Auwahi **Wind**

September 3, 2021

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Via Email

SUBJECT: Auwahi Wind Farm Project Habitat Conservation Plan FY 2021 (Year 9) Annual Report

Dear Mr. LeBlanc and Dr. Radley:

Please find the attached annual report for the Auwahi Wind Farm Project Habitat Conservation Plan (HCP), prepared in compliance with the U.S. Fish and Wildlife Service Incidental Take Permit (ITP) TE64153A-1 and Department of Land and Natural Resources Incidental Take License (ITL) ITL-17. This annual report covers monitoring and mitigation activities conducted from July 1, 2020 through June 30, 2021. The report identifies each HCP requirement and ITP and ITL condition completed, ongoing requirements and conditions, compliance status, and basis for determining compliance. Also, in compliance with HCP monitoring requirements, a post-construction mortality monitoring update is included.

Should you have any questions on this annual report, please feel free to contact me at (808) 876-4100 or via email at gjakau@aepes.com.

Sincerely,

George Akau

Project Biologist/Auwahi Wind Farm

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Auwahi Wind Farm Habitat Conservation Plan FY 2021 Annual Report

Incidental Take Permit TE64153A-1/ Incidental Take License ITL-17

Submitted To:

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An AEP Company
BOUNDLESS ENERGY
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Acronyms and Abbreviations

Auwahi Wind	Auwahi Wind Energy, LLC
CPT	carcass persistence trial
DOFAW	Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife
EoA	Evidence of Absence
FY	Fiscal Year
HCP	Habitat Conservation Plan
ITL	Incidental Take License
ITP	Incidental Take Permit
Kahikinui PMA	Kahikinui Petrel Management Area
LWSC	low-wind speed curtailment
m/s	meters per second
MBTA	Migratory Bird Treaty Act
PCMM	post-construction mortality monitoring
Project	Auwahi Wind Farm Project
SEEF	searcher efficiency
Tetra Tech	Tetra Tech, Inc.
USFWS	U.S. Fish and Wildlife Service

1.0 Introduction

Auwahi Wind Energy, LLC (Auwahi Wind) finalized a Habitat Conservation Plan (HCP) for the construction and operation of the Auwahi Wind Farm Project (Project) on east Maui, Hawaiʻi in 2012 (Tetra Tech 2012a). The HCP and the associated Incidental Take Permit (ITP; number TE64153A-1) from the U.S. Fish and Wildlife Service (USFWS) and Incidental Take License (ITL; number ITL-17) from the Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife (DOFAW) authorize incidental take (hereafter take) for the Hawaiian petrel (*Pterodroma sandwichensis;* ʻua ʻu), Hawaiian goose (*Branta sandvicensis;* nēnē), Hawaiian hoary bat (*Lasiurus cinereus semotus;* ʻōpeʻapeʻa), and Blackburn's sphinx moth (*Manduca blackburni;* ʻenuhe), collectively referred to as the Covered Species. This report provides a summary of monitoring and mitigation activities that have occurred during Fiscal Year (FY) 2021 (from July 1, 2020 to June 30, 2021). This report includes an overview of post-construction mortality monitoring (PCMM) and mitigation activities, addresses other required annual reporting items as identified in the HCP, reviews an annual work plan for the upcoming year, and details annual cost expenditures as required under the ITP and ITL.

2.0 Post-Construction Mortality Monitoring

The HCP includes a detailed description of the monitoring protocol. In FY 2021, standardized carcass searches were performed around all eight turbines and the meteorological tower every 7 days using a canine and handler (canine search team). Bias trials consisting of carcass persistence trials (CPT), and searcher efficiency (SEEF) trials were conducted throughout FY 2021. Results of PCMM in Sections 2.1 and 2.3 are presented for FY 2021 and not the period of take analysis presented in Section 2.4. Take analysis (Section 2.4) is based on a calendar year except when changes to the search protocol were incorporated, as discussed in Section 2.1.

Other permits also required for compliance include a Migratory Bird Special Purpose Utility permit (Permit No. MB92518A-1) for handling migratory bird carcasses, which was reissued by USFWS on April 1, 2021, and a State Protected Wildlife Permit (Permit No. WL20-07) for handling native bird and bat carcasses, which was reissued by DOFAW on May 26, 2020.

2.1 Fatality Monitoring

2.1.1 Systematic Carcass Searches

The canine search team searched for downed wildlife along all pads and roads that occur within a 100-meter radius of the turbines and within 10 meters of the meteorological tower. Pads and roads have regularly scheduled vegetation management, as well as provide even and stable footing for the canine search team. These factors improve the detectability of fatalities and decrease the risk of injuries for the canine search team. The search area size and configuration varied among turbine pads based on the shape of the pads and roads and was delineated using geographic information system (GIS) tools to assess search coverage. The areas searched at the Project represented a total of 54 percent of the large bird fall distribution and 77 percent of the bat fall distribution (Sempra Energy 2015). These values are consistent with results based on a theoretical carcass distribution model (Hull and Muir 2010).

2.1.2 Detections Outside of Designated Searches and Searched Areas

Project staff, contractors, and ranch personnel with access to the Project area may detect downed wildlife in the course of their regular activities. The USFWS protocol for incidental detections (USFWS 2018) is applied to determine if the detections should be included in Project fatality estimates depending on the location of the recovered animal or carcass relative to the search area, the timing of the detection relative to the next search, and the likelihood of detection based on estimates of carcass persistence from Project-specific bias correction trials.

2.2 Downed Wildlife Observations

Eleven fatalities were documented and reported in FY 2021; 10 of these fatalities were documented during standardized carcass searches and one was detected incidentally (Table 2-1). Two of the recorded fatalities were species protected under the Migratory Bird Treaty Act (MBTA). Four of the recorded fatalities were Covered Species—all Hawaiian hoary bats. One injured individual, a white-tailed tropicbird, was transferred to DOFAW staff for care and subsequently released (Table 2-2).

Table 2-1. Documented Fatalities at the Project in FY 2021

Species	Legal Status[1]	Found Date	Location (Turbine)	Type of Detection	Outside Search Area	Outside Scheduled Search
Wedge-tailed Shearwater *(Ardenna pacifica)*	MBTA	7/20/2020	6	Incidental Finding	X	–
Hawaiian Hoary Bat *(Lasiurus cinereus semotus)*	FE, SE	8/10/2020	1	Carcass Survey	–	–
African Silverbill (*Euodice cantans*)	None	8/10/2020	3	Carcass Survey	–	–
Hawaiian Hoary Bat *(Lasiurus cinereus semotus)*	FE, SE	9/7/2020	2	Carcass Survey	–	–
Hawaiian Hoary Bat *(Lasiurus cinereus semotus)*	FE, SE	9/14/2020	2	Carcass Survey	–	–
Hawaiian Hoary Bat *(Lasiurus cinereus semotus)*	FE, SE	9/14/2020	7	Carcass Survey	–	–
Common Myna *(Acridotheres tristis)*	None	11/2/2020	7	Carcass Survey	–	–
Black Francolin (*Francolinus francolinus*)	None	2/15/2021	7	Carcass Survey	–	–

Species	Legal Status[1]	Found Date	Location (Turbine)	Type of Detection	Outside Search Area	Outside Scheduled Search
Black Francolin (*Francolinus francolinus*)	None	4/5/2021	4	Carcass Survey	–	–
Bulwer's Petrel (*Bulweria burlwerii*)	MBTA	6/7/2021	4	Carcass Survey	–	–
Black Francolin (*Francolinus francolinus*)	None	6/28/2021	5	Carcass Survey	–	–
1. FE = Federally endangered, SE= State endangered, MBTA=Protected under the Migratory Bird Treaty Act.						

Table 2-2. Documented Wildlife Injuries at the Project in FY 2021

Species	Legal Status	Found Date	Location (Turbine)	Type of Detection	Outside Search Area	Outside Scheduled Search
White-tailed Tropicbird (*Phaethon aethereus*)	MBTA	3/1/2021	6	Incidental Finding	X	X

2.3 Carcass Persistence Trials

Sixty-three CPTs were conducted during FY 2021 and are summarized by carcass size class in Table 2-3. The objective of these trials is to estimate the likelihood that carcasses persist to the next search at the Project. Species used for CPTs include wedge-tailed shearwater (*Ardenna pacifica*), cattle egret (*Bubulcus ibis*), rock pigeon (*Columbia livia*), black francolin (*Francolinus francolinus*), and zebra dove (*Geopelia striata*) as surrogates for HCP-covered bird species; medium sized black rats (*Rattus rattus*) were used as surrogates for Hawaiian hoary bats.

Surrogate carcasses were placed at randomly generated points on turbine pads and roads within search plots. Carcasses were typically checked a minimum of twice per week in FY 2021 (every Monday during canine team searches and one additional check weekly), until carcasses were no longer detectable, or the trial period was complete. Trial periods were up to 35 days in length. Changes in carcass condition were tracked and documented with photos. A detailed description of field methods is included in Attachment 1 of the 2013 HCP annual report (Tetra Tech 2013). Probability of carcass persistence and 95 percent confidence intervals for each carcass category were estimated using the single class module of Evidence of Absence software (EoA; Dalthorp et al. 2017).

Auwahi Wind has controlled mammalian scavengers (e.g., cats, rats, mongoose) on site since the fall of 2013. Prior to initiation of site-wide trapping by Auwahi Wind, probabilities of carcass persistence until the next search were 0.44 for bats and 0.79 for large birds. CPT results since the implementation of site-wide trapping (FY 2014 to FY 2021) have resulted in probabilities of carcass persistence of at least 0.74 for bats and 0.98 for large birds. The probability that a bat carcass would persist until the next search was 0.888 in FY 2021 (Table 2-3). The probability that a large bird carcass would persist until the next search was 1.00 in FY 2021 (Table 2-3). Due to consistent CPT results over the past 9 years and to reduce the risk of attracting predators to the search areas, a request was made to DOFAW/USFWS to reduce the number of large bird CPT to 5 trials per year. This request was granted on June 12, 2020 (Lasha Salbosa, USFWS, pers. comm.).

Table 2-3. Carcass Persistence Estimates for Systematic Searches at the Project in FY 2021

Carcass Size Class	N	Probability of Carcass Persistence until Next Search	95 Percent Confidence Interval	Search Interval (days)
Bats	51	0.888	[0.847, 0.919]	7
Large Birds	12	1	[1, 1]	7

2.4 Searcher Efficiency

Fifty-seven SEEF trials were conducted during FY 2021 (Table 2-4). The objective of these trials was to assess the effectiveness of the canine search team at finding downed wildlife. Each trial was conducted by the Project biologist or environmental technician (tester) on site. The canine search team had no prior knowledge of the trials; every fatality search day was treated as if it had the potential to be a SEEF trial day. During FY 2021, 45 SEEF trials were performed for bats and 12 for large birds. Species used for SEEF trials were the same used for carcass persistence trials. SEEF carcasses were placed at randomly generated points on turbine pads and roads within search plots. Carcasses found during SEEF trials were left in place and were then monitored for carcass persistence (Section 2.3). All trial carcasses were found by the canine search team in FY 2021. Estimates of searcher efficiency and 95 percent confidence intervals for each carcass category were calculated using the single class module of EoA (Table 2-4; Dalthorp et al. 2017). Searcher efficiency was 100 percent for bats and 100 percent for large birds (Table 2-4). A request to reduce the number of large bird searcher efficiency trials will be proposed in a coordination meeting with DOFAW/USFWS in FY 2022.

Table 2-4. Searcher Efficiency Estimates for Wildlife Fatality Searches at the Project in FY 2021

Carcass Size Class	Search Method	Carcasses Available	Carcasses Found	Average Searcher Efficiency	95 Percent Confidence Interval
Bats	Canine	45	45	1	[0.946, 1]
Large birds	Canine	12	12	1	[0.815, 1]

2.5 Take

2.5.1 Direct Take

Auwahi Wind evaluated Project compliance under the ITL and ITP by estimating unobserved take using EoA software. The EoA analysis incorporated observed fatalities, results of bias correction trials (SEEF and CPT), search intervals, and proportions of the carcass distributions searched. EoA provides an estimate of total mortality for a given level of credibility to help evaluate if the number of fatalities has exceeded a given threshold of take. An 80-percent credibility level has been required by USFWS and DOFAW to assess compliance with an ITP and ITL so that there is only a 20 percent probability that actual take exceeds estimated take.

Auwahi Wind used EoA to model past Project take with PCMM data collected over the past 8.5 years for the Hawaiian hoary bat and Hawaiian petrel (Table 2-5; Attachment 1). Because the fiscal year does not coincide with the Project's operational year, the observed fatalities, carcass persistence, searcher efficiency, and detection bias values in Table 2-5 represent values for calendar years, with the period from January 1, 2021 through June 30, 2021 representing 2021 (Year 9). Therefore, values differ from those reported for the full FY 2021 in the sections above.

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Table 2-5. Summary of PCMM Data at the Project, From the Start of the Project through June 2021 (2013 - 2021)

Calendar Year	Low-wind Speed Curtailment (5 m/s)	Low-wind Speed Curtailment (6.9 m/s)[1]	Number of Fatalities Detected	Proportion of Carcass Distribution Searched	Average Search Interval (days)	Probability of Carcass Persistence	Average Searcher Efficiency	Detection Bias[2]	Cumulative Direct Take Estimate[3]	Cumulative Indirect Take Estimate	Cumulative Total Take Estimate
Hawaiian Hoary Bat										**Adult Equivalents[4]**	**Adult Equivalents**
2013	No	No	1	0.97	9	0.44	0.57	0.28	8	1 (0.47)	9
2014	No	No	4	0.94	5	0.75	0.52	0.55	16	1 (0.74)	17
2015	Yes	No	1	0.76	3	0.73	0.68	0.45	18	1 (0.74)	19
2016	Yes	No	7	0.76	3	0.76	0.76	0.55	34	4 (3.03)	38
2017[5]	Yes	No	3	0.76	3-4	0.88	0.67	0.60	39	5 (4.25)	44
2018	Yes	No	1	0.76	4-7	0.77	1	0.52	41	5 (4.25)	46
2019	Yes	Yes	7	0.77	7	0.93	1	0.72	52	6 (5.05)	58
2020[6]	Yes	Yes	4	0.77	7	0.93	1	0.71	59	7 (6.03)	66
2021[7]	Yes	Yes	0	0.77	7	0.81	1	0.62	58	6 (5.63)	64
Hawaiian Petrel										**Juvenile Equivalents[8]**	**Adult Equivalents**
2013	No	No	0	0.91	9	0.79	0.74	0.67	0	0	0
2014	No	No	1	0.91	5	0.98	0.75	0.84	2	1 (0.63)	3
2015	Yes	No	0	0.56	3	0.99	0.89	0.55	2	1 (0.63)	3
2016	Yes	No	0	0.56	3	0.96	0.96	0.48	3	1 (0.63)	4
2017	Yes	No	0	0.56	3-4	0.99	0.96	0.55	3	1 (0.63)	4
2018	Yes	No	0	0.56	4-7	0.99	1	0.55	3	2 (1.26)	4
2019	Yes	Yes	0	0.54	7	0.99	1	0.53	3	2 (1.26)	4
2020	Yes	Yes	0	0.54	7	1.00	1	0.54	3	2 (1.26)	4
2021[7]	Yes	Yes	0	0.54	7	1.00	1	0.51	3	2 (1.26)	4

1. 6.9 m/s curtailment from August 1 – November 1; Section 2.8.1.
2. Detection bias calculated using EoA software (Dalthorp et al. 2017).
3. Estimate of direct take based on EoA single class module; values represent the upper 80 percent confidence interval (see Attachment 1).
4. Estimate of indirect take based on USFWS 2016 guidance. Take estimates subject to change pending genetic analysis of observed fatalities. The actual value is presented in parentheses and the value rounded up to the nearest whole number is presented first.
5. Detection bias calculated using pooled data with custom search interval in single class module from EoA software.
6. Ultrasonic acoustic bat deterrents installed at all turbines in June 2020.
7. Calendar year 2021 includes the dates from January 1 through June 30.
8. Estimate of indirect take based on calculations in the HCP. The actual value is presented in parentheses and the value rounded up to the nearest whole number is presented first.

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2.5.1.1 Hawaiian Hoary Bat

Based on the 29 bat fatalities detected during fatality searches and seven fatalities detected incidentally during 8.5 years of PCMM, this analysis can be interpreted as: there is an 80 percent probability that actual direct take at the Project was less than or equal to 58 Hawaiian hoary bats. Based on results from the EoA, up to 22 undetected bat fatalities may have occurred.

2.5.1.2 Hawaiian Petrel

Based on the one Hawaiian petrel fatality detected during fatality surveys and one fatality detected incidentally during 8.5 years of PCMM, this analysis can be interpreted as: there is an 80 percent probability that actual direct take at the Project was less than or equal to three Hawaiian petrels.

2.5.2 Indirect Take

It is assumed that take of an adult bird or bat during the breeding season may result in the indirect loss of a dependent young. Thus, for every petrel or bat carcass detected during the breeding season, modifiers are applied to estimate indirect take to account for the likelihood that a given adult is reproductively active, the likelihood that the loss of a reproductively active adult results in the loss of its young, and average reproductive success (Tetra Tech 2012a: Section 5.2).

2.5.2.1 Hawaiian Hoary Bat

Indirect take is estimated to account for the potential loss of individuals that may occur indirectly as the result of the loss of an adult female through direct take during the breeding period when females may be pregnant or supporting dependent young. The seasonal timing and sex of all observed fatalities (those observed in fatality monitoring as well as incidental to fatality monitoring) is used in the calculation of indirect take. USFWS guidance was used for fatalities that lacked verified sex information (USFWS 2016). All detected bat fatalities have genetically verified sex information as provided in Pinzari and Bonaccorso (2018); the proportion of female take detected at Auwahi Wind through FY 2021 is 0.44. Indirect take was estimated as 5.63 adult Hawaiian Hoary bats (Attachment 2).

2.5.2.2 Hawaiian Petrel

Two Hawaiian petrel fatalities have been observed within the breeding season (May 1 through September 30) at the Project. The Hawaiian petrel observed on site during systematic fatality monitoring was found in 2014. One Hawaiian petrel was observed incidentally (outside of the search plot) in 2018. Based on estimates from EoA, up to one additional petrel fatality may have occurred and been undetected. The detection of an adult Hawaiian petrel recorded during the breeding season is assumed to result in the loss of one chick (Tetra Tech 2012a). The average reproductive success for Hawaiian petrels on Maui was previously estimated at 63 percent (Simons and Bailey 2020). The final assessment of indirect take at the end of the permit term will round up to the nearest whole number.

Indirect take is estimated to account for the potential loss of individuals (i.e., offspring) that may occur as the result of the loss of their parents. Both parents of the Hawaiian petrel care for their young until fledging (Simons and Bailey 2020). The point during the breeding season when an adult is taken determines to what extent offspring may be affected. Indirect take was calculated as 1.26 juveniles (observed take of 2 adults during the breeding season * 0.63 average reproductive success).

2.5.3 Total Take

2.5.3.1 Hawaiian Hoary Bat

The total Hawaiian hoary bat take estimated to have occurred at the Project through FY 2021 is 64 adult bats (58 direct + 6 indirect [rounded up from 5.63]).

2.5.3.2 Hawaiian Petrel

The total Hawaiian petrel take estimated to have occurred at the Project through FY 2021 is 4 adult petrels. This reflects the sum of 3 from direct take and 1 from indirect take (1.26 juveniles * 0.3 surviving to adulthood rounded up to the nearest whole number).

2.6 Take Projection and Estimated Fatality Rates for Hawaiian Hoary Bat

Auwahi Wind used EoA to estimate the Hawaiian hoary bat direct take projected for the remainder of the permit term based on the past monitoring data. The direct take estimate does not account for indirect take, which is based on agency guidance, and the seasonal timing and gender of observed fatalities. Auwahi Wind reports the direct take projection at the 80-percent credibility level as required by USFWS and DOFAW to assess compliance with an ITP and ITL. As such, there is a greater than 50 percent chance that the projected take is higher than actual take will be in future years. The take authorization is based on a direct take estimate of 129 bats. The median take projection (as calculated using EoA) is estimated as 127 bats (interquartile range: 116 to 140 bats) in the last year of expected operations, 2032.

Table 2-6. EoA Estimated Hawaiian Hoary Bat Baseline Annual Fatality Rate

Source	Metric	Take Value
Value calculated from EoA analysis of PCMM data	Baseline Annual Fatality Rate[1]	6.29
Comparison values from the HCP	Annual Threshold Value	6.45
	Average annual take rate to remain within Tier 4	4.05
	Average annual take rate to remain within Tier 5	5.75

1. Any estimated Baseline Fatality Rate partially through the sampling year may skew results by estimating bias correction trial results with smaller data sets than would be available after a full year of study.

The estimated Baseline Fatality Rate calculated by EoA is 6.29 (95 percent confidence interval, 4.22 to 8.79), which currently does not exceed the Threshold Value of 6.45 (Table 2-6), as specified in the HCP. The Project began implementing its Adaptive Management Plan in FY 2020 and has begun planning for Tier 5 mitigation (Section 3.2.4).

2.7 Wildlife Education and Incidental Reporting

Auwahi Wind continues to implement a wildlife education and incidental reporting program for contractors, Project staff members, and ʻUlupalakua Ranch staff who are on site regularly. Annual training enables staff to identify the Covered Species that may occur in the Project area, record observations of these species, and take appropriate steps for documenting and reporting any species encountered during the operation of the Project. Auwahi Wind trained 64 contractors and new staff in FY 2021. The wildlife education program was limited over the past year, due to COVID restrictions, visits by educational groups, summer internships, and outreach events within the community were cancelled.

2.8 Avoidance and Minimization

Avoidance and minimization measures outlined in the HCP continue to be implemented in FY 2021. Actions taken for avoidance and minimization measures for Hawaiian hoary bat and Blackburn's sphinx moth are described below.

2.8.1 Hawaiian Hoary Bat

Auwahi Wind continues to implement low-wind speed curtailment (LWSC) at cut-in speeds of 5 meters per second (m/s) from November through July. August through October, LWSC cut-in speeds are increased to 6.9 m/s. For all periods, LWSC is implemented from 30 minutes before sunset to 30 minutes after sunrise. In addition to LWSC, Auwahi Wind installed NRG ultrasonic acoustic deterrents at all Project turbines in June of 2020. Ultrasonic acoustic deterrents operate at a minimum from 1 hour before sunset until 1 hour after sunrise, year-round.

2.8.2 Blackburn's Sphinx Moth

Areas within 10 meters of roadsides and edges of turbine pads are targeted for tree tobacco (*Nicotiana glauca*) removal because these areas may present a proximity hazard for the moth due to exposure to dust, possible trampling, and increased chance of vehicle collisions (USFWS and DOFAW email instructions Feb 7, 2014). Through continued implementation of this removal approach, there has been a decrease in tree tobacco plants occurring within hazard areas. During FY 2021, 47 tree tobacco plants were removed from the Project with most plants observed to be in the immature vegetative state. The removal of the plants followed USFWS guidance for take avoidance and minimization (USFWS 2020). Auwahi continued monthly field surveys for Blackburn's Sphinx Moth (BSM) in FY 2021 following the survey protocol described in Auwahi Wind's state Native Invertebrate Research Permit (Endorsement #I1303; NPS 2019). The presence of BSM was not detected during any monthly surveys, and no BSM were translocated from the Project in FY 2021.

3.0 Mitigation

Auwahi Wind has fulfilled mitigation obligations for Blackburn's sphinx moth, Hawaiian goose and red ʻilima (*Abutilon menziesii*) and are detailed in previous annual reports (Tetra Tech 2012b, Sempra Energy 2016, Tetra Tech 2019a). Ongoing mitigation efforts by Auwahi Wind for the Hawaiian petrel and Hawaiian bat are described below.

3.1 Hawaiian Petrel Mitigation

Beginning in August 2013, Auwahi Wind implemented its Hawaiian Petrel Management Strategy (Tetra Tech 2012c) within Kahikinui Petrel Management Area (Kahikinui PMA; Figure 3-1) with the main objective to increase the survival of Hawaiian petrels and reproductive success of the breeding colony. As in previous years, the objectives of the 2020 Kahikinui PMA management season were to monitor Hawaiian petrel burrows and determine the number of active burrows, evaluate reproductive success, and implement the current predator control strategy. To achieve these objectives in 2020, Auwahi Wind performed the following actions:

1. Conducted checks at known burrows to estimate the number of active burrows and their reproductive success. While performing burrow checks, trained technicians opportunistically searched nearby suitable habitat for additional burrows.
2. Deployed game cameras at active burrows to further document activity of petrels and any predation events.
3. A comprehensive assessment of predator presence and distribution was conducted across the entire Kahikinui PMA prior to nesting (February) and in August (halfway through the year), using 1-day and 3-day tracking tunnel indices for rodents and mongooses, respectively.
4. Continued use of the predator control strategy, including the deployment of traps year-round, and evaluation of trap effectiveness and placement. Conducted trap maintenance in the field.

Table 3-1. Annual Hawaiian Petrel Management Strategy Activities at Kahikinui PMA

Calendar Year	Monitoring Year	HCP Comprehensive Burrow Survey [1]	HCP Predator Control	HCP Burrow Monitoring[2]	Voluntary Activities
2012	NA	x		x	
2013	1		x	x	Burrow survey
2014	2		x	x	Burrow survey
2015	3		x	x	Burrow survey

Calendar Year	Monitoring Year	HCP Comprehensive Burrow Survey [1]	HCP Predator Control	HCP Burrow Monitoring[2]	Voluntary Activities
2016	4		x		Burrow survey, monthly burrow monitoring
2017	5		x		Burrow survey, monthly burrow monitoring
2018	6	x	x	x	
2019	7		x		Burrow survey, monthly burrow monitoring
2020	8		x		Burrow survey, monthly burrow monitoring
2021	9		x	x	Burrow survey

1. Comprehensive burrow survey = complete check of colony to determine total number of new and existing burrows.
2. Burrow monitoring = multiple checks of the burrow for reproductive status.

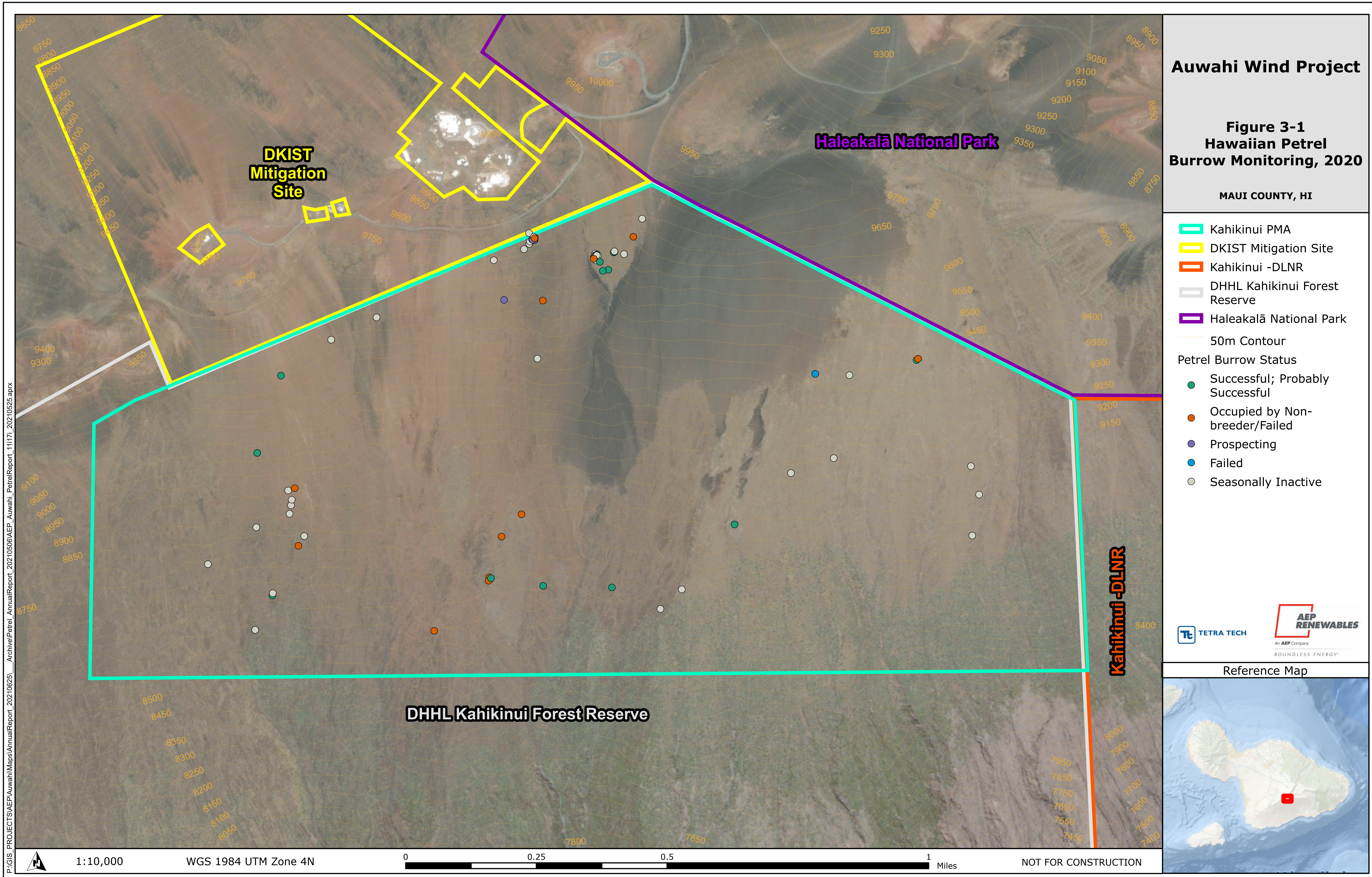
Additional actions implemented by Auwahi Wind in 2020 to meet the objectives and adaptively manage to increase the fledging success and adult survival were:

1. Discussed and confirmed with USFWS/DOFAW that calculations of net benefit of Hawaiian petrel mitigation actions (past and future) will meet HCP success criteria for Tier 1 (see Benefits below).
2. Formalized transition moving forward to assess predators' impacts on burrows using game camera data.

3.1.1 Petrel Burrow Monitoring

Auwahi Wind monitors petrel burrows using two methods 1) burrow checks, and 2) game cameras. Whereas burrow checks using the "toothpick method" (NPS 2012, Tetra Tech 2013) were the original method to assess burrow activity, more definitive documentation of burrow status and reproductive success are provided by Reconyx Hyperfire game cameras. The cameras also document activity by predators and goats. Burrow checks were conducted twice a month by Auwahi Wind personnel from March through July 2020, and then active burrows were monitored until November 2020. Burrows were classified into one of six categories of seasonal status based on the activity patterns observed during the burrow checks and from footage captured by 37 game cameras (Tetra Tech 2020b). Game cameras are rotated among burrows to prioritize monitoring of burrows that show signs of activity. A table of burrow status from game camera data is provided in Attachment 2. Auwahi Wind included burrows in the reproductive success calculations based on each burrow's seasonal status. For all calculations of reproductive success, it was assumed there was a maximum of one egg or fledgling per burrow, and burrows categorized as prospecting or seasonally inactive were excluded. Metrics of reproductive success are described in previous reports (e.g., Tetra Tech 2020b).

Bi-weekly visits to monitor burrow activity began on January 31, 2020. Monitoring temporarily ceased after the February 18, 2020, visit due to the COVID-19 pandemic, and resumed on May 11, 2020. Monitoring ended on November 2, 2020, at which time all the burrows had ceased to be active. One new burrow was located in 2020. A total of 77 petrel burrows were monitored (38 were monitored using game cameras at some point during the season), 37 showed signs of activity during the breeding season, and 28 burrows were consistently active throughout the breeding season (Figure 3-1; Table 3-2). By the end of the breeding season, 14 burrows had or probably had successfully fledged a chick for an estimate of 14 Hawaiian petrel chicks successfully fledging. Thirteen of the fledging events were documented via game camera; the burrow classified as probably successful appeared to have a fledgling in October, but the photos (Attachment 3) were insufficient to definitively identify the individual as an adult or a fledgling. The two known failed burrows had an egg roll out (Attachment 3).


Auwahi Wind Project
Figure 3-1
Hawaiian Petrel
Burrow Monitoring, 2020
MAUI COUNTY, HI
Kahikinui PMA
DKIST Mitigation Site
Kahikinui -DLNR
DHHL Kahikinui Forest Reserve
Haleakalā National Park
50m Contour
Petrel Burrow Status
Successful; Probably Successful
Occupied by Non-breeder/Failed
Prospecting
Failed
Seasonally Inactive
TETRA TECH
AEP RENEWABLES
BOUNDLESS ENERGY
Reference Map
DKIST Mitigation Site
Haleakalā National Park
Kahikinui -DLNR
DHHL Kahikinui Forest Reserve
1:10,000
WGS 1984 UTM Zone 4N
0
0.25
0.5
1
Miles
NOT FOR CONSTRUCTION
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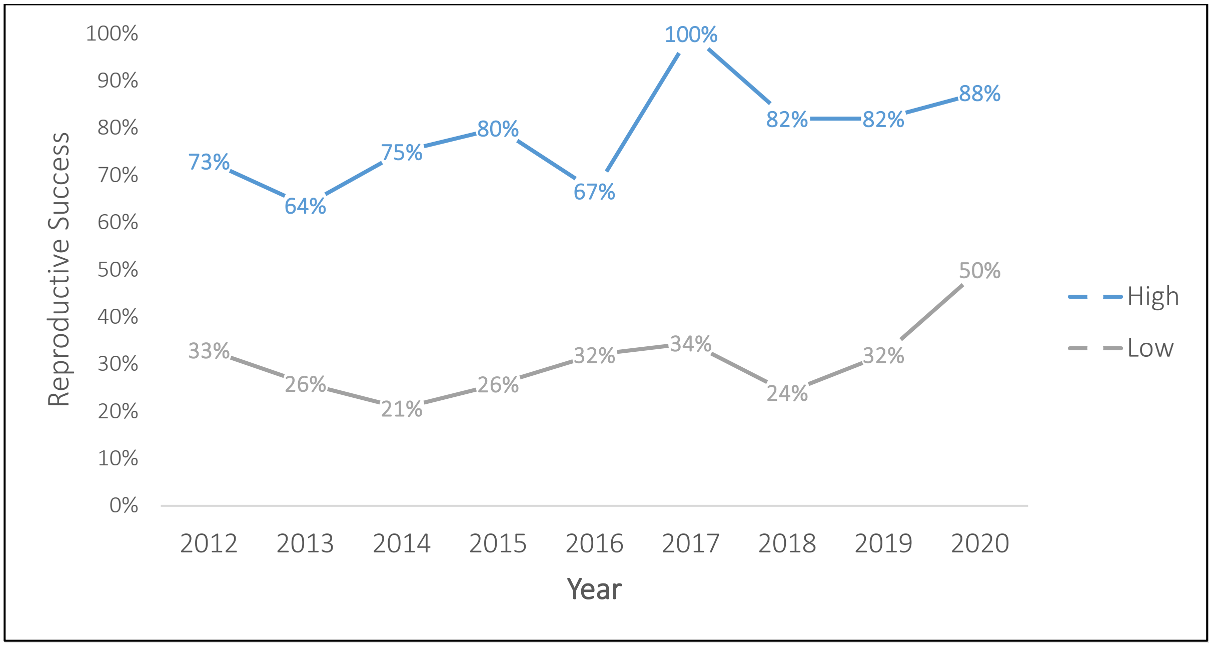
The remaining 14 burrows that were consistently active either failed or showed signs of occupation by a non-breeder. There were no clear, documented signs of depredation or reproductive sign observed at these burrows, either by the biologist monitoring the burrows or captured on game cameras stationed at the burrows. There were no signs of petrel depredation documented in 2020; however, game cameras detected cats at one burrow twice, and a mongoose at another burrow (Photos 1 and 2 respectively, Attachment 3); neither burrow showed signs of breeding activity. The number of burrows known to have fledged a chick per number of active burrows within the management area ranged between 50 and 88 percent (Figure 3-2). There was no significant difference in reproductive success in the eight monitoring seasons for which the entire season was monitored, using the conservatively low value for reproductive success (x^2=7.985, df =7 p=0.334) or the high value for reproductive success (x^2=6.351, df =7 p=0.499). The number of consistently active burrows has remained relatively constant throughout the 9 years of monitoring (average of 29 active burrows; range = 25–33).

Table 3-2. Seasonal Status of Hawaiian Petrel Burrows within Kahikinui PMA in 2020

<table>
<tr><th>Seasonal Status</th><th>No. of Burrows</th><th colspan="3">Categories for Assessing Reproductive Success</th></tr>
<tr><td>Successful</td><td>13</td><td rowspan="5">37 Active</td><td rowspan="4">28 Consistently Active</td><td rowspan="3">16 Breeding Activity</td></tr>
<tr><td>Probably Successful</td><td>1</td></tr>
<tr><td>Failed</td><td>2</td></tr>
<tr><td>Occupied by Non-breeder/Failed</td><td>12</td><td>Excluded</td></tr>
<tr><td>Prospecting</td><td>9</td><td colspan="2">Excluded</td></tr>
<tr><td>Seasonally Inactive</td><td>40</td><td colspan="3">Excluded</td></tr>
<tr><td>TOTAL</td><td colspan="4">77</td></tr>
</table>

Figure 3-2 Reproductive Success within Kahikinui PMA, 2012 – 2020

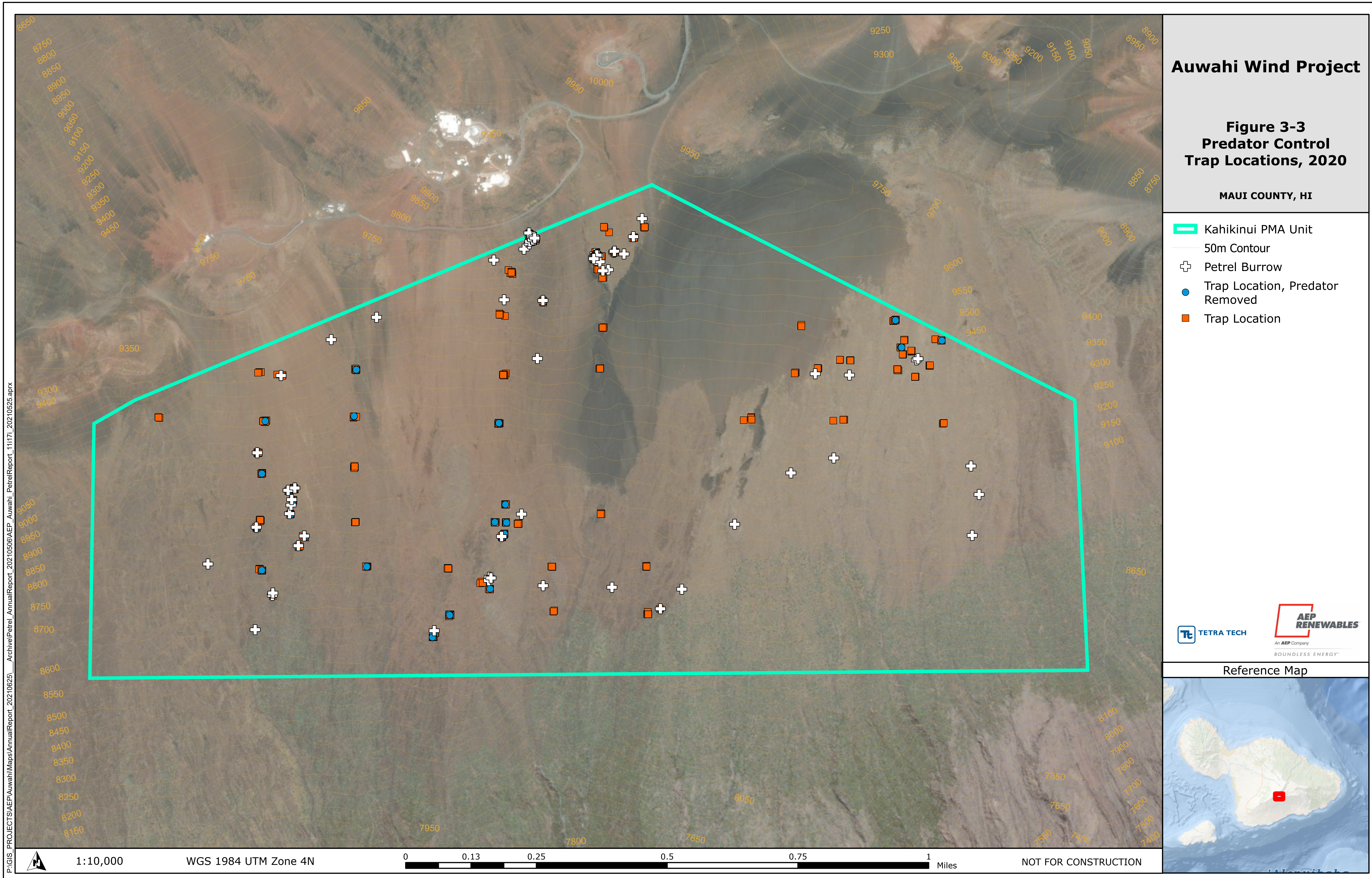


High assumes only those burrows with reproductive sign had breeding adults; and low assumes all consistently active burrows had breeding adults.

3.1.2 Predator Monitoring and Control

Auwahi Wind has historically used tracking tunnels to perform an assessment of the presence and distribution of small mammals (rodents and mongooses) within Kahikinui PMA in February and August of each year. Small mammal relative abundance (i.e., activity index) was calculated in February 2020 as the mean percentage of tunnels with tracks of the target species per transect (Gillies and Williams 2007); an assessment was not possible in August 2020 because of restrictions due to COVID-19.

Auwahi Wind continues to implement predator control year-round through the use of a trapping grid, with placement of traps informed by February tracking tunnel results and game camera data. A combination of four trap types were used which included 49 DOC250 kill traps, 44 Goodnature A24 traps, three Victor foothold traps (equipped with Reconyx cellular cameras), and 39 KaMate traps (Figure 3-3). Traps were checked throughout the year with a break in March due to a break in the field work for COVID precautions.


Auwahi Wind Project
Figure 3-3
Predator Control
Trap Locations, 2020
MAUI COUNTY, HI
Kahikinui PMA Unit
50m Contour
Petrel Burrow
Trap Location, Predator Removed
Trap Location
TETRA TECH
AEP RENEWABLES
An AEP Company
BOUNDLESS ENERGY
Reference Map
1:10,000
WGS 1984 UTM Zone 4N
0
0.13
0.25
0.5
0.75
1
Miles
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The 1-day tracking index was 1.6 percent of tunnels with rodent tracks in early February. No mongooses were detected along any of the transects in February, with the 3-day tracking index of zero percent of tunnels with mongoose tracks. Goats were present at burrows throughout the breeding season but were detected via game cameras at the most burrows between June and September (22 – 29 burrows). Predator control efforts removed 69 targeted mammalian predators from Kahikinui PMA, consisting of 54 mice, 12 rats, three mongooses, and two cats.

3.1.2.1 Benefits

Petrel management activities will be considered successful if (1) predator control is successfully implemented and (2) mitigation efforts result in an increase in reproduction that offsets authorized take, as outlined in the Hawaiian Petrel Management Plan (Tetra Tech 2012c). Auwahi Wind has measured reproductive success of Hawaiian petrels and predator activity within Kahikinui PMA for the past 8 years. Auwahi Wind, USFWS, and DOFAW, have discussed the benefit of Auwahi Wind's mitigation actions. The measures of success and the implementation status are listed in Table 3-3.

Table 3-3. Hawaiian Petrel Mitigation Measures of Success and Implementation Status

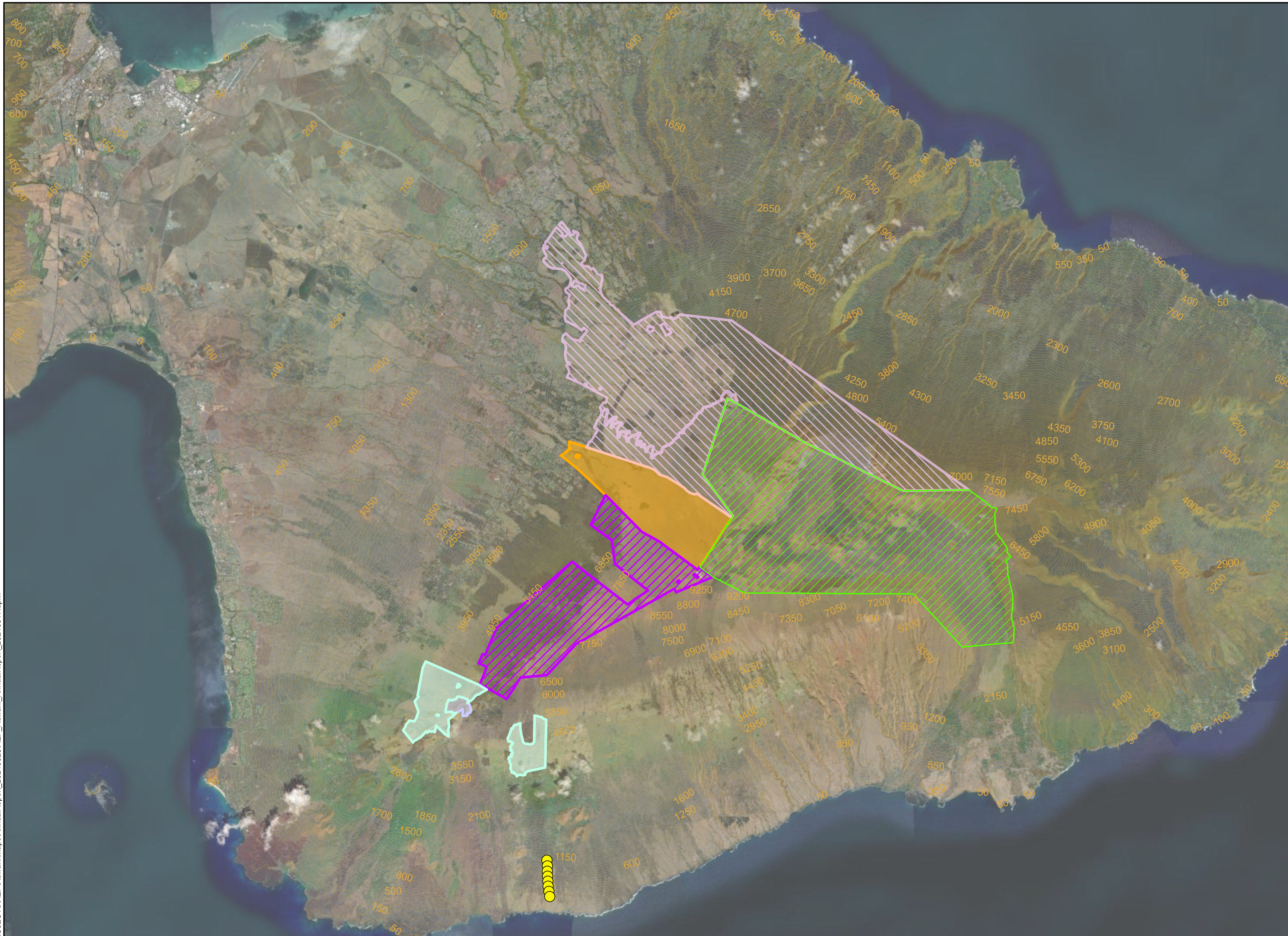
Measures of Success	Implementation Status
Predator control is implemented.	Complete for 2020 Ongoing on annual basis
Predator control methods are successful in capturing predators.	Complete for 2020 Ongoing on annual basis
Mitigation efforts result in one more fledgling or adult than that required to compensate for the requested take of the required tier.	Ongoing, expected to complete Tier 1 no later than 2032

Auwahi Wind received concurrence from USFWS and DOFAW regarding the mitigation credit for Hawaiian petrel mitigation. The Auwahi Wind HCP outlines two potential burrow counts for assessing the benefit of predator control: 33 active burrows or 44 active burrows (Attachment 3). However, the number of active burrows varies from year to year. The average number of active burrows Auwahi Wind has observed does not fall between the estimates of 33 or 44 active burrows described in the HCP, but rather ranges between 25 - 37. Auwahi Wind updated the initial number of managed burrows within the HCP model based on the number of burrows observed at the Kahikinui PMA. The effects of predator control can be assessed using the same calculations as in the HCP, modifying only the number of active burrows from 33 assumed in the HCP (Table 6-5a from the Auwahi Wind HCP; Tetra Tech 2012a) to 29.75 active burrows observed at the Kahikinui PMA (average from 2012–2019). Using the HCP mild predation model, the benefit of mitigation is slightly reduced, from an increase of 25.6 Hawaiian petrel adult equivalents estimated in the HCP to 23.1 adult equivalents, based on the average number of active burrows observed from 2012-2019. The mild predation model is likely conservative because the number of active breeding pairs at the PMA in Year 8 falls midway between the projected values of the mild and minimal predation scenarios (Attachment 4). The updated 23.1 adult Hawaiian petrels fully offsets the take for Auwahi Wind's Tier 1 take authorization for Hawaiian petrels (19 adults and 7 juveniles, or 21.2 adult equivalents).

USFWS and DOFAW provided written concurrence on this modification of the mitigation benefit (June 29, 2021 and April 27, 2021, respectively). Auwahi Wind continues to implement mitigation actions as outlined in the HCP and Petrel management plan for the remainder of the permit term (2032).

3.2 Hawaiian Hoary Bat Mitigation and Monitoring

Tier 1 bat mitigation is on-going at the Puʻu Makua parcel of the Waihou Mitigation Area, located on ʻUlupalakua Ranch (Figure 3-4). Tier 1 mitigation consists of the restoration of native forest on approximately 53 hectares of pastureland (including installation of an ungulate proof fence, ungulate removal, and native reforestation). This parcel was placed into a conservation easement held by the Hawaiian Islands Land Trust on December 18, 2012, and will be protected in perpetuity. Tier 2/3 mitigation consisted of funding Hawaiian hoary bat research to contribute to the overall knowledge of the Hawaiian hoary bat on Maui and was completed and reported upon in FY 2020 (Tetra Tech 2020a). Implementation of Tier 4 mitigation is ongoing and focuses on protecting, managing, and enhancing habitat that is suitable for bat foraging and roosting on a 709-hectare parcel within ranch land. Tier 1-4 of mitigation have been funded and either are completed or are still being implemented in accordance with mitigation plans approved by USFWS and DOFAW. A map showing the location of all ongoing or completed habitat-based Hawaiian hoary bat mitigation relative to the Project Area is provided in Figure 3-4.



Auwahi Wind Project

Figure 3-4
Hawaiian Hoary Bat Mitigation Parcels

MAUI COUNTY, HI

- Project Turbine
- 50m Contour
- Tier 1 Mitigation Area
- Tier 4 Mitigation Area
- Kamehamenui Forest Reserve (Proposed Tier 5/6 Mitigation Area)

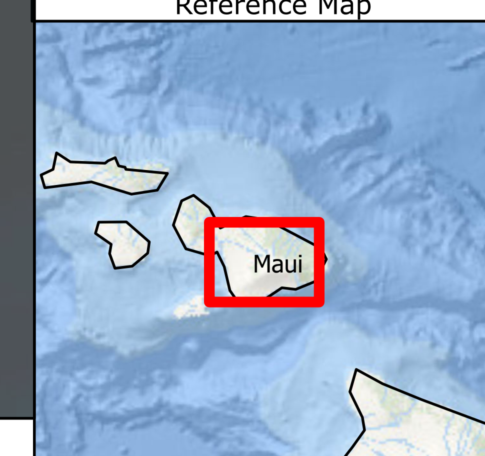
Relevant Neighboring Parcels

- Kula Forest Reserve
- Haleakalā Ranch
- Haleakalā National Park

TETRA TECH

AEP RENEWABLES
An AEP Company
BOUNDLESS ENERGY

Reference Map



1:150,000 WGS 1984 UTM Zone 4N

0 1 2 4 6 8 Miles

NOT FOR CONSTRUCTION

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3.2.1 Tier 1 Mitigation

Auwahi Wind is in its seventh year of habitat restoration efforts at the Pu'u Makua mitigation site. The habitat restoration included ungulate fence installation, ungulate removal, invasive plant species removal, and plantings of native trees and shrubs. The ungulate fence, installed in 2013, is in good condition. The 2.4-meter tall ungulate exclusion fence surrounding the parcel was inspected in FY 2021, and the parcel remains ungulate-free. Follow-up management within the plots continued in FY 2021 and included target invasive plant species removal. The addition of habitat restoration efforts to the surrounding Tier 4 mitigation lands will add additional ungulate barriers to this parcel (Section 3.2.2). Cattle grazing continues by the landowner, ʻUlupalakua Ranch, on the surrounding ranch lands including the Tier 4 mitigation lands.

3.2.1.1 Management

Major flooding events in March of 2021 caused damage to the surrounding areas of the Tier 1 restoration site. Although there were fallen trees and washed out fences in the vicinity of Puʻu Makua, the mitigation area remained ungulate free. Fence checks were performed quarterly in FY 2021.

Additional vegetation monitoring of the restoration site was performed in FY 2021 and included collecting information on tree height and leaf area index. Plots planted with koa (*Acacia koa*) 20 years ago at 3 x 3-meter densities had an average leaf area index (LAI) of 0.69 and average height of 7.7 meters. Interestingly, plots planted with koa 6 years ago at a 4 x 4-meter density had a higher LAI of 0.88 and average height of 5.2 meters, whereas trees planted at the same time at 6 x 6-meter density had a LAI of 0.34 and average height of 3.6 meters. Detailed findings of the research can be found in Jenkins (2020).

3.2.1.2 Benefits

The measures of success as defined in the HCP and current status of each measure of success are presented below in Table 3-4.

Table 3-4. Hawaiian Hoary Bat Tier 1 Measures of Success and Implementation Status

Measures of Success	Implementation Status
After 6 years, mitigation fencing is completed and ungulates have been removed from within the fenced area.	Completed in FY 2014
Over the 25-year permit term, the fence is maintained and the area is kept free of ungulates.	Ongoing. Quarterly fence inspections continued in FY 2021. Puʻu Makua continues to be free of ungulates in FY 2021.
After 25 years, the cover of invasive species (excluding kikuyu grass) in the managed areas is less than 50 percent.	Ongoing. Invasive species cover of 23.9 percent in Year 5. Will be monitored again in Year 10.
After 25 years, reforested areas within the Waihou mitigation area have greater than 50 percent cover dominated by native woody species.	Ongoing. Overall native woody cover of 27.7 percent in Year 5. Will be monitored again in Year 10.

3.2.2 Tier 4 Mitigation

Tier 4 Mitigation is located on 709 hectares of ʻUlupalakua Ranch land. The objective of the Tier 4 Mitigation is to protect, manage, and enhance habitat that is suitable for bat foraging and roosting through the addition of features necessary for those stages of the Hawaiian hoary bat life cycle. These features include hedgerows, ponds, and livestock watering troughs. The final conservation easement was fully executed by all parties and recorded by the State of Hawaii Bureau of Conveyances on December 7, 2020. Detailed progress regarding milestones for Tier 4 mitigation management and monitoring activities per FY quarter are provided in Attachment 5.

3.2.2.1 Management

Auwahi Wind began fence construction in FY 2021 and a total of 44 hectares was fenced off from cattle. A total of 30 hectares was planted with koa, approximately 10,000 plantings, within the newly constructed hedgerow areas. Quarterly fence inspections began in 2021 and the area remains cattle free. Two 50,000-gallon capacity ponds were constructed in FY 2021 (Attachment 5). Older growth outplanted koas were included in one of the pond locations and both fenced areas have been outplanted with additional koa plantings. No barbwire was used in the construction of new fences within the Tier 4 mitigation area. Auwahi Wind contracted barbwire removal along the Western portion of the mitigation area bordering the OW ranch. ʻUlupalakua Ranch works with volunteers to remove barbwire as a work trade where volunteers earn the opportunity to hunt in the mitigation area.

Damage to newly constructed and outplanted areas were documented as a result of the major flooding events in March 2021. As a result of the flooding the ponds filled to 100 percent capacity. All fences were repaired by Auwahi Wind in April 2021 and all areas remain cattle free.

3.2.2.2 Monitoring

Auwahi Wind initiated insect monitoring in the Tier 4 mitigation site in FY 2021. Three malaise traps were checked at a minimum of quarterly in FY 2021, with data analyzed through April 2021 at the time of reporting. The number of large moths detected peaked during the June – August 2020 sampling period, with the pond location having the highest numbers of moths detected (85 compared to 56 at the pasture location and 17 at the hedgerow location). However, the pasture location had the highest large moth counts more frequently than the other two locations. A complete report will be included in the FY 2022 annual report.

The first year of acoustic monitoring was completed for the Tier 4 mitigation site in FY 2021. The average amount of detections throughout the study area was 11.85 ± 0.68 calls per detector night (Attachment 5). The highest rate of detections occurred at two upper elevation detector sites located within mesic land cover types, with one of these located next to a pond. The lowest rate of detections occurred outside of the mitigation site at the two lowest elevation detector sites, both of which were the only detector sites located within dry land cover types.

The measures of success as defined in the HCP and current status of each measure of success are presented below in Table 35 with additional detail provided in Attachment 5.

Table 3-5. Hawaiian Hoary Bat Tier 4 Mitigation Measures of Success and Implementation Status

Measures of Success	Implementation Status
Protect the mitigation parcel in perpetuity through a conservation easement with oversight of the parcel by Hawaiian Islands Land Trust (or other appropriate conservation entity).	Completed
Install two additional ponds in the Mitigation Area according to the HCP, or other number as specified through adaptive management.	Completed, two ponds installed and fenced in FY2021
Increase forest cover to 20 percent within the pasture parcels through hedgerow reforestation at approximately 500 trees per hectare, or other cover and parcels as specified through adaptive management.	Ongoing, 30 hectares of plantings in FY2021
Record an increase in bat activity through acoustic monitoring over the baseline monitoring year(s). The statistical power with which the increase is recorded will also be reported.	Ongoing,
Summarize and report the results of monitoring in annual reports.	Ongoing

3.2.3 Hawaiian Hoary Bat Occupancy Monitoring

Auwahi Wind funded a single-year occupancy study of the Hawaiian hoary bat on Leeward Haleakalā. The study area spans from ʻĀhihi-Kīnaʻu Natural Area Reserve to Kaupō Gap, and from the summit of Haleakalā to the coast. The study was completed in FY 2021 with the report included as Attachment 6. Overall bat detection and occupancy rates were much higher than a similar study performed over 3 years on Oʻahu. Bat activity rates were 80 percent in the Leeward Haleakalā study over a 1-year period compared to 3 percent over a 3-year period on Oʻahu (Attachment 6).

3.2.4 Tier 5 Mitigation

Auwahi Wind initiated coordination with the DOFAW Forestry Program in November 2020 in advance of exceeding the Tier 5 planning threshold. Coordination by Auwahi Wind with the Forestry Program was specific to the use of portions of the newly created Kamehamenui Forest Reserve to offset Tier 5 Hawaiian hoary bat take. Initial components of the site-specific mitigation implementation plan (SSMIP) have been discussed with the Forestry, Trails, and Wildlife Managers at DOFAW to ensure that they are compatible with DOFAW's own multi-use management plan for the reserve which is in the early drafting stage. Auwahi Wind will continue to coordinate closely with DOFAW in the development of Auwahi Wind's SSMIP. Once a draft plan has been prepared and a Memorandum of Understanding (MOU) is in place with DOFAW, Auwahi Wind will discuss the plan with the DOFAW and USFWS HCP coordinators. A draft MOU to initiate baseline studies and coordinate on a SSMIP will be submitted to DOFAW in July 2021.

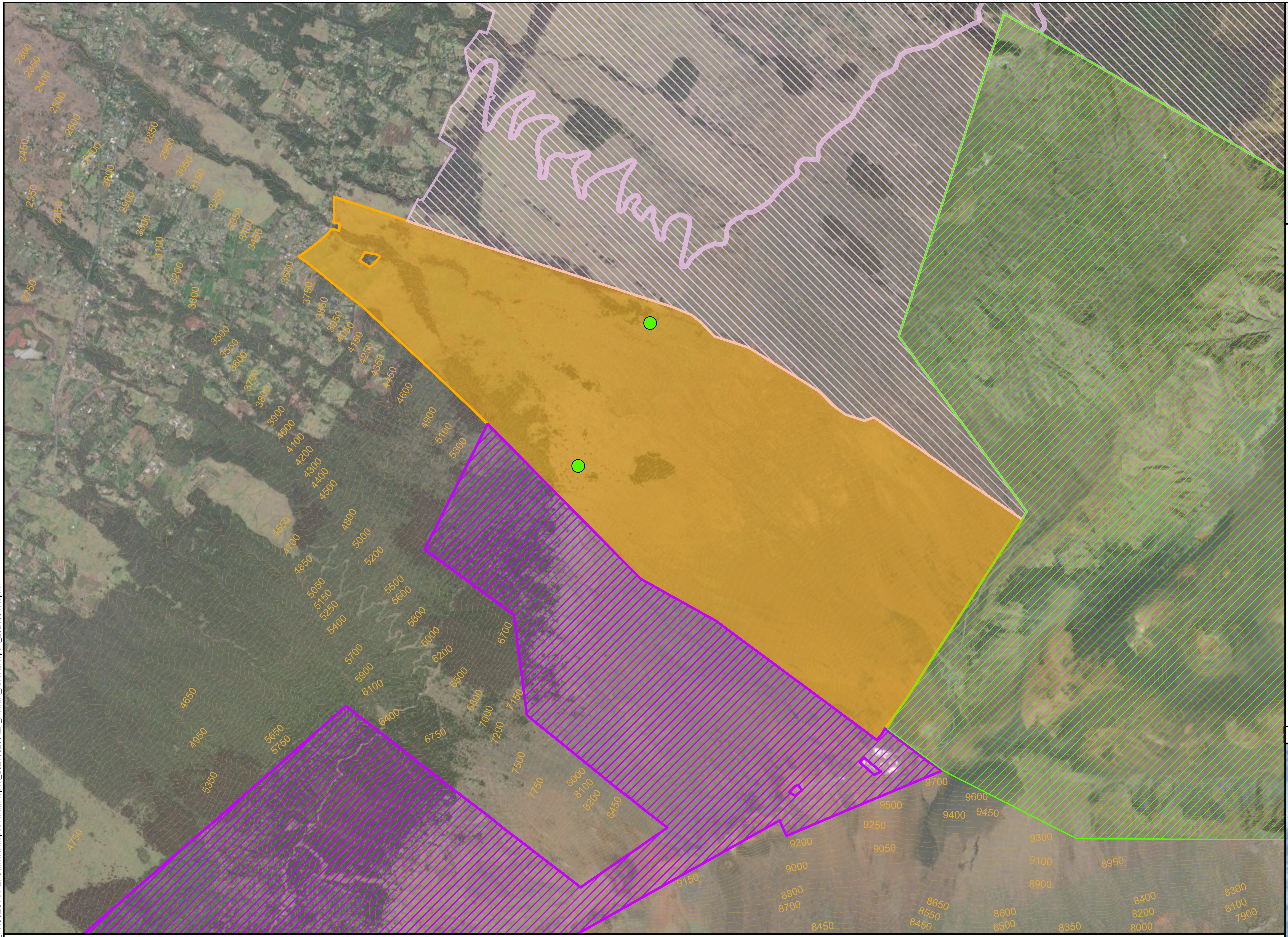
3.2.4.1 Baseline Monitoring

Auwahi Wind deployed two acoustic detectors on May 12 and May 13, 2021 to gather baseline information on bat acoustic activity of the proposed Tier 5/6 mitigation area at Kamehamenui (Figure 3-5). Detectors were checked on May 27, 2021 to ensure they were functioning properly.

Auwahi Wind Project

Figure 3-5
Tier 5/6 Baseline Bat Monitoring

MAUI COUNTY, HI

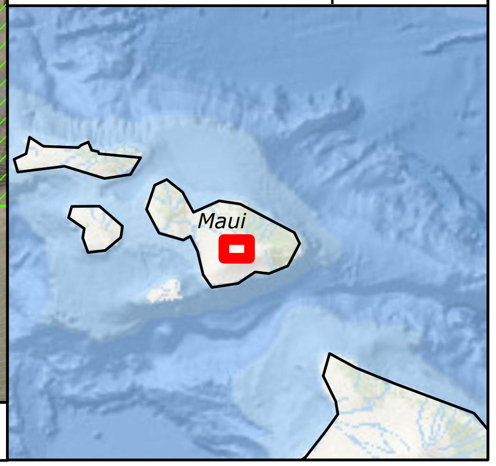


Tier 5/6 Baseline Bat Acoustic Detector
50m Contour
Kamehamenui Forest Reserve (Proposed Tier 5/6 Mitigation Area)
Relevant Neighboring Parcels
Kula Forest Reserve
Haleakalā Ranch
Haleakalā National Park

TETRA TECH

AEP RENEWABLES
An AEP Company
BOUNDLESS ENERGY

Reference Map



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4.0 Adaptive Management

4.1 Minimization

Auwahi Wind made the following changes to improve minimization measures at the Project in FY 2021:

- Several Hawaiian geese were observed nesting within the Project area. Restrictions on vegetation management and live capture traps deployment were used to reduce risks to the Hawaiian goose during the nesting season. Additional notices were sent to staff and contractors to be aware of Hawaiian geese and the areas of occurrence to reduce potential interactions. Auwahi Wind notified the DOFAW-Maui Branch with band number information and will provide notification of future nesting occurrences of Hawaiian goose.

4.2 Post-Construction Mortality Monitoring

Auwahi Wind investigated bat fatality events at Project turbines in FY 2021. Auwahi Wind staff continued to collect thermal camera data from the turbines after the completion of the U.S. Geological Survey study (Gorresen et al. 2020) and after ultrasonic acoustic deterrents had been installed at all Project turbines. Data collected in FY 2021 were subsequently analyzed by WEST (unpublished data). After analyzing the data, no fatality events were detected via thermal camera. The analysis indicated that bats spent less time in the collision risk zone compared to during the U.S. Geological Survey study when ultrasonic acoustic deterrents had not yet been installed at the Project. The deterrent system may be a contributing factor of reducing risk to bats by reducing their time spent in the risk zone.

4.3 Mitigation

Auwahi Wind, in coordination with USFWS and DOFAW, updated the success criteria for estimating the benefits of Hawaiian petrel mitigation (Section 3.1.2). Auwahi Wind will rely on game camera data for assessing the presence of small mammals near petrel burrows in future years, and will not implement tracking tunnel studies after calendar year 2021.

4.4 Reporting

To align the ITP and ITL HCP annual report deadlines and to provide sufficient time to report on additional HCP amendment requirements, Auwahi Wind received agreement from USFWS and DOFAW on June 15, 2021 (Lasha Salbosa, USFWS, pers. comm.) on the extended annual report deadline of September 15.

5.0 Changed or Unforeseen Circumstances

No changed or unforeseen circumstances occurred in FY 2021. An unidentified storm-petrel fatality detected in FY2020 and previously reported by Auwahi Wind (Tetra Tech 2020a) was confirmed by genetic analysis on August 5, 2020 to be a band-rumped storm-petrel (*Oceanodroma castro*; PCMB 2020). This species is state endangered and was federally listed as endangered on October 31, 2016.

6.0 Auwahi Wind Community Involvement

Highlights of Auwahi Winds community involvement in FY 2021 are:

- Annual Maui Nui Seabird Recovery Project banding of ʻuaʻu kani breeding colonies on Maui and partnered with Maui Nui Seabird Recovery Project to assist with management of other seabird colonies
- Worked with multiple landowners to conduct Leeward Haleakalā Hawaiian Hoary bat occupancy and distribution study
- Loaned DOFAW bat acoustic detectors and provided training on detector deployments and maintenance
- Provided resources to DHHL Kahikinui families to construct a bus stop
- Repurposed bat detector locations as koa outplanting locations. Replaced detectors with Koa, Ohia, and ʻaʻaliʻi (*Dodonaea viscosa*) in small fenced areas throughout Leeward Haleakalā
- Donated to Maui Food Bank and Maui Health Foundation to support food bank operations and provide funds for PPE during COVID pandemic

7.0 Annual Workplan and Schedule

A work plan for FY 2021 is provided in Attachment 7. This work plan identifies major monitoring and mitigation activities and their associated timelines.

8.0 Cost Expenditures and Budget

A summary of HCP-related expenditures for FY 2021 is provided in Attachment 8. This summary lists costs (including staff labor) that Auwahi Wind has expended toward fulfilling the terms of the HCP in FY 2021, as well as cumulatively, and compares them against the budgeted amounts specified in the HCP.

9.0 References

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Attachment 1

Evidence of Absence Software Inputs and Outputs – Fatality Estimation

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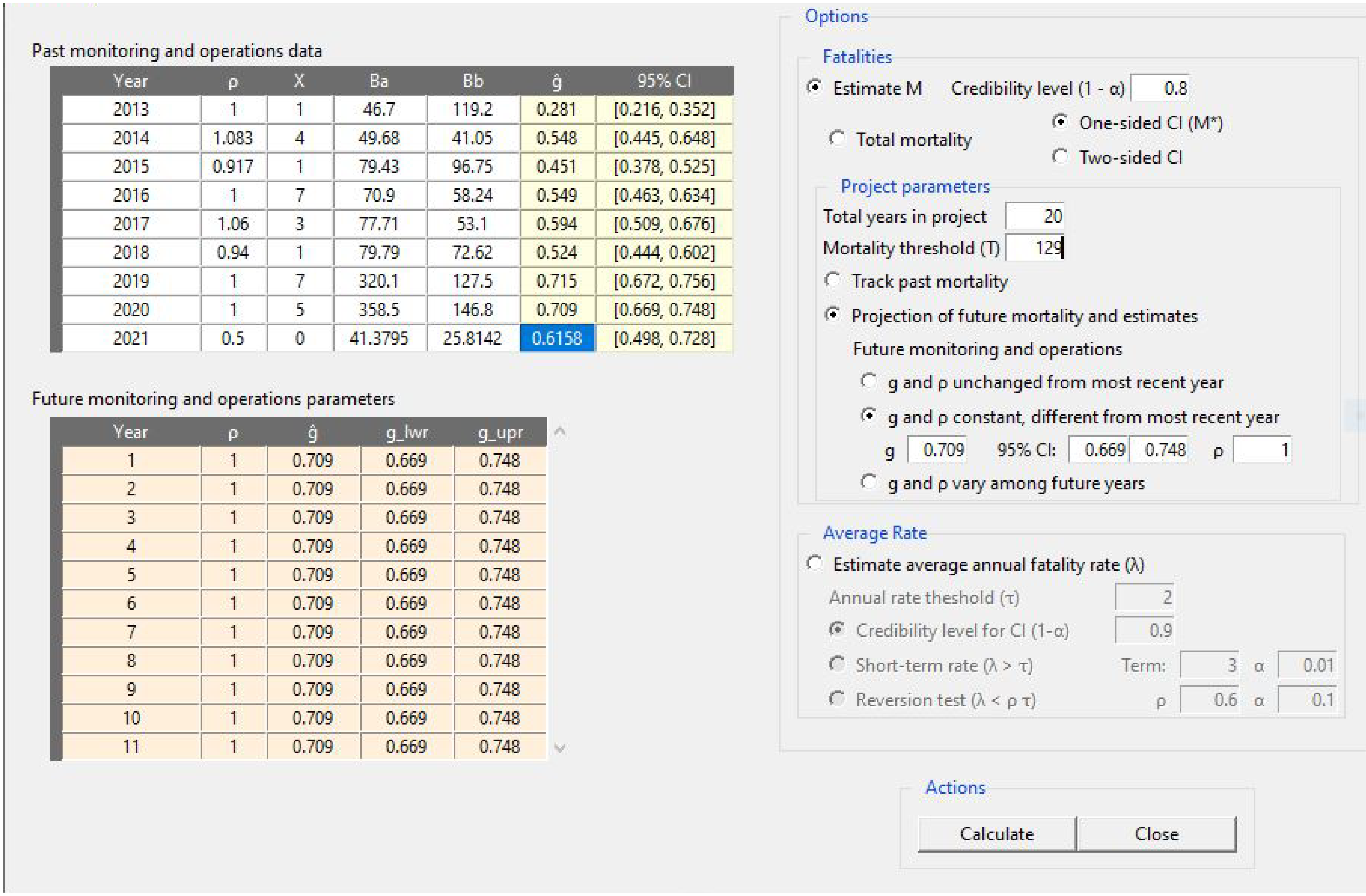


Figure 1. Evidence of Absence Software Input for Hawaiian Hoary Bats Multi-Year Analysis in FY 2021 (Dalthorp et al. 2017).

```
Summary statistics for total mortality through 9 years
------------------------------------
Results
M* = 58 for 1 - a = 0.8, i.e., P(M <= 58) >= 80%

Estimated overall detection probability: g = 0.552, 95% CI = [0.526, 0.578]
   Ba = 777.29, Bb = 631.06

Estimated baseline fatality rate: lambda = 6.293, 95% CI = [4.22, 8.79]


Test of assumed relative weights (rho) and potential bias              Fitted rho
Assumed rho     95% CI
      1     [0.049, 2.130]
   1.08     [0.385, 2.438]
  0.917     [0.037, 1.453]
      1     [0.848, 3.472]
   1.06     [0.202, 1.910]
   0.94     [0.031, 1.244]
      1     [0.652, 2.651]
      1     [0.402, 2.121]
    0.5     [0.001, 0.565]

p = 0.16841 for likelihood ratio test of H0: assumed rho = true rho
Quick test of relative bias: 1.028

Posterior distribution of M
m      p(M = m) p(M > m)
0       0.0000   1.0000
1       0.0000   1.0000
2       0.0000   1.0000
3       0.0000   1.0000
4       0.0000   1.0000
5       0.0000   1.0000
6       0.0000   1.0000
7       0.0000   1.0000
8       0.0000   1.0000
9       0.0000   1.0000
10      0.0000   1.0000
11      0.0000   1.0000
12      0.0000   1.0000
13      0.0000   1.0000
14      0.0000   1.0000
15      0.0000   1.0000
16      0.0000   1.0000
17      0.0000   1.0000
18      0.0000   1.0000
19      0.0000   1.0000
20      0.0000   1.0000
21      0.0000   1.0000
22      0.0000   1.0000
23      0.0000   1.0000
24      0.0000   1.0000
25      0.0000   1.0000
26      0.0000   1.0000
27      0.0000   1.0000
28      0.0000   1.0000
29      0.0000   1.0000
```

Figure 2. Evidence of Absence Output for Hawaiian Hoary Bats Multi-Year Analysis in FY 2021 (Dalthorp et al. 2017)

30	0.0000	1.0000
31	0.0000	1.0000
32	0.0000	1.0000
33	0.0000	0.9999
34	0.0001	0.9998
35	0.0003	0.9995
36	0.0007	0.9988
37	0.0015	0.9973
38	0.0027	0.9946
39	0.0046	0.9899
40	0.0074	0.9825
41	0.0110	0.9715
42	0.0156	0.9559
43	0.0211	0.9348
44	0.0272	0.9076
45	0.0336	0.8740
46	0.0401	0.8339
47	0.0461	0.7878
48	0.0514	0.7364
49	0.0557	0.6807
50	0.0586	0.6221
51	0.0602	0.5619
52	0.0603	0.5016
53	0.0591	0.4425
54	0.0567	0.3859
55	0.0533	0.3326
56	0.0492	0.2834
57	0.0446	0.2388
58	0.0398	0.1990
59	0.0349	0.1641
60	0.0302	0.1339
61	0.0257	0.1081
62	0.0216	0.0865
63	0.0180	0.0685
64	0.0147	0.0538
65	0.0119	0.0418
66	0.0096	0.0322
67	0.0076	0.0246
68	0.0060	0.0187
69	0.0046	0.0141
70	0.0036	0.0105
71	0.0027	0.0078
72	0.0021	0.0057
73	0.0015	0.0042
74	0.0012	0.0030
75	0.0008	0.0022
76	0.0006	0.0015
77	0.0005	0.0011
78	0.0003	0.0008
79	0.0002	0.0005
80	0.0002	0.0004
81	0.0001	0.0002
82	0.0001	0.0001
83	0.0001	0.0001
84	0.0000	0.0000
85	0.0000	0.0000
86	0.0000	0.0000

==

Figure 2. (Cont.) Evidence of Absence Output for Hawaiian Hoary Bats Multi-Year Analysis in FY 2021 (Dalthorp et al. 2017)

Input

Year (or period)	rel_wt	X	Ba	Bb	ghat	95% CI
2013	1.000	1	46.7	119.2	0.281	[0.216, 0.352]
2014	1.083	4	49.68	41.05	0.548	[0.445, 0.648]
2015	0.917	1	79.43	96.75	0.451	[0.378, 0.525]
2016	1.000	7	70.9	58.24	0.549	[0.463, 0.634]
2017	1.060	3	77.71	53.1	0.594	[0.509, 0.676]
2018	0.940	1	79.79	72.62	0.524	[0.444, 0.602]
2019	1.000	7	320.1	127.5	0.715	[0.672, 0.756]
2020	1.000	5	358.5	146.8	0.709	[0.669, 0.748]
2021	0.500	0	41.38	25.81	0.616	[0.498, 0.728]

Figure 2. (Cont.) Evidence of Absence Output for Hawaiian Hoary Bats Multi-Year Analysis in FY 2021 (Dalthorp et al. 2017)

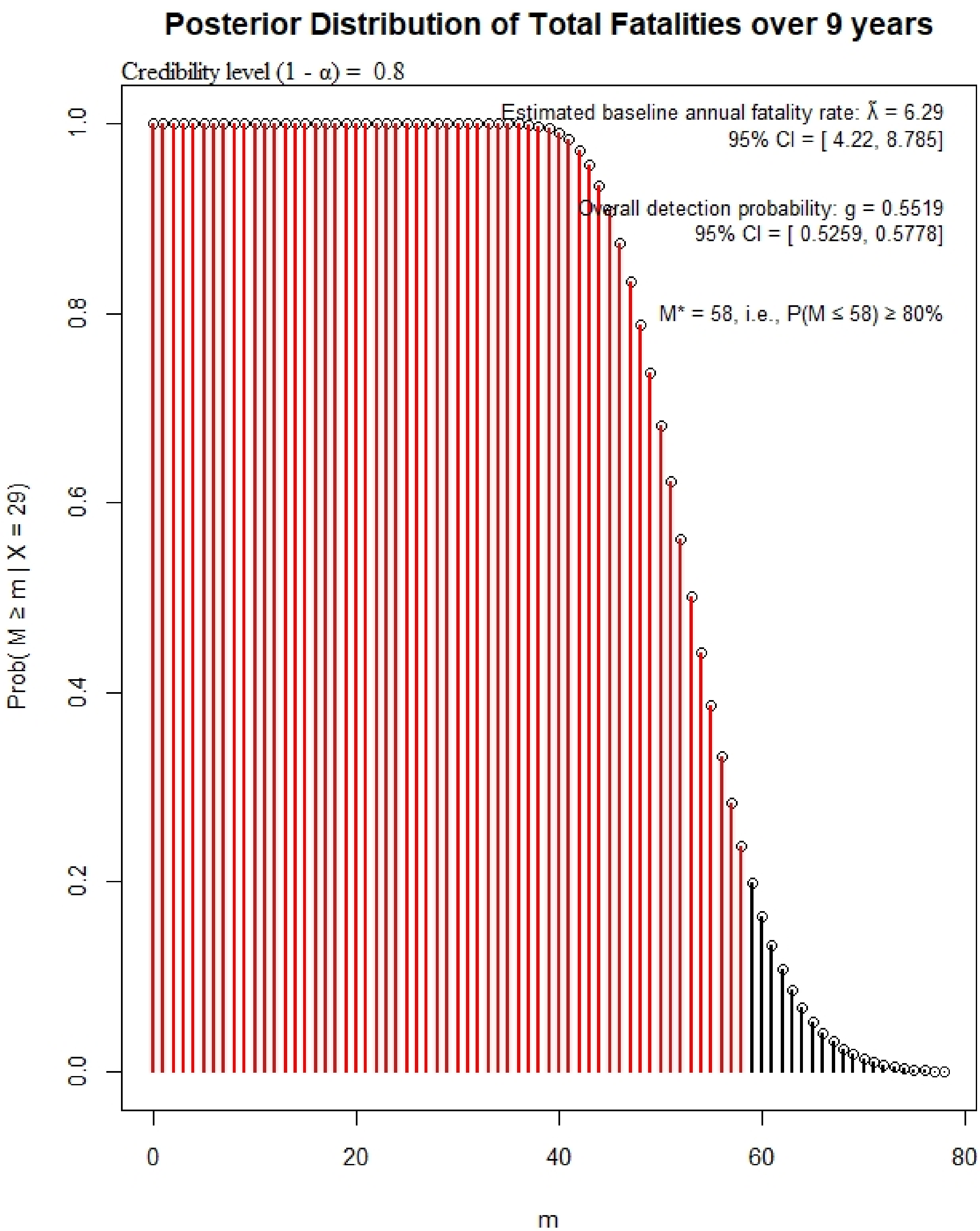
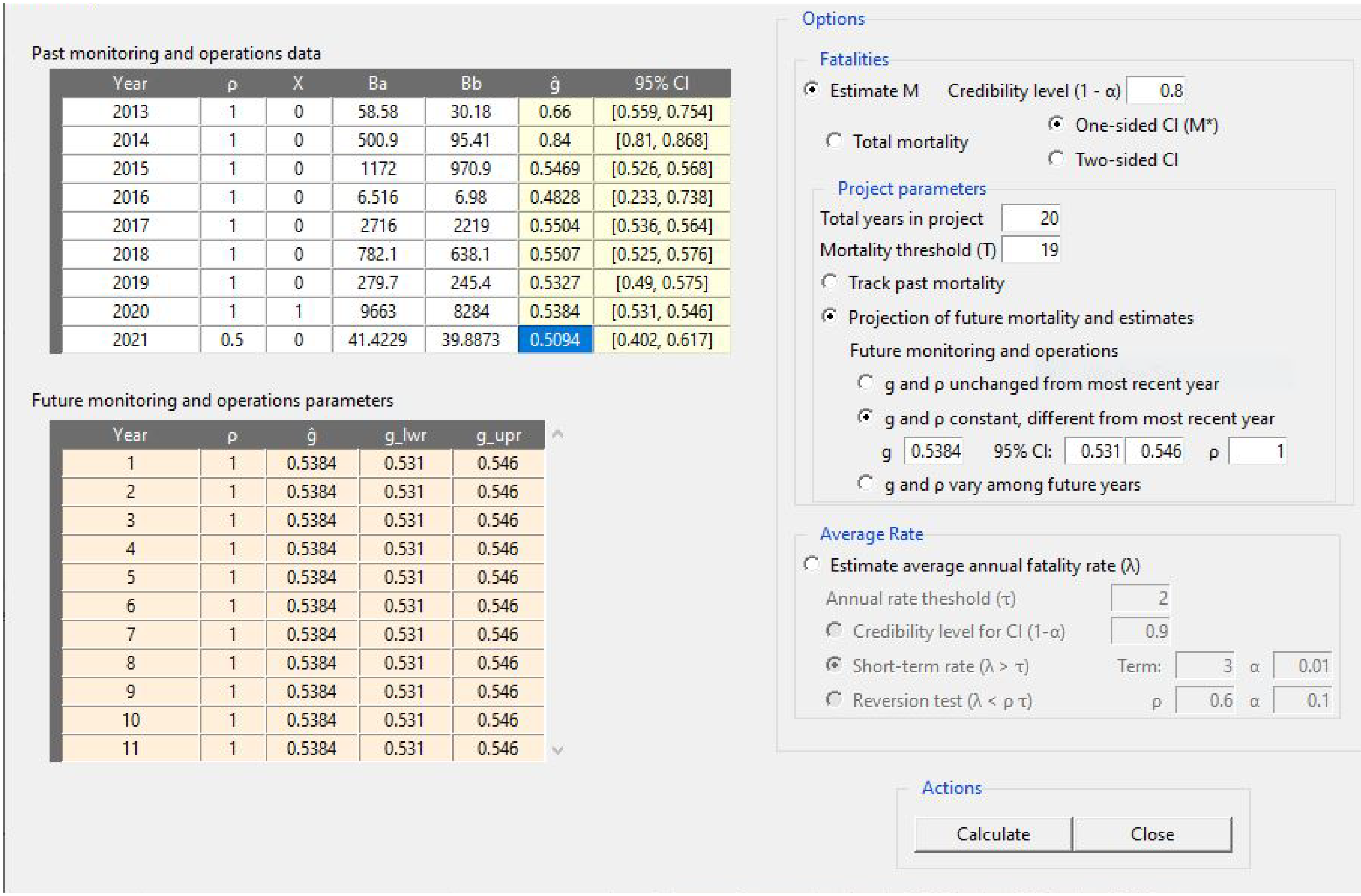


Figure 3. Evidence of Absence Posterior Probability Distribution Output for Hawaiian Hoary Bats Multi-Year Analysis for FY 2021 (Dalthorp et al. 2017)



Past monitoring and operations data

Year	ρ	X	Ba	Bb	ĝ	95% CI
2013	1	0	58.58	30.18	0.66	[0.559, 0.754]
2014	1	0	500.9	95.41	0.84	[0.81, 0.868]
2015	1	0	1172	970.9	0.5469	[0.526, 0.568]
2016	1	0	6.516	6.98	0.4828	[0.233, 0.738]
2017	1	0	2716	2219	0.5504	[0.536, 0.564]
2018	1	0	782.1	638.1	0.5507	[0.525, 0.576]
2019	1	0	279.7	245.4	0.5327	[0.49, 0.575]
2020	1	1	9663	8284	0.5384	[0.531, 0.546]
2021	0.5	0	41.4229	39.8873	0.5094	[0.402, 0.617]

Future monitoring and operations parameters

Year	ρ	ĝ	g_lwr	g_upr
1	1	0.5384	0.531	0.546
2	1	0.5384	0.531	0.546
3	1	0.5384	0.531	0.546
4	1	0.5384	0.531	0.546
5	1	0.5384	0.531	0.546
6	1	0.5384	0.531	0.546
7	1	0.5384	0.531	0.546
8	1	0.5384	0.531	0.546
9	1	0.5384	0.531	0.546
10	1	0.5384	0.531	0.546
11	1	0.5384	0.531	0.546

Figure 4. **Evidence of Absence Software Inputs for Hawaiian Petrels Multi-Year Analysis in FY 2021 (Dalthorp et al. 2017).**

```
Summary statistics for total mortality through 9 years
------------------------------------
Results
M* = 3 for 1 - a = 0.8, i.e., P(M <= 3) >= 80%

Estimated overall detection probability: g = 0.583, 95% CI = [0.549, 0.617]
   Ba = 474.96, Bb = 339.55

Estimated baseline fatality rate: lambda = 0.303, 95% CI = [0.0218, 0.945]


Test of assumed relative weights (rho) and potential bias              Fitted rho
Assumed rho      95% CI
      1      [0.003, 3.068]
      1      [0.002, 2.774]
      1      [0.004, 3.868]
      1      [0.008, 4.539]
      1      [0.005, 3.571]
      1      [0.003, 3.707]
      1      [0.005, 3.759]
      1      [0.180, 5.840]
    0.5      [0.005, 3.731]

p = 0.81553 for likelihood ratio test of H0: assumed rho = true rho
Quick test of relative bias: 0.959

Posterior distribution of M
m      p(M = m)  p(M > m)
0       0.0000   1.0000
1       0.4375   0.5625
2       0.2795   0.2830
3       0.1474   0.1355
4       0.0724   0.0632
5       0.0342   0.0289
6       0.0158   0.0131
7       0.0072   0.0059
8       0.0033   0.0026
9       0.0015   0.0012
10      0.0007   0.0005
11      0.0003   0.0002
12      0.0001   0.0001
13      0.0001   0.0000
14      0.0000   0.0000
15      0.0000   0.0000
================================================================================
Input
Year (or period) rel_wt  X    Ba      Bb   ghat    95% CI
2013             1.000   0  58.58  30.18 0.660 [0.559, 0.754]
2014             1.000   0  500.9  95.41 0.840 [0.810, 0.868]
2015             1.000   0   1172  970.9 0.547 [0.526, 0.568]
2016             1.000   0  6.516   6.98 0.483 [0.233, 0.738]
2017             1.000   0   2716   2219 0.550 [0.536, 0.564]
2018             1.000   0  782.1  638.1 0.551 [0.525, 0.576]
2019             1.000   0  279.7  245.4 0.533 [0.490, 0.575]
2020             1.000   1   9663   8284 0.538 [0.531, 0.546]
2021             0.500   0  41.42  39.89 0.509 [0.402, 0.617]
```

Figure 5. Evidence of Absence Output for Hawaiian Petrels Multi-Year Analysis in FY 2021 (Dalthorp et al. 2017)

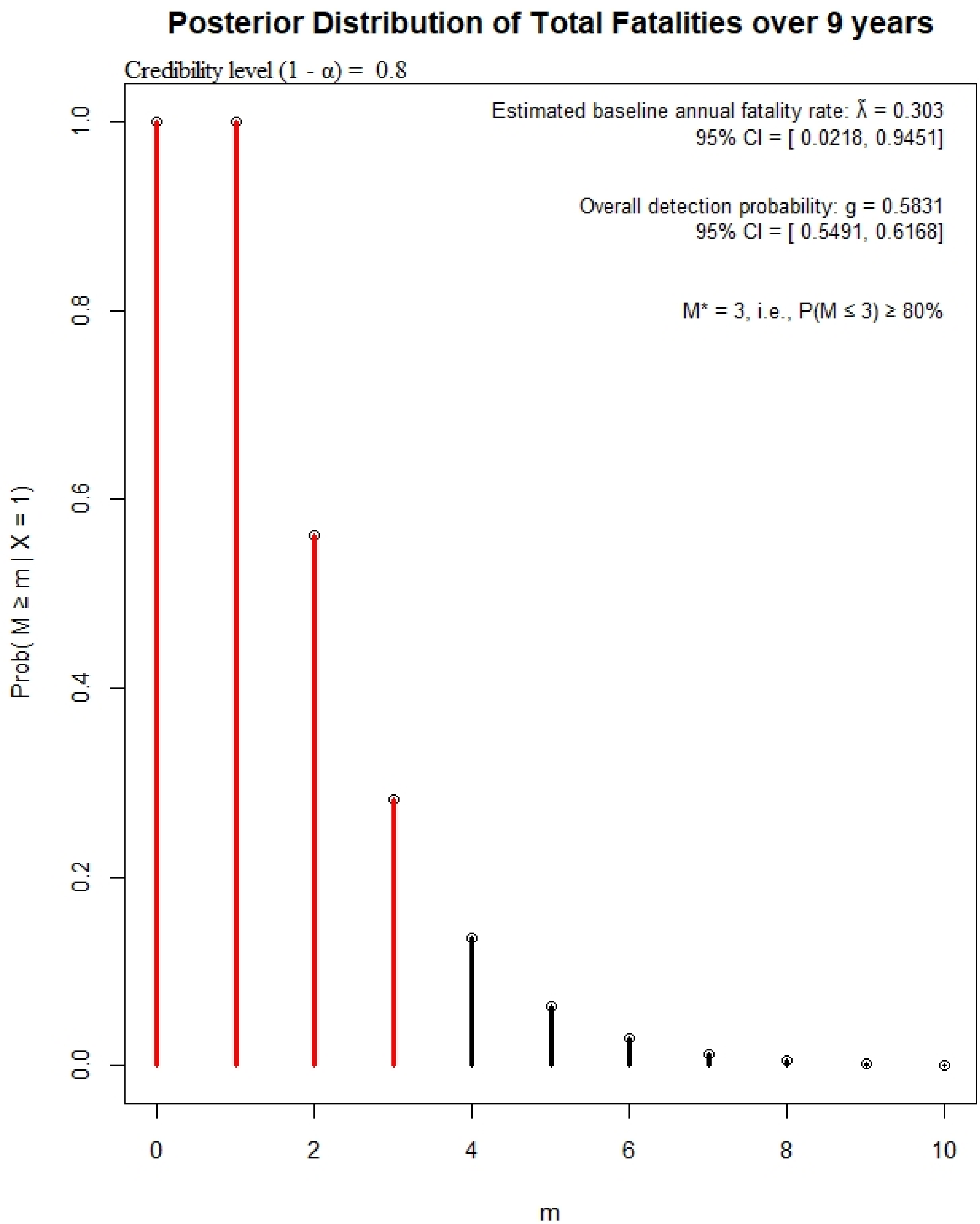


Figure 6. Evidence of Absence Posterior Probability Distribution for Hawaiian Petrels Multi-Year Analysis in FY 2021 (Dalthorp et al. 2017)

Attachment 2

Indirect Take Calculations for Hawaiian Hoary Bat at the Project in FY 2021

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Parameter	Description	Calendar Year									Total
		2013	2014	2015	2016	2017	2018	2019	2020	2021	
A	Observed Breeding Female Take	0	0	0	2	2	1	2	1	0	**8**
B	Indirect Take from Observed Breeding Female Take (A x 1.8)	0	0	0	3.6	3.6	1.8	3.6	1.8	0	**14.4**
C	Observed Breeding Unknown Sex Take	0	0	0	0	0	0	0	0	0	**0**
D	Indirect Take from Observed Breeding Unknown Sex Take (C * 0.44 * 1.8)	0	0	0	0	0	0	0	0	0	**0**
E	All Observed Take (Search and Incidental)	1	3	2	7	5	3	10	5	0	**36**
F	Estimated Take Multiplier (58 / 36)	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61
G	Estimated Direct Take (E x F)	1.61	4.83	3.22	11.28	8.06	4.83	16.11	8.06	0.00	**58**
H	Unobserved Direct Take (G - E)	0.61	1.83	1.22	4.28	3.06	1.83	6.11	3.06	0.00	**22**
I	Indirect Take Calculated from Unobserved Take (H * 0.44 * 0.25 * 1.8)	0.12	0.36	0.24	0.85	0.61	0.36	1.21	0.61	0.00	**4.36**
Total Indirect Take (B + D + I; juveniles)											**18.76**
Total Indirect Take (B + D + I)*0.3 (adults)											**5.63**

Attachment 3

2020 Game Camera Hawaiian Petrel Burrow Monitoring Summary, Calculation of Benefits, and Example Burrow Photos

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Table 1. Game Camera Hawaiian Petrel Burrow Monitoring Summary, 2020

Burrow Number	Seasonal Status	Last Date of Activity	Successfully Fledged Date
3	Successful	11/2/2020	11/2/2020
4	Successful	10/22/2020	10/22/2020
6	Successful	10/22/2020	10/22/2020
25	Successful	10/22/2020	10/22/2020
31	Successful	10/18/2020	10/18/2020
32	Successful	10/21/2020	10/21/2020
33	Successful	10/26/2020	10/26/2020
34	Successful	10/15/2020	10/15/2020
42	Successful	10/10/2020	10/10/2020
62	Successful	10/26/2020	10/26/2020
72	Successful	10/17/2020	10/17/2020
74	Successful	10/27/2020	10/27/2020
75	Successful	10/5/2020	10/5/2020
51	Probably Successful	10/16/2020	10/16/2020
1	Seasonally Inactive		
2	Seasonally Inactive		
5	Seasonally Inactive		
7	Seasonally Inactive		
8	Seasonally Inactive		
11	Seasonally Inactive		
12	Seasonally Inactive		
14	Seasonally Inactive		
16	Seasonally Inactive		
17	Seasonally Inactive		
18	Seasonally Inactive		
19	Seasonally Inactive		
21	Seasonally Inactive		
24	Seasonally Inactive		
26	Seasonally Inactive		
28	Seasonally Inactive		
29	Seasonally Inactive		
30	Seasonally Inactive		
36	Seasonally Inactive		
37	Seasonally Inactive		

Burrow Number	Seasonal Status	Last Date of Activity	Successfully Fledged Date
38	Seasonally Inactive		
40	Seasonally Inactive		
41	Seasonally Inactive		
43	Seasonally Inactive		
44	Seasonally Inactive		
45	Seasonally Inactive		
46	Seasonally Inactive		
47	Seasonally Inactive		
48	Seasonally Inactive		
49	Seasonally Inactive		
53	Seasonally Inactive		
56	Seasonally Inactive		
57	Seasonally Inactive		
60	Seasonally Inactive		
61	Seasonally Inactive		
66	Seasonally Inactive		
69	Seasonally Inactive		
70	Seasonally Inactive		
71	Seasonally Inactive		
76	Seasonally Inactive		
13	Prospecting	7/7/2020	
20	Prospecting	7/21/2020	
23	Prospecting	7/7/2020	
27	Prospecting	7/20/2020	
50	Prospecting	5/11/2020	
64	Prospecting	7/7/2020	
65	Prospecting	7/3/2020	
67	Prospecting	7/21/2020	
79	Prospecting	7/25/2020	
9	Occupied by Non-breeder/Failed	8/26/2020	
15	Occupied by Non-breeder/Failed	8/4/2020	
52	Occupied by Non-breeder/Failed	8/22/2020	
54	Occupied by Non-breeder/Failed	8/26/2020	
55	Occupied by Non-breeder/Failed	8/7/2020	
58	Occupied by Non-breeder/Failed	8/10/2020	

Burrow Number	Seasonal Status	Last Date of Activity	Successfully Fledged Date
59	Occupied by Non-breeder/Failed	8/8/2020	
63	Occupied by Non-breeder/Failed	9/24/2020	
68	Occupied by Non-breeder/Failed	9/12/2020	
73	Occupied by Non-breeder/Failed	8/25/2020	
77	Occupied by Non-breeder/Failed	8/9/2020	
78	Occupied by Non-breeder/Failed	8/13/2020	
22	Failed[1]	8/4/2020	
39	Failed[2]	8/21/2020	

1. Egg rollout found on 6/22/2020.
2. Egg rollout found on 7/7/2020.

Figure 1. Hawaiian Petrel Calculation of Benefit of Predator Control

		HCP Estimate			Average Number of Active Burrows 2012-2019			
	Active Burrows	33			29.75			
	Number of Breeding Pairs (Avg * 0.75)	24.75			22.31			
	Scenario	Moderate Predation	Mild Predation	Minimal Predation	Moderate Predation	Mild Predation	Minimal Predation	Estimated Number of Breeding Pairs Based on Observed Active Burrows
Calendar Year	Lambda	0.933	0.978	1.009	0.933	0.978	1.009	
	Monitoring Year	Population of breeding pairs						
2012	0							24.75
2013	1	24.8	24.8	24.8	22.3	22.3	22.3	19.50
2014	2	23.1	24.2	25.0	20.8	21.8	22.5	21.75
2015	3	21.5	23.7	25.2	19.4	21.3	22.7	23.25
2016	4	20.1	23.2	25.4	18.1	20.9	22.9	18.75
2017	5	18.8	22.6	25.7	16.9	20.4	23.1	21.75
2018	6	17.5	22.1	25.9	15.8	20.0	23.3	27.75
2019	7	16.3	21.7	26.1	14.7	19.5	23.5	21.00
2020	8	15.2	21.2	26.4	13.7	19.1	23.8	21.00
2021	9	14.2	20.7	26.6	12.8	18.7	24.0	
2022	10	13.3	20.3	26.8	12.0	18.3	24.2	
2023	11	12.4	19.8	27.1	11.2	17.9	24.4	
2024	12	11.5	19.4	27.3	10.4	17.5	24.6	
2025	13	10.8	19.0	27.6	9.7	17.1	24.8	
2026	14	10.0	18.5	27.8	9.1	16.7	25.1	
2027	15	9.4	18.1	28.1	8.5	16.3	25.3	
2028	16	8.7	17.7	28.3	7.9	16.0	25.5	
2029	17	8.2	17.3	28.6	7.4	15.6	25.8	
2030	18	7.6	17.0	28.8	6.9	15.3	26.0	
2031	19	7.1	16.6	29.1	6.4	15.0	26.2	
2032	20	6.6	16.2	29.3	6.0	14.6	26.5	
		Difference between Moderate and *Mild* Predation		9.59	**Difference between Moderate and *Mild* Predation**		**8.65**	
		Estimated benefit of predator control (number of breeding pairs * 2/0.75)		25.6	Estimated benefit of predator control (number of breeding pairs * 2/0.75)		**23.1**	
		Difference between Moderate and *Minimal* Predation		22.72	Difference between Moderate and *Minimal* Predation		20.48	

Photo 1. Cat detected at burrow 55, March 13, 2020

Photo 2. Mongoose detected at burrow 79, October 18, 2020

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Attachment 4

Tier 4 Mitigation Checklist and Installed Pond Photos

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Auwahi Wind HCP Tier 4 Bat Mitigation Actions	Current Status	FY21 Q4	FY20 thru FY21 Total	HCP Total Required	Notes
Provide a copy of the conservation easement to USFWS and DOFAW	Complete	N/A	N/A	N/A	Provided copy to USFWS/DOFAW on 12/12/2020
Letter of credit in the amount of $4,013,047 payable to DOFAW	Complete	N/A	N/A	N/A	$3,019,543 bond balance for 2021, submitted on 4/26/2021 for agency concurrence
Record the conservation easement for the Leeward Haleakala Mitigation Project land to preserve it in perpetuity.	Complete	N/A	N/A	N/A	HILT recorded with State of Hawaii Bureau of Conveyances 12/7/2020
Install Ponds	Complete	N/A	2 pond installed	2 ponds installed	1 pond completed in 2020. Second pond completed 3/5/2021. Photos taken for documentation
Install acoustic detectors	Complete	N/A	58 acoustic detectors installed	58 acoustic detecors installed	Tier 4 mitigation area detectors installed.
Install wildlife egress structures in all troughs within the mitigation area	Complete	N/A	10 troughs installed	10 troughs installed	Photos taken for documentation
Consider and install understory with hedgerow canopy	Complete	N/A	5 acres planted	None required	Aalii added
Quarterly insect monitoring for the baseline monitoring period	Complete	N/A	3 malaise traps checked quarterly	3 malaise traps checked quarterly	Data analysis and report pending
Fence ponds	Complete	0	2 ponds fenced	2 ponds fenced	Koa added to perimeter area
Install hedgerow fencing	In Progress	100 acres fenced	100 acres fenced	311 acres fenced	Site visits conducted for next 100 acre fence installation
Install hedgerow plantings	In Progress	18 acres planted	73 acres planted	311 acres planted	Plants looking good. Arranging with Nursery for future needs
Quarterly detector checks	In Progress	38 acoustic detectors checked	38 acoustic detectors checked quarterly	38 acoustic detectors checked quarterly in yrs 0, 1, 2, 3, 5, 7, 9, 11	Year 0 complete. Year 1 data collection initiated
Annually analyze acoustic monitoring data to ensure units working properly	In Progress	data from 38 acoustic detectors analyzed	data from 38 acoustic detectors analyzed annually	38 acoustic detector data analyzed annually in monitoring	All units working properly. Analysis underway
Quarterly pond monitoring	In Progress	ponds checked	2 ponds checked quarterly	Quarterly checks of ponds in years 1, 2, 3, 5, 7, 9, and	Ponds intact
Remove barbed wire from the mitigation area	In Progress	47 acres of barbed fencing removed	67 acres of barbed fencing removed	1752 acres of barbed fencing removed	Ranch utilizing volunteers to remove barbed fencing
Quarterly fence inspections	In Progress	1 check of fencelines	Fencelines checked quarterly	None required	Fencelines intact
Use thermal cameras to document the behavior of bats at ponds and/or water troughs.	In Progress	1 thermal camera installed	1 thermal camera installed at 1 pond	3 months of monitoring by thermal camera	Initial data collected shows bat use of pond
Twice annual insect monitoring in years 1, 2, 3, 5, 7, 9, and 11.	In Progress	3 malaise traps checked	3 malaise traps checked quarterly	3 malaise traps checked quarterly	Monitoring reduced from quarterly

Photo 1. Tier 4 Mitigation Area Pond 1

Photo 2. Tier 4 Mitigation Area Pond 2

Attachment 5

Tier 4 Bat Baseline Study Final Report

ENVIRONMENTAL & STATISTICAL CONSULTANTS
2725 NW Woodland Blvd, Corvallis, OR 97330
Phone: 307-214-2799 ◆ www.west-inc.com ◆ Fax: 307-637-6981

TECHNICAL MEMORANDUM

Date: August 30, 2021

To: George Akau – Auwahi Wind

From: Joel Thompson and Kristina Hammond – WEST, Inc.

Subject: Tier 4 Bat Mitigation Monitoring: Baseline Monitoring Summary for February 2020 – April 2021

INTRODUCTION

Auwahi Wind Energy LLC (Auwahi Wind) deployed 38 acoustic bat detectors in spring 2020 to begin monitoring Hawaiian hoary bat (HAHOBA) activity at their Tier 4 Mitigation Site (Mitigation Site) on the island of Maui (Figure 1). The goals of the acoustic monitoring study are to assess changes in HAHOBA activity at the Mitigation Site over time, and to assess the impacts of management actions on bat activity and verify their consistency with the overall management program at the Mitigation Site. Auwahi Wind provided and managed all of the acoustic monitoring equipment, consisting of 38 acoustic bat detectors and associated accessories (e.g., microphones, solar panels, and batteries). Auwahi Wind staff manage all field aspects of the study, including the ongoing maintenance of the detectors and swapping of data cards. Once collected in the field, Auwahi Wind staff upload the raw data for QAQC and analysis by Western EcoSystems Technology, Inc. (WEST). This Technical Memorandum (Memo) provides a summary of the cumulative dataset for the February 2020 - April 2021 monitoring period, for which WEST completed the review and analysis of all available data collected from the 38 detectors over the period spanning February 26, 2020, through April 8, 2021.

In addition to the bat activity data presented herein, WEST is currently working on a power analysis to assess the number of acoustic detectors needed to ensure a robust monitoring program capable of documenting changes (increases) in bat activity over the life of the Tier 4 Mitigation program (an anticipated 12 years). Additional details and results of the power analysis will be provided as an addendum to this report as soon as the analysis is completed.

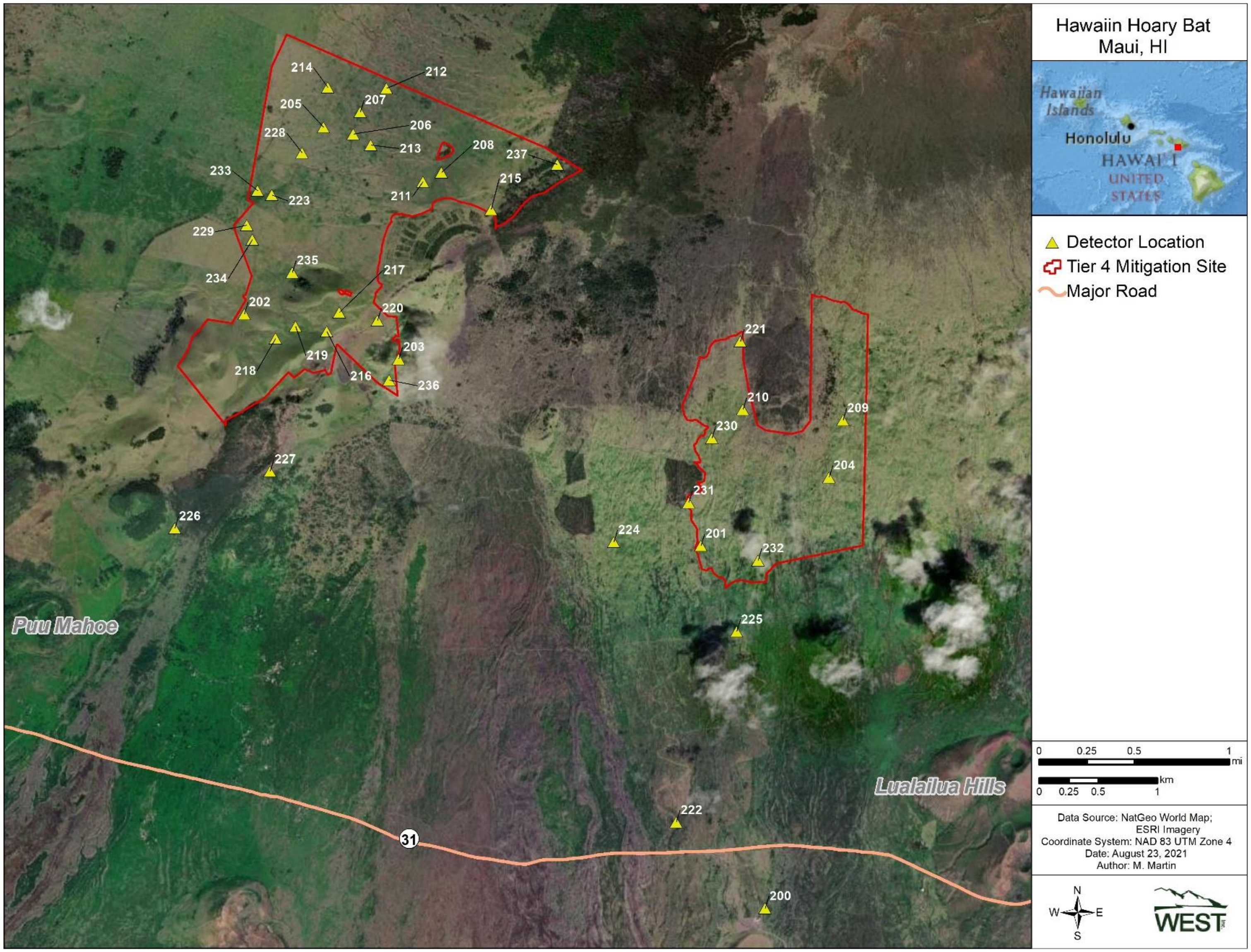

Figure 1. Overview of the Auwahi Wind Tier 4 Hawaiian hoary bat mitigation site and acoustic bat detector locations, Maui, Hawaii.

METHODS

Thirty-eight Wildlife Acoustics SM4Bat full spectrum bat detectors (Wildlife Acoustics, Maynard, Massachusetts) were deployed across the Mitigation Site with future mitigation activities in mind. Sampling locations throughout the Mitigation Site were selected using a spatially balanced (Generalized Random Tessellation Sampling; Stevens and Olsen [2004]) design based on a grid of 100 x 100 meter grid cells. Within selected grid cells, there was leeway to place detectors according to the habitat subtype requirements of Auwahi Wind's Habitat Conservation Plan (HCP). Thirty detectors were subset into three habitat subtypes for future management activities within the Mitigation Site: pasture, hedgerow, and water trough/pond. Eight additional detectors were placed outside of the Mitigation Site and spread among similar habitat features (i.e., pasture, trough, and hedgerow). These eight locations are meant to serve as controls when conducting analyses to assess increasing trends in bat activity within the Mitigation Site following mitigation activities, although it is not known how distant from the Mitigation Site the impacts on bat acoustic activity may be observed. For the purposes of the baseline year of monitoring summarized in this memo, a baseline habitat type was identified for each detector station. The baseline conditions for the 30 sampling stations within the Mitigation site included 20 pasture and 10 trough/pond locations (nine trough and one pond; Table 1). As mitigation activities are completed and hedgerows and ponds are installed, it is anticipated that pasture stations located within 100 meters of installed features will transition to hedgerow or pond stations during future analyses. The eight detectors located outside the Mitigation Site included one trough, two hedgerow, and five pasture locations (Table 1). Additional details on the sampling design and mitigation requirements can be found in Auwahi Wind's amended HCP (Tetra Tech 2019).

Acoustic data from the 38 bat detectors was collected by Auwahi Wind staff and transferred to WEST. Once downloaded and verified for completeness, WEST completed a quality check of the summary and acoustic files to ensure detectors and microphones were properly functioning. Full spectrum data were then processed and converted to zero-cross data using the software package Kaleidoscope Pro (version 5.1.0; Wildlife Acoustics), reducing the overall file sizes for storage and further analysis. During the conversion process, Kaleidoscope filtered zero-cross files suspected to be noise into a folder separate from the other zero-cross files. Once converted and filtered, all zero-cross files, including suspect noise files, were reviewed as digital sonograms and labeled by a bat biologist using program Analook (Titley Scientific). This process was used to confirm the presence of sufficient echolocation pulses (a minimum of two) to qualify as a bat call, consistency with the call parameters of HAHOBA (both call frequency and pattern), and to classify the call type (i.e., searching/location calls or feeding buzzes). Data handling procedures were consistent with those used by WEST for other acoustic studies being conducted in Hawaii (i.e., the Oahu and Leeward Haleakala occupancy studies) to ensure consistent organization and comparability of data across studies (this study and Thompson and Starcevich 2021a, 2021b).

Once all call files were reviewed and bat presence verified, the call data were used to calculate the bat use metrics requested by Auwahi Wind:

1. **Call abundance** = total bat calls / total active detector-nights; and
2. **Call nightly detection** = total nights with bat calls / total active detector-nights.

A second set of metrics was generated based on feeding buzzes only:

1. **Feeding buzz abundance** = total feeding buzzes / total active detector-nights; and
2. **Feeding buzz nightly detection** = total nights with feeding buzzes / total active detector-nights.

A detector-night was defined as one detector operating for one full night.

RESULTS

For the period February 26 – April 9, 2021, the number of detector nights ranged from 302 to 407 among the 38 acoustic detectors, totaling 13,695 detector-nights (Table 1). Bat calls were recorded at all 38 detectors, ranging from a low of 269 calls at station AW222 to a high of 59,143 calls at station AW237 (Table 1). Bat call abundance averaged 11.85 calls/detector night across all stations during the survey period, and varied from a low of 0.80 at station AW222 to a high of 171.43 at station AW237 (Table 1; Figure 2). Call nightly detection averaged 0.76 across all stations during the survey period, and varied from a low of 0.38 at detector AW222 to a high of 0.96 at stations AW226 and AW215 (Table 1). Bat calls were recorded on more than 50% of all detector nights at 35 of the 38 detectors and more than 75% of detector nights at 20 of the 38 detectors.

Feeding buzzes were recorded at 22 of the 38 stations (58%); however, the majority (66%) of all feeding buzzes were recorded at only two stations, AW215 and AW237 (Table 2). Feeding buzz abundance averaged 0.02 buzzes/detector night and varied from a low of zero at multiple detectors to a high of 0.21 at stations AW237 and AW215 (Table 2). The feeding buzz nightly detection rate was consistently low, averaging 0.01 across all stations (Table 2). With the exception of detectors AW215 and AW237, which recorded feeding buzzes on 14% and 12% of detector nights, respectively, all detectors recorded feeding buzzes on 2% or fewer detector nights (Table 2).

DISCUSSION

Based on the data collected during the monitoring period, HAHOBA were regularly active throughout the Mitigation Site, with bat activity recorded at all 38 stations and on most nights (76% of nights on average across all detectors). Only two stations (AW222 and AW200) averaged less than one call per detector night (0.80 and 0.91, respectively), while 89% averaged more than two calls per detector night. Stations AW200 and AW222 are the lowest elevation and driest sites within the dataset, and are also the only two detectors located in “Dry” land cover types (Figure 2). Detector AW237 is the only detector located in close proximity to a pond, and recorded by far the most calls per detector night (171 calls/detector night), with 49% more nightly calls than the next most active station (AW215) and more than 12 times more activity than all other sites. While

AW237 was located in close proximity to a pond, it was also among the highest elevation sites and was located in a small opening within the largest area of mesic forest land cover within or adjacent the Mitigation Site (Figure 2). The higher elevation and proximity to the larger mesic forest patch are two characteristics also shared with detector AW215, which exhibited the second highest activity rate (115 calls/detector night) and more than eight times the next highest activity rate (14 calls/detector night at detector AW226). This pattern of activity was consistent with that recorded in the Leeward Haleakala occupancy study conducted in 2019 – 2020 immediately east of the Mitigation Site (Thompson and Starcevich 2021b), which also found higher activity rates at upper elevation sites associated with mesic land cover types. The USGS study conducted in the Waihou Mitigation Area from 2015-2018 (Pinzari et al. 2019) also documented substantially higher activity rates (based on mean monthly detection rate) at their two upper most sample sites, which were located in roughly the same areas as AW215 and AW237. With the exception of detectors AW215 and AW237, activity rates in and around the Mitigation Site were generally consistent with the activity rates measured in the Leeward Haleakala study at similar elevations (approximately 2–18 bat calls/detector night; Thompson and Starcevich 2021b).

Monitoring of bat activity in and surrounding the Mitigation Site is planned for the next 11 years as mitigation activities (e.g., hedgerow plantings, water source installations) are implemented. The goal of the ongoing monitoring is to quantify bat activity rates relative (both spatially and temporally) to the mitigation activities and ideally provide a robust means of determining mitigation success; (i.e., did the mitigation actions increase bat abundance/use, as measure by bat activity rates, within the Mitigation Site relative to areas outside the Mitigation Site).

Table 1. Results for all bat detections during acoustic surveys conducted at 38 stations within the Auwahi Wind Energy Project's tier 4 mitigation area, Maui, Hawaii from February 26 – April 8, 2021. Calls are separated by total number of bat calls, the number of detector-nights bats were detected, total number of detector-nights, call abundance, and nightly detection rate.

Station	Associated Habitat Feature	# of Bat Calls	Detector-Nights with Bat Calls	Total Detector-Nights	Call Abundance[a] (Bat Calls/ Detector-Night)	Nightly Detection (Nights Bats Detected/Total Detector-Nights)
AW200*	trough	307	145	336	0.91± 0.08	0.43
AW201	pasture	591	176	376	1.57± 0.12	0.47
AW202	pasture	1,622	255	358	4.53± 0.34	0.71
AW203	pasture	2315	281	336	6.89± 0.40	0.84
AW204	pasture	877	267	371	2.36± 0.15	0.72
AW205	trough	1,592	324	392	4.06± 0.23	0.83
AW206	trough	2,016	337	392	5.14± 0.31	0.86
AW207	trough	1,704	341	392	4.35± 0.25	0.87
AW208	trough	1,379	243	331	4.17± 0.30	0.73
AW209	pasture	839	271	371	2.26± 0.14	0.73
AW210	pasture	933	265	365	2.56± 0.17	0.73
AW211	pasture	1,560	286	329	4.74± 0.28	0.87
AW212	pasture	1,308	309	389	3.36± 0.22	0.79
AW213	pasture	2,113	341	389	5.43± 0.30	0.88
AW214	pasture	1,706	319	390	4.37± 0.25	0.82
AW215	pasture	35,772	299	310	115.39± 9.56	0.96
AW216	pasture	2,771	314	346	8.01± 0.41	0.91
AW217	pasture	2,177	286	346	6.29± 0.38	0.83
AW218	pasture	1,713	240	373	4.59± 0.31	0.64
AW219	pasture	1,101	221	344	3.20± 0.25	0.64
AW220*	pasture	2,874	275	304	9.45± 0.49	0.90
AW221*	pasture	1,285	288	339	3.79± 0.22	0.85
AW222*	pasture	269	128	335	0.80± 0.07	0.38
AW223	pasture	1,520	298	392	3.88± 0.22	0.76
AW224*	pasture	773	215	335	2.31± 0.18	0.64
AW225*	pasture	634	187	335	1.89± 0.21	0.56
AW226*	hedgerow	4,291	290	302	14.21± 0.78	0.96
AW227*	hedgerow	3,602	284	302	11.93± 0.65	0.94
AW228	pasture	1,353	271	389	3.48± 0.22	0.70
AW229	pasture	1,985	317	392	5.06± 0.31	0.81
AW230	pasture	933	266	372	2.51± 0.16	0.72
AW231	trough	994	250	376	2.64± 0.18	0.66
AW232	pasture	901	238	375	2.40± 0.18	0.63
AW233	trough	1,877	321	407	4.61± 0.30	0.79
AW234	trough	1,849	293	407	4.54± 0.30	0.72
AW235	trough	2,335	296	407	5.74± 0.47	0.73
AW236	trough	1,836	279	345	5.32± 0.35	0.81
AW237	pond	59,143	327	345	171.43±11.84	0.95
Total		**152,850**	**10,343**	**13,695**	11.85± 0.68[b]	0.76[b]

[a] estimate ± bootstrapped standard error

[b] average of individual detectors to account for unbalanced design (i.e., differing number of detector nights)

* indicates detector location is outside the Tier 4 Mitigation Site

Table 2. Results for feeding buzz detections during acoustic surveys conducted at 38 stations within the Auwahi Wind Energy Project's tier 4 mitigation area, Maui, Hawaii from February 26 – April 8, 2021. Calls are separated by number of feeding buzz calls, detector-nights buzz calls were detected, total detector-nights, feeding buzz abundance, and feeding buzz nightly detection rate.

Station	Baseline Habitat Type	# of Feeding Buzzes	Detector-Nights with Feeding Buzz Calls	Total Detector - Nights	Feeding Buzz Abundance[a] (Feeding Buzzes Calls/ Detector-Night)	Feeding Buzz Nightly Detection (Nights Feeding Buzz detected/Total Detector-Nights)
AW200*	trough	0	0	336	0.00±0.00	0.00
AW201	pasture	0	0	376	0.00±0.00	0.00
AW202	pasture	0	0	358	0.00±0.00	0.00
AW203	pasture	4	4	336	0.01±0.01	0.01
AW204	pasture	0	0	371	0.00±0.00	0.00
AW205	trough	2	2	392	0.01±0.00	0.01
AW206	trough	3	3	392	0.01±0.00	0.01
AW207	trough	2	2	392	0.01±0.00	0.01
AW208	trough	5	5	331	0.02±0.01	0.02
AW209	pasture	6	6	371	0.02±0.01	0.02
AW210	pasture	0	0	365	0.00±0.00	0.00
AW211	pasture	0	0	329	0.00±0.00	0.00
AW212	pasture	0	0	389	0.00±0.00	0.00
AW213	pasture	1	1	389	0.00±0.00	0.00
AW214	pasture	0	0	390	0.00±0.00	0.00
AW215	pasture	64	42	310	0.21±0.03	0.14
AW216	pasture	1	1	346	0.00±0.00	0.00
AW217	pasture	6	6	346	0.02±0.01	0.02
AW218	pasture	6	6	373	0.02±0.01	0.02
AW219	pasture	1	1	344	0.00±0.00	0.00
AW220*	pasture	7	7	304	0.02±0.01	0.02
AW221*	pasture	1	1	339	0.00±0.00	0.00
AW222*	pasture	0	0	335	0.00±0.00	0.00
AW223	pasture	1	1	392	0.00±0.00	0.00
AW224*	pasture	0	0	335	0.00±0.00	0.00
AW225*	pasture	0	0	335	0.00±0.00	0.00
AW226*	hedgerow	2	2	302	0.01±0.00	0.01
AW227*	hedgerow	3	3	302	0.01±0.01	0.01
AW228	pasture	0	0	389	0.00±0.00	0.00
AW229	pasture	0	0	392	0.00±0.00	0.00
AW230	pasture	1	1	372	0.00±0.00	0.00
AW231	trough	0	0	376	0.00±0.00	0.00
AW232	pasture	0	0	375	0.00±0.00	0.00
AW233	trough	0	0	407	0.00±0.00	0.00
AW234	trough	3	3	407	0.01±0.00	0.01
AW235	trough	8	8	407	0.02±0.01	0.02
AW236	trough	7	7	345	0.02±0.01	0.02
AW237	pond	71	41	345	0.21±0.04	0.12
Total		205	153	13,695	0.02±0.00 [b]	0.01 [b]

[a] estimate ± bootstrapped standard error

[b] average of abundance estimates for individual detectors to account for unbalanced design (i.e., differing number of detector nights)

* indicates detector location is outside the Tier 4 Mitigation Site

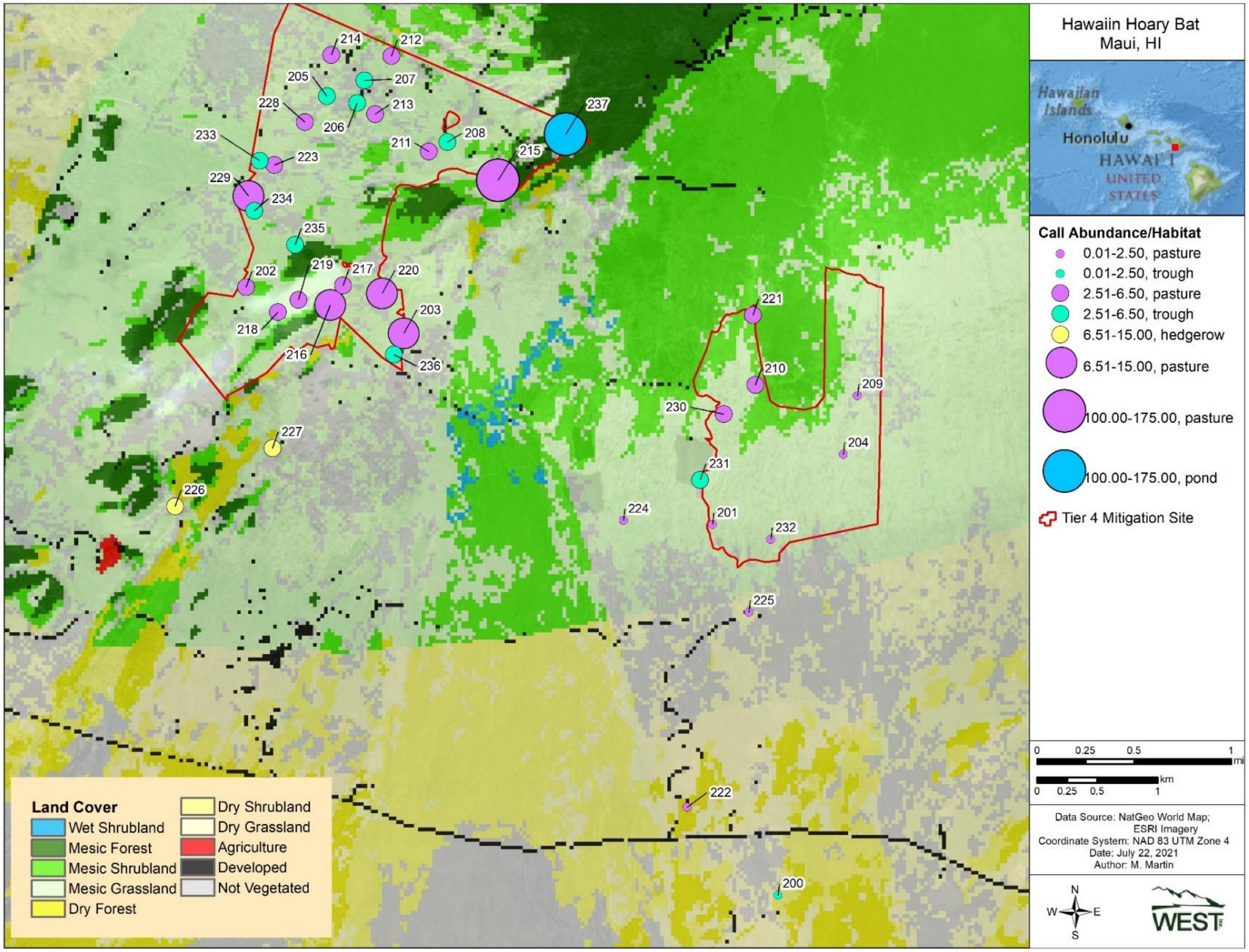

Figure 2. Call abundance by habitat feature type at Auwahi Wind's Tier 4 Hawaiian hoary bat mitigation site for the period February 2020 – April 2021.

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Attachment 6

Leeward Haleakalā Hoary Bat Report

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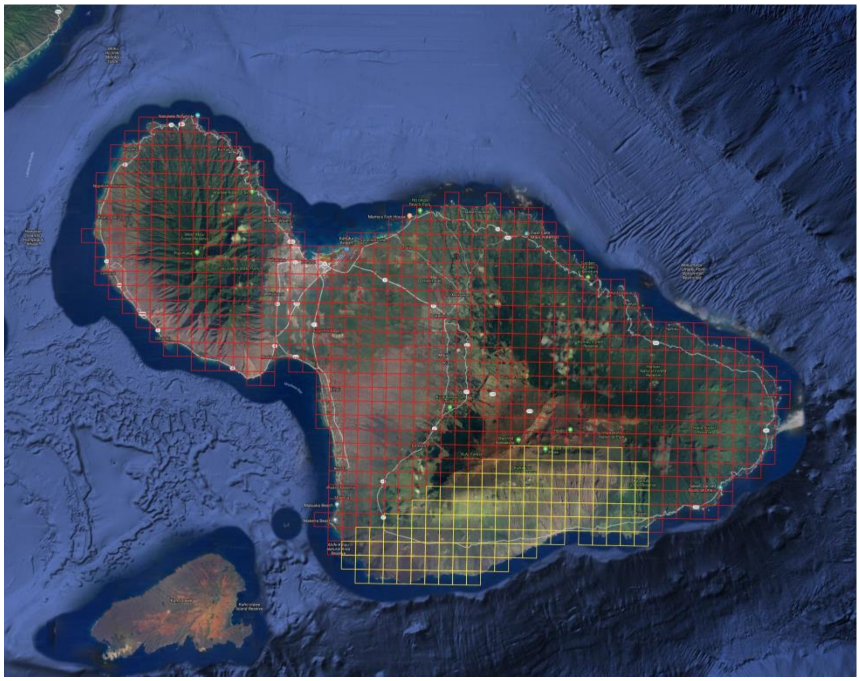
FINAL REPORT

Hawaiian Hoary Bat Distribution and Occupancy Study
Leeward Haleakala

Maui, Hawaii



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July 30, 2021

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Introduction

Western EcoSystems Technology, Inc. (WEST) was contracted by AEP Wind Holdings LLC to develop and implement a study to assess the seasonal occupancy of Hawaiian hoary bats (HAHOBA) in a roughly 300-km^2 area on the southeastern side of Maui, along the leeward slopes of Haleakala (Figure 1). WEST developed a Study Plan similar to that being implemented by WEST on the island of Oahu for Hawaii's Endangered Species Recovery Committee (ESRC) to ensure data were comparable to WEST's Oahu Study (Thompson and Starcevich 2021; hereafter referred to as the Oahu Study), to the extent possible. The primary objectives of the study were to estimate seasonal occupancy rates within the study area and to acquire baseline data useful in informing future studies designed to assess trends in occupancy over time.

Study Area and Survey Design

The study area was located on the leeward side of Haleakala, in the vicinity of the Auwahi I and proposed Auwahi II wind projects. The study design was developed in such a manner that it could readily be broadened to the entire island of Maui in a fashion similar to that currently being implemented in the Oahu Study, should opportunity to expand the effort come available in the future. Where appropriate, habitat and/or other environmental variables that could improve model performance were to be considered in the occupancy analyses. While the survey design was consistent with the island-wide design of the Oahu Study, given its focus on the leeward side of Haleakala, inference from the study are only applicable to the leeward Haleakala study area.

The sampling frame (i.e., all areas available for sampling) included all areas on the leeward side of Haleakala (see yellow cells on Figure 1), which essentially covers the southerly aspects of Haleakala from Kepio Point in the east to the lava fields of Cape Kinau in the west. The sampling frame consists of a grid of 2.3 km^2 sample units (i.e., cells), which are based on the mean core foraging area of HAHOBA as described by Bonaccorso et al. (2015) and consistent with the sampling frame used in the Oahu Study. The sampling frame of 2.3 km^2 grid cells was obtained by overlaying Maui with a grid spacing of 1.52 km in both directions (Figure 1). The result was a finite sampling frame of 896 grid cells across the entire island, with 141 cells located within the leeward Haleakala study area (Figure 1). Based on an assessment of previous work conducted on HAHOBA on Maui during the lactation/post-lactation periods (e.g., Kahikinui data from Todd et al. 2015, Auwahi Wind Data from Hurley and Schwab 2016) and results from analysis associated with the Oahu Study, 20 cells/detectors were targeted as our initial sample.

The sample cells were chosen using a spatially balanced sample design (i.e., Generalized Random Tessellation Stratified Sample; Stevens and Olsen 2003, 2004), with a primary sample of 20 cells chosen from the study-area sampling frame of 141 grid cells (Figure 1). An oversample of 10 additional cells was chosen to facilitate optional detector locations should any of the primary 20 cells be unusable for various reasons; however, the oversample was not necessary as access was gained to all 20 cells within the primary sample.

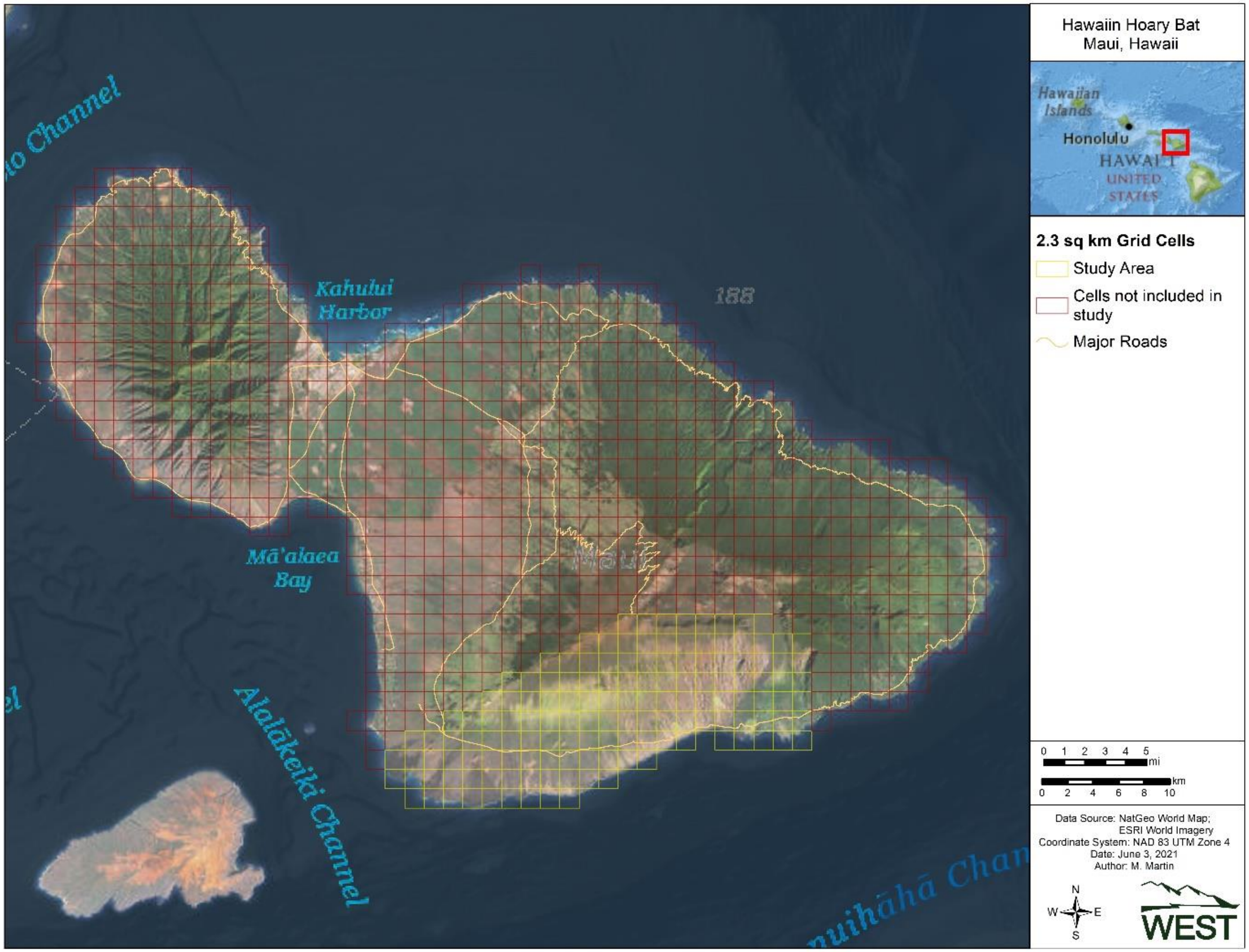

Figure 1. Leeward Haleakala study area and grid of cells used for site selection in the Leeward Haleakala Hawaiian hoary bat occupany study.

Detector Locations

Rules for detector placement within sampled grid cells were defined prior to the survey so that detectors were placed in an appropriate location. Detectors were placed in areas that were legally accessible and safely reachable by observers. Furthermore, detectors were restricted to areas where the detector could function properly (e.g., solar exposure) and where false-positive detections were minimized due to the presence of vegetative or structural clutter (Loeb et al. 2015). Detector placement for occupancy analysis often exploits habitats more likely to be used by the target species. For example, the North American Bat Monitoring Program (NABat, Loeb et al. 2015) suggests that detectors "be placed in areas that maximize the number and quality of recordings." Establishing the detector within the "best" habitat within a selected grid cell provides a basis for establishing occupancy/use within that cell, but perhaps restricts inference to what are considered the "best" habitats across the area of interest. This placement approach benefits occupancy analysis, but may negatively impact habitat-use analysis due to underrepresentation of habitats used less-frequently or not at all.

Consistent with the study on Oahu, detectors were placed at the "best" location within a selected cell that was accessible, suitable, and maximized the probability of detecting bats if bats were present within the cell. This approach was developed based on discussions with the ESRC Bat Subcommittee in regard to the study on Oahu, during which it was determined that estimating occupancy and distribution was of higher priority than habitat selection using this study design. In addition to the practical rules of access and suitability, rules for locating the detector within the cell were also considered, such that detectors were placed in a consistent manner across cells. The "best" habitat within a cell may vary from cell to cell and may include areas optimal for foraging, areas with access to water, or areas used for commuting. If multiple sites of similar suitability are available within a selected cell, then ease of access and security of equipment were considered in the final placement of detectors.

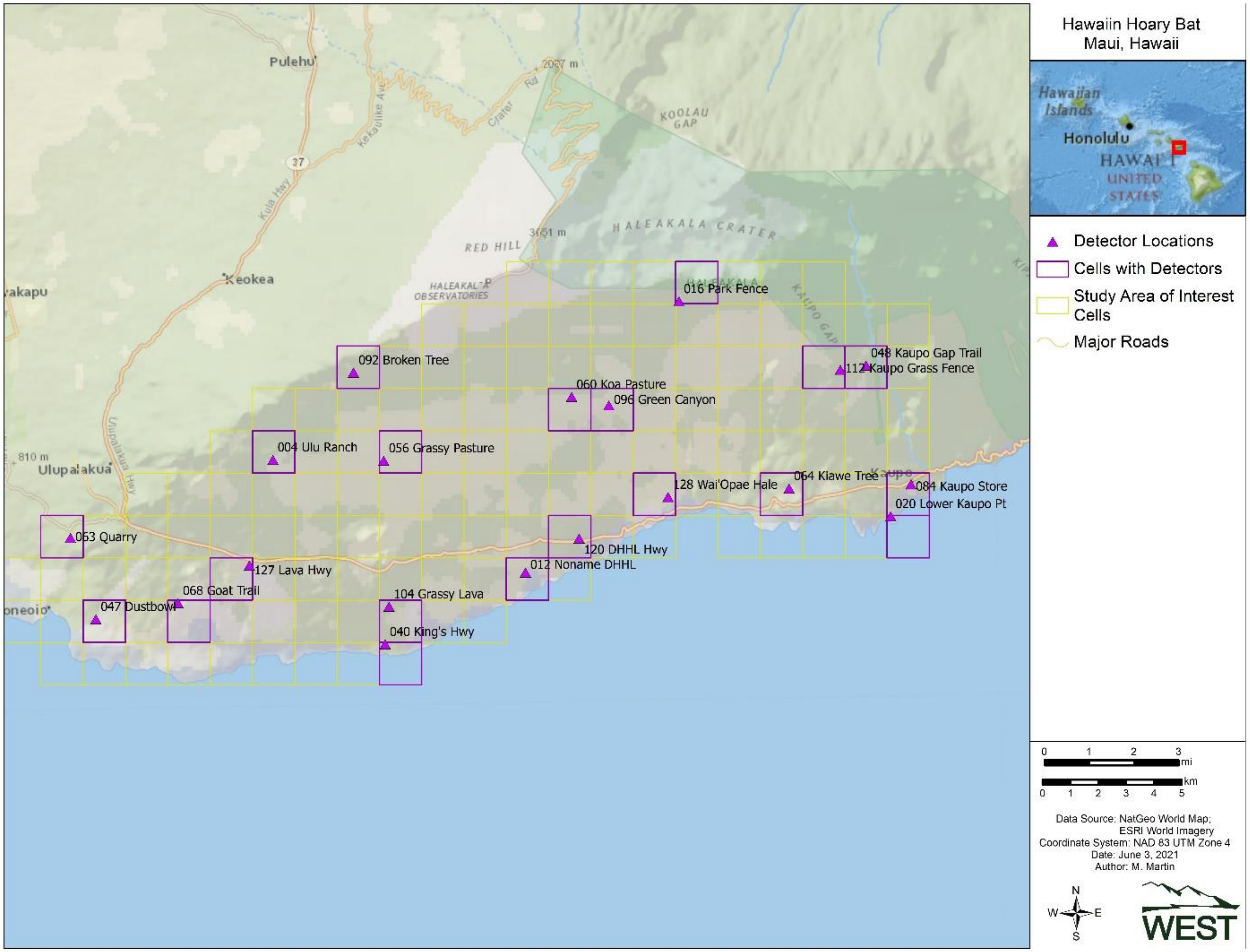

Figure 2. Leeward Haleakala study area and acoustic bat detector locations monitored from July 2019 – August 2020.

Methods

Acoustic Equipment

Wildlife Acoustics Song Meter SM4Bat (SM4) full spectrum bat detectors fitted with model SMM-U2 ultrasonic microphones (Wildlife Acoustics, Inc., Concord, Massachusetts) were used for all data collection. The SM4 detectors are small, measuring roughly eight inches (in) tall x five in wide x three in deep (20 centimeters [cm] tall x 13 cm wide x eight cm deep) and are fully self-contained. Detectors utilized an external battery and accompanying solar panel as a power source (Figure 3).

Detectors were attached to existing structures (e.g., fence posts) or newly installed t-posts, via attachment of a 10-foot (ft; 3-meter) length of 0.75 in (1.9 cm) diameter metal conduit used to extend the microphone approximately three meters above ground (Figure 3). The detector, and external battery and solar panels (when used), were mounted low on the pole with the microphone mounted at the top of the pole (Figure 3). Detectors were surrounded by fencing to keep them safe from ungulates (deer, goats, cattle) that are prone to rubbing on the posts and/or chewing on microphone and/or power cables.

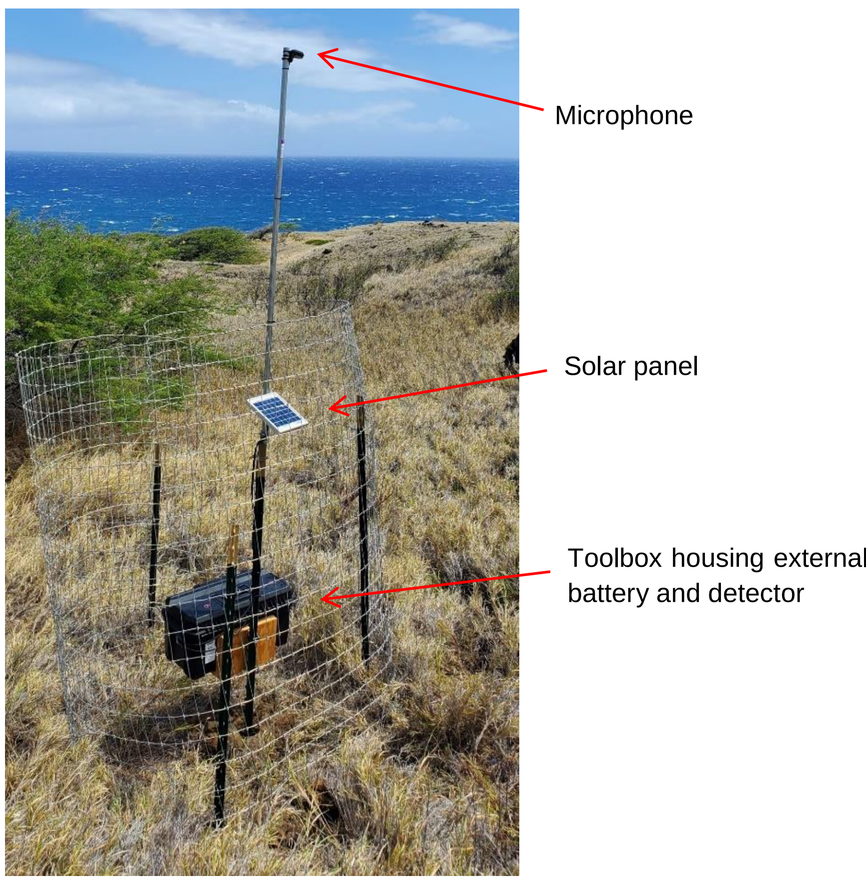

Figure 3. Example of set-up used in deployment of the Wildlife Acoustics SM4Bat detectors used in the Hawaiian hoary bat study on leeward Haleakala, Maui, Hawaii.

Data Collection and Managment

Detector settings were refined and finalized before deploying detectors in the field, such that all detectors were operating under the same specifications. Detectors were programmed to operate nightly, from approximately one hour prior to sunset to approximately one hour after sunrise. Within the SM4 Detector Configurator, the following settings were selected: detector sample rate of 192 kilohertz (kHz); gain of 12 decibels (dB); minimum signal duration of 1.5 milliseconds; maximum signal duration off; minimum trigger frequency of 10 kHz; trigger level of 12 dB; and trigger window of three seconds. Detectors were visited regularly to swap data cards and ensure detectors were functioning properly. Following initial set-up in July 2019, detectors were checked once approximately every two months through December 2019, prior to the onset of the COVID-19 Pandemic, then once every three to six months through the end of the study (as travel restrictions allowed).

Data cards were downloaded and processed on a regular basis using data handling procedures consistent with those used on the Oahu study to ensure consistent organization and comparability of data across studies. To expedite call analysis, call recordings were processed with the Kaleidoscope Pro 5 software package (Wildlife Acoustics 2019) to convert the full-spectrum call files to zero-cross files and remove noise (i.e., non-bat) files. For all files classified as containing a bat echolocation call, a biologist manually reviewed the zero-cross call files using program Analook (Titley Scientific) to ensure detections contained a minimum of two distinct pulses and to confirm the recording was consistent with that of a HAHOBA. Manual review of all recorded bat calls by a bat biologist helped minimize the potential for false positives to be included in the final dataset. Social calls and feeding buzzes were noted during the manual review process for later assessment of behavioral activity at sites. A subset of noise files was also examined to ensure detectors were functioning properly when several consecutive nights with no recordings occurred.

Occupancy Analysis

Occupancy and detection rates of HAHOBA in the leeward Haleakala study area were modeled from nightly detector data collected during the Study Period (July 16, 2019 – August 31, 2020). Multi-state occupancy models (Royle 2004, Royle and Link 2005, Nichols et al. 2007, Kery and Royle 2020) were used to determine if occupied cells with higher HAHOBA activity as recorded by the detectors were associated with specific habitat characteristics. In this approach, the occupancy state is recorded as either unoccupied (state 1), occupied at low activity (state 2), or occupied at high activity (state 3). We used the static model of occupancy (Table 1) rather than the dynamic multi-state occupancy model because identifying habitat covariates related to HAHOBA activity were of primary interest and convergence was an issue with the parameter-rich dynamic models. We assumed closure within reproductive seasons as defined by Gorresen et al. (2013, as adapted from Menard 2001): lactation season from mid-June to August; post-lactation season from September to mid-December; pre-pregnancy season from mid-December to March; and pregnancy season from April to mid-June. Because only the lactation season was surveyed more than once, the five seasons were treated as independent time strata and no effect due to the reproductive season was modeled.

Table 1: Multi-state parameters for the static multi-season occupancy model

Occupancy Model Parameter	Description
psi	Occupancy rate.
r	Probability of high activity given occupancy.
p2	Probability that the true state is low-activity occupancy and is accurately observed as such.
p31	Probability that the true state is high-activity occupancy but is observed as unoccupied.
p32	Probability that the true state is high-activity occupancy but is observed as low-activity occupancy.
p33	Probability that the true state is high-activity occupancy and is accurately observed as such.
alpha.lpsi	Regression intercept for predictor of low occupancy state.
beta.lpsi	Regression coefficient for predictor of low occupancy state.
alpha.lr	Regression intercept for predictor of high activity state given occupancy
beta.lr	Regression coefficient for predictor of high activity state given occupancy.

Consistent with covariates used on the Oahu Study, we obtained spatial data for site slope, site elevation, and land cover distributions (Jacobi et al. 2017) for categories such as agriculture, developed land, dry grassland, forest cover, wetlands, and other cover types. Elevation was converted from meters to kilometers to improve convergence. The mean of the site slope and site elevation and the percentage of each land cover category (Table 2) was calculated for each grid cell. These cell-level covariates were used to model occupancy and abundance states, and detection and classification processes were modeled as a function of season. To reduce the set of possible models, we used Wilcoxon rank sum tests to test whether the covariates differed between occupied and unoccupied cells. The two-sided test of model predictors was assessed by determining if the 95%-credible interval for the model covariate contains zero.

Table 2: Relative area of land cover categories used for occupancy modeling. Percent coverage provided for the island of Maui and the Leeward Haleakala Study Area

Land Cover Type	% (Island-wide)	% (Study Area)
Agriculture	14.04	0.01
Developed	8.24	0.69
Dry Forest	7.55	6.78
Dry Grassland	8.53	20.68
Dry Shrubland	5.66	9.27
Mesic Forest	12.11	4.70
Mesic Grassland	7.91	23.55
Mesic Shrubland	3.71	9.83
Not Vegetated	8.56	23.80
Wet Forest	20.16	0.45
Wet Grassland	0.50	0.00
Wet Shrubland	2.63	0.23
Wetland	0.39	0.00

We evaluated the independence of counts over time at a grid cell to examine if the counts were correlated over time. We modeled the counts by site with the auto.arima function in the *forecast* package (Hyndman et al. 2021). If the counts for consecutive nights were correlated as evidenced by resulting autoregressive and/or moving-average models, then counts for a systematic random sample taken every four nights were modeled with the auto.arima function. If temporal correlation was still detected, then systematic random samples of every seven, 10, and 14 nights were examined until a model assuming independent counts was obtained.

All modeling was conducted in R (R Development Core Team 2021). The dynamic occupancy model for correlated detections (Hines et al. 2014) was applied in a Bayesian context with the *rjags* package (Plummer 2019) and the jagsUI package (Kellner 2019). We assumed uniform (0,1) priors for all unknown probability parameters and vague Gaussian priors (Normal [0, 0.01]) for regression parameters. Three parallel Monte Carlo Markov chains were used, each sampling for 10,000 iterations after a burn-in phase of 2,000 iterations. Model diagnostics included convergence checks, trace plot review, and posterior predictive checking (Gelman et al. 2013). Model selection was conducted with the Watanabe-Akaike information criteria (WAIC; Watanabe 2010).

Results

All 20 detectors were deployed over a three-day period from July 16-18, 2019 and remained in the field through at least August 9, 2020. Due to the COVID-19 Pandemic, the time between detector checks was substantially longer in 2020 than in 2019, resulting in some loss of data late in the Study Period as data cards filled prior to collection. The removal of detectors from the field was also affected, with detectors removed as travel/work restrictions allowed. This resulted in detectors being removed from the field at varied times from mid-August 2020 through early January 2021. For the purposes of our study, analyses were restricted to the dataset spanning July 16, 2019 through August 31, 2020 (the Study Period).

Detector Data

Total Detections

Bat calls were recorded at all 20 detectors during the Study Period, ranging from a low of 118 to a high of 7,299, totaling 35,390 HAHOBA detections calls across all detectors and seasons (Table 3). The number of detector nights sampled by site during the Study Period ranged from 322 to 412 (Table 3) and totaled 7,644 detector nights.

Detections per Detector Night

The mean number of site-level detections per detector night ranged from 0.35 to 17.76 among sites for all seasons combined (Table 3, Figure 4). Variability among mean detection rates differed somewhat across seasons, ranging from 1.46-21.38 during the lactation season, 0.46-20.28 during post-lactation, 0.03-9.80 during pre-pregnancy, and 0-40.81 during the pregnancy season (Appendix A; Figure 5). Bat calls were recorded at all detectors during all but the pregnancy season, when no detections were recorded at one site, 040-King's Hwy (Appendix A; Figure 5).

Detection rates were consistently higher at the mid to upper elevations in all seasons (Figure 5). Detector rates were lower during the pre-pregnancy season, when the highest detection rate recorded was 9.80 calls/detector night at site 096 Green Canyon, which was among the top two highest activity sites across all four seasons (Figure 5).

Proportion of Detector Nights

The proportion of detector nights with detections (i.e., frequency of detection) ranged from 0.13 to 0.93 among sites for all seasons combined (Table 3). The proportion of detector nights with detections varied among seasons, ranging from 0.39-0.96 during the lactation season, 0.24-0.97 during post-lactation, 0.03-0.89 during pre-pregnancy, and from 0-0.97 during the pregnancy season (Appendix A; Figure 6). The proportion of detector nights with detections demonstrated a similar seasonal pattern to that of mean detections per detector night, with the detections during the pre-pregnancy period consistently lower at sites than during the other seasons (Appendix A; Figure 6). In contrast, whereas detection rates were consistently higher across the mid to upper elevation sites during all seasons, frequency of detection varied more across seasons, with some sites having relatively high frequencies of detection in some seasons and much lower frequencies of detection in other seasons (Figure 6).

Feeding Buzzes and Social Calls

For the Study Period, 1,133 feeding buzzes and 159 social calls were recorded. Feeding buzzes were identified from call files recorded at all 20 detectors, with the greatest number of feeding buzzes recorded at the highest activity sites at the upper elevations; however, feeding buzz activity was relatively high at some lower elevations sites as well (e.g., sites 47, 64, 84; Table 3). Social calls were only identified at nine of the 20 detectors, with the vast majority (89%) recorded at two of the highest activity sites (sites 60 and 96; Table 3). The presence of feeding buzzes and social calls is reported only for informational purposes, and were not been incorporated into the occupancy analyses.

Table 3. Total detections, total detector nights, mean detections per night, and proportion of nights with detections by site within the leeward Haleakala study area from July 2019 – September 2020.

Site ID	Site Name	Detections	Detector Nights[a]	Mean Detections Per Detector Night	Nights with Detections	Proportion of Detector Nights with Detections	Buzz Calls	Social Calls
4	Ulu Ranch	1,024	341	3.00	234	0.69	36	1
12	Noname-DHHL	227	327	0.69	86	0.26	17	0
16	Park Fence	1,495	360	4.15	241	0.67	101	0
20	Lower Kaupo Point	1,181	384	3.08	215	0.56	29	2
40	Kings Hwy	118	342	0.35	46	0.13	7	0
47	Dust Bath	702	412	1.70	250	0.61	49	0
48	Kaupo Gap Trail	3,216	411	7.82	330	0.80	73	2
56	Grassy Pasture	712	411	1.73	217	0.53	13	0
60	Koa Pasture	4,156	411	10.11	382	0.93	106	21
63	Quarry	688	411	1.67	253	0.62	24	0
64	Kiawe Trees	472	389	1.21	162	0.42	72	1
68	Goat Trail	404	412	0.98	164	0.40	10	0
84	Kaupo Store	781	389	2.01	164	0.42	87	0
92	Broken Tree	4,518	408	11.07	373	0.91	226	5
96	Green Canyon	7,299	411	17.76	373	0.91	142	120
104	Grassy Lava	157	371	0.42	89	0.24	16	0
112	KaupoGrassyFence	6,897	411	16.78	359	0.87	59	5
120	DHHL Hwy	409	330	1.24	111	0.34	22	2
127	Lava Fields	470	391	1.20	163	0.42	33	0
128	Waiopae Cabin	464	322	1.44	135	0.42	11	0

[a] Denotes nights that the detector was fully functional

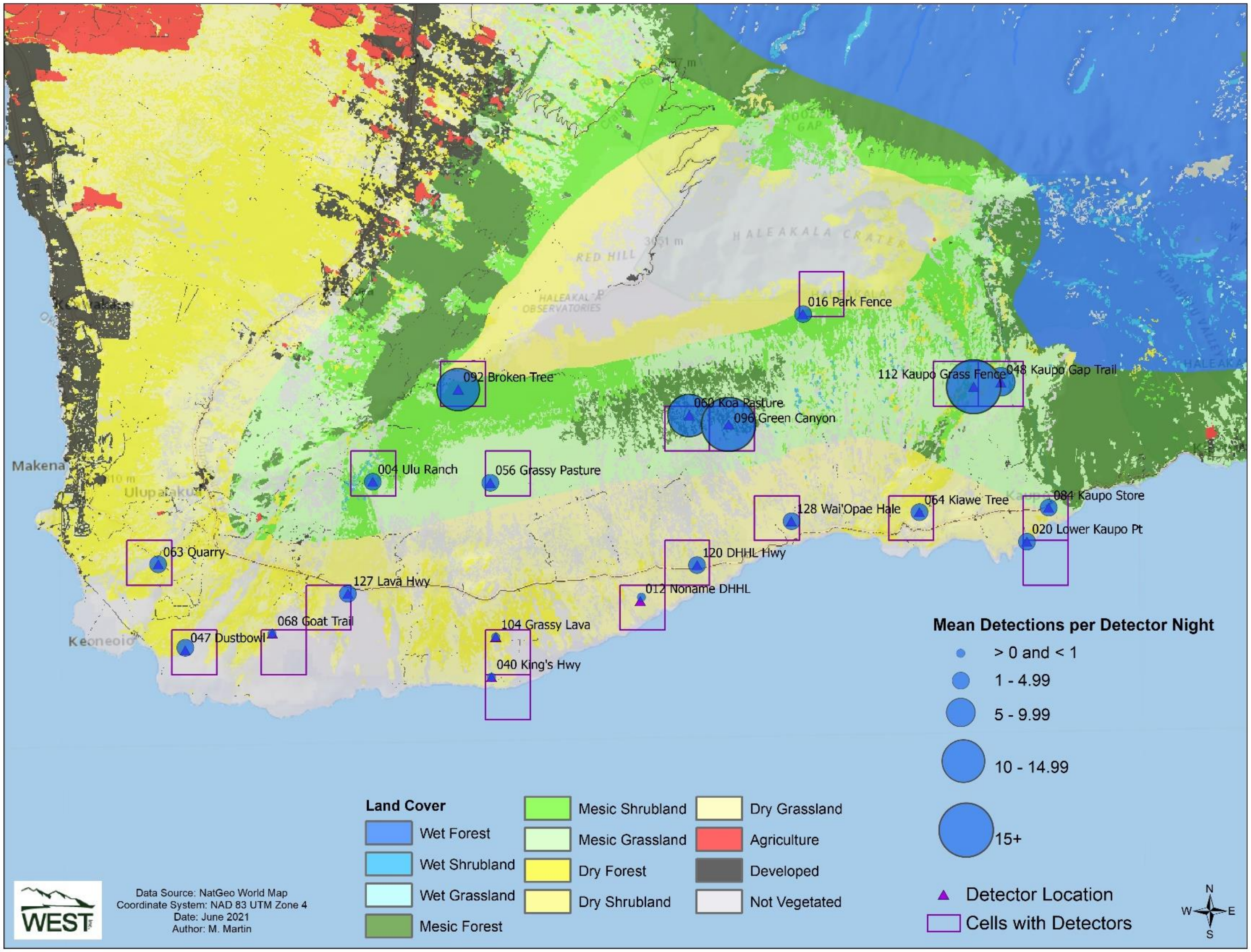

Figure 4: Mean detections per detector night by site between July 2019 and August 2020.

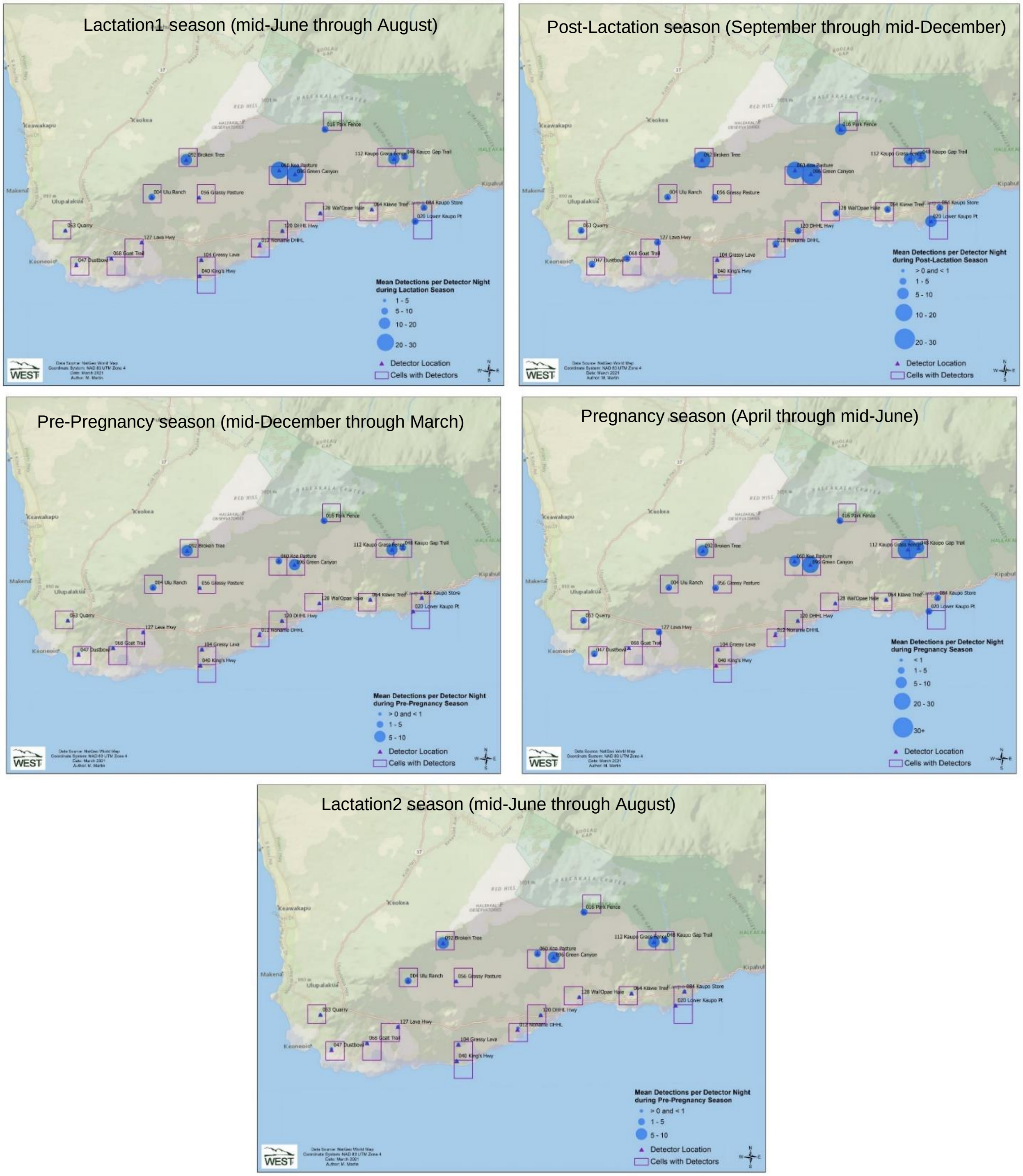

Figure 5. Spatial pattern of mean detections per detector night by site and season during acoustic bat surveys conducted from July 2019 – August 2020 in the leeward Haleakala study area, Maui, Hawaii.

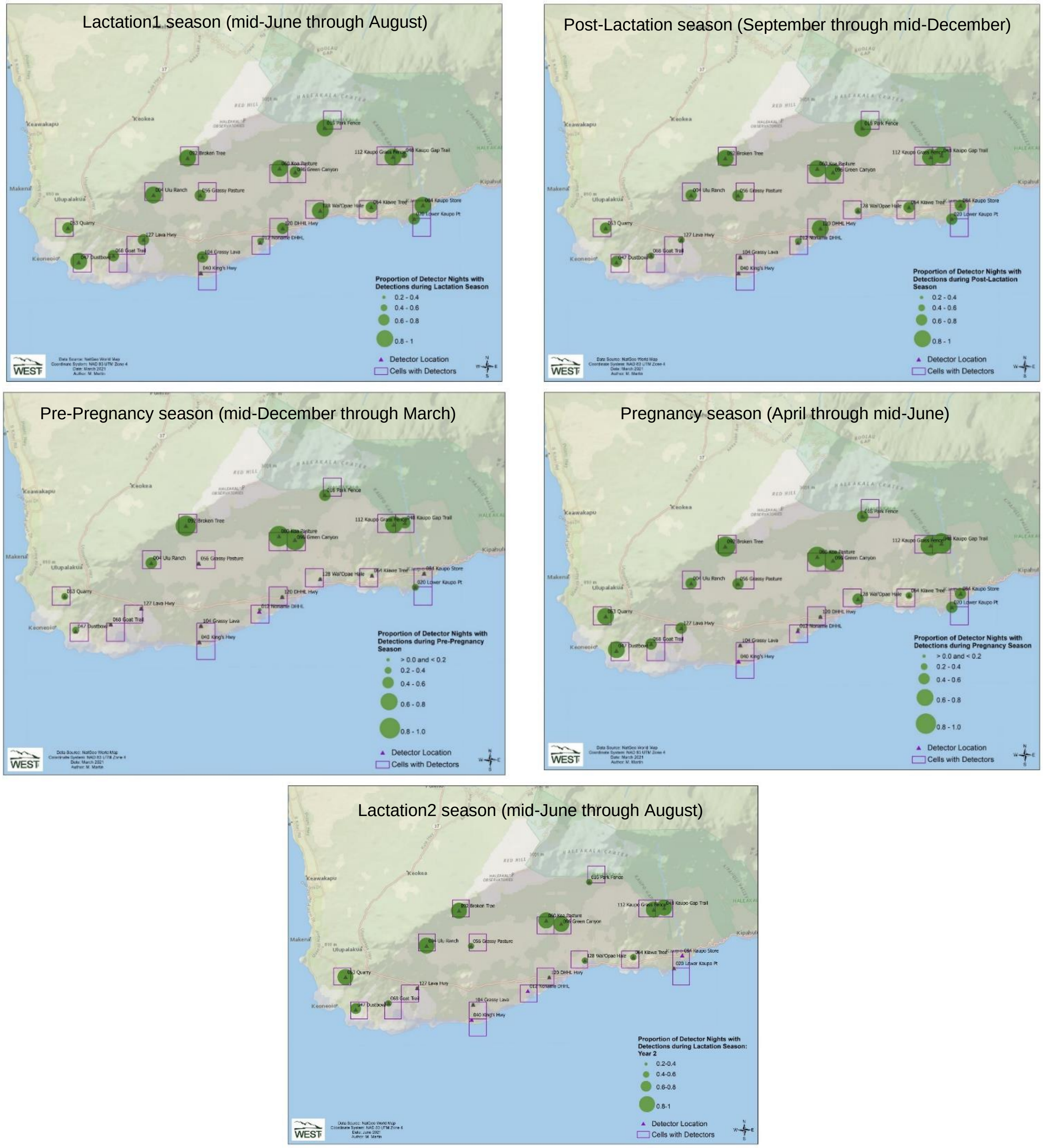

Figure 6. Spatial pattern of proportion of detector nights with detections by site and season in the leeward Haleakala study area between July 2019 and August 2020, Maui, Hawaii.

Occupancy Modeling

A median of one HAHOBA detection per night was observed across all sites and detector nights. The median nightly detection rate was 1.72 calls/detector night by site and 1.93 calls/detector night by site and season. To reflect these median values a cutoff of two detections per detector night was used to differentiate the low and high occupancy states.

Using the auto.arima function to model the time series of detections for each site, seven of the 20 sites required no autoregressive or moving average structure when counts from every seven days were used. For eight sites, a systematic sample of nights taken every 10 days was sufficient to assume independence, and for two sites a 14-day interval removed the autocorrelation among nightly detections. For three sites, correlation among nightly counts persisted even at an interval of 14 days. To ensure an adequate number of revisits to all sites, a 14-day interval of counts was used for all modeling.

Site-level covariates were examined with box plots (Figure 7), and mean values for occupied and unoccupied sites were compared with a Wilcoxon rank sum test. Covariates consisting of greater than 85% zeros or with a limited range near zero were omitted from the model selection process. Hypothesis tests indicated evidence of a shift in the covariates for slope (p-value = 0.0183), elevation (p-value = 0.0138), and percentage of dry grassland (p-value = 0.1278). These three covariates were used for multi-state occupancy model selection. All other p-values exceeded 0.2.

Model selection (Table 4) was conducted with the Watanabe-Akaike information criteria (WAIC; Watanabe 2010). The multi-state model with the lowest WAIC predicted overall occupancy as a function of elevation and season and high-activity occupancy only as a function of season. The model results (Table 5) include the regression coefficient for the mean elevation in each cell. The coefficient (beta.lpsi) is positive (11.98, 95%-credible interval: 3.39, 24.71), indicating that the probability of HAHOBA occupancy increases with elevation. Back-transformation of the coefficient reveals that a one-meter increase in mean grid cell elevation corresponds to a 1.21% increase in the odds of low-activity occupancy for a given season (95%-credible interval: 0.34%, 2.50%). High-activity occupancy was modeled only as a function of season. The probability of high-activity occupancy was highest during the first lactation season and lowest during the pregnancy season (Figure 8). It should be noted that the modeling results observed for occupancy states defined by a cutoff of two detections per night were nearly identical to those obtained when a cutoff of five detections was used.

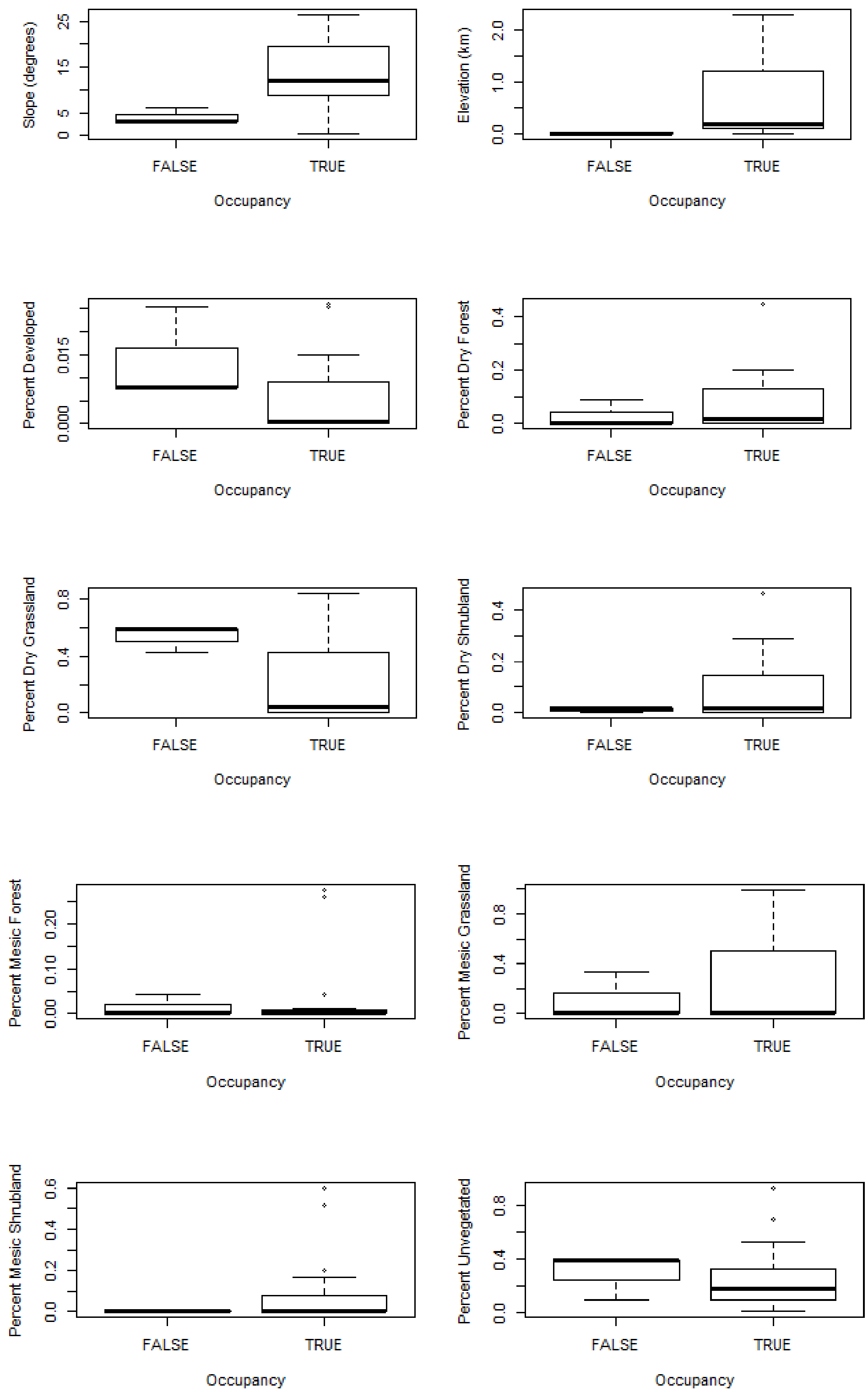

Figure 7: Boxplots of covariates for unoccupied (occupancy = FALSE) and occupied (occupancy = TRUE) cells.

Table 4: Multi-state occupancy model selection results

Occupancy Model (psi)	High-activity Model (r)	WAIC	# of Additional Parameters
elev	1	931.4	1
elev	DryGr_Pct	931.7	2
1	DryGr_pct	933.2	1
elev	slope	934.5	2
1	1	934.6	0
1	slope	935.9	1
DryGr_pct	1	940.2	1
1	elev	942.8	1
DryGr_Pct	slope	944.5	2
slope	DryGr_Pct	945.5	2
slope	1	948.1	1
DryGr_Pct	elev	948.9	2
slope	elev	951.2	2

Table 5: Multi-state occupancy model estimates for five seasons and a subsample of detections measured every 14 days

Parameter	Mean	SE	95%-Credible Interval Lower Bound	95%-Credible Interval Upper Bound
psi[1]	0.96	0.03	0.88	1.00
psi[2]	0.96	0.03	0.87	1.00
psi[3]	0.89	0.07	0.74	0.98
psi[4]	0.89	0.07	0.74	0.99
psi[5]	0.89	0.07	0.73	0.99
r[1]	0.91	0.06	0.77	0.99
r[2]	0.80	0.09	0.61	0.94
r[3]	0.60	0.12	0.36	0.83
r[4]	0.55	0.11	0.33	0.77
r[5]	0.74	0.11	0.51	0.93
p2[1]	0.62	0.23	0.09	0.95
p2[2]	0.30	0.10	0.13	0.50
p2[3]	0.25	0.07	0.12	0.39
p2[4]	0.29	0.08	0.16	0.46
p2[5]	0.30	0.13	0.09	0.58
p31[1]	0.20	0.05	0.11	0.30
p31[2]	0.22	0.04	0.15	0.30
p31[3]	0.42	0.06	0.31	0.54
p31[4]	0.15	0.05	0.07	0.25
p31[5]	0.24	0.06	0.14	0.37
p32[1]	0.19	0.05	0.10	0.30
p32[2]	0.23	0.04	0.16	0.31
p32[3]	0.28	0.05	0.18	0.38
p32[4]	0.18	0.05	0.10	0.29
p32[5]	0.14	0.05	0.07	0.24
p33[1]	0.61	0.06	0.48	0.73
p33[2]	0.55	0.05	0.46	0.64
p33[3]	0.30	0.06	0.19	0.42
p33[4]	0.67	0.06	0.53	0.79
p33[5]	0.61	0.07	0.48	0.74
alpha.lpsi[1]	1.96	1.05	0.09	4.26
alpha.lpsi[2]	1.94	1.04	0.08	4.17
alpha.lpsi[3]	0.49	0.94	-1.18	2.58
alpha.lpsi[4]	0.57	1.00	-1.16	2.83
alpha.lpsi[5]	0.54	1.06	-1.30	2.88
alpha.lr[1]	2.57	0.81	1.18	4.36
alpha.lr[2]	1.47	0.59	0.43	2.73
alpha.lr[3]	0.42	0.56	-0.59	1.58
alpha.lr[4]	0.22	0.49	-0.70	1.19
alpha.lr[5]	1.13	0.64	0.03	2.53
beta.lpsi	11.98	5.45	3.39	24.71

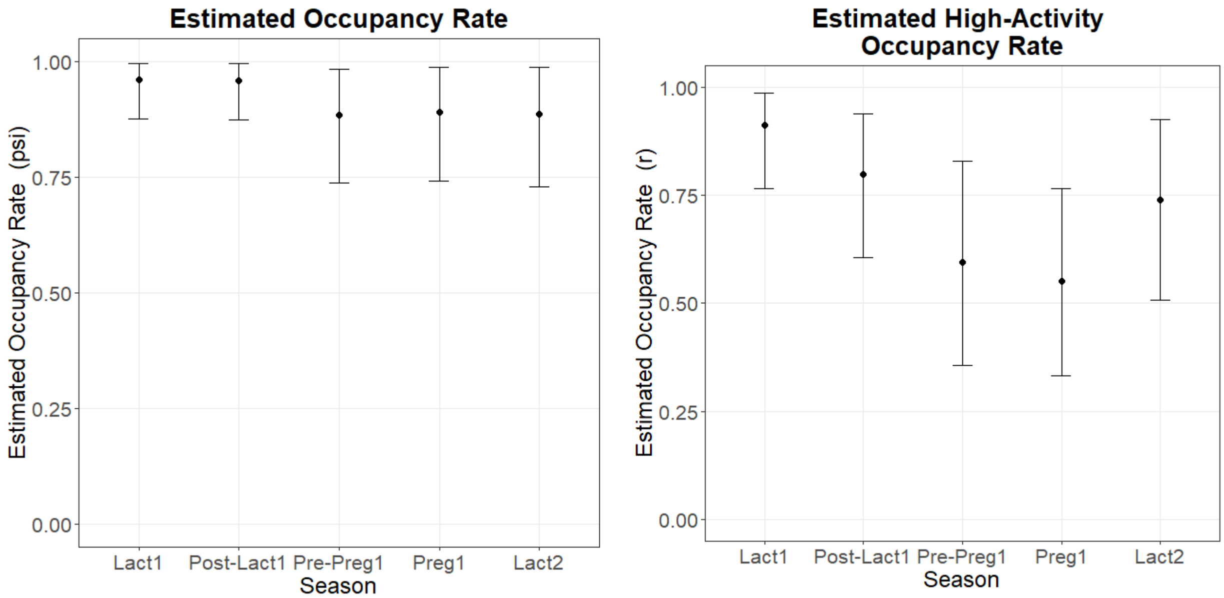

Figure 8: Plots of the overall occupancy rate (left panel) and high-activity occupancy rate (right panel) by season with 95%-credible intervals.

Discussion

Estimates of overall occupancy and high-activity occupancy were obtained in an attempt to identify habitat characteristics associated with high levels of HAHOBA activity. Our final model estimated the overall occupancy rate as a function of elevation and reproductive season, while the high-activity occupancy state was modeled solely as a function of reproductive season. Overall occupancy for the study area was consistently high across all seasons, ranging from 0.88 to 0.94 (Figure 8). High-activity occupancy was highest during the lactation seasons and lowest during the pre-pregnancy and pregnancy seasons. The temporal trend in occupancy is consistent with interim results from the Oahu Study, which has also shown lower occupancy rates during the pre-pregnancy and pregnancy seasons relative to the lactation and post-lactation seasons (Thompson and Starcevich 2021).

Based on the data collected during this study, it appears that HAHOBA use of the Leeward Haleakala Study Area is both widespread and variable in the level of activity. While bat calls were recorded in greater numbers at higher elevation sites, bats were identified during all seasons at all elevation gradients, with evidence of foraging activity documented at all detector locations. No habitat covariates were included in the top models; however, a mosaic of mesic land cover types (mesic shrub, mesic forest, and mesic grassland; see Figure 4) dominated the mid and upper elevations (elevation being positively associated with occupancy). While no one mesic land cover type appeared more important than the others (based on the models), the mesic zone is likely driven by elevation and its impacts on cloud cover and precipitation. As such, these land cover types (in some combination) may be more important than elevation in and of itself. Given the results of this study are only applicable to the Study Area, it is unknown if elevation would be as significant in other areas, such as the northeastern slopes of Haleakala, where higher elevation sites are dominated by wetter land cover types (e.g., wet forest, wet shrub, and wet grasslands; see Figure 4).

While inference from this study may be limited to the Leeward Haleakala study area, the results were consistent in some ways with those from the Oahu Study in that detection rates and occupancy were consistently higher during the lactation and post-lactation seasons relative to the pregnancy and pre-pregnancy periods. However, overall activity rates were much greater in the Leeward Haleakala study area than on Oahu. For the first three years of study on Oahu, bat activity only exceeded on one call per detector night at thee of 87 sites, with the highest rate of activity being 4.28 calls/detector night (Thompson and Starcevich 2021). In contrast, bat activity rates in the Leeward Haleakala study area exceeded one call per detector night at 16 of 20 (80%) sites, with the four highest activity sites having activity levels approximately 2.5 to four times greater than the highest activity sites on Oahu.

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Appendix A: Detections per Detector Night and Proportion of Detector Nights with Detections by Season for the Leeward Haleakala Occupancy Study, July 2019 – August 2020.

Appendix A. Hawaiian hoary bat detections per detector night and proportion of detector nights with detections by season for the Leeward Haleakala occupancy study, July 2019 – August 2020.

Site ID	Site Name	Mean Detections per Detector Night					Proportion of Nights with Detections				
		Lactation1	Post-Lactation	Pre-Pregnancy	Pregnancy	Lactation2	Lactation1	Post-Lactation	Pre-Pregnancy	Pregnancy	Lactation2
4	Ulu Ranch	8.89	2.77	1.21	2.24	4.25	0.96	0.75	0.57	0.57	0.88
12	Noname-DHHL	1.93	1.18	0.04	0.15	NA	0.57	0.47	0.03	0.12	NA
16	Park Fence	9.58	7.25	1.73	1.21	0.93	0.89	0.85	0.50	0.60	0.48
20	Lower Kaupo Point	5.07	6.02	0.86	2.41	0.84	0.78	0.74	0.39	0.59	0.30
40	Kings Hwy	1.46	0.46	0.03	0.00	0.00	0.39	0.24	0.03	0.00	0.00
47	Dust Bath	4.02	2.43	0.31	1.55	1.45	0.91	0.70	0.21	0.73	0.73
48	Kaupo Gap Trail	9.13	9.89	1.91	9.87	10.53	0.60	0.93	0.55	0.92	0.99
56	Grassy Pasture	4.31	2.52	0.31	1.39	1.47	0.78	0.72	0.19	0.53	0.59
60	Koa Pasture	21.38	11.44	4.44	7.92	11.78	0.96	0.95	0.89	0.91	0.96
63	Quarry	1.74	1.90	0.36	2.08	2.78	0.72	0.68	0.29	0.64	0.91
64	Kiawe Trees	2.60	2.56	0.10	0.41	0.79	0.78	0.69	0.10	0.28	0.41
68	Goat Trail	2.11	1.45	0.04	0.91	1.06	0.63	0.54	0.04	0.47	0.50
84	Kaupo Store	6.69	3.44	0.23	1.25	0.00	0.93	0.70	0.15	0.44	0.00
92	Broken Tree	19.44	16.49	5.37	5.99	11.53	0.96	0.93	0.82	0.92	0.99
96	Green Canyon	20.56	20.86	9.80	20.08	20.77	0.62	0.97	0.88	0.95	0.99
104	Grassy Lava	1.74	0.54	0.05	0.19	0.28	0.62	0.40	0.05	0.19	0.21
112	KaupoGrassyFence	10.13	9.85	6.12	40.31	22.09	0.96	0.93	0.63	0.97	0.99
120	DHHL Hwy	3.13	3.44	0.24	0.27	0.91	0.72	0.81	0.11	0.19	0.23
127	Lava Fields	2.89	1.47	0.14	1.81	0.56	0.76	0.53	0.09	0.59	0.32
128	Waiopae Cabin	4.26	1.08	0.33	0.75	2.50	0.83	0.54	0.16	0.43	0.55

Attachment 7

FY 2021 Annual Work Plan and Timeline

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<tr><td>Carcass Persistence Trials</td><td colspan="12">Quarterly Trials</td></tr>
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Attachment 8

FY 2021 Expenditures for HCP Implementation

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	Tier, Ongoing, or One-time	Event	Proposed Costs	Total Costs Incurred to Date (up to June 2021)	Costs Incurred FY 13 (July 1, 2012 - June 30, 2013)	Costs Incurred FY 14 (July 1, 2013 -June 30, 2014)	Costs Incurred FY 15 (July 1, 2014 -June 30, 2015)	Costs Incurred FY 16 (July 1, 2015 -June 30, 2016)	Costs Incurred FY 17 (July 1, 2016 -June 30, 2017)	Costs Incurred FY 18 (July 1, 2017 - June 30, 2018)	Costs Incurred FY 19 (July 1, 2018 - June 30, 2019)	Costs Incurred FY 19 (July 1, 2019 - June 30, 2020)	Costs Incurred FY 19 (July 1, 2020 - June 30, 2021)
General Measures	Ongoing	Wildlife Education and Incidental Reporting Program	$5,000	$4,667	$3,000	$1,500	$167	N/A	N/A	N/A	N/A	N/A	N/A
	Ongoing	Downed Wildlife Post-Construction Monitoring and Reporting and Mitigation Monitoring	$1,810,000	$1,204,547	$100,000	$185,145	$152,901	$108,727	$96,700	$140,167	$154,185	$176,497	$90,225
	Ongoing	*DOFAW Compliance Monitoring (only if needed)	$200,000	$41,298	N/A	N/A	$2,423	N/A	4600	$8,100	$15,600	$7,800	$2,775
		Subtotal General Measures	*$2,015,000*	*$1,250,512*	*$103,000*	*$186,645*	*$155,491*	*$108,727*	*$101,300*	*$145,267*	*$169,785*	*$184,297*	*$93,000*
Hawaiian Hoary Bat	Tier 1	Retrofit fencing and restoration measures at the Waihou Mitigation Project	$522,000	$1,108,143	$314,900	$63,173	$128,410	$149,833	$126,463	$124,852	$137,337	$36,937	$26,238
	Tier 1	Acoustic Monitoring onsite	$40,000	$39,827	$5,000	$8,691	$14,663	$11,473	N/A	N/A	N/A	N/A	N/A
	Tier 2	Telemetry Research	$250,000	$249,999	N/A	$32,726	$8,308	$142,819	$66,146	N/A	N/A	N/A	N/A
	Tier 3	USGS Expanded Research	$250,000	$503,853	N/A	$32,726	$8,308	$142,819	$234,360	$81,518	$4,122	N/A	N/A
	Tier 4	Ulupalakua Ranch Conservation Easement and Related Work	$4,013,047	$1,069,613	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$188,161	$881,452
	Ongoing	Minimization Adaptive Management	N/A	$223,615	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$223,615	N/A
		Subtotal Bats	*$5,075,047*	*$3,195,050*	*$319,900*	*$137,316*	*$159,689*	*$446,944*	*$426,969*	*$206,370*	*$141,459*	*$448,713*	*$907,690*
Hawaiian Petrel	Tier 1	Burrow Monitoring and Predator Control	$550,000	$1,013,898	$214,000	$74,572	$107,743	$56,410	$62,731	$116,885	$187,437	$76,083	$118,037
		Subtotal Petrels	*$550,000*	$1,013,998	*$214,000*	*$74,572*	*$107,743*	*$56,410*	*$62,731*	*$116,885*	*$187,437*	*$76,183*	*$118,037*
Nene	One-Time	Research and Management Funding	$25,000	$25,000	$25,000	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Subtotal Nene	*$25,000*	*$25,000*	*$25,000*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
Backburn's Sphinx Moth	One-Time	Restoration of 6 acres of Dryland Forest	$144,000	$144,000	$144,000	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Subtotal Moth	*$144,000*	*$144,000*	*$144,000*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
		Total HCP-related Expenditures	**$7,809,047**	**$5,625,560**	**$805,900**	**$398,533**	**$422,923**	**$612,081**	**$591,000**	**$468,522**	**$498,681**	**$709,193**	**$1,118,727**

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