Hawaiian Hoary Bat Tier 5 Site-Specific Mitigation Implementation Plan

Prepared for

AUWAHI WIND

Prepared by

TETRA TECH

November 2022

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Acronyms and Abbreviations

C-CAP	NOAA Coastal Change Analysis Program
DOFAW	Division of Forestry and Wildlife
HCP	Habitat Conservation Plan
HRS	Hawai‘i Revised Statutes
KFR	Kamehamenui Forest Reserve
Mitigation Area	Tier 5 Mitigation Area
MOU	Memorandum of Understanding
SSMIP	Site-Specific Mitigation Implementation Plan
USFS	U. S. Forest Service
USFWS	U. S. Fish and Wildlife Service

1.0 Introduction

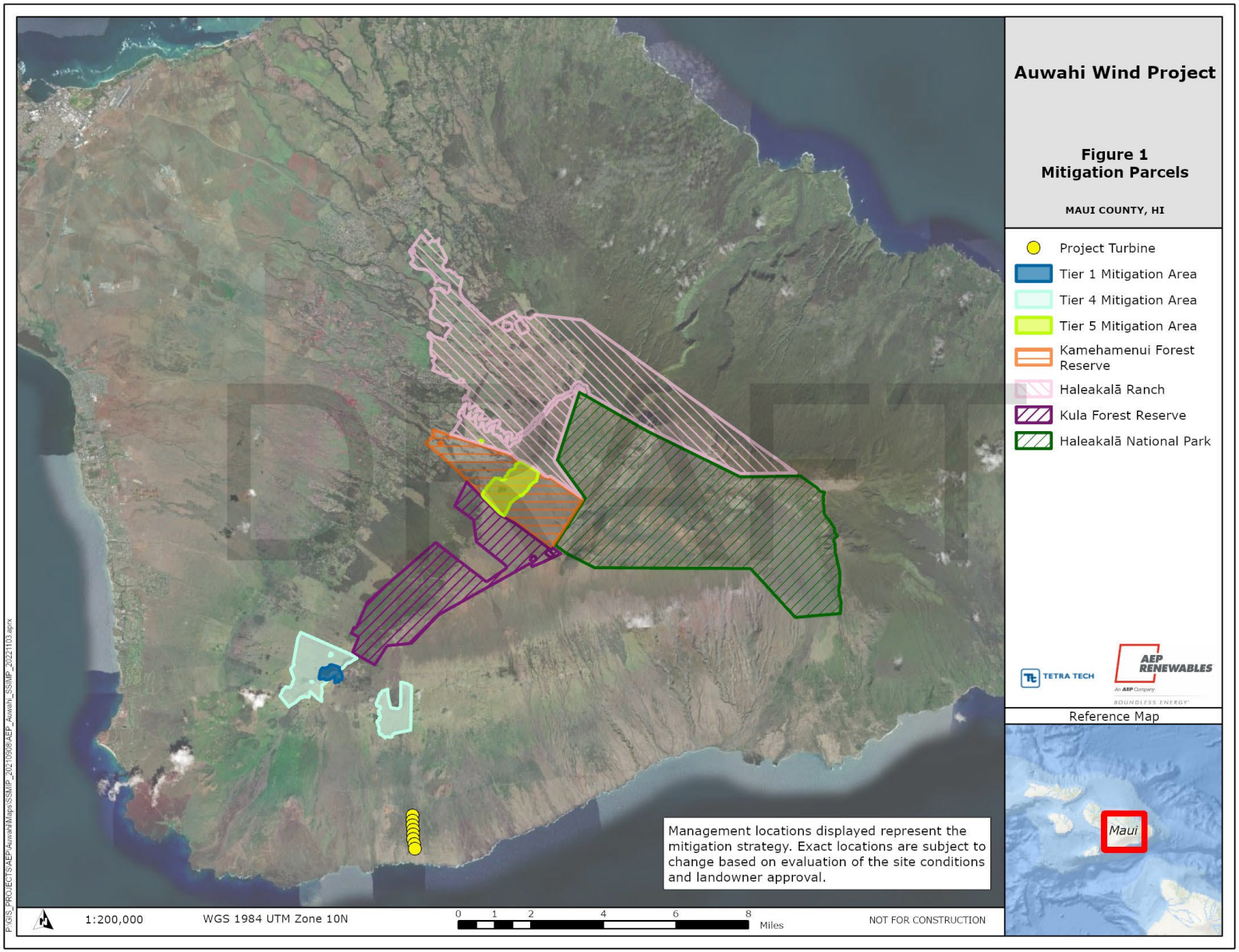
This Tier 5 Site-Specific Mitigation Implementation Plan (SSMIP) follows the mitigation planning for the Hawaiian hoary bat or ʻōpeʻapeʻa (*Lasiurus semotus*), as outlined in the Auwahi Wind Farm (Project) Habitat Conservation Plan (HCP) and as amended in 2019 (Auwahi Wind 2012, Tetra Tech 2019). The SSMIP identifies specific mitigation actions for review and approval by the U.S. Fish and Wildlife Service (USFWS) and Hawaiʻi Division of Forestry and Wildlife (DOFAW) at the time mitigation is triggered. Tier 5 mitigation must offset the take of 34 bats. The Auwahi Wind Energy LLC (Auwahi Wind) proposed Tier 5 bat mitigation site is located within the Kamehamenui (public land) parcel on Maui and a small area of adjacent Haleakalā Ranch (private landowner) lands. The State of Hawaiʻi Department of Land and Natural Resources acquired the 3,433-acre Kamehamenui property in 2020, and DOFAW has added the Kamehamenui parcel to the Forest Reserve System to create the Kamehamenui Forest Reserve (KFR). DOFAW is in the process of creating a management plan for the KFR. As part of their preparation of the SSMIP, Auwahi Wind has consulted USFWS and DOFAW HCP staff and with staff at the DOFAW Maui Branch for input and approval of mitigation actions that would be beneficial to the Hawaiian hoary bat within the proposed mitigation site. Auwahi Wind also consulted with Haleakalā Ranch on proposed mitigation actions on their land (Attachment 1). This SSMIP describes Auwahi Wind's mitigation actions, all of which are additive and complementary to the management actions planned by DOFAW Maui for the KFR.

1.1 Objective

The objective of the SSMIP is to manage and enhance bat foraging and roosting habitat to support the Hawaiian hoary bat through the addition, enhancement, and protection of natural landscape features utilized by the Hawaiian hoary bat. Auwahi Wind has leveraged results of the research, restoration, and management efforts conducted in Tiers 1 – 4 (Figure 1), data from other applicable studies, and USFWS and DOFAW mitigation guidance, to identify appropriate Tier 5 mitigation actions that will offset the incidental take of 34 bats for Tier 5 (Tetra Tech 2019).

1.2 Hawaiian Hoary Bat Life History

The Hawaiian hoary bat is a tree roosting and 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 (<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 (Todd 2012, Gorresen et al. 2018). Bats are documented to travel up to 7 miles per night on the island of Hawaiʻi to reach foraging grounds (Bonaccorso et al. 2015).


Auwahi Wind Project
Figure 1
Mitigation Parcels
MAUI COUNTY, HI
Project Turbine
Tier 1 Mitigation Area
Tier 4 Mitigation Area
Tier 5 Mitigation Area
Kamehamenui Forest Reserve
Haleakalā Ranch
Kula Forest Reserve
Haleakalā National Park
TETRA TECH
AEP RENEWABLES
Reference Map
Maui
Management locations displayed represent the mitigation strategy. Exact locations are subject to change based on evaluation of the site conditions and landowner approval.
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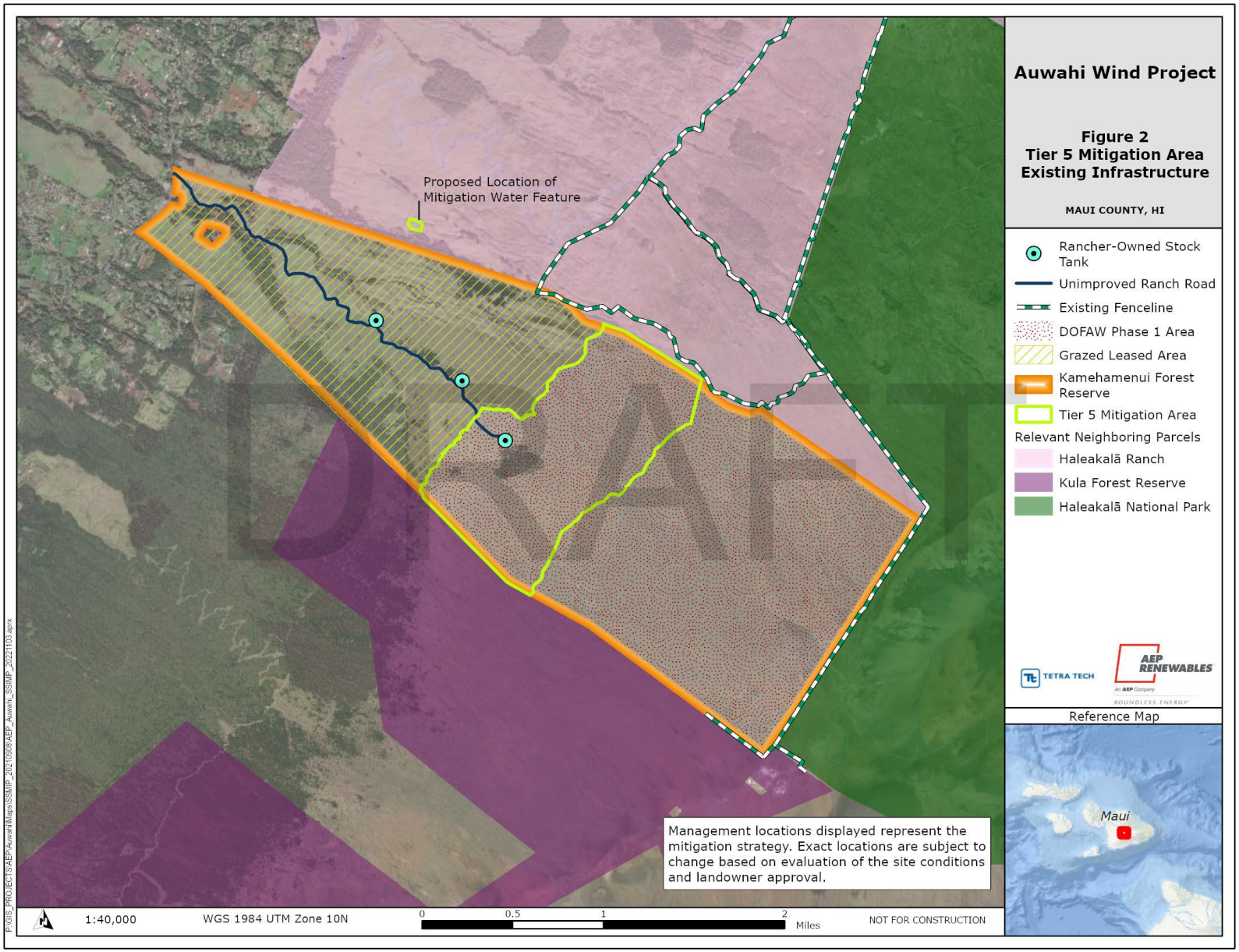
The Hawaiian hoary bat feeds primarily in edge, open habitats, and open bodies of water (USFWS 1998) which is supported by call structure, wing shape, and behavioral observations. Hawaiian hoary bats weigh about 45 percent less than mainland hoary bats, which are open area foragers (Fenton 1990), and this smaller body mass leads to lower wing loading and an increased aptitude for flying in both open and more cluttered environments (Jacobs 1996), such as edge habitats. Hawaiian hoary bats use high-intensity echolocation calls with a mix of narrow and broadband components, which is consistent with forest edge habitat foraging behavior. Edge habitats in general provide efficient foraging habitat that minimizes commuting energy costs and maximizes foraging opportunities (Grindal and Brigham 1999). Edge habitats also provide benefits to some insect species (Langhans and Tockner 2014), as well as providing shelter where insects congregate and where bat foraging activity increases (Grindal and Brigham 1999). Based on acoustic data, Hawaiian hoary bats selectively foraged in gulches, low-density developed, and grassland habitats among nine habitat types in a study on Maui focused in the Kula area (H.T. Harvey 2020).

Hawaiian hoary bats forage across a wide array of habitat types and plant communities from sea level to at least 12,000 feet above sea level. Bats occupy and actively forage among a variety of high elevation habitats both seasonally and nightly and are even suggested to travel relatively long distances on the island of Hawai'i (> 1 mile) to access some high elevation habitats for the purpose of foraging (Bonaccorso et al. 2016). The importance of high elevation habitat, although not completely understood, is well established, as the use of high elevation habitats has been observed on the islands of Hawai`i (Menard 2001, Todd 2012, Gorresen et al. 2013, Bonaccorso et al. 2016) and Maui (Todd et al. 2016). On Maui, vast portions of high elevation native forest, particularly on the west and southwest slopes of Haleakalā, have been lost due to fire, introduced ungulates, and landscape-level invasion of non-native grasses. (Perkins et al. 2014). The loss of this high elevation native forest habitat may be a limiting factor for Hawaiian hoary bats, particularly during the non-breeding season when bats are most likely to occupy these areas.

Bats are documented to use water for drinking and a foraging substrate (Brooks and Ford 2005, Heim et al. 2017, Jackrel and Matlack 2010, Tuttle et al. 2006, Vindigni et al. 2009). The Hawaiian hoary bat is no exception. Lack of water availability may also be a limiting factor for Hawaiian hoary bats. The species has been documented utilizing ponds installed as part of Auwahi Wind's Tier 4 mitigation area (Thompson and Hammond 2021, Thompson and Hammond 2022; also see Section 4.0).

1.3 Mitigation Overview

Auwahi Wind will implement Hawaiian hoary bat Tier 5 mitigation within the KFR located on Leeward Haleakalā, Maui (Mitigation Area; Figure 2). DOFAW suggested the KFR to Auwahi Wind as a desirable site to consider for bat mitigation (S. Fretz, pers. comm., 2018), and thus, KFR was incorporated as a potential mitigation site into the Amended HCP approved by the USFWS and DOFAW in 2019 (Tetra Tech 2019).


Proposed Location of
Mitigation Water Feature
Auwahi Wind Project
Figure 2
Tier 5 Mitigation Area
Existing Infrastructure
MAUI COUNTY, HI
Rancher-Owned Stock Tank
Unimproved Ranch Road
Existing Fenceline
DOFAW Phase 1 Area
Grazed Leased Area
Kamehamenui Forest Reserve
Tier 5 Mitigation Area
Relevant Neighboring Parcels
Haleakalā Ranch
Kula Forest Reserve
Haleakalā National Park
TETRA TECH
AEP RENEWABLES
Reference Map
Maui
Management locations displayed represent the mitigation strategy. Exact locations are subject to change based on evaluation of the site conditions and landowner approval.
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The goal of Tier 5 Hawaiian hoary bat mitigation is to protect, enhance, and increase bat roosting habitat, bat foraging habitat, and bat prey availability. This mitigation will be accomplished by increasing native forest cover at this site though the mitigation actions of fence maintenance, ungulate removal, outplantings of native species, and vegetation management within KFR. These mitigation actions will provide host plants for insect prey and wind breaks for foraging, and roosting habitat (Racey 1982, Grinevitch et al. 1995). In addition to outplanting for native vegetation communities within KFR, Auwahi Wind will install a 50,000-gallon pond on neighboring Haleakalā Ranch land, targeting its use specifically for bats. Open water features are scarce on leeward Haleakalā and monitoring from Tier 2-3 research and Tier 4 mitigation has demonstrated the importance of water features and koa (*Acacia koa*) trees for bats on Maui. The Tier 5 mitigation actions will also augment the connectivity between nearby State Forest Reserves and other conservation areas that currently provide bat habitat (Figure 2).

Auwahi Wind anticipates it will have fulfilled its Hawaiian hoary bat Tier 5 mitigation obligation at the end of the Project's planned 20-year operational period (December 2032; Section 1.1 in Tetra Tech 2019). Auwahi Wind's power purchase agreement ends at this time, and continued operation for the final 5 years of the permit term would require a new or revised power purchase agreement.

The mitigation actions will fully offset the incidental take of 34 Hawaiian hoary bats for Tier 5 and provide a net benefit based on the following:

- The Amended HCP established mitigation acreage amounts for the bat take associated with Tier 5 (Section 6.2.5 in Tetra Tech 2019;). Auwahi Wind will manage at least 690 acres[1] to mitigate for the 34 bats covered in Tier 5, and Auwahi Wind's mitigation actions will be distributed across the Mitigation Area so as to achieve benefits to bats across the entire Mitigation Area;
- Hawaiian hoary bat experts' discussion of Core Use Area suggests that enhancement of bat habitat through the addition of key resource features will reduce the size of an area required for Hawaiian hoary bats to meet foraging and roosting needs (Johnston 2020; DOFAW 2020);
- A combination of open foraging areas, edge habitat, and closed canopy is expected to best meet the species' foraging habitat requirements (Johnston 2020, Section 3.8.1.1 in Tetra Tech. 2019);
- The Mitigation Area contains 690 acres of shrub scrub, pasture/hay, and grassland habitat suitable for managing for Hawaiian hoary bats, including enhancement with key resource features; and

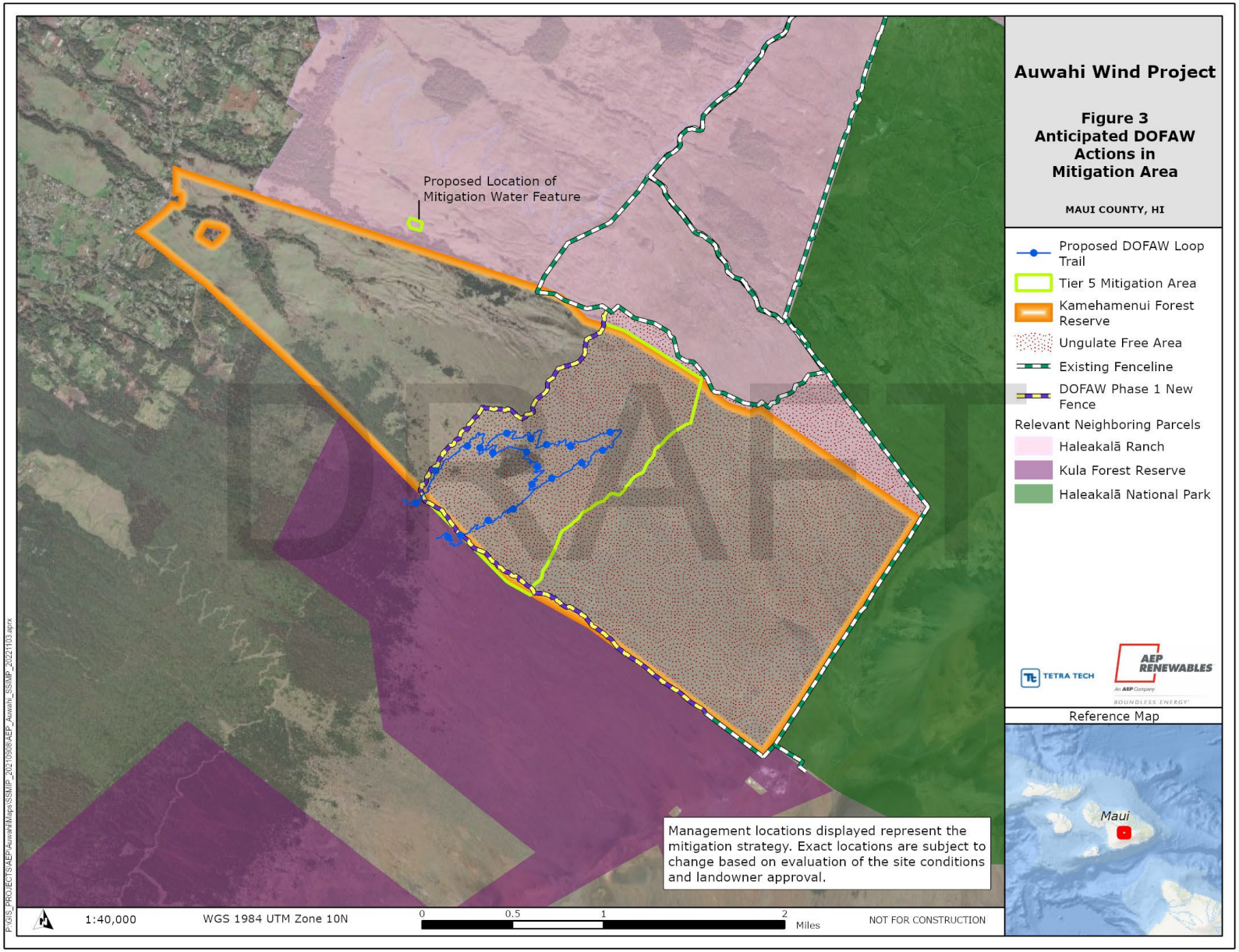
[1] In the HCP Amendment (Tetra Tech 2019), Auwahi Wind commits to 690 acres of mitigation for Tier 5. Auwahi Wind may exceed this value by a nominal amount to ensure that the required mitigation obligations have been fulfilled.

- An agreement (i.e., Memorandum of Understanding [MOU]) is recorded with the DOFAW and Haleakalā Ranch respectively, that lists restrictions on the property for the protection of Hawaiian hoary bats.

Specific habitat enhancements associated with higher bat activity rates, (Thompson and Hammond 2021, Thompson and Hammond 2022) will be implemented to improve and expand currently available bat habitat (e.g., foraging, roosting) in the Mitigation Area. The Mitigation Area will be protected from grazing pressure, through the maintenance of fencing, to promote natural (passive) regeneration of vegetation. Outplanting of native species will be completed to develop native vegetation communities and create edge habitat throughout the currently grazed pasture; thus, enhancing the habitat for bat foraging and roosting. The DOFAW Maui Forest Reserve program has acquired fencing material and procured a fencing contractor to install ungulate fencing to protect their Phase 1 area[2]. This new fencing will provide connectivity to the Haleakalā Ranch fence, the Kula Forest Reserve, and mauka to the Haleakalā National Park, protecting the Mitigation Area within the larger DOFAW Maui Phase 1 area (Figure 3). Auwahi Wind will be responsible for the ungulate removal in the 690-acre Mitigation Area, and ongoing ungulate removal if needed to maintain the Outplanting Area as ungulate free to promote tree establishment (see Section 4.3). Auwahi Wind assumes the fenced Phase 1 area will keep ungulates out of the Outplanting Area, but if outplanting occurs before the DOFAW Maui Forest Reserve program completes the fencing and ungulate removal of the Phase 1 area, Auwahi Wind will fence the Outplanting Areas and remove any ungulates within that specific area, to ensure protection of the outplantings. With ungulates removed throughout the Mitigation Area the native vegetation seed bank is expected to flourish (Forest Starr, pers. comm., June 2022; Lance DeSilva, pers. comm., June 2022) and provide widespread regrowth. Similar regrowth has been seen in the Kahikinui Forest Reserve and within Haleakalā National Park after ungulates were removed in fenced areas. The maintenance of this area as ungulate free provides mitigation benefits for the bat throughout the entirety of the newly fenced Phase 1 area.

Based on the natural history characteristics of the Hawaiian hoary bat and monitoring results from the Auwahi Wind Tier 1 bat mitigation actions, Auwahi Wind expects to provide high value foraging resources for Hawaiian hoary bats in the Mitigation Area through the creation of native vegetation communities, thereby increasing available insect biomass. Additionally, the Tier 5 mitigation actions will augment the connectivity between nearby State Forest Reserves and other conservation areas that currently provide bat habitat.

[2] DOFAW Maui Forest Reserve Program's Phase 1 area is the area within which DOFAW has prioritized near term management actions and for which it has initiated revocation of grazing rights (Section 2.1.2).


Proposed Location of Mitigation Water Feature
Auwahi Wind Project
Figure 3
Anticipated DOFAW Actions in Mitigation Area
MAUI COUNTY, HI
Proposed DOFAW Loop Trail
Tier 5 Mitigation Area
Kamehamenui Forest Reserve
Ungulate Free Area
Existing Fenceline
DOFAW Phase 1 New Fence
Relevant Neighboring Parcels
Haleakalā Ranch
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2.0 Mitigation Area

2.1 Site Description

The Mitigation Area includes 690-acres of mitigation land in order to meet the requirement to mitigate for 34 bats under Tier 5. That will include a combination of an approximately 690-acre area of managed habitat within the KFR and a 2-acre parcel on Haleakalā Ranch within which a pond will be installed. Both of these portions of the Mitigation Area are within the mesic to subalpine zones (between 4,900– 7,600 feet elevation) on the north slopes of Haleakalā (Figure 2). Haleakalā National Park is adjacent to the Mitigation Area to the east, the Kula Forest Reserve is adjacent to the south, and Haleakalā Ranch borders it to the north (Figure 2). The proposed makai fence line of DOFAW's Phase 1 area serves as the lower boundary of the Mitigation Area in the KFR, with the upper boundary generally following the 7,600-foot contour (Figure 2, Figure 3). The current habitat within the Mitigation Area is subject to grazing pressure from cattle as well as feral pigs, goats, deer, and sheep. This ungulate pressure has denuded the vegetation leaving many areas bare or vegetated by sparse short stature non-native pasture grasses; however, the Mitigation Area also includes one, approximately 20-acre forested area and a second roughly 1-acre forested area, both of which have endured the grazing pressure.

2.1.1 Kamehamenui Site Description

DOFAW Maui utilized USFWS Section 6 Grant Award funds to acquire the 3,433 acre Kamehamenui parcel and create the Forest Reserve. In obtaining this grant, DOFAW recognized the need for HCP mitigation options and its potential to co-occur at the site with shared goals for habitat management.

DOFAW contracted Starr Environmental to perform biological surveys throughout the parcel. Starr Environmental characterizes the parcel as follows (see Attachment 2):

> *The land is steep, and there are many small gullies. Much of the area is pasture, with short statured shrubland up high, and scattered forest areas in the pastures, gulches, and along the property margins. The elevation ranges from 3,700 to 9,800 feet above sea level. Annual rainfall averages 27-40 inches. Annual air temperature averages 44-61 degrees Fahrenheit.*

Little infrastructure exists within the newly acquired KFR. The site has three lessee owned water tanks, one of which occurs within the Mitigation Area. The State acquired a well with the purchase, located near the makai boundary of the KFR. The well is used to pump water to the water tanks. Water resources are generally limited in Leeward Haleakalā (USGS 2013); however, one livestock water tank (approximately 50,000 gallons in size) owned by a rancher (the current lessee) is present within the Mitigation Area (see Section 3.1).

There are currently no established trails within the Mitigation Area, and the only road is a 300-foot segment of the unimproved ranch road (Figure 2). The site has no permanent fencing but does border parcels which have existing fencing.

2.1.2 KFR Existing Legal Protections

The Trust for Public Land purchased the Kamehamenui forest lands from the Shizuka Asakawa Revocable Trust in July 2020, and then conveyed the property to DOFAW on August 31, 2020. Most of the acquisition funding was provided by grants from the U.S. Forest Service (USFS) Forest Legacy Program and the USFWS Habitat Conservation Plan Acquisition Program, both funded as part of the federal Land and Water Conservation Fund. State funding secured through legislative appropriation provided the matching funds needed to complete the purchase.

DOFAW now manages the KFR parcel, which is subject to a grazing lease that expires in 2031. DOFAW's stated purpose of acquiring the parcel was to enable "complementing required mitigation being performed pursuant to the respective HCPs and to contribute to the long-term recovery of the covered species as well as for 10 additional endangered species" (BLNR 2019). DOFAW's management goals include the following:

- Develop a comprehensive multi-use management plan based on public input and grant requirements (anticipate finalizing in 2023).
- Fund and implement actions for management purpose as undeveloped wilderness, open space, and forest restoration.
- Conform to the requirements of the USFS grant:
    - Increase forest cover of KFR to 75 percent, including restoration of subalpine areas.
- Conform to the requirements of the KFR grazing lease agreement:
    - The lessee exercised their option to extend the lease for one additional 10-year period that expires in 2031. This was conveyed with the purchase of the parcel.
    - Pursuant to the amended and revised grazing lease and hunting license agreement, the lessor can exercise such right or privilege to withdraw all or portions of the leased land under several conditions which in part includes that the lessor provide 12-month prior notice of withdrawal.
    - DOFAW has initiated revocation of the grazing lease for approximately 2,200 acres of high elevation lands including approximately 120 acres of pasture/hay and grasslands and over 1,050 acres of shrubland (i.e., Phase 1 area; see Figure 2, Figure 3).
- Conform to requirements of the Forest Reserve System under Hawai'i Revised Statutes (HRS) Chapter 183 and Hawai'i Administrative Rules Chapter 104, which prohibit the following actions (among others):
    - The capture, injury, or killing of plants or animals;
    - The removal, damage, or disturbance of natural features or resources;
    - The introduction of any plant or animal except as approved by the Board; and

  - Actions which could result in a wildfire.
- Conform to the requirements of the USFWS Grant Award F18AP00085:
  - Protect the KFR in perpetuity to enhance recovery efforts for federally listed endangered species, including ʻuaʻu or Hawaiian petrel (*Pterodroma sandwichensis*), nēnē or Hawaiian goose (*Branta sandvicensis*), Hawaiian hoary bat, and Blackburn's sphinx moth (*Manduca blackburni*; Covered Species).
  - Complement required mitigation being performed pursuant to the respective HCPs.
  - Contribute to the long-term recovery of the Covered Species as well as for 10 additional endangered species.
  - Protect and restore suitable habitat, increasing survival and reproductive success of those listed species.
  - Develop a multi-resource management plan for the KFR that includes management strategies and recovery efforts to benefit federal listed species on the property.
  - Consult with USFWS during the development of the multi-resource management plan.

2.1.3 Haleakalā Ranch Site Description

Auwahi Wind will install a pond for bat use on the adjacent Haleakalā Ranch lands north of the KFR. Due to concerns by DOFAW Maui regarding safety, a pond would not be suitable for installation in the KFR. Auwahi Wind has worked with Haleakalā Ranch to identify an approximately 2-acre portion of a parcel (Parcel number 230050030000) within the existing ranch lands at 4,900 feet in elevation (Figure 2). More details on the pond can be found in Section 4.4.

The Haleakalā Ranch parcel is near the main access road for Haleakalā National Park; the road traverses the northern edge of the parcel adjacent to the KFR. Haleakalā Ranch also has additional lands north of the Haleakalā Highway. In addition to this main road, the ranch has several ranch roads and some cabins on the pasturelands surrounding the parcel which are used to support ranch operations. Haleakalā Ranch maintains cattle fencing along the perimeter of this pasture.

2.1.4 Haleakalā Ranch Existing Legal Protections

The lands owned by Haleakalā Ranch have no existing legal protections that provides benefits specifically for the Hawaiian hoary bat.

3.0 Baseline Habitat Conditions

The state of the Mitigation Area prior to acquisition of the KFR by DOFAW reflects the baseline habitat conditions. Baseline habitat conditions described below provide the starting point from which mitigation benefits will be measured.

3.1 KFR Baseline Habitat Conditions

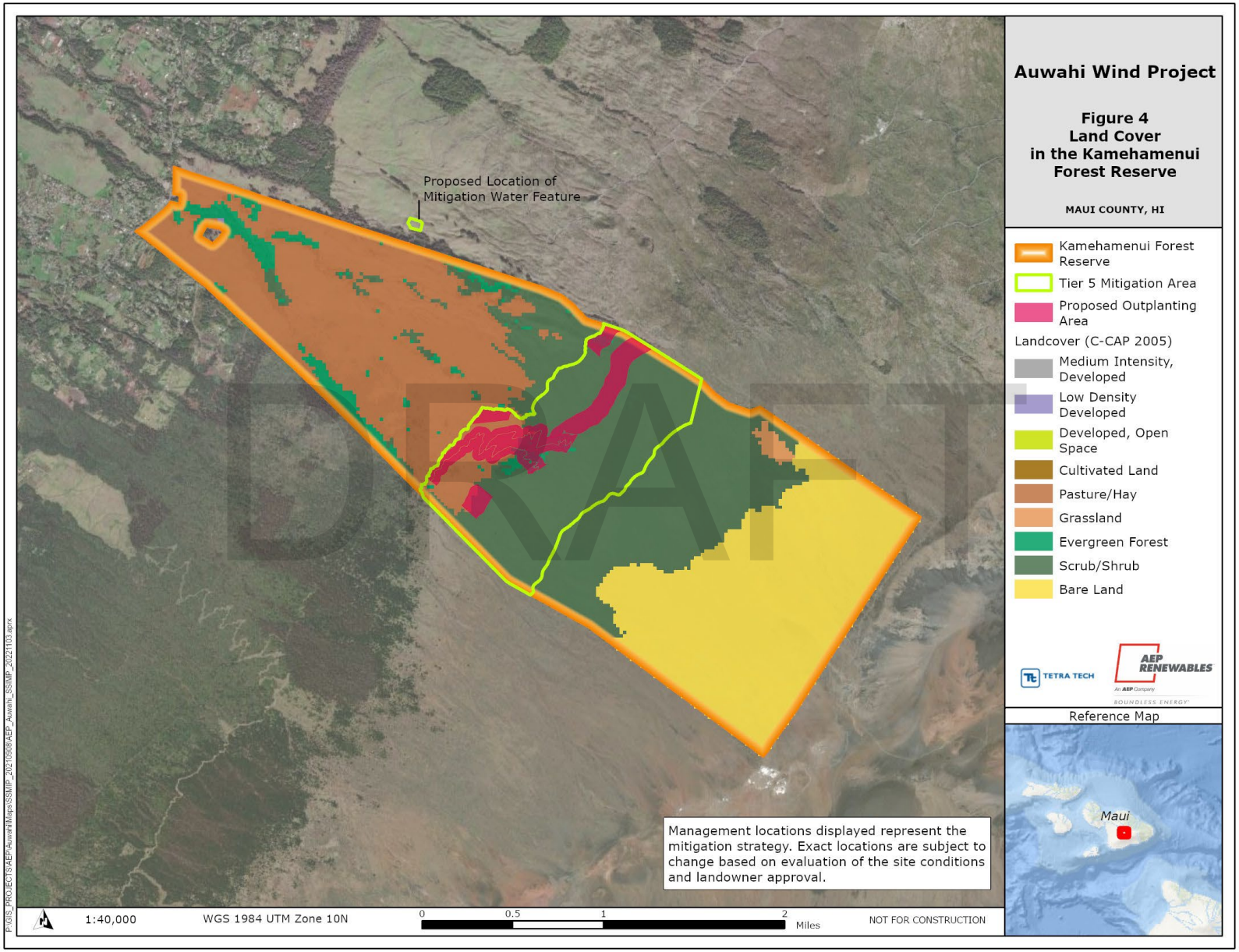
The Starr Environmental survey report from 2021 describes the baseline habitat conditions within the KFR (Attachment 2). In summary, the habitat across the entire KFR parcel is comprised of three main vegetation types: Grassland/Pasture, Mesic Forest, and Subalpine Shrubland. These vegetation communities are associated with elevation levels within KFR. The majority of the area below 6,500 feet is dominated by pasture with vast areas of open grassland and non-native species. Mesic forest is scattered within the grassland, especially near gullies (Figure 4). Most of the tree species within these pockets of forest are non-native but native trees still persist, generally in areas above 5,500 feet. Subalpine shrubland exists above 6,500 ft and is dominated by native shrubs with sparse grasses and ferns. At the highest elevations of the subalpine shrubland, vegetation is very sparse and, in some areas, does not exist.

The current and past use of KFR is ranching, and the vegetative communities were largely unmanaged. As a condition of the sale of the parcel, the State agreed to a conditional approval of the existing ranching lease. The rancher grazes cattle on leased land within the KFR, including the Mitigation Area. In addition to grazing, feral ungulates have affected the plant communities throughout the Mitigation Area; cattle, sheep, deer, and goats can currently be found throughout the Mitigation Area. The Mitigation Area has some fencing on adjacent parcels but without a complete fence feral ungulates roam freely through the parcel.

DOFAW plans to remove ranching throughout a majority of the Forest Reserve lands although the timing of ranch lease revocation is uncertain. DOFAWs initial step of transitioning away from ranching will be to convert the portion of the parcel, above approximately 6,000 feet elevation to conservation from grazing. DOFAW is prioritizing habitat protection in this area through fencing and eradication of feral ungulates (L. DeSilva, pers. comm., March 30, 2021). The grazing rights in the Phase 1 area will be revoked as of January 2023.

Although a water tank exists within the Mitigation Area, legal agreements require the removal of this tank, and no ponds exist within the KFR. As noted in Section 2.1.1, one livestock water tank (approximately 50,000 gallons in size) owned by the current lessee is present within the Mitigation Area (Figure 5). Under the existing lease, the rancher is required to remove the water tank upon expiration of their grazing lease in 2023. DOFAW has expressed an interest in having water available on the site, however it remains to be seen if DOFAW will coordinate to maintain this water tank. Therefore, the baseline as it relates to water tanks or ponds is that none will be present within the KFR by the end of 2023.

The subalpine portion of the KFR includes some portions of intact native subalpine ecosystem that is designated federal critical habitat for 10 rare plant and bird species. These areas are expected to be important for species' adaptation to climate change as habitats shift under changing conditions. No federal critical habitat occurs within the Mitigation Area.


Auwahi Wind Project
Figure 4
Land Cover
in the Kamehamenui
Forest Reserve
MAUI COUNTY, HI
Proposed Location of
Mitigation Water Feature
Kamehamenui Forest Reserve
Tier 5 Mitigation Area
Proposed Outplanting Area
Landcover (C-CAP 2005)
Medium Intensity, Developed
Low Density Developed
Developed, Open Space
Cultivated Land
Pasture/Hay
Grassland
Evergreen Forest
Scrub/Shrub
Bare Land
TETRA TECH
AEP RENEWABLES
Reference Map
Maui
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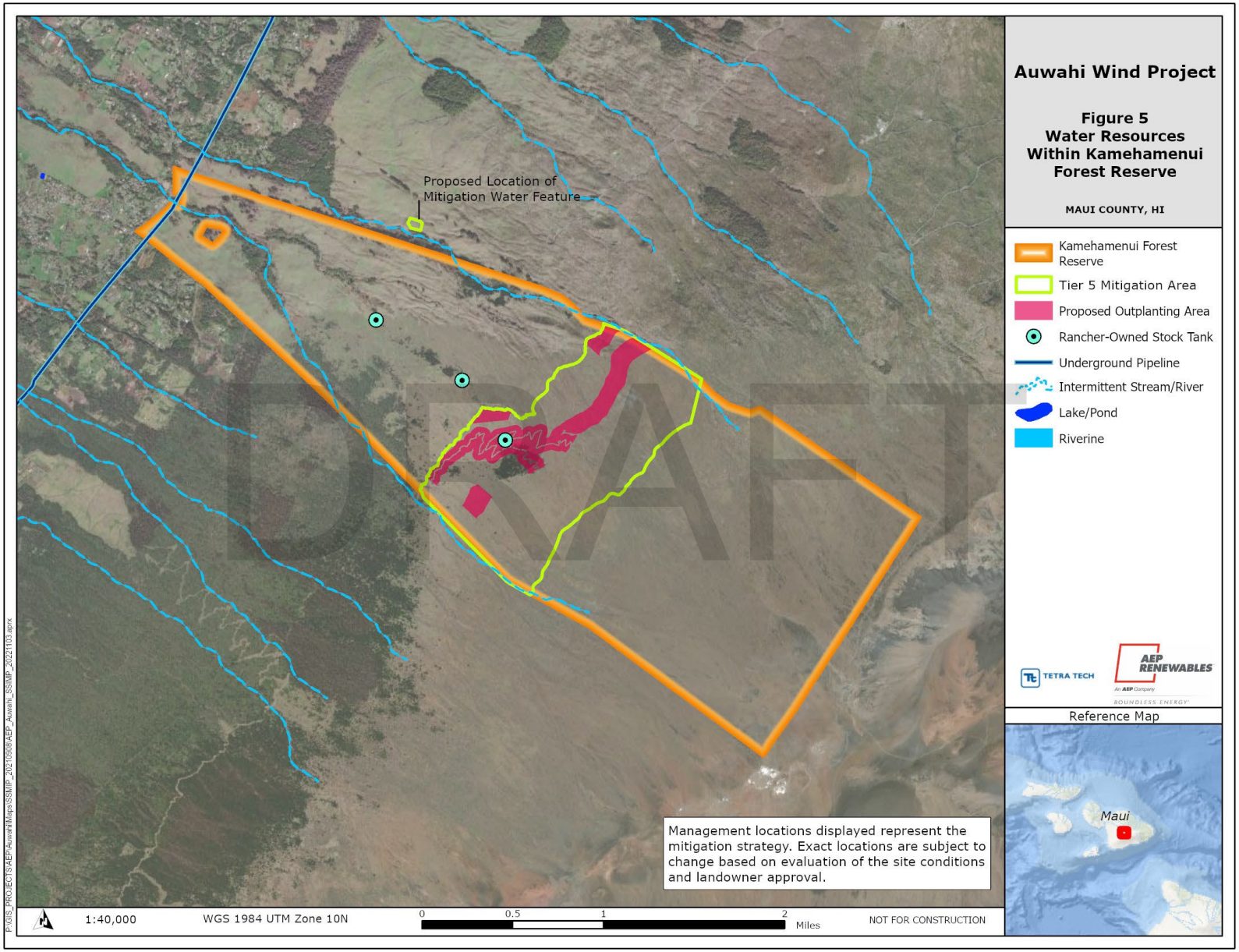
Proposed Location of
Mitigation Water Feature
Auwahi Wind Project
Figure 5
Water Resources
Within Kamehamenui
Forest Reserve
MAUI COUNTY, HI
Kamehamenui Forest Reserve
Tier 5 Mitigation Area
Proposed Outplanting Area
Rancher-Owned Stock Tank
Underground Pipeline
Intermittent Stream/River
Lake/Pond
Riverine
TETRA TECH
AEP RENEWABLES
Reference Map
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Little forest cover exists within the Mitigation Area. Table 1 shows land cover estimates from the NOAA Coastal Change Analysis Program (C-CAP) (Figure 4). Although characterized as scrub/shrub habitat by C-CAP much of the vegetation in the Mitigation Area is low stature and sparse as illustrated by field surveys (Attachment 2).

Table 1. Land Cover in the Proposed Mitigation Area

Land Cover	Tier 5 Mitigation Area[1]	
	Acres	Percentage
Scrub Shrub	563	82
Pasture/Hay	105	15
Evergreen	22	3
TOTAL	690[1]	100

[1]The final Mitigation Area will total 690 acres and will include lands from both the KFR and an approximately 2-acre parcel on Haleakalā Ranch, within which a pond will be constructed. This area will be located within the larger area summarized here.

Hawaiian hoary bats have been noted to use gulches (Todd et al. 2016, H.T. Harvey 2020), and several prominent gulches pass through the Mitigation Area that could also provide priority habitat for the Hawaiian hoary bat (Photo 1).

Photo 1. Aerial Photo of the Current Conditions of the Kamehamenui Forest Reserve

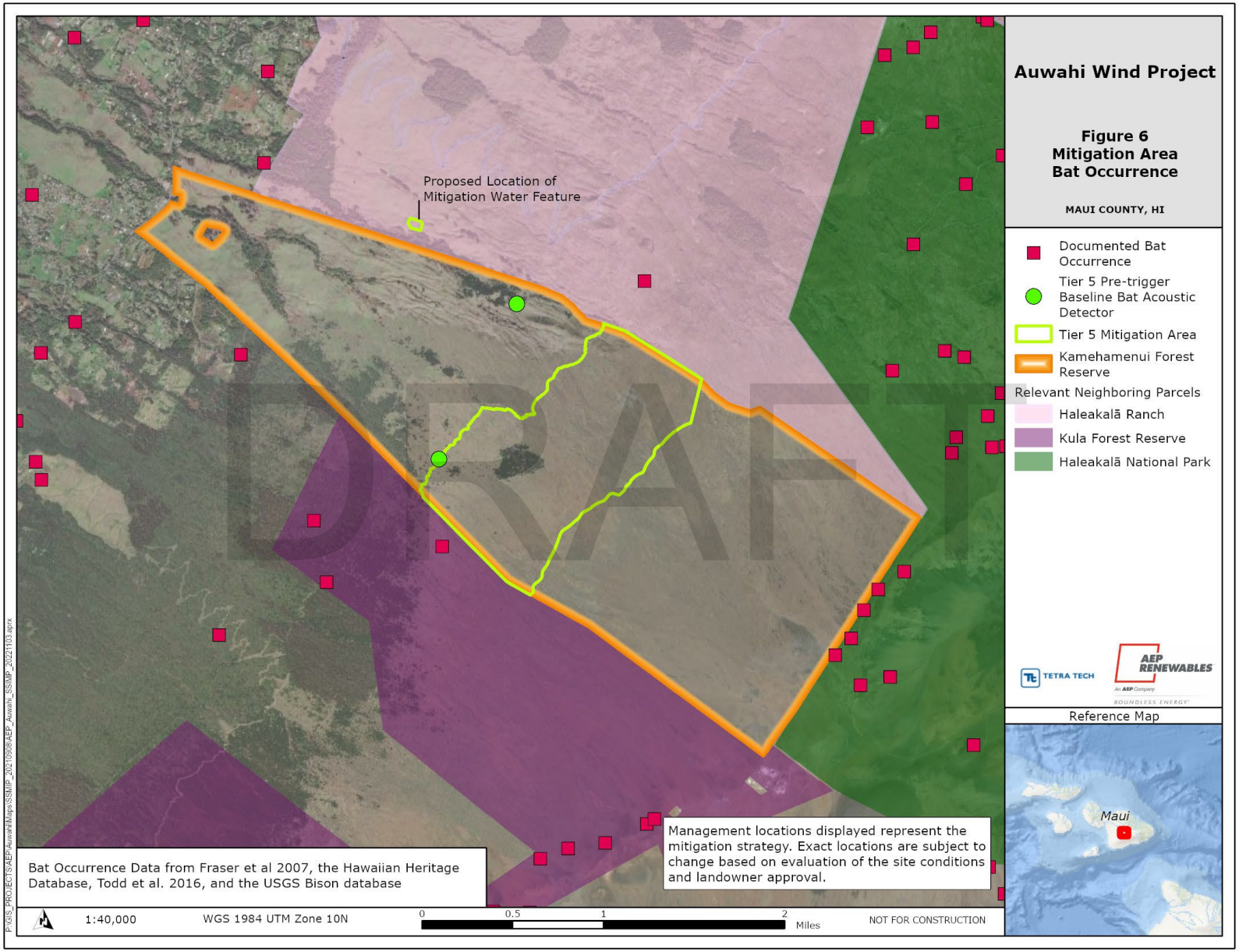
(Photo credit: DLNR n.d.)

Hawaiian hoary bats occur adjacent to the Mitigation Area based on documented occurrences from the Hawaiian Heritage Database, the U.S. Geological Survey's Bison database, and results from the Endangered Species Recovery Committee (ESRC)-approved research (Figure 6; H.T. Harvey 2019). Furthermore, telemetry work by H.T. Harvey (2020) demonstrated overlap of several individual bat Core Use Areas and foraging areas within the Mitigation Area. Auwahi Wind has implemented one year of Pre-Trigger, Baseline Monitoring at KFR (see Section 6.0). Monitoring to date shows bat activity, and Auwahi Wind will document use rates in a summary report following the completion of Pre-trigger, Baseline Monitoring.

3.2 Haleakalā Ranch Existing Habitat Conditions

The baseline habitat conditions within the adjacent Haleakalā Ranch lands to the north are similar to the existing habitat conditions at the KFR. This parcel includes thousands of acres, currently grazed by cattle and also used by feral goats, pigs, and deer. The vegetation is predominantly a mix of kikuyu grass (*Pennisetum clandestinum*) and short stature shrubs of pūkiawe (*Leptecophylla tameiameiae*), aʻaliʻi (*Dodonaea viscosa*), and some hedgerows of eucalyptus (*Eucalyptus* sp.) are near the approximately 2-acre Haleakalā Ranch mitigation parcel. The ranch is also working to plant koa for forestry practices at densities ranging from 6 to 100 trees per acre in pastures along the Haleakalā Highway. No existing ponds are present on the parcel directly north of KFR. The parcel where the new pond will be located is within the larger Haleakalā Ranch described here and is currently grazed grassland.

Given the proximity to KFR and bats capability for movement, Auwahi presumes bat activity in the Haleakalā Ranch lands are similar to the bat activity rates documented within the KFR, through Pre-Trigger, Baseline Monitoring.


Auwahi Wind Project
Figure 6
Mitigation Area
Bat Occurrence
MAUI COUNTY, HI
Proposed Location of
Mitigation Water Feature
Documented Bat Occurrence
Tier 5 Pre-trigger Baseline Bat Acoustic Detector
Tier 5 Mitigation Area
Kamehamenui Forest Reserve
Relevant Neighboring Parcels
Haleakalā Ranch
Kula Forest Reserve
Haleakalā National Park
TETRA TECH
AEP RENEWABLES
Reference Map
Maui
DRAFT
Management locations displayed represent the mitigation strategy. Exact locations are subject to change based on evaluation of the site conditions and landowner approval.
Bat Occurrence Data from Fraser et al 2007, the Hawaiian Heritage Database, Todd et al. 2016, and the USGS Bison database
1:40,000
WGS 1984 UTM Zone 10N
0 0.5 1 2
Miles
NOT FOR CONSTRUCTION
P:\GIS_PROJECTS\AEP-Auwahi\Maps\SSMIP_20210308\AEP_Auwahi_SSMIP_20221103.aprx

4.0 Mitigation Actions

The objective of Auwahi Wind's mitigation actions will be to increase bat night-roosting and foraging habitat, and prey availability within the 690-acre Mitigation Area. These actions have been reviewed by DOFAW-Maui as part of a collaborative process with Auwahi Wind to develop and implement mitigation actions which are both beneficial to the Hawaiian hoary bat and complementary to DOFAW's long term management goals for the KFR property.

As previously identified, the Mitigation Area primary land cover type is scrub shrub with small areas of pasture/hay, evergreen, and grassland habitats (Table 1), and provides limited bat roosting habitat. A portion of the Mitigation Area contains one, approximately 20-acre forested area and another roughly 1-acre forested area that may serve as roost habitat and provide edge habitat important for foraging, but generally the Mitigation Area is devoid of roosting habitat. Removal of ungulates will remove grazing pressure on those two forest stands. If the existing forest stands need to be removed for any reason, Auwahi Wind will plant native trees to continue to meet the mitigation requirement. The creation of roosting habitat in this area should enhance bat foraging efficiency by decreasing the distance bats are required to transit to reach high density foraging resources (see discussion in the HCP Amendment, Sections 3.8.1.1 [biology] and 6.2.4.2 [mitigation actions]; Tetra Tech 2019). Thus, the location of the Mitigation Area within the subalpine zone increases its conservation value for bats (and other species). Outplantings in a 138-acre section of the Mitigation Area would provide additional roosting and foraging habitat (Table 1, Figure 4).

The acquisition of the KFR by the State provides an opportunity for improving the habitat to increase its suitability for the Hawaiian hoary bat. A condition of DLNR's acquisition of Kamehamenui Forest is the staged revocation of the current lessees grazing and hunting rights and termination of grazing and hunting no later than 10 years after the date of acquisition. Had the parcel not been acquired, the presence of cattle, sheep, deer, and goats throughout the Mitigation Area would likely have continued indefinitely. One water tank is currently located within the Mitigation Area; it does not have wildlife egress structures, nor is it currently used by the State for fire management purposes, and it is slated for removal by the lessee at the termination of their lease in 2023 (see Section 3.1).

As discussed in detail in the HCP Amendment (Tetra Tech 2019), the Hawaiian hoary bat uses a variety of habitats for a variety of purposes; thus, a combination of open foraging areas, edge habitat, and closed canopy is expected to best meet the species' needs. As a result, Auwahi Wind will achieve its Tier 5 mitigation objective by implementing the following mitigation actions by the end of the planned operational period of the Project (December 2032) on the KFR and Haleakalā Ranch lands (Figure 7):

1) Protect existing habitat and promote passive native species regeneration (Lance Desilva, pers. comm., 2021; Forest Starr, pers. comm., 2022) by:
    a. Removing feral ungulates as necessary to protect the Outplanting Area,

b. Providing fence maintenance, repair, or retrofit, to create sub-units within the Phase 1 area to support the ongoing outplanting efforts and protect juvenile plants from ungulate grazing and trampling.

2) Create edge habitat within the Outplanting Area (e.g., outplanting sites) to be used by bats as foraging and roosting substrate and travel corridors, through:

   a. Targeted outplanting of 138 acres of koa at 100 trees per acre, or approximately 13,800 koa.

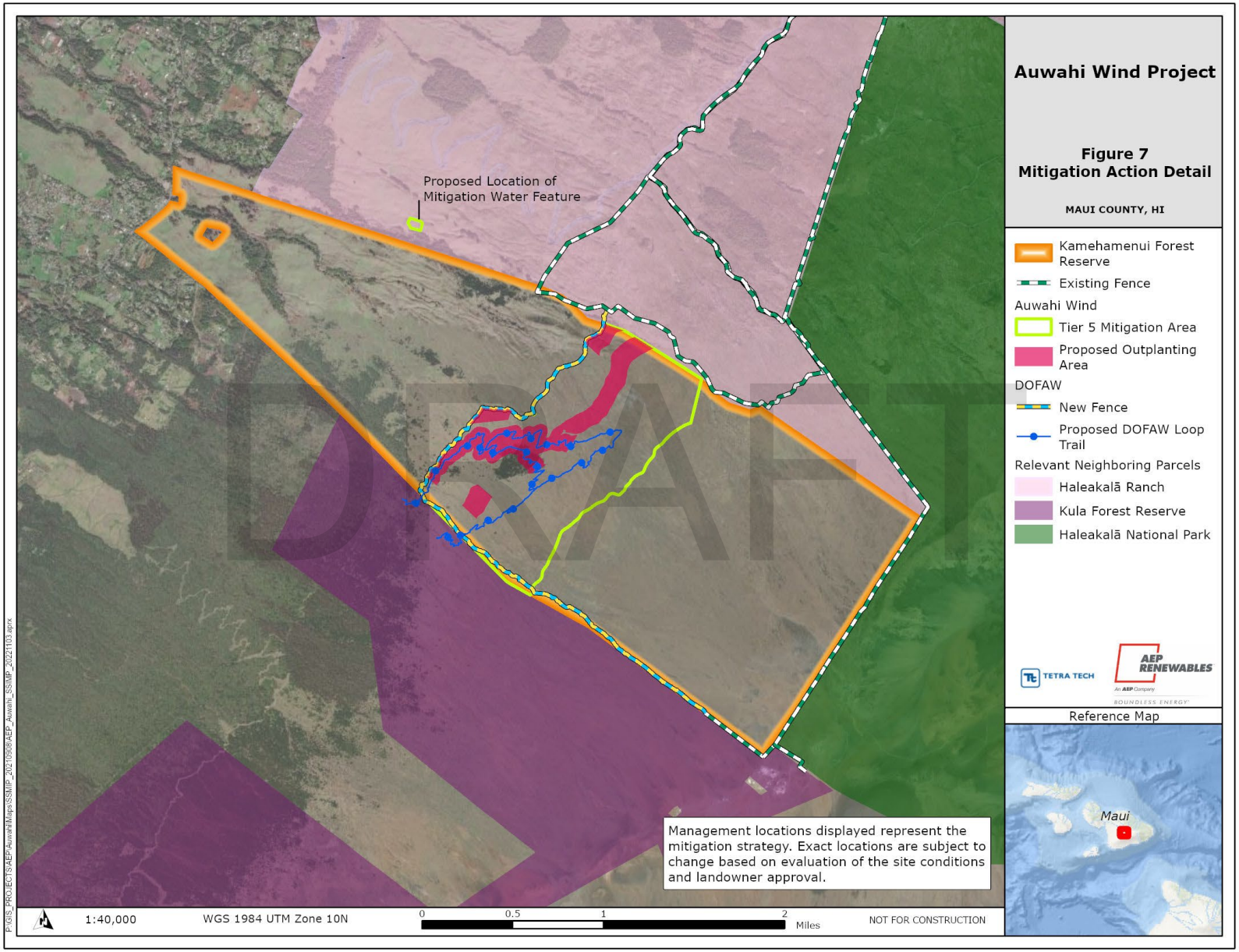
   b. Inclusion of interspersed gaps to provide three-dimensional structure.

3) Ensure water features within the Mitigation Area have wildlife egress structures, and

4) Construct one additional pond for bat drinking or foraging.

These habitat enhancements and features will increase the amount of available foraging and roosting resources for Hawaiian hoary bats on Maui. The combination of these specific mitigation actions will provide immediate, near-term, and long-term benefits to bats. The mitigation actions described here and summarized below draw heavily upon literature cited within the HCP Amendment (Tetra Tech 2019).

Auwahi Wind will coordinate with the DOFAW Maui forestry manager throughout the development of its management plan for the KFR to ensure that Auwahi Wind's proposed mitigation actions are compatible. Lessons learned from similar Hawaiian hoary bat mitigation actions performed by Auwahi Wind for Tiers 1 – 4 will be applied. The success of creating edge habitats to increase bat activity has been demonstrated at Auwahi's Tier 1 mitigation area where forest cover has increased rapidly as a result of outplanted koa (Photo 2, Photo 3). Additionally, in their Auwahi Tier 2/3 bat mitigation study, the U.S. Geological Survey noted a degree of co-occurrence of adult bats adjacent to the Tier 1 mitigation site that has not been seen elsewhere and suggests that either prey was not limiting, or resources facilitated tolerance of intraspecific competition, or high spatial-temporal turn over in a high resource area (Pinzari et al. 2019). Additional acoustic and thermal monitoring at the Tier 4 mitigation area shows higher relative activity rates adjacent to the Pu'u Makua mitigation site likely due to increased forest cover edge habitat (Photo 4; Tetra Tech 2021).


Proposed Location of
Mitigation Water Feature
Auwahi Wind Project
Figure 7
Mitigation Action Detail
MAUI COUNTY, HI
Kamehamenui Forest Reserve
Existing Fence
Auwahi Wind
Tier 5 Mitigation Area
Proposed Outplanting Area
DOFAW
New Fence
Proposed DOFAW Loop Trail
Relevant Neighboring Parcels
Haleakalā Ranch
Kula Forest Reserve
Haleakalā National Park
TETRA TECH
AEP RENEWABLES
Reference Map
Maui
Management locations displayed represent the mitigation strategy. Exact locations are subject to change based on evaluation of the site conditions and landowner approval.
1:40,000
WGS 1984 UTM Zone 10N
0
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Miles
NOT FOR CONSTRUCTION
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Photo 2. Pu'u Makua Forest Cover June 2018

Photo 3. Pu'u Makua Forest Cover October 2021

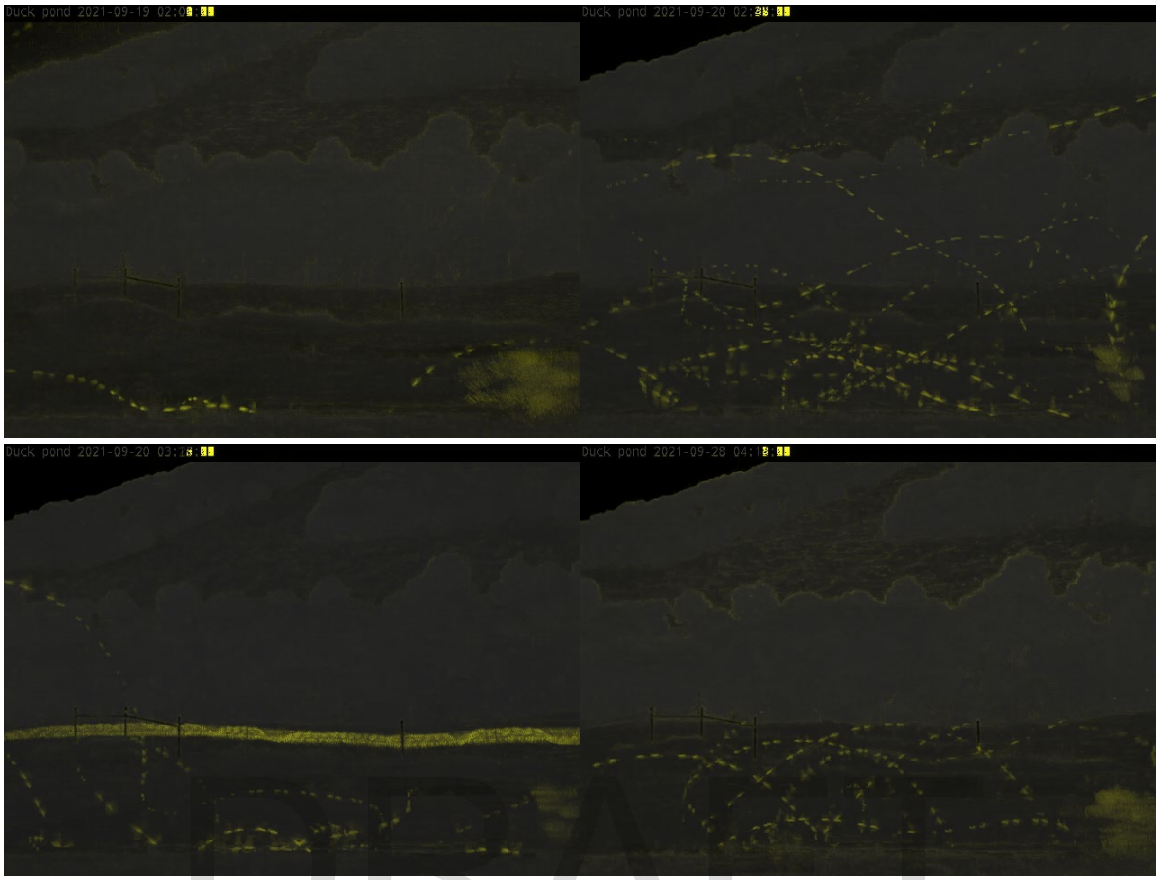

Photo 4. Example Photos Illustrating Hawaiian Hoary Bat Activity Varying over Several Nights from the Newly Installed Tier 4 Ponds in September 2021

Open water features are scarce on leeward Haleakalā and monitoring from Tier 2-3 research and Tier 4 mitigation monitoring has demonstrated the importance of water features for bats on Maui. In the Tier 4 mitigation area, bats were documented at notably higher densities at the existing duck ponds. The capture of eight adult males over two sampling periods spanning eight months and within the limited area suitable for netting bats, indicated a degree of co-occurrence as-yet not observed elsewhere. Bats have also been documented utilizing the new ponds installed as part of Auwahi Wind's Tier 4 mitigation within 6 months of being filled. In March 2021 the ponds were filled, and by September 2021 when thermal monitoring occurred at the newly installed ponds, the thermal monitoring documented bats using the pond throughout the night, suggesting multiple bats are benefiting from the pond installation with minimal lag time from pond completion.

Table 2 summarizes the baseline conditions of various resources within the Mitigation Area that will be managed by Auwahi Wind for the purposes of creating, protecting, and enhancing bat roosting and foraging habitat. The actions implemented by Auwahi Wind will be distinct from those implemented by DOFAW Maui. Auwahi Wind may fund DOFAW Maui or a contractor to implement actions necessary to achieve the bat habitat enhancement and protection measures described in this document. Auwahi Wind alone is responsible for implementing these measures and meeting

the associated success criteria. If DOFAW Maui is to perform the work, they will be treated the same as any other contractor performing the work and will need to adhere to Auwahi Wind contractor policies and procedures. For more specific timing of when these activities will occur refer to Section 10.

Table 2. Summary of Proposed Management Actions to be implemented by Auwahi Wind in the Mitigation Area

Resource	Understanding of Baseline Condition	Management and Monitoring Action
Forest Cover (Outplanting)	Approximately 3 percent forest cover within the Mitigation Area provide core use areas and foraging areas for a small number of individual bats within the Mitigation Area. Quantify Pre-Trigger, Baseline Monitoring levels of bat activity in the Mitigation Area using 2 acoustic detectors. Prey species of insects present in Mitigation Area (inferred from telemetry monitoring). Quantify baseline levels of insect abundance in the Mitigation Area using at least 3 insect traps.	Plant 138 acres (Outplanting Area) to increase and maintain forest cover (i.e., 20 percent of the 690-acre Mitigation Area) Quantify bat activity in response to mitigation actions in the Mitigation Area using at least 14 acoustic detectors. Utilize additional monitoring methods as appropriate (e.g., thermal cameras). Provide thermal monitoring of Mitigation Area to improve understanding of bat use of water tanks and improve understanding of how bats use newly established outplantings. Quantify insect abundance in response to mitigation actions in the Mitigation Area using the same number of traps as Baseline Monitoring .
Fencing	Mitigation Area partially enclosed by ungulate-proof fencing along boundary with Haleakalā National Park and Haleakalā Ranch	Support DOFAW Forest Reserve actions to maintain fencing to prevent tree growth suppression resulting from unmanaged grazing. If needed, to supplement DOFAW Forest Reserve Actions, install bat-safe fencing where needed to protect edge habitat areas (i.e., outplanting sites).
Feral Ungulates	Present throughout Mitigation Area	Removal and exclusion from entire Mitigation Area.
Water Features	One 50,000-gallon open water tank which will be removed at expiration of ranch lease. Quantify Pre-Trigger, Baseline Monitoring levels of bat activity in the Mitigation Area using 2 acoustic detectors.	Install a new pond on Haleakalā Ranch land, install bat safe fencing, and maintain. Install wildlife egress structures for any water tank within the Mitigation Area. Quantify bat activity in response to mitigation actions in the Mitigation Area using at least 14 acoustic detectors. Utilize additional monitoring methods as appropriate (e.g., thermal cameras). Provide thermal monitoring of Mitigation Area to improve understanding of bat use of water tanks and improve understanding of how bats use newly established outplantings.

Resource	Understanding of Baseline Condition	Management and Monitoring Action
Fire Risk	High wildfire threat in Mitigation Area	Enable use of one water feature that would not otherwise exist in the Mitigation Area for fire prevention. Create a fuel break between the Mitigation Area and the adjacent Kula Forest Reserve through a buffer in the Outplanting Area.

4.1 Legal Protections to Benefit Hawaiian Hoary Bats

4.1.1 KFR – Legal Protections

The following land protections are expected to be incorporated into DOFAW's final comprehensive multi-use management plan. Auwahi Wind will prepare an MOU associated with this SSMIP and mutually developed by DOFAW that defines the respective responsibilities of each party relative to the KFR and the Mitigation Area specifically:

- Feral ungulate removal throughout the KFR within 10 years; within the Mitigation Area by 2024;
- No surface disturbance within the KFR except as needed for management actions that provide for long-term forest health and sustainability (e.g., accessibility for management purposes, infrastructure improvements);
- No trees over 15 feet tall within the KFR may be removed during bat pupping season[1] (June 1 through September 15 of each year);
- Any insect pest control work (i.e., application of pesticides) within the KFR must follow an integrated pest control approach that minimizes impacts to insects used as prey by bats;
- All mitigation outplantings within the KFR must be protected from grazing, removal[3] or other damage;
- No artificial stocking of ponds in the KFR with fish known to reduce insect populations utilized as a food source for the Hawaiian hoary bat will be allowed; and
- Prohibition on the use of barbed wire when installing fencing or other such structures. Although DOFAW may use barbed wire fencing if necessary to protect critical infrastructure[4], DOFAW has indicated it will not install barbed wire in the Mitigation Area

[3] DOFAW removal of mitigation outplantings would be authorized for the protection of human health, safety, or the protection of mitigation resources such as in the case of fire breaks. Bat fatalities associated with DOFAW felling during the pupping season would be the responsibility of DOFAW, and not attributable to Auwahi Wind.

[4] Bat fatalities associated with DOFAW use of barbed wire would be the responsibility of DOFAW, and not attributable to Auwahi Wind.

(L. DeSilva, pers. comm., January 26, 2022). The use of barbed wire by Auwahi Wind is prohibited.

4.1.2 Haleakalā Ranch – Legal Protections

Auwahi Wind will prepare a 20-year easement (or equivalent legal protection) to protect the installed mitigation pond on Haleakalā Ranch for the benefit of the bat. The pond will likely outlast the easement assuming Haleakalā Ranch plans to continue to use it for livestock water once the easement has expired. The easement will follow the same principle as the Tier 4 mitigation easement and be structured with a statement of conservation values that references this plan but allows for modification so long as the management is consistent with the conservation values. That flexibility allows for adaptation of management over time, if needed, to best benefit the bat. The easement will allow Haleakalā Ranch to draw water for watering cattle or outplanting independent of the Auwahi Wind mitigation, so long as the draw down does not deplete the utility of the pond for bats (Section 4.4). Operational controls, such as an elevated outlet, will limit how much water can be drawn from such a pond for watering.

4.2 Habitat Management to Increase Forest Edge Bat Habitat

The Hawaiian hoary bat is an edge habitat specialist and open water body forager. Creation of edge habitat is recommended to facilitate bats transiting the Mitigation Area and to serve as a foraging and roosting substrate (Entwistle et al. 2001, Jantzen 2012). Similar to Tier 4 mitigation (Tetra Tech 2019), the outplanting and maintenance of open areas dispersed throughout the Outplanting Area and remainder of the Mitigation Area is expected to provide the Hawaiian hoary bat a patchwork of open foraging areas, edge habitat, and closed canopy which provide shelter from strong winds, night-roosting habitat, and available prey for foraging (Thompson and Hammond 2021, Thompson and Hammond 2022).

Auwahi Wind will outplant and maintain areas within the Outplanting Area to achieve a total of 138 outplanted acres in Tier 5, or 20 percent of the 690-acre Mitigation Area (Figure 7). Twenty percent forest cover corresponds to the first statistically significant peak in mainland hoary bat utilization (Jantzen 2012). For Hawaiian hoary bats, canopy cover has been documented to be negatively related to bat detection (Gorresen et al. 2015, H.T. Harvey 2019) supporting the findings from mainland hoary bats, which suggest open areas for foraging in proximity to trees is important. Therefore, Auwahi Wind will maintain the outplantings as a matrix of open, edge, and canopied areas. A buffer of 8 feet or greater will be implemented along the loop trails proposed by DOFAW (Figure 3). Outplanting will be focused primarily within a 50-meter buffer around the DOFAW interpretive trail which will provide edge habitat both along the trail and along the exterior of the buffer. DOFAW Maui Forest Reserve program and the Hawai‘i Agricultural Research Center will also be planting trees in the Mitigation Area and have a long-term goal of 75 percent forest cover. Auwahi Wind will coordinate with those entities on the location and timing of plantings to ensure that edge habitat is maintained at least through the planned operational period of the Project (December 2032). Auwahi Wind will plant fast growing species (koa) to achieve forest cover more

quickly (approximately 5 feet/year under ideal conditions; Elevitch et al. 2006), while the DOFAW Maui Forest Reserve program intends to plant slower growing species (e.g., ʻiliahi or sandalwood [*Santalum* sp.]) which grow more slowly (typically 1 –2 feet/year; Merlin et al. 2006). This temporal difference in planting and the difference in species, will maitain edge habitat for Hawaiian hoary bat.

Within the Outplanting Area, trees will be planted to a density of approximately 100 trees per acre, or 20-foot spacing between the trees. The specific species of trees used for foraging does not appear important to Hawaiian hoary bats (Gorresen et al. 2013, Bonaccorso et al. 2015). However, as described in Tetra Tech 2019 for Tier 4 mitigation, Auwahi Wind will plant the Outplanting Area with koa at 100 trees per acre, unless other species are mutually agreed on by the DOFAW Maui Forestry Manager and Auwahi Wind. Koa was selected as the only native tree which could grow fast enough to reasonably attain the necessary height to be suitable for bat roosting and increasing edge habitat by the end of the planned operational period of the Project (December 2032). Koa is also identified as providing food for Hawaiian hoary bat insect prey on Maui (Pinzari et al. 2019).

The metric used to assess forest coverage will be the number of acres outplanted by Auwahi Wind with trees. To facilitate species diversity, Auwahi Wind will also plant an additional tree per acre of ʻōhiʻa (*Metrosideros polymorpha*), ʻiliahi, or māmane (*Sophora chrysophylla*). Because ʻōhiʻa, māmane, and ʻiliahi are slow growing, these supplemental trees will not be included in the assessment of canopy height, connectivity, or forest cover as they will likely not be of suitable size for bat use until well beyond the end of the planned operational period of the Project (December 2032).

Additional fencing may be required to protect outplanted areas from ungulates, if ungulates have not been removed from the area by the time planting occurs. The fenced areas will be constructed with bat-safe (smooth wire) fencing to prevent ungulates from damaging the outplanted trees until such time as feral ungulates have been removed from the Phase 1 area. Auwahi Wind will utilize existing bat-safe fences where available.

4.3 Protection of Outplantings

Auwahi Wind is committed to ensuring the outplantings reach maturity to provide benefits to bats. To protect the outplanted trees from non-native ungulates, Auwahi Wind will work with DOFAW Forest Reserve to facilitate ungulate removal. The DOFAW Forest Reserve Manager has estimated that through the process of fencing, community hunting, followed by aerial shooting, the Phase 1 area can be ungulate free within 1 year of fence completion (Figure 3; Lance Desilva, pers. comm., 2021).

Maintaining the Phase 1 area free of ungulates will facilitate passive forest restoration. The Phase 1 area has remnant forest and is expected to have a significant native seed bank which will facilitate passive restoration once ungulates are removed. Similar ungulate removal efforts have yielded passive restoration results at Haleakalā National Park and in the Kahikinui Forest Reserve/Nakula Natural Area Reserve. Restoration specialists Forest and Kim Starr similarly expect passive restoration resulting from ungulate removal to result in native regeneration throughout the Phase 1

area (Forest Starr, pers. comm., 2022). Auwahi Wind is not relying on this passive restoration to fulfill the measures of success. Given expected lags in establishment of trees from the native seed bank, over timeframes longer than the mitigation project, this would be expected to contribute a more diverse patchwork of forest suitable for bat roosting and foraging.

In addition to providing support for initial ungulate removal, Auwahi Wind will support DOFAW in fence maintenance, or sub-unit fencing and additional maintenance. Auwahi Wind will also provide support for ongoing ungulate removal over the remainder of the planned operational period of the Project (December 2032) (or success criteria is met, i.e. outplantings established). These ongoing mitigation actions are necessary to maintain the Phase 1 area for outplantings to establish.

4.4 Pond Design and Construction

Auwahi Wind will add a pond within the approximately 2-acre mitigaton parcel on Haleakalā Ranch (Figure 5, Figure 7) to increase the availability of water sources for the Hawaiian hoary bat. A pond design agreed upon with Haleakalā Ranch will be constructed. An example of a potential design is described in Section 6.2.4.2 of the HCP Amendment and has a size of 314 square feet (20 feet in diameter) and a volume of approximately 50,000 gallons. This pond size matches the ponds installed for Tier 4 mitigation, where bat activity was observed as consistent throughout thermal monitoring nights within 6 months of installation. The pond design would incorporate varying water depth to facilitate insect species associated with shallow water that serve as prey for bats, though the minimum depth needed for fire response will be maintained (Section 4.5). The exact size and shape of the pond will depend on the site conditions. Installation of such a pond would be expected to increase bat foraging and drinking resources.

Auwahi Wind will fence the pond to exclude ungulates, and such fencing will be sufficiently far from the pond so as not to pose a collision hazard for bats and will not be constructed with barbed wire. The newly installed pond would be expected to be naturally replenished by rainfall and may be supplemented by catchment or pumped water from existing Haleakalā Ranch sources. Should rainfall be insufficient, management of the water supply will be modified to ensure water retention to benefit bats and serve as an adequate source for fire prevention (Section 4.5).

4.5 Fire Prevention

The pond installed by Auwahi Wind will be designed to enable use for fire preventionThe pond will be designed to have a 50,000 gallon capacity, and will maintain at least 4-foot water levels at all times. Auwahi Wind is committed to protecting the Mitigation Area against fire and the roles and responsibilities of each party will be outlined in the MOU. As described in Section 4.1.2 the easement will allow Haleakalā Ranch to draw water for watering cattle or outplanting independent of the Auwahi Wind mitigation, so long as the draw down does not deplete the utility of the pond for bats. The same principle will be outlined in the easement for use of water for fire response. The intention would be to retain enough water in the pond so that bats can continue to use it for drinking water; however, if there is a need to deplete the pond beyond that level, in order to

properly respond to a fire in the Mitigation Area, it would be coordinated with the USFWS and DOFAW.

5.0 DOFAW Management Actions

In addition to the actions planned by Auwahi Wind (outlined above), DOFAW's management plan for KFR includes complementary actions. The DOFAW Maui Forest Reserve program has acquired fencing material and procured a fencing contractor for 22,000 feet of fence necessary to connect from the existing Haleakalā Ranch fence, along the makai boundary of the Phase 1 area to the Kula Forest Reserve, and mauka to the Haleakalā National Park (Figure 3). DOFAW also plans to enhance the Outplanting Area with ʻiliahi, and ʻōhiʻa. The Outplanting Area will provide a seed source. Plans to place ʻiliahi plantings between the koa trees are being planned with Hawaiʻi Agricultural Research Center. These additional species plantings will not be required to meet Auwahi Wind's forest cover goals but the diversity of supplemental valuable forestry species will provide additional net benefits. Another benefit of the outplantings is to support sustainable harvest of koa and sandalwood with restrictions such as seasonal protections on tree felling and a limit of harvesting not more than 5 trees per year. The utilization of the Outplanting Area for other forestry activities such as seed orchards and forestry operations will be implemented in a way that presents no known adverse effects for Hawaiian hoary bats. The timeline for growth of other species besides koa varies based on species and environmental conditions, for example, ʻiliahi requires 7 years or more before flowering and 10 years before heartwood develops. Because of the distinct growth timelines for each species, the benefits of Auwahi Wind's koa outplanting can easily be distinguished from other species outplanted when assessed as outlined below in Section 10.0.

6.0 Monitoring

Auwahi Wind will conduct compliance monitoring to determine the response of the Hawaiian hoary bat to the mitigation actions implemented by Auwahi Wind in the Mitigation Area. Monitoring includes acoustic, vegetation, thermal, and insect monitoring. The primary monitoring success criteria will be to discern an increase in bat activity at the site, with acoustic monitoring being the primary means Auwahi Wind will use to quantify bat activity.

6.1 Monitoring Periods

Monitoring in the Mitigation Area will be conducted over three periods:

- Pre-Trigger, Baseline Monitoring.
- Baseline Monitoring, and
- Post-Mitigation Implementation Monitoring.

Pre-Trigger, Baseline Monitoring consists of an initial deployment of acoustic detectors to document site-specific Hawaiian hoary bat activity. This information will be used to determine the

level of acoustic monitoring required to measure pre-mitigation baseline activity levels and post-mitigation implementation activity levels. Pre-trigger, Baseline Monitoring will conclude when mitigation implementation begins.

Baseline Monitoring and Post-Mitigation Implementation Monitoring will include measures of acoustic bat activity (Section 6.2), percent forest cover (Section 6.3), thermal monitoring (Section 6.4), and insect monitoring (Section 6.5). Baseline Monitoring will occur before mitigation actions have had an opportunity to affect the local bat population and Post-Mitigation Implementation Monitoring will occur periodically thereafter in order to measure the effect of the mitigation actions.

Baseline Monitoring will occur as soon as practicable and no later than 6 months from the start of mitigation implementation. The acoustic Baseline Monitoring to assess increases in bat activity in the Mitigation Area will consist of the 5 years after approval of this SSMIP by USFWS and DOFAW HCP staff. Baseline monitoring periods are shorter for other variables, due to the expectation that responses to mitigation actions measured by the monitoring are likely to occur more quickly or due to a recognition that completion of the mitigation action sooner, rather than later, would have a more immediate benefit for bats (e.g., installation of the pond). These monitoring periods are described in the individual sections below and the associated information will be primarily used to inform adaptive management actions, if required.

Post-Mitigation Implementation Monitoring will consist of the remainder of the planned operational period of the Project (December 2032) after the 5-year Baseline Monitoring period (or success criteria is met, i.e. detections increase).

6.2 Acoustic Monitoring

Auwahi Wind has implemented acoustic monitoring at KFR, following the commitments in the HCP Amendment (Section 6.2.5.1 in Tetra Tech 2019). Auwahi Wind has deployed two acoustic detectors for Pre-Trigger, Baseline Monitoring. Auwahi Wind collaborated with DOFAW Maui in May 2021 to establish two acoustic monitoring locations to document site-specific Hawaiian hoary bat activity. Accoustic monitoring locations were selected based on accessibility and adjacency to where the Mitigation Area was expected to be located. Due to the relative homogeneity of the habitat and land use, the monitors could have been located virtually anywhere to get a representative sample of bat activity. This acoustic monitoring will quantify Hawaiian hoary bat occurrence in the Mitigation Area, provide information on activity rates, inform seasonal fluctuations in activity at the Mitigation Area, and be used to perform a power analysis to determine the power with which a change in activity rates can be detected. Auwahi Wind will conduct Pre-Trigger, Baseline Monitoring for up to 2 years beginning May 13, 2021, when the second bat detector was deployed. The Pre-Trigger, Baseline Monitoring will be suspended at the initiation of Baseline Monitoring.

Acoustic Baseline Monitoring for the Hawaiian hoary bat will be conducted in the Mitigation Area for the first 5 years of SSMIP implementation. Auwahi Wind will conduct acoustic monitoring (Post-Mitigation Implementation Monitoring) after the Baseline Monitoring period every other year for

the remainder of the planned operational period of the Project (December 2032) or until success criteria have been satisfied; acoustic monitoring will begin no later than six months after mitigation actions have started. Acoustic monitoring will be established at 14 or more locations within the Mitigation Area. The locations are based on a ratio of one or more detectors for approximately every 85 acres, which is a density three to seven times greater than similar studies (Gorresen et al. 2015, Todd et al. 2016), to provide a high level of granularity in bat use and response to management within the Mitigation Area. Four of these detectors will be placed within the Outplanting Area, including one at the existing water tank. The remaining detectors will be distributed throughout the Mitigation Area including one detector at the pond installation location, stratified by habitat type (e.g., scrub shrub, grassland) and land use (i.e, recreational use and forestry areas). Detector checks are planned monthly but will occur no less than twice per year in monitoring years, with data collection, metrics, and analyses following that described for Tier 4 (Tetra Tech 2019). Methods and results will be included in the annual report for the years when acoustic monitoring occurs.

One of the goals of monitoring is to provide a comparable measure of bat activity. Therefore, any modification of the acoustic monitoring must be done systematically to account for any previous monitoring. Additionally, efforts will be made to ensure that all monitoring is comparable; minimizing changes in location, technology (such as microphones), or software/firmware to maximize the ability to compare pre- and post- mitigation actions.

The number of calls will be the primary tool to evaluate the success of management actions. An active detector night is when the acoustic detector remains active for more than half of the hours from sunset to sunrise. Each detector will be evaluated for active detector nights, thus 1 night with 14 active detectors is 14 active detector nights. The number of calls will be evaluated and compared to the location of water feature(s) and outplanting sites that have been developed. Two metrics will be evaluated:

1) Call abundance (total number of calls recorded per active detector night), gives an estimate of total activity

$$Call\ Abundance = \frac{Total\ calls}{Total\ active\ nights}$$

2) Call nightly detection (proportion of total active detector nights with calls), which gives an estimate of seasonal variation in bat activity; and

$$Call\ Nightly\ Detection = \frac{Total\ nights\ with\ calls}{Total\ active\ nights}$$

3) Active minutes, which provides an assessment of what portion and times of night the site is utilized. This metric can provide both periods of activity and breaks in activity which can help to indicate different periods of use, which likely correlate to different bats. This metric is not standard and has not been used previously so it is not incorporated into success criteria but will be provided with reporting to provide a qualitative assessment of bat use at the mitigation site.

$$Active\ Minutes = \frac{Total\ Minutes\ with\ bat\ detections\ per\ night}{Total\ Minutes\ per\ night}$$

The data collected during the acoustic monitoring portion of this study will be summarized as call abundance, call nightly detection, and active minutes for each site during each month as described previously. The frequency and spatial distribution of calls will not be known until data collection begins; therefore, data analysis methods may need to be modified if these values differ greatly from expected (e.g., large number of sites with no calls recorded or calls recorded every night). Call abundance and call nightly detection are proportions and can be analyzed within the generalized linear mixed model framework. Call nightly detection and call abundance can be modeled as a binomial distribution that models the number of successes during some number of trials. The results from each monitoring location will be autocorrelated and results adjusted to include location as a random variable. The power will likely be increased by comparing pre- and post-changes for each location directly.

This analysis provides flexibility for different data types and additional complexity of the model. If a substantial portion of monitoring locations have no calls recorded, a more complex zero-inflated model could be considered. Competing models can be compared using Akaike information criterion (AIC) values (Akaike 1973). AIC is a quantitative comparison of models and provides a means of model selection. Models within 2 AIC units of the best model will be considered to have some support (Burnham and Anderson 2002) and model averaged parameter values could be calculated.

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 results of this study could also be influenced by changes in the overall bat population on the island.

An increase in call nightly detection is expected in the monitoring years following the completion of pond installation. The call nightly detection will be evaluated per habitat type to provide insight into the impacts of the individual and combined effects of the variables: open areas (currently pasturelands), forest edge, and water features.

The data will be analyzed after years in which monitoring is performed. Data analysis will compare the covariates of water features, vegetation management (i.e., fire break, grazing, trail maintenance) and outplanting site to determine the impacts of each management action and the call abundance and call nightly detection at the site. The results of this analysis will be summarized in the annual report following the completion of each monitoring year.

6.3 Percent Forest Cover

Optimal forest cover as documented by Jantzen (2012) is 20 to 25 percent cover of the Mitigation Area to optimize hoary bat utilization of the site. The percent forest cover of the Mitigation Area will be assessed through GIS analysis using aerial imagery; either imagery taken by satellite if less than 1 year old or taken by drone. The perimeter of the established koa within the Outplanting area

will determine the boundary. Percent forest cover will be assessed during the Baseline Monitoring period, and the baseline forest cover will be established following the final year of Baseline Monitoring. Percent forest cover will then be resampled during subsequent monitoring years.

It is assumed that the percent forest cover will increase each year and that the goal of at least 20 percent (138 acres) forest cover will be reached by Year 5 after outplanting is completed (likely 2030 – 2031). As long as forest cover is increasing, no additional actions are necessary. If, in Year 5 forest cover has not reach the goals of 20 percent, then Auwahi Wind will replant native plants necessary to bring the native plant cover up to 20 percent. Prior to additional required planting, Auwahi Wind may first error check or resample the Outplanting Area to ensure that any measurement that does not meet success criteria was not the result of seasonal variation or inconsistencies in the data collection method. Once the goal of 20 percent forest cover is reached, DOFAW management actions aimed at selective harvest or thinning of forest, to improve habitat conditions for bats, could be completed, as long as the total forest cover does not decrease below 20 percent.

6.4 Thermal Camera Monitoring

Thermal monitoring is a valuable tool for characterizing bat behavior. That said, thermal monitoring provides no more clarity regarding bat population than acoustic monitoring. The goal of thermal monitoring is to provide additional insight into bat behavior to improve management decisions for improving bat habitat.

6.4.1 Bat Use of Water Features

Although Hawaiian hoary bats are theorized to use water tanks and other man-made features, the level of use, use patterns, intensity, and frequency have not been documented. If bats are documented to use water tanks for foraging, drinking, or both, it would add to the body of knowledge regarding bat management. Auwahi Wind will collect bat use and associated behavior data by installing a thermal camera at the existing water tank in the Mitigation Area during Baseline Monitoring, provided the water feature has not yet been removed (expected in 2023). The purpose of this thermal monitoring is to determine if bats are currently using the existing lessee-owned water tank within the Mitigation Area.

Auwahi Wind will also document bat use in response to installation of the pond, as described in Section 4.4. Thermal Monitoring will be limited to one season (around the August 1 through October 31 time period), in one year of the first three bat reproductive seasons after approval of the SSMIP and installation of the pond. If no bat activity is documented, a second season of monitoring will be performed in the one of the subsequent three bat reproductive seasons.

6.4.2 Bat Use of Outplanted Trees Over Time

Thermal monitoring of bat use of foraging habitats relative to habitat features may improve our understanding of bat foraging strategies. Bats use of forest habitat has been well documented as described in the HCP Amendment, and this management plan. However, no study has looked at how

bats use vegetation of different stature, or age. Additionally, bat experts have theorized that bats may use the top of forest canopy similar to edge habitats, which would vastly increase the current assessment of available foraging resources for bats. This mitigation provides a unique opportunity to investigate these bat/habitat interactions over time, as forest vegetation develops and vertical structure changes.

Auwahi Wind will use two thermal cameras in the high activity months of August through October to monitor forest canopy and forest edge during the first year following approval of the SSMIP, and at 2-year intervals, thereafter. That will include monitoring in years 1, 3, and 5 during the Baseline Monitoring period. For the remainder of the planned operational period of the Project (December 2032) , at the 2-year intervals, Auwahi will re-deploy these cameras to measure activity rates in the Outplanting Area. Once success criteria are met, Auwahi Wind, the USFWS, and DOFAW will discuss whether continued monitoring is warranted. Any additional monitoring would examine changes in bat activity over time, as the forest structure changes, and would be separate from Implementation Monitoring, once success criteria are achieved.

Auwahi Wind will use the relative activity rates at 10-minute intervals from sunset to sunrise to characterize bat activity rates and compare activity rates between monitoring years. This is a new method of monitoring and will therefore not be tied to success criteria but will provide both a quantitative and qualitative assessment of bat use rates over time and bat behavioral changes observed as a result of outplanted koa age and forest cover.

6.5 Insect Monitoring

Insect monitoring is a tool to assess the impact of mitigation actions and identify appropriate changes to management if necessary, through adaptive management. Auwahi Wind will conduct quarterly insect monitoring for the Baseline Monitoring period (up to 2 years) for both managed edge habitat and water features. Following Baseline Monitoring, semiannual (twice yearly) Post-Mitigation Implementation Monitoring for insects will be conducted in years 3, 5, and 7, or until success criteria have been achieved (Table 3). Monitoring will consist of one malaise trap per managed feature (e.g., Outplanting Area, pond). Following the sampling, the lepidopteran and coleopterans will be identified and the abundance of each order (for insects over 10 millimeters) will be reported in the annual report. If bat activity is not increased relative to the baseline, Auwahi Wind will compare the baseline insect abundance to the insect abundance at the time adaptive management is triggered to assess if insect abundance is a likely cause for not finding an increase in acoustic bat activity.

6.6 Other Monitoring

Other monitoring may be added or substituted to the monitoring protocol if Auwahi Wind determines that there are more effective ways of determining whether success criteria are being met. Changes in monitoring protocols will be coordinated with USFWS and DOFAW. Additional tools or monitoring methods may be developed or adopted as industry standards which are not available today or are currently considered experimental. Auwahi Wind will continue to evaluate

the state of science and assess the applicability of tools to meet the success criteria for the mitigation. Table 3 provides a summary of expected mitigation and monitoring actions by year.

Table 3. Summary of Expected Mitigation and Monitoring Actions by Monitoring Year

Action	Monitoring Year[1, 2]									
	1	2	3	4	5	6	7	8	9	10
	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Complete ungulate exclusion	X									
Complete feral ungulate removal	X	X								
Install pond		X								
Complete plantings in Outplanting Area				X						
Acoustic monitoring in Mitigation Area (Section 6.2)	B	B	B	B	B		I		I	
Thermal monitoring in Outplanting Area (Section 6.4)	B		B		B		I		I	
Acoustic monitoring at new pond	B		I		I		I		I	
Thermal monitoring at new pond and existing water feature			I							
Quarterly baseline insect monitoring	B	B								
Twice yearly insect monitoring			I		I		I		I	
Assess percent forest cover of Mitigation Area (Section 6.3)	B				B	I	I	I	I	I

X = Action will be completed; B = Baseline monitoring; I – Implementation monitoring

1. The timeline for the associated actions described are Auwahi Wind'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 pond). 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 4.0, 6.0, and their respective subsections.

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

7.0 Success Criteria

Because the Hawaiian hoary bat is a solitary tree-roosting species, monitoring can be difficult. Industry standard methods of monitoring have included using acoustic monitoring of bat activity, particularly the quantification of feeding buzzes to assess changes in foraging activity as a result of mitigation actions. Todd (2012) and Gorresen et al. (2018) used similar acoustic monitoring approaches to assess foraging activity in different habitats. Supplementing acoustic monitoring with thermal camera videography can provide a qualitative assessment of behavior.

Auwahi Wind has developed success criteria for Tier 5 in the HCP Amendment (Section 6.2.5.1 in Tetra Tech 2019) which follow the approved success criteria for Tier 4 (Section 6.2.4 in Tetra Tech 2019) to ensure that the objectives of protecting and enhancing bat foraging and roosting habitat are being met.

1. Acoustic (or other) monitoring for bat activity (Section 6.0) is successfully implemented at the Mitigation Area. The data are analyzed and reported.
2. Ungulate fencing is maintained, and ungulate removal efforts are sufficient to allow for establishment of outplantings.
3. Record an increase in bat activity through acoustic monitoring or other method over the Baseline Monitoring year(s). The statistical power with which the increase is recorded will also be reported.
4. Increase forest cover of the 690 acres of Mitigation Area to 20 percent (138 acres) by Year 5 following the completion of planting, using outplanting, to increase edge habitat
5. Install egress structures at purchased or installed water features used by bats.
6. Install at least one pond that will enhance bat habitat, by providing a source of water and supporting insect populations.
7. Utilize thermal camera monitoring techniques to document bat use and behavior at constructed pond.
8. Summarize and report the results of monitoring in annual reports.

7.1 Take Offset/Net Benefit

For Tier 5 Mitigation, 690 acres will be improved to offset the take of 34 bats. Auwahi Wind will include a bat monitoring program to document an increase in bat activity at the site as a result of mitigation actions. If habitat is improved for the benefit of bats as determined through monitoring, the mitigation actions will be considered to offset bat take.

7.2 Additional Ecological Benefits

In addition to benefits to the Hawaiian hoary bat, management and enhancement of habitat within the Mitigation Area is expected to protect native ecosystems and other native species. Fencing,

ungulate removal and native flora and fauna recovery are expected to enhance recovery efforts for other endangered wildlife including the ʻuaʻu, forest birds, and nēnē. ʻUaʻu have been documented in the Mauka portion of the KFR and will likely experience a decrease in burrow trampling after ungulates are removed resulting in more ʻuaʻu surviving to adulthood. Forest birds such as iʻiwi are documented in the adjacent Kula Forest Reserve and will benefit from the increase in native tree habitat. Nēnē are known to suffer from predation from feral pigs and will likely experience increased survival as a result of fencing and ungulate removal. These additional benefits support the HRS 195(D)(4)(g)(8) requirement ʻto provide net environmental benefits.ʼ

8.0 Reporting

Quantitative measures identified for each monitoring variable described in Section 6.0, along with the success criteria summarized in Section 7.0 will be the primary metrics for analysis. Auwahi Wind will include in the annual report a summary of the data by year, including the Baseline Monitoring year(s). Specifically, Auwahi Wind will include:

- The date the MOU with DOFAW's Forest Reserve system was fully executed;
- Photos of existing water tanks, egress structures, and created pond;
- In the year(s) in which the acoustic monitoring is conducted, Auwahi Wind will report the results and changes from the baseline, including the statistical power with which any change is documented;
- Auwahi Wind will also summarize the mitigation actions implemented and associated results of changes that occur during the restoration process. These parameters may include:
    - Number of trees planted, acreage planted, and percent of forest cover above baseline;
    - Length of edge habitat created;
    - Size in gallons, and surface area of new pond;
    - Number of bats detected (call abundance, call nightly detection, and active minutes) utilizing installed features;
    - A summary of insect abundance by quarter and year, and a comparison to acoustic monitoring results in years of monitoring;
    - A summary of the thermal monitoring results for both:
        - Bat use of water features (pond, tanks, troughs); and,
        - Bat use of outplanted trees over time;
- Any adaptive mitigation actions taken; and

- Any additional pertinent summary information needed to provide a full picture of mitigation actions.

9.0 Adaptive Management

Because the benefit of each of the mitigation actions are likely to vary, adaptive management will be an essential component of the Tier 5 mitigation. All initial mitigation actions will be evaluated against the success criteria outlined in Section 7.0. Each evaluation will be an opportunity for adaptive management to be triggered. Any additional monitoring that is required in response to adaptive management, beyond what is outlined in this document, will be discussed with USFWS and DOFAW when adaptive management measures are decided upon and implemented. Triggers and corresponding responses developed for Tier 4 mitigation (Tetra Tech 2019) will also be used for Tier 5.

Beyond understanding that benefits to specific implemented mitigation actions may vary and require adaptive management, Auwahi Wind recognizes that all or part of the implementation of Tier 5 mitigation actions in the Mitigation Area may not be feasible within the estimated timeline (Section 10.0). Should this occur, Auwahi Wind will identify an alternate or supplemental mitigation area within which to perform all or component parts of the identified mitigation actions in coordination with USFWS and DOFAW. Auwahi Wind has had preliminary discussions with Haleakalā Ranch, bordering the Mitigation Area (Figure 2, Figure 7), and has determined that it is a suitable location for implementation of a supplemental component of the mitigation plan (See Attachment 1), should the need arise.

The following outline describes the adaptive management workflow to be used for triggering and responding to conditions at the Mitigation Area. Broadly, this approach uses information from the implementation and monitoring program to identify and respond effectively to root causes for failure to meet mitigation goals. Several representative potential adaptive management scenarios resulting from this workflow are described in Section 9.1.

1. If the amount of koa seed is not available to sufficiently complete outplantings as described in this document, alternate plants will be included in the seed mix to ensure the acreage requirements are met. Any changes in seed mix will be coordinated with USFWS and DOFAW.
2. If call abundance or call nightly detections are increased relative to baseline monitoring in Post-Mitigation Implementation monitoring, no adaptive management will be triggered. Adaptive management will be triggered if either of the following scenarios occur: 1) both call abundance and call nightly detection are less than or equal to the baseline, or 2) either the call abundance or call nightly detection is equal to or less than the baseline, and the other variable is not at least doubled. The adaptive management response will include:
    - The evaluation of insect composition and forest cover relative to baseline conditions and an evaluation of the monitoring response of the prior management actions

implemented (see Section 9.1). If it is determined that insect composition has increased and is sufficient to support an increase in bat activity, then Auwahi Wind will complete outreach to the USFWS and DOFAW, as well as others monitoring bat activity in the region to determine if the lack of increased bat activity is due to a regional decline in bat activity, or an anomaly.

- If the insect monitoring does not show that species needed for bat foraging are present (principally moths and beetles, or other species documented through diet analysis of the Hawaiian hoary bat) and the monitoring response of the prior management actions support this approach, Auwahi Wind will either[5]:
  - Change the species composition or replace native canopy plant species that have not survived with different canopy plant species shown to support Hawaiian hoary bat foraging and/or roosting, as appropriate based on the monitoring of forest cover (Sections 6.2 and 6.3); or
  - Supplement the understory/sub-canopy native plant species within the outplanting sites with native plant species shown to support Hawaiian hoary bat foraging and/or roosting.
- Otherwise, or if deemed appropriate through coordination with DOFAW and USFWS, Auwahi Wind will implement actions supported by the results of the evaluation of the monitoring response of the prior management actions or results of new relevant research.

9.1 Modification of Mitigation Actions

The goal of adaptive management actions is to collect data on the effectiveness of the management actions and respond with measures that are shown to be effective at having a positive influence on success criteria. As there is uncertainty in the response of Hawaiian hoary bats to the management actions, Auwahi Wind has a number of options available for modifying the proposed management actions. If it is determined through monitoring that Auwahi Wind is not meeting the biological objectives of the HCP Amendment, it may be necessary to modify mitigation actions in order to remain in compliance with the HCP and permit. Potential changes to mitigation actions may include but are not limited to:

1. Additional water features (e.g., constructing a pond for bat use);
2. Additional outplanting of plant species to facilitate bat use of the habitat;
3. Additional outplanting of plant species at higher densities within the Outplanting Area;
4. Alteration of canopy species management (i.e., trimming, clearing, weeding, collecting, harvesting);

[5] Auwahi Wind may initiate either action earlier than the triggering of adaptive management. The initiation of these actions prior to adaptive management triggers will be considered adaptive management.

5. Alteration of understory species management (i.e., trimming, clearing, weeding, collecting, harvesting); and
6. Relocation of planned management actions to an alternative land parcel other than KFR if implementation timelines cannot be met by DOFAW Maui.

By having options for future adaptive management, Auwahi Wind avoids implementing management actions that do not positively impact the Hawaiian hoary bat population and prioritizes management actions that are correlated with increased Hawaiian hoary bat activity. If adaptive management is triggered, modifications to the proposed management actions (described below) will be implemented.

The adaptive management action will be determined from the monitoring response of the prior management actions implemented. To determine if management actions are positive, the measurement of distance to features will be used to conduct a generalized linear mixed model, selecting multiple input models. The model with the lowest AIC value will be selected to determine which covariates provide the greatest prediction of bat activity. If no significance can be determined, the data will also be summarized for trends. A map of the scale of results will also be produced to determine if there are geographic trends. Therefore, the impact of the prior management actions will be compared, and the management action (either outplanting sites or water features) that elicited a greater response will be implemented for adaptive management. If both outplanting sites and water features have a similar response, outplanting sites will be prioritized.

9.2 Alternative Mitigation Actions

If the modification of mitigation actions described in Section 9.1 is not feasible as an appropriate adaptive mitigation action, Auwahi Wind will work with USFWS and DOFAW to identify appropriate alternative actions based on the monitoring data.

9.3 Monitoring

The monitoring plan may be adjusted based on the result of the corresponding power analysis and updated in subsequent years if assumptions are found to be incorrect. Any change to monitoring will be provided to the USFWS and DOFAW for review and modifications will be coordinated with both agencies and noted in the annual report.

10.0 Timeline

As mentioned above, in August 2021, the mitigation planning trigger was reached for Tier 5. Permit conditions require that a draft SSMIP be prepared within 5 months of reaching the Tier 5 planning trigger. A draft was submitted to the agencies in November 2021 and, since that time, several rounds of revisions and discussions have been completed. Based on initial agency input supportive of the proposed Mitigation Area, Auwahi Wind began Pre-Trigger, Baseline Monitoring using two

acoustic monitors to aid in establishing a Baseline Monitoring program of the Mitigation Area prior to implementing any mitigation actions. Such monitoring is important to enable documenting changes to the landscape and demonstrating that success criteria are met. Anticipated critical path timelines and expected time for completion are shown in Table 4.

Table 4. Approximate Timeline for Actions to be Implemented by Auwahi Wind

Timeline[1,2]	Monitoring Period	Mitigation Period	Description of Actions
2021	Pre-Trigger, Baseline Monitoring Year 1	Pre-Trigger	• Auwahi Wind deployed two acoustic detectors at KFR. These detectors will be deployed for up to two years or incorporated into acoustic Baseline Monitoring.
2021 – 2022	Pre-Trigger, Baseline Monitoring Year 1 +	Pre-Trigger	• Preparation and submittal of MOU and SSMIP to DOFAW and USFWS, including revisions responsive to agency comments.
2022 – 2023	Baseline Monitoring Year 1	Year 1	• MOU is signed by applicable parties. • DOFAW completes its comprehensive multi-use management plan for the Forest Reserve. • Acoustic and thermal monitoring in Outplanting Area (Sections 6.2, 6.4, 6.5). • Focused acoustic and thermal monitoring at existing water feature, potential acoustic and thermal monitoring at location of future pond installation. • Quarterly baseline insect monitoring (Section 6.5). • Assess percent forest cover of Mitigation Area (Section 6.3), • DOFAW completes fence and gates for Phase 1 area. • Hunting to remove feral ungulates begins.
2023 – 2024	Baseline Monitoring Year 2	Year 2	• Feral ungulate removal from Phase 1 area completed. • One pond installed. • Outplanting begins in Outplanting Area. • Acoustic monitoring in Outplanting Area (Sections 6.2). • Focused acoustic and thermal monitoring at existing water feature and at new pond, following install.[3] • Quarterly baseline insect monitoring.
2024 – 2025	Baseline Monitoring Year 3	Year 3	• Acoustic and thermal monitoring in Outplanting Area (Sections 6.2, 6.4). • Twice yearly insect implementation monitoring (Section 6.5). • Outplanting continues in Outplanting Area.

Timeline[1,2]	Monitoring Period	Mitigation Period	Description of Actions
2025 – 2026	Baseline Monitoring Year 4	Year 4	• Acoustic monitoring in Outplanting Area (Sections 6.2). • Planting completed in Outplanting Area (achieve total of 20 percent [138 acres]).
2026 – 2027	Baseline Monitoring Year 5	Year 5	• Acoustic and thermal monitoring in Outplanting Area (Sections 6.2, 6.4). • Twice yearly insect implementation monitoring (Section 6.5). • Measure baseline percent forest cover (Section 6.3).
2027 – 2028	Post-Mitigation Implementation Monitoring Year 1	Year 6	• Measure percent forest cover (Section 6.3).
2028 – 2029	Post-Mitigation Implementation Monitoring Year 2	Year 7	• Acoustic and thermal monitoring in Outplanting Area (Sections 6.2, 6.4). • Twice yearly insect implementation monitoring (Section 6.5). • Measure percent forest cover (Section 6.3).
2029 – 2030	Post-Mitigation Implementation Monitoring Year 3	Year 8	• Measure percent forest cover (Section 6.3).
2030 – 2031	Post-Mitigation Implementation Monitoring Year 4	Year 9	• Acoustic and thermal monitoring in Outplanting Area (Sections 6.2, 6.4). • Twice yearly insect implementation monitoring (Section 6.5). • Measure percent forest cover (Section 6.3).
2031 – 2032	Post-Mitigation Implementation Monitoring Year 5	Year 10	• Measure percent forest cover (Section 6.3).

1. The timeline for the associated actions described are Auwahi Wind'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 pond). 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 4.0, 6.0, and their respective subsections.

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

3. Thermal monitoring can actually occur in one of any of the three years following installation of the pond (Section 6.4.1).

11.0 Cost Estimates

Approximate costs to implement the mitigation plan are identified in Table 5.

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Attachment 1. Haleakalā Ranch Company Letter of Support for Performing Tier 5 Mitigation Work on Haleakalā Ranch

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HALEAKALA RANCH
• EST. MAUI 1888 •

March 8, 2022

To: USFWS/DOFAW HCP staff:

Subject: Landowner support for Auwahi Wind Energy LLC's proposed Tier 5 mitigation work on Haleakala Ranch

Haleakala Ranch is very interested in partnering with Auwahi Wind Energy, LLC in its development and implementation of the Site-Specific Mitigation Implementation Plan to support the Auwahi Wind Habitat Conservation Plan.

It is our understanding that the Tier 5 Mitigation process would fund the protection of 690 acres, the construction of new water features, invasive species control, and reforestation of pastures (especially with Koa), all which would provide significant net benefit and mitigate project impacts on the Hawaiian hoary bat. Haleakala Ranch fully supports this work on our land, provided it can be done in a manner that meets all of the Parties' operational, administrative and compliance goals. We think it could be a really good fit and provide multiple long-lasting ecological services and community benefits far beyond the scope of the HCP.

Haleakala Ranch has a long and demonstrated history of proactive, responsible land stewardship and conservation. We have partnered successfully with DOFAW and USFWS on numerous important conservation/recovery efforts on our own lands and continue to develop and support ecological restoration in our pastures, licensed areas, lands held under Conservation Easement, and regional lands managed via Watershed Partnerships and other Partners. This new potential partnership with Auwahi Wind is consistent with that history and vision.

We welcome any opportunity to show you our work so you can gain a better understanding of our commitment to conservation and our innovative approaches to land stewardship.

Please feel free to contact me at your convenience to discuss this further. I am more than happy to answer any questions, comments or concerns you may have.

Respectfully,

Jordan Jokiel
Vice President/Land Management

Cc: J. Scott Meidell, President and CEO
Lake Estes, Senior Vice President/Real Estate
Greg Friel, Vice President/Livestock Managent

HALEAKALA RANCH COMPANY • 529 KEALALOA AVENUE • MAKAWAO, HI 96768 • PH: 808.572.1500 FAX 808.572.7288

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Attachment 2. Flora and Fauna Survey Kamehamenui Forest Reserve, Maui

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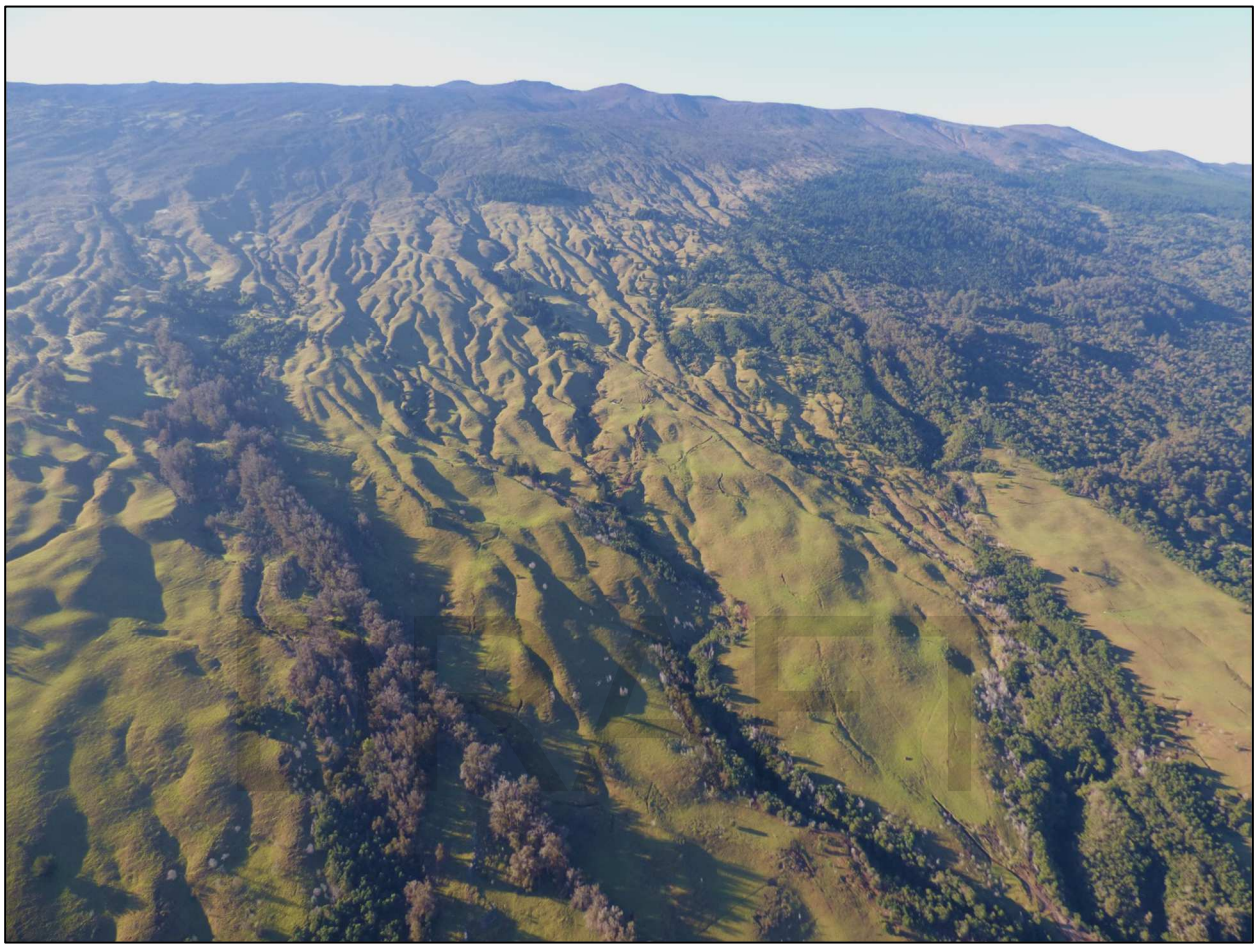
FLORA AND FAUNA SURVEY
KAMEHAMENUI FOREST RESERVE, MAUI



Prepared By:
FOREST & KIM STARR

Prepared For:
DIVISION OF FORESTRY AND WILDLIFE
DEPARTMENT OF LAND AND NATURAL RESOURCES

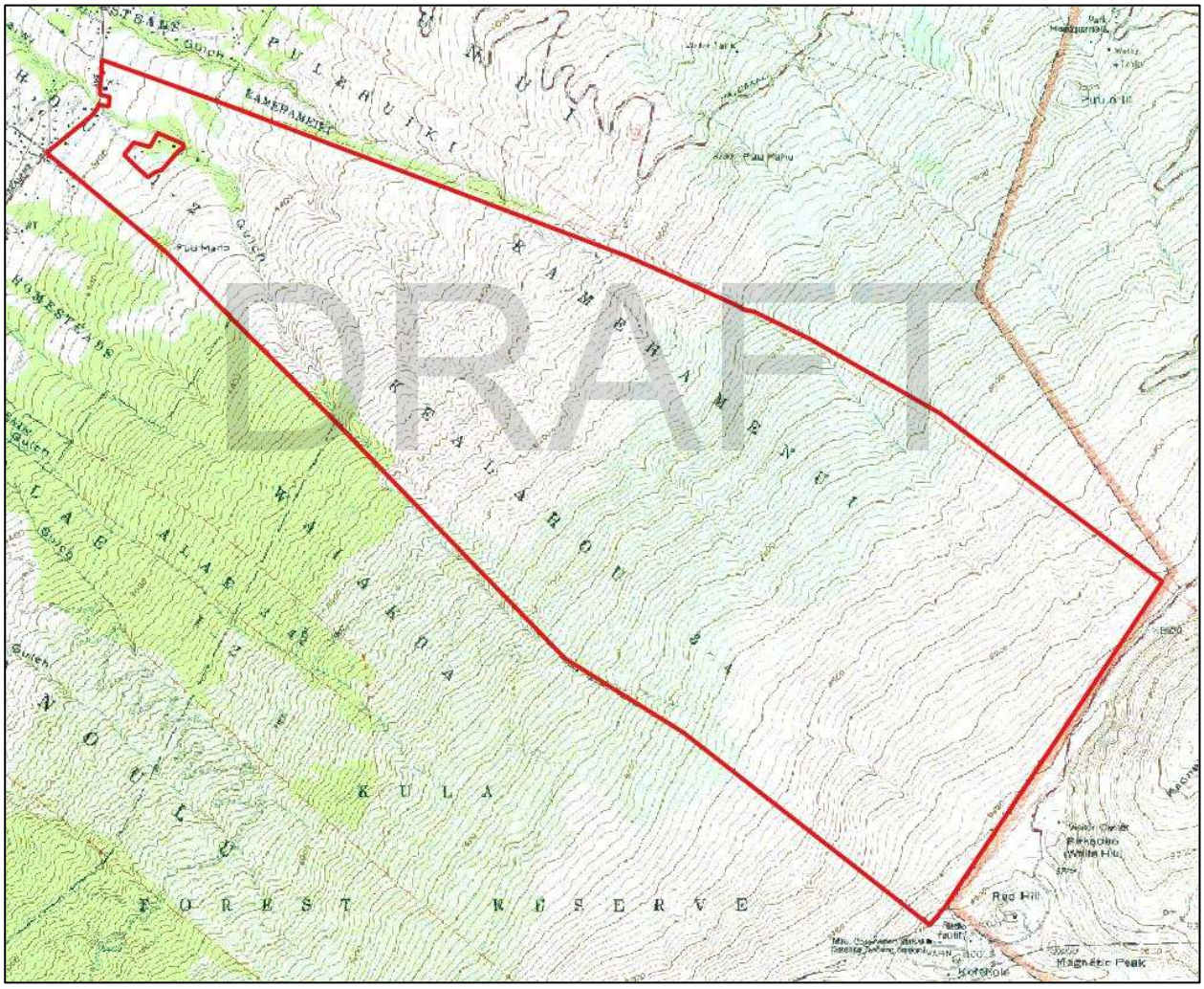
2021

INTRODUCTION

The Kamehamenui Forest Reserve encompasses about 3,434 acres (TMK 230050020000) on the west slope of East Maui. The goal of this survey was to inventory the flora and fauna in the area, to provide current information to be included in a management plan for the reserve.

SITE DESCRIPTION

The land is steep, and there are many small gullies. Much of the area is pasture, with short-statured shrubland up high, and scattered forest areas in the pastures, gulches, and along the property margins. The elevation ranges from 3,700 to 9,800 feet above sea level. Annual rainfall averages 27-40 inches. Annual air temperature averages 44-61 degrees Fahrenheit.



Project area, Kamehamenui Forest Reserve, Maui.

SURVEY OBJECTIVES

The main objectives of the survey were to:

- Document what plant (terrestrial vascular flora) and animal (birds, bats, mammals, insects) species occur in the reserve or may likely occur in the existing habitat.

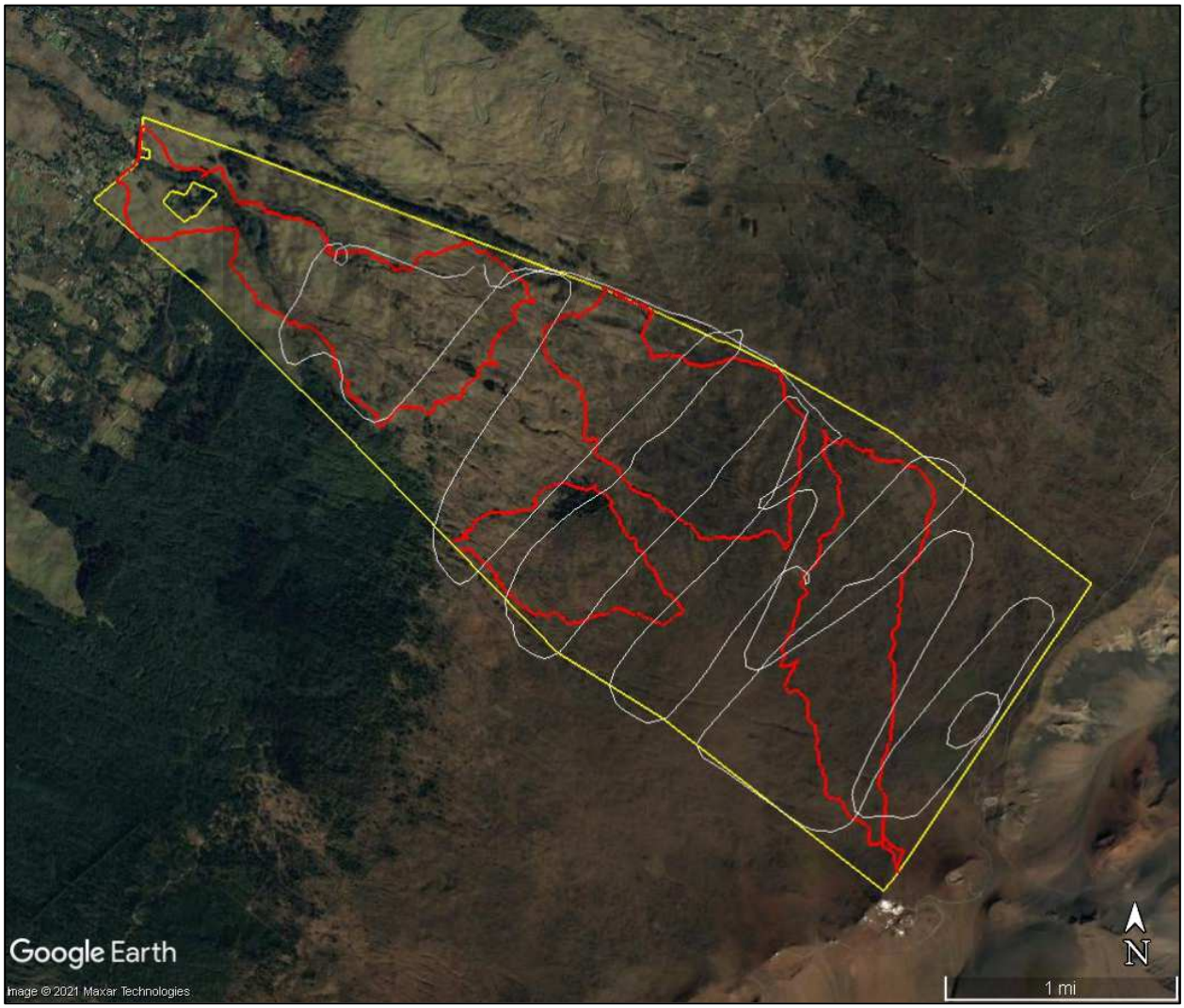
- Write up findings in a report that includes checklists of species, along with images and discussion of some of the more conspicuous and noteworthy elements of the flora and fauna.

SURVEY METHODS

A walk-through survey method was used over representative areas of the reserve in April-June, 2021. Extra emphasis was placed on areas with potential for high diversity, such as gullies and remnant native plants. Notes were made on plant and animals species encountered. In addition, a sweep net was used to get closer looks at insects. A helicopter overflight was also done to get a big picture overview, look at areas we didn't get to on foot, and get images for this report.

Taking notes on flora and fauna.

Sweeping for insects in subalpine vegetation.



Area surveyed. Red lines are ground survey, white lines are aerial survey.

RESULTS

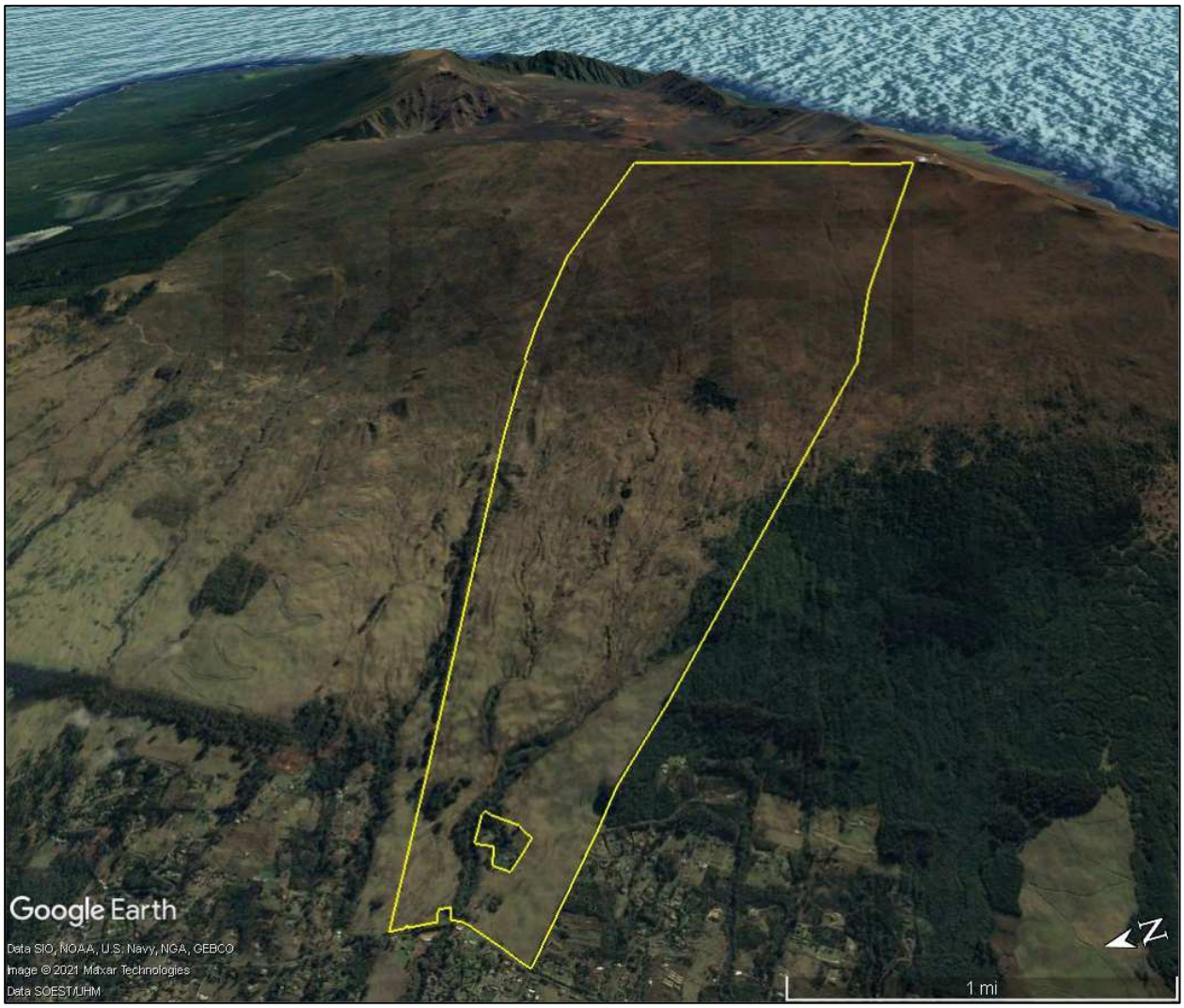
VEGETATION

There are three main vegetation types in Kamehamenui:

Grassland/Pasture: The bulk of the area below 6,500 ft. is dominated by pasture. This section is characterized by vast areas of open grassland and non-native species.

Mesic Forest: Scattered about the grassland are groves of mostly non-native trees, especially in and near gullies. Pockets of native trees persist, especially above 5,500 ft.

Subalpine Shrubland: Above 6,500 ft. native shrubs dominate, along with sparse grasses and ferns. At the top of the reserve, the vegetation is very sparse with large areas of no vegetation.



Kamehamenui Forest Reserve.

SUBALPINE SHRUBLAND

Upper subalpine shrubland, Kamehamenui Forest Reserve.

The highest elevations of the Kamehamenui Forest Reserve, 6,500-9,800 ft. are comprised of mostly the shrub kupaoa (*Dubautia menziesii*). Just below the summit area, the dominant vegetation quickly becomes pūkiawe (*Leptecophylla tameiameiae*) shrubs. Most of the vegetation in this zone is native.

The upper reaches of the reserve have sparse and short vegetation. As one descends in elevation, the vegetation becomes taller, thicker, and more diverse. The vegetation is heavily browsed.

Pūkiawe is by far the most common plant in this zone. Other native shrubs in this area include kūpaoa (*Dubautia menziesii*), ʻōhelo (*Vaccinium reticulatum*), and kukaenēnē (*Coprosma ernodeoides*).

ʻAʻaliʻi (*Dodonaea viscosa*) is the most common tree in this zone, often found in small groves. Other trees in this zone include māmane (*Sophora chrysophylla*), Haleakalā sandalwood (*Santalum haleakalae*), and hōʻawa (*Pittosporum confertiflorum*). All of these are in poor health due to intense ungulate pressure.

Haleakalā silverswords or ʻāhinahina (*Argyroxiphium sandwicense* subsp. *macrocephalum*) are found in the upper most reaches of the subalpine zone, as is the native pamakani or Haleakalā tetramolopium (*Tetramolopium humile* subsp. *haleakalae*).

Non-native herbs and low growing plants in the subalpine shrubland include evening primrose (*Oenothera stricta* subsp. *stricta*), sheep sorrel (*Rumex acetosella*), hairy horseweed (*Conyza bonariensis*), fireweed (*Senecio madagascariensis*), and hairy cat's ear (*Hypochoeris radicata*).

Native grasses are predominantly hairgrass (*Deschampsia nubigena*) and pili uka (*Trisetum glomeratum*).

Non-native grasses include Sweet vernal grass (*Anthoxanthum odoratum*), Yorkshire fog (*Holcus lanatus*), rattail (*Vulpia* sp.), and cheatgrass (*Bromus tectorum*).

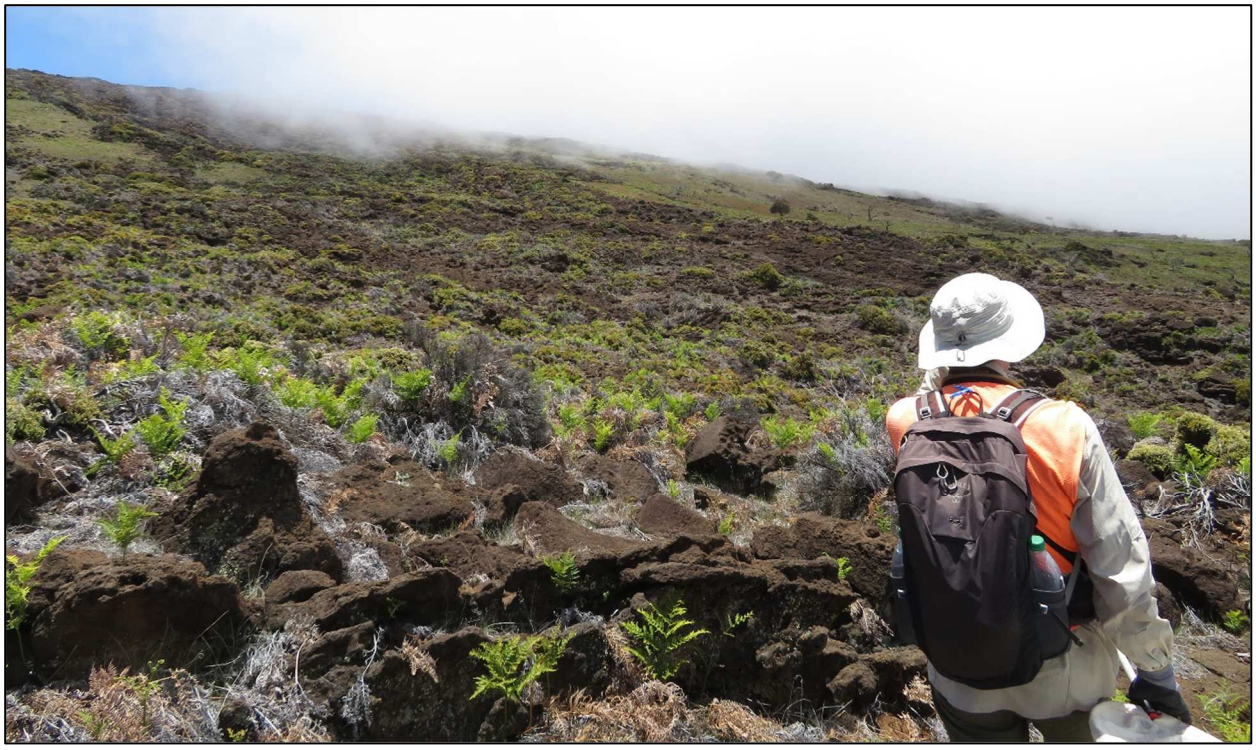
By far the most common native fern in this zone is kīlau or bracken fern (*Pteridium aquilinum* subsp. *decompositum*). This hardy fern is one of the only plants growing over vast sections of the reserve with the heaviest ungulate pressure.

Other native ferns in this zone include kalamoho (*Pellaea ternifolia*), ʻiwaʻiwa (*Asplenium adiantum-nigrum*), and maidenhair spleenwort (*Asplenium trichomanes* subsp. *densum*). The most common non-native fern in this zone is the golden fern (*Pityrogramma austroamericana*).

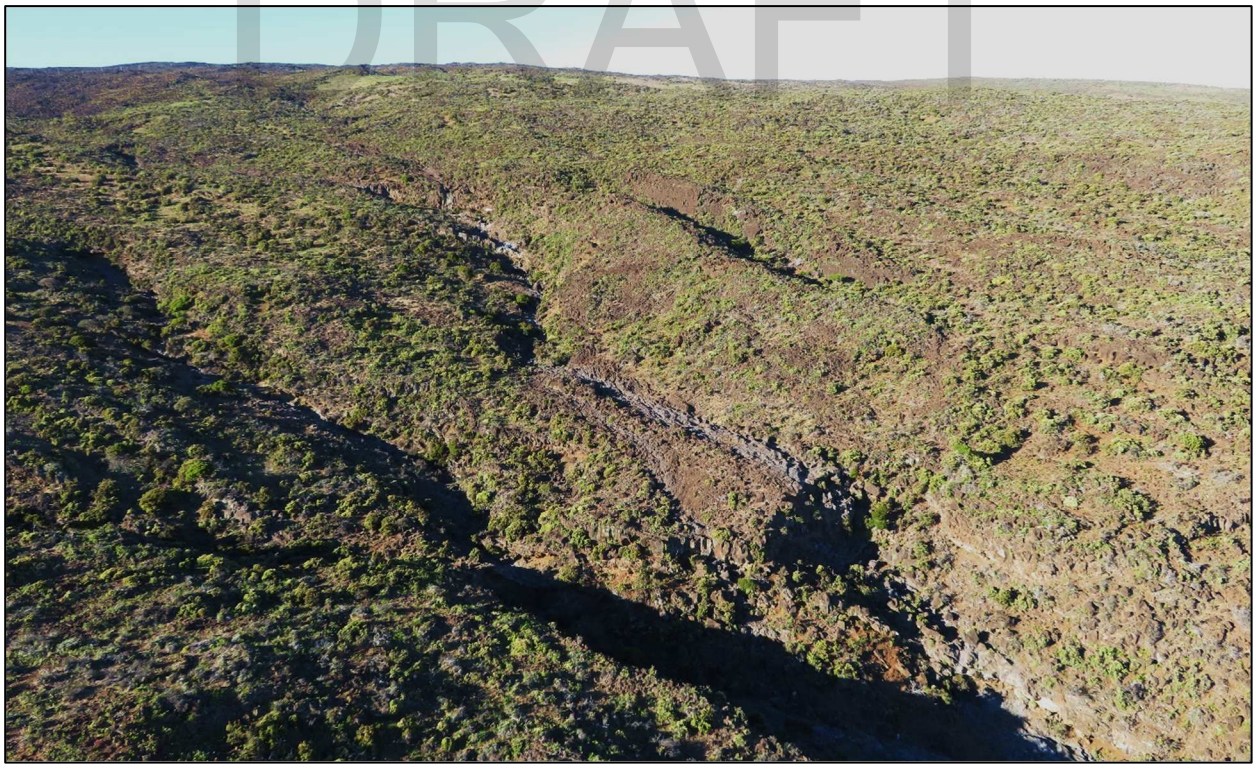
There are many areas of the subalpine shrubland at Kamehamenui where all other vegetation has been destroyed by ungulates, and only kīlau or bracken fern is able to survive.

Vegetation is naturally sparse in the highest elevations of the reserve due to the cold, dry, windy environment.

Virtually all the plants in the highest elevations of the reserve are native. Pūkiawe (*Leptecophylla tameiameiae*) is by far the most common plant, able to survive ungulates and the harsh environment.



Lower down the mountain, there is much more subalpine vegetation. It remains native dominated, though the diversity is low given the heavy ungulate pressure in the area.



The northern portion of the reserve near Hāpapa Gulch has the most remnant subalpine vegetation diversity. The bulk of the sandalwood (*Santalum*) we came across were in this area, as was the hō‘awa (*Pittosporum*).

Pūkiawe shrubs remain the dominant plant in the subalpine zone, along with occasional ʻaʻaliʻi trees.

In areas where ungulate pressure is greatest, most of the vegetation has been taken down to dirt.

In some areas there are "māmane graveyards", with scores of dead tree skeletons and a handful of remnant trees on the cusp of death. Bracken fern often dominates in these areas.

A remnant sandalwood tree, the largest of about a dozen we came across. This tree was in decline, it's trunk and foliage heavily browsed, and the roots undermined. On the horizon is a similarly browsed ʻaʻaliʻi.

Pūkiawe is the dominant plant within the subalpine shrubland.

Tetramolopium humile **is locally abundant in the highest elevations of the reserve, often tucked next to stones.**

A few Haleakalā silverswords or ʻāhinahina (*Argyroxiphium sandwicense* subsp. *macrocephalum*) reside in the highest elevations of the subalpine zone.

Vast areas of bracken fern occur in the subalpine shrubland, making it almost more of a fernland in places.

Hairgrass (*Deschampsia nubigena*) is present in the subalpine shrubland. As with many other species, this clumping native grass will likely become more prevalent if ungulates are removed.

Haleakalā sandalwoods or ʻiliahi occur as scattered individuals and small groves in the reserve. Most are in decline or near death, due to the heavy ungulate pressure.

MESIC FOREST

Native ʻōhiʻa trees in the mesic forest portion of Kamehamenui Forest Reserve.

Below 6,500 ft. trees become more prevalent. The dominant native tree in this zone is ʻōhiʻa (*Metrosideros polymorpha*), which persists on steep gulch walls as small groves, mostly between 5,500-7,500 ft. Perhaps it would be a stretch to call it a forest today, but not long ago, that's what it was. Two "varieties" of ʻōhiʻa are present (*incana* and *glaberrima*), occasionally on the same tree, though the glabrous form (*glaberrima*) is most common.

We only came across a handful of koa (*Acacia koa*) trees, perhaps a half dozen, clinging to gulch walls near the 4,500 ft. level. The ranchers have been controlling black wattle (*Acacia mearnsii*) near the koa trees to help protect them from being overrun.

Black wattle is the most common non-native tree in the reserve. It is especially abundant below 6,000 ft. on the southern boundary of the reserve and in gulches. Not long ago, much of the area this wattle forest occupies was open pasture.

There are a few conifer plantings in the reserve. The largest and most mauka (6,700 ft.) is predominantly Monterey pine (*Pinus radiata*) with some redwood (*Sequoia sempervirens*). Other conifers encountered include Maritime pine (*Pinus pinaster*).

A long line of blue gum eucalyptus (*Eucalyptus globulus*) marks the northern boundary of the reserve. These trees are in decline due to multiple new insects and pathogens. Eucalyptus is also spreading from these plantings into nearby areas.

Fire tree (*Morella faya*) is present on both boundaries between 5,000-7,000 ft. as incipient groves and scattered trees. This tree seems to prefer areas where ʻōhiʻa also likes to grow.

Pūkiawe (*Leptecophylla tameiameiae*) is the most common shrub in this zone. Other native shrubs present in much lower numbers include ʻakala berry (*Rubus hawaiensis*), hinahina (*Artemisia mauiensis*), pilo (*Coprosma montana*), and ʻaʻaliʻi (*Dodonaea viscosa*).

Non-native shrubs include Canary Island St. John's wort (*Hypericum canariense*), pamakani (*Ageratina adenophora* and *A. riparia*), and Mysore raspberry (*Rubus niveus*).

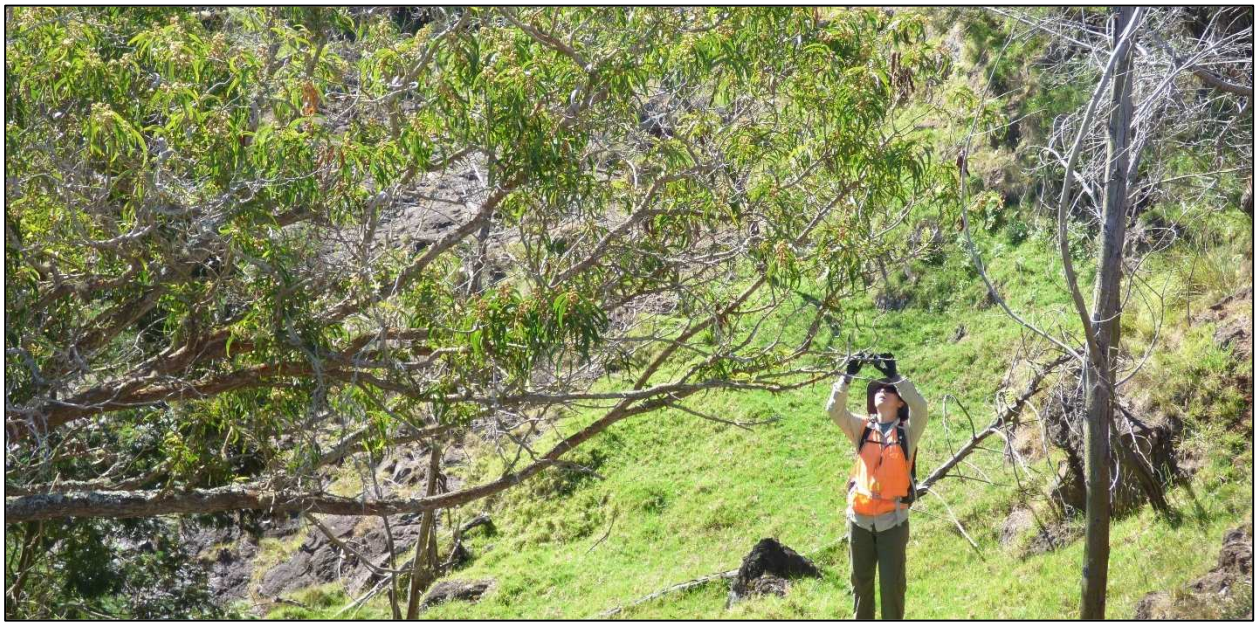
The dominant grass in this zone is Kikuyu (*Cenchrus clandestinus*), though the understory beneath all these non-native trees is mostly barren.

Native sedges include *Carex macloviana* subsp. *subfusca* and *Carex wahuensis* and wood rush (*Luzula hawaiiensis*).

Non-native herbs include daisy fleabane (*Erigeron karvinskianus*), fireweed (*Senecio madagascariensis*), and bull thistle (*Cirsium vulgare*). Banana poka (*Passiflora tarminiana*) is the most prevalent non-native vine.

In steep sites protected from ungulates with some sun, ferns and shrubs are able to eke out a living. Native ferns encountered include ʻamaʻu (*Sadleria cyatheoides*), polystichum (*Polystichum haleakalense*), mākuʻe (*Elaphoglossum paleaceum*), laukahi (*Dryopteris wallichiana*), palapalai (*Microlepia strigosa*), and pohole (*Diplazium sandwichianum*).

Non-native ferns include blechnum (*Blechnum appendiculatum*), Australian brake (*Pteris tremula*), and downy wood fern (*Cyclosorus dentatus*).



One of a handful of remnant native koa trees in Kamehamenui.

Small patches of remnant ʻōhiʻa forest can still be found in steep, rocky gulches, such as Hāpapa Gulch.

The remnant ʻōhiʻa able to survive ungulate pressure are growing mostly on cliff walls.

The largest patch of koa we came across in the reserve was just a handful of trees growing on cliff walls. Ranchers have been controlling black wattle nearby to help keep the koa from being overtaken.

The handful of koa trees left in the reserve survived the ungulate pressure by growing on cliffs. These were the largest koa trees we came across in the reserve.

Black wattle forest dominates much of the southern portion of reserve. This forest is relatively young, having recently over taken what used to be mostly pasture, especially in and near Keahuaiwi Gulch.

The wattle forest understory is mostly barren.

There are multiple pine/conifer groves planted in the reserve. Pines are also spreading from the plantings into nearby shrubland and creating new groves.

The conifers can get quite large, with an understory of virtually no other plants.

A long line of blue gum eucalyptus in poor health marks the northern boundary of the reserve. The bright green trees are fire tree, which is beginning to dominate in areas with remnant ʻōhiʻa.

Many of the eucalyptus trees are massive.

Small local sites in the mesic zone gulches where ungulates have a hard time reaching are able to support lush vegetation, both native and non-native, such as this fern grotto.

In similar areas where the non-native trees have started to fill in to the point of a closed canopy, fern grottos still exist, but the vegetation is less lush.

‘Ōhi‘a is the most common native forest tree in Kamehamenui.

This hinahina (*Artemisia mauiensis*) growing out of a crack on a cliff wall was the only one we came across.

Native parasitic mistletoe or hulumoa (*Korthalsella complanata*) growing on a pūkiawe shrub.

Pohole fern (*Diplazium sandwichianum*) found in grottos where ungulates can't easily reach.

***Polystichum haleakalense*, a locally common fern in the area.**

Cliff brake fern (*Pteris cretica*) growing out of a cliff.

PASTURE / GRASSLAND

Pasture/grasslands in the Kamehamenui Forest Reserve.

Much of the reserve below 7,000 ft. is dominated by non-native grasses. The most common grass is Kikuyu (*Cenchrus clandestinus*). Other grasses encountered include Natal red top (*Melinis repens*), sweet vernal (*Anthoxanthum odoratum*), weeping lovegrass (*Eragrostis curvula*), and Yorkshire fog (*Holcus lanatus*).

Pūkiawe shrubs are scattered about the pastures in the highest elevations, but are mostly absent below 5,500 ft. In the lowest elevations, incipient non-native shrubs are taking hold, including Canary Island St. John's wort (*Hypericum canariense*), cotoneaster (*Cotoneaster pannosus*), and firethorn (*Pyracantha* spp.).

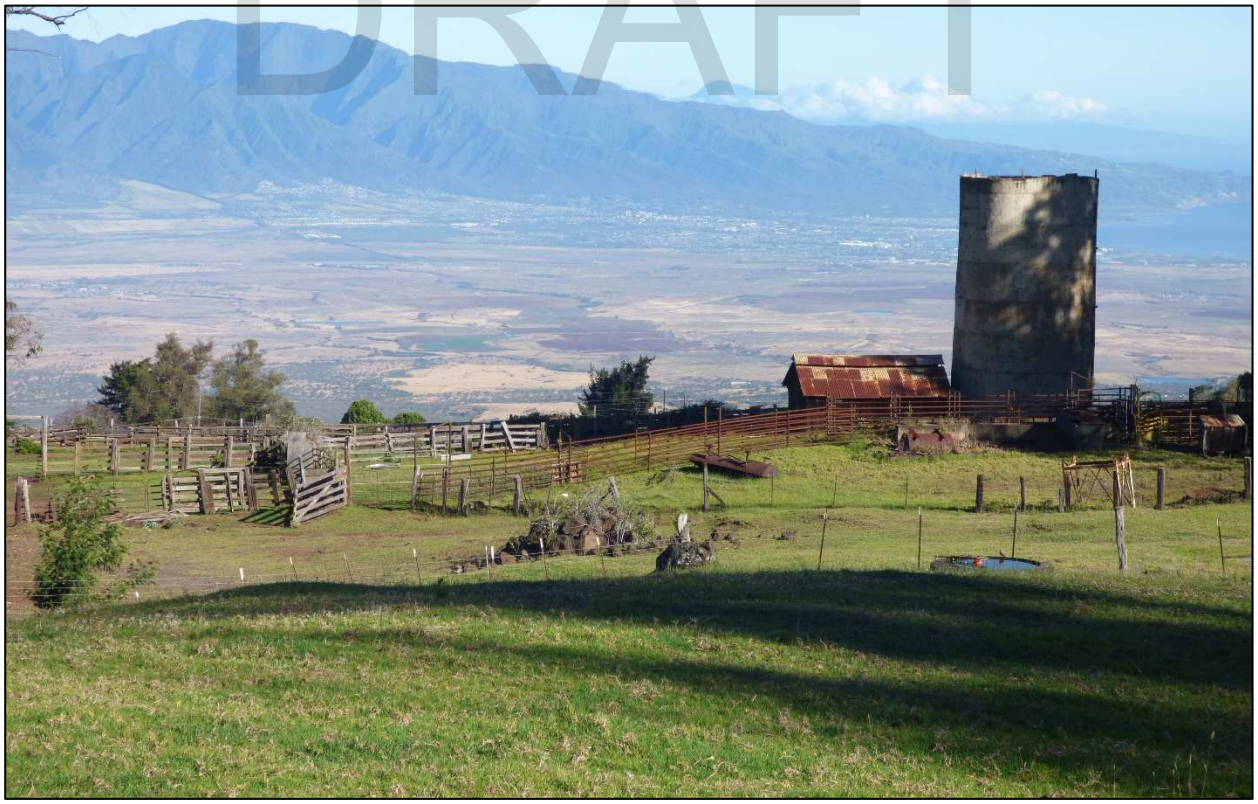
Non-native herbs in this zone include red clover (*Trifolium pratense* var. *sativum*), fireweed (*Senecio madagascariensis*), black medic (*Medicago lupulina*), scarlet pimpernel (*Anagalis arvensis*), common dandelion (*Taraxacum officinale*), and bitter herb (*Centaurium erythraea subsp. erythraea*).

Moa (*Psilotum nudum*) and a few other native ferns are tucked into rocks including kalamoho (*Pellaea ternifolia*) and ʻiwaʻiwa (*Asplenium adiantum-nigrum*).

Mauka portion of the grasslands.

The pastures are heavily grazed, resulting in low-growing non-native grass over vast areas.

Makai portion of the grasslands.



Corral, fences, and water tank in makai pastures.

Kikuyu is the dominant grass over much of the area. Other than grass, only small weedy herbs such as fireweed are able to survive ungulate browsing in the most open areas.

Low numbers of ferns and other more delicate vegetation is present in small pockets of the open pastures, but is restricted to areas protected by steep terrain.

Natal Red Top (*Melinis repens*).

Sweet Vernal Grass (*Anthoxanthum odoratum*)

Moa (*Psilotum nudum*).

Pānini (*Opuntia ficus-indica*).

Weeping lovegrass (*Eragrostis curvula*).

Red Clover (*Trifolium pratense* var. *sativum*).

RARE PLANTS

Many plants considered common in other areas are "rare" in the reserve given the heavy ungulate pressure, such as koa (*Acacia koa*), mamane (*Sophora chrysophylla*) and kūpaoa (*Dubautia menziesii*). If ungulates are removed, these species will likely once again become common, especially with additional plantings.

Another subset of species currently in the reserve are rare even in the best areas of East Maui and will likely require additional care to thrive in the reserve, such as Haleakalā sandalwood or ʻiliahi (*Santalum haleakalae*) and hōʻawa (*Pittosporum confertiflorum*).

Rare plants not encountered in the reserve that could be a focus of future restoration activities include nohoanu (*Geranium arboreum*), a native mint *Stenogyne microphylla*, a rare fern *Diplazium molokaiense*, and many more.

Nearby Haleakalā National Park has a greenhouse with many of the rare plants found within the subalpine region of East Maui, and would be a good propagule source for restoration plantings of rare plants at Kamehamenui, including Haleakalā silverswords.

Hōʻawa (*Pittosporum confertiflorum*) flowers on the lone tree we came across in the reserve. Hōʻawa would be a good species to include in restoration plantings, along with sandalwood and other increasingly rare plants.

INCIPIENT PLANTS

Though many non-native plants are already well established in the reserve. There are other invasive plants that are just starting get a foothold in the reserve. Below are some of them. Most are located in the lowest reaches of the reserve, especially in and near gulches.

Early detection and rapid response efforts to address these invasive species while they are still in low numbers will be most successful. Efforts will also be much more effective if undertaken while ungulates are still present, as the ungulates are doing just as much to damage to the non-native species as they are to the native plants. And once ungulates are removed, these plants will be released from that pressure and will shift to a much faster rate of expansion through the area.

- Banana poka (*Passiflora tarminiana*)
- Canary Island St. John's Wort (*Hypericum canariense*)
- Coast banksia (*Banksia integrifolia*)
- Cotoneaster (*Cotoneaster pannosus*)
- Firethorn (*Pyracantha* spp.)
- Japanese honeysuckle (*Lonicera japonica*)
- Mock orange (*Pittosporum undulatum*)
- Pampas grass (*Cortaderia* spp.)
- Night blooming jasmine (*Cestrum nocturnum*)
- Smoke bush (*Buddleia* spp.)
- Tree poppy (*Bocconia frutescens*)

Canary Island St. John's Wort (*Hypericum canariense*) is establishing in the lower gulches of the reserve.

PLANT SPECIES LIST

Following is a checklist of all vascular plant species inventoried during field studies. Abundance of each species within the project area:

- Dominant = Forming a major part of the vegetation within the project area.
- Common = Widely scattered throughout the area or locally abundant within a portion.
- Occasional = Scattered sparsely throughout the area or occurring in a few small patches.
- Rare = Only a few isolated individuals within the project area.

Family	Scientific Name	Common Name	Nativity	Abundance
Fabaceae	*Acacia koa*	Koa	Endemic	Rare
Fabaceae	*Acacia mearnsii*	Wattle	Non-native	Common
Pteridaceae	*Adiantum hispidulum*	Rough maidenhair fern	Non-native	Occasional
Asparagaceae	*Agave attenuata*	Swan's neck agave	Non-native	Rare
Asteraceae	*Ageratina adenophora*	Maui pamakani	Non-native	Occasional
Asteraceae	*Ageratina riparia*	Hamakua pamakani	Non-native	Occasional
Primulaceae	*Anagalis arvensis*	Scarlet pimpernel	Non-native	Occasional
Poaceae	*Anthoxanthum odoratum*	Sweet vernal grass	Non-native	Common
Asclepiadaceae	*Asclepias physocarpa*	Balloon plant	Non-native	Occasional
Asteraceae	*Argyroxiphium sandwicense* subsp. *macrocephalum*	Haleakalā silversword, ʻāhinahina	Endemic	Rare
Asparagaceae	*Asparagus asparagoides*	Bridal creeper	Non-native	Rare
Aspleniaceae	*Asplenium adiantum-nigrum*	ʻIwaʻiwa	Indigenous	Occasional
Aspleniaceae	*Asplenium trichomanes* subsp. *densum*	Maidenhair spleenwort	Endemic	Occasional
Asteraceae	*Artemisia mauiensis*	Hinahina	Endemic	Rare
Poaceae	*Axonopus fissifolius*	Narrow-leaved carpetgrass	Non-native	Occasional
Proteaceae	*Banksia integrifolia*	Coast banksia	Non-native	Rare
Blechnaceae	*Blechnum appendiculatum*	Blechnum	Non-native	Rare
Papaveraceae	*Bocconia frutescens*	Tree poppy	Non-native	Occasional
Poaceae	*Bromus catharticus*	Rescue grass	Non-native	Rare
Poaceae	*Bromus diandrus*	Ripgut	Non-native	Rare
Poaceae	*Bromus tectorum*	Cheat grass	Non-native	Occasional
Scrophulariaceae	*Buddleja davidii*	Butterfly bush	Non-native	Rare
Scrophulariaceae	*Buddleja madagascariensis*	Smoke bush	Non-native	Rare
Cyperaceae	*Carex macloviana subsp. subfusca*	Carex	Indigenous	Rare
Cyperaceae	*Carex wahuensis*	Carex	Endemic	Rare
Poaceae	*Cenchrus clandestinus*	Kikuyu grass	Non-native	Common
Asteraceae	*Centaurium erythraea* subsp. *erythraea*	Bitter herb	Non-native	Rare
Valerianaceae	*Centranthus ruber*	Valerian	Non-native	Rare

Family	Scientific Name	Common Name	Nativity	Abundance
Caryophyllaceae	*Cerastium fontanum* subsp. *vulgare*	Mouse-ear chickweed	Non-native	Rare
Solanaceae	*Cestrum nocturnum*	Night blooming cestrum	Non-native	Occasional
Pteridaceae	*Cheilanthes viridis*	Green cliff brake	Non-native	Rare
Poaceae	*Chloris gayana*	Rhodes grass	Non-native	Rare
Asteraceae	*Cirsium vulgare*	Bull thistle	Non-native	Rare
Commeliniaceae	*Commelina diffusa*	Honohono	Non-native	Rare
Asteraceae	*Conyza bonariensis*	Hairy horseweed	Non-native	Rare
Rubiaceae	*Coprosma ernodeoides*	Kukaenene	Endemic	Rare
Rubiaceae	*Coprosma montana*	Pilo	Endemic	Rare
Poaceae	*Cortaderia jubata*	Pampas grass	Non-native	Rare
Rosaceae	*Cotoneaster pannosus*	Cotoneaster	Non-native	Occasional
Thelypteridaceae	*Cyclosorus dentatus*	Downy wood fern	Non-native	Occasional
Poaceae	*Cynodon dactylon*	Bermuda grass	Non-native	Rare
Cyperaceae	*Cyperus stoloniferus*	Cyperus	Non-native	Rare
Dryopteridaceae	*Cyrtomium caryotideum*	Kaapeape	Indigenous	Rare
Poaceae	*Dactylis glomerata*	Cocksfoot	Non-native	Occasional
Asteraceae	*Delairea odorata*	Cape ivy	Non-native	Occasional
Poaceae	*Deschampsia nubigena*	Hairgrass	Endemic	Occasional
Convolvulaceae	*Dichondra micrantha*	Dichondra	Non-native	Rare
Athyriaceae	*Diplazium sandwichianum*	Pohole	Endemic	Rare
Sapindaceae	*Dodonaea viscosa*	ʻAʻali'i	Indigenous	Occasional
Dryopteridaceae	*Dryopteris wallichiana*	Laukahi	Indigenous	Occasional
Asteraceae	*Dubautia menziesii*	Kūpaoa	Endemic	Common
Dryopteridaceae	*Elaphoglossum paleaceum*	Māku‘e	Indigenous	Rare
Geraniaceae	*Erodium cicutarium*	Pin clover	Non-native	Occasional
Myrtaceae	*Eucalyptus globulus*	Blue gum	Non-native	Common
Myrtaceae	*Eucalyptus robusta*	Swamp mahogany	Non-native	Rare
Poaceae	*Eragrostis curvula*	Weeping love grass	Non-native	Occasional
Asteraceae	*Erigeron karvinskianus*	Daisy fleabane	Non-native	Occasional
Poaceae	*Festuca rubra*	Red fescue	Non-native	Common
Apiaceae	*Foeniculum vulgare*	Fennel	Non-native	Occasional
Asteraceae	*Gamochaeta* sp.	Gamochaeta	Non-native	Occasional
Geraniaceae	*Geranium homeanum*	Cranesbill	Non-native	Occasional
Proteaceae	*Grevillea robusta*	Silky oak	Non-native	Rare
Asteraceae	*Heterotheca grandiflora*	Telegraph weed	Non-native	Rare
Poaceae	*Holcus lanatus*	Yorkshire fog	Non-native	Common
Hypericaceae	*Hypericum canariense*	Canary Islands St. John's wort	Non-native	Occasional

Family	Scientific Name	Common Name	Nativity	Abundance
Asteraceae	*Hypochoeris radicata*	Hairy cat's ear	Non-native	Occasional
Convolvulaceae	*Ipomoea indica*	Koali ʻawa	Indigenous	Rare
Bignoniaceae	*Jacaranda mimosifolia*	Jacaranda	Non-native	Rare
Juncaceae	*Juncus* sp.	Juncus rush	Non-native	Rare
Santalaceae	*Korthalsella complanata*	Hulumoa	Indigenous	Rare
Poaceae	*Lachnagrostis filiformis*	Heʻupueo	Indigenous	Rare
Asteraceae	*Lapsana communis*	Nipplewort	Non-native	Rare
Ericaceae	*Leptecophylla tameiameiae*	Pūkiawe	Indigenous	Common
Caprifoliaceae	*Lonicera japonica*	Japanese honeysuckle	Non-native	Rare
Juncaceae	*Luzula hawaiiensis*	Wood rush	Endemic	Rare
Lythraceae	*Lythrum maritimum*	Lythrum	Non-native	Rare
Fabaceae	*Medicago lupulina*	Black medic	Non-native	Occasional
Poaceae	*Melinis minutiflora*	Molasses grass	Non-native	Occasional
Poaceae	*Melinis repens*	Natal red top	Non-native	Occasional
Myrtaceae	*Metrosideros polymorpha* var. *glaberrima*	ʻŌhiʻa	Endemic	Rare
Myrtaceae	*Metrosideros polymorpha* var. *incana*	ʻŌhiʻa	Endemic	Rare
Dennstaedtiaceae	*Microlepia strigosa*	Palapalai	Indigenous	Rare
Myricaceae	*Morella faya*	Firetree	Non-native	Common
Solanaceae	*Nicandra physalodes*	Apple of Peru	Non-native	Occasional
Onagraceae	*Oenothera laciniata*	Cut-leaved evening primrose	Non-native	Rare
Onagraceae	*Oenothera stricta subsp. stricta*	Evening primrose	Non-native	Rare
Oleaceae	*Olea europaea subsp. cuspidata*	African olive	Non-native	Occasional
Cactaceae	*Opuntia ficus-indica*	Pānini	Non-native	Rare
Oxalidaceae	*Oxalis corniculata*	Yellow wood sorrel	Non-native	Rare
Passifloraceae	*Passiflora tarminiana*	Banana poka	Non-native	Occasional
Pteridaceae	*Pellaea ternifolia*	Kalamoho	Indigenous	Occasional
Polygonaceae	*Persicaria capitata*	Pink knotweed	Non-native	Rare
Solanaceae	*Physalis peruviana*	Poha	Non-native	Occasional
Phytolaccaceae	*Phytolacca octandra*	Pokeweed	Non-native	Occasional
Pinaceae	*Pinus pinaster*	Maritime pine	Non-native	Rare
Pinaceae	*Pinus radiata*	Monterey Pine	Non-native	Common
Pittosporaceae	*Pittosporum confertiflorum*	Hōʻawa	Endemic	Rare
Pittosporaceae	*Pittosporum undulatum*	Victorian box	Non-native	Rare
Pteridaceae	*Pityrogramma austroamericana*	Golden fern	Non-native	Rare
Plantaginaceae	*Plantago lanceolata*	Narrow-leaved plantain	Non-native	Occasional
Dryopteridaceae	*Polystichum haleakalense*	Polystichum	Endemic	Rare
Rosaceae	*Prunus campanulata*	Taiwan cherry	Non-native	Occasional

Family	Scientific Name	Common Name	Nativity	Abundance
Asteraceae	*Pseudognaphalium sandwicensium var. sandwicensium*	ʻEnaʻena	Endemic	Rare
Psilotaceae	*Psilotum nudum*	Moa	Indigenous	Rare
Hypolepidaceae	*Pteridium aquilinum* subsp. *decompositum*	Kīlau, bracken fern	Indigenous	Common
Pteridaceae	*Pteris cretica*	Cretan brake	Indigenous	Occasional
Pteridaceae	*Pteris tremula*	Australian brake	Non-native	Rare
Rosaceae	*Pyracantha angustifolia*	Firethorn	Non-native	Occasional
Rosaceae	*Pyracantha koidzumii*	Formosa firethorn	Non-native	Occasional
Rosaceae	*Rubus argutus*	Black berry	Non-native	Rare
Rosaceae	*Rubus hawaiensis*	ʻAkala	Endemic	Rare
Rosaceae	*Rubus niveus*	Mysore raspberry	Non-native	Common
Rosaceae	*Rubus rosifolius*	Thimbleberry	Non-native	Occasional
Polygonaceae	*Rumex acetosella*	Sheep sorrel	Non-native	Occasional
Blechnaceae	*Sadleria cyatheoides*	ʻAmaʻu	Endemic	Rare
Santalaceae	*Santalum haleakalae var. haleakalae*	ʻIliahi, Haleakalā sandalwood	Endemic	Rare
Asteraceae	*Senecio madagascariensis*	Fireweed	Non-native	Common
Taxodiaceae	*Sequoia sempervirens*	Redwood	Non-native	Rare
Rubiaceae	*Sherardia arvensis*	Blue fieldmadder	Non-native	Rare
Solanaceae	*Solanum americanum*	Pōpolo	Indigenous	Rare
Solanaceae	*Solanum linnaeanum*	Apple of Sodom	Non-native	Occasional
Fabaceae	*Sophora chrysophylla*	Māmane	Endemic	Rare
Poaceae	*Sporobolus indicus*	Smut grass	Non-native	Occasional
Caryophyllaceae	*Stellaria media*	Common chickweed	Non-native	Rare
Asteraceae	*Taraxacum officinale*	Common dandelion	Non-native	Occasional
Asteraceae	*Tetramolopium humile subsp. haleakalae*	Haleakalā tetramolopium	Endemic	Occasional
Bignoniaceae	*Thunbergia alata*	Black-eyed Susan vine	Non-native	Rare
Fabaceae	*Trifolium pratense var. sativum*	Red clover	Non-native	Occasional
Fabaceae	*Trifolium repens*	White clover	Non-native	Occasional
Poaceae	*Trisetum glomeratum*	Pili uka	Endemic	Occasional
Ericaceae	*Vaccinium reticulatum*	ʻŌhelo	Endemic	Rare
Verbenaceae	*Verbena litoralis*	Vervain	Non-native	Rare
Plantaginaceae	*Veronica arvensis*	Corn speedwell	Non-native	Rare
Fabaceae	*Vicia sp.*	Vetch	Non-native	Occasional
Apocynaceae	*Vinca sp.*	Vinca	Non-native	Rare
Poaceae	*Vulpia sp.*	Fescue	Non-native	Rare
Iridaceae	*Watsonia borbonica*	Watsonia	Non-native	Rare
Asteraceae	*Youngia japonica*	Oriental hawksbeard	Non-native	Occasional

BATS

We did not survey for Hawaiian Hoary Bats or ʻŌpeʻapeʻa (*Lasiurus cinereus semotus*), as a year-long monitoring program with an array of ultrasonic bat detectors is being done by others.

Anecdotally, bats are present over all of East Maui, and some of their highest numbers occur in forested sections of the mid-elevations.

Our guess is there will be low levels of transiting bats anywhere within the reserve, with the most down by Kekaulike Ave., and the least up high near the summit where there is no vegetation.

The bats will likely follow gulches and forage in and near there. And any groves of trees will also likely be utilized, even non-native, especially the leeward sides out of the weather where insects would seek refuge, those sorts of locations attract foraging bats.

Hawaiian Hoary Bats tend to roost in large trees in sheltered locations. We anticipate most of the bat roosting sites will be in the lowest elevations of the reserve.

Very little is known about this nocturnal native, but many bats likely call Kamehamenui home.

Hawaiian Hoary Bat or ʻŌpeʻapeʻa (*Lasiurus cinereus semotus*), Olinda, Maui.

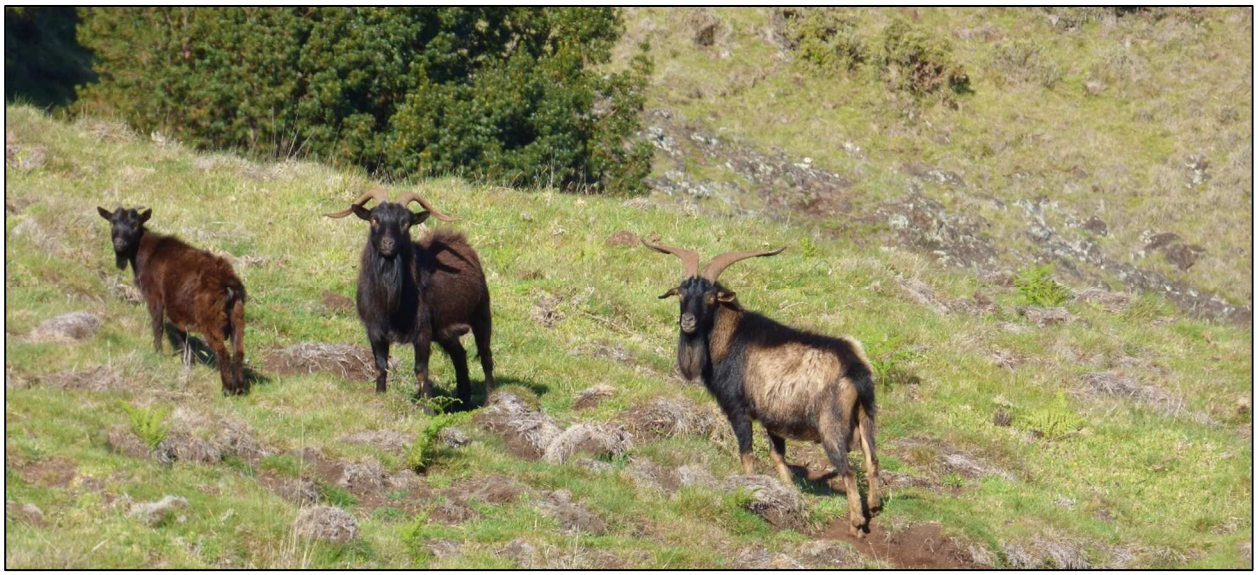
NON-NATIVE MAMMALS

The Kamehamenui Forest Reserve is currently an active ranch with numerous cows (*Bos taurus*), goats (*Capra hircus*), pigs (*Sus scrofa*), axis deer (*Axis axis*), and sheep (*Ovis aries*). Ungulate signs are evident over the entire reserve, though are markedly less in the highest elevations.

There are some nice looking pastures down low. However, damage to the native plants from the ungulates is severe, with vast areas completely denuded and taken down to dirt and stone.

Other mammals likely to utilize this property, but which were not observed or heard include rats (*Rattus* spp.), mice (*Mus domesticus*), cats (*Felis domesticus*), dogs (*Canis lupus familiaris*), and mongooses (*Herpestes javanicus*).

Cattle (*Bos taurus*).



Goats (*Capra hircus*).

Pig (*Sus scrofa*).

Axis Deer (*Axis axis*).

Sheep (*Ovis aries*).

Many previously vegetated areas of the reserve have been grazed and grubbed down to dirt by ungulates.

Bleached skeletons are all that remain of the native subalpine shrubland that once called this area home. Vast areas of the reserve are currently like this.

Pig damage is severe over much of the reserve.

Pigs are even able to uproot pūkiawe bushes.

Wool caught on barbed wire as sheep duck under the fence. ʻŌhiʻa trees in the background.

Sheep wool at the base of an ʻōhiʻa tree being used as a rubbing post.

Sandalwood tree heavily damaged by ungulates. All the sandalwood trees we encountered in the reserve are near death as a result of ungulate damage.

The base of another sandalwood tree. It's amazing the tree is still alive given the damage.

Newly installed fence adjacent to the reserve. Mostly ungulate free on the left, outside the reserve.

Same fence on the ground. Less vegetation and more pig digging on the right, inside the reserve.

BIRDS

There are a variety of habitats and elevational range in the reserve, resulting in a variety of birds. Of the native birds, the Maui ʻAmakihi (*Chlorodrepanis virens* var. *wilsoni*) is the most common, found in forested or densely vegetated shrubland from 4,000-7,500 ft.

ʻApapane (*Himatione sanguinea*) are also locally prevalent, but appeared less widespread, they were encountered in heavily forested areas from 5,500-7,500 ft. As with ʻAmakihi, they were present in both native and non-native forest.

Though not encountered in the reserve, ʻIʻiwi (*Vestiaria coccinea*) and Maui Creeper or ʻAlauahio (*Paroreomyza montana newtoni*) occur in nearby Kula Forest Reserve.

A Hawaiian Owl or Pueo (*Asio flammeus sandwichensis*) was observed gliding over open areas around 6,000 ft. They could occur over the entire range of the reserve. Though not encountered, Hawaiian Geese or Nēnē (*Branta sandvicensis*) likely also occur in the reserve at times.

Pacific Golden-Plovers or Kōlea (*Pluvialis fulva*) were regularly encountered on our first field day in late April. However, by the next week in early May, they had all left for Alaska. As a result, our bird distribution map does not convey the actual distribution, which is that Kōlea likely seasonally occur in all open areas from the bottom of the reserve to 8,500 ft.

Hawaiian Petrels or ʻUaʻu (*Pterodroma sandwichensis*) nest in burrows dug in the ground in the higher elevations of the reserve. Though no live petrels were observed or heard, one dead petrel was found below powerlines near the summit, and we came across many recently active burrows.

Though seemingly barren and empty during the day, once darkness arrives, the night sky at the summit fills with seabirds and their raucous calls. With protection, the highest elevations of the reserve have the potential to support a huge number of seabirds.

Along with the Hawaiian Petrel, the Band-rumped Storm-Petrel (*Oceanodroma castro*) and Newell's Shearwaters (*Puffinus newelli*) may be able to utilize the habitat, especially as the area is further protected and restored.

Looking and listening for birds.

Eurasian Skylarks (*Alauda arvensis*) were omni-present over much of the reserve, given the vast open areas. There was almost constant singing by one to a few skylarks in many areas.

Non-native passerines found in forested areas in the reserve include Red-billed Leiothrix (*Leiothrix lutea*), Japanese Bush-warbler (*Cettia diphone*), Warbling White-eye (*Zosterops japonicus*), House Finch (*Haemorhous mexicanus*), Common Myna (*Acridotheres tristis*), Northern Mockingbird (*Mimus polyglottos*), and Northern Cardinal (*Cardinalis cardinalis*).

Game birds and doves heard or seen were Ring-necked Pheasant (*Phasianus colchicus*), Chukar (*Alectoris chukar*), Mourning Dove (*Zenaida macroura*), Zebra Dove (*Geopelia striata*), and Rock Pigeon (*Columba livia*).

A Barn Owl (*Tyto alba*) flushed from a rock cave in a cliff in the pasture zone as we approached.

Many birds are only found in the lowest parts of the reserve, including Chestnut Munia (*Lonchura atricapilla*), House Sparrow (*Passer domesticus*), and Junglefowl (*Gallus gallus*).

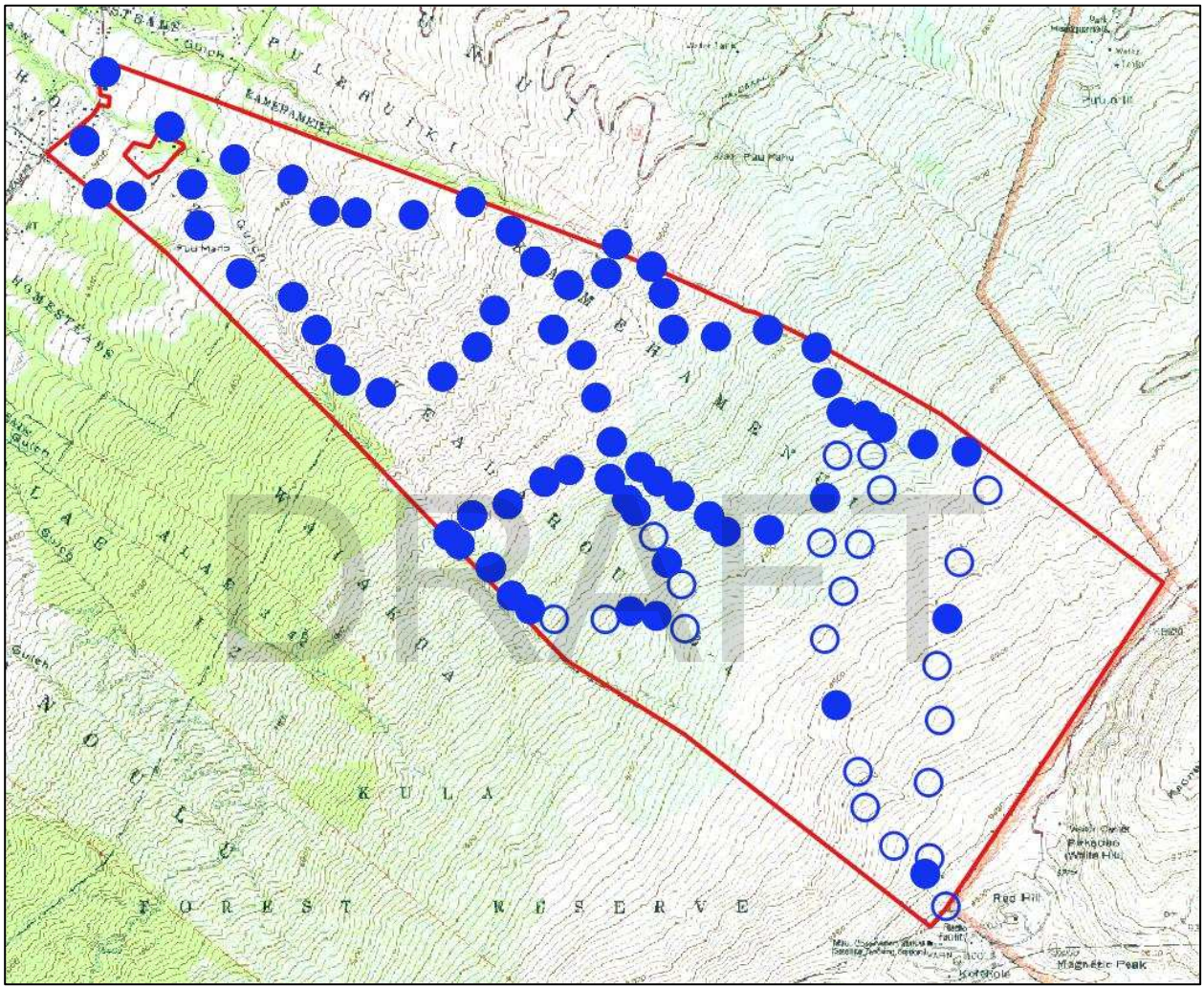
Chestnut Munia (*Lonchura atricapilla*) resting in a wattle snag on the edge of a pasture.

Hawaiian Petrel or ʻUaʻu burrow dug under a stone outcrop in the summit region, with burrow number.

Dead Hawaiian Petrel or ʻUaʻu under powerlines in the summit region. The vast and mostly barren summit region has the potential to support huge numbers of seabirds.

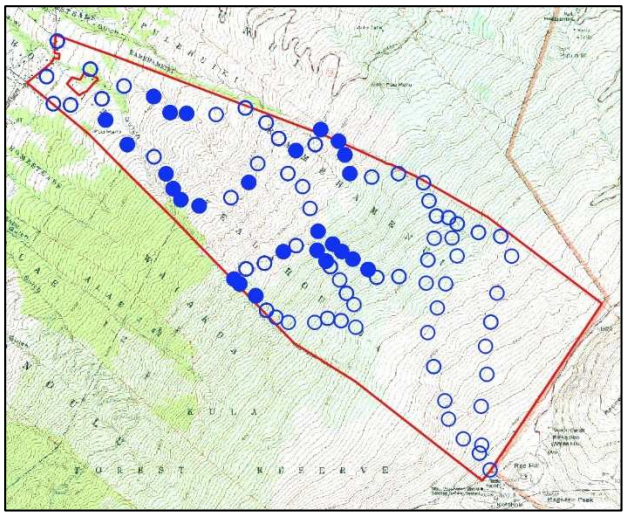
BIRD COUNTS

91 travelling counts of variable time and length were done across a range of habitat types and elevations. The average distance travelled for each count was 280 meters, and the average duration was 18 minutes. All birds observed or heard for an unlimited distance were recorded. Solid blue circles indicate detection, open blue circles indicate no detection.

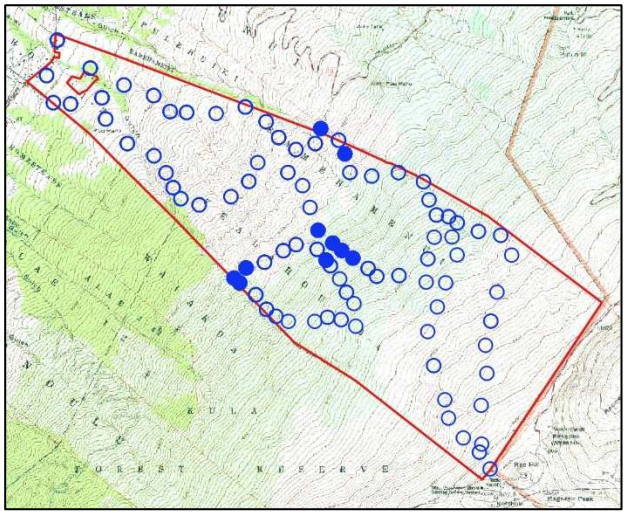


All bird count locations.

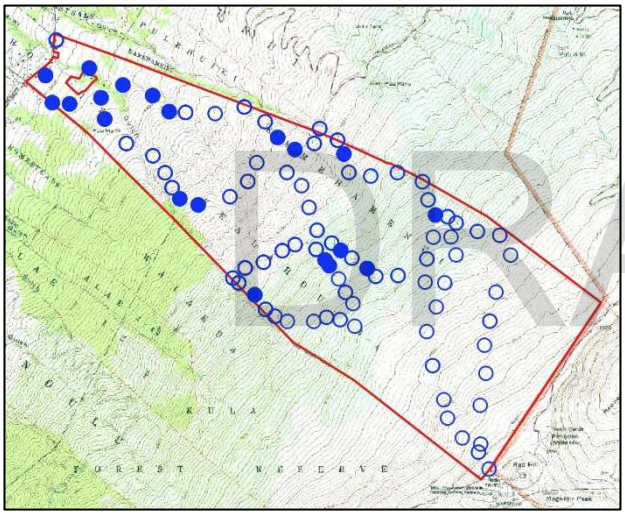
Looking and listening for birds.



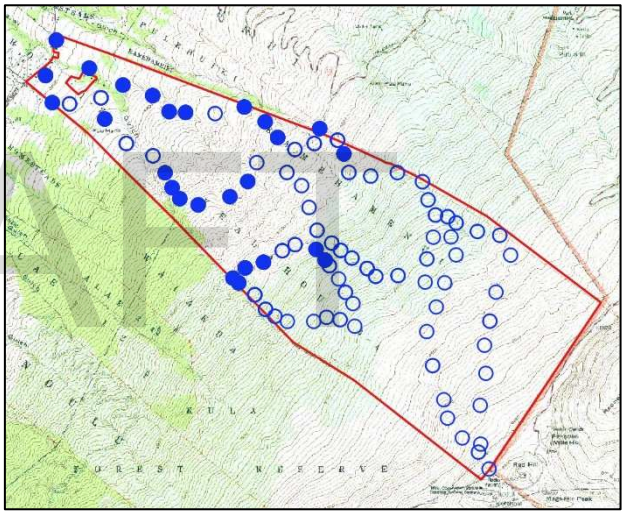
Maui ʻAmakihi



ʻApapane

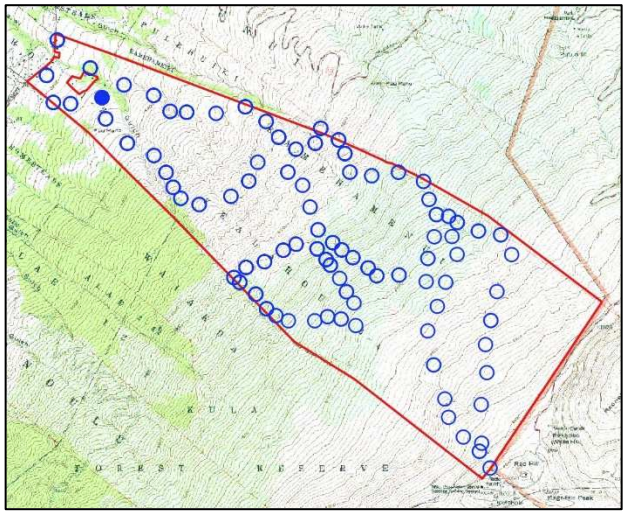


Warbling White-eye

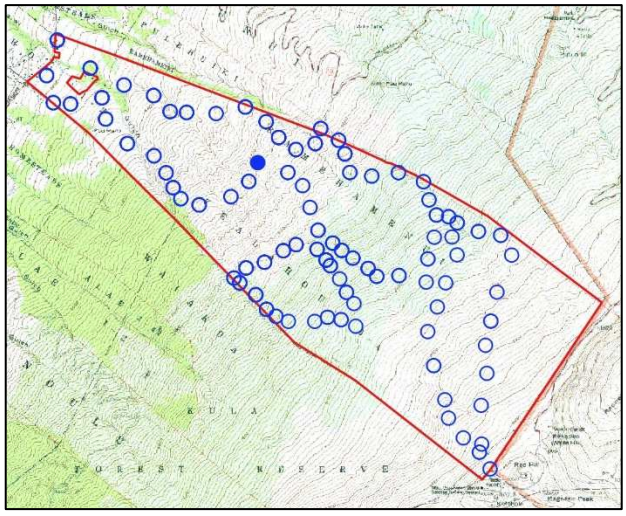


Red-billed Leiothrix

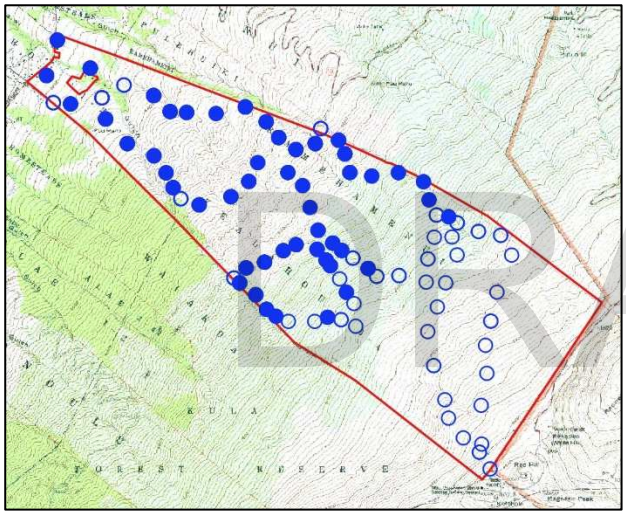
ʻApapane calling in ʻōhiʻa canopy, Kahikinui Forest Reserve.



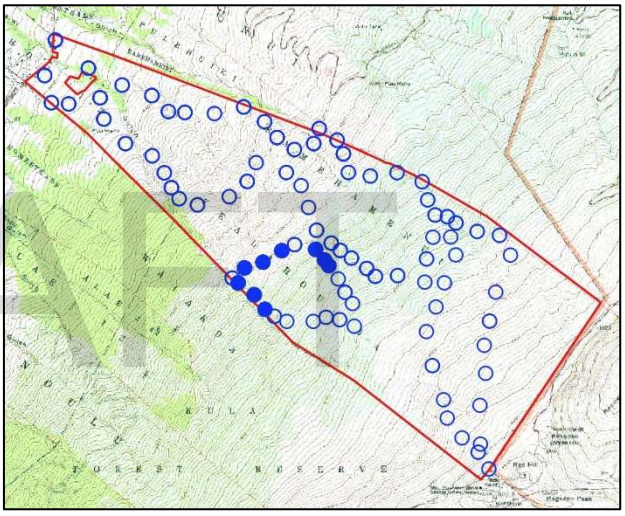
Hawaiian Owl or Pueo



Barn Owl

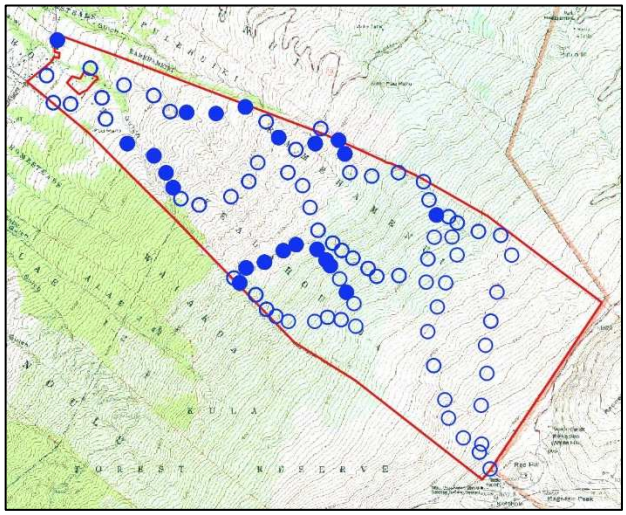


Eurasian Skylark

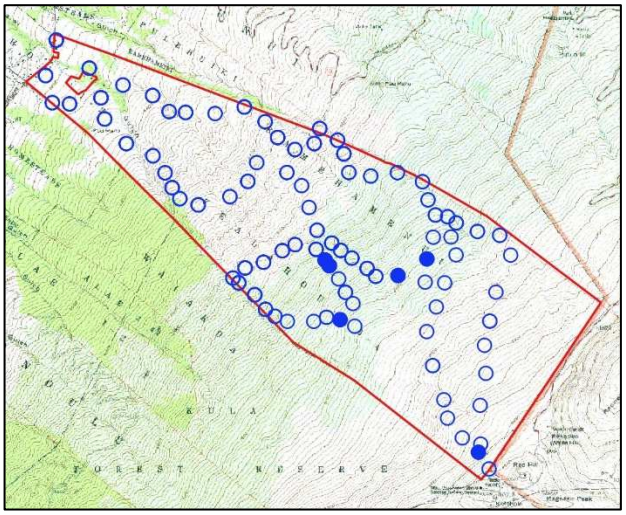


Pacific Golden-Plover or Kōlea

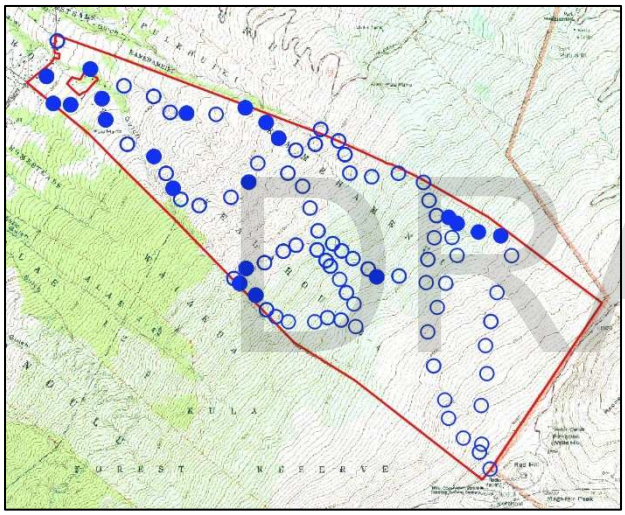
Hawaiian Owl or Pueo chick, Kula.



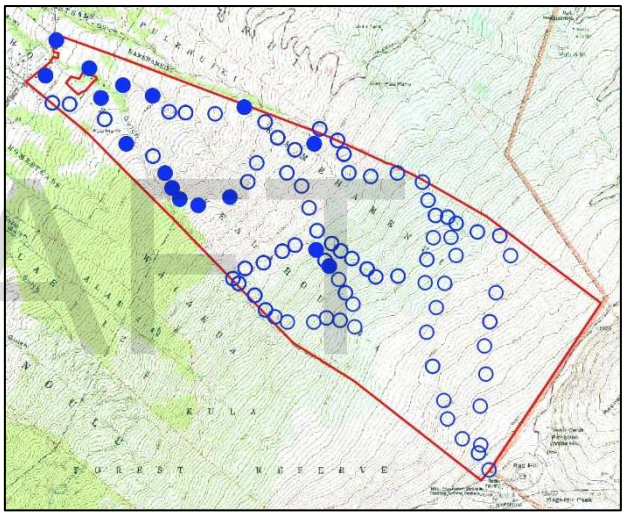
Ring-necked Pheasant



Chukar

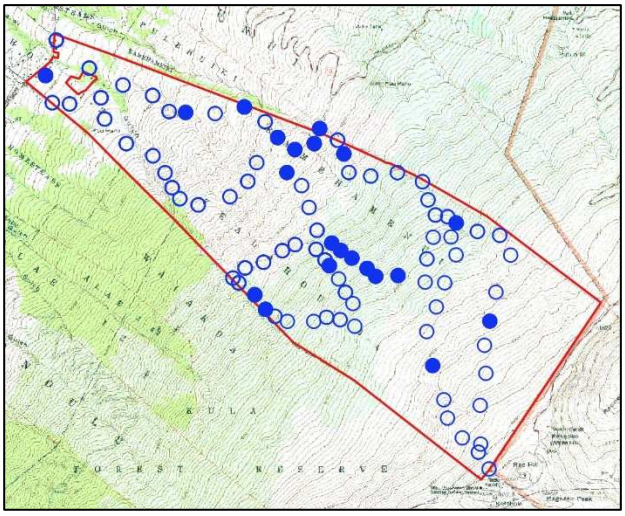


House Finch

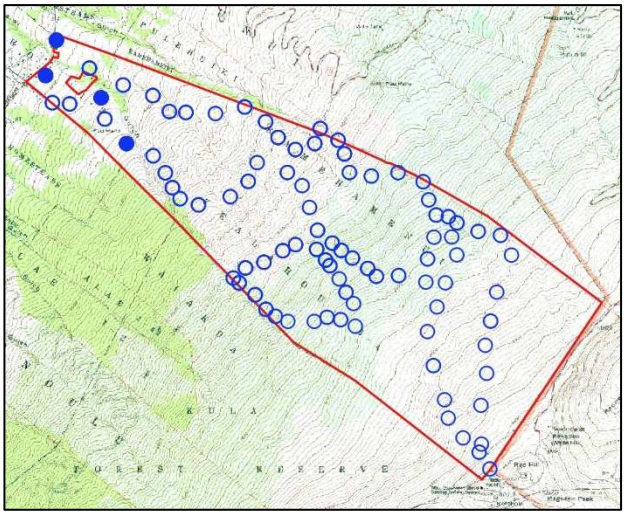


Northern Cardinal

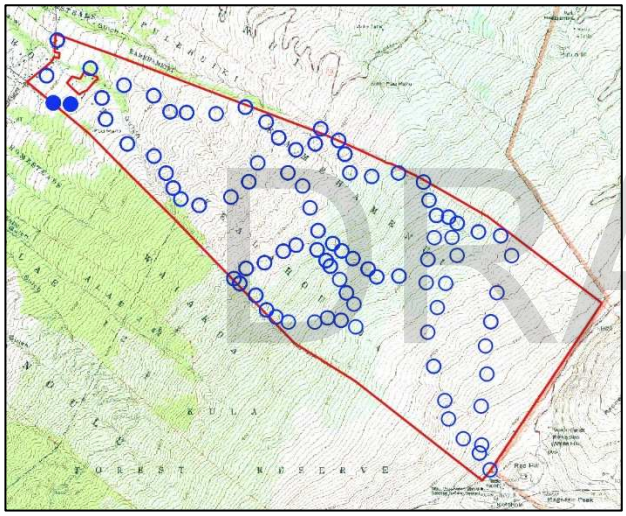
Ring-necked Pheasant, ʻUlupalakua.



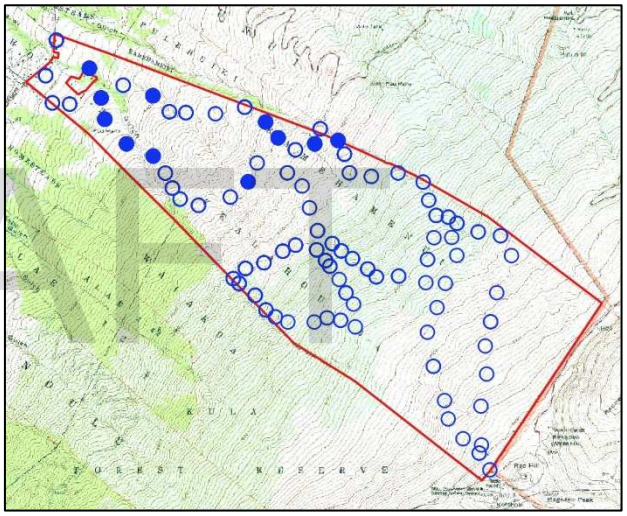
Northern Mockingbird



Red Junglefowl

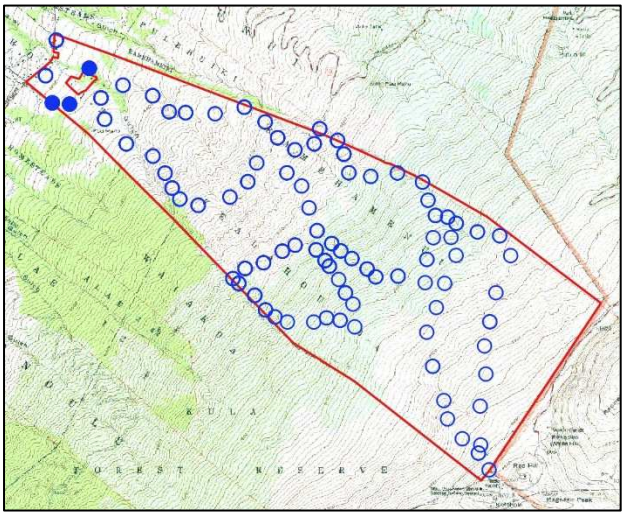


Chestnut Munia

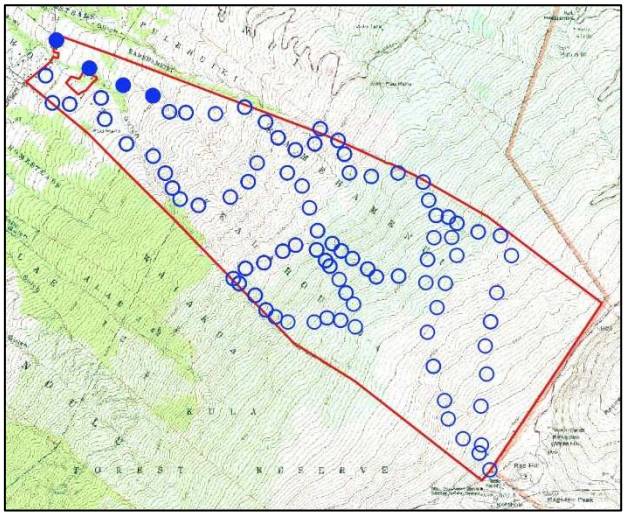


Common Myna

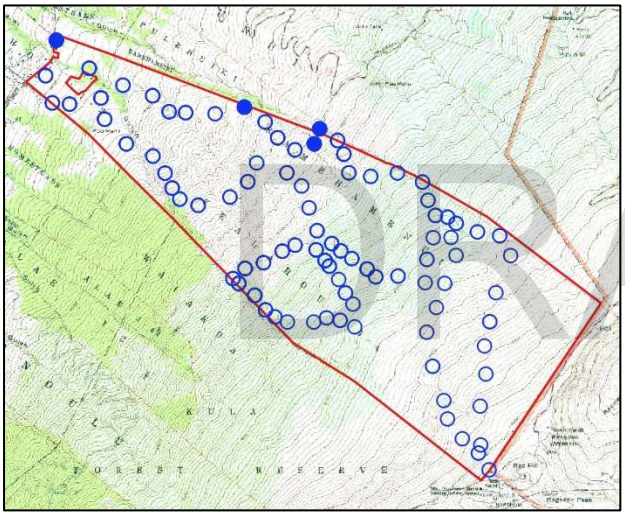
Common Myna birds, Midway Atoll.



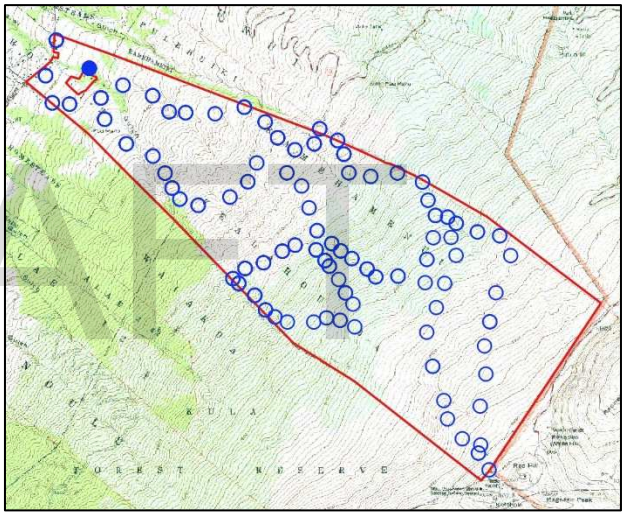
House Sparrow



Mourning Dove



Rock Pigeon



Zebra Dove

A lost Rock Pigeon at the Haleakalā summit visitor center parking lot.

BIRD SPECIES LIST

Following is a checklist of the bird species inventoried during the field work.

Abundance of each species within the project area:

- Abundant = Many flocks or individuals seen throughout area at all times of day.
- Common = A few flocks or well scattered individuals throughout the area.
- Uncommon = Only one flock or several individuals seen within the project area.
- Rare = only one or two seen within the project area.

Common name	Scientific name	Nativity	Abundance
ʻApapane	*Himatione sanguinea*	Endemic	Occasional
Barn Owl	*Tyto alba*	Non-native	Rare
Chestnut Munia	*Lonchura atricapilla*	Non-native	Rare
Chukar	*Alectoris chukar*	Non-native	Occasional
Common Myna	*Acridotheres tristis*	Non-native	Occasional
Eurasian Skylark	*Alauda arvensis*	Non-native	Common
Hawaiian Owl	*Asio flammeus sandwichensis*	Endemic	Rare
Hawaiian Petrel	*Pterodroma sandwichensis*	Endemic	Rare
House Finch	*Haemorhous mexicanus*	Non-native	Common
House Sparrow	*Passer domesticus*	Non-native	Occasional
Maui ʻAmakihi	*Chlorodrepanis virens wilsoni*	Endemic	Occasional
Northern Cardinal	*Cardinalis cardinalis*	Non-native	Occasional
Northern Mockingbird	*Mimus polyglottos*	Non-native	Occasional
Pacific Golden-Plover	*Pluvialis fulva*	Migratory	Occasional
Red Junglefowl	*Gallus gallus*	Non-native	Rare
Red-billed Leiothrix	*Leiothrix lutea*	Non-native	Common
Ring-necked Pheasant	*Phasianus colchicus*	Non-native	Common
Rock Pigeon	*Columba livia*	Non-native	Occasional
Warbling White-eye	*Zosterops japonicus*	Non-native	Common
Zebra Dove	*Geopelia striata*	Non-native	Occasional

Maui ʻAmakihi visiting ʻōhiʻa flowers in Kahikinui Forest Reserve.

INSECTS

A complete inventory of the insects was beyond the scope of this survey. Conspicuous insects were noted and special effort was made to look for insects of conservation concern. Very little survey work has been done on insects in the Kamehamenui Forest Reserve, and there is still much to be discovered, including new undescribed species. Some of the more conspicuous and noteworthy insects we came across are noted below.

YELLOW-FACED BEES

Native yellow-faced bees (*Hylaeus* spp.) (Hymenoptera: Colletidae) are abundant in the subalpine shrubland of the reserve, especially on and near pūkiawe and ʻaʻaliʻi plants in bloom. These black bees with yellow and sometimes red markings are important pollinators of the Haleakalā silversword and other plants. Once common across all Hawaiʻi, subalpine East Maui is now one of the only places these native bees are still abundant. The upper reaches of the reserve, 7,500-9,500 ft., have some of the highest numbers of yellow-faced bees we've encountered.

Yellow-faced bee (*Hylaeus nivicola*), an important pollinator of native plants such as silverswords. These increasingly rare native bees are abundant over much of the subalpine shrubland of Kamehamenui.

Kleptoparasitic yellow-faced bee (*Hylaeus volatilis*). Instead of visiting flowers to collect pollen and nectar, these native bees lay their eggs in the nests of other native bees while they are out foraging, like cuckoo birds.

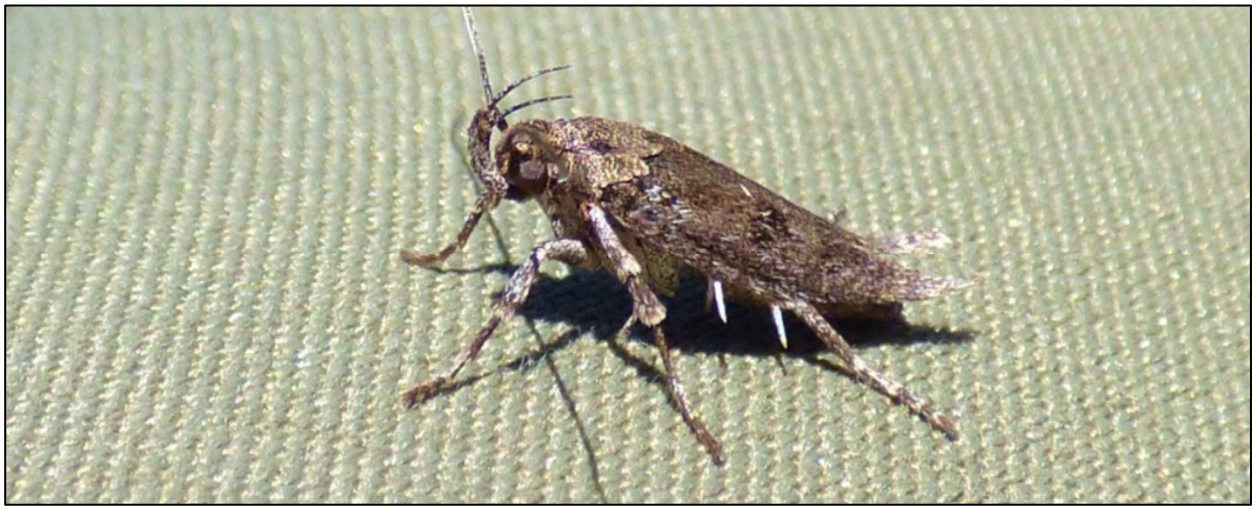
KOA BUTTERFLY

Native native koa butterflies (*Udara blackburni*) (Lepidoptera: Lycaenidae) are locally abundant in the reserve. The larvae of this species feed on koa, ʻaʻaliʻi, and perhaps black wattle. As these plant species become more common, so too should this small but showy native butterfly.

Koa butterfly (*Udara blackburni*) in the koa/wattle forest of Kamehamenui Forest Reserve.

FLIGHTLESS MOTHS

The highest elevations of the reserve are home to the native Haleakalā flightless moth (*Thyrocopa apatela*) (Lepidoptera: Xyloryctidae). This brown moth can occasionally be seen hopping around the cinders and stones in the summit region. The moths are largely diurnal, being more active in the day. The larva is likely a generalist, feeding on plant debris. These ground bound moths benefit from no invasive ants in the highest elevations of the reserve.



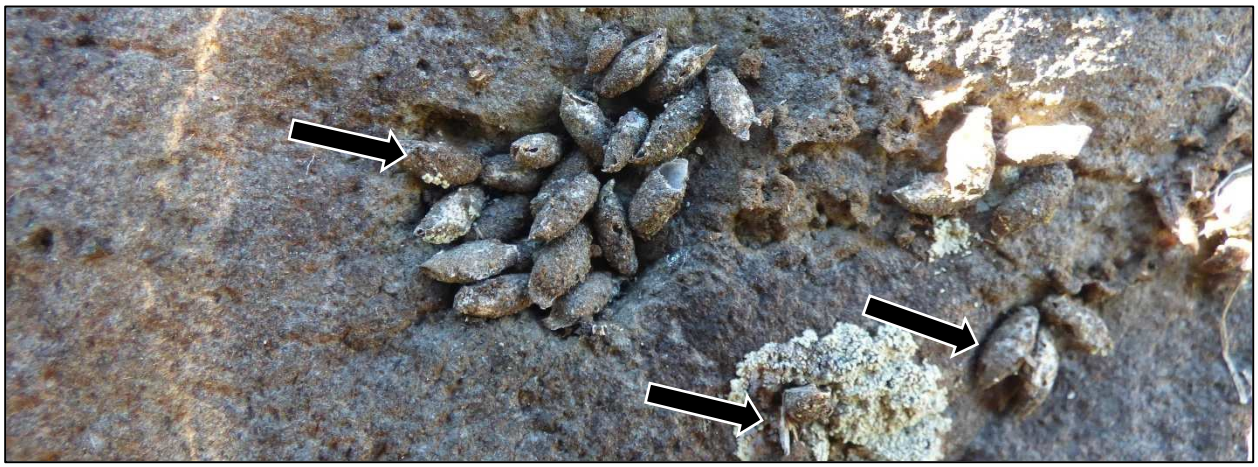
Haleakalā flightless moth (*Thyrocopa apatela*) in the summit region of Kamehamenui Forest Reserve.

FANCY-CASED MOTHS

Able to survive in some of the least hospitable areas of Hawai‘i, native fancy-cased moths (*Hyposmocoma* spp.) (Lepidoptera: Cosmopterigidae) are abundant over much of Kamehamenui. Most prevalent to our eyes were the "burrito" shaped larvae/pupae that were common in sheltered areas on large stones and cliff faces across the entire reserve. We also came across cases of the "carnivorous/snail eater" and "candy wrapper" types. In most places in the reserve, *Hyposmocoma* were the most common moths in our sweep net.

The larvae of the "burrito" moths create a sleeping bag type structure they stick bits of mud and lichen to while they crawl around and graze on lichen and fungi. Larvae pupate in the cases. Adults emerge as small moths. The "carnivorous" larvae eat snails or possibly other *Hyposmocoma*. Many of the *Hyposmocoma* moths encountered in the reserve are new undescribed native species. Entomologists at the University of Hawai‘i are further working up and archiving the specimens. There is still much to learn about these small native moths.

***Hyposmocoma* spp. habitat in sheltered areas on stones and cliff faces.**



***Hyposmocoma* sp. "burrito" shaped larvae/pupae adorned with bits of soil and lichen.**

Hyposmocoma **sp. "carnivorous" larva / caterpillar adorned with white lichen.**

Adult *Hyposmocoma* moths showing some of the diversity found in Kamehamenui Forest Reserve.

Looking for native *Hyposmocoma* moths, which are super abundant in Kamehamenui Forest Reserve.

NATIVE TEPHRITID FLIES

Once common over much of Hawai‘i, native tephritid or fruit flies (Diptera:Tephritidae) have now become restricted to the least disturbed habitats of Hawai‘i. Subalpine East Maui is one of the last significant refugia for these flies. Though less diverse than it once was, the Kamehamenui Forest Reserve still contains multiple species of native tephritid flies.

Most abundant is *Trupanea cratericola*, which lays eggs on flowers of kūpaoa (*Dubautia* spp.) and Haleakalā silverswords. The larvae eat the seeds and pupate within them. *T. limpidapex* lays eggs in the shoot tips of *Dubautia*. Pupal cases and characteristic damage to *Dubautia* from both of these species was observed in the subalpine shrubland.

Though no adults or pupae were observed, *T. artemisae* is likely utilizing the flowers of hinahina (*Artemisia mauiensis*) within the reserve. Additionally, *T. crassipes*, which utilizes the flowers and seeds of the non-native Spanish needle (*Bidens pilosa*) may episodically become abundant.

Tephritid fly (*Trupanea cratericola*) swept from vegetation in subalpine region.

Tephritid fly (*Trupanea cratericola*) pupal case in seedhead of kūpaoa (*Dubautia menziesii*).

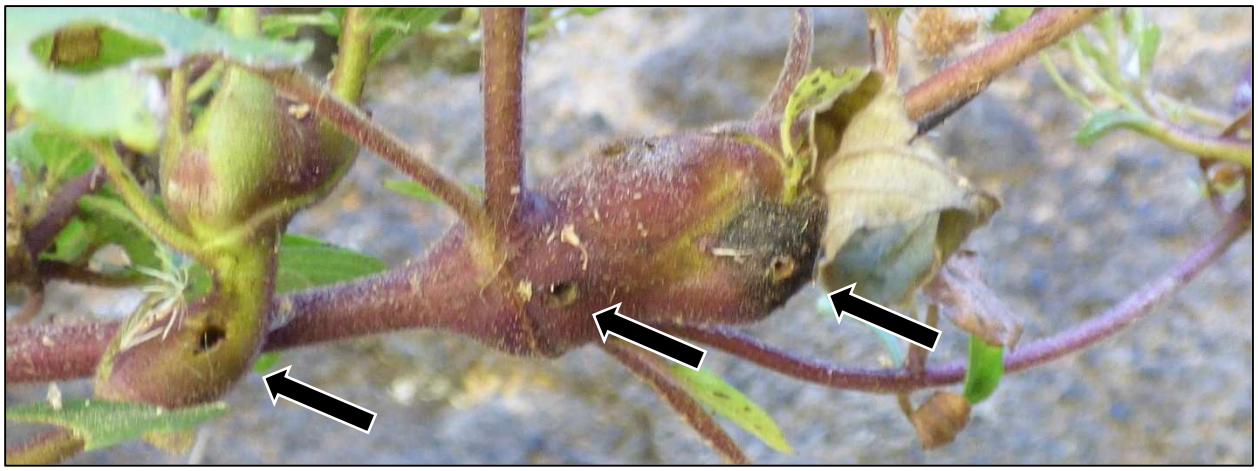
Remnants of tephritid fly (*Trupanea limpidapex*) pupa in shoot tip of kūpaoa (*Dubautia menziesii*).

NON-NATIVE TEPHRITID FLIES

A number of non-native tephritid flies (Diptera: Tephritidae) have been introduced to Hawai‘i for biocontrol of weeds.

When pamakani (*Ageratina* spp.) became a serious pest in agriculture and forestry in Hawai‘i, the gall forming tephritid flies, *Procecidochares utilis* and *P. alani* were imported. Within a few years of introduction, they dramatically reduced populations of pamakani.

P. utilis is present within the reserve virtually everywhere Maui pamakani is.



Gall and exit holes of stem galler (*Procecidochares utilis*) in Maui pamakani (*Ageratina adenophora*).

ANTS

Hawai‘i has no native ants (Hymenoptera: Formicidae). Just two species were encountered in the reserve, Argentine ant (*Linepithema humile*) and glaber ant (*Ochetellus glaber*), both were in the lowest elevations. Anecdotally, the reserve appears to have vast areas mostly devoid of invasive tramp ants, which bodes well for the native insects, which can be heavily impacted by ants.

Detailed ant surveys including baiting were not done for this project and more ant species likely exist within the reserve. An ant survey of part of the reserve in 2008 by Paul Krushelnycky found three additional species *Cardiocondyla kagutsuchi*, big-headed ant (*Pheidole megacephala*), and *Hypoponera opaciceps*. Again the tramp ants were only found in the lowest elevations.

Argentine ants (*Linepithema humile*) at bait card at nearby Waipoli Rd.

PLANTHOPPERS

Native planthoppers (*Nesosydne* sp.) (Hemiptera: Delphacidae) are present within the reserve. The *Nesosydne* genus is an adaptive radiation of host-specialized Hawaiian planthoppers. It has been said that each species of native Hawaiian plant likely has its own species of *Nesosydne* that evolved to feed on it. The Haleakalā silversword even has its own, *N. argyroxiphii.* As the native plants within the reserve become more abundant, so too will these native planthoppers.

Native planthopper (*Nesosydne* sp.) swept from subalpine vegetation.

SPIDERS

Spiders are present in small numbers over the entire reserve. Of note are the native wolf spiders (*Lycosa hawaiiensis*) (Araneae: Lycosidae), which hunt for prey in the subalpine shrubland. These spiders live under stones, and at times carry dozens of live young baby spiders on their backs. Other native spiders observed include predatory crab spiders (*Mecaphesa* sp.) (Araneae: Thomisidae), which wait in flowers or vegetation to ambush their prey, and long-jawed spiders *Tetragnatha acuta* (Araneae: Tetragnathidae) which were swept from the subalpine vegetation.

Hawaiian wolf spider (*Lycosa hawaiiensis*) on silversword, Haleakalā National Park.

Long-jawed spider *(Tetragnatha acuta)*, swept from subalpine vegetation of Kamehamenui.

INSECT SPECIES LIST

Following is a checklist of the insect species inventoried during the field work. A more thorough arthropod inventory was done in similar shrubland in nearby Haleakalā National Park by Paul Krushelnycky (2007). Many of the insects identified in that survey likely also occur in Kamehamenui. Groups he found most diverse included Hemiptera (Bugs), Diptera (Flies), Lepidoptera (Moths and Butterflies), Coleoptera (Beetles), and Araneae (Spiders), which is similar to what we encountered in Kamehamenui.

Order	Family	Scientific Name	Common Name	Nativity
Araneae	Araneidae	*Gasteracantha mammosa*	Asian spiny back spider	Non-native
Araneae	Lycosidae	*Lycosa hawaiiensis*	Wolf spider	Endemic
Araneae	Salticidae	*?*	Jumping spider	Non-native
Araneae	Tetragnathidae	*Tetragnatha acuta*	Hawaiian long-jawed spider	Endemic
Araneae	Thomisidae	*Mecaphesa* sp.	Crab spider	Endemic
Coleoptera	Chrysomelidae	*Chrysophtharta m-fuscum*	Eucalyptus tortoise beetle	Non-native
Coleoptera	Coccinellidae	*Coccinella septempunctata*	Seven-spotted ladybird	Non-native
Coleoptera	Coccinellidae	*Cryptolaemus montrouzieri*	Mealybug destroyer	Non-native
Coleoptera	Coccinellidae	*Olla v-nigrum*	Ashy gray lady beetle	Non-native
Coleoptera	Curculionidae	*Gonipterus scutellatus*	Eucalyptus snout beetle	Non-native
Diplopoda	?	*?*	Millipede	Non-native
Diptera	Muscidae	*?*	House fly	Non-native
Diptera	Sepsidae	*?*	Dung fly	Non-native
Diptera	Syrphidae	*?*	Syrphid flies	Non-native
Diptera	Tephritidae	*Procecidochares utilis*	Pamakani stem gall	Non-native
Diptera	Tephritidae	*Trupanea cratericola*	Hawaiian fruit fly	Endemic
Diptera	Tephritidae	*Trupanea limpidapex*	Hawaiian fruit fly	Endemic
Diptera	Tipulidae	*?*	Crane fly	?
Hemiptera	Cicadellidae	*?*	Cicadellid	?
Hemiptera	Cixiidae	*Oliarus* sp.	Planthopper	Endemic
Hemiptera	Delphacidae	*Nesosydne* spp.	Planthopper	Endemic
Hemiptera	Lygaeidae	*Nysius* spp.	False chinch bugs	Endemic
Hemiptera	Miridae	*?*	Mirid bugs	?
Hemiptera	Psyllidae	*?*	Psyllids	?
Hemiptera	Tingidae	*Corythucha morrilli*	Lace bug	Non-native
Hemiptera	Tingidae	*Teleonemia scrupulosa*	Lantana lace bug	Non-native
Hymenoptera	Apidae	*Apis mellifera*	Honey bee	Non-native
Hymenoptera	Braconidae	*?*	Braconid wasp	?
Hymenoptera	Colletidae	*Hylaeus nivicola*	Yellow faced bee	Endemic
Hymenoptera	Colletidae	*Hylaeus volatilis*	Yellow faced bee	Endemic
Hymenoptera	Formicidae	*Linepithema humile*	Argentine ant	Non-native
Hymenoptera	Formicidae	*Ochetellus glaber*	Glaber ant	Non-native

Order	Family	Scientific Name	Common Name	Nativity
Hymenoptera	Vespidae	*Odynerus* sp.	Potter wasp	Endemic
Lepidoptera	Cosmopterigidae	*Hyposmocoma* spp.	Fancy cased moths - "burrito" (at least 3 species)	Endemic
Lepidoptera	Cosmopterigidae	*Hyposmocoma* sp.	Fancy cased moths - "small burrito"	Endemic
Lepidoptera	Cosmopterigidae	*Hyposmocoma* spp.	Fancy cased moths - "candy wrapper" (at least 2 species)	Endemic
Lepidoptera	Cosmopterigidae	*Hyposmocoma* sp.	Fancy cased moths - "carnivore/snail eater"	Endemic
Lepidoptera	Erebidae	*Secusio [Galtara] extensa*	Fireweed biocontrol moth	Non-native
Lepidoptera	Lycaenidae	*Udara blackburni*	Koa butterfly	Endemic
Lepidoptera	Nymphalidae	*Danaus plexippus*	Monarch butterfly	Non-native
Lepidoptera	Nymphalidae	*Vanessa virginiensis*	American painted lady butterfly	Non-native
Lepidoptera	Pieridae	*Abaeis nicippe*	Sleepy orange butterfly	Non-native
Lepidoptera	Pieridae	*Pieris rapae*	Cabbage looper	Non-native
Lepidoptera	Schreckensteiniidae	*Schreckensteinia festaliella*	Rubus biocontrol moth	Non-native
Lepidoptera	Xyloryctidae	*Thyrocopa apatela*	Haleakalā flightless moth	Endemic
Neuroptera	Hemerobiidae	*?*	Brown lacewing	Non-native
Odonata	Libellulidae	*?*	Skimmer	?
Orthoptera	Gryllidae	*?*	Cricket	Non-native

Searching for native *Hyposmocoma* moths in Hāpapa Gulch. These cryptic native moths, many of which are new undescribed species, are abundant and diverse in Kamehamenui.

MOLLUSKS

Native tornatellid snails (*Tornatellides* sp.) (Gastropoda: Achatinellidae) were encountered on foliage and stones. This genus of snails is found in a variety of habitats from the Northwestern Hawaiian Islands to the main Hawaiian Islands. Tornatellid snails are known to be eaten by some species of native *Hyposmocoma* moths, which capture snails with silk and eat them alive.

Also observed were non-native garlic snails (*Oxychilus alliarius*). This invasive snail is a predator of small snails, and negatively impacts native snail communities where introduced.

We looked for, but did not find, the rare native ground snail (*Vitrina tenella*). It was previously known from Kamehamenui, where it was collected on ferns, shrubs, and the ground (6,000-8,500 ft.). However, it is currently only known from one site on Mauna Kea. It could have possibly been wiped out in Kamehamenui by the garlic snail (*Oxychilus*).

Further surveys would undoubtedly turn up more species of snails in the reserve. Native amber snails (*Succinea* spp.) are able to utilize both native and non-native dominated habitat, and are likely in parts of the reserve. And perhaps *Vitrina* is still present and just overlooked.

Non-native garlic snail (*Oxychilus alliarius*).

Native tornatellid snail (*Tornatellides* sp.).

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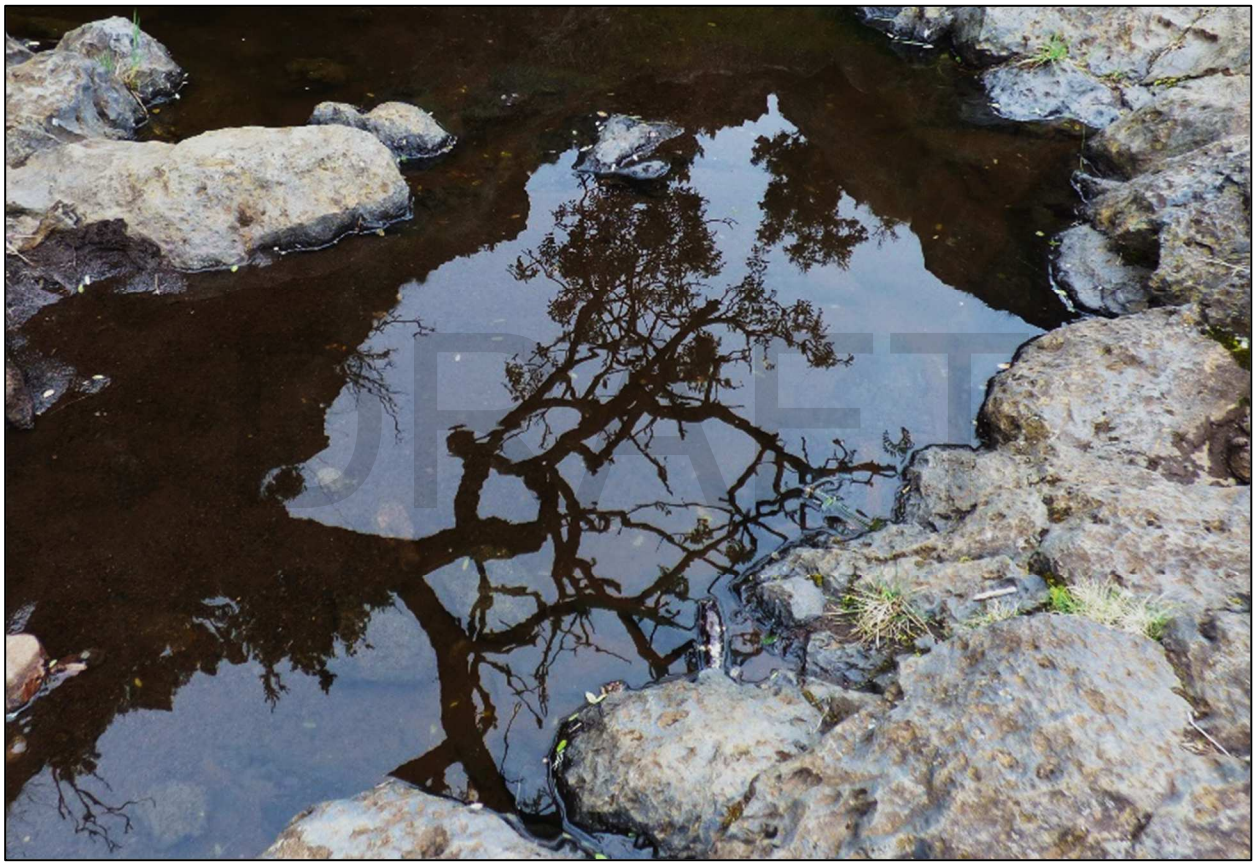

Ephemeral pool of water under a māmane tree in Kamehamenui Forest Reserve.
***"Hahai nō ka ua i ka ululā‘au"* - The rain follows the forest.**