, T. Zinn, D. Gross, K. Montoya-Aiona, K. Brinck, P. Gorresen, and F. Bonaccorso. 2019. Hawaiian hoary bat (*Lasiurus cinereus semotus*) activity, diet and prey availability at the Waihou Mitigation Area, Maui.
- Racey, P.A. and A.C. Entwistle. 2000. Life-history and Reproductive Strategies of Bats, *Reproductive Biology of Bats*, 10.1016/B978-012195670-7/50010-2, (363-414).
- Rautenbach, I. L., Kemp, A. C., and Scholtz, C. H. 1988. Fluctuations in Availability of Arthropods Correlated with Microchiropteran and Avian Predator Activities. *Koedoe*, 31(1), 77-90.

- Saint-Germain, M., C. M. Buddle, M. Larrivee, A. Mercado, T. Motchula, E. Reichert, T. E. Sackett, Z. Sylvain, and A. Webb. 2007. Should biomass be considered more frequently as a currency in terrestrial arthropod community analyses? *Journal of Applied Ecology*. 44(2): 330-339.
- Scott, S.J., G. McLaren, G. Jones, S. Harris. 2010. The impact of riparian habitat quality on the foraging and activity of pipistrelle bats (*Pipistrellus* spp.). *Journal of Zoology*. Volume 280, Issue 4. Pp. 371-378. April.
- Studier, E.H., V.L. Lysengen, M.J. O'Farrell. 1973. Biology of *Myotis thysanodes* and *M. lucifugus* (Chiroptera: Vespertilionidae)—II. Bioenergetics of pregnancy and lactation. *Comparative Biochemistry and Physiology Par A: Physiology*. Volume 44, Issue 2. Pp 467-471. February.
- Tetra Tech (Tetra Tech, Inc.). 2019. Auwahi Wind Habitat Conservation Plan Amendment. Prepared for Auwahi Wind by Tetra Tech. July 2019.
- Teixeira, D., M. Maron, and B.J. Rensburg. 2019. Bioacoustic monitoring of animal vocal behavior for conservation. *Conserv. Sci. Pract.* 1: e72. doi:10.1111/csp2.72.
- Thompson, J. and K. Hammond. 2021. Technical Memorandum. Tier 4 Bat Mitigation Monitoring: Baseline Monitoring Summary for February 2020 – April 2021. Prepared for Auwahi Wind by Western EcoSystems Technology, Inc.
- Thompson, J. and K. Hammond. 2022. Technical Memorandum. Tier 4 Bat Mitigation Monitoring: 2 Year Baseline Monitoring Summary for February 2020–March 2022. Prepared for Auwahi Wind by Western EcoSystems Technology, Inc.
- Thompson, J. and K. Hammond-Rendon. 2024. Tier 4 Bat Mitigation Monitoring: Interim Monitoring Summary for February 2020 – April 2024. Prepared for Auwahi Wind LLC, Chicago, Illinois. Prepared by Western EcoSystems Technology, Inc. (WEST), Corvallis, Oregon. July 25, 2024. 14 pages + appendices.
- Todd, C.M. 2012. Effects of Prey Abundance on Seasonal Movements of the Hawaiian Hoary Bat (*Lasiurus cinereus semotus*). MSc Thesis, University of Hawai'i.
- Todd, C.M., C.A. Pinzari, and F.J. Bonaccorso. 2016. Acoustic Surveys of Hawaiian Hoary Bats in Kahikinui Forest Reserve and Nakula Natural Area Reserve on the Island of Maui. Hawai'i Cooperative Studies Unit Technical Report HCSU-078.
- Tuttle, S. R., C. L. Chambers, and T. C. Theimer. 2006. Potential effects of livestock water-trough modifications on bats in northern Arizona. *Wildlife Society Bulletin* 34(3): 602 – 608.
- USGS (U.S. Geological Survey). 2013. National Hydrography Geodatabase: The National Map viewer available on the World Wide Web (<https://viewer.nationalmap.gov/viewer/nhd.html?p=nhd>), accessed 16 March 2018.
- Vindigni, M. A., A. D. Morris, D. A. Miller, M. C. Kalcounis-Rueppell. 2009. Use of modified water sources by bats in a managed pine landscape. *Forest Ecology and Management* 258:2056–2061. 10.1016/j.foreco.2009.07.058.

Whitaker, Jr, J.O., and P.Q. Tomich. 1983. Food habits of the hoary bat, *Lasiurus cinereus*, from Hawai'i. *Journal of Mammalogy*, 64(1), pp.151-152.

Wunder, B. A. (1985). Energetics and thermoregulation. In *Biology of New World Microtus*: 812-844. Tamarin, R. H. (Ed.). Spec. Publ. Am. Soc. Mammalogists No. 8.

Attachment A