



Draft State Habitat Conservation Plan for Pakini Nui Wind Farm

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PREPARED FOR
Tawhiri Power LLC

PREPARED BY
SWCA Environmental Consultants

DRAFT STATE HABITAT CONSERVATION PLAN FOR PAKINI NUI WIND FARM

Prepared for

Tawhiri Power LLC
1291 E. Hillsdale Blvd., Suite 213
Foster City, California 94404
Attn: Steven Pace
(650) 358-1550, ext. 11

Prepared by

SWCA Environmental Consultants
307a Kamani Street
Honolulu, Hawai'i 96813
(808) 548-7922
www.swca.com

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EXECUTIVE SUMMARY

Pakini Nui Wind Farm, located near South Point on the Island of Hawai‘i, is a 20.5-megawatt (MW) operating wind energy facility (Project). Construction of the Project began in August 2006 and was completed in April 2007. The Project, consisting of 14 General Electric 1.5-MW SE turbines, began operations on April 3, 2007. Tawhiri Power LLC (Tawhiri) owns and operates the Project.

As of May 20, 2019, three Hawaiian hoary bat (*Lasiurus cinereus semotus*) fatalities have been observed at the Project Area. This species is listed as endangered under the Endangered Species Act of 1973 (ESA), 16 United States Code 1531-1544, and also Hawai‘i Revised Statutes (HRS) §195D. The first Hawaiian hoary bat fatality was found on August 31, 2013, during a scheduled search the first week of initiating a weekly monitoring effort. The second Hawaiian hoary bat was found on March 1, 2016, and the third Hawaiian hoary bat was found on April 12, 2018. Prior to the weekly searches, Tawhiri performed monthly searches of all turbines starting at the beginning of commercial operations on April 4, 2007. During this monthly search period, no fatalities of state- and ESA-listed species were found. The Hawaiian hoary bat is the only state and ESA listed species that has been found at the Pakini Nui Wind Farm.

Based on desktop risk assessments and avian field surveys (SWCA 2015a, 2015b, 2019), Tawhiri has determined that the Pakini Nui Wind Farm has the potential for incidental take of three species due to continued operation of the Project. All three species are state and ESA federally listed. These three species, which make up the Covered Species discussed in this Habitat Conservation Plan (HCP) (see Section 3), and the requested take amounts are listed below:

- Hawaiian hoary bat (‘ōpe‘ape‘a; federally and state endangered); 26 bats
- Hawaiian petrel (‘ua‘u; *Pterodroma sandwichensis*; federally and state endangered); 3 petrels
- Hawaiian goose (nēnē; *Branta sandvicensis*; federally and state endangered); 3 nēnē

No other listed, proposed, or candidate species have been found or are known or expected to be present in the Project Area, with the exception of the federally and state-listed band-rumped storm-petrel (*Oceanodroma castro*). The band-rumped storm-petrel was state listed as endangered prior to 1998 and federally listed as endangered on September 30, 2016. This species is exceptionally rare on Hawai‘i Island, and because the risk of death or injury is discountable, it is not included as a Covered Species.

ESA Section 9 prohibits take, unless authorized as incidental take under Section 10. Incidental take as a result of collision with turbines, the meteorological evaluation tower (MET), vehicles, etc. may occur as a result of the operation of the Project. Therefore, to comply with the ESA and HRS, and to avoid future potential violations of ESA Section 9 and the HRS §195D take prohibition, Tawhiri is voluntarily preparing this HCP and applying to the U.S. Fish and Wildlife Service for an incidental take permit (ITP), in accordance with Sections 10(a)(1)(B) and 10(a)(2) of the ESA, and to the Hawai‘i Division of Forestry and Wildlife for an incidental take license (ITL), pursuant to HRS §195D. This HCP has been prepared to fulfill regulatory requirements of both the ITP and ITL applications.

This HCP contains operational minimization measures—most notably, low wind speed curtailment—and mitigation measures to offset the impacts of potential incidental take. Mitigation for the Hawaiian hoary bat consists of habitat improvement at the Kahuku Unit of Hawai‘i Volcanoes National Park (HVNP). Habitat improvement includes removing invasive plant species and planting desired native species. Mitigation for the Hawaiian petrel consists of predator trapping, predator surveillance, and fence maintenance around a Hawaiian petrel nesting colony in HVNP. Mitigation for nēnē is for predator control and nest protection at a breeding pen located at Pi‘ihonua. All mitigation measures were developed with the intention of providing a net ecological benefit to the species in alignment with state and federal recovery goals.

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ABBREVIATIONS

BLNR	Board of Land and Natural Resources
CARE	carcass retention
CFR	Code of Federal Regulations
cm	centimeter
COD	Commercial Operation Date
DLNR	Department of Land and Natural Resources
DOFAW	Division of Forestry and Wildlife
ESA	Endangered Species Act
ESRC	Endangered Species Recovery Committee
GE	General Electric
ha	hectare
HCP	Habitat Conservation Plan
HRS	Hawai'i Revised Statutes
HVNP	Hawai'i Volcanoes National Park
ITL	incidental take license
ITP	incidental take permit
km	kilometer
m	meter
MBTA	Migratory Bird Treaty Act
MET	meteorological evaluation tower
MW	megawatt
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NPS	National Park Service
O&M	operations and maintenance
SD	Standard Deviation
SEEF	searcher efficiency
SHA	Safe Harbor Agreement
SWCA	SWCA Environmental Consultants
U.S.	United States
USFWS	U.S. Fish and Wildlife Service

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1 INTRODUCTION AND PROJECT OVERVIEW

Pakini Nui Wind Farm is a 20.5-megawatt (MW) operational wind energy facility (the Project; Figure 1.1) near South Point on the Island of Hawai‘i. Construction of the Project began in August 2006 and was completed in April 2007. The Project, consisting of 14 General Electric (GE) 1.5-MW SE turbines, began operations on April 3, 2007 (Commercial Operation Date [COD]). Tawhiri Power LLC (Tawhiri) owns and operates the Project.

Tawhiri has completed a number of wildlife studies at the Project. These efforts include the following:

- Avian report (Day 2005)
- Fatality searches, searcher efficiency, and carcass retention trials reports (Tawhiri Power 2007–2013; SWCA 2015b; Appendix I)
- Avian Point Count Surveys at Pakini Nui Wind Farm (SWCA Environmental Consultants [SWCA] 2015a; Appendix G)
- Acoustic bat activity monitoring (SWCA 2019; Appendix H)

As of May 20, 2019, three Hawaiian hoary bat (*Lasiurus cinereus semotus*) fatalities have been found in the Project Area. This species is listed as endangered under the Endangered Species Act of 1973 (ESA), 16 United States Code 1531-1544, and as endangered by the State of Hawai‘i under Hawai‘i Revised Statutes (HRS) §195D. Tawhiri performed monthly searches of all turbines from the COD through August 26, 2013, during which no fatalities were found. Weekly downed wildlife searches began at the site the week of August 26, 2013. The first recorded fatality of a Hawaiian hoary bat was on August 31, 2013. This Hawaiian hoary bat was found at the start of the weekly monitoring effort, during a scheduled search. The second Hawaiian hoary bat was found on March 1, 2016, and the third Hawaiian hoary bat was found on April 12, 2018. All three animals showed (or were subsequently reported to have) body penetrations, visible deformations, or missing body parts. The first bat,¹ a male found by Tawhiri technicians, appeared to be in the best condition. The second bat, also a male, was reported to have visible puncture wounds in its body. The remains of the third bat (sex undetermined as of May 2019), found by a canine searcher, was missing its head, thorax, abdomen, and internal organs and had both wing bones disarticulated from the main body cavity and was stripped of flesh.

A nightly and year-round low wind speed curtailment regime was instituted in March 2014 (described in more detail in Section 6.2.1). Fatality searches that included trials to calculate searcher efficiency and determine carcass retention times began on March 27, 2014. Weekly fatality searches using a canine began in July, 2017. The probability of detection for each year of searching is reported in Section 4.1.1.

Based on initial desktop-based risk assessments and avian field surveys (SWCA 2015a, 2015b, 2019), Tawhiri has determined that the incidental take of three species could occur from the continued operation of the Project. All three species are both ESA and state listed as endangered. These three species, which make up the Covered Species discussed in this Habitat Conservation Plan (HCP) (see Section 3), are listed below:

¹ The necropsy report provided for the first bat noted, “Signs of blunt force trauma included disarticulation of the ribs and spine, fracture of the skull, and tearing of the diaphragm. In my opinion . . . these changes were caused by the blow of a wind turbine blade, which rapidly resulted in the death of the bat.” The radiographic portion of the report noted no body fractures or metal density objects were found while the visible examination noted holes in the sides of the abdomen up to 8 millimeters in diameter; the right zygomatic arch (cheekbone) was fractured at mid-body; the gastrointestinal tract was absent; and the spleen, pancreas, adrenal glands, and gallbladder were indistinct or absent. No necropsy reports have been provided to date for the second or third bat fatalities.

- Hawaiian hoary bat (‘ōpe‘ape‘a; state and federally endangered)
- Hawaiian petrel (‘ua‘u; *Pterodroma sandwichensis*; state and federally endangered)
- Hawaiian goose (nēnē; *Branta sandvicensis*; state and federally endangered)

One additional species, the band-rumped storm-petrel (*Oceanodroma castro*), was state listed as endangered prior to 1998 and federally listed as endangered on September 30, 2016. This species was considered but not included as a Covered Species because, as discussed in Section 4.3.1., the risk of death or injury from the Project is discountable. However, as certain minimization and mitigation measures in the HCP may benefit this species, it is included in this HCP.

To comply with the ESA and to avoid future potential violations of the ESA Section 9 take prohibition, Tawhiri is voluntarily preparing this HCP and applying to the U.S. Fish and Wildlife Service (USFWS) for an incidental take permit (ITP), in accordance with Sections 10(a)(1)(B) and 10(a)(2) of the ESA, and to the Department of Land and Natural Resources (DLNR) for an incidental take license (ITL), pursuant to Hawai‘i Revised Statutes (HRS) §195D. This HCP has been prepared to fulfill regulatory requirements of both the ITP and ITL applications.

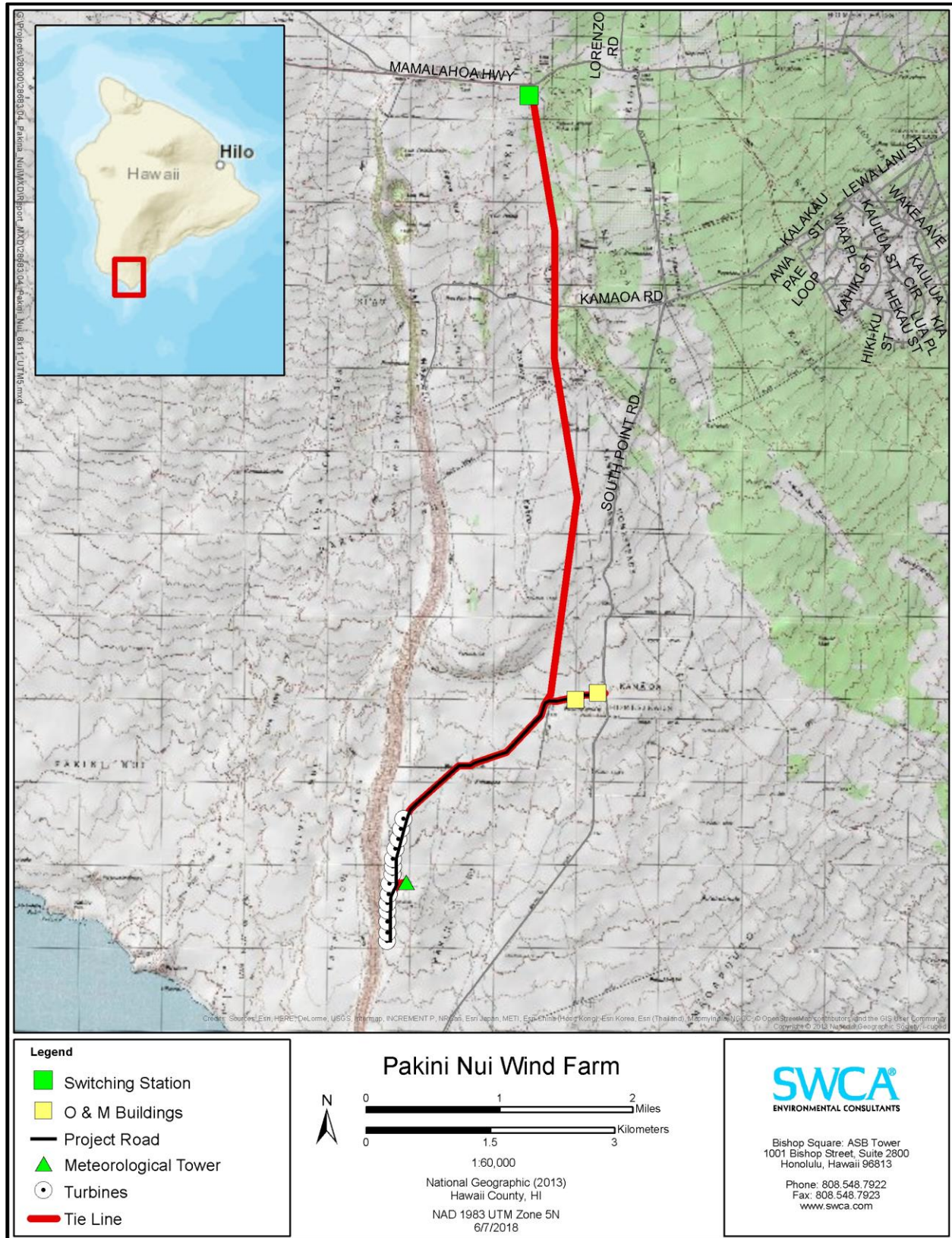


Figure 1.1. Pakini Nui Wind Farm Project location (O&M = operations and maintenance).

1.1 Applicant

The applicant for incidental take authorization related to the Project is Tawhiri.

1.2 Project Description

The Project, located near South Point on the Island of Hawai‘i, is a 20.5-MW operating wind energy facility (see Figure 1.1). Construction of the Project began in August 2006 and was completed in April 2007. The Project, consisting of 14 GE 1.5-MW SE turbines, began operations on April 3, 2007. Tawhiri owns and operates the Project.

A number of Project components are on leased lands (Figure 1.2). The Project wind turbine easement is 9.8 hectare (ha) (24.3 acres), the tie-line easement is 22.2 ha (54.9 acres), and the meteorological evaluation tower (MET) easement is 0.09 ha (0.22 acre). Together these lands comprise the Project Area, which totals 32.09 ha (79.42 acres).

Turbines are constructed of tubular towers with a hub height of approximately 65 meters (m) (213 feet); the rotor blades are approximately 70 m (230 feet) in diameter and reach a maximum height of 100 m (328 feet). Project turbines can be programmed to begin spinning at specific wind speeds and stop spinning (shut down) at specific wind speeds. The turbines are operated independently, based on individual turbine anemometry. One lattice structure MET tower 62 m (205 feet) high is approximately 183 m (600 feet) east of the middle of the turbine string.

The Project uses a 9.6-kilometer (km)-long (6-mile-long) aboveground transmission line to deliver power generated at the wind farm to the local power grid. This line is a single-conductor three-circuit line operating at 69 kilovolts (grid voltage). There are 82 poles in total: 53 are 17.3 m (57 feet) tall, 21 are 18.5 m (61 feet) tall, two are 15.8 m (52 feet) tall, two are 21.3 m (70 feet) tall, two are 22.9 (75 feet) tall, one is 20 m (66 feet) tall, and one is 24.0 m (79 feet) tall. Spacing between poles is approximately 122 m (400 feet), with three poles having two guy wires, six poles having four guy wires, one pole having six guy wires, and three poles having eight guy wires. The remaining posts are freestanding. Most of the guyed poles (eight) occur along the lower 2.4 km (1.5 miles) of the transmission line. A static line runs along the top of the poles and a fiber optic communications line is located approximately 20 feet from the ground.

The Project also comprises approximately 3.2 km (2 miles) of roads, 1.6 km (1 mile) of underground connector lines, a 0.6-ha (1.5-acre) operations and maintenance (O&M) building area, and a 0.48-ha (1.2-acre) substation (see Figure 1.1). Monthly on-site equipment checks using both 2-wheel- and 4-wheel-drive vehicles are conducted.

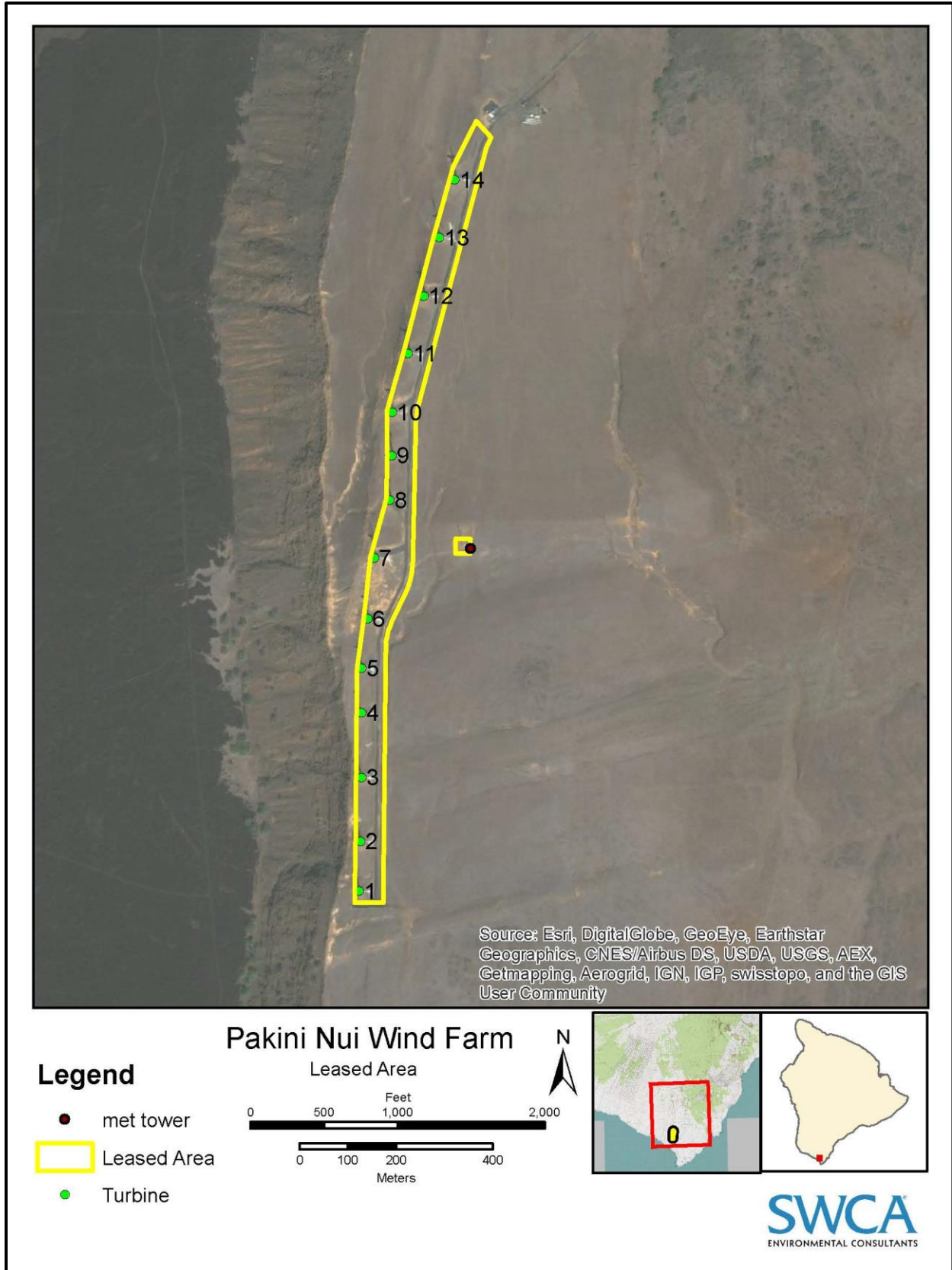


Figure 1.2. Close-up of total Pakini Nui Wind Farm Leased Area.

Minimization measures implemented at the Project Area and intended to decrease the risk of take to Covered Species are as follows (also described in Section 6.1):

- Minimize nighttime activities to avoid the use of lighting that could attract Hawaiian petrels and possibly Hawaiian hoary bats. This measure will also further reduce the attraction risk of band-rumped storm-petrels, which, due to discountable risk of death or injury, are not included as Covered Species in this HCP.
- Observe a speed limit of 40 km (25 miles) per hour while driving in the Project Area. This will help minimize collisions with Covered Species, in the event they are using habitat on-site or are injured. If nēnē are observed at or near the site, a speed limit of 24.1 km (15 miles) per hour will be observed.
- Do not use barbed wire on perimeter fencing within the Leased Area (see Figure 1.2) because it poses an entangling risk to Hawaiian hoary bats.
- If gaps in grazing activity occur, Tawhiri will do its best to maintain vegetation height of less than 9 inches within the Leased Area so as not to attract nēnē breeding behavior.
- Refrain from purposely approaching and maintain a distance (by foot or vehicle) of 30 m (100 feet) from nēnē when present on-site in order to avoid erratic flight behavior that may increase strike risk.
- Implement low wind speed curtailment, as described in Section 6.2.1.

1.3 Purpose and Need

Tawhiri and its managing member, Apollo Energy Corporation, have been providing clean, renewable energy from wind facilities located near South Point on the Island of Hawai‘i since the mid-1980s. The current Project was installed in 2007 to replace the old Kamao‘a Wind Farm, an obsolete and decommissioned farm located several miles northwest of the Project Area (where the current O&M building is located). The new wind farm uses turbines with greater efficiency, power performance, and output, resulting in significantly reduced hub rotational speeds. Fourteen turbines are able to triple the generation that 37 smaller turbines had provided. These new turbines are also able to “ride through” all but the most significant grid events, staying online and providing critical power to rate payers when other conventional fossil-fueled generators have tripped offline. Finally, the Project is able to provide up to 20% of the Island of Hawai‘i’s total electrical generation needs, providing a significant contribution to the county and state renewable portfolio while providing cost-effective, clean, renewable energy for nearly 18,000 homes annually.

The first recorded fatality of a Hawaiian hoary bat carcass on August 31, 2013, marked the first site-specific data available to Tawhiri indicating the potential for incidental take of an ESA- and state-listed species could occur at the Project. Therefore, to comply with the ESA and HRS, and to avoid potential violations of ESA Section 9 and HRS §195D take prohibitions as a result of fulfilling contractual obligations to continue operation of the Project, Tawhiri is voluntarily preparing this HCP and applying to the USFWS for an ITP in accordance with Sections 10(a)(1)(B) and 10(a)(2) of the ESA, and to the Hawai‘i Division of Forestry and Wildlife (DOFAW) for an ITL, pursuant to HRS §195D. This purpose of this HCP is to fulfill regulatory requirements of both the ITP and ITL applications.

1.4 Covered Activities

Covered Activities discussed in this HCP are those operational and decommissioning activities within the Permit Area (see Section 1.5) that could result in an incidental take of one or more Covered Species and

for which Tawhiri seeks incidental take authorization (see Section 1.2). In the context of this document, *decommissioning* refers to site deconstruction and the removal of all aboveground facilities except for any buildings that the lessors wish to remain standing. Of the Project components and activities described in Section 1.2, only the ongoing existence of the MET tower and the existence and operation of turbines present a likelihood for an incidental take of a Covered Species. Approximately 9.6 km (6 miles) of aboveground tie-lines connect the Project to the island’s power grid. Although the risk of collision between a Covered Species and a portion of the Project tie-line is discountable (see Sections 3.1.2, 3.2.2, 3.3.2, and 3.4.2), it is also included as a Covered Activity. Therefore, these are the only Project components and activities for which Tawhiri seeks incidental take authorization. Presence and use of the O&M building and substation do not present potential effects to Covered Species.

1.5 Permit Area and Plan Area

The Permit Area for this HCP is the geographical area within which incidental take resulting from Covered Activities is expected to occur. The Permit Area consists of the Project Area, which comprises the lands leased by Tawhiri, and the search plots around the turbines, which extend outside of these leased lands and the Project tie-line (Table 1.1). The Permit Area is shown in Figure 1.3 and is approximately 45 ha (111.2 acres).

Table 1.1. TMKs, Legal Description, and Landowners of the Permit Area

TMK	Legal Description	Landowner(s)
Turbine search plots and Project facilities		
393001006	Hawai'i County, Zone 9, Section 3, Plat 1	Kamehameha Schools
393002006	Hawai'i County Zone 9, Section 3, Plat 2	Apollo Energy Corporation
Tie-line		
393001006	Hawai'i County, Zone 9, Section 3, Plat 2	Govt. State
393001006	Hawai'i County, Zone 9, Section 3, Plat 1	Kamehameha Schools
393004001	Hawai'i County, Zone 9, Section 3, Plat 1	Kamehameha Schools

Cattle and feral goats routinely graze the areas below and surrounding the turbines. Vegetation in these areas consists mostly of buffelgrass (*Cenchrus ciliaris*), which is grazed to stubble and interspersed with occasional lantana bush (*Lantana camara*) and kiawe tree (*Prosopis pallida*). The cliff west of the turbine string has similar vegetation but offers shelter from both wind and ungulates; therefore, this area hosts more and larger kiawe trees. The areas south and east of the Project Area consist mostly of grazed buffelgrass grasslands interspersed with non-native trees, such as kiawe tree. North of the Project Area, the vegetation becomes gradually more shrubby and woody, with mostly non-native tree and shrub species. At the northernmost portion of the tie-line, the vegetation consists of mostly native forest, with ‘ōhi‘a (*Metrosideros polymorpha*) and pūkiawe (*Leptecophylla tameiameiae*) as dominant species.

The Permit Area experiences relatively high average wind speeds. Wind direction is predominantly between 70° north and 90° north.

Additional lands addressed in the HCP are those that will be used for mitigation. Those areas are addressed in Section 6.

Together, the Permit Area and mitigation lands define the Plan Area.

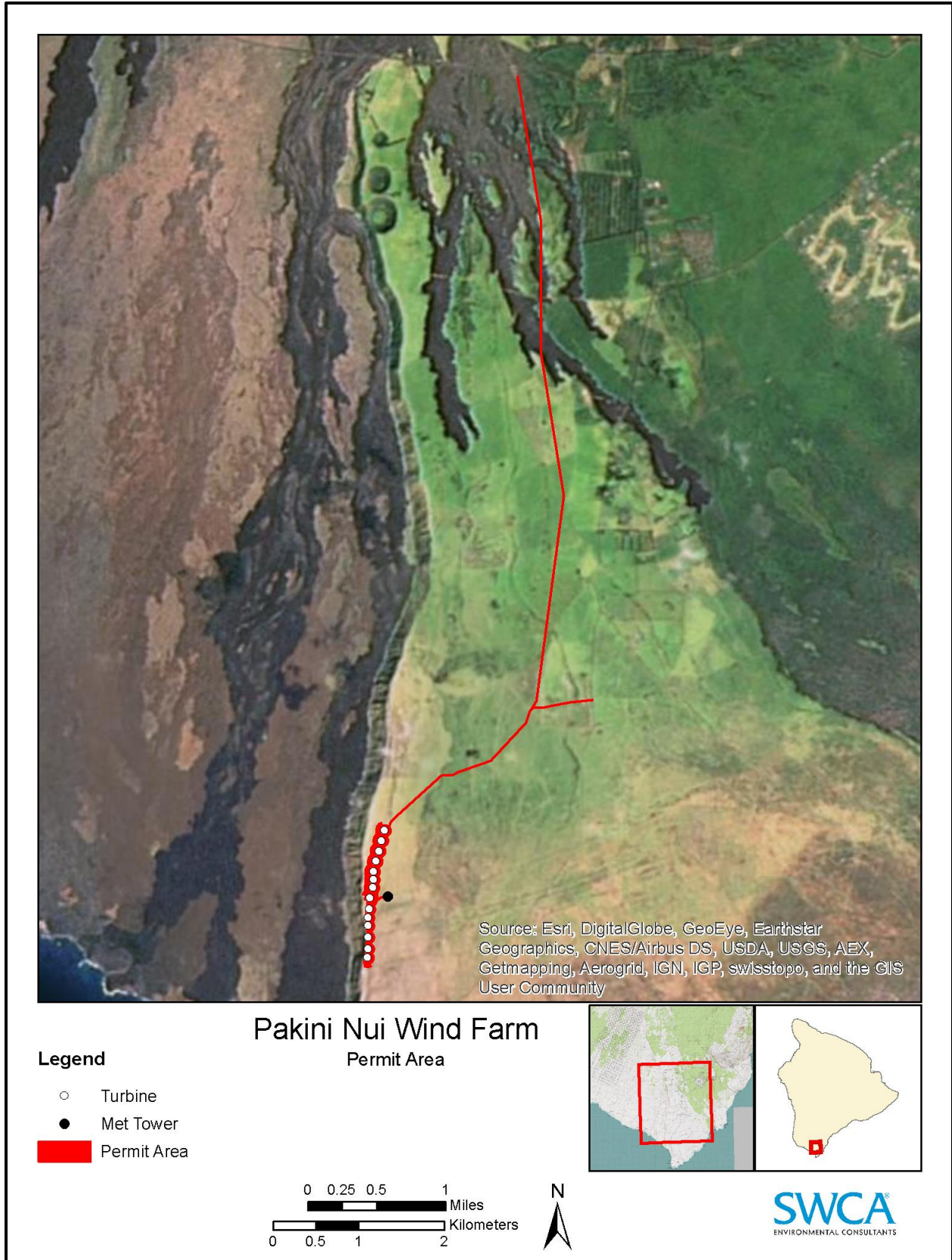


Figure 1.3. Pakini Nui Wind Farm Permit Area.

A number of project components are on leased lands (see Figure 1.3). The Project wind turbine easement is 9.8 ha (24.3 acres), the tie-line easement is 22.2 ha (54.9 acres), and the MET tower easement is 0.09 ha (0.22 acre).

1.6 Incidental Take Permit/Incidental Take License Duration

Tawhiri seeks incidental take authorization for a period of 10 years from the date of USFWS and DLNR authorization. This covers the anticipated remaining operating life of the Project that, as of April 4, 2019, is 8 years as well as the decommissioning stage (the period of time subsequent to the end of the operating life of the Project but prior to the end of the ITP/ITL permit duration of 10 years, currently anticipated to be 2.5 years and further defined in Section 1.4). Should a new power purchase agreement be instated after the remaining operating life of 8 years, a new HCP and ITP/ITL application will be created.

2 REGULATORY FRAMEWORK

This HCP has been prepared to fulfill regulatory requirements of both the ITP and ITL applications, as described below. Tawhiri is responsible for complying with all federal, state, and local laws.

2.1 Endangered Species Act

The ESA protects wildlife and plant species that have been listed as threatened or endangered. It is designed to conserve the ecosystem on which the species depend. Candidate species, which may be listed in the near future, are not afforded protection under the ESA until they are formally listed as endangered or threatened.

Section 9, and rules promulgated under Section 4(d), of the ESA prohibits the unauthorized take of any endangered or threatened species of wildlife listed under the ESA. Under the ESA, the term *take* means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect species listed as endangered or threatened, or to attempt to engage in any such conduct. As defined in regulations, the term *harm* means an act that actually kills or injures wildlife; it may include significant habitat modification or degradation, which actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering (50 Code of Federal Regulations [CFR] 17.3). The regulations define *harass* to mean an intentional or negligent act or omission that creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns, which include, but are not limited to, breeding, feeding, or sheltering (50 CFR 17.3).

By issuance of an ITP under Section 10, the USFWS may permit, under certain terms and conditions, any take otherwise prohibited by Section 9, or a rule under Section 4(d), of the ESA, if such take is incidental to the carrying out of an otherwise lawful activity (*incidental take*). To apply for an ITP, an applicant must develop and fund a USFWS-approved HCP to minimize and mitigate the effects of the incidental take. Such take may be permitted, provided the following ITP issuance criteria of ESA Section 10(a)(2)(B), 50 CFR 17.22(b)(2), and 50 CFR 17.32(b)(2) are met:

- The taking of a Covered Species will be incidental.
- The applicant will, to the maximum extent practicable, minimize and mitigate the impacts of such taking.
- The applicant will ensure that adequate funding for the HCP and procedures to deal with unforeseen circumstances will be provided.

- The taking will not appreciably reduce the likelihood of the survival and recovery of the Covered Species in the wild.
- Other necessary or appropriate measures required by the Secretary of the Interior, if any, will be met and the secretary has received such other assurances as he or she may require that the HCP will be implemented.

To obtain an ITP, an applicant must prepare a supporting HCP that provides the following information, described in ESA Sections 10(a)(2)(A) and (B), 50 CFR 17.22(b)(1), and 50 CFR 17.32(b)(1):

- The impact that will likely result from such taking.
- The measures that the applicant will undertake to monitor, minimize, and mitigate such impacts; the funding that will be available to implement such measures; and the procedures to be used to deal with unforeseen circumstances.
- The alternative actions to such taking considered by the applicant and the reasons why such alternatives are not proposed to be used.
- Such other measures that the secretary may require as necessary or appropriate for purposes of the HCP.

The *Habitat Conservation Planning and Incidental Take Permit Processing Handbook (HCP Handbook)*, published by the USFWS and the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (together, Services) in November 1996, provides additional policy guidance concerning the preparation and content of HCPs. The USFWS and NOAA published an addendum to the *HCP Handbook* on June 1, 2000 (*Federal Register* 65:35242–3525). This addendum, also known as the Five-Point Policy, provides clarifying guidance for applicants applying for ITPs and the Services issuing ITPs under ESA Section 10. The five components addressed in the policy are discussed briefly below.

Biological Goals and Objectives: HCPs must include biological goals (broad guiding principles for the conservation program and the rationale behind the minimization and mitigation strategies) and biological objectives (the measurable targets for achieving the biological goals). These goals and objectives must be based on the best scientific information available, and they are used to guide conservation strategies for species covered by the HCP.

Adaptive Management: The Five-Point Policy encourages the development of adaptive management plans as part of the HCP process under certain circumstances. Adaptive management is an integrated method for addressing biological uncertainty and devising alternative strategies for meeting biological goals and objectives. An adaptive management strategy is essential for HCPs that would otherwise pose a significant risk to the Covered Species due to significant information gaps.

Monitoring: Monitoring is a mandatory element of all HCPs under the Five-Point Policy. For this reason, an HCP must provide for monitoring programs to gauge the effectiveness of the HCP in meeting the biological goals and objectives and to verify that the terms and conditions of the HCP are being properly implemented.

Permit Duration: Regulations provide several factors that are used to determine the duration of an ITP, including the duration of the applicant's proposed activities and the expected positive and negative effects on Covered Species associated with the proposed duration (50 CFR 17.32 and 222.307). Under the Five-Point Policy, the USFWS also will consider the level of scientific and commercial data underlying the proposed operating conservation program of the HCP, the length of time necessary to implement and achieve the benefits of the program, and the extent to which the program incorporates adaptive management strategies.

Public Participation: Under Five-Point Policy guidance, the USFWS announced its intent to expand public participation in the HCP process to provide greater opportunity for the public to assess, review, and analyze HCPs and associated documentation (e.g., National Environmental Policy Act [NEPA] review). As part of this effort, the USFWS has expanded the public review process for most HCPs from a 30-day comment period to a 60-day period.

2.2 Hawai'i Revised Statutes Chapter 195D

The purpose of HRS §195D is “to insure the continued perpetuation of indigenous aquatic life, wildlife, and land plants, and their habitats for human enjoyment, for scientific purposes, and as members of ecosystems.” Chapter 195D-4 states that any endangered or threatened species of fish or wildlife recognized by the ESA shall be so deemed by state statute. Like the ESA, the unauthorized take of such endangered or threatened species is prohibited (HRS §195D-4(e)). Under §195D-4(g), the Board of Land and Natural Resources (BLNR), after consultation with the state’s Endangered Species Recovery Committee (ESRC), may issue a temporary ITL to allow a take otherwise prohibited if the take is incidental to the carrying out of an otherwise lawful activity.

To qualify for an ITL, the following must occur (language adapted from HRS §195D-4(g)):

- The applicant minimizes and mitigates the impacts of the incidental take to the maximum extent practicable (i.e., implements an HCP).
- The applicant guarantees that adequate funding for the HCP will be provided.
- The applicant posts a bond; provides an irrevocable letter of credit, insurance, or surety bond; or provides other similar financial tools, including depositing a sum of money in the endangered species trust fund created by HRS §195D-31, or provides other means approved by the BLNR adequate to ensure monitoring of the species by the state and to ensure that the applicant takes all actions necessary to minimize and mitigate the impacts of the incidental take.
- The plan increases the likelihood that the species will survive and recover.
- The plan takes into consideration the full range of the species on the island so that cumulative impacts associated with the incidental take can be adequately assessed.
- The activity permitted and facilitated by the license to incidentally take a species does not involve the use of submerged lands, mining, or blasting.
- The cumulative impact of the activity, which is permitted and facilitated by the license, provides net environmental benefits.
- The incidental take is not likely to cause the loss of genetic representation of an affected population of any endangered, threatened, proposed, or candidate plant species.

Chapter 195D-4(i) directs the DLNR to work cooperatively with federal agencies in concurrently processing HCPs, ITLs, and ITPs. Chapter 195D-21 deals specifically with HCPs, and its provisions are similar to those in federal regulations. According to this section, HCPs submitted in support of an ITL application shall do the following:

- Identify the geographic area encompassed by the HCP; the ecosystems, natural communities, or habitat types within the Plan Area that are the focus of the plan; and the endangered, threatened, proposed, and candidate species known or reasonably expected to be present in those ecosystems, natural communities, or habitat types in the Plan Area.

- Describe the activities contemplated to be undertaken in the Plan Area with sufficient detail to allow the department to evaluate the impact of the activities on the particular ecosystems, natural communities, or habitat types in the Plan Area that are the focus of the plan.
- Identify the steps that will be taken to minimize and mitigate all negative impacts, including, without limitation, the impact of any authorized incidental take, with consideration of the full range of the species on the island so that cumulative impacts associated with the incidental take can be adequately assessed, and the funding that will be available to implement those steps.
- Identify those measures or actions to be undertaken to protect, maintain, restore, or enhance the ecosystems, natural communities, or habitat types in the Plan Area; a schedule for implementation of the measures or actions; and an adequate funding source to ensure that the actions or measures, including monitoring, are undertaken in accordance with the schedule.
- Be consistent with the goals and objectives of any approved recovery plan for any endangered species or threatened species known or reasonably expected to occur in the ecosystems, natural communities, or habitat types in the Plan Area.
- Provide reasonable certainty that the ecosystems, natural communities, or habitat types will be maintained in the Plan Area throughout the life of the plan in sufficient quality, distribution, and extent to support in the Plan Area those species typically associated with the ecosystems, natural communities, or habitat types, including any endangered, threatened, proposed, and candidate species known or reasonably expected to be present in the ecosystems, natural communities, or habitat types within the Plan Area.
- Contain objective, measurable goals, the achievement of which will contribute significantly to the protection, maintenance, restoration, or enhancement of the ecosystems, natural communities, or habitat types; time frames within which the goals are to be achieved; provisions for monitoring (such as field sampling techniques), including periodic monitoring by representatives of the department or the ESRC, or both; and provisions for evaluating progress achieving the goals quantitatively and qualitatively.
- Provide for an adaptive management strategy that specifies the actions to be taken periodically if the plan is not achieving its goals.
- Contain sufficient information for the BLNR to ascertain with reasonable certainty the likely effect of the HCP upon any endangered, threatened, proposed, or candidate species in the Plan Area and throughout their habitat ranges.

In addition to the above requirements, all HCPs and actions authorized under the HCPs will be designed to result in an overall net benefit to the threatened and endangered species in Hawai‘i (HRS §195D-30).

Chapter 195D-25 provides for the creation of the ESRC, which is composed of biological experts, representatives of relevant federal and state agencies (e.g., the USFWS, U.S. Geological Survey, and DLNR), and appropriate governmental and nongovernmental members. The ESRC serves as a consultant to the DLNR and BLNR on matters relating to endangered, threatened, proposed, and candidate species. The ESRC reviews all applications for HCPs and makes recommendations to the DLNR and BLNR on whether they will be approved, amended, or rejected.

Following the preparation of the proposed HCP, it and the application must be made available for public review and comment no fewer than 60 days before approval. If the DLNR approves the HCP, the participant in the HCP (e.g., the ITL holder) must submit an annual report to the DLNR within 90 days of each fiscal year ending June 30, as further detailed in Section 7 and Appendix J; this report must include a description of activities and accomplishments, analysis of the problems and issues encountered in meeting

or failing to meet the objectives set forth in the HCP, areas needing technical advice, status of funding, and plans and management objectives for the next fiscal year (HRS §195D-21).

2.3 National Environmental Policy Act

Issuing an ITP is a federal action subject to compliance with NEPA. The purpose of NEPA is to promote agency analysis and public disclosure of the environmental issues surrounding a proposed federal action to reach a decision that reflects NEPA's mandate to strive for harmony between human activity and the natural world. The scope of NEPA goes beyond that of the ESA by considering the impact of a federal action on non-wildlife resources, such as water quality, air quality, and cultural resources. The USFWS will prepare and provide for public review an environmental assessment that evaluates the potential environmental impacts of approving the HCP and issuing an ITP. The purpose of the environmental assessment is to determine if ITP issuance and HCP implementation will significantly affect the quality of the human environment. If the USFWS determines that significant impacts are likely to occur, a comprehensive environmental impact statement for the proposed action will be prepared and distributed for public review; otherwise, a finding of no significant impact will be issued. The USFWS will not make a decision on ITP issuance until after the NEPA process is complete.

2.4 Migratory Bird Treaty Act

The three bird species addressed in this HCP—Hawaiian petrel, band-rumped storm-petrel, and nēnē—are also protected under the Migratory Bird Treaty Act of 1918 (MBTA), as amended (16 USC 703-712). The MBTA prohibits the take of migratory birds. A list of birds protected under MBTA implementing regulations is provided at 50 CFR 10.13. Unless permitted by regulations, under the MBTA, “it is unlawful to pursue, hunt, take, capture or kill; attempt to take, capture or kill; possess, offer to or sell, barter, purchase, deliver or cause to be shipped, exported, imported, transported, carried or received any migratory bird, part, nest, egg or product.” The USFWS does not currently have a comprehensive program under the MBTA to permit the take of migratory birds by otherwise lawful activities. On December 22, 2017, the Department of the Interior, Office of the Solicitor issued a memorandum opinion concluding that the MBTA does not prohibit incidental take of migratory birds.

On March 23, 2012, the USFWS released *Land-Based Wind Energy Guidelines* (USFWS 2012a). These voluntary guidelines provide recommended approaches for assessing and avoiding impacts to wildlife and their habitats, including migratory birds, associated with wind energy project development. The guidelines also help ensure compliance with federal laws such as the MBTA. The approach described in this document for the operation of this Project is consistent with these guidelines. To avoid and minimize impacts to migratory birds, the proposed HCP incorporates design and operational features based on the application of the USFWS Interim Guidelines to Avoid and Minimize Wildlife Impacts from Wind Turbines (issued May 13, 2003). These guidelines contain materials to assist in evaluating possible wind power sites, wind turbine design and location, and pre- and postconstruction research to identify and/or assess potential impacts to wildlife. Specific measures that have been adopted by Tawhiri into the HCP to avoid and minimize the potential for adverse impacts to migratory birds are detailed in Section 6 of this HCP. This HCP also specifies that any migratory bird collisions or other impacts that occur with the implementation of Covered Activities will be documented and reported to the USFWS.

3 ECOLOGY OF THE COVERED SPECIES AND BAND-RUMPED STORM-PETREL

3.1 Hawaiian Hoary Bat

3.1.1 *Population, Biology, and Distribution*

The Hawaiian hoary bat is the only native land mammal present in the Hawaiian archipelago. It is a subspecies of the hoary bat (*Lasiurus cinereus*), which occurs across much of North and South America. Males and females have a wingspan of approximately 0.3 m (1 foot), although females are typically larger and heavier than males, weighing on average 17.9 grams (0.6 ounce). Males average 14.2 grams (0.5 ounce). Both sexes have a coat of brown and gray fur. Individual hairs are tipped or frosted with white (DLNR 2015; Jacobs 1993; Mitchell et al. 2005).

Hawaiian hoary bats roost in native and non-native vegetation at least 1 m (3 feet) above ground level. They have been observed roosting in 'ōhi'a, hala (*Pandanus tectorius*), coconut palm (*Cocos nucifera*), ironwood (*Casuarina equisetifolia*), kukui (*Aleurites moluccana*), kiawe tree, avocado (*Persea americana*), mango (*Mangifera indica*), shower tree (*Cassia javanica*), pūkiawe, and fern clumps; they are also suspected to roost in eucalyptus (*Eucalyptus* spp.) and sugi pine (*Cryptomeria japonica*) stands. The species has been rarely observed using lava tubes, cracks in rocks, or human-made structures for roosting. While roosting during the day, Hawaiian hoary bats are solitary, although mothers and pups roost together (Kawailoa Wind Power 2014; USFWS 1998). One lychee tree in Hilo has been used as a nursery tree by multiple bats (personal communication, D. Sether, USFWS, September 14, 2015).

A preliminary study (November 2004 to August 2008) of a small sample of Hawaiian hoary bats (n = 28) on the Island of Hawai'i had a mean, estimated, short-term (3–13 calendar days) core use area of 25.5 ha (63.0 acres) (Bonaccorso et al. 2015). The size of home ranges and core areas varied widely among individuals. Core areas included feeding ranges that were actively defended—especially by males—against conspecifics. Female core ranges overlapped with male ranges. Hawaiian hoary bats typically feed along a line of trees, forest edges, or roads, and a typical feeding range stretches approximately 275 m (902 feet). Hawaiian hoary bats will spend 20–30 minutes hunting in a feeding range before moving on to another (Bonaccorso 2011).

It is suspected that breeding primarily occurs between May and October (Gorresen et al. 2013). Lactating females have been documented from June to September (personal communication, D. Sether, USFWS, September 14, 2015), indicating that this is the period when non-volant young are most likely to be present. Breeding has been documented on the Islands of Hawai'i and Kaua'i, as well as a singular observation on O'ahu (Baldwin 1950; Kawailoa Power, LLC 2014; Kepler and Scott 1990; Menard 2001). Seasonal changes in the abundance of Hawaiian hoary bats at different elevations indicate that altitudinal movements occur on the Island of Hawai'i. During the pupping period (May through October), Hawaiian hoary bat occurrences increase in the lowlands and decrease at high-elevation habitats. In the winter, bat occurrences increase in high-elevation areas (above 1,525 m [5,000 feet]) from January through March (Bonaccorso 2011; Gorresen et al. 2013; Menard 2001).

Hawaiian hoary bats feed on a variety of native and non-native night-flying insects, including moths, beetles, crickets, mosquitoes, and termites (Whitaker and Tomich 1983). They appear to prefer moths ranging from 16 to 20 millimeters (0.60 to 0.89 inch) in size (Bellwood and Fullard 1984; Fullard 2001). Koa moths (*Scotorythra paludicola*), which are endemic to the Hawaiian Islands and use koa (*Acacia koa*) as a host plant (Haines et al. 2009), are frequently targeted as a food source (personal communication, M.P. Gorresen, 2013). Microchiroptera bats locate their prey using echolocation. Typical

peak frequency for echolocation hunting behavior occurs at 27.8 kilohertz, whereas social calls are recorded at a peak frequency of 9.6 kilohertz (Bellwood and Fullard 1984). Water courses and edges (e.g., coastlines and forest-pasture boundaries) appear to be important foraging areas (Brooks and Ford 2005; Francl et al. 2004; Grindal et al. 1999; Menzel et al. 2002; Morris 2008). In addition, Hawaiian hoary bats are attracted to insects that congregate near lights (Bellwood and Fullard 1984; DLNR 2015; Mitchell et al. 2005; USFWS 1998). They begin foraging either just before or after sunset, depending on the time of year (DLNR 2015; Jacobs 1993; Mitchell et al. 2005; USFWS 1998).

Hawaiian hoary bats have been confirmed on all of the main islands except Ni‘ihau (Day and Cooper 2002, 2008; HBMP 2007; Heber 2017; SWCA 2011). The species is most common on the islands of Hawai‘i, Maui, and Kaua‘i (Kepler and Scott 1990). The largest known breeding populations are thought to occur on Kaua‘i and Hawai‘i, although breeding was recently documented on Oahu (Kawailoa Wind Power 2013). Relatively little research has been conducted on the Hawaiian hoary bat, and data regarding its population status is very limited. Population estimates for this species range from hundreds to a few thousand; however, these estimates are based on limited and incomplete data due to the difficulty in estimating populations of patchily distributed bats (USFWS 2007). Acoustic monitoring of bat activity throughout the main Hawaiian Islands almost always picks up bat detections; however, there is no way to convert acoustic detections into a viable population estimate.

Understanding population status and specific habitat requirements of the Hawaiian hoary bat have been identified as primary data needs for species recovery (Gorresen et al. 2013; USFWS 1998). Occupancy models and genetic studies have been, and continue to be, conducted to attempt to estimate population indices and effective population sizes, although effective population does not necessarily equate to actual population size (Gorresen 2008; Gorresen et al. 2013). Although population estimates are not currently available, studies indicate that the bat population on Hawai‘i Island is stable and potentially increasing (Gorresen et al. 2013).

Hawaiian hoary bats have been observed year-round in a wide variety of habitats and elevations below 7,500 feet (2,286 m) and a few sightings from limited surveys have been reported as high as 13,199 feet (4,023 m). Hawaiian hoary bats have been detected in both wet and dry areas of Hawai‘i but seem to be more abundant on the drier leeward side (Jacobs 1994) and generally less abundant in wet areas (Kepler and Scott 1990). Several researchers have examined spatial and temporal variation in occurrence patterns of bats in Hawai‘i with conflicting conclusions about possible altitudinal or regional migration (Bonaccorso et al. 2015; Gorresen et al. 2013; Jacobs 1994; Menard 2001; Tomich 1986).

3.1.2 Threats

Little is known regarding threats to the Hawaiian hoary bat. The presumed decline of the species may be due to the decrease in canopy cover during historic times (Nowak 1994; Tomich 186)—in particular, the severe deforestation on O‘ahu in the early nineteenth century (Tomich 1986). The main observed mortalities of the Hawaiian hoary bat in the State of Hawai‘i have been from bats snagging on barbed wire, striking vehicles, and colliding with wind turbines. It also may be preyed upon by predatory birds such as owls (Amlin and Siddiqi 2015). The extent of the impact of barbed wire fences is unknown, because most are not checked regularly. The extent of mortality at wind farms is well documented (Table 3.1) because intensive monitoring is carried out to document such fatalities. Other threats may include pesticide use, which in the past has impacted federally listed bat species (Clark et al. 1978), and the introduction of non-native species such as introduced invertebrates, which alter the possible prey composition, and coqui frogs, which have the capacity to attain very high densities (Beard et al. 2009), resulting in reductions of total insect biomass (Bernard 2011).

3.1.3 Known Fatalities at Hawaiian Wind Farms

Fatalities of Hawaiian hoary bats have been documented at six operational wind farms in Hawai‘i, including the Project (see Table 3.1).

Table 3.1. Documented Fatalities of Hawaiian Hoary Bats at Wind Farms in Hawai‘i as of May 2019

Location	Observed Fatalities*	Calculated Take (80% Dalthorp [†])
Auwahi Wind Farm (Maui)	17	46
Kaheawa Wind Farm (Maui)	8	28
Kaheawa II Wind Farm (Maui)	12	37
Kahuku Wind Farm (O‘ahu)	4	12
Kawailoa Wind Farm (O‘ahu)	35	73
Pakini Nui Wind Farm (Hawai‘i)	3	Not applicable

* Sources: Tetra Tech (2018); Kaheawa Wind Power, LLC (2018a, 2018b); Kahuku Wind Power, LLC (2018); Tetra Tech (2019).

[†] The take estimate is based on Evidence of Absence software (Dalthorp et al. 2014; Dalthorp et al. 2017), existing literature, and site-specific data. It includes the indirect take estimate.

In their North American range, hoary bats are known to be more susceptible to collision with wind turbines than most other bat species (Erickson 2003; Johnson 2005; Johnson et al. 2000). Most mortality has been detected during the fall migration period. Hoary bats in Hawai‘i do not migrate in the traditional sense; although, as indicated, some seasonal altitudinal movements occur.

Baerwald et al. (2009) conducted a study during the peak period of migration (August 1–September 7, 2007) for hoary and silver-haired bats (*Lasionycteris noctivagans*) at a wind energy installation in southwestern Alberta, Canada, where the dominant fatalities were from the two bat species. Three treatment groups were tested (control turbines, treatment turbines with increased cut-in speed, and experimental idling turbines with the blades manipulated to be motionless during low wind speeds), combining the two experimental treatment results and comparing them to control turbines, Baerwald et al. (2009) conclude that the experimental turbines had lower fatality rates for each species (Arnett et al. 2013).

Cryan et al. (2014) analyzed wind turbine activities at a facility in northwestern Indiana using thermal video surveillance cameras supplemented with near-infrared video, acoustic detectors, and radar. Key findings were that wind speed and blade rotation speed influence the way that bats approach turbines. Bats approached turbines less frequently when their blades were spinning fast, and the prevalence of leeward approaches to the nacelle increased with wind speed at turbines with slow-moving or stationary blades (Cryan et al. 2014).

Studies from 10 different operational mitigation wind farms in North America found reductions in fatality rates by altering turbine operations. Most studies found at least a 50% reduction in bat fatalities when turbine cut-in speed was increased by 1.5 m (5 feet) per second above the manufacturer’s cut-in speed. Similar reductions in bat fatalities were reported by one study that implemented a raised cut-in speed given temperatures were above 9.5 degrees Celsius. One study demonstrated equally beneficial reductions with a low-speed idling approach, whereas another discovered that feathering turbine blades (pitched 90 degrees and parallel to the wind) at or below the manufacturer’s cut-in speed resulted in up to 72% fewer bats killed when turbines produced no electricity into the power grid (Arnett et al. 2013).

3.1.4 Known Occurrences in the South Point Area

Hawaiian hoary bats appear to be widespread on the Island of Hawai‘i (Jacobs 1994). According to Day (2005), Hawaiian hoary bats have been recorded at South Point. Bats also have been detected in the southern portion of the Kahuku Unit of Hawai‘i Volcanoes National Park (HVNP) and are widespread and present year-round (Fraser and HaySmith 2009). The Kahuku Unit is across the road from the transmission line of the Project and is approximately 12.5 km (7.8 miles) from the Project’s turbine string.

Bats have been documented in forests as well as pastureland and may use less forested areas during the nonbreeding season (Gorresen et al. 2013). Gorresen et al. (2013) found that, contrary to expectations, bat occupancy was not greater at less windy sites. Hawaiian hoary bats were as likely to occur at windy sites as at low-wind sites, although the authors did not directly correlate activity levels and wind speeds. Based on these findings, bats are expected to occur at the Project Area, although the sites included in Gorresen et al.’s (2013) study had lower average wind speeds than those recorded at the Project Area. The presence of Hawaiian hoary bats at the Project Area was confirmed when a Hawaiian hoary bat carcass was found below Turbine 12 on August 31, 2013.

As described in Appendix H, from December 2013 through December 2017 acoustic detectors were placed in various locations and distances from Project turbines and the permanent MET tower to ensure representative coverage of activity across the Project. Two detectors were placed at the rear of the nacelles in the southern- (Turbine 1) and northern- (Turbine 14) most turbines. Two detectors were placed on the ground, one halfway between Turbine 1 and Turbine 2, and another placed just downwind of Turbine 14. A fifth detector was placed at the base of the MET tower. A sixth detector was placed off-site west of Turbine 1 at the lip of the cliff to detect potential bat activity occurring in the lee of this cliff. Bat activity at Pakini Nui Wind Farm was detected at all locations, during all months of the year, and in all years of the study period. Average on-site bat activity for the study period was 0.43 pass per detector-night. Bat activity rates peaked in August and September along the turbine string. This seasonality in activity compares well with other Hawaiian hoary bat research, which may indicate that bats on Hawai‘i Island migrate to higher altitudes from the lowlands from September to March (post-lactation and pre-pregnancy time frames) (Menard 2001). Considering data from all the detectors located along the turbine string, bat activity was six times higher at ground height than nacelle height.

Bat activity at the detector west of Turbine 1 (located at the cliff edge) recorded over 15 times more passes (nearly 8-1/2 times more passes per detector-night) than at detectors located at ground level along the turbine string or MET tower, and some 165 times more passes (nearly 162 times more passes per detector-night) than the highest-recording nacelle detector. This difference is most apparent in 2015. It is possible that bats could be flying and feeding in the lee of the cliff where wind speeds can expect to be near zero during normal trade-wind periods, which is more than 95% of the time at Pakini Nui Wind Farm.

A recent study by Corcoran and Weller (2018) indicates that the mainland hoary bat may occasionally use “micro” calls (acoustic calls with very low sound energy that are very difficult or impossible to detect with current acoustic detection technology) or periodically not echolocate at all. Although this behavior has not been documented in the Hawaiian subspecies, it raises the question whether acoustic surveys accurately depict hoary bat use of an area.

3.2 Hawaiian Petrel

3.2.1 Population, Biology, and Distribution

The Hawaiian petrel was once abundant on all main Hawaiian Islands except Ni‘ihau (DLNR 2015; Mitchell et al. 2005). The population was most recently estimated to consist of approximately 17,000–34,000 individuals, with 4,000–5,000 breeding pairs (Spear et al. 1995). The once significant breeding populations of Hawaiian petrels on the Island of Hawai‘i were reduced to very small numbers by the end of the twentieth century (Banko 1980; Conant 1980; Richardson and Woodside 1954). Today there are an estimated 100 to 200 breeding pairs on the Island of Hawai‘i (Pyle and Pyle 2017). Hawaiian petrels continue to breed in high-elevation colonies on Maui, Hawai‘i, Kaua‘i, and Lāna‘i (Richardson and Woodside 1954; Simons and Hodges 1998; Telfer et al. 1987). Radar studies conducted in 2002 also suggest that breeding may occur on Moloka‘i (Day and Cooper 2002). It is believed that breeding no longer occurs on O‘ahu (Harrison 1990). The largest known breeding colony is at Haleakalā National Park on Maui, where as many as 1,000 pairs have been thought to nest annually (DLNR 2015; Mitchell et al. 2005). HVNP currently encompasses the largest active Hawaiian petrel colony on the Island of Hawai‘i. An accurate population estimate for Hawai‘i Island is lacking; however, a rudimentary estimate suggests approximately 2,000 individuals (Cooper and Day 2004).

Hawaiian petrels subsist primarily on squid, fish, and crustaceans caught near the sea surface. Foraging may take place thousands of km from their nesting sites during both breeding and nonbreeding seasons (Spear et al. 1995). In fact, recent studies using satellites and transmitters attached to Hawaiian petrels show that they can range across more than 10,000 km (6,200 miles) during 2-week foraging expeditions (Adams 2008).

Hawaiian petrels are active in their nesting colonies for approximately 8 months each year. The birds are long-lived (approximately 30 years) and return to the same nesting burrows each year between March and April. The nesting season occurs between late February and November, with Hawaiian petrels accessing their underground burrows nocturnally (Simons 1985). Breeding and prospecting birds fly to the nesting site in the evening and leave for foraging trips before dawn. Mean altitude during transitory inland flight is approximately 190 m (623 feet) aboveground for Maui birds (Day et al. 2003). Flight altitude is not believed to vary with the season (Cooper and Day 2004), although flight altitudes tend to be higher inland than at coastal locations (Cooper and Day 1998) and higher in the evening than at dawn (Day and Cooper 1995). Present-day Hawaiian petrel colonies are typically located at high elevations above 2,500 m (8,200 feet); however, seabird surveys at HVNP have focused on Hawaiian petrels in subalpine areas between 1,825 m (6,000 feet) and 3,050 m (10,000 feet) in elevation (Swift and Burt-Toland 2009). The types of habitats used for nesting are diverse and range from xeric habitats with little or no vegetation, such as at Haleakalā National Park on Maui, to wet forests dominated by ‘ōhi‘a with a uluhe (*Dicranopteris linearis*) understory, such as those found on Kaua‘i (DLNR 2015; Mitchell et al. 2005). Utilized lava flows range in age from 2,000 to 8,999 years old. Despite the extensive age range, the surfaces of all nesting flows were oxidized and broken (Hu et al. 2001). A 2001 study reveals that approximately half of the nests examined are located in pāhoehoe pits that exhibited evidence of human modification. The other half are located in various naturally occurring features such as lava tubes, cracks in tumuli (fractured hills on the surface of pāhoehoe flows), spaces created by the uplift of pāhoehoe slabs, and other miscellaneous nature features (Hu et al. 2001). Females lay only one egg per year, which is incubated alternately by both parents for approximately 55 days. Eggs hatch in June or July, after which both adults fly to sea to feed and return to feed the nestling. The young fledge and depart for the sea in October and November. Adult birds do not breed until age 6 and may not breed every year, but pre-breeding and nonbreeding birds nevertheless return to the colony each year to socialize

3.2.2 Threats

The main factors contributing to population declines of ground-nesting seabirds such as Hawaiian petrels are habitat degradation; the loss of nesting habitat; predation of eggs, hatchlings, and adults at nesting sites by introduced mammals (e.g., dogs [*Canis familiaris*], mongooses [*Herpestes javanicus*], cats [*Felis catus*], rats [*Rattus* spp.], and pigs [*Sus scrofa*]); and urban lighting and associated structures (e.g., power lines, buildings, and fences) that cause disorientation and fall-out of juvenile birds (Ainley et al. 1997; DLNR 2015; Hays and Conant 2007; Mitchell et al. 2005). In addition, introduced ungulates such as feral goats (*Capra hircus*) cause mortality and nest failure by trampling burrows (USFWS 2005a). The most serious cause of mortality and breeding failure of Hawaiian petrels is predation by introduced mammals (Hodges 1994; Simons 1985; Simons and Hodges 1998).

Introduced mammals have the potential to severely impact ground-nesting seabirds. Mongooses are abundant in low elevations, with an upper elevation limit of approximately 2,100 m (6,900 feet). As a result, they can prey on ground-nesting seabird species that nest along the coast or at low elevations (Swift and Burt-Toland 2009); mongooses may have displaced Hawaiian petrels at lower elevation breeding sites, where they were once common at all elevations on all the main islands (Simons 1985; Simons and Hodges 1998). Feral cats are more widely distributed, ranging from sea level to subalpine areas, and provide a major threat to ground-nesting birds at high elevations (Hodges 1994; Winter 2003). Disorientation and fall-out as a result of light attraction are less of an issue on Hawai‘i Island because of Hawai‘i County’s Outdoor Lighting Ordinance (Hawai‘i County Code, Chapter 14, Article 9). The ordinance requires shielded low-pressure sodium lamps for all ground illumination, thereby minimizing upward light pollution. This greatly reduces the risk of fall-out from seabirds. Towers, power lines, and obstructions (e.g., wind turbines) are hazards to seabirds (USFWS 2005b).

3.2.3 Known Fatalities at Hawaiian Wind Farms

Hawaiian petrel fatalities have been documented at Kaheawa and Auwahi Wind Farms on Maui (Table 3.2). These birds are presumed to have collided with turbines while flying to or from their nesting colony (SWCA 2012). Mortality of Hawaiian petrels as a result of collisions with power lines, fences, and other structures near breeding sites or attraction to bright lights has been documented (Ainley et al. 1997). Juvenile birds are sometimes grounded when they become disoriented by lights on their nocturnal first flight from inland breeding sites to the ocean (Ainley et al. 1997).

Table 3.2. Documented Fatalities of Hawaiian Petrels at Wind Farms in Hawai‘i as of May 2019

Location	Observed Fatalities	Calculated Take (80% Dalthorp)*
Auwahi Wind Farm (Maui)	1	4
Kaheawa Wind Farm (Maui)	6	15
Kaheawa II Wind Farm (Maui)	0	0
Kahuku Wind Farm (O‘ahu)	0	0
Kawailoa Wind Farm (O‘ahu)	1	Not applicable (N/A)
Pakini Nui Wind Farm (Hawai‘i)	0	N/A

Sources: Kaheawa Wind Power, LLC (2018a, 2018b); Kahuku Wind Power, LLC (2018); Tetra Tech (2018, 2019).

* The take estimate is based on Evidence of Absence software (Dalthorp et al. 2014; Dalthorp et al. 2017), existing literature (i.e., Huso et al. 2015), and site-specific data. It includes the indirect take estimate but does not include lost productivity, which is in addition to what is reported at the 80% assurance level.

3.2.4 Known Occurrences in the South Point Area

Day et al. (2003) studied the movements and distribution of Hawaiian petrels and Newell's shearwaters (*Puffinus newelli*) on the Island of Hawai'i using radar in 2001 and 2002. Because radar data do not identify passage rates by species and because there are no recent records of nesting Newell's shearwaters on Hawai'i Island—the most recent evidence from the Puna region being from 1993 (Reynolds and Richotte 1997)—radar detections from Day et al. (2003) are understood to be primarily Hawaiian petrels. Movement rates of Hawaiian petrels on the island are generally low (0.0–3.2 targets per hour), with the exception of Waipi'o Valley. The timing of evening movements suggested to the authors that Hawaiian petrels fly over the northern and southern parts of the island. Birds flying over the Project will have a low target rate of approximately 1–2 targets per hour, similar to what was observed at nearby coastal locations (Ho'opuloa and Punalu'u) (Day et al. 2003).

The closest known Hawaiian petrel colony is on the southwest flank of Mauna Loa, within the Kahuku Unit of HVNP, approximately 15.3 km (9.5 miles) upslope from the Project (Figure 3.1) (Swift and Burt-Toland 2009). Based on the Day et al. (2003) radar data, most of the birds nesting in this colony fly inland in the southwestern and southeastern parts of the island. A few Hawaiian petrels can be expected to fly over the southern part of the Island of Hawai'i during their flights inland toward or seaward from these nesting colonies (Day et al. 2003). A small-scale satellite telemetry study conducted in HVNP indicated that Hawaiian petrels from the largest colony on the island (the eastern slope of Mauna Loa, 54.7 km [34 miles] from the Project Area) may pass by or cross the Project Area on flights to and from the nesting colony.

Three other known colonies are on the southeast flank of Mauna Loa, also within HVNP, approximately 56.3 km (35 miles) from the Project. The park currently encompasses the largest active Hawaiian petrel colony on the Island of Hawai'i.

SWCA was unable to find information to support any hypothesis related to the effect of wind direction and landscape features on flight patterns of the Hawaiian petrel.

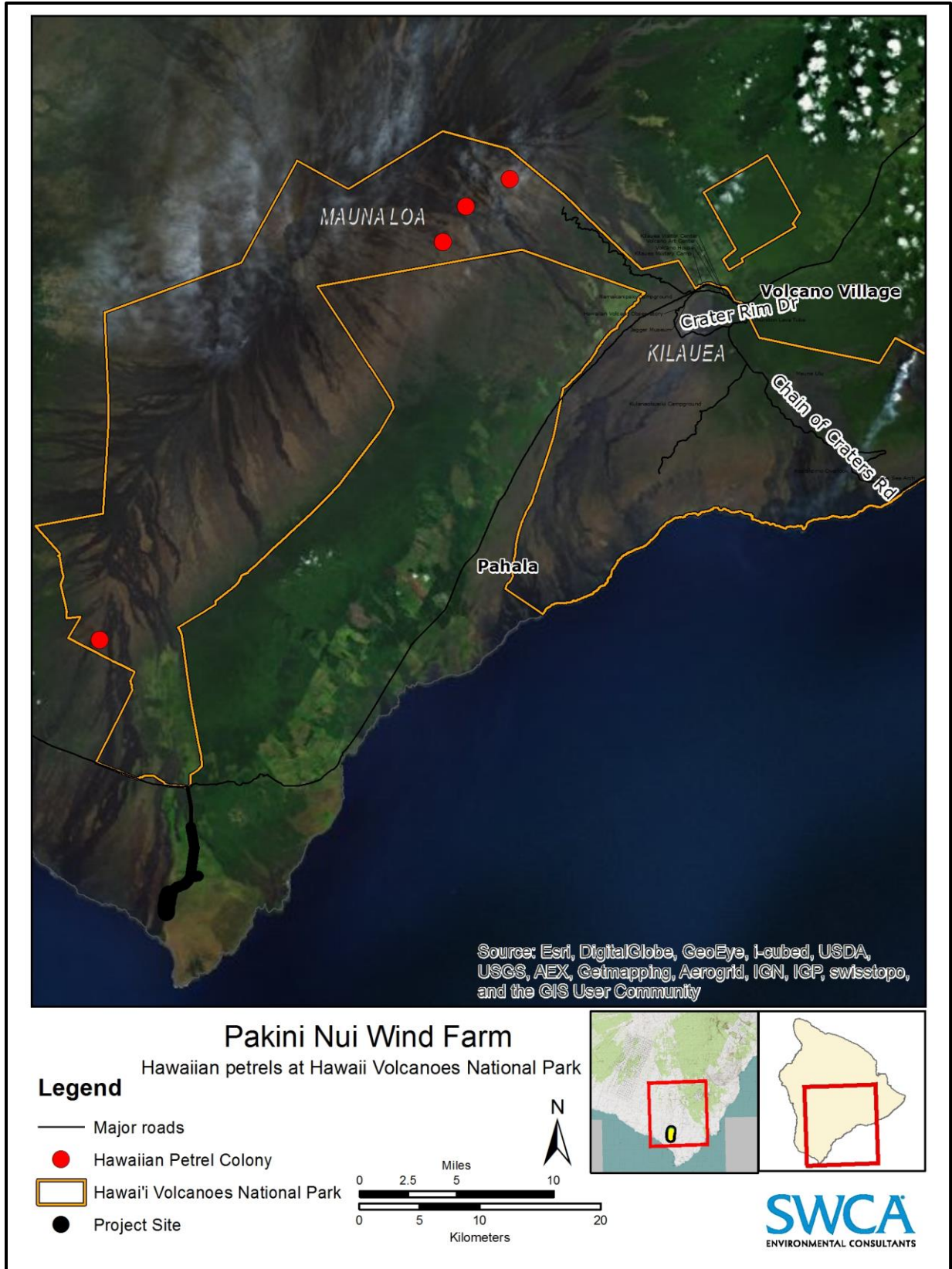


Figure 3.1. Approximate locations of Hawaiian petrel colonies in Hawai'i Volcanoes National Park (from Swift and Burt-Toland 2009).

3.3 Nēnē

3.3.1 *Population, Biology, and Distribution*

The nēnē is adapted to a terrestrial and largely nonmigratory lifestyle in the Hawaiian Islands, with negligible dependence on freshwater habitat. Compared to the related Canada goose (*Branta canadensis*), nēnē wings are smaller by approximately 16% and their flight capability is comparatively weak. Nonetheless, the nēnē is capable of both inter-island and high-altitude flight (Banko et al. 1999; Miller 1937).

After nearly becoming extinct in the 1940s and 1950s, the nēnē population has been slowly rebuilt through captive breeding programs. Wild populations of nēnē occur on Hawai‘i, Kaua‘i, Maui, and O‘ahu. The population of nēnē was estimated in 2014 at 3,047 individuals, with the largest population on Kaua‘i (personal communication, J. Charrier, USFWS, March 7, 2016.). The Hawai‘i Island population was estimated at 1,140 individuals (personal communication, J. Charrier, USFWS, March 7, 2016). Approximately 400 birds were slated to be moved from Kaua‘i to Maui, Moloka‘i, and Hawai‘i under an emergency declaration by then governor Neil Abercrombie. A significant portion of these birds has been moved to Hawai‘i Island.

The nēnē has an extended breeding season, with eggs reported from all months except May, June, and July, although the majority of birds in the wild nest during the rainy (winter) season between October and March (Banko et al. 1999; Kear and Berger 1980). Nēnē nest on the ground in a shallow scrape in the dense shade of a shrub or other vegetation. A clutch typically contains three to five eggs, and incubation lasts for 29–31 days. The female incubates the eggs, with the male standing guard nearby, often from an elevated location. Once hatched, the young remain in the nest for 1–2 days (Banko et al. 1999). Fledging of captive birds occurs at 10–12 weeks, but wild birds may fledge later. During molt, adults are flightless for a period of 4–6 weeks. Molt occurs after eggs hatch, such that the adults generally attain their flight feathers at about the same time as their offspring. When flightless, goslings and adults are extremely vulnerable to predators such as dogs, cats, and mongooses. From June to September, family groups join others in post-breeding aggregations (flocks), often far from nesting areas.

Nēnē occupy various habitat types, ranging from beach strand, shrub land, and grassland to lava rock at elevations ranging from coastal lowlands to alpine areas (Banko 1988; Banko et al. 1999). The geese eat plant material, and the composition of their diet depends largely on the vegetative composition of their surrounding habitat. They appear to be opportunistic in their choice of food plants, as long as the plants meet their nutritional demands (Banko et al. 1999; Woog and Black 2001).

3.3.2 *Threats*

The main factor limiting the recovery of nēnē populations is predation by introduced mammals, most notably cats, rats, and mongooses (Baker and Baker 1995; USFWS 2004). Additional threats may include predation by other mammalian predators, limited access or availability of nutritional resources during breeding, anthropomorphic disturbances (including car strikes, disturbance of nesting and feeding, and fatalities at golf courses), infectious/inflammatory diseases (e.g., *Toxoplasma gondii*), and toxicoses (e.g., lead poisoning) (USFWS 2004; Work et al. 2015). Breeding habitat, particularly at low elevations, may be limited (USFWS 2004).

3.3.3 Known Fatalities at Hawaiian Wind Farms

Fatalities of nēnē with wind turbines have been documented at wind farms on Maui. These fatalities have occurred in the Kaheawa area, where a resident population of nēnē is present year-round (SWCA 2012) (Table 3.3).

Table 3.3. Documented Total Nēnē Fatalities at Wind Farms in Hawai‘i as of May 2019

Location	Observed Fatalities*	Calculated Take (80% Dalthorp†)
Auwahi Wind Farm (Maui)	0	0
Kaheawa Wind Farm (Maui)	23	39
Kaheawa II Wind Farm (Maui)	6 (including one gosling)	14
Pakini Nui Wind Farm (Hawai‘i)	0	Not applicable

* Sources: Kaheawa Wind Power, LLC (2018a, 2018b); Tetra Tech (2018).

† The take estimate is based on Evidence of Absence software (Dalthorp et al. 2014; Dalthorp et al. 2017), existing literature, and site-specific data. It includes indirect take.

3.3.4 Known Occurrences in the South Point Area

Over 100 nēnē have been identified using the Kahuku Unit of HVNP over the past 10 years (personal communication, K. Misajon, HVNP, July 2016). These birds are wide-ranging, with the closest known population within the Kahuku Unit. The range of the nēnē in the park is shown in Figure 3.2. The Project’s turbines are approximately 40 km (25 miles) from this known population.

Day (2005) also mentions that there have been a few anecdotal sightings of nēnē near South Point itself. Potential nēnē feeding habitat in the form of grass seeds is present at the Project Area. If there is a temporary break in grazing in the areas surrounding the Project Area, and if buffelgrass is allowed to set seed, this may attract nēnē to the Project vicinity. Therefore, sporadic presence of nēnē at the Project Area can be expected; however, there is no shrubby vegetation that will attract nēnē to the Project Area for nesting. SWCA biologists surveyed six point count stations from January to December 2014, typically between 6:00 and 11:00 a.m. and 2:00 and 7:00 p.m., during each visit to the Project. During these surveys, no nēnē were observed (SWCA 2015a). Nēnē were incidentally observed by SWCA biologists in November 2015 (two individuals) and January 2016 (one individual).

The nēnē population on the Island of Hawai‘i is estimated to be 1,140 individuals as of 2014 and is expected to continue to expand in the coming years as a result of the 598 nēnē that were translocated from Kaua‘i to the Island of Hawai‘i and through other ongoing conservation actions (personal communication, A. Siddiqi, DLNR August 2016). As the population expands, the nēnē will likely start to occupy more of its historical range, which includes South Point (Day 2005), and birds could be observed more frequently at the Project Area.

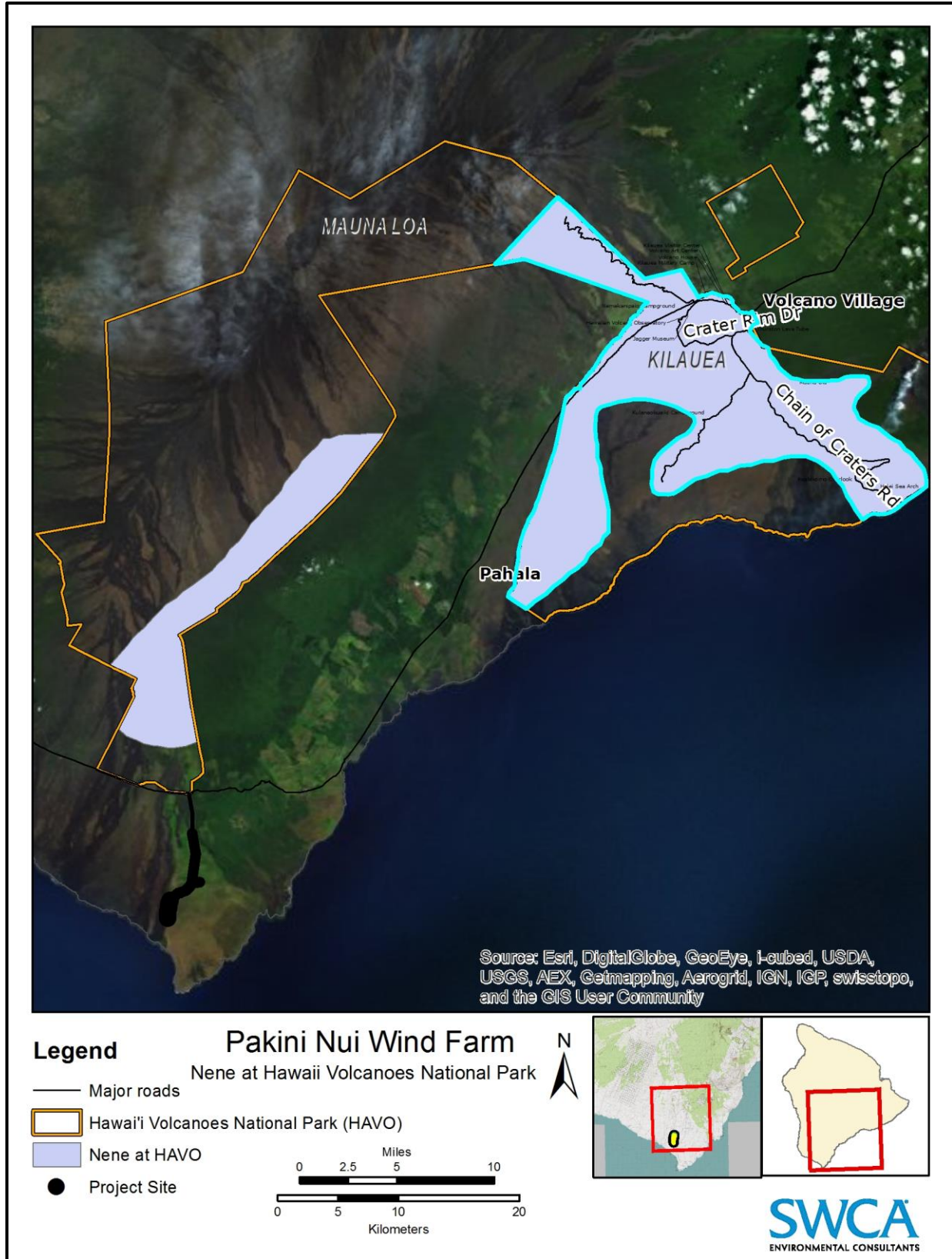


Figure 3.2. Range of nēnē at Hawai'i Volcanoes National Park (HVNP) (HVNP 2012; Pratt et al. 2011).

3.4 Band-Rumped Storm-Petrel

3.4.1 *Population, Biology, and Distribution*

Band-rumped storm-petrels are considered the rarest breeding seabird in Hawai‘i (Banko et al. 1991; Slotterback 2002). The Hawaiian population is listed as an endangered species under the Hawai‘i State Endangered Species Act (HRS §195D-4(a)) (USFWS 2012c) and was listed as endangered under the ESA on September 30, 2016.

The band-rumped storm-petrel is a small, highly pelagic species dispersed widely around the world’s tropical and subtropical ocean regions. Breeding occurs in localized populations in several areas spread along the Atlantic and Pacific Oceans. In the Pacific Ocean, breeding colonies have been documented only in the Galapagos Islands, Japan, the Hawaiian Islands, and possibly Cocos Island near Costa Rica (Pyle and Pyle 2017; USFWS 2012c). The Hawaiian population was once categorized as a distinct subspecies, but it has been included in a single taxon containing all Pacific band-rumped storm-petrel populations (USFWS 2012c).

Based on fossil evidence, band-rumped storm-petrels were once abundant and widespread throughout Hawai‘i. However, recent surveys only found small breeding locations on remote cliffs on Kaua‘i, a cave on Lehua Islet off Ni‘ihau, and high-elevation lava fields on the Island of Hawai‘i, (DLNR 2015; Mitchell et al. 2005; USFWS 2012c). Of an estimated total southeastern Hawaiian Islands breeding population of 330 pairs, approximately 50 (15%) are thought to occur on Hawai‘i Island (Pyle and Pyle 2017). On the Island of Hawai‘i, downy chicks were found near the town of Volcano in 1949, near Kulani Correctional Facility in 1988, and on the northeast slope of Mauna Loa in both 1994 and 2001 (Pyle and Pyle 2017). A dead adult and an inactive nest were also found on the southeast slope of Mauna Loa (Pyle and Pyle 2017). Pyle and Pyle (2017) also state the following:

Adults have also been heard calling along the southwest rift of Mauna Loa in 1968, 1973, and 1992; the latter observation involved “several dozen birds assumed nesting in the area” along the Upper Mauna Loa strip road on the nights of 22 and 23 Jun 1992 [see also Wood et al. 2002]. Calling birds were also reported over Captain Cook on 13 Jul 1990, one was reportedly found dead in Hilo 28 Jul 1993, one was probably observed near Kaimu SB 17 Jul 2013, and several individuals were recorded during shore-based seawatches, primarily from Keahole Point, 24 Jun-1 Sep 2014. Radar surveys around the island have also detected birds beginning in the 2010s [Reynolds et al. 1997; USFWS 2005c, 2015]. Finally, multiple calling birds have been recorded along the S slopes of Mauna Kea at the Pohakuloa Training Facility, a storm-petrel was video-recorded entering a cavity and a predated chick was found there [Galase et al. 2016].

Band-rumped storm-petrels have been documented vocalizing on Maui within the Haleakalā Crater, but evidence of breeding is lacking (Pyle and Pyle 2017). Kaua‘i is estimated to have as many as 250 breeding pairs (Pyle and Pyle 2017). Worldwide population estimates are unlikely to exceed 25,000 breeding pairs (DLNR 2015; Mitchell et al. 2005).

Band-rumped storm-petrels typically begin breeding sometime between their third and seventh year, and individuals may live up to 20 years. Pairs produce a single egg per season. In Hawai‘i, calling birds are heard and eggs are laid between May and July, and nestlings fledge between August and November (DLNR 2015; Mitchell et al. 2005; Pyle and Pyle 2017). Breeding habits are not well documented, and nests are typically difficult to locate. Nests have been found in crevices and cracks along steep, rugged cliffs and talus slopes (Pyle and Pyle 2017).

Foraging is typically done alone or in small groups, although “rafts” of band-rumped storm-petrels numbering from a few to approximately 100 are observed occasionally off Kaua‘i, perhaps waiting for nightfall before returning to the breeding colony (USFWS 2012c). Band-rumped storm-petrels are reported at various distances offshore in coastal waters around Kaua‘i, Ni‘ihau, and the Island of Hawai‘i. Of 39 reported sightings in Hawai‘i since 1995, 30 have been from Kaua‘i (USFWS 2012c).

3.4.2 Threats

Very little is known about breeding and threats to the band-rumped storm-petrel. Introduced predators such as cats, mongooses, dogs, and barn owls (*Tyto alba*) (Wood et al. 2002) may be the most serious threats on land. Additional threats include habitat destruction by introduced ungulates and disorientation due to artificial lighting—especially in coastal areas—resulting in collisions with structures (e.g., power lines, buildings, and fences) (Banko et al. 1991) or individuals becoming grounded (Harrison et al. 1990).

3.4.3 Known Fatalities at Other Hawaiian Wind Farms

No band-rumped storm-petrel fatalities have been documented at other Hawaiian wind farms. However, birds have reportedly been killed by collisions with human-made objects in the Hawaiian Islands, especially when there are bright lights to attract them (Slotterback 2002).

3.4.4 Known Occurrences in the South Point Area

Vocalizations of band-rumped storm-petrels were heard within the Kahuku Unit of HVNP during surveys (Swift and Burt-Toland 2009). Band-rumped storm-petrels have been detected in known Hawaiian petrel colonies in HVNP via calls and several carcasses. Based on vocalization surveys (Swift and Burt-Toland 2009), the closest known band-rumped storm-petrel occurrence is along a rift in the Southwest Rift Zone on Mauna Loa and one in the southern portion of the Kahuku Unit, an estimated 15.3 km (9.5 miles) away from the Project Area. Since 1994, three band-rumped storm-petrel carcasses have been found in HVNP between 2,400 m and 2,600 m (7,800 and 8,500 feet) on Mauna Loa, and one band-rumped storm-petrel was caught in mist nets at 2,600 m (7,800 feet) in 2003. These data suggest that band-rumped storm-petrels still breed on Mauna Loa.

Day (2005) noted that band-rumped storm-petrels have been seen staging on the ocean (before flying inland to nesting colonies after dark) in the immediate vicinity of South Point (including a flock of 22 birds), and it is therefore possible that some birds fly over the Project on their way to their nesting grounds.

4 TAKE ANALYSES

The potential for wind energy turbines to cause fatalities of birds and bats is well documented in the continental United States (e.g., Erickson 2003; Horn et al. 2008; Johnson et al. 2003a, 2003b; Kerlinger and Guarnaccia 2005; Kingsley and Whittam 2007; Kunz et al. 2007). In Hawai‘i, wind-powered generation facilities are relatively new. Incidental take of listed species has been observed at each of the five wind-powered generation facilities in Hawai‘i that have incidental take authorizations. Tawhiri has conducted postconstruction monitoring to document downed wildlife at the Project Area since operations began in April 2007 (SWCA 2015b).

Irrespective of other causes of mortality, the modes of take (resulting in death or injury to a Covered Species) with the potential to occur at the Project is by collision with turbines, overhead transmission lines, vehicles, or the MET tower. Measures within the control of Tawhiri will be implemented at the

Project to avoid the potential for other effects to rise to the level of take (see Sections 1.2 and 6). An example is the observation of speed limits while at the Project to avoid Covered Species strikes. Should a Covered Species become injured as a result of Covered Activities, Tawhiri will adhere to the Downed Wildlife Protocol (Appendix E) and cover any veterinary or rehabilitation expenses.

Below are the quantitative take analyses for the Covered Species, and the results of these analyses

4.1 Hawaiian Hoary Bat

The take request for Hawaiian hoary bats is based on Evidence of Absence software model, Version 2.0 (Dalthorp et al. 2017); existing literature; and site-specific data. The Evidence of Absence software model is considered more robust than others in estimating fatality rates when the number of observed fatalities is relatively low (i.e., < 5). The software uses Bayesian-based statistics to measure uncertainty around the actual mortality estimate, expressed as credible limits. The 80% upper credible limit, not the actual mortality, is routinely used for mitigation planning in Hawai'i and is applied here. The take estimates are based on data from 4 years of standard monitoring (dates ranging from April 15, 2014, to April 15, 2018) with seasonal searcher efficiency (SEEF) and carcass retention (CARE) trials. Two bat fatalities were observed during this 4-year period (on March 1, 2016, and April 12, 2018) and are being included in the calculation of the fatality rate used as the basis for the take projection in this HCP. Of the three bat fatalities found to date, one was observed before standard monitoring began; SEEF and CARE correction factors are unknown for this time period, so this observation was not included in the calculation used to establish the fatality rate.

4.1.1 Collision Fatality Estimate

Monthly fatality monitoring was completed by Tawhiri staff from the COD until August 2013. Intensive, weekly, site-specific monitoring was initiated by Tawhiri in August 2013. In accordance with USFWS guidance, SWCA began searches in March 2014 on plots within a 60-m search radius upwind of each turbine and a 90-m search radius downwind of each turbine, which included trials to calculate carcass retention (CARE)—the mean amount of time a carcass stays on the ground before being removed by scavengers or otherwise disappears—and SEEF, the probability that a carcass is discovered by a searcher (also described in Section 7.2.1). Canine-led searches replaced human-led searches on July 7, 2017, and this search method continues to be used to date.

The fatality projection for the permitted period is based on a lambda (annual fatality rate) calculated from more than 4 years of fatality monitoring data, from March 2014–April 2018. The temporal sampling coverage (v) was 1.0 for that period. The monitoring data were partitioned by year, running April 1 to March 31, to match the initiation of SEEF and CARE trials (e.g., monitoring year 2015 runs April 1, 2015, to March 31, 2016).

SEEF was calculated by dividing the number of surrogate carcasses found by the total amount of surrogate carcasses deployed within the single class module of Evidence of Absence for each monitoring year. SEEF field trials were proctored by SWCA biologists, and searches were done independently by an SWCA biologist who was not knowledgeable of the carcasses' locations. From April 29, 2014, through June 19, 2017, plastic replicas of the hoary bat were deployed for SEEF trials because rat carcasses, which are often used for SEEF trials as proxies for bats, were being scavenged before the searcher had a chance to search for the carcass, significantly hampering the effectiveness of the SEEF trials. The use of plastic proxy carcasses was initially instated with the approval of the USFWS, but in 2015, the agency began recommending Tawhiri use rats for all SEEF and CARE trials. Rat carcasses were used for SEEF trials beginning July 19, 2017, when canine-led searches replaced human searchers. Rat carcasses will continue to be used in SEEF trials as a surrogate for bats under this ITP/ITL. SEEF varied among

monitoring years and by searcher type (Table 4.1). As can be seen in Table 4.1, the Project experienced high variability in SEEF results when human searchers were used. This ranged from approximately 70% efficiency for one searcher (2014) down to a low of 12.5% for another searcher (used during 2016 and 2017). Monthly searcher efficiency results were visually evaluated for seasonal patterns. No obvious seasonal patterns in SEEF or land use were present, so it was decided that it was not necessary to evaluate SEEF seasonally and that the annual estimates of SEEF would be used in the fatality projection. The factor by which SEEF changes with each successive search (k) could not be determined using plastic bats since scavenging/carcass degradation by microbes does not occur on plastic at the same rate as a live carcass. Consequently, a k of 0.1 was assumed for the analysis per the recommendation of the USFWS (Widmer 2018).

Table 4.1. Annual Searcher Efficiency Estimates for Monitoring Years 2014–2017 by Searcher Type

Searcher Type	Monitoring Year (April 1–March 31)	Surrogate Carcasses Placed	Surrogate Carcasses Found	SEEF (\hat{p})	95% C.I.	
					Lower	Upper
Canine-handler team	2017	15	13	0.867	0.637	0.971
Human	2014	76	55	0.714	0.607	0.806
	2015	38	23	0.605	0.447	0.748
	2016	47	6	0.128	0.055	0.244
	2017	8	1	0.125	0.014	0.454
	All years (human)	169	85	0.503	0.428	0.578

The site-specific CARE rate for bats was calculated from field trials using rats. Data was parsed on an annual basis, using the built-in “distribution selection” function in Evidence of Absence software. CARE trials consisted of 14-day-long trials in which surrogate carcasses were deployed on-site to known locations. Rats were used as surrogates for bats during the CARE trials. The use of similar-sized proxy carcasses is a common practice for listed species, and the proxies are assumed to be subject to the same scavenging rates and treatment as the carcasses of the listed species.² The number of days that a rat carcass was retained was recorded visually or by game camera imaging.³ A placed carcass was considered scavenged if it did not persist for 14 days. Only five of the 64 carcasses persisted for at least 14 days.

The software identified the best-fitting distribution for each year of data: Weibull for monitoring year 2014, exponential for year 2017, and lognormal for years 2015 and 2016. The CARE rates for rats (β and 95% confidence interval for β in days) are provided in Table 4.2. Overall, there is a 50% probability that the carcass of an animal killed between search intervals will be available for detection during the next search given a search interval of 7 days (i.e., $r = 0.503$, as reported in Table 4.2).

Carcass retention can be controlled to some extent by implementing predator control. Scavenger trapping was initiated at the Project Area from November 2014 to April 2015, and a total of seven feral cats and one mongoose were trapped.

² Given that the three bats have been found to date with various internal or complete body parts missing would—if it is established they have been scavenged—bring this assumption into question. No CARE rat was ever captured on camera being partially consumed.

³ Game cameras typically recorded cats and mongoose, but dogs, goats, cows, a mouse, a magpie, and a songbird were also recorded.

Table 4.2. Annual Carcass Retention Estimates for Rats for Monitoring Years 2014–2017

Monitoring Year (April 1–March 31)	Surrogate Carcasses Placed	Surrogate Carcasses Scavenged	r [*]	Shape (a)	Scale (β) (days)	95% C.I. for β (days)	
						Lower	Upper
2014	22	22	0.584	2.0247	4.7952	3.536	6.503
2015	13	11	0.491	2.595	0.978	-0.306	2.262
2016	22	20	0.359	0.8981	0.61	0.095	1.126
2017	7	7	0.463	0.2581	3.8751	0.9269	16.200
All years	64	60	0.503	1.007	1.08	0.416	0.594

* r is the probability the carcass will survive to the next survey, given surveys at 7-day intervals.

During these SEEF and CARE trials, turbine search plots were elliptical in shape, with a 90-m search radius downwind of each turbine and a 60-m search radius upwind of each turbine. All 14 turbines were searched, but five of the search plots were only partially searchable due to turbine proximity to a cliff located 30 m downwind, on average. The fatality estimate was corrected by the percentage of the search plot surface areas that were searchable. This was calculated to be 87% overall for the 14 turbines. Note that this percentage was not corrected by carcass density, overestimating the percentage of small carcasses that would fall into unsearchable areas; per the ballistics models of Hull and Muir (2010), fewer than 1% of bat carcasses would be expected to fall into unsearchable areas. A change to a density-weighted search area correction is proposed under this ITP/ITL for future monitoring (see Section 7.2.1), consistent with the instructions in the *Evidence of Absence (v2.0) Software User Guide* (Dalthorp et al. 2017).

The overall probability of detection (g) was calculated for each monitoring year (Table 4.3). For the 2017 monitoring year, the year was split into two periods based on the detection probability difference between canine-assisted and human-only searches, then assigned the appropriate rho value corresponding to the temporal period represented.

Table 4.3. Probability of Detection (g) for Monitoring Years 2014–2017

Monitoring Year (April 1–March 31)	Searcher Type	g (rho [*])	95% C.I. for g		Fitted Beta (β) Distribution Parameters	
			Lower	Upper	βa	βb
2017	Canine-handler team	0.342 (0.73)	0.147	0.572	6.0064	11.5554
2014	Human	0.366 (1.00)	0.269	0.470	31.7163	54.8437
2015		0.262 (1.00)	0.134	0.415	9.35	26.3502
2016		0.0431 (1.00)	0.0155	0.0838	5.6615	125.5523
2017		0.0688 (0.27)	0.00468	0.208	1.4221	19.2491
All years		0.223 (1.00)	0.174	0.277	55.5865	193.4975

* rho is the proportion of the year represented by this searcher type.

A take projection was made for 8 years of Project operation. It is now projected that there will be, at most, 7.5 years of operations remaining, assuming ITP/ITL issuance occurs by October 1, 2019. Whatever remaining duration of the permit period would consist of decommissioning activities, during which no Covered Activities with the potential to impact bats would take place; therefore, no bat take would be

expected. (See Section 1.4 for the definition of *decommissioning* in the context of the Project.) This is primarily because between ceasing operations and beginning decommissioning activities, the rotor lock on the high-speed side of the gearbox would be engaged, keeping the rotor from turning. To date, bats have not been documented flying into stationary turbines (Arnett et al. 2008; Barclay et al. 2007). The multiple years module in Evidence of Absence was used to project fatality over the 8 years of permitted operation. The existing 4 years of monitoring data (2014–2017), plus the first 2 months of monitoring from 2018, were used to set the estimated annual baseline fatality rate (λ) for this period.

Annual estimates of g and counts of carcasses found were input into the multiple years module of Evidence of Absence software. The estimate of g for 2017 was split by assigning a ρ of 0.27 to the human searches and 0.73 to the canine-assisted searches. The estimate of g from the canine-assisted searches in 2017 was applied to 2018 monitoring data, and the ρ was set to 0.17 to represent the 2 months of searches. Two bat carcasses were found during this monitored period, one in monitoring year 2015 and one in 2018 (i.e., two in 5 years). The first recorded fatality (August 31, 2013) was not included in modeling and projections because SEEF and CARE trials were not being conducted at the time, making it difficult to model potential unobserved fatalities without making assumptions about searcher and scavenger conditions. These methods were approved by the USFWS (Widmer 2018).

The multiple years module projected out 8 future years of operation. For the 8 future years, a constant g equal to the human searcher median (All years, Human in Table 4.3) was assumed because it was more conservative than the g for the canine-assisted searches and a canine searcher may not be available for use for the whole ITP/ITL duration. The credibility level was set to 0.8. The result was with 80% certainty that no more than 23 direct bat fatalities will occur in 8 years of operation, provided there are no changes to site use, operations, or monitoring intensity.

4.1.2 Indirect Effects Rising to the Level of Take

The equation described in Table 4.4 was used to estimate the requested level of indirect take for the take projection for 8 years of operation. as directed by the *Wildlife agency guidance for calculation of Hawaiian hoary bat indirect take* (USFWS 2016), provided on October 1, 2016.

Indirect take is likely to occur in the form of mortality of an uncared for dependent offspring as the result of a direct take of a parental bat. There are several variables that come into play when calculating indirect take: the proportion of take assumed to be adults, the proportion of take that is assumed to be female (only female bats care for dependent young), the proportion of the year that is the breeding (or pupping) season, the likelihood that the loss of a reproductively active female results in the loss of its offspring, and the average reproductive success. Table 4.4 outlines these criteria, gives a rationale for each of the variables used in the calculation of indirect take, and lists the estimated probabilities for indirect take as it relates to the Project.

Table 4.4. Pakini Nui Indirect Bat Take Equation Description

Component	Description/Rationale	Result
A. Total direct take (bats per tier)	Estimated total direct take	23
B. Proportion of take that is adult	Erring toward a conservative estimate, it is assumed that 100% of take (observed and unobserved) will be adult individuals, despite the opportunity for first-year juveniles to pass through the Project Area.	1.00

Component	Description/Rationale	Result
C. Proportion of take that is female	Hawaiian hoary bats are assumed to have a ratio of 1:1. Furthermore, it is assumed there is no sex-based bias for differential susceptibility for fatal interaction with turbines. Therefore, approximately 50% of bats are assumed to be females.	0.50
D. Proportion of year that is the pupping period (24 of 52 weeks)	Adults are present in the Project Area throughout the year, but the pupping season is recorded as occurring from April to September 15, or 24 weeks. Indirect take of an offspring can only occur from direct take of an adult during these months.	0.46
E. Proportion of breeding adults taken with dependent young	Juvenile bats are completely dependent on females until they are weaned and therefore their survival depends on the mother bat's ability to provide care. Therefore, all direct take of females with young during the pupping season results in the offspring's indirect take.	1.00
F. Average offspring/breeding pair	Reproductive success is based on Bogan (1972) and Koehler and Barclay (2000)	1.8
G. Conversion of juveniles to adults	Juveniles are converted to adults by multiplying by 0.3, which is in accordance with the <i>Wildlife agency guidance for calculation of Hawaiian hoary bat indirect take</i> (USFWS 2016).	0.3
H. Total indirect take	Indirect take is estimated by multiplying the probabilities of lines A–G. This estimate is rounded up to the nearest whole number.	3

4.1.3 Take Projection and Estimation

Real-time estimated take for the duration of the Project will be calculated based on the results of the compliance (i.e., fatality) monitoring. The direct take will be calculated with Evidence of Absence (Version 2.0 or most recent) software (Dalthorp et al. 2017) and indirect take will be added, as described above. The direct observed and unobserved take at the 80% credibility level plus the indirect take based on the standardized guidance provided by the USFWS (2016) will be used to estimate with 80% confidence that the permitted total take has not been exceeded.

The projected take estimate during the remaining Project operation is 26 Hawaiian hoary bats (23 direct takes, 3 indirect takes; Table 4.5). It is assumed that no take will occur during the decommissioning period because the turbines will not be operational. Should monitoring and modeling indicate that take has reached 75% of this take request before 75% of the operational period has expired (i.e., approximately 5.5 years if permit issuance occurs by October 1, 2019), Tawhiri will immediately meet with the USFWS and DLNR to determine if take is expected to exceed the permitted limit during the remaining duration of the ITP/ITL. If the USFWS, DOFAW, and Tawhiri determine that permitted take will be exceeded before cessation of operations, additional minimization measures will be employed through adaptive management to maintain take below the permitted limit or a formal amendment will be proposed.

Table 4.5. Take Estimate for Hawaiian Hoary Bat at Pakini Nui Wind Farm*

Permitted Direct Take (80% credibility level)	Permitted Assumed Indirect Take of Juveniles (80% credibility level) †	Permitted Total Take Authorization
23	3	26

* Includes remaining years of operation and decommissioning.

† Indirect take is calculated as described in Section 4.1.2.

4.1.4 Adaptive Management Trigger

If the monitoring data signal a potentially unsustainable mortality rate that would lead to exceedance of the long-term limit before the end of operations, then Tawhiri will, after consultation with the USFWS and DOFAW, take additional steps to reduce the current and future rate of take to stay within the permitted level. The multiple years module of Evidence of Absence software has a built-in test called the “short-term test” that will be used to detect an unsustainable mortality rate using empirical data collected over the previous 4 years of operation. After each observed bat fatality caused by an impact with a wind turbine, the short-term test will be run by Tawhiri and the results provided to the USFWS and DOFAW.

For the short-term test in the Evidence of Absence software, the user will enter the annual rate threshold ($\tau = 23$ direct take/7.5 years = 3.06 bats/year), the number of years over which to calculate the rate (term = 4 years), the sensitivity of the test ($\alpha = 0.01$), and the monitoring data (g [detection probability] and X [carcasses observed] for the last 4 years). If the test indicates that the average annual fatality rate is significantly greater than 2.93 bats per year, then Tawhiri will implement incremental adaptive management actions. A significant result would indicate that there is less than a 1% probability that the difference between the annual rate threshold and the observed fatality rate resulted from an atypical sample; it can be stated that the observed fatality rate is greater than the annual rate threshold with greater than 99% confidence.

Tawhiri will implement adaptive management response within 30 days (or such time as Tawhiri, DOFAW, and the USFWS agree is reasonable) if Tawhiri and the agencies determine Tawhiri has reached the adaptive management trigger. Adaptive management actions may include operational changes (i.e., changes to the curtailment regime or times of turbine operation), deployment of approved deterrent technologies, and/or actions to improve detection probability. Tawhiri will consult with the USFWS and DOFAW to identify an appropriate adaptive management response.

4.1.5 Impacts of the Taking

As shown in Table 4.5, the projected permitted take estimate for the Project is 26 Hawaiian hoary bats. Hawaiian hoary bats are thought to occur in the greatest numbers on the Islands of Hawai‘i, Maui, and Kaua‘i (Menard 2001). Results from a limited study conducted at several sites on Hawai‘i from 2007 to 2011, suggested that the population trends in those areas varied from negligible change to a slightly positive change from year to year; however, the study was not conclusive (Gorresen et al 2013). No population estimates were provided. Bats on the Island of Hawai‘i are habitat generalists and occur from sea level to the highest peaks on the island (Gorresen et al. 2013). The Hawaiian hoary bat is reproductively mature at 1 year of age, and a female Hawaiian hoary bat is estimated to produce on average 1.8 pups a year, 30% of which are estimated to survive. If take is equally distributed across the life of the ITP/ITL (i.e., 2.6 individual takes per year), it will take the offspring of approximately five reproductively active females each year to replace the lost individuals. However, this is a replacement of lost individuals and not a net increase. The proposed mitigation is designed to contribute to preventing the degradation and improving the quality of native bat foraging and roosting habitat in the ways described in Section 6.2. Mitigation measures both 1) compensate for impacts of the taking, and 2) provide additional roosting and foraging habitat, resulting in an overall net conservation benefit for the Hawaiian hoary bat (see Section 6.2).

4.2 Hawaiian Petrel

The incidental take estimate for Hawaiian petrels is calculated using existing radar data from studies conducted near South Point, which constitute the best available scientific data. The passage rates from these studies are used to model the expected fatality rates at the Project.

4.2.1 Collision Fatality Estimate

The best available data from radar surveys were used to estimate potential collision fatality rates. Because of the nocturnal nature of inland movements of Hawaiian petrels, an effective way to determine passage rates is by using radar surveys. Radar surveys are useful in areas with relatively high seabird passage rates. However, seabirds, including the Hawaiian petrel, have very limited distribution and abundance on the Island of Hawai'i (Ainley et al. 1997; Day et al. 2003; Reynolds et al. 1997; Simons and Hodges 1998). During radar surveys in 2001 and 2002, Day et al. (2003) recorded very low numbers of seabirds (0.0–3.2 targets per hour) flying inland at all sites sampled, with the exception of the Waipi'o Valley. Limitations of the use of radar surveys to determine seabird passage rates include the inability to distinguish between seabird species. Very few, and often none, of the targets are visually observed and identified to species. In addition, other birds are similar to Hawaiian petrels in size and flight speed, resulting in target contamination. This results in a positive bias in passage rates. Species that artificially may inflate passage rates include sooty terns (*Onychoprion fuscatus*), mallard-Hawaiian duck hybrids (*Anas wyvilliana* x *platyrhynchos*), and Pacific golden-plovers (*Pluvialis fulva*). There are no recent records of nesting Newell's shearwaters on the Island of Hawai'i, and this species is not considered to be at risk of collision with Project components.

Although population viability analyses suggest that the Mauna Loa breeding population of Hawaiian petrels may not persist (Hu et al. 2001), Hawaiian petrel breeding colonies where predator control is implemented, at HVNP, appear fairly stable (National Park Service [NPS] 2010, 2011, 2012). Birds outside of this protected area are likely exposed to higher levels of predation—in particular, by cats (Natividad Hodges 1994; Simons 1985; Winter 2003). Therefore, it is reasonable to assume that the Island of Hawai'i breeding population of Hawaiian petrels is either stable or decreasing, and the Day et al. (2003) and the more recent Hamer (2008a and b) data represent an accurate or conservative proxy for 2014 passage rates for the Hawaiian petrel. The average passage rates of the two nearest radar sites were used for analyses in this HCP.

The two locations closest to the Project Area at which Day et al. (2003) collected radar data in 2001 and 2002 are Ho'opuloa and Punalu'u, located approximately 32 km (20 miles) northwest and 25 km (16 miles) northeast of the Project, respectively. At Ho'opuloa, the average passage rate in May–June of 2001 and 2002 was 1.2 targets per hour, and at Punalu'u, the passage rate was 1.6 targets per hour (mean = 1.4 targets per hour). Day and Cooper (2003) performed a 5-day survey near the Manuka State Wayside Park in July 2003 and recorded only one seabird target during 5 days of radar sampling. More recently, radar surveys in fall and spring 2008 approximately 2 miles north of Pakini Nui Wind Farm resulted in the detection of three and 20 targets, respectively, during 5 days of sampling (Hamer 2008a, 2008b). The passage rate during this study was much lower than those recorded at Ho'opuloa and Punalu'u in 2003 by Day et al. (2003). During the Hamer (2008a, 2008b) studies, the average flight altitude was 312.55 m above ground level. None of the targets flew below 132.44 m above ground level and therefore none of these targets would have flown within the altitude of the Project's rotor swept zone.

Based on a passage rate of 1.4 targets per hour per 1.5-km-radius sample area, on average, 0.21 Hawaiian petrels fly in the space occupied by each turbine per year (Tables 4.6 and 4.7), and 0.00 Hawaiian petrels fly in the space occupied by the MET tower each year (Table 4.8). Hawaiian petrels are adapted to nocturnal flight and able to navigate forests near their nests under low light conditions. Evidence suggests

that Hawaiian petrels are highly capable of avoiding vertical structures under low light conditions, resulting in high avoidance rates (Cooper and Day 1998; KWP 2009, 2010; Tetra Tech 2008). Based on avoidance rates of 95% and 99% from collision with Project turbines or the MET tower, respectively, annual fatality rates of Hawaiian petrels range from 0.022 to 0.004 fatality per year (Tables 4.6–4.10).

The best available existing data on the Island of Hawai‘i were used to estimate seabird passage rates and fatality estimates for the ITP/ITL term.

Table 4.6. Estimated Average Exposure Rates and Fatality Rates of Hawaiian Petrel for the 1.5-Megawatt GE Turbines Rotor Swept Zone at Pakini Nui Wind Farm

Variable		
Movement Rate		
A	Mean movement rate (birds/hour/ha)	0.001980198
B	Daily movement rate (birds/day/ha) A × 5	0.00990099
C	Fatality domain (days)	210
D	Annual movement rate (birds/year) B × C	2.079207921
E	Proportion of birds flying within rotor swept zone	0.25
F	Annual movement rate within rotor swept zone D × E	0.51980198
Horizontal Interaction Probability		
G	Volume occupied by rotor swept zone (m ³)	356637.0133
H	Volume of a 1-ha area from minimum to maximum rotor height (m ³)	880000
I	Horizontal interaction probability G ÷ H	0.405269333
Exposure Index		
J	Daily exposure index (birds/rotor swept zone/day) B × E × I	0.001003142
K	Annual exposure index (birds/rotor swept zone/year) F × I	0.210659802
Fatality Probability		
L	Probability of striking a blade on frontal approach	0.146664833
M	Probability of fatality if striking a blade	1
N	Probability of fatality if an interaction on frontal approach L × M	0.146664833
Fatality Index		
O	Annual fatality rate with 90% exhibiting collision avoidance (birds/turbine/year) K × N × 0.1	0.003089638
P	Annual fatality rate with 95% exhibiting collision avoidance (birds/turbine/year) K × N × 0.05	0.001544819
Q	Annual fatality rate with 99% exhibiting collision avoidance (birds/turbine/year) K × N × 0.01	0.000308964

Table 4.7. Estimated Average Exposure Rates and Fatality Rates of Hawaiian Petrel for the 1.5-Megawatt GE Turbines Tubular Tower at Pakini Nui Wind Farm

Variable		
Movement Rate		
A	Mean movement rate (birds/hour/ha)	0.001980198
B	Daily movement rate (birds/day/ha) A × 12	0.00990099
C	Fatality domain (days)	210

Variable		
D	Annual movement rate (birds/year/ha) $B \times C$	2.079207921
Probability of a 1-ha plot with a turbine		0.5
E	Proportion of birds flying below rotor swept zone	0.25
F	Annual movement rate below rotor swept zone $D \times E$	0.25990099
Horizontal Interaction Probability		
G	Volume occupied by tubular tower (m^3)	942
H	Volume of 1-ha area below hub	750000
I	Horizontal interaction probability $G \div H$	0.001256
Exposure Index		
J	Daily exposure index (birds/tubular tower/day) $B \times E \times I$	3.10891E-06
K	Annual exposure index (birds/tubular tower/year) $F \times I$	0.000326436
Fatality Probability		
L	Probability of striking a tubular tower if in airspace	1
M	Probability of fatality if striking a tubular tower	0.95
N	Probability of fatality upon interaction $L \times M$	1
Fatality Index		
O	Annual fatality rate with 90% exhibiting collision avoidance (birds/tower/year) $K \times N \times 0.1$	3.26436E-05
P	Annual fatality rate with 95% exhibiting collision avoidance (birds/tower/year) $K \times N \times 0.05$	1.63218E-05
Q	Annual fatality rate with 99% exhibiting collision avoidance (birds/tower/year) $K \times N \times 0.01$	0.0000032644

Table 4.8. Estimated Average Exposure Rates and Fatality Rates of Hawaiian Petrel for the MET Tower at Pakini Nui Wind Farm

Variable		
Movement Rate		
A	Mean movement rate (birds/hour/ha)	0.001980198
B	Daily movement rate (birds/day/ha) $A \times 12$	0.00990099
C	Fatality domain (days)	210
D	Annual movement rate (birds/year) $B \times C$	2.079207921
E	Proportion of birds flying below MET tower (< 60 m)	0.25
F	Annual movement rate below MET tower (< 60 m) $D \times E$	0.51980198
Horizontal Interaction Probability		
G	Volume occupied by MET tower (m^3)	420.1840223
H	Volume of 1-ha area MET tower (< 80 m) (m^3)	800000
I	Horizontal interaction probability $G \div H$	5.25E-04
Exposure Index		
J	Daily exposure index (birds/tower/day) $B \times E \times I$	1.30E-06
K	Annual exposure index (birds/tower/year) $F \times I$	2.73E-04
Fatality Probability		
L	Probability of striking a MET tower if in airspace	1

Variable		
M	Probability of fatality if striking a MET tower	1
N	Probability of fatality upon interaction L × M	1
Fatality index		
O	Annual fatality rate with 90% exhibiting collision avoidance (birds/tower/year) $M \times P \times 0.05$	2.73016E-05
P	Annual fatality rate with 95% exhibiting collision avoidance (birds/tower/year) $M \times P \times 0.05$	1.36508E-05
Q	Annual fatality rate with 99% exhibiting collision avoidance (birds/tower/year) $M \times P \times 0.01$	0.0000027302

Table 4.9. Combined Fatality Estimates for Hawaiian Petrel at Pakini Nui Wind Farm

	Turbine (n = 14)	MET Tower	Total Fatality	10-Year Fatality Estimate
Annual fatality rate with 90% exhibiting collision avoidance (birds/year)	0.04371	0.00003	0.04374	0.4374
Annual fatality rate with 95% exhibiting collision avoidance (birds/year)	0.02186	0.00001	0.02187	0.2187
Annual fatality rate with 99% exhibiting collision avoidance (birds/year)	0.00437	0.00000	0.00437	0.0437

There is a growing body of evidence that collision avoidance of Hawaiian petrels is close to 99% (Sanzenbacher and Cooper 2013); therefore, a range of 95%–99% avoidance rate is used here for the fatality estimate. The 10-year combined fatality estimate of Hawaiian petrels for the Project is between 0.0437 and 0.2187, for 99% and 95% avoidance rates, respectively (Table 4.9). Therefore, it is unlikely that a fatality will be detected during the 10-year ITP/ITL duration. To cover for the stochastic event of an incidental take of Hawaiian petrels, the direct requested take is two Hawaiian petrels.

Recent monitoring of bird strikes at power lines on Kaua‘i indicate that the occurrence of seabird collisions with some power lines is significantly higher than previously reported (Travers et al. 2014). On Kaua‘i, take of Newell’s shearwater (a seabird with similar flight behavior to the Hawaiian petrel) associated with 1,843 km (1,145 miles) of transmission, distribution, and secondary lines in 2008 was estimated to be 15.5 breeding adults and 63 nonbreeding or immature individuals (Planning Solutions et al. 2010). Kaua‘i is estimated to host 75% of the total population of Newell’s shearwater, which was estimated to be 21,250 breeding and nonbreeding birds in 2008 (Planning Solutions et al. 2010). This amounts to 0.067 fatality per year per 1 mile of power line. The populations of inland nesting seabirds on south Hawai‘i are much smaller than those on Kaua‘i. With a Hawaiian petrel population of approximately 100–200 breeding pairs on the Island of Hawai‘i (Pyle and Pyle 2017), collision rates with overhead power lines are expected to be much lower on the Island of Hawai‘i than estimated for Kaua‘i; and for the Project, the collision incidence is expected to be discountable. Flight height data from nearby (approximately 5.5 miles) radar surveys in 2008 (Hamer 2008a, 2008b) show that the average flight altitude of seabird targets was 312.55 m (1,025 feet) above ground level. None of the targets flew below 132.44 m (435 feet) above ground level; therefore, none of these targets would have flown within the altitude of the Project’s tie-line or rotor swept zone.

Much of the underreporting of seabird collisions with power lines on Kaua‘i is due to the fact that very few seabirds fall directly to the ground after colliding with power lines. This indicates that ground searches are not an effective method to document fatalities resulting from power line collisions. However,

only 7% of the observed power line strikes resulted in a documented downed bird; therefore, the exact impacts of power line collisions are not well understood. This monitoring effort also showed significant variations of strike rates between different sections of power line. The highest strike rates were associated with particular areas on Kaua‘i, with power lines at higher altitudes and lines that stood the highest above the local topography and vegetation (Travers et al. 2014).

4.2.2 Indirect Effects Rising to the Level of Take

Adult and immature Hawaiian petrels have the potential to collide with turbines and MET towers while moving between nesting and feeding grounds during the pre-laying period (March–April) and breeding, incubation, and chick-feeding periods (May–October). The risk of collision outside the pre-laying period or breeding season (November–February) is considered negligible because Hawaiian petrels do not return to land and therefore would not be passing through the Project during this period.

Take of an adult bird during the breeding, incubation, and chick-feeding period (May–October) could result in indirect effects to eggs or chicks, if present. Effects could include the total loss of eggs or chicks, which would rise to the level of take. Survivability of offspring following take of 1 parent is dependent on the time of year during which the parent is lost. Both Hawaiian petrel parents alternate incubating the egg (May–July), allowing the other to leave the colony to feed. Therefore, during the incubation period, it is expected that both parents are essential for the successful hatching of the egg (Simons 1985). Both parents also contribute to feeding the chicks. Chicks are fed 95% of the total food they will receive from their parents within 90 days of hatching (Simons 1985). Because hatching generally occurs in late June, chicks should have received 95% of their food by the end of September. After September, it is likely that chicks could fledge successfully without further parental care because chicks have been documented as abandoned by their parents up to 3 weeks before successful fledging (Simons 1985). Consequently, it is considered probable that after the initial 90 days of parental care, chicks also are capable of fledging if care was provided by only one parent. Therefore, for purposes of this HCP, both parents are considered essential to the survival of a Hawaiian petrel chick through September, after which a chick has a 50% chance of fledging successfully if adult take occurs (in October).

Not all adult Hawaiian petrels visiting a nesting colony breed every year. Simons (1985) found that 11% of breeding-age females at nesting colonies were not breeding. Eggs are laid and incubated between May and July, and an average of 74% of eggs hatch successfully (Simons 1985). Therefore, there is an 89% chance ($100\% - 11\% = 89\%$) that an adult petrel taken from May through June was actually breeding or incubating and a 66% ($0.89 \times 0.74 = 0.66$) chance in July and August that the individual successfully had produced a chick. Most nonbreeding birds and failed breeders leave the colony for the season by mid-August (Simons 1985). Therefore, there is nearly a 100% chance that birds taken in September or October are likely to be young fledglings. Based on the life history parameters above, and as identified in Table 4.10, indirect effects rising to the level of take (loss of eggs or chicks) will be assessed at a rate of 0.89 egg per adult taken between May and July; 0.66 chick per adult taken in August; 1.00 chick per adult taken in September; and 0.50 chick per adult taken in October.

Table 4.10. Calculation of Indirect Take of Hawaiian Petrel

Hawaiian Petrel	Season	Average No. of Chicks per Pair (A)	Likelihood of Breeding (B)	Parental Contribution (C)	Indirect Take (A x B x C)
Adult	March–April	–	0.00	–	0
Adult	May–July	1	0.89	1.0	0.89 egg
Adult	August	1	0.66	1.0	0.66 chick

Hawaiian Petrel	Season	Average No. of Chicks per Pair (A)	Likelihood of Breeding (B)	Parental Contribution (C)	Indirect Take (A × B × C)
Adult	September	1	1.00	1.0	1.00 chick
Adult	October	1	1.00	0.5	0.50 chick
Adult	November–April	–	0.00	–	0
Immature	All year	–	0.00	–	0

For the actual take (observed and unobserved) of two birds, an indirect take of one egg/chick will be added to the total take request, for a take request of three Hawaiian petrels (see Section 4.2.3).

4.2.3 Take Estimate

The 10-year fatality estimate of Hawaiian petrels for the Project is between 0.0437 and 0.2187, for 99% and 95% avoidance rates, respectively (see Table 4.9). Therefore, it is unlikely that a fatality will be detected during the remaining years of operation and the decommissioning period. However, to cover for the stochastic event of an incidental take of Hawaiian petrels, and allowing for unobserved direct take, the requested take is based on the direct take of two Hawaiian petrels. The indirect take is one egg/chick; therefore, the total requested take is three Hawaiian petrels.

4.2.4 Impacts of the Taking

The possible take of three Hawaiian petrels over the 10-year life of the ITP/ITL will not have a population-level effect on the species. Mitigation measures both 1) compensate for impacts of the taking, and 2) provide additional mitigation, resulting in an overall net conservation benefit for the species (Section 6.3).

4.3 Nēnē

4.3.1 Collision Fatality Estimate

Most nēnē on Hawai‘i Island are known to occur in HVNP (USFWS 2004). These birds are wide-ranging and may be found in the Kahuku Unit of the park, the southern boundary of which is approximately 40 km (25 miles) from the turbine string at the Project.

During 12 months of avian surveys, no nēnē were observed at or near the Project. Nēnē were incidentally observed by SWCA biologists in November 2015 (two individuals) and January 2016 (one individual). Potential nēnē feeding habitat in the form of grass seeds is present at the Project Area. Furthermore, abundant foraging habitat is not limited at the Project Area and occurs adjacent to the Project Area throughout the South Point area. If there is a temporary break in grazing near the Project Area, and if buffelgrass is allowed to set seed, this may attract nēnē to the Project Area vicinity. Therefore, sporadic presence of nēnē can be expected in the Project Area. Additionally, the population on the Island of Hawai‘i is expected to expand in the coming years as nēnē from Kaua‘i are translocated to the Island of Hawai‘i. As the population expands, nēnē likely will start to occupy more of their historical range, which includes South Point (Day and Cooper 2005), and birds could be observed more frequently in the Project Area. The USFWS therefore recommends that, although only three nēnē have been seen in the Project Area (SWCA 2015a), nēnē will be included as a Covered Species (personal communication, J. Charrier, USFWS, February 20, 2014).

It is assumed that adult nēnē are most likely to collide with turbines and the MET tower during the nonbreeding period (May–July) or at the end of the breeding period (breeding season is August–April) when adults and young may travel in family groups. Nēnē are highly territorial during the breeding season (Banko et al. 1999), and males are likely to defend nesting territories while females are incubating. Upon hatching, both parents attend to heavily dependent young. Adult nēnē also molt while in the latter part of their breeding period and are therefore flightless for 4–6 weeks (USFWS 2004). These adults attain their flight feathers at about the same time as their goslings (USFWS 2004). Consequently, such birds are more likely to be in flight within the Project Area only when goslings already have fledged.

Considering the low risk of incidental take of nēnē at the Project, the take estimate attributed to direct take is two nēnē.

4.3.2 Indirect Effects Rising to the Level of Take

Indirect effects rising to the level of take include loss of dependent young as a result of adult fatalities. This take will be assessed for adult nēnē only when the mortality occurs during the breeding season (August–April). Adults found during October–March will be assumed to have had a 60% chance of having been actively breeding because 60% of the population has been recorded to breed in any given year (Banko et al. 1999). Adult nēnē mortality that occurs outside the peak breeding season (April, August, and September) will be assumed to have had a 25% chance of breeding. Male and female nēnē care for their young fairly equally; therefore, take of dependent young will be assessed equally to the take of any adult male or female nēnē take observed during the breeding season. Because breeding nēnē are not expected to collide with wind turbines before the fledging of their young, the number of young possibly affected by loss of an adult is based on the average number of fledglings produced per pair (studies indicate that average number of fledglings produced annually per pair of nēnē is 0.3 [Hu 1998]).

Based on these assumptions, the additional take by loss of dependent young that will be assessed for each take (fatality) of an adult nēnē during October–March is 0.09 (Table 4.11). The amount of additional take by loss of a dependent young that will be assessed for each actual take (fatality) of an adult nēnē during the remainder of the breeding season is 0.04.

Table 4.11. Calculation of Indirect Take of Nēnē

Nēnē	Season	No. of Fledglings per Pair (A)	Likelihood of Breeding (B)	Parental Contribution (C)	Indirect Take (A × B × C)
Adult, any gender	October–March	0.3	0.60	0.5	0.09
Adult, any gender	April, August, and September	0.3	0.25	0.5	0.04
Adult, any gender	May–July	–	0.00	–	0.00
Immature	All year	–	0.00	–	0.00

For purposes of this HCP, it is assumed that all birds taken, including unobserved take, will be adults. Because nēnē could be flying through the Project Area at any time of year, the likelihood of a nēnē being taken in breeding condition is 37.5% based on a breeding period of 4.5 months (a 1-month incubation period followed by parental care for 3.5 months; $4.5 \div 12 = 0.375$).

Following Table 4.11, take will be calculated in addition to nēnē lost through observed and unobserved take at the rate of 0.06 fledgling/nēnē ($0.3000 \times 0.3750 \times 0.5000 = 0.0563$). The total indirect take for two nēnē is 0.12 fledgling, which is rounded up to 1.

4.3.3 Take Estimate

The total estimated take for nēnē is three.

4.3.4 Impacts of the Taking

The possible take of three nēnē over the 10-year life of the ITP/ITL will not have a population-level effect on the species. Mitigation measures both 1) compensate for impacts of the taking, and 2) provide additional mitigation, resulting in an overall net conservation benefit for the species (Section 6.5).

4.4 Band-Rumped Storm-Petrel

4.4.1 Collision Risk

Band-rumped storm-petrels are the rarest breeding seabird in Hawai‘i (Banko et al. 1991; Slotterback 2002), and most of the Hawaiian population is thought to breed on Kaua‘i (USFWS 2012c). There is a degree of uncertainty regarding the very low passage rates on or near the Project because very little is known regarding the distribution and abundance of band-rumped storm-petrels on the Island of Hawai‘i (Reynolds and Cooper 1997; Slotterback 2002). Band-rumped storm-petrel breeding has been confirmed at Pohakuloa Training Center (Galase et al 2015), with two confirmed nesting sites (Heber 2018). None of the radar studies cited identified any of their targets as band-rumped storm-petrels. Considering the extremely rare nature of the band-rumped storm-petrel, it is assumed the passage rates on or near the Project are considerably lower than those of the Hawaiian petrel and consequently collision risk with Project components is expected to be considerably lower than that of the Hawaiian petrel, for which the 10-year fatality estimate is less than one bird. Therefore, the risk of take of band-rumped storm-petrels at the Project is considered discountable and therefore no take authorization is requested for the species and the species is not included in the Covered Species.

4.5 Cumulative Impacts

The only other wind projects on Hawai‘i Island are the 3.3-MW Lalamilo Wind Farm at South Kohala and the 10.56-MW Hawi Wind Farm at Upolu Point. There is the potential for cumulative impacts to the Covered Species on Hawai‘i Island due to the presence of these other wind farms. Lalamilo Wind Farm is in the process of preparing an HCP. Two federally and state-listed wildlife species have been identified as having the potential to be adversely impacted by operation of the Lalamilo project: Hawaiian hoary bat and Hawaiian petrel. Mitigation measures to compensate for the take of these Covered Species at Lalamilo has been developed in coordination with the USFWS, DOFAW, and the ESRC.

On a broader scale, the Pakini Nui project represents one of many projects of various types that can be expected to occur on the Island of Hawai‘i. Some of the causes of population declines of the Covered Species (such as predation, bright light disorientation, and loss of nesting or roosting habitats) may be due to increasing impacts from human activity, and these pressures will likely continue to increase in the future. Even when conducted in compliance with all applicable local, state, and federal environmental regulations, there is the potential for cumulative impacts to occur from these projects because many do not trigger review under endangered species provisions and thus are not required to meet the net environmental benefit standard. Conversely, the Pakini Nui Wind Farm will provide an overall net benefit to the environment by helping reduce greenhouse gas emissions caused by human activity. By implementing this HCP, Tawhiri will ensure that the net effects of this Project will contribute to the

recovery of the Covered Species and thus not contribute to cumulative impacts that may occur as a result of other human-caused activity.

It is important to note that rapid ‘ōhi‘a death (ROD), a fungal disease that has killed hundreds of thousands of ‘ōhi‘a trees, occurs on Hawai‘i Island. ‘Ōhi‘a is the most abundant native tree in the state and constitutes important habitat for wildlife, including the Hawaiian hoary bat and nēnē. Loss of these trees constitutes an important island-wide loss and degradation of wildlife habitat.

Take for the Covered Species has been authorized on O‘ahu, Maui, Kaua‘i, and Hawai‘i through several HCPs and Safe Harbor Agreements (SHAs). Tables 4.12 and 4.13 list take permitted for all HCPs and SHAs that effect the Covered Species. Tables 3.1, 3.2, and 3.3 of this HCP list known and modeled takes of these species from other wind farms in the state, which may differ from permitted take.

Table 4.12. Habitat Conservation Plans Affecting Covered Species

Name	Permit Duration	Location	Species and Total Take Authorization for Permit Term*	Species and Total Take Pending Approval (total includes previous authorized take)†
Tower Kauai Lagoons Land, LLC	12/09/2016–11/09/2042	Lihue, Kaua‘i	Hawaiian petrel (1) Hawaiian goose (15)	N/A
Kahuku Wind Farm‡	06/07/2010–06/06/2030	Kahuku, O‘ahu	Hawaiian hoary bat (32) Hawaiian petrel (12)	N/A
Kawailoa Wind Power	12/08/2011–12/07/2031	Haleiwa, O‘ahu	Hawaiian hoary bat (60)	Hawaiian hoary bat (265) Hawaiian petrel (7)
Na Pua Makani Wind Project – Phase I	Not yet issued	Kahuku, O‘ahu		Hawaiian hoary bat (51)
U.S. Army Kahuku Training Area Single Wind Turbine	Federal biological opinion covering 05/05/2010–05/09/2030	Kahuku, O‘ahu	Hawaiian hoary bat (2 adults, 2 pups)	N/A
Auwahi Wind Farm	02/24/2012–02/23/2037	Ulupalakua, Maui	Hawaiian hoary bat (21) Hawaiian petrel (87) Hawaiian goose (5)	Hawaiian hoary bat (140)
Kaheawa Wind Power I (KWP I)	04/30/2012§–01/29/2026	Kaheawa, Maui	Hawaiian hoary bat (50) Hawaiian petrel (38) Hawaiian goose (60)	N/A
Kaheawa Wind Power II (KWP II)	1/03/2012–1/02/2032	Kaheawa, Maui	Hawaiian hoary bat (11) Hawaiian petrel (43) Hawaiian goose (30)	Hawaiian hoary bat (38) Hawaiian goose (44)
Big Island Beef Community Wind Project¶	N/A	Paauiilo, Hawai‘i	N/A	N/A
Hawi Wind Farm	Not yet issued	Upolu Point, Hawai‘i		Application not yet submitted
Lalamilo Wind Farm Repowering Project	Not yet issued	Lalamilo, Hawai‘i		Hawaiian hoary bat (6) Hawaiian petrel (3)
North Kohala Microgrid Project¶	N/A	North Kohala, Hawai‘i	N/A	N/A
Pelekane Bay Watershed Restoration Project	2010 federal biological opinion covering 02/05/2010–02/04/2030	Pelekane Bay, Hawai‘i	Hawaiian hoary bat (16)	N/A

Name	Permit Duration	Location	Species and Total Take Authorization for Permit Term*	Species and Total Take Pending Approval (total includes previous authorized take)†
Waikoloa Water Community Wind Project‡	N/A	Waikoloa, Hawai‘i	N/A	N/A

* Other species may also have incidental take authorizations not reported here.

† Projected take based on using an 80% credibility level in Evidence of Absence software (Dalthorp et al. 2014, 2017) and includes indirect take.

‡ Federal biological opinion. Take numbers listed are from the State of Hawai‘i ITL.

§ Original permit was issued in 2006 and amended in 2012.

¶ Informal consultation completed with a “not likely to adversely affect” determination—no incidental take (turbines inactive at night).

One SHA is proposed on Hawai‘i Island: Kamehameha Schools, Keauhou and Kilauea Forest (Table 4.13). Under an SHA, a property owner voluntarily undertakes management activities on their property to enhance, restore, or maintain habitat benefiting species listed under the ESA and/or HRS Chapter 195D. These agreements assure property owners they will not be subjected to increased property-use restrictions if their efforts attract listed species to their property or increase the numbers or distribution of listed species already on their property. The USFWS and/or DOWFAW issues the applicant an enhancement of survival permit, which authorizes any necessary future incidental take through Section 10(a)(1)(A) of the ESA and HRS Chapter 195D-22. Accordingly, all impacts associated with these SHA permits have been mitigated.

Table 4.13. Safe Harbor Agreements Affecting Covered Species

Permittee	Permit Duration	Location	Species Covered
Pu‘u o Hoku Ranch	Unknown. Approved in 2001.	Moloka‘i	Nēnē
Unknown	Unknown. Approved in 2003.	Moloka‘i	Nēnē
Umikoa Ranch	Unknown. Approved in 2001.	Hawai‘i	Nēnē Hawaiian duck
Piiholo Ranch	50 years (September 2004–September 2054)	Makawao, Maui	Nēnē
Kamehameha Schools, Keauhou and Kilauea Forest	50 years	Kau, Hawai‘i	Hawaiian hawk Nēnē Hawaiian hoary bat

4.5.1 Nēnē

The only authorized take of nēnē is currently approved on Hawai‘i Island under an SHA (see Tables 4.12 and 4.13). One Hawai‘i Island take authorization for this species is being requested for Pakini Nui Wind Farm due to the potential for colliding with wind turbines and other Project components. Statewide, take of 121 nēnē is permitted or pending approval, not including take requested for Pakini Nui. Other developments on Hawai‘i Island with the potential to have cumulative impacts to nēnē include developments that decrease nesting and foraging habitat and golf courses that may attract nēnē to the area, increasing their vulnerability to vehicular collisions or golf ball strikes (DLNR 2015; Mitchell et al. 2005).

Proposed mitigation measures for nēnē at Pakini Nui are expected to more than offset the anticipated take and will contribute to the species' recovery by providing a net conservation benefit, as required by state law. Similar offsets can be expected for other projects with permitted take based on the requirement under state law to provide an overall net environmental benefit for the species. Similar measures are expected for other developments on Hawai'i Island and statewide with the potential to impact nēnē. Given the low expected rate of take at Pakini Nui and the expectation that impacts of any future projects will include mitigation to provide a measurable net benefit for nēnē, the cumulative impact of take for Pakini Nui combined with previous and future authorized take on other islands is not expected to result in a significant cumulative impact to the species.

4.5.2 Hawaiian Petrel

The only authorized take of Hawaiian petrel on Hawai'i Island is at the Lalamilo Wind Farm, although Lalamilo has not documented any takes of this species (see Table 3.2). In order to mitigate impacts to Hawaiian petrel, Lalamilo proposes to conduct predator control actions at an unfenced subcolony of petrels located in HVNP. This mitigation effort is expected to offset the requested take and provide a net benefit to the species. Statewide, take of 191 Hawaiian petrels is authorized or pending approval, not including the take requested for Pakini Nui. Other developments on Hawai'i Island with the potential to have cumulative impacts to the Hawaiian petrel include tall structures (communication towers, turbines, etc.), developments with excessive lighting, and developments that decrease nesting habitat.

The proposed mitigation measures described for the Hawaiian petrel are expected to more than offset the anticipated take and contribute to the recovery of the species by providing a net conservation benefit, as required by state law. Similar offsets are expected for the Lalamilo Wind Farm. With the low expected rate of take at Pakini Nui, the proposed mitigation measures are expected to produce a measurable net benefit in the form of a marginal increase in the population of the Hawaiian petrel, as estimated prior to any issuance of an ITP/ITL for the Project. For this reason, the cumulative impact of take authorized for Pakini Nui combined with previous and future authorized take throughout Hawai'i, is not expected to result in a significant cumulative impact to the species.

4.5.3 Hawaiian Hoary Bat

There are several factors that, when combined, have contributed to the current status of the Hawaiian hoary bat. Historically, conversion of native forests to nonarborescent-based agriculture or the expansion of cities has resulted in a significant reduction in Hawaiian hoary bat roosting habitat.

Original incidental take estimates for permitted wind facilities in Hawai'i were underestimated due to a lack of baseline data on the Hawaiian hoary bat and other factors that were beyond available scientific knowledge at the time of permitting. Each permitted wind facility operating in Hawai'i has required an amendment to its HCP to increase the amount of authorized take of the Hawaiian hoary bat. Assessing risk to the Hawaiian hoary bat with respect to wind facilities, in combination with substantial gaps in baseline population and life history information for the Hawaiian hoary bat, has increased concern regarding the potential cumulative impacts on the species. Sources of these potential impacts include existing and future wind energy development and other sources of anthropogenic take, such as biomass energy development, habitat destruction, increased human or predator activities, and other environmental and biological effects. However, post-construction fatality monitoring results and preliminary research efforts suggest that the population of Hawaiian hoary bats throughout the Hawaiian Islands is larger and more widespread than previously was known (personal communication, F. Bonaccorso, United States Geological Survey-Biological Resources Division, 2014).

Three factors suggest this Project, along with similar wind energy facilities, will not contribute significantly to cumulative impacts for the Hawaiian hoary bat: 1) the Hawaiian hoary bat is more widespread than previously assumed, 2) mitigation commitments in this HCP are designed to provide a net benefit to the species, and 3) other wind facilities in Hawai'i will similarly provide compensatory mitigation for the anticipated take of Hawaiian hoary bat.

Tree trimming and harvesting activities are not necessarily incompatible with bat habitat needs (Johnson and Strickland 2003; Patriquin and Barclay 2003), although they have the potential to impact juvenile bats that may be unable to fly away from an occupied tree when it is cut or disturbed. The USFWS recommends that harvesting or trimming woody plants more than 15 feet tall should not occur between June 1 and September 15. It is not known exactly how much bat take occurs statewide as a result of tree trimming and harvesting. However, the amount is likely so small that it does not contribute significantly to the cumulative impacts to the species.

Mortality has been documented from bats snagging on barbed wire. Annual mortality estimates range from 0 to 0.8 Hawaiian hoary bats per 100 kilometers of barbed wire (Zimpfer and Bonaccorso 2010). Although observed fatalities are uncommon, the extent of the impact of barbed wire fences is largely unknown because most fences are not checked regularly and any bats that may be caught on these fences may be quickly taken by scavengers. Based on the low estimates of mortality related to bat impalement on barbed wire fences, this impact is not expected to contribute significantly to the cumulative impacts to the species.

Authorized take levels of other listed species covered by permitted Hawai'i wind farm HCPs are typically higher than actual fatality rates based on current monitoring data. The potential for take of these species associated with individual projects appears to be fairly well understood, conservatively estimated, and mitigated to achieve a net benefit for the species.

There is no currently authorized take of Hawaiian hoary bat on Hawai'i Island. Hawaiian hoary bat take of six individuals has been requested at Lalamilo Wind Farm due to the potential for colliding with turbines and other project components, but the project is still undergoing the permitting process. Statewide, take of 586 Hawaiian hoary bats has been authorized or is pending approval, not including the take requested for Pakini Nui. Section 3.1.3 of this document describes fatalities that have occurred at other wind farms. Other developments on Hawai'i Island with the potential to have cumulative impacts to the Hawaiian hoary bat include resort or recreational developments, farming, road construction, pesticide use, and other developments that decrease roosting and foraging habitat. Although predatory relationships are largely unknown, it is possible the bat is preyed upon by barn owls, which may further impact populations.

The proposed mitigation measures described in this document for the Hawaiian hoary bat are expected to more than offset the anticipated take and contribute to the recovery of the species by providing a net conservation benefit, as required by state law. Similar offsets are expected for the Lalamilo Wind Farm, the other wind farm on Hawai'i Island seeking coverage for Hawaiian hoary bat take. With the low expected rate of take at Pakini Nui, the proposed mitigation measures are expected to produce a measurable net benefit in the form of an increase in the population (as estimated prior to Project take) of the species by increasing the quality of available foraging and roosting/pupping habitat, as described in Section 6.2.

For this reason, the cumulative impact of take authorized for Pakini Nui combined with previous and future authorized take statewide is not expected to result in a cumulative impact to the species.

5 BIOLOGICAL GOALS AND OBJECTIVES

The 2000 *HCP Handbook* addendum defines *biological goals* as the broad, guiding principles that clarify the purpose and direction of the conservation components of an HCP (*Federal Register* 65:35241). The following biological goals and objectives are designed to address the anticipated impacts of the incidental take resulting from the Covered Activities and consider the overall conservation needs of the Covered Species and their habitat. Minimization and mitigation measures identified in this HCP apply the best available science and provide the means for achieving these biological goals and objectives, which are described below.

Goal 1. Result in net conservation benefit for the Hawaiian hoary bat.

Objective 1. Restore existing but degraded habitat for increased use by Hawaiian hoary bats through implementation of a habitat restoration project at the Kahuku Unit of HVNP at a scale commensurate with the authorized take, which will result in islands of native forest.

Goal 2. Result in net conservation benefit for the Hawaiian petrel.

Objective 2a. Protect existing habitat for Hawaiian petrels by contributing to maintenance and monitoring of an existing predator fence, which will keep out introduced ungulates that cause harm to nesting habitat for seabird species on Mauna Loa.

Objective 2b. Protect existing populations of Hawaiian petrel through contributing to efforts to fence out and trap cats, which have substantial negative impacts on the survival and reproductive success of this seabird species. The population to be protected is located on Mauna Loa in HVNP.

Goal 3. Result in net conservation benefit for the nēnē.

Objective 3. Protect the existing population of nēnē through the construction, maintenance, and monitoring of a new breeding pen on the Island of Hawai‘i.

Goal 4. Increase knowledge.

Objective 4. Increase the knowledge and understanding of Covered Species by monitoring and sharing data with the USFWS and DLNR during the ITP/ITL term at the Project Area, the bat mitigation site at the Kahuku Unit, the petrel mitigation site on Mauna Loa, and the nēnē mitigation site.

6 MINIMIZATION AND MITIGATION

6.1 General Measures

Measures intended to avoid or minimize the likelihood of take of bat and avian species at wind farms often are related to the development (e.g., siting) and construction (e.g., seasonality) phases of a wind farm. Minimization measures implemented at the Project Area and intended to decrease the risk of take to Covered Species are as follows:

- Only emergency work will be scheduled during nighttime hours to avoid the use of lighting that could attract Hawaiian petrels, band-rumped storm-petrels, and possibly Hawaiian hoary bats.
- Use shielded fixtures for all lighting during the infrequent occasions when workers are in the Project Area at night. Outdoor lighting will be fully shielded. Outdoor lights will be restricted to what are needed for safety reasons and will only be used in emergency situations. Otherwise, no nighttime activities will occur on-site.

- Observe a speed limit of 40 km (25 miles) per hour while driving within the Project Area. This will help minimize collision with Covered Species, in the event they are using habitat in the Project Area or are injured. If nēnē are observed at or near the Project Area, a speed limit of 25 km (15 miles) per hour will be observed.
- Avoid use of the top strand of barbed wire within the Leased Area to reduce or eliminate the possibility of entangling Hawaiian hoary bats.
- Refrain from purposely approaching, and maintain a distance (by foot or vehicle) of 30 m (100 feet) from, nēnē when present in the Project Area in order to avoid erratic flight behavior that may increase strike risk.
- Observe year-round low wind speed curtailment, as described in Section 6.2.1.
- Do not create open water that may attract nēnē or Hawaiian hoary bat.
- Should the Project be decommissioned during the life of the ITP/ITL, these minimization measures will also apply to the decommissioning period. In addition, once decommissioned, the high-speed rotor lock will be engaged, stopping the turbine's ability to spin, and effectively eliminating collision risk to the Covered Species.
- If an effective, viable bat-deterrent technology becomes available during the Project's ITP/ITL term, Tawhiri will consult with the USFWS and DOFAW to determine if implementation of the technology is appropriate. Use of viable bat deterrent technology is discussed in Section 10.1.7.

6.2 Hawaiian Hoary Bat

This section describes minimization measures specific to the Hawaiian hoary bat (i.e., curtailment) and a proposed mitigation project (i.e., a forest restoration mitigation project in the Kahuku Unit of HVNP). The combination of minimization and mitigation described in this HCP leaves no remaining impacts of the taking of Hawaiian hoary bats that could be further mitigated or minimized. In other words, the biological value that will be lost from Covered Activities will be fully replaced through implementation of conservation measures (minimization and mitigation) with equivalent or greater biological value and the mitigation is equal with the impacts of taking for the following reasons:

- A resource equivalency analysis (REA) was conducted to quantify, using reasonable assumptions based on the best available science, the conservation benefit of the proposed forest restoration mitigation project in relation to the impacts of the proposed taking. The baseline assumptions and results are provided in detail in Section 6.2.3 and Appendix A. According to the REA, for Tawhiri to get credit for the mitigation project for 10 years, approximately 1,074 acres of habitat restoration fully offsets the impacts of the requested take of 26 bats. This is because multiple generations of bats will be expected to use the restored area given its long-term designation as a National Park. In total, 1,200 acres of forest restoration will be completed to provide a net conservation benefit to the species (46.2 acres per bat). The Hawaiian hoary bat population will benefit from this forest restoration mitigation project by gaining additional roosting habitat along with greater forage diversity.
- In addition to fully offsetting the impacts of the taking, the proposed amount and form of mitigation is the maximum extent practicable because there are no other reasonably available, practicable mitigation options available to Tawhiri. Habitat enhancement—particularly forest restoration—is currently one of very few agency-approved mitigation options available for implementation (in addition to wetland improvements, land acquisition, and research). The forest restoration mitigation project proposed in this HCP is based on the assumption that converting vegetation from invasive species to native forest will 1) provide more potential roosting locations,

and 2) improve foraging (i.e., arthropod diversity) over current conditions. As currently understood, none of the other options for mitigation have been proven to be better than the forest restoration mitigation project proposed in this HCP.

- The Project currently conducts a nightly curtailment regime with a cut-in speed of 5.5 m (18.0 feet) per second. This curtailment regime is described in greater detail in Section 6.2.1 and will continue for the life of the ITP/ITL. Low wind speed curtailment is a wind industry best management practice thought to be highly effective at minimizing bat take.
- Based on the best available information, the Hawaiian hoary bat population of Hawai'i Island is not trending toward extinction. The best available information is that it is "stable to slightly increasing," as reported in a recent study (Gorresen et al. 2013, p. 20); however, this trend is not conclusive because of the design of the study. The proposed mitigation, which is designed to fully offset the impact of the taking, will increase the likelihood of recovery through the mitigation measures proposed herein (Section 6.2.3) and provide a net environmental benefit to the population. Therefore, the overall impact of the taking will remain low.

The mitigation proposed in this HCP also meets the recommendations put forth in the *Endangered Species Recovery Committee Hawaiian Hoary Bat Guidance Document* (Amlin and Siddiqi 2015).

The adaptive management triggers, as defined in this HCP, will keep actual take (calculated every time take is observed and annually following ITP/ITL issuance) within the permitted limits. If the number of bats that will be taken has been underestimated, this HCP includes a mechanism for additional mitigation through a formal amendment, as described below.

6.2.1 Low Wind Speed Curtailment

One operational minimization measure being used at wind farms where native populations of bats reside, and that may help minimize Hawaiian hoary bat fatalities, is to increase the turbine cut-in speed to at least 5.0 m (16.4 feet) per second. Available data indicate that bat fatalities most commonly occur during lower wind speeds (Arnett et al. 2011; Arnett et al. 2013). Therefore, applying brakes to the turbines or allowing them to freewheel at less than 5.0 m (16.4 feet) per second may reduce the risk of fatality to bats. This measure has been implemented at wind farms in Hawai'i to reduce fatalities of Hawaiian hoary bats.

The Project implemented an interim curtailment program in March 2014. The Project currently curtails turbines year-round between the hours of 6:00/6:30 p.m. (approximately 1 hour before civil sunset) and 6:30/7:00 a.m. (approximately 1 hour after civil sunrise). Turbines shut down and the blades are feathered if the 10-minute average wind speed is 5.0 m (16 feet) per second or less (cut-out wind speed) and will start back up if the 10-minute average wind speed is greater than or equal to 5.5 m (18.0 feet) per second (cut-in wind speed). Blade feathering refers to when the turbines are offline and blades are pitched to 83 degrees parallel to the wind, which allows rotors to freewheel to minimize damage to drivetrain bearings. This curtailment regime will continue for the life of the ITP/ITL, as described below.

Data collected during Project acoustic monitoring show that bat activity rates peak in August and September (Appendix H). However, despite the strong seasonal nature of bat activity at the Project, Tawhiri will continue to implement year-round low wind speed curtailment after ITP/ITL issuance. Low wind speed curtailment will consist of operating turbines at an individually automated 10-minute average cut-out speed of 5.0 m (16.4 feet) per second and a 10-minute average cut-in speed of 5.5 m (18.0 feet) per second between the hours of 6:00/6:30 p.m. and 6:30/7:00 a.m. The turbines are curtailed on an individual basis as determined by on-board turbine anemometry. When offline, blades are feathered, as described above. Rotational speeds at these wind speeds are less than can be measured with the installed equipment (< 0.1 revolutions per minute). Note that this is not the same as "pitching" blades to slow

down rotor speeds. The turbines at the Project Area are unable to pitch blades sufficiently to significantly slow rotor rotation to speeds below those experienced prior to normal shutdown because of insufficient wind speeds.

DOFAW recommends a minimum cut-in speed of 5.0 meters per second (Amlin and Siddiqi 2015). Also, current science concerning the Hawaiian hoary bat does not establish that raising the cut-in speed will significantly reduce Hawaiian hoary bat fatalities. For these reasons, Tawhiri will continue with the current curtailment regime, as described above. During the duration of the ITP/ITL, the rate of bat take will be analyzed both per annum and cumulatively, and Tawhiri will discuss a potential increase of the cut-in speed through adaptive management with the USFWS and DOFAW if it becomes clear that the rate of take is too high to stay within permitted take limits.

6.2.2 Project Acoustic Monitoring

To comply with an ESRC requirement, Tawhiri will install six acoustic bat detectors at the Project to monitor the intensity of bat activity along the turbine string. These detectors will be placed semi-permanently on the nacelles of turbines 2, 4, 6, 8, 10, and 12.

The equipment installed at each detector location will consist of one SM4BAT detector (Wildlife Acoustics) connected to internal turbine power and an SMM-U2 omnidirectional microphone. Each microphone will be mounted on the MET mast of the turbine nacelle, and although omnidirectional, all microphones face the same direction. Two SanDisk (SD) memory cards with 128 gigabytes or greater of data storage will be used to record full spectrum data in each detector. The cards will be programmed to start recording approximately 1 hour before sunset and to stop 1 hour after sunrise. The cards will be exchanged monthly for a continuous sampling period for the duration of the operational life of the Project.

Data will be analyzed by a trained biologist using the appropriate software. All pertinent information on each recorded bat file will be housed in a Microsoft Excel spreadsheet or Access database. Such information would include the file name, date and time of recording, number of call sequences and passes per file (defined below), whether more than one bat was recorded, and whether social calls or feeding buzzes were recorded.

Acoustic files originating from bats will be classified as bat-call sequences and bat passes. A *bat call* (or pulse) is a one-frequency, modulated sweep. A *call sequence* consists of a continuous recording of one or more bat calls. A *bat pass* is a call sequence consisting of a grouping of two or more calls separated by a time interval of more than 1 second between the next call or grouping of calls. Passes are used to better represent the amount of bat activity recorded at the site.

An annual report will summarize the bat activity documented on-site based on all data collected during each field year. The report will include a summary of monthly and yearly patterns in recorded bat activity and average bat activity patterns throughout the night (sunset to sunrise).

6.2.3 Forest Restoration Mitigation Project

This forest restoration mitigation project will be completed in partnership with HVNP. HVNP has developed a forest restoration mitigation project to restore 1,200 acres of degraded lowland mesic-wet 'ōhi'a forest within the Kahuku Unit of HVNP, which is located approximately 9 miles north of the Project. This forest restoration mitigation project is expected to benefit the Hawaiian hoary bat and numerous other wildlife species (Appendix B, Table B-1). The full description of this forest restoration mitigation project is detailed below and in Appendix B. This forest restoration mitigation project will take

place in an area that has experienced decades of land clearing and has been utilized for cattle grazing, resulting in primarily non-native vegetation (Figure 6.1). HVNP acquired the 150,865-acre Kahuku Unit in 2003 for the preservation of habitat for threatened, endangered, and other rare plants and animals. Cattle grazing continued on the site under a special use permit until 2009.

HVNP is a proven and reliable partner with which to complete this forest restoration mitigation project for the following reasons. First, it manages large swaths of contiguous lands, some of which need restoration to support a diverse suite of native species. Under federal protection, these large swaths of land will be managed into perpetuity, which guarantees that the forest restoration mitigation project will benefit Hawaiian hoary bat into the foreseeable future. And HVNP has the institutional knowledge and infrastructure in place to support such a large-scale and complex forest restoration project, which will ensure that this mitigation project is implemented efficiently and correctly. For example, the method of restoration described herein has been tested and perfected on nearby lands, increasing the chances of project success. The partnership with HVNP has been approved by the USFWS since 2014, when HCP discussions began.

The official mission of the NPS is to “preserve unimpaired the natural and cultural resources and values of the National Park System for the enjoyment, education, and inspiration of this and future generations” (NPS 2018). This framework of preservation provides an ideal opportunity for mitigation partnerships in which mitigation monies are used to fund active conservation and restoration in areas preserved by HVNP for purposes of preserving natural scenery and historical objects. There is currently no management plan for the Kahuku Unit of HVNP. Outside funding, such as these mitigation funds, is necessary to implement restoration to improve the habitat for rare species. The mitigation work proposed by this HCP would not be completed with federal funds if private funds were not provided. HVNP provides habitat for several ESA-listed species. Restoration actions to address all these species in HVNP would require considerable funds in addition to HVNP’s operating funds. This forest restoration mitigation project provides an opportunity for this mitigation program to contribute to the conservation of multiple species in an area with long-term preservation guarantees that would not otherwise be restored.



Figure 6.1. Current condition of the forest restoration mitigation project area. Photograph courtesy of Hawai'i Volcanoes National Park.

The overall forest restoration mitigation project goal is to produce a self-sustaining, biologically diverse, multilayered native forest dominated by 'ōhi'a or mixed 'ōhi'a/koa forest that increases foraging and roosting opportunities for the Hawaiian hoary bat. The methods of the forest restoration mitigation project consist of controlling invasive plants, planting native trees and shrubs, and scarification around existing koa trees to regenerate the existing koa seed bank. This work will take place in an area where seed supplies for native tree species are limited and competition from invasive or aggressive grasses and woody species inhibits forest recovery. With the threat of the spread of rapid 'ōhi'a death into the HVNP Kahuku Unit, forest restoration projects of this type gain high importance in maintaining roosting habitat for the Hawaiian hoary bat because of the potential for the existing 'ōhi'a stands to die off. In June 2018, the Kilauea eruption dropped ash on the forest restoration mitigation project area, making it inhospitable to human presence. However, the NPS believes this impact was short term and will not impede the forest restoration mitigation project's chances for success (personal communication, Sierra McDaniel, HVNP, June 13, 2018). Tawhiri will assure restoration of an area commensurate with the level of take requested in this HCP.

As stated above, HVNP acquired the 150,865-acre Kahuku Unit in 2003 for the preservation of habitat for threatened, endangered, and other rare plants and animals. To this end, HVNP utilized federal funding to fence more than 5,000 acres of land within which it removed ungulates to reduce the immediate threat to the preservation of these rare species and their habitats (see Appendix A, Figure 1 for the exact location of fencing). The final mouflon sheep were removed by September 30, 2017, which rendered the 5,000-acre area ungulate-free (personal communication, Rhonda Loh, HVNP, September 28, 2018). These federally-funded actions will contribute to the success of the forest restoration mitigation project because

Tawhiri's funds can be applied solely to the reforestation aspect of the project. The forest restoration mitigation project area is situated inside the fenced acreage and is adjacent to the Ka'ū Forest Reserve. It provides habitat for several rare, threatened, and endangered species, including the Hawaiian hoary bat and nēnē. Hawaiian hoary bats were detected in the forest restoration mitigation project area year-round, although a density of individuals was not estimated (Fraser and HaySmith 2009). Much of the Kahuku lowland forest (< 1,372 m [4,500 feet] elevation) is badly degraded by decades of land clearing and destruction by cattle, mouflon sheep, and pigs. Large forest tracts have been converted to alien grass pastures and are invaded by Christmas berry (*Schinus terebinthifolius*), strawberry guava (*Psidium cattleianum*), and kāhili ginger (*Hedychium gardnerianum*). These invasive plant species are still in incipient stages and are at relatively low densities providing the perfect opportunity to remove before they potentially dominate the area. HVNP staff have constructed boundary fences and removed animals, but additional measures, such as invasive plant control and the planting of native trees, are needed to facilitate forest recovery and restoration of wildlife habitat. Without active restoration, much of the area would remain dominated by non-native pasture grasses and would not provide roosting or pupping habitat for the species.

Requested bat take will be mitigated through funding of \$1,463,728 for a contiguous 1,200 acres of forest restoration within HVNP that would be permanently protected by the NPS. Tawhiri and HVNP will provide a copy of a signed contract or Memorandum of Understanding between Tawhiri and HVNP that outlines the payment, performance schedule, and responsibilities of each party. The signed contract or Memorandum of Understanding will be in place before the take authorization contained in the ITP/ITL becomes effective.

The forest restoration mitigation project area is within the known range of the Hawaiian hoary bat and is proposed on lands for which there is currently no management plan nor is there funding for habitat restoration. The methods used by the NPS to achieve this restoration (described in detail below) are reliable because the removal of invasive plants, reintroduction of native plants, and overall increased native biodiversity of the vegetation are expected to boost bat forage biodiversity and availability within the first few years after planting. In 2007, HVNP completed a forest restoration project on an experimental plot within the 5,000-acre fenced enclosure to refine the forest restoration methods used for this mitigation project and increase the chance of success for future projects. Long-term roosting and potential pupping resources are expected to begin establishing after 6 years (when koa seedlings are expected to reach over 15 feet or more in height; personal communication, Sierra McDaniel, HVNP, June 13, 2018). As such, roosting habitat within the entire forest restoration mitigation project area is expected to be fully established within 14 years after starting the mitigation effort. Figures 6.2 and 6.3 depict the 2007 experimental plot 8-years post-planting. Further, the newly established koa trees are expected to support koa moths, which is thought to be a preferred food resource of the Hawaiian hoary bat. Due to the design, the improved functionality and resources of the forest restoration mitigation project area is expected to continue to provide those resources for the lifespan of each successful tree, which in some cases could be hundreds of years. Prior to implementation of the forest restoration mitigation project, it is assumed that this 1,200-acre forest restoration mitigation project area supports one bat per 80 acres to account for the provision of low-quality forage and transitory space.

The Pakini Nui Project site does not have any roosting or pupping habitat because of a dearth of trees. Furthermore, it is expected there are few native arthropods available for foraging in the predominant invasive plants. It is most likely that any bats frequenting the area are searching for prey in the lee of the nearby cliff and only infrequently enter the area occupied by turbines. The forest restoration mitigation project area is located 9.1 to 11.1 miles away from the northernmost turbine. Once restored, it will provide islands of closed canopy forested habitat comprised mostly of native species, providing roosting/pupping and improved foraging habitat for Hawaiian hoary bats. The forest restoration mitigation project will mitigate for impacts to low-quality habitat by improving roosting and pupping

habitat in a perpetually protected location that currently constitutes low-quality habitat. Bats affected by habitat destruction due to recent lava flows may also translocate to the forest restoration mitigation project area. The forest restoration mitigation project area is far enough away from the Project to not attract bats to the Project. This is supported by Bonaccorso et al. (2015), which found that the mean long axis of the Hawaiian hoary bat foraging range on Hawai‘i Island spanned from 1.6 to 2.6 miles. The foraging range consists of the area traversed by an individual as it searches for food and feeds as well as movements to and from day roosts and the night roost. It is unknown where the bats that are thought to forage near the Project Area roost during the day.



Figure 6.2. Condition of experimental restoration plot 8 years post-planting. Photograph courtesy of Hawai‘i Volcanoes National Park.

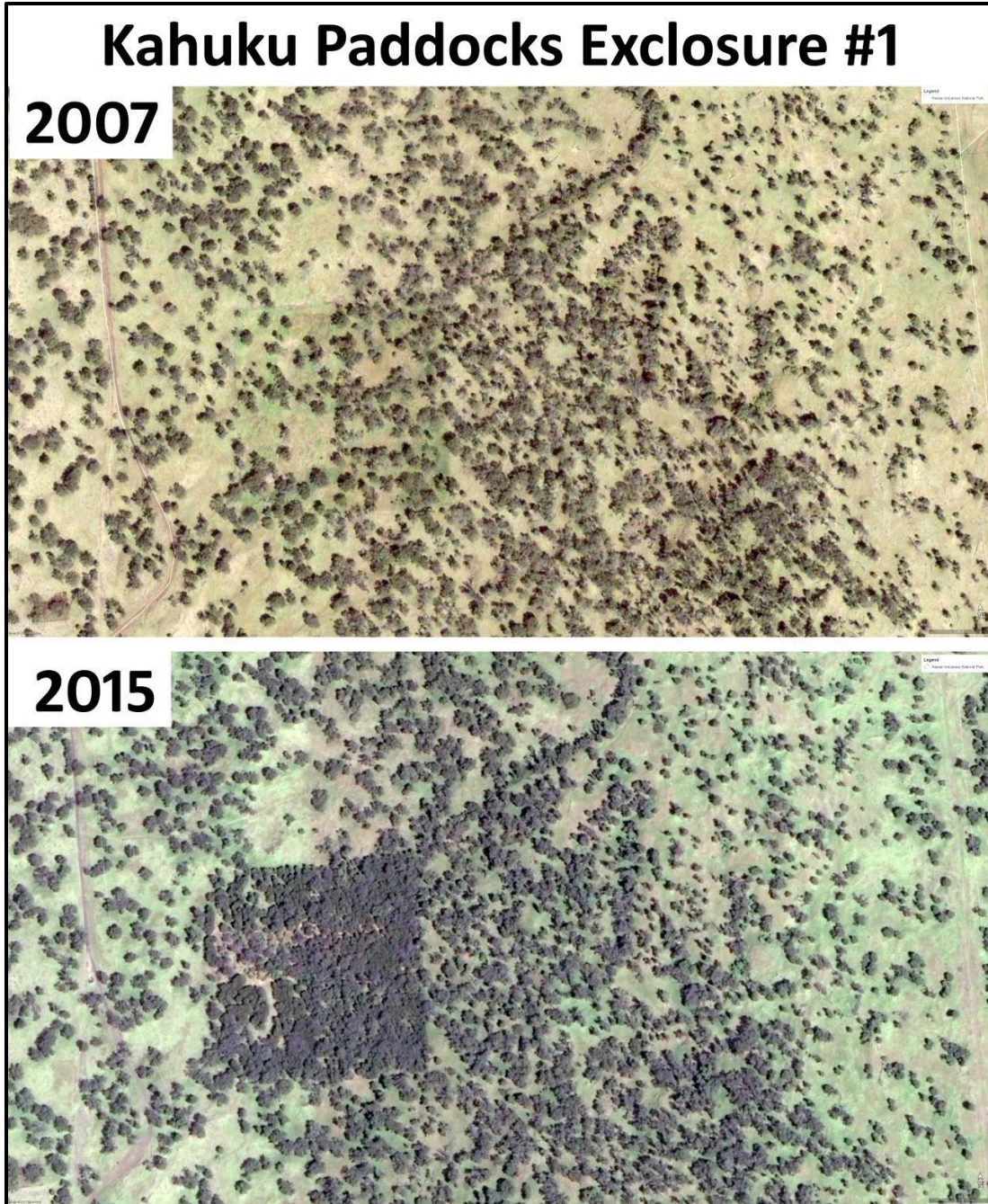


Figure 6.3. Experimental restoration plot 8 years post-planting (dense forest left of center). Photograph courtesy of Hawai'i Volcanoes National Park.

6.2.3.1 DETERMINATION OF MITIGATION PROJECT SIZE

An REA was completed to provide biologically sound logic for the size of the forest restoration mitigation project that would fully offset the impact of the anticipated level of take. REA is an economic model that provides a science-based, peer-reviewed method of quantifying interim and permanent resource losses (i.e., losses of animals) associated with an environmental disturbance and scaling compensatory mitigation to offset those losses (Allen et al. 2005; Dunford et al. 2004; King 1997; NOAA

2006, 2009). An REA quantifies and balances losses (take due to Project operation) and gains (benefits of compensatory mitigation) in animal-years. On the loss side of the REA, animal-years is the sum of the additional years the animals would have lived if they had not been killed by the environmental disturbance. On the gains side of the REA, animal-years is the sum of the increased per-acre carrying capacity of the animal over the lifetime of the mitigation project.

Appendix A provides detail and support for the inputs and calculations used to inform this REA, which are summarized in Table 6.1. Although Tawhiri acknowledges that some of the Hawaiian hoary bat life history inputs are not known and must be based on surrogates, the REA is presented as the best available method in the absence of better methods or definitive agency guidance.

Table 6.1. Data Need, Estimates Used, and Sources for Pakini Nui Hawaiian Hoary Bat Mitigation Resource Equivalency Analysis

Data Need	Estimates Used	Source
The timing and duration of the disturbance and an estimated number of animal fatalities.	26 takes in 8 years of operation	Section 4.1 of this HCP
An estimate of the animal's normal lifespan and the age distribution of the population so that the average animal-years lost per animal killed can be estimated without knowing the actual ages of the animals killed; age distribution can be estimated from age-specific survival rates if lifespan is known.	Maximum lifespan is 10 years. Assumed annual survival rates of juveniles (30%) and adults (85%) were used to characterize the age distribution of the population.	Lifespan: as noted in Amlin and Siddiqi (2015) Adult survival: O'Shea et al. 2011; Pryde et al. 2006 Juvenile survival: <i>Wildlife agency guidance for calculation of Hawaiian hoary bat indirect take</i> (USFWS 2016)
An estimate of the new resource services produced by the mitigation project per unit of application (e.g., number of animals supported per year per acre of habitat improved).	The forest restoration mitigation project area may currently support limited use by bats. Bats were detected at the project by Fraser and HaySmith 2009), but bat roosting and pupping habitat is limited. The bat use baseline is estimated in the model as one bat per 80 acres (0.5 bat per 40 acres). One bat-year per 80 acres is a conservative assumption that includes the possibility that bats may currently travel through and potentially forage in the forest restoration mitigation project area. For comparison, two bat-years per 40 acres is considered full carrying capacity based on mapping core range habitat sizes (Bonaccorso et al. 2015). The model assumes that the forest restoration mitigation project area will support two bat-years per 40 acres in the sixth year following planting in each section (full value).	Professional opinion, Fraser and HaySmith 2009; Bonaccorso et al. 2015

Data Need	Estimates Used	Source
The timing and duration of the mitigation project, including the time of implementation and the time to full benefit.	Funding for the forest restoration mitigation project will be provided in year 1 of the ITP/ITL. Noxious and invasive plant removal and the planting of tree seedlings will take place on approximately an eighth (12.5%) of the forest restoration mitigation project area every year for years 2–9 of the mitigation project. Koa, the fastest growing tree species to be planted and/or regenerated, will reach 15 feet in height after about 5 years and will provide roosting habitat 6 years following scarification/planting. Therefore, the creation of pupping habitat will begin on 12.5% of the forest restoration mitigation project area 6 years after planting (year 7 of the forest restoration mitigation project) and expand an additional 12.5% of the forest restoration mitigation project area until year 14 of the mitigation project (final planting in year 9 plus 6 years of growth, including the initial year). High-quality pupping habitat would result following 15–20 years of tree growth.	Professional opinion based on design of project, as described in Appendix B
The economic discount rate being used.	0% annual discount rate	The standard rate typically used in REAs (e.g., USFWS eagle take REA) is 3%; however, 0% is consistent with the discount rate used for the Indiana Bat REA.

The REA assumes that the forest restoration mitigation project will begin the first year of ITP/ITL implementation, with roosting benefits occurring 6 years following scarification/planting. As stated above, the REA takes into account the mitigation project duration and will credit fewer acres per bat if more than one generation may use the same territory (i.e., if the mitigation project will persist beyond the average bat lifetime). This forest restoration mitigation project is designed such that tree saplings will be planted in dense nodes that will outcompete the invasive grasses for the life of the tree without additional management intervention, which in some cases may be hundreds of years. As described in Section 6.2.4.1 (vegetation monitoring), if less than 60% of the seedlings survive the first year, additional herbicide application and plantings will take place. According to the REA, with Tawhiri maintaining credit for the forest restoration mitigation project for 10 years following ITP/ITL issuance, a minimum of 1,074 acres would need to be restored to fully offset the impacts of the proposed take (see Appendix A for a description of the calculation), which is less than the 1,200 acres proposed in this HCP.

Another factor considered in determining the forest restoration mitigation project’s size is its location in a National Park. Although this means the mitigation project will be protected into perpetuity, it also can be asserted that mitigation would have been more valuable on private lands that could otherwise be subject to development. For this reason, an adjustment factor is sometimes added to mitigation projects on federal lands whereby additional mitigation is completed. In this HCP, the forest restoration mitigation project’s ultimate size is approximately 12% greater than the acreage resulting from the REA (i.e., (1,200 acres – 1,074 acres) ÷ 1,074 acres). This size inflation accounts for the project taking place on federal land and ensures a net conservation benefit to the population.

After taking the results of the REA and the location on federal land into consideration, it was determined that a forest restoration mitigation project consisting of 1,200 acres (46.2 acres per bat) would fully offset the impacts of the proposed taking for the following reasons:

- It encompasses the estimate provided by the REA.
- It is commensurate with the 40 acre per bat mitigation recommendation described in Amlin and Siddiqi (2015), which is based on research by Bonaccorso et al. (2015).

- It adds a 12% upwards adjustment factor to the forest restoration mitigation project because the mitigation will take place on federal land.

6.2.3.2 OBJECTIVES

The overall forest restoration mitigation project goal is to produce a self-sustaining, biologically diverse, multilayered native forest dominated by ‘ōhi‘a or mixed ‘ōhi‘a/koa forest that increases foraging and roosting opportunities for the Hawaiian hoary bat. Forest restoration mitigation project objectives are as follows:

- Prevent establishment of target weed species to promote natural recovery and an increase in native biodiversity.
- Plant 90,000 nursery-reared seedlings to facilitate forest recovery in 1,200 acres of degraded former pasture in the Kahuku Unit according to the methods and implementation schedule described below.
- Create islands of native forest habitat where degraded pastureland previously existed.
- Evaluate vegetation community changes within the forest restoration mitigation project area.
- Evaluate bat activity and arthropod diversity within the forest restoration mitigation project area.

6.2.3.3 METHODS

The forest restoration mitigation project methods are as follows. These methods have been tested at an experimental paddock in the Kahuku Unit and have been shown to be successful.

- To prevent establishment of target weed species, work crews will conduct ground searches to locate target weed species. Global positioning system data will be collected for areas searched and the number of plants treated. Target species include blackberry, strawberry guava, kahili ginger, and Christmas berry. Control methods will follow established HVNP-prescribed treatments for each species. Target invasive plant species are still in incipient stages since the ungulate removal was achieved. Currently, they are at relatively low densities, providing the perfect opportunity to remove before they potentially dominate the area.
- Remove grasses from 0.6- to 10-acre areas around select existing koa trees (depending on the configuration of existing koa stands) using mechanical scarification or herbicide to regenerate koa from the seed bank totaling approximately 30 acres.
- Plant 90,000 nursery-reared seedlings of ‘ōhi‘a, pilo, aalii, olapa, hoawa, and kolea in a total of 48 50 × 50-m islands. Each island will receive approximately 1,875 seedlings, which is one plant per 1.3 square meters. This spacing will ensure canopy closure and long-term suppression of grasses. Six islands will be planted each year for 8 years. Seeds of native tree and shrub species will be collected within the local area and processed for propagation at the HVNP native plant facility. The native plant facility will be kept free of pest species; individuals will be rigorously monitored and sanitized before planting to avoid contamination of target locations. Techniques for propagating and planting common native species have been developed and applied at HVNP. Prior to planting, alien grasses will be temporarily suppressed by applying a 2% solution of imazapyr and glyphosate.
- Planting and scarification will be strategically placed to link existing forest fragments or build biodiversity around existing solitary trees. Forest islands built around scattered, tall ‘ōhi‘a and koa trees in the pasture may attract birds to disperse seeds and have higher nutrient inputs because of leaf litter and higher moisture levels because of cloud water interception. Planting seedlings in

dense islands will reduce light levels as the canopy develops and suppress the dominate invasive grasses. This will create a closed canopy forest habitat that would be extant for the life of the trees, needing very little long-term management.

- Alien grasses will be periodically treated with herbicide as needed for two years following planting to help ensure seedlings survive to maturity.
- To monitor forest restoration mitigation project success, vegetation monitoring plots will be established within the forest restoration mitigation project area to evaluate impacts of management actions on the vegetation community composition and structure. Pre-planting/scarification plots (baseline) will be established and reevaluated at year 10 of the ITP/ITL. Results of the monitoring will be compared to the baseline to determine if native biodiversity and the canopy cover have changed significantly.

6.2.3.4 IMPLEMENTATION SCHEDULE

Because of the large size of the forest restoration mitigation project, the planting and scarification schedule will be staggered so that a manageable portion of the overall forest restoration mitigation project area is reforested each year (i.e., in restoration sections). HVNP has proposed to split the 1,200-acre project into eight sections of an average of 150 acres each and reforest each part according to the example schedule provided in Table 6.3. Monitoring actions are described below.

Table 6.3. Example Reforestation and Monitoring Schedule, Forest Restoration Mitigation Project

Restoration Section	Forest Restoration Mitigation Project Year										
	1	2	3	4	5	6	7	8	9	10	
1	Project coordination, site visits with work leaders, collection of plant material, and propagation.	Plant seedlings and scarify	Monitor seedling survival	Monitor general plant health. Re-treat grasses with herbicide in planting plots as needed.	Monitor general plant health. Re-treat grasses with herbicide in planting plots as needed.						Monitor invertebrate diversity, bat activity, and vegetation
2	Survey baseline vegetation, bat activity, and invertebrate diversity monitoring for restoration section 1.	Baseline vegetation, bat activity, and invertebrate diversity monitoring	Plant seedlings and scarify	Monitor seedling survival	Monitor general plant health. Re-treat grasses with herbicide in planting plots as needed.	Monitor general plant health. Re-treat grasses with herbicide in planting plots as needed.					Monitor invertebrate diversity, bat activity, and vegetation
3			Baseline vegetation, bat activity, and invertebrate diversity monitoring	Plant seedlings and scarify	Monitor seedling survival	Monitor general plant health. Re-treat grasses with herbicide in planting plots as needed.	Monitor general plant health. Re-treat grasses with herbicide in planting plots as needed.				Monitor invertebrate diversity, bat activity, and vegetation
4				Baseline vegetation, bat activity, and invertebrate diversity monitoring	Plant seedlings and scarify	Monitor seedling survival	Monitor general plant health. Re-treat grasses with herbicide in planting plots as needed.	Monitor general plant health. Re-treat grasses with herbicide in planting plots as needed.			Monitor invertebrate diversity, bat activity, and vegetation
5					Baseline vegetation, bat activity, and invertebrate diversity monitoring	Plant seedlings and scarify	Monitor seedling survival	Monitor general plant health. Re-treat grasses with herbicide in planting plots as needed.	Monitor general plant health. Re-treat grasses with herbicide in planting plots as needed.		Monitor invertebrate diversity, bat activity, and vegetation

Restoration Section	Forest Restoration Mitigation Project Year									
	1	2	3	4	5	6	7	8	9	10
6						Baseline vegetation, bat activity, and invertebrate diversity monitoring	Plant seedlings and scarify	Monitor seedling survival	Monitor general plant health. Re-treat grasses with herbicide in planting plots as needed.	Monitor invertebrate diversity, bat activity, and vegetation
7							Baseline vegetation, bat activity, and invertebrate diversity monitoring	Plant seedlings and scarify	Monitor seedling survival	Monitor invertebrate diversity, bat activity, and vegetation
8								Baseline vegetation, bat activity, and invertebrate diversity monitoring	Plant seedlings and scarify	Monitor seedling survival, invertebrate diversity, and bat activity.

6.2.4 Monitoring

Monitoring actions for vegetation, bat activity, and invertebrates are described below, with the timing of actions displayed in Table 6.3, along with the forest restoration mitigation project implementation schedule. Costs anticipated for monitoring are detailed in Appendix C.

Bat activity and invertebrate diversity monitoring will be conducted by a qualified third party and will require obtaining a research permit from HVNP, which will be done at the time of ITP/ITL issuance.

6.2.4.1 VEGETATION

Vegetation monitoring plots will be established both within and adjacent to the forest restoration mitigation project area to evaluate impacts of management actions on the vegetation community composition and structure. Three control, or baseline, plots and three treatment plots will be established and monitored in or near each restoration section, ultimately totaling 21 baseline and 21 treatment monitoring plots (six per year for seven years). The vegetation will not be monitored in this manner the eighth year because not enough time will have elapsed to produce meaningful monitoring results. Vegetation monitoring methods will mimic those described in McDaniel et al. (2011). The area of each plot will be 50 × 50 m. Vegetation baseline conditions will be measured in three monitoring plots in or near each restoration section prior to conducting the treatment and resurveyed in year 10 of the forest restoration mitigation project.

Seedling survival will be monitored the year following planting. If fewer than 60% of the seedlings have survived 1 year, additional herbicide applications and planting/scarification may occur. If normal weather patterns persist (i.e., no drought or flooding occurs), NPS has found that a 60% seedling survival rate is a very good indication of long-term survival (personal communication, Sierra McDaniel, NPS, July 8, 2019). Additionally, to enhance the potential for seedling success, alien grasses will be periodically treated with herbicide as needed for 2 years following planting to help ensure seedlings survive to maturity. NPS personnel will also monitor the general health of the growing seedlings and will be able to course-correct if they observe an unusual die back to ensure the success criteria (Section 6.2.4) are met.

The vegetation monitoring results will be compared with the baseline to measure changes in forest structure and diversity. The variables measured in each plot will be 1) percent of outplanted seedling survival, 2) native species richness, and 3) stand density and species comprising the forest canopy (native versus non-native).

6.2.4.2 BAT ACTIVITY

The USFWS requires that the forest restoration mitigation project also include a bat monitoring component (personal communication, D. Sether, USFWS, August 17, 2015). Monitoring will be accomplished by measuring two variables:

- Changes in Hawaiian hoary bat activity and behavior (i.e., documented foraging attempts) over time in the forest restoration mitigation project area
- Changes in insect biomass over time in the forest restoration mitigation project area

The null hypothesis will be that bat activity will not change in the restoration sections over time.

Between two and 16 acoustic bat detectors will be deployed at any one time (no more than two per restoration section) to document call type (i.e., feeding buzzes) and frequency as an index of Hawaiian hoary bat activity levels. The detector and microphone technology deemed to be best suited at the time of

deployment to record the subspecies and for the local conditions will be used (such as Wildlife Acoustics SM3 or SM4 models). As shown in Table 6.3, acoustic sampling stations will be deployed for a 1-month period during peak bat activity in each restoration section prior to restoration actions to document baseline conditions and again in year 10 to document post-restoration bat activity. This sampling structure will result in a total of 32 detector-months (two detectors for both baseline and post-restoration sampling in each of eight restoration sections for one-month deployment each). Acoustic data collected after restoration will be compared with each section's baseline conditions.

Bat passes will be quantified at each acoustic sampling station. Feeding buzzes and search phase sequences will be distinguished and tallied and compared with the baseline dataset. Mean weekly bat passes will be compared within the forest restoration mitigation project area before and after restoration of the areas. This monitoring will be conducted by a qualified third party to be determined at the time of ITP/ITL issuance. Should new technology for monitoring bat activity levels become commercially available during the monitoring period, Tawhiri may deploy this technology in lieu of acoustic detectors, with approval from the USFWS and DOFAW.

6.2.4.3 INVERTEBRATE DIVERSITY

Samples of invertebrate species richness will be compared over time. Data collected during the year prior to beginning reforestation actions will constitute baseline activity for comparisons over time. Invertebrate sampling will be conducted using light sampling methods twice annually (rainy season and dry season) and during the acoustic monitoring. Light sampling will be conducted during the same moon phase within each restoration section and will take place for the same amount of time for each sampling effort. Invertebrates will be funneled into a collection device. They will be sorted into bat forage and non-forage groups. The forage group will be identified to species, if possible, and quantified for species richness.

The results of the vegetation, acoustic, and invertebrate monitoring will be summarized in the annual report corresponding with the year of monitoring.

6.2.5 Success Criteria

Habitat restoration of 1,200 acres of degraded forest/pasture will take place within the Kahuku Unit of HVNP (forest restoration mitigation project), according to the methods provided above and in Appendix B and amounts and schedules provided in Appendix C (Mitigation Costs and Funding). A Memorandum of Understanding between Tawhiri and HVNP will be in place before the take authorization contained in the ITP/ITL becomes effective. Success will be achieved when the following tasks are completed (given that the changed and unforeseen circumstances listed in Section 10 of this HCP do not occur):

- 1,200 acres are swept for control of target weed species according to established HVNP-prescribed treatments to promote natural native plant establishment
- 90,000 native tree and shrub seedlings of 'ōhi'a, pilo, aalii, olapa, hoawa, and kolea are planted in a total of 48 50 × 50-m islands.
- Approximately 0.6- to 10-acre areas around existing koa trees are scarified (depending on the configuration of existing koa stands).
- Six vegetation monitoring plots (three baseline and three treatment) measuring 50 × 50 m are established within each of the restoration sections to evaluate impacts of management actions on the vegetation community composition and structure, seedling survival is monitored 1 year post-planting, and native species richness and canopy cover/species are resurveyed on the schedule presented in Table 6.3

- Successful mitigation results indicate the following when compared with the baseline:
 - 60% seedling survival 1 year following planting/scarification
 - Native species richness increases over time
 - The canopy comprises entirely native tree species
 - Monitoring for increases in bat activity and invertebrate diversity
- Status and results of the restoration and monitoring efforts (including expenses) are provided in annual reports to DOFAW and the USFWS.

This mitigation project is designed to provide benefits to the HVNP Hawaiian hoary bat population. These actions have been identified as being the most likely to benefit the population; however, these actions are very difficult to translate directly into an increase in the bat population, especially within the 10-year ITP/ITL duration. Also, events outside of Tawhiri's control, such as drought, volcanic activity, ingress of predators, etc., mean that the criteria for the success of this project are most logically related to completion of certain tasks and not to direct increases in the Hawaiian hoary bat population.

6.2.6 Adaptive Management Trigger

A report will be submitted annually to the USFWS and DOFAW that will analyze whether the native vegetation biodiversity, acoustic activity, and invertebrate biodiversity are increasing as expected in the forest restoration mitigation project. Adaptive management actions will be taken if it is apparent that the success criteria will not be achieved following submittal of the forest restoration mitigation project year 4 report. Adaptive management actions may consist of reapplying herbicide, rebroadcasting seed, planting additional seedlings, conducting additional scarification, increasing or altering tree survival monitoring activities, or other actions necessary to achieve the success criteria.

Research on Hawaiian hoary bat is currently being planned for mitigation credit for other Hawai'i wind power projects. Results of this research will be reviewed annually by the USFWS and DOFAW and may suggest a completely new strategy for bat mitigation in the future or other refinements to improve effectiveness of existing hoary bat habitat management strategies. In addition, the *Endangered Species Recovery Committee Hawaiian Hoary Bat Guidance* recommends review of research priorities every 5 years and making modifications to respond to new information. At the future direction of the USFWS and DOFAW, mitigation activities may consist entirely of restoration, research, or a combination of both. As new information becomes available, Tawhiri will incorporate it into the adaptive management program.

6.3 Hawaiian Petrel

HVNP constructed a 5-mile barrier fence encompassing over 600 acres of nesting habitat to protect the largest subcolony of endangered Hawaiian petrels on Hawai'i Island. Construction began in 2013 and was completed in 2016. HVNP conducted predator control and surveillance within the fence during the 2016 and 2017 breeding seasons. No cats have been detected and no predation events were documented; therefore, the area has been deemed free of cats. Tawhiri will augment postconstruction management actions for 3 years, as described in this section and Appendix D.

HVNP conducts one complete fence inspection per year. Funds provided by Tawhiri will support more frequent fence inspections and rapid responses to potentially damaging events, like a significant storm, with a complete inspection and repair as needed, thus minimizing potential impacts to nesting birds, such as predator ingress.

Real-time surveillance for predator ingress will be improved with the addition of eight remote texting game cameras, which will be funded by Tawhiri. Images are sent to park staff via emails, allowing for a rapid response by HVNP staff should ingress be detected. Monitoring for ingress predators within the enclosure is best accomplished by placing cameras at nest sites, as potential routes are excluded by the fence, thus providing additional reproductive data on a subset of nests. This will improve HVNP's estimate of reproductive success, as cameras have proven to provide more accurate information on this cryptic species than human observation of indirect cues (such as guano and the presence of chick down).

Although the fence was completed in 2016, the primary strike deterrent (two strands of white woven tape) was installed in 2013 when the fence posts were installed; this alerts birds to the presence of the poles and conditions them to anticipate the coming fence. With funds provided by Tawhiri, the white tape will be replaced as soon as it is deemed necessary.

HVNP conducted 5 consecutive years of a nest density survey to establish baseline density estimates before and during fence construction and to refine the new monitoring protocol techniques. This level of monitoring is not sustainable given current fiscal uncertainty and will, therefore, occur only when funding is available. Funds provided by Tawhiri will provide the support needed to conduct this systematic monitoring at 5 to 6 years following fence construction, an appropriate time to expect change given the maturation rate of the species.

HVNP staff will be responsible to carry out the methods and monitoring, as described in this section. Methods are as follows:

- Set remote texting game cameras to monitor in real time for ingress of predators.
- Conduct additional fence inspections each year to better ensure the integrity of the fence. An inspection will be in response to a potentially damaging event, if one occurs; otherwise, it will be planned opposite HVNP's annual inspection.
- Replace deteriorated anti-strike devices (white marking tape or an alternate) to ensure that the fence remains visible to transiting birds.

Surveillance for ingress of predators and annual fence inspections will take place in years 1–3 of the mitigation project. The deteriorated anti-strike devices will be replaced in years 1, 2, or 3 (when needed).

The proposed mitigation will be sufficient to 1) offset the impacts of authorized take of Hawaiian petrels, and 2) result in an overall net conservation benefit for the species by ensuring that the colony remains protected from predators. Mitigation measures are expected to contribute to increased survival rates of adults in the area and/or in increased fledgling production. Mitigation efforts will not include or overlap with other projects.

6.3.1 Monitoring

The following monitoring activities will take place in the Hawaiian petrel colony during the life of the mitigation project:

- Reproductive success will be monitored at a subset of nests using the game cameras for each of 3 successive years.
- Pedestrian nest surveys will be conducted in 50 × 50-m grids as outlined in the Hawaiian Petrel Monitoring Protocol (Hu et al. 2015). Data collected will be used to calculate nest densities and contribute to the detection of trends over time.

Due to the slow maturation and reproductive rate of the species, monitoring on an annual time frame does not provide the long-term data necessary to determine a trend in petrel numbers or an increase in fledging rates. The results of the nest surveys conducted for this mitigation project will be compared with the HVNP 5-year nest density survey that was conducted before and during fence construction. Results of effectiveness monitoring will be included in the annual reports that are submitted to DOFAW and the USFWS.

6.3.2 Success Criteria

A Memorandum of Understanding between Tawhiri and HVNP will be in place before the take authorization contained in the ITP/ITL becomes effective. The following criteria will be used to determine the success of the mitigation project:

- Replacement of 10 miles (two strands) of white tape is completed to ensure that the fence remains visible to Hawaiian petrels.
- Reproductive success results are reported for a subset of Hawaiian petrel nests for each of 3 successive years and shared in the annual report.
- Results of consistent, remote surveillance for ingress predators are reported annually.
- Comprehensive annual fence inspections and repairs are conducted.
- Predator removal and nest density estimates are reported and are comparable to the estimates obtained before and during construction of the fenced area.
- Annual reports detailing mitigation activities and progress toward success criteria are provided to the USFWS and DOFAW.

In the case of the Hawaiian petrel mitigation project, success criteria cannot be defined as the addition of a certain number of fledglings to the population primarily because of the design of the mitigation project and the small size of the benefiting population (personal communication, Rhonda Loh, HVNP, September 28, 2018). This mitigation project is designed to provide indirect benefits to the HVNP Hawaiian petrel population, such as a reduction of fence strikes and predator ingress. The actions proposed by this mitigation project are those that HVNP has identified as being the most likely to benefit the population; however, these actions are very difficult to translate directly into an increase in the population, especially within the 10-year ITP/ITL duration. Second, the fenced population of Hawaiian petrel is so small that it is extremely difficult to detect significant increases in breeding rates from year to year. Also, small populations can be disproportionately impacted by unpredictable events outside of Tawhiri's control, such as drought, decline in forage availability, or ingress of predators. For these reasons, the criteria for the success of this project is most logically related to completion of certain tasks and not to direct increases in the population of Hawaiian petrel.

6.3.3 Adaptive Management Trigger

Adaptive management actions will be triggered if, after year 3 of the mitigation project, Tawhiri, the USFWS, and DOFAW determine that the methods described above were not effective at reducing predators from the fenced colony. Tawhiri will work with HVNP, the USFWS, and DOFAW to identify necessary actions to improve predator control methods within 9 months (or such time as Tawhiri, DOFAW, and the USFWS agree is reasonable) after the entities determine the mitigation was not successful, with the ultimate goal of achieving the success criteria.

6.4 Nēnē

As a result of the emergency declaration by Governor Abercrombie in 2011 to move 598 nēnē from Kauaʻi, the conservation needs for this species have shifted since work on this HCP first began (personal comment, A. Siddiqi, DLNR, August 2016). This nēnē mitigation project will provide a net benefit by increasing the nēnē population on Hawaiʻi Island above the level of take requested.

Mitigation for nēnē will consist of construction of a new 7-acre breeding pen on Hawaiʻi Island approximately 1.25 miles from existing DOFAW-managed breeding pens. The new 7-acre pen would contain two reservoirs and part of a hill. Nēnē have been seen in the area, but no nesting attempts or fledging has been observed. The predator-proof fence would be constructed during the first year of the nēnē mitigation project. The remaining funds would be used to maintain the fence and enclosure, completing tasks such as repair of fences, purchase of vegetation maintenance equipment (i.e., lawn mowers and weed trimmers), repair of the reservoir to maintain year-round water, and control of predators. Funding for this nēnē mitigation project is detailed in Appendix C (Mitigation Costs and Funding). This nēnē mitigation project is intended to provide a net benefit to the species in alignment with state and federal species recovery goals to promote the recovery of the species within portions of its historic range and to contribute to an increase in adult or juvenile survival and/or increased productivity (average number of fledglings per pair) at the mitigation site.

Because adult nēnē will be replaced by fledglings, the possible loss of production during the lag years between take of adult birds and the sexual maturity of the fledglings will be accounted for. Female nēnē mature at age 3 and males at age 2 (Banko et al. 1999). For the purpose of this HCP, it is assumed that an adult lost in year 1 will be replaced by fledglings in year 1 (with indirect take separately accounted for, as described in Section 4.3.2), and no gosling production will occur in years 2 and 3 because the fledgling would still be immature. The female fledgling produced in year 1 could begin breeding in year 4. Only 1 year of lost productivity will be attributed for the take of a mature male.

Average loss of productivity through mortality of one adult has been determined to be 0.09 goslings/individual/year (see Section 4.3.2). Because adults will be replaced by goslings, loss of productivity will be assessed at an additional 0.09 fledglings for an adult male (1 year loss of productivity) and 0.18 fledglings for an adult female (2 years loss of productivity) assuming same-year replacement (Table 6.4). The mortality of captive-reared released goslings to year 1 was reported to be 16.8% for females and 3% for males (Banko et al. 1999; Hu 1998). For the purpose of this HCP, an annual survival rate of 83% is assumed to occur for both genders of geese through maturity (age 2 or 3, depending on gender). Males and females are assumed to be equally vulnerable to collision with the turbines and associated structures. Table 6.4 identifies the number of fledglings that will be produced to offset the take anticipated for nēnē during operation of the Project. It is anticipated that all take will be replaced with fledglings within the same year or earlier. If increased adult survival can be demonstrated, the estimate can be adjusted accordingly.

Based on the numbers provided in Table 6.4, if the full amount of projected take of nēnē occurs at the Project over the 10-year life of the mitigation project (three nēnē), a net accrual of six (5 + 1) fledglings would result in a net benefit for the species.

A Memorandum of Understanding between Tawhiri and DOFAW for the mitigation project will be in place before the take authorization contained in the ITP/ITL becomes effective. Mitigation for nēnē will be considered successful and complete following the completion of pen construction and 4 years of maintenance and predator control, as described above.

Table 6.4. Fledgling Requirement for Nēnē Take Assuming Same-Year Replacement

	Direct Take		Indirect Take	
	Male	Female	Fledglings	Total Required Fledglings
Total requested baseline take	1	1	1	
Fledglings required	1.5 (= 1.0 ÷ 0.83 ÷ 0.83)	1.8 (= 1.0 ÷ 0.83 ÷ 0.83 ÷ 0.83)	1	4.3 (= 1.5 + 1.8 + 1)
Loss of productivity	0.09 (= 0.09 × 1 × 1 year)	0.18 (=0.09 × 1 × 2 years)		0.27 (= 0.9 + 0.18)
Total				4.6, rounded up to 5

6.4.1 *Monitoring*

The increase in the number of nēnē fledglings produced after pen construction will be determined through near-daily monitoring by DOFAW employees. Fledglings will be banded at 8–12 weeks in age, and fledging will be considered successful when a chick leaves the breeding pen on its own. Nēnē have been observed in the area, but no nesting attempts or fledging has been observed; therefore, any successful fledging will be attributable to the presence of the new pen (i.e., baseline is 0).

6.4.2 *Success Criteria*

The following criteria will be used to determine success of the mitigation project:

- A new 7-acre breeding pen is constructed and maintained for 4 years.
- Six 8- to 12-week fledglings have hatched from the pen.
- Annual reports detailing mitigation activities and progress toward success criteria are provided to the USFWS and DOFAW.

6.4.3 *Adaptive Management Trigger*

Adaptive management will be triggered if Tawhiri, the USFWS, and DOFAW agree that at least four fledglings (80% of mitigation amount) have not been produced from the pen by the third breeding season following pen construction. Adaptive management actions may include incorporating changes to the trapping protocol to increase the chances of nest success and increased monitoring to ensure documentation of fledging success.

6.5 *Band-Rumped Storm-Petrel*

Although the band-rumped storm-petrel is not a Covered Species, the minimization and mitigation designed for the Hawaiian storm-petrel will also benefit this species.

7 HABITAT CONSERVATION PLAN IMPLEMENTATION

7.1 Habitat Conservation Plan Administration

Tawhiri will administer this HCP. The DLNR and USFWS, as well as experts and biologists from other agencies (e.g., the U.S. Geological Survey) and conservation organizations, consultants, and academia, may be consulted as needed. HCP-related issues may also be brought before the ESRC for formal consideration when deemed appropriate by Tawhiri.

7.2 Monitoring and Reporting

Implementation of this HCP includes compliance (i.e., fatality) monitoring and effectiveness monitoring. Compliance monitoring will be implemented to ensure accordance with the terms and conditions of the ITP/ITL. Compliance monitoring will be funded by Tawhiri as a separate expense. Effectiveness monitoring will be undertaken to assess the effectiveness of the HCP's minimization and mitigation measures toward meeting the biological goals and objectives described in Section 5 of this HCP. Effectiveness monitoring is funded and implemented as part of the proposed mitigation plans. All monitoring activities on-site and off-site will be coordinated by Tawhiri's natural resources manager, with the aid of trained staff, as appropriate. Monitoring efforts for which Tawhiri is responsible are described in the following sections. Any changes to monitoring will only be made with the concurrence of the USFWS and DOFAW.

Pursuant to HRS §195D, DOFAW may conduct independent monitoring tasks during the life of the ITL to ensure compliance with the terms and conditions of the ITP/ITL. The USFWS also may conduct inspections and monitoring in accordance with the ESA and its implementing regulations (currently codified at 50 CFR 13.47).

7.2.1 Compliance Monitoring

Fatality monitoring provides a scientifically defensible means of determining compliance with ITP/ITL take limits and authorizations. An assigned third party approved by the USFWS and DOFAW will conduct systematic fatality monitoring to ensure adequate fatality search data are collected for the Project. In addition to over 4 years of weekly pre-ITP/ITL fatality monitoring, compliance monitoring, as set forth below, will be conducted throughout the life of the ITP/ITL.

Fatality monitoring of the site will continue to be conducted weekly for every turbine. Search frequency at turbines may be changed with concurrence from the USFWS and DOFAW, if considered prudent based on site-specific data (SEEF and CARE trial results). Searches of the MET tower will also be conducted on a weekly basis; seabirds could collide with the tower but bats are not expected to. A canine searcher will be used in searches to the extent available.

The search plots for all species will be elliptical, with a 60-m search radius upwind of each turbine and a 90-m search radius downwind of each turbine. The search plot for birds around the MET tower will have a search radius equal to 50% of the tower height. Where search plots overlap due to closely spaced turbines, the overlapping areas will only be searched once per survey. These search radii were determined using the ballistics models of Hull and Muir (2010) and are consistent with those used by other projects in the region. Hull and Muir (2010) found that for small turbines (65-m [213-foot] hub height and 66-m [217-foot] rotor diameter), 99% of bat fatalities landed within 45 m (148 feet) of the turbine base, and for large-sized carcasses, 99% fall within 97 m (318 feet) of the turbine base. The turbines at Pakini Nui are

consistent with this small turbine size, having a 65-m hub height and a 70-m rotor diameter; thus, these model results are applicable to the Project Area.

Search plots at wind farms in Hawai'i typically range from 75–100% of turbine height. Prior to ITP/ITL issuance, it was agreed, with USFWS and DLNR concurrence (meeting with the USFWS and DLNR, February 20, 2014), that the upwind portion of the search plot could be set to 60% of the turbine height, whereas the downwind portion could be lengthened to 90% of the turbine height (Figure 7.1) because of the strong prevailing winds that blow from the east (between 70 and 90 degrees) more than 95% of the time. Generally, more carcasses are expected to be found either up or down the array or toward the downwind portion of the site because of the prevailing winds, although carcasses could fall into the “upwind” (east) direction during Kona wind events. Per the models in Hull and Muir (2010), these search plots are sized to capture 96% of large birds and > 99% of small birds and bats before accounting for unsearchable areas.

A downwind portion of the search plots of Turbines 1–5 will be unsearchable due to their proximity to vertical cliffs (see Figure 7.1). This reduction in the searchable area will be accounted for in the Evidence of Absence (Version 2.0 or most recent) model by calculating the density-weighted searched area. This calculation considers the decreasing density of carcasses with the distance from the turbine so that the unsearchable areas far from the turbine result in fewer carcass losses than unsearchable areas close to the turbine mast. The density-weighted searched area is 0.99, 0.93, 0.90, 0.98, and 0.99 for bats at Turbines 1–5, respectively, and 1.0 for Turbines 6–14, producing an overall density-weighted searched area adjustment of 0.97 for the whole Project Area. This adjustment for unsearchable areas reduces the carcass detection rate and increases uncertainty and, thus, results in a higher upper confidence level on the take estimate (Dalthorp et al. 2017).

Tawhiri will obtain from the USFWS and DOFAW an approved compliance monitoring plan at the time of ITP/ITL issuance. The search area size and shape will be reviewed periodically and modified under adaptive management if new information reveals that a different search pattern is necessary.

The ground cover at the search area is dominated by short grass. Two types of ground cover are present: short grass/bare ground is the dominant ground cover, whereas a small area of taller grass is present in the upwind section of the site (upwind of Turbines 4–6). To maximize a searcher's ability to spot carcasses—particularly those of small bats—the vegetation in the easement areas around the turbines will be maintained as short as possible by Tawhiri. Tawhiri will also coordinate with local ranchers to maintain the vegetation as short as practical outside of the Project turbine easement areas. Currently, depending on the intensity of grazing at different locations, grass height ranges from ankle to knee high in the Project Area, making carcasses relatively easy to find. It is anticipated that continued grazing by cattle and goats will assure that additional anthropogenic vegetation maintenance will not be necessary.

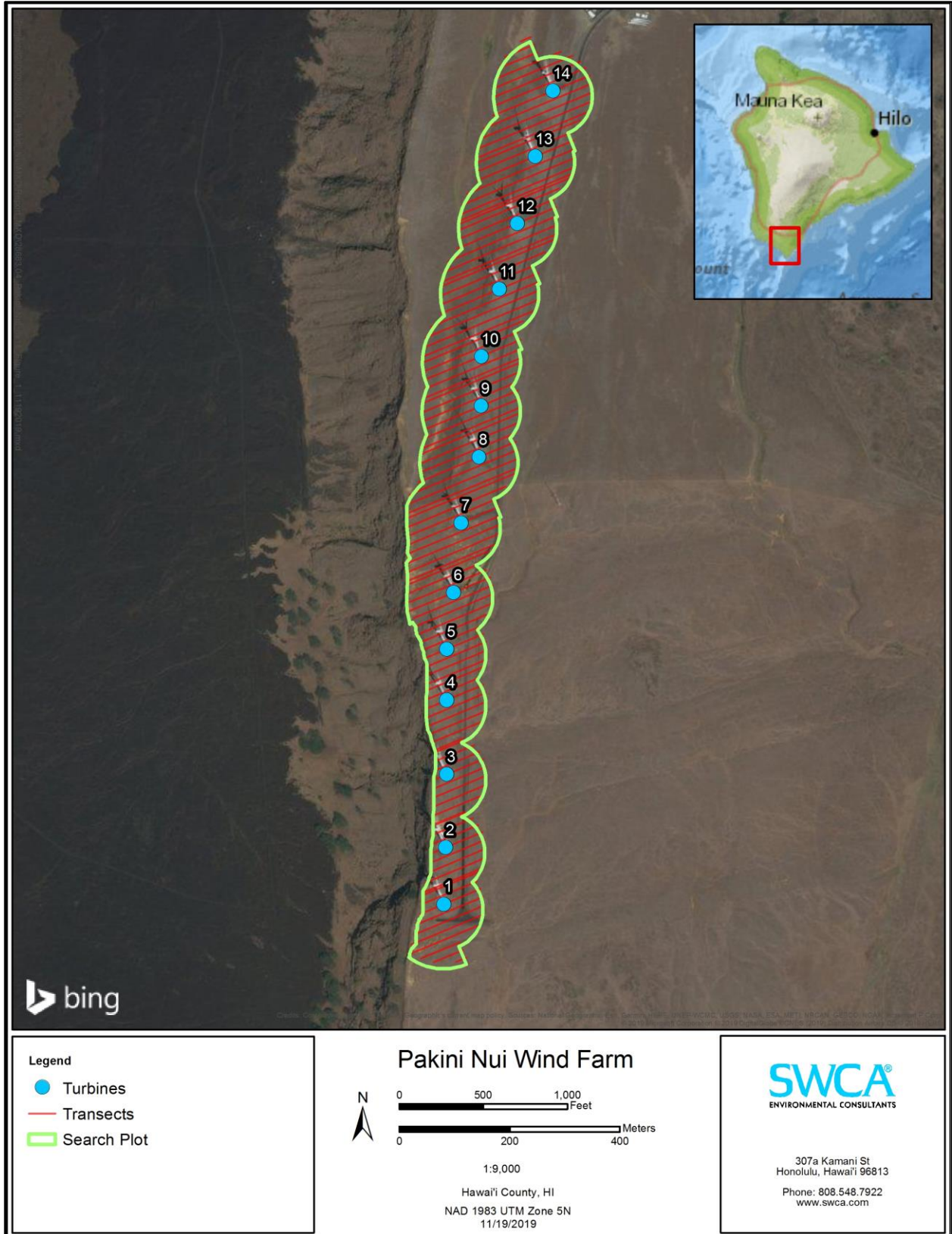


Figure 7.1. Pakini Nui Wind Farm, showing search plot areas, search transects, and numbered turbines.

Searching will be conducted either by one or more human searchers on foot or by a human and canine search team. Human searchers will follow parallel transects, spaced 5 m (16.4 feet) apart, searching 2.55 m (8.2 feet) on either side. (see Figure 7.1). During canine searches, transects will range from 10 m to 25 m depending on temperature, wind, and rain, and 100% of the plot will be searched. Generally, dog transects are wider than human transects due to dogs' superior detection capabilities. All data collected—including information about any carcasses discovered, turbines searched, weather conditions, search dates, as well as SEEF and CARE status—will be entered into a Microsoft Excel spreadsheet format. Data collected that is pertinent to determining the calculated take estimate for Hawaiian hoary bat will be used in Evidence of Absence (Version 2.0 or most recent) software (Dalthorp et al 2017). Game cameras will be used for CARE trials to document the state of the rat proxy (still present, partially scavenged, removed from area). The data inputs and outputs from this modeling will be shared with DOFAW and the USFWS.

CARE and SEEF trials for Hawaiian hoary bats will be carried out each year that fatality monitoring is conducted to determine detectivity. Measuring SEEF and CARE in these areas on a regular basis will be an essential part of the bat fatality monitoring program. SEEF trials for seabird and nēnē will also be carried out each year fatality monitoring is conducted. All trials will be proctored by a third party approved by the USFWS and DOFAW, and staff responsible for the fatality searches will not be made aware of when SEEF trials are being conducted; this will help to avoid searcher bias. DOFAW will be notified by the proctor and provided with a map of the surrogate locations at least 2 days prior to the planned date of the trials.

For CARE trials, dead rats will be used as surrogates for the Hawaiian hoary bat. The approximate body size of the rats is 11.5 centimeters (cm) (4.5 inches) long. At least 10 successful trials will be performed during each season (wet and dry) to form a robust data set with which to estimate take.

Random locations stratified by proportional density (based on Hull and Muir (2010)) for placement of surrogate carcasses by the proctor will be generated using ESRI's ArcGIS software. The carcasses will be placed by navigating to the selected location, then tossing the carcass over the shoulder to further avoid bias in carcass placement. For CARE trials, carcass retention will be confirmed either directly by the searcher on a daily basis or by deploying motion-triggered game cameras. The cameras have the added benefit of aiding in documenting the cause of carcass removal.

For SEEF trials, rats will be used as surrogates for the Hawaiian hoary bat. Large (10- to 14-ounce) and extra extra large (2.5- to 4.5-pound) chickens will be used as surrogates for Hawaiian petrels and nēnē, respectively. At least 10 successful trials will be performed during each season (wet and dry, a minimum of 20 annually) to form a robust data set with which to estimate take. The searcher must be unaware of either the timing of SEEF trials or of the number of surrogate carcasses placed during these trials. When a carcass is found by the searcher, the approximate location, carcass type, and closest turbine will be recorded on the Project avian inspection report and communicated by email and/or cell phone text message to the person tasked with overseeing the trials. Carcasses will be pulled immediately after trials to minimize attracting scavengers to the Project Area. If the placed carcass is scavenged prior to the search (i.e., the carcass is not present immediately after the trial), the trial will be deemed unsuccessful and repeated. Searcher efficiency is calculated as the number of surrogate carcasses found divided by the total number of surrogate carcasses placed.

Direct take of Hawaiian hoary bat will be estimated using the Evidence of Absence (Version 2.0 or most recent) software (Dalthorp et al 2017). The numerical values for all parameters input into the Evidence of Absence software will be provided in the reports to the USFWS and DOFAW. This will include the data sheets in compatible file format used for the Evidence of Absence software and the software outputs. Indirect take will be added to the direct take using *wildlife agency guidance for calculation of Hawaiian hoary bat indirect take* (USFWS 2016).

Should a carcass of a Covered Species or suspected Covered Species be discovered, DOFAW and the USFWS will be notified as soon as possible within 24 hours by phone, and an incident report will be filed within 3 business days (see Appendix E). Reporting of carcasses that are not MBTA species or Covered Species may be reduced to annual reporting upon future agreement with DOFAW and the USFWS. Carcass and downed wildlife handling, including handling of injured wildlife, is described in Appendix E, as updated by DOFAW and the USFWS. Tawhiri will follow the agency guidelines for carcasses found incidentally (not during routine searches), which can be found in Appendix F.

As part of the annual and semiannual reports, a table summarizing the results of incidental observations will be submitted to DOFAW and the USFWS twice each year. The first will be submitted in January (post-fledging for Hawaiian petrels in the previous year) and the second in July (post-fledging for nēnē). In addition, in accordance with the Downed Wildlife Protocol, which was promulgated by DOFAW (see Appendix E), biologists at DOFAW and the USFWS will be notified whenever an MBTA species or Covered Species is found dead or injured.

In addition to fatality searches, Tawhiri personnel will be trained by DOFAW or another qualified biologist to look for and identify MBTA species and Covered Species while at the Project Area for O&M activities to increase the potential for incidental fatalities to be documented. This will ensure ongoing monitoring of the Project.

The likelihood of a Covered Species colliding with the tie-line is discountable, as described in Sections 3.1.2, 3.2.2, 3.3.2, and 3.4.2. Ground searches have proven to be highly ineffective (Travers et al. 2014), and acoustic monitoring of the tie-line will only cover a relatively small part of the tie-line because the sound of a strike does not jump across poles. Considering the discountable likelihood of a strike, sampling is not expected to result in any detections; therefore, fatality searches associated with the tie-line are not included in the compliance monitoring for this HCP. Similarly, the likelihood of a Covered Species colliding with the MET tower is discountable (see Table 4.8).

7.2.2 Effectiveness Monitoring

Effectiveness of the mitigation projects will be monitored as outlined in Sections 6.2.3, 6.3.1, and 6.4.1 of this document.

Unless otherwise specified, measures included in this HCP will be considered successful if they have been implemented as described and achieved the criteria listed in this document (Sections 6.2.4, 6.3.2, and 6.4.2). Mitigation measures go directly toward effectively achieving the biological goals and objectives described in Section 5 of this HCP. Implementation of mitigation measures will be reported annually to the DOFAW and USFWS, as described in detail below.

7.2.3 Reporting

Within 30 days of receiving confirmation that a Hawaiian hoary bat fatality occurred as a result of turbine operations, Tawhiri will submit to DOFAW and the USFWS a new modeled take estimate (including observed, unobserved, and indirect take) at the 80% credibility level. Annual and semiannual reports summarizing all activities implemented under this HCP, and per the conditions of the ITP/ITL, will be submitted by Tawhiri to DOFAW and the USFWS. These reports will include 1) results of compliance (i.e., fatality dates and species) and effectiveness monitoring; 2) actual frequency of the monitoring of individual search plots; 3) results of SEEF and CARE trials with recommended statistical analyses, if any; 4) numbers used for input into, and copies of the outputs (calculated at the 80% credibility level), from the Evidence of Absence (Version 2.0 or most recent) model, or other USFWS approved analysis methodology when calculating Hawaiian hoary bat take on an annual and cumulative

(since ITP/ITL issuance) basis; 5) a detailed description of the current status of the mitigation projects and whether there is a need to modify the mitigation for subsequent years; 6) efficacy of monitoring protocols and whether monitoring protocols need to be revised; 7) implementation and results of mitigation efforts; 8) description of any changed circumstances, evaluation of exceedance of adaptive management triggers, and adaptive management decisions, if any; 9) budget and implementation schedule for the upcoming year; and 10) continued evidence of Tawhiri's ability to fulfill funding obligations.

The annual report will be submitted by August 1 each year, along with electronic copies of relevant data. The report will cover the period from July of the previous year through June of the current year and will follow the DOFAW reporting template (see Appendix J). The USFWS and DOFAW will have 30 calendar days to respond to the report, after which a final report incorporating responses to any USFWS and DOFAW questions will be submitted by September 30. The report may also be presented to the ESRC, as required. The semiannual reports will be submitted to the USFWS and DOFAW within 30 days of January 31 and will cover the period from July through December. Take is estimated at the 80% credibility level and is monitored and calculated for each fatality shown to be caused by Project operations as well as at the time of scheduled reports.

A formal amendment process will be initiated if it is shown that Project operations have resulted in the take of a nēnē or Hawaiian petrel (refer to Section 10.3.2).

8 ADAPTIVE MANAGEMENT

Per USFWS policy (see *Federal Register* 65:5242), *adaptive management* is defined as a formal, structured approach to dealing with uncertainty in natural resources management, using past management experience and current research as an ongoing feedback loop for continuous improvement. Uncertainties may include a lack of biological information for the Covered Species, a lack of knowledge about the effectiveness of mitigation or management techniques, and doubt about the anticipated effects of the Project. Adaptive approaches to management recognize that the answers to all management questions are not known and that the information necessary to formulate answers is often unavailable. Adaptive management also includes, by definition, a commitment to change management practices when it is determined this is the appropriate mechanism to maintain compliance with the terms and conditions of an ITP/ITL.

Adaptive management is a required component of HCPs that allows for the incorporation of new information into conservation and mitigation measures during HCP implementation. Effective implementation of this approach requires explicit and measurable objectives and identifies what actions are to be taken and when they are to occur. If any of the proposed mitigation projects do not meet the defined success criteria, and the determination is made that the anticipated cost of a successful mitigation project will be exceeded in order to meet the success criteria, Tawhiri will consult with and obtain approval from the USFWS and DOFAW when determining the best course of action. Specific adaptive management triggers are defined in Sections 4.1.4, 6.2.5, 6.3.3, and 6.4.3. Data resulting from compliance (i.e., fatality) and effectiveness monitoring, or significant and relevant new, published information, may indicate the need for adaptive management. Funding assurance for adaptive management is included in the contingency fund, as outlined in the funding matrix (see Appendix C).

Regardless of recorded take levels, the avoidance and minimization measures described in Section 6.0 will be employed for the duration of the Pakini Nui Wind Farm project. The only exception would be if evidence clearly demonstrates that removing the avoidance or minimization measure will not appreciably increase take. Removing any avoidance and minimization measure would only take place with USFWS

and DOFAW approval. For example, if bat take is low or fatality is determined to be caused by factors other than the wind turbines or it is shown that removing low wind speed curtailment does not appreciably increase bat take, then curtailment could be removed.

Monitoring of bat mitigation efforts is intended to inform Tawhiri, the USFWS, and DOFAW whether these efforts are adequately compensating for take of Hawaiian hoary bat. If monitoring reveals that a particular mitigation effort is not achieving the necessary level of success, Tawhiri will consult with the USFWS and DOFAW whether the mitigation effort is being conducted appropriately and/or requires USFWS and DOFAW approval to develop and implement a revised mitigation strategy.

Options for adaptive management actions for Hawaiian hoary bats will be evaluated on an ongoing basis to reduce the rate of take. Adaptive management responses may include one or more of the following: raising the cut-in speed of the low wind speed curtailment regime or reducing nighttime operation. If incremental adaptive management actions are not successful and the take of Hawaiian hoary bats exceeds 75% of the requested limit within 75% of the remaining operational period subsequent to ITP/ITL issuance (currently, approximately 5.5 years, depending on the ITP/ITL effective date), Tawhiri will consult with the USFWS and DOFAW to determine if additional take for Hawaiian hoary bat may be anticipated and whether or not a major amendment process needs to be initiated. Following consultation with the USFWS and DOFAW, operational practices such as those listed above may be used to maintain the rate of take at a level so as not to exceed the permitted amounts pending any decision on whether an amendment will be required. Any changes to the mitigation and operations efforts will be made after consultation with and approval by the USFWS and DOFAW.

An amendment to this HCP will be triggered if it is shown that any fatality to a Hawaiian petrel or nēnē was caused by a Project wind turbine. If a fatality of either species is observed, the USFWS and DOFAW will be notified and consulted on the appropriate course of action to minimize potential for future take while an amendment is pursued.

After review of the annual monitoring report, if the USFWS, DOFAW, or Tawhiri finds that an adaptive management trigger may have been reached, it will notify the other entities, which will meet promptly to determine concurrence. If the USFWS, DOFAW, and Tawhiri concur that the trigger has been reached, Tawhiri will implement the approved adaptive management changes in order to meet the biological objectives described in this HCP. These adaptive management changes will be implemented within such time as Tawhiri, the USFWS, and DOFAW agree is reasonable and after written confirmation signed by all that Tawhiri has reached the applicable adaptive management trigger. Each time the Project rate of take is calculated (i.e., each time it is shown a wind turbine has caused a Hawaiian hoary bat fatality or annually, whichever is greater), the applied adaptive management changes will be evaluated for effectiveness and may be removed upon approval by DOFAW, the USFWS, and Tawhiri if projected take falls below the permitted take amount.

Tawhiri will meet at least semiannually with the USFWS and DOFAW. Additional meetings/conferences may be called by any of the entities at any time to address immediate concerns. The purpose of the regular meetings will be to evaluate the efficacy of monitoring methods, compare the results of monitoring to the estimated take, evaluate the success of mitigation, and develop recommendations for future monitoring and mitigation. Regular meetings will also provide opportunities to consider the need for adaptive management measures. In addition, Tawhiri will meet annually with the ESRC to provide updates concerning monitoring, mitigation, and adaptive management and to solicit input and recommendations for future efforts. Additional meetings may be requested by Tawhiri, the USFWS, or DOFAW at any time to address immediate questions or concerns.

9 FUNDING

Consistent with ESA Section 10 and HRS §195D, a funding plan has been designed to ensure that all identified conservation actions described in this HCP will be funded in total. Costs included in this HCP constitute a best estimate based on information available at this time.

Prior sections of this HCP describe measures that Tawhiri will undertake to minimize, mitigate, and monitor the incidental take of Covered Species. Further, this HCP describes minimization and mitigation measures intended to provide a net conservation benefit, as measured in biological terms, pursuant to HRS §195D. This section summarizes planning-level cost estimates to implement the HCP and describes funding and funding assurances. As described in the funding assurances section below, Tawhiri is responsible for covering all costs to meet mitigation obligations. All cost estimates are stated in constant 2019 dollar terms, assuming the ITP/ITL is issued in 2019.

9.1 Habitat Mitigation Costs and Investments

HCP implementation will require investment in the mitigation listed below and described in Section 6.0 in detail.

- Hawaiian hoary bat habitat restoration (Section 6.2)
- Hawaiian petrel population protection (Section 6.3)
- Nēnē mitigation (Section 6.4)

9.2 Funding Strategies

As detailed in Appendix C, direct Project operator funding of all mitigation costs needed for the Hawaiian hoary bat, Hawaiian petrel, and nēnē proposals will be provided on an annual basis upon issuance of the ITP/ITL. All other demonstrable expenses for mitigation costs for the Covered Species spanning the life of the ITP/ITL will be paid out as detailed in Appendix C. A USFWS-requested contingency fund, consisting of 10% of the mitigation and compliance costs (less up-front contributions) will cover adaptive management, changed circumstances, and inflation. An additional DOFAW-requested contingency fund consisting of 5% of the total mitigation project costs will be available to cover mitigation project management, if needed.

Costs are included in the funding matrix (see Appendix C) for DLNR HCP program compliance monitoring audit, which is authorized under HRS §195D-23 (c)(4)(d). This program was formed to establish a habitat conservation technical assistance program to assist landowners in developing, reviewing, or monitoring HCPs by providing technical assistance. Under this program, the department may collect fees and payment for costs incurred for use of the technical assistance program in the development, review, or monitoring of a specific HCP. Fees are charged at an hourly rate of \$50. The fees and payment for costs collected are deposited into the endangered species trust fund established under §195D-31. Billing by the DLNR for this program is paid by the license holder upon receipt of billing up to the amount budgeted per annum, or higher in connection with development of an amendment for the HCP, when substantial adaptive management is required or if there are major compliance or legal issues.

9.3 Funding Assurances

All mitigation and compliance monitoring costs total \$2,218,828 over the 10-year ITP/ITL term. Total costs for mitigation, compliance monitoring, and the contingency funds described in Section 9.2 are

\$2,487,205. Following ITP/ITL issuance, a total of \$296,473 will immediately be paid toward Hawaiian hoary bat (\$151,373), Hawaiian petrel (\$115,100), and nēnē (\$30,000) mitigation and mitigation project monitoring. Any remaining mitigation, compliance monitoring, DLNR compliance audit, and contingency fund costs (projected to be \$2,190,734) will be assured with a letter of credit (LOC) and will be in place before the take authorization contained in the ITP/ITL becomes effective. The LOC will be issued by a financial institution organized or authorized to do business in the United States and identify the DLNR as the sole payee with the full authority to demand immediate payment in the case of default in the performance of the terms of the ITP/ITL and HCP. The LOC presented for approval will contain the following provisions:

- it will be payable to the State of Hawai‘i DLNR;
- the expiration date will not be less than 1 year from the effective date of the LOC and will contain a provision for automatic renewal for periods of not less than 1 year unless the bank provides written notice of its election not to renew to the DLNR at least 90 days prior to the originally stated or extended expiration date of the LOC;
- it will contain provisions allowing collection of the remainder of the costs by the DLNR for failure of Tawhiri to replace the LOC when a 90-day notice is given by the bank that the LOC will not be renewed and the LOC is not replaced by another LOC approved by the USFWS and DLNR at least 30 days before its expiration date; and
- the LOC will be payable to the DLNR upon demand, in part or in full, upon notice stating the basis thereof (e.g., default in compliance with the ITP/ITL or HCP or the failure to have a replacement for an expiring LOC).

LOCs will include 1) guarantee of funds for adaptive management, and 2) sufficient contingency funds to cover inflation and changed circumstances to ensure that success criteria are met, as reflected in the funding matrix (see Appendix C). The LOC will be renewed annually based on the outstanding mitigation cost at the start of the following year. The purpose of the LOC will be to secure the necessary funds to cover any remaining mitigation and monitoring measures in the unlikely event that there are unmet mitigation obligations.

Annual payments, as presented in Appendix C, will meet HVNP funding requirements and ensure that the mitigation projects are continually funded. Tawhiri and HVNP will provide a copy of a signed contract or Memorandum of Understanding between Tawhiri and HVNP that outlines the payment and performance schedule and responsibilities of each party. The signed contract or Memorandum of Understanding will be in place before the take authorization contained in the ITP/ITL becomes effective. Likewise, the Memorandum of Understanding between DOFAW and Tawhiri will be signed and provided to the USFWS and DOFAW before the take authorization contained in the ITP/ITL becomes effective.

10 UNFORESEEN AND CHANGED CIRCUMSTANCES

10.1 Changed Circumstances

Changed circumstances are changes in circumstances affecting a species or geographic area covered by a conservation plan or agreement that can reasonably be anticipated by plan or agreement developers and the [USFWS] and that can be planned for (e.g., the listing of new species, or a fire or other natural catastrophic event in areas prone to such events) (50 CFR 17.3).

The following section lists changed circumstances and methods for adapting the HCP in response to each. If changed circumstances occur that are not provided for in this section, and all other actions are being implemented in accordance with this HCP, the USFWS and DLNR will not require any conservation and mitigation measures in addition to those provided for in the HCP without the consent of Tawhiri.

10.1.1 *Designation of Critical Habitat*

If the USFWS designates Critical Habitat, and such Critical Habitat may be adversely affected by the activities covered in the HCP, the USFWS may consider this to be a changed circumstance. If the USFWS makes such a determination, Tawhiri, in consultation with the USFWS, may implement adjustments in Covered Activities in the area of designated Critical Habitat to ensure that Project activities are not likely to result in adverse modification of the Critical Habitat. Tawhiri will make practicable adjustments in activities until Tawhiri has applied for an amendment to the HCP/ITP/ITL and the USFWS has approved the amendment, if agreed to be appropriate, in accordance with then applicable statutory and regulatory requirements or until the USFWS notifies Tawhiri that these adjustments are no longer necessary.

10.1.2 *Hurricane, Severe Storm, Volcanic Eruption, or Fire*

Hurricanes and severe storms periodically strike or affect the Hawaiian Islands, and the likelihood of a hurricane, severe storm, volcanic eruption, or fire causing severe damage on Hawai‘i during the term of the HCP is high enough to merit treatment as a changed circumstance. Such a hurricane, severe storm, volcanic eruption, or fire could affect the activities covered by the HCP in several ways. For instance, it could cause significant damage to or destruction of Project facilities or pose a threat to the Covered Species by causing injury or death either directly or indirectly through the destruction of habitat in ways that increase or decrease the potential effects of Project facilities on the Covered Species.

Construction and operation of the facilities at Pakini Nui is consistent with applicable codes and industry standards, which are intended to avoid significant damage in severe weather conditions. Should a hurricane, severe storm, volcanic eruption, or fire cause significant damage to Hawai‘i during the term of the HCP, any resulting effects on the Covered Species will be considered based on the best available information at the time. The HCP mitigation efforts will be modified to respond to impacts from a hurricane, storm, volcanic eruption, or fire should the USFWS and DOFAW reasonably determine, in consultation with Tawhiri, that such a response is necessary.

10.1.3 *Invasive Species*

Introduced animal and plant species have had, and will continue to have, a detrimental effect on the Covered Species. The likelihood that the threat from this source will increase during the term of this HCP is sufficient to warrant treating this threat as a changed circumstance. The habitat enhancement and management measures to be implemented through this HCP could be compromised by new and/or

increased populations of invasive species. Should these measures be compromised by invasive species during the term of this HCP, the HCP mitigation efforts that have not yet been paid for and implemented will be modified should the USFWS and DOFAW reasonably determine, in consultation with Tawhiri and HVNP, that such a response is necessary.

10.1.4 *Changes in Status*

If a new species that occurs on the Island of Hawai‘i is added to the federal or state endangered species lists, Tawhiri will evaluate the likelihood of incidental take of the species due to Project operation. If incidental take appears possible, Tawhiri may seek coverage for the newly listed species under an amendment to the existing HCP/ITP/ITL. Tawhiri may also reinitiate consultation with the USFWS and DOFAW to discuss whether mitigation measures in place provide a net benefit to the newly listed species or if additional measures may be recommended by the USFWS or DOFAW. Should any of the Covered Species become delisted over the ITP/ITL term, mitigation measures may be discontinued.

10.1.5 *Disease Outbreaks in a Covered Species or Covered Species Habitat*

Should the prevalence of disease increase substantially and become identified by the DLNR and USFWS as a major threat to the survival of a Covered Species or Covered Species habitat, Tawhiri will consult with the USFWS and DOFAW to determine if changes in mitigating, monitoring, or reporting are warranted. This changed circumstance would apply if rapid ‘ōhi‘a death disease impacts the success of the forest restoration mitigation project, which is assumed to constitute roosting and pupping habitat for the Hawaiian hoary bat. Any such changes will be approved by DOFAW and the USFWS and will be performed to achieve the monitoring and reporting objectives described in the HCP.

10.1.6 *Changes in Distribution of Currently Listed Species*

New research could alter the understanding of the potential impacts to species listed at the time this HCP was prepared. The likelihood that our understanding of risks to species and/or the distribution of their populations would change in a manner that would alter the assessment made in preparing this HCP is sufficient to warrant treating this possibility as a changed circumstance. If, as a result of new information, incidental take of a non-covered federally or state-listed species appears possible, or if an increase in take of a Covered Species is reasonably anticipated, Tawhiri would seek coverage under an amendment to the HCP. Tawhiri would also reinitiate consultation with the USFWS and DOFAW to discuss whether mitigation measures in place meet permit issuance criteria for the non-covered listed species or if additional measures are warranted.

10.1.7 *Development of an Effective, Economical, and Commercially Viable Bat Deterrent*

Preliminary research indicates that technologies may be developed during the Project ITP/ITL term that could deter the Hawaiian hoary bat from flying into the airspace near the wind turbine rotors (Arnett et al 2013; Szewczak and Arnett 2007). Such a development could be used independently of, or in coordination with, low wind speed curtailment to further reduce the risk of Hawaiian hoary bat fatalities. As noted in Section 6.1, if an effective, economical, and commercially viable bat deterrent technology becomes available during the Project’s ITP/ITL term, Tawhiri will consult with the USFWS and DOFAW to determine if implementation of the technology is appropriate and, if implemented, how to measure the effectiveness of the measure.

10.1.8 Global Climate Change Substantially Alters the Status of the Covered Species

Global climate change within the term of the HCP (20 years) conceptually has the potential to affect Covered Species through regionwide changes in weather patterns, sea level, average temperature, and levels of precipitation affecting the species or their habitats (Intergovernmental Panel on Climate Change 2007). Covered Species may be affected through changes in temperature, precipitation, the distribution of their food resources, and possible changes in the vegetation at their preferred habitats.

As an expected result of global climate change, hurricanes or storms may occur with greater intensity (U.S. Climate Change Science Program 2009; Webster et al. 2005), which may increase the risk of damage to established mitigation sites. Sea level is predicted to rise approximately 1 m in Hawai'i by the end of the twenty-first century (Fletcher 2009). Given this prediction, any rise in sea level experienced during the life of the Project likely will be less than 1 m (3 feet).

Precipitation may decline by 5%–10 % in the wet season and increase by 5% in the dry season, due to climate change (Giambelluca et al. 2009). This may result in altered hydrology at mitigation sites. Vegetation may change with decreased precipitation or increased temperatures and threat of fire. Other mitigation sites may be considered for continued investment of unexpended mitigation funds if selected sites are considered no longer suitable. Upon USFWS and DLNR approval, appropriate alternate mitigation site(s) will be chosen by Tawhiri.

10.1.9 Discovery of a Band-Rumped Storm-Petrel Carcass

In the extremely unlikely scenario a band-rumped storm-petrel carcass is discovered at the Project (as described in Section 4.4) and it is determined it was struck or otherwise killed due to the presence of the Project, Tawhiri will initiate an amendment with USFWS and DOFAW. This amendment will document a plan to mitigate for the observed take as well as future predicted take. The mitigation plan would include predator (including barn owl) control at known breeding locations and associated monitoring to ensure the efficacy and species benefits of such mitigation.

10.2 Unforeseen Circumstances and “No Surprises” Policy

Unforeseen circumstances are defined as changes in circumstances affecting a Covered Species or geographic area covered by an HCP that could not reasonably have been anticipated by the plan and that result in a substantial and adverse change in the status of the Covered Species (50 CFR 17.3). Should the USFWS determine, based on considerations outlined in 50 CFR §17.22(b)(5)(iii)(c), that unforeseen circumstances have arisen during the ITP/ITL term, the USFWS and DLNR will notify Tawhiri in writing.

This HCP incorporates by reference the ITP assurances set forth in the Habitat Conservation Plan Assurances (No Surprises) Rule adopted by the USFWS (*Federal Register* 63:8859–8871) and codified at 50 CFR 17.22 (b)(5). The No Surprises regulations provide Tawhiri with assurances that, assuming the plan is being properly implemented, the USFWS will not require additional measures or funding beyond what was agreed to in the HCP without Tawhiri's consent.

10.3 Amendment Procedures

Different procedures allow for the amendment of the HCP and ITP/ITL. However, the cumulative effect of any amendments must not jeopardize the continued existence of any listed species. The USFWS and DLNR must be consulted on all proposed amendments. Amendment procedures are described below.

10.3.1 *Minor Amendments*

Informal, minor amendments are permissible without a formal amendment process provided that the change or changes necessitating such amendment or amendments do not cause an adverse effect on any of the Covered Species that is significantly different from the effects considered in the original HCP. Such informal amendments could include routine administrative revisions or changes to surveying or monitoring protocols that do not decrease the level of mitigation or increase take. A request for a minor amendment to the HCP and ITP/ITL may be made with written notice to the USFWS and DLNR. A public review process may be required for the DLNR minor amendment. The amendment will be implemented upon receiving concurrence from the USFWS and DLNR.

10.3.2 *Formal Amendments*

A formal amendment may be considered if all options for minimization and adaptive management have been exhausted, there is observed take of any Hawaiian petrel or nēnē as a direct result of Project activities, or Tawhiri wishes to significantly modify the Project already in place. Formal amendments are required if the change or changes necessitating such an amendment or amendments could produce a net adverse effect on any of the Covered Species that is substantially different from adverse effects considered in the original HCP and ITP/ITL. A formal amendment will be required if any of the following occurs:

- The documented level of take for Hawaiian hoary bat exceeds that covered by the ITP/ITL.
- Observed take as a direct result of Project activities of another ESA-listed species not covered by the ITP/ITL occurs and such take is not addressed in a separate HCP or Section 7 consultation.
- Observed take as a direct result of Project activities of one Hawaiian petrel or nēnē.
- If 75% of the requested Hawaiian hoary bat take is reached (i.e., 20) and there is more than 25% of planned operations (exclusive of the deconstruction period) remaining on the ITP/ITL, Tawhiri will evaluate all available actions to minimize take to negate the need to proceed with an amendment.

The HCP and ITP/ITL may be formally amended upon written notification to the USFWS and DOFAW with the supporting information similar to that provided with the original ITP/ITL application. Along with the calculated rate of take for the Hawaiian hoary bat, the need for a formal amendment will be assessed annually and any time a Covered Species carcass is detected. A formal amendment will not be considered until all options for minimization have been exhausted. Tawhiri will review and implement additional avoidance measures that may pose a threat to the species, if, after the timely filing of an amendment application, the permitted take level is reached prior to an amended ITP/ITL being obtained. A formal amendment may require additional or modified minimization, and/or mitigation measures, and/or additional or modified monitoring protocols, and appropriate funding assurances. Formal amendments undergo the same regulatory process as an original HCP and may require a supplemental NEPA evaluation and additional public review.

If the need for a formal amendment should arise, Tawhiri will work with the USFWS and DOFAW to follow the most current agency regulations and handbook.

10.4 Renewal and Extension

This HCP proposed by Tawhiri may be renewed or extended and amended if necessary, beyond its initial 10-year term with the approval of the USFWS and DLNR. A written request will be submitted to the USFWS and DLNR that will certify that the original information provided is still current and conditions are unchanged or, alternatively, will provide a description of relevant changes to the implementation of the HCP that will take place. Such a request shall be made at least 180 days before the conclusion of the term of the ITP/ITL. Under federal law, the HCP shall remain valid and in effect while the renewal or extension is being processed, but under State of Hawai‘i law, the HCP will remain valid and in effect during processing only if the renewal or extension is processed during the original ITP/ITL term. Any request for renewal or extension will follow the appropriate administrative process and would not preclude the need for a formal amendment (as described in Section 10.3.2), if one is needed.

11 ALTERNATIVES

ESA Section 10(a)(2)(A)(iii) requires that an applicant consider and include in the HCP a description of alternative actions to the proposed take authorization that were considered but not adopted. Additionally, an applicant must describe why those alternatives are not being used. Alternatives focused on the development and preconstruction phases of a wind farm (e.g., timing of construction, micrositing of turbines and other infrastructure) are not applicable for consideration as alternatives at an already-operational facility such as the Project. Therefore, four alternative actions to the proposed take authorization were identified, considered, and rejected by Tawhiri. The rejected No Action Alternative and Alternatives 2–4 are described in further detail below. Section 4 provides a detailed description of the chosen take authorization.

11.1 No Action Alternative

Under the No Action Alternative, all facility turbines would be shut down. This alternative would likely reduce the risk of take of the Covered Species to at or below a negligible level and no ITP/ITL would be needed. Under this alternative, the USFWS would not authorize incidental take of Covered Species and Tawhiri would not have the regulatory assurance requested to avoid a potential violation of the ESA. Any incidental take would not be authorized.

This alternative would result in complete loss of renewable electricity production. This would completely reduce the total renewable-based power production and negate Tawhiri’s power purchase agreement, resulting in an economically unviable project. However, inclusion of the No Action Alternative is prescribed by the federal CEQ regulations (40 CFR 1502.14(d)) and is carried forward for analysis in the associated environmental impact statement.

11.2 Alternative 1. Proposed Alternative

The Proposed Alternative is described above in Sections 1–10.

11.3 Alternative 2. Decreased Curtailment

As described in Section 1.2, the Project implemented a curtailment program starting in March 2014 as a precaution to minimize the risk of take of a Hawaiian hoary bat. The Project currently curtails turbines between the hours of 6:00/6:30 p.m. and 6:30/7:00 a.m. Under Alternative 2, the turbines would shut

down if the 10-minute average wind speed is 5.0 m (16 feet) per second or less (cut-out wind speed) and would start back up if the 10-minute average wind speed is greater than or equal to 5.5 m (18 feet) per second (cut-in wind speed).

Under Alternative 2, turbines would operate at an individually automated cut-in speed of 4.5 m (14.7 feet) per second, and this curtailment would occur during a shortened period (e.g., between 7:00/7:30 p.m. [near the time of civil sunset] and 5:30/6:00 a.m. [near the time of civil sunrise, or seasonally]). The reduced cut-in speed and shortened curtailment window proposed under Alternative 2 would likely result in an increase in the amount of time during which the turbine blades would be rotational.

A measure commonly implemented at wind facilities with the intent of minimizing the risk of bat fatalities is to increase the turbine cut-in speed to 5.0 m (16 feet) per second. As indicated by the data, it is widely held among experts that bat fatalities most commonly occur during lower wind speeds. Thus, applying brakes to the turbines or allowing them to freewheel at less than 5.0 m (16 feet) per second may reduce the risk of fatality to bats. Therefore, while a reduced cut-in speed and shortened curtailment period would likely result in increased energy production at the Project, these variables may also present a greater risk of bat mortality. For this reason, Tawhiri did not adopt this alternative.

11.4 Alternative 3. Increased Curtailment

Under Alternative 3, turbines would operate at an individually automated cut-in speed of 6.5 m (21.3 feet) per second. This curtailment would occur nightly and year-round. The increased cut-in speed proposed under Alternative 3 would result in a decreased amount of time during which turbine blades rotate. While there may be a lesser risk of bat mortality under this alternative, the exact level of increased benefit to bats cannot be identified. Furthermore, energy production would decrease. This alternative was not selected because the Proposed Action, as described above, meets the USFWS issuance criteria at a lesser cost to the Project. Although this alternative would also meet the USFWS issuance criteria, it would create a financial hardship for Tawhiri, and thus, this alternative was not adopted.

11.5 Alternative 4. Nighttime Shut Down

Under this alternative, turbines would be shut down daily between the hours of 6:00/6:30 p.m. and 6:30/7:00 a.m. This measure may result in less risk of bat fatalities during the nighttime period. However, the Project would experience annual production losses exceeding 50%. This type of production loss would rapidly push the Project into a financially stranded situation. Therefore, Tawhiri did not adopt this alternative.

12 LITERATURE CITED

- Adams, J. 2008. Petrels in the Pacific: Tracking the Far-ranging Movements of Endangered ‘Ua‘u (Hawaiian Petrel). U.S. Geological Survey, Western Ecological Research Center. Available at: http://www.microwavetelemetry.com/uploads/newsletters/spring_2007Page4.pdf. Accessed October 9, 2013.
- Ainley, D.G., T.C. Telfer, and M.H. Reynolds. 1997. Townsend’s and Newell’s Shearwater (*Puffinus auricularis*). In *The Birds of North America*, No. 297, edited by A. Poole and F. Gill. The Birds of North America, Inc., Philadelphia, Pennsylvania.
- Allen, P.D. II, D.J. Chapman, and D. Lane. 2005. Scaling environmental restoration to offset injury using habitat equivalency analysis. In *Economics and Ecological Risk Assessment: Applications to Watershed Management*, edited by R.F. Bruins and M.T. Heberling, pp. 165–184. Boca Raton, Florida: CRC Press.
- Amlin, A., and A. Siddiqi. 2015. *Endangered Species Recovery Committee Hawaiian Hoary Bat Guidance Document*. State of Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife, Honolulu.
- Arnett, E.B., W.K. Brown, W.P. Erickson, J.K. Fiedler, B.L. Hamilton, T.H. Henry, C.P. Nicholson, T.J. O’Connell, M.D. Piorkowski, and R.D. Tankersley, Jr. 2008. Patterns of bat fatalities at wind energy facilities in North America. *The Journal of Wildlife Management* 72(1):61–78.
- Arnett, E.B., M.M.P. Huso, M.R. Schirmacher, and J.P. Hayes. 2011. Altering Turbine Speed Reduces Bat Mortality at Wind-Energy Facilities. *Frontiers in Ecology and the Environment* 9(4):209–214.
- Arnett, E.B., G.D. Johnson, W.P. Erickson, and C.D. Hein. 2013. *A synthesis of operational mitigation studies to reduce bat fatalities at wind energy facilities in North America*. A report submitted to the National Renewable Energy Laboratory. Bat Conservation International, Austin, Texas.
- Baerwald, E.F., J. Edworthy, M. Holder, and R.M.R. Barclay. 2009. A Large-Scale Mitigation Experiment to Reduce Bat Fatalities at Wind Energy Facilities. *Journal of Wildlife Management* 73:1077–1081.
- Baldwin, P.H. 1950. Occurrence and Behavior of the Hawaiian Bat. *Journal of Mammalogy* 31:455–456.
- Banko, P.C. 1988. Breeding Biology and Conservation of the Nēnē, Hawaiian Goose (*Nesochen sandvicensis*). Ph.D. dissertation, University of Washington, Seattle.
- Banko, P.C., J.M. Black, and W.E. Banko. 1999. Hawaiian Goose (Nēnē) (*Branta sandvicensis*). In *The Birds of North America*, No. 434, edited by A. Poole and F. Gill. The Birds of North America, Inc., Philadelphia, Pennsylvania.
- Banko W.E. 1980. *History of endemic Hawaiian birds: population histories, species accounts: seabirds: Hawaiian Dark-rumped Petrel (‘Ua‘u)*. CPSU/UH Avian History Report 5B. Cooperative National Park Resources Studies Unit. University of Hawai‘i at Mānoa, Department of Botany, Honolulu.
- Banko, W.E., P.C. Banko, and R.E. David. 1991. Specimens and Probable Breeding Activity of the Band-rumped Storm-Petrel on Hawai‘i. *The Wilson Bulletin* 103:650–655.

- Barclay, R.M., E.F. Baerwald, and J.C. Gruver. 2007. Variation in bat and bird fatalities at wind energy facilities: assessing the effects of rotor size and tower height. *Canadian Journal of Zoology* 85(3): 381–387.
- Beard K.H., E.A. Price, and W.C. Pitt. 2009. Biology and Impacts of Pacific Island Invasive Species: *Eleutherodactylus coqui*, the Coqui Frog (Anura: Leptodactylidae). *Pacific Science* 63:297–316.
- Bellwood, J.J., and J.H. Fullard. 1984. Echolocation and Foraging Behaviour in the Hawaiian Hoary Bat, *Lasiurus cinereus semotus*. *Canadian Journal of Zoology* 62:2113–2120.
- Bernard, R. 2011. Dietary Overlap: Does the Invasive Coqui Frog (*Eleutherodactylus coqui*) Have the Potential to Compete with the Endemic Hawaiian Hoary Bat (*Lasiurus cinereus semotus*) on the Island of Hawai‘i. Master’s thesis. University of Hawai‘i at Hilo.
- Board of Land and Natural Resources, State of Hawai‘i (BLNR). 2018. A Contested Case Hearing RE Final Habitat Conservation Plan and Incidental Take License for the Na Pua Makani Wind Energy Project by Applicant Na Pua Makani Power Partners, LLC; Tax Map Key Nos. (1) 5-6-008:006 and (1) 5-6-006:018, Ko‘olauloa District, Island of O‘ahu, Hawai‘i: Findings of Fact, Conclusions of Law, and Decision and Order.
- Bonaccorso, F.J. 2011. Ope‘ape‘a – Solving the Puzzles of Hawai‘i’s Only Bat. *Bats* 28(4):10–12.
- Bonaccorso, F.J., C.M. Todd, A.C. Miles, and P.M. Gorresen. 2015. Foraging Range Movements of the Endangered Hawaiian Hoary Bat, *Lasiurus cinereus semotus* (Chiroptera: Vespertilionidae). *Journal of Mammalogy* 96(1):64–71.
- Bogan, B.A. 1972. Observations on Parturition and Development in the Hoary Bat, *Lasiurus cinereus*. *Journal of Mammalogy* 53:611–614.
- Brooks, R.T., and W.M. Ford. 2005. Bat Activity in a Forest Landscape of Central Massachusetts. *Northeastern Naturalist* 12(4):447–462.
- Clark, D.R., R.K. LaVal, and D.M. Swineford. 1978. Dieldrin-induced Mortality in an Endangered Species, the Gray Bat. *Science* 199:1357–1359.
- Conant, S. 1980. Recent Records of the ‘U‘au (Dark-rumped Petrel) and the ‘A‘o (Newell’s Shearwater) in Hawai‘i. *‘Elepaio* 41:11–13.
- Cooper, B.A., and R.H. Day. 1998. Summer Behavior and Mortality of Dark-Rumped Petrels and Newell’s Shearwaters at Power Lines on Kauai. *Colonial Waterbirds* 21(1):11–19.
- . 2003. *Petrel and Shearwater Surveys Near County of Hawai‘i Emergency Communications Towers, July 2003*. Prepared for Scientel America, Inc., Lombard, Illinois, and PBR Hawai‘i and Associates, Honolulu.
- . 2004. Results of Endangered Bird and Bat Surveys at the proposed Kaheawa Pastures Wind Energy Facility, Maui Island, Hawai‘i, fall 2004. Unpublished report prepared for Kaheawa Wind Power, LLC, Makawao, Hawai‘i; and UPC Wind Management, LLC, Newton, Massachusetts. Report prepared by ABR, Inc., Forest Grove, Oregon, and Fairbanks, Alaska.
- Corcoran A.J., and T.J. Weller. 2018. Inconspicuous Echolocation in Hoary Bats (*Lasiurus cinereus*). *Proceedings of the Royal Society B* 285: 20180441. Available at: <http://dx.doi.org/10.1098/rspb.2018.0441>.

- Cryan, P.M., P.M. Gorresen, C.D. Hein, M.R. Schirmacher, R.H. Diehl, M.M. Huso, D.T.S. Hayman, P.D. Fricker, F.J. Bonaccorso, D.H. Johnson, K. Heist, and D.C. Dalton. 2014. Behavior of Bats at Wind Turbines. *Proceedings of the National Academy of Sciences* 111(42):15126–15131.
- Dalthorp, D., M. Huso, and D. Dail. 2017. *Evidence of Absence (v2.0) Software User Guide*. U.S. Geological Survey Data Series 1055. Available at: <https://doi.org/10.3133/ds1055>.
- Dalthorp, D., M. Huso, D. Dail, and J. Kenyon. 2014. *Evidence of Absence Software User Guide*. U.S. Geological Survey Data Series 881.
- Day, R.H. 2005. *Analysis of bird and bat issues related to the Pakini Nui wind farm near South Point, Hawai'i Island*. Prepared for Apollo Energy.
- Day, R.H., and B.A. Cooper. 1995. Patterns of Movement of Dark-rumped Petrels and Newell's Shearwaters on Kauai. *Condor* 97:1011–1027.
- . 2002. *Petrel and shearwater surveys near Kalaupapa, Moloka'i Island, June, 2002*. Final report to the National Park Service, Hawai'i Volcanoes National Park. ABR, Inc., Fairbanks, Alaska.
- Day, R.H., B.A. Cooper, and R.J. Blaha. 2003. Movement Patterns of Hawaiian Petrels and Newell's Shearwaters on the Island of Hawai'i. *Pacific Science* 57:147–160.
- Department of Land and Natural Resources (DLNR). 2015. Hawai'i's State Wildlife Action Plan. Prepared by H.T. Harvey and Associates, Honolulu, Hawai'i.
- Dunford, R.W., T.C. Ginn, and W.H. Desvousges. 2004. The Use of Habitat Equivalency Analysis in Natural Resource Damage Assessments. *Ecological Economics* 48(2004):49–70.
- Erickson, W.P. 2003. Updated Information Regarding Bird and Bat Mortality and Risk at New Generation Wind Projects in the West and Midwest. National Wind Coordinating Committee, Wildlife Workgroup Meeting, November 18, 2003. Resolve, Inc., Washington, D.C. Available at: <http://old.nationalwind.org/events/wildlife/2003-2/presentations/erickson.pdf>. Accessed October 9, 2013.
- Francl, K.E., W.M. Ford, and S.B. Castleberry. 2004. Bat Activity in Central Appalachian Wetlands. *Georgia Journal of Science* 62:87–94.
- Fraser, H., and L. HaySmith. 2009. *Hawaiian Hoary Bat Monitoring Protocol*. Pacific Island Network. Natural Resource Report NPS/PWR/PACN/NRR. 2009/DRAFT. National Park Service, Fort Collins, Colorado.
- Fullard, J.H. 2001. Auditory Sensitivity of Hawaiian Moths (Lepidoptera: Noctuidae) and Selective Predation by the Hawaiian Hoary Bat (Chiroptera: *Lasiurus cinereus semotus*). *Proceedings of the Royal Society of London B* 268:1375–1380.
- Galase, N.K., R.E. Doratt, N.V. Inman-Narahari, T.M. Lackey, L.D. Schnell, and P.J. Peshut. 2016. *2015 Seabird Project Technical Report: Band-rumped Storm Petrel (*Oceanodroma castro*) Colony Presence and Flight Paths at Pohakuloa Training Area, Hawaii*. Natural Resources Office, Pohakuloa, Hawai'i.
- Gorresen M.P., F.J. Bonaccorso, C.A. Pinzari, C.M. Todd, K. Montoya-Aiona, and K. Brinck. 2013. *A Five-Year Study of Hawaiian Hoary Bat (*Lasiurus cinereus semotus*) Occupancy on the island of Hawai'i*. Hawai'i Cooperative Studies Unit, Hilo.

- Grindal, S.D., J.L. Morisette, and R.M. Brigham. 1999. Concentration of Bat Activity in Riparian Habitats over an Elevational Gradient. *Canadian Journal of Zoology* 77:972–977.
- Haines, W.P., M.L. Heddle, P. Welton, and D.A. Rubinoff. 2009. Recent Outbreak of the Hawaiian Koa Moth, *Scotorythra paludicola* (Lepidoptera: Geometridae), and a Review of Outbreaks between 1892 and 2003. *Pacific Science* 63(3):349–369.
- Hamer Environmental, L.P. 2008a. *Endangered Bird and Bat Surveys at a Proposed Verizon Cell Tower Site, South Point, Hawai‘i. Draft Report, Spring 2008*. Prepared for Rana Productions, Ltd., Kailua-Kona, Hawai‘i.
- . 2008b. *Endangered Bird and Bat Surveys at a Proposed Verizon Cell Tower Site, South Point, Hawai‘i. Draft Report, Fall 2008*. Prepared for Bureau Veritas North America, Inc., Kailua, Hawai‘i.
- Harrison, C.S. 1990. *Seabirds of Hawai‘i: Natural History and Conservation*. Cornell University Press, Ithaca, New York.
- Hays, W.S.T., and S. Conant. 2007. Biology and Impacts of Pacific Island Invasive Species. 1. A Worldwide Review of Effects of the Small Indian Mongoose, *Herpestes javanicus* (Carnivora: Herpestidae). *Pacific Science* 61:3–16.
- Heber, Emily. 2017. Hawaiian Hoary Bat Confirmed on Kaho‘olawe Island. Island Conservation. Available at: <https://www.islandconservation.org/hawaiian-hoary-bat-kahoolawe-island/>. Accessed August 9, 2018.
- . 2018. Band-rumped Storm-petrel Nests Found on Mauna Loa. Island Conservation. Available at: <https://www.islandconservation.org/nesting-sites-hawaii-endangered-storm-petrel/>. Accessed August 9, 2018.
- Hodges, C.S.N. 1994. Effects of Introduced Predators on the Survival and Fledging Success of the Endangered Hawaiian Dark-rumped Petrel (*Pterodroma phaeopygia sandwichensis*). M.S. thesis. University of Washington, Seattle.
- Horn, J.W., E.B. Arnett, and T.H. Kunz. 2008. Behavioral Responses of Bats to Operating Wind Turbines. *Journal of Wildlife Management* 72(1):123–132.
- Hu, D. 1998. Causes of Extinction and Endangerment in Hawaiian Birds. Ph.D. dissertation, University of California, Davis.
- Hu, D., G.E. Ackerman, C.S.N. Bailey, D.C. Duffy, and D.C. Schneider. 2015. Hawaiian Petrel Monitoring Protocol, Pacific Island Network. Natural Resource Report NPS/PACN/NRR. National Park Service, Fort Collins, Colorado.
- Hu D., C. Glidden, J.S. Lippert, L. Schnell, J.S. MacIvor, and J. Meisler. 2001. Habitat Use and Limiting Factors in a Population of Hawaiian Dark-rumped Petrels on Mauna Loa, Hawai‘i. *Avian Biology* 22:234–242.

- Hull, C.L., and S. Muir. 2010. Search Areas for Monitoring Bird and Bat Carcasses at Wind Farms Using a Monte-Carlo Model. *Australasian Journal of Environmental Management* 17(2):77–87.
- Intergovernmental Panel on Climate Change (IPCC). 2007. *Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Core Writing Team, R.K. Pachauri and A. Reisinger (eds.). IPCC, Geneva, Switzerland.
- Jacobs, D.S. 1993. Character Release in the Endangered Hawaiian Hoary Bat, *Lasiurus cinereus semotus*. Ph.D. dissertation, University of Hawai‘i, Honolulu.
- . 1994. Distribution and Abundance of the Endangered Hawaiian Hoary Bat, *Lasiurus cinereus semotus*, on the Island of Hawai‘i. *Pacific Science* 48(2):193–200.
- Johnson, G.D. 2005. A Review of Bat Mortality at Wind-Energy Developments in the United States. *Bat Research News* 46:45–49.
- Johnson, G.D., W.P. Erickson, and M.D. Strickland. 2003a. Mortality of Bats at Large-scale Wind Power Development at Buffalo Ridge, Minnesota. *American Midland Naturalist* 150(2):332–342.
- . 2003b. What is known and not known about bat collision mortality at wind plants? In *Workshop on Avian Interactions at Wind Turbines*, edited by R.L. Carlton. October 16–17, 2002. Jackson Hole, Wyoming. Electric Power Research Institute, Palo Alto, California.
- Johnson, G.D., W.P. Erickson, M.D. Strickland, M.F. Shepherd, and D.A. Shepherd. 2000. *Final Report, Avian Monitoring Studies at the Buffalo Ridge, Minnesota Wind Resource Area: Results of a 4-year study*. Prepared for Northern States Power Company, Minneapolis, Minnesota. Western Ecosystems Technology, Inc.
- Kaheawa Wind Power, LLC. 2009. *Kaheawa Pastures Wind Energy Generation Facility, Habitat Conservation Plan: Year 3 Annual Report*. First Wind Energy, LLC, Wailuku, Hawai‘i.
- . 2010. *Kaheawa Pastures Wind Energy Generation Facility, Habitat Conservation Plan: Year 4 Annual Report*. First Wind Energy, LLC, Wailuku, Hawai‘i.
- . 2014a. *Kaheawa Pastures Wind Energy Generation Facility, Kaheawa I Habitat Conservation Plan: Year 8 Annual Report*. First Wind Energy, LLC, Wailuku, Hawai‘i.
- . 2014b. *Kaheawa Pastures Wind Energy Generation Facility, Kaheawa II Habitat Conservation Plan: Year 2 Annual Report*. First Wind Energy, LLC, Wailuku, Hawai‘i.
- . 2018a. *Kaheawa Wind Power Habitat Conservation Plan, Annual Report: FY 2018*. Wailuku, Hawai‘i. August. Available at: <https://dlnr.hawaii.gov/wildlife/files/2019/02/Kaheawa-Wind-Power-I-HCP-FY-2018-Annual-Report-Final.pdf>. Accessed May 6, 2019.
- . 2018b. *Kaheawa Wind Power II Habitat Conservation Plan, Annual Report: FY 2018*. Wailuku, Hawaii. August. <https://dlnr.hawaii.gov/wildlife/files/2019/02/Kaheawa-Wind-Power-II-HCP-FY-2018-Annual-Report-Final.pdf>. Accessed May 6, 2019.

- Kahuku Wind Power, LLC. 2014. *Kahuku Habitat Conservation Plan – FY-2014 Annual Report Year 4*. First Wind Energy, LLC, Kahuku, Hawai‘i.
- . 2018. *Kahuku Wind Power Habitat Conservation Plan, Annual Report: FY 2018*. Kahuku, Hawai‘i. August. Available at: <https://dlnr.hawaii.gov/wildlife/files/2019/02/Kahuku-Wind-Power-HCP-FY-2018-Annual-Report-Final.pdf>. Accessed May 6, 2019.
- Kawailoa Wind Power, LLC. 2014. *Kawailoa Habitat Conservation Plan – FY-2014 Annual Report Year 2*. First Wind Energy, LLC, Haleiwa, Hawai‘i.
- Kear, J., and A.J. Berger. 1980. *The Hawaiian Goose: An Experiment in Conservation*. Buteo Books, Vermillion, South Dakota.
- Kepler, C.B., and J.M. Scott. 1990. Notes on Distribution and Behavior of the Endangered Hawaiian Hoary Bat (*Lasiurus cinereus semotus*), 1964–1983. *Elepaio* 50:59–64.
- Kerlinger, P., and J.A. Guarnaccia. 2005. *Phase I Avian Risk Assessment for the Highland New Wind Project, Highland County, Virginia*. Report prepared for Highland New Wind Development, LLC, by Curry and Kerlinger, LLC, Cape May Point, New Jersey.
- King, D.M. 1997. *Comparing Ecosystem Services and Values, with Illustrations for Performing Habitat Equivalency Analysis*. Prepared by King and Associates, Inc., Washington, D.C., for the U.S. Department of Commerce, Silver Spring, Maryland.
- Kingsley, A., and B. Whittam. 2007. *Wind Turbines and Birds: A Background Review for Environmental Assessment*. Draft April 2, 2007. Prepared for the Canadian Wildlife Service, Gatineau, Quebec.
- Koehler, C.E., and R.M.R. Barclay 2000. Post-natal Growth and Breeding Biology of the Hoary Bat (*Lasiurus cinereus*). *Journal of Mammalogy* 81:234–244.
- Kunz, T.H., E.B. Arnett, B.M. Cooper, W.P. Erickson, R.P. Larkin, T. Mabee, M.L. Morrison, M.D. Strickland, and J.M. Szwczak. 2007. Assessing Impacts of Wind-Energy Development on Nocturnally Active Birds and Bats: A Guidance Document. *Journal of Wildlife Management* 71:2449–2486.
- McDaniel, S., R. Loh, S. Dale, and C. Yanger. 2011. *Experimental restoration of mesic and wet forests in former pastureland, Kahuku Unit, Hawaii Volcanoes National Park*. Technical Report No. 175. Pacific Cooperative Studies Unit, University of Hawai‘i, Honolulu. 26 p. Available at: <https://scholarspace.manoa.hawaii.edu/bitstream/10125/34416/1/v175.pdf>. Accessed June 25, 2018.
- Menard, T. 2001. Activity Patterns of the Hawaiian Hoary Bat (*Lasiurus cinereus semotus*) in Relation to Reproductive Time Periods. Master’s thesis, University of Hawai‘i at Mānoa, Honolulu.
- Menzel, M.A., T.C. Carter, J.M. Menzel, M.F. Ford, and B.R. Chapman. 2002. Effects of Group Selection Silviculture in Bottomland Hardwoods on the Spatial Activity Pattern of Bats. *Forest Ecology and Management* 162:209–218.
- Miller, A.H. 1937. Structural Modifications in the Hawaiian Goose (*Nesochen sandvicensis*): A Study in Adaptive Evolution. *University of California Publications in Zoology* 42(1):1–80.

- Mitchell, C., C. Ogura, D.W. Meadows, A. Kane, L. Strommer, S. Fretz, D. Leonard, and A. McClung. 2005. Hawai'i's Comprehensive Wildlife Conservation Strategy. Department of Land and Natural Resources, Honolulu, Hawai'i. Available at: <http://www.state.hi.us/dlnr/dofaw/cwcs/>. Accessed October 9, 2013.
- Morris, A.D. 2008. Use of Forest Edges by Bats in a Managed Pine Forest Landscape in Coastal North Carolina. Master's thesis, University of North Carolina, Chapel Hill.
- National Park Service (NPS). 2010. *Natural Resource Management Supplemental Annual Report for Natural Resource Condition Assessment, FY 2009*. Hawai'i Volcanoes National Park. Unpublished report, Hilo, Hawai'i.
- . 2011. *Natural Resource Management Supplemental Annual Report for Natural Resource Condition Assessment, FY 2010*. Hawai'i Volcanoes National Park. Unpublished report, Hilo, Hawai'i.
- . 2012. *Natural Resource Management Annual Report for Natural Resource Condition Assessment, FY 2011*. Hawai'i Volcanoes National Park. Unpublished report, Hilo, Hawai'i.
- . 2015. Hawai'i Volcanoes National Park *Natural Resource Condition Assessment*.
- . 2018. About Us. Available at: <https://www.nps.gov/aboutus/index.htm>. Accessed May 31, 2018.
- Natividad Hodges, C.S. 1994. Effects of Introduced Predators on the Survival and Fledging Success of the Endangered Hawaiian Dark-rumped Petrel (*Pterodroma phaeopygia sandwichensis*). Master's thesis. Department of Forest Resources, University of Washington, Seattle.
- NatureServe. 2016. NatureServe Explorer: An Online Encyclopedia of Life. Version 7.0. NatureServe, Arlington, Virginia. Available <http://www.natureserve.org/explorer>. Accessed April 24, 2016.
- Nowak, R.M. 1994. *Walker's Bats of the World*. Johns Hopkins University Press, Baltimore, Maryland.
- O'Shea, T.J., L.E. Ellison, and T.R. Stanley. 2011. Adult Survival and Population Growth Rate in Colorado Big Brown Bats (*Eptesicus fuscus*). *Journal of Mammalogy* 92(2):433–443.
- Parkes, J. 1993. Feral Goats: Designing Solutions for a Designer Pest. *New Zealand Journal of Ecology* 17(2):71–83.
- Planning Solutions, Inc. 2010. *Revised Final Environmental Impact Statement Kaheawa Wind Power II Wind Energy Generation Facility, Ukumehame, Maui, Hawai'i*. Planning Solutions, Inc., Honolulu, Hawai'i.
- Pratt, L.W., T.K. Pratt, and D. Foote. 2011. Rare and Endangered Species of Hawaii Volcanoes National Park. Hawai'i Cooperative Studies Unit Technical Report HCSU-025. University of Hawai'i at Hilo.
- Pryde, M.A., M. Lettink, and C.F.J. O'Donnell. 2006. Survivorship in Two Populations of Long-tailed Bats (*Chalinolobus tuberculatus*) in New Zealand. *New Zealand Journal of Zoology* 33:2.
- Pyle, R.L., and P. Pyle. 2017. The Birds of the Hawaiian Islands: Occurrence, History, Distribution, and Status. B.P. Bishop Museum, Honolulu, Hawai'i. Version 2 (1 January 2017). Available at: <http://hbs.bishopmuseum.org/birds/rlp-monograph/>. Accessed October 10, 2018.

- Reynolds, M.H., B.A. Cooper, and R.H. Day. 1997. Radar Study of Seabirds and Bats on Windward Hawai'i. *Pacific Science* 51:97–106.
- Reynolds, M.H., and G. Ritchotte. 1997. Evidence of Newell's Shearwater Breeding in Puna District, Hawaii. *Journal of Field Ornithology* 68:26–32.
- Richardson, F., and D.H. Woodside. 1954. Rediscovery of the Nesting of Dark-rumped Petrel in the Hawaiian Islands. *The Condor* 56: 323–327.
- Sempra Energy. 2014. *Auwahi Wind Farm Habitat Conservation Plan FY2014 Annual Report*. Prepared for Auwahi Wind Energy, LLC. Maui, Maui County, Hawai'i.
- Simons, T.R. 1985. Biology and Behavior of the Endangered Hawaiian Dark-rumped Petrel. *Condor* 87:229–245.
- Simons, T.R., and C.N. Hodges. 1998. Dark-rumped Petrel (*Pterodroma phaeopygia*). In *The Birds of North America*, No. 345, edited by A. Poole and F. Gill. The Birds of North America, Inc. Philadelphia, Pennsylvania.
- Slotterback, J. 2002. Band-rumped Storm-Petrel (*Oceanodroma castro*) and Tristram's Storm-Petrel (*Oceanodroma tristrami*). No. 675. In *The Birds of North America*, edited by A. Poole and F. Gill. The Birds of North America, Inc. Philadelphia, Pennsylvania.
- Spear, L.B., D.G. Ainley, N. Nur, and S.N.G. Howell. 1995. Population Size and Factors Affecting At-Sea Distributions of Four Endangered Procellariids in the Tropical Pacific. *Condor* 97:613–638.
- SWCA Environmental Consultants (SWCA). 2012. *Kaheawa Wind Power II Wind Energy Generation Facility Habitat Conservation Plan*. SWCA, Honolulu, Hawai'i.
- . 2015a. *Avian Point Count Surveys at Pakini Nui Wind Farm*. SWCA, Honolulu, Hawai'i.
- . 2015b. *Fatality Searches, Searcher Efficiency and Carcass Retention Trials Report at Pakini Nui Wind Farm*. SWCA, Honolulu, Hawai'i.
- . 2019. *Hawaiian Hoary Bat Surveys at Pakini Nui Wind Farm in Years 2014–2017*. SWCA, Honolulu, Hawai'i.
- Swift, R., and E. Burt-Toland. 2009. *Surveys of Procellariiform Seabirds at Hawai'i Volcanoes National Park, 2001-2005*. Pacific Cooperative Studies Unit Technical Report 163, University of Hawai'i at Mānoa, Department of Botany, Honolulu.
- Tawhiri Power LLC. 2007–2013. Monthly fatality search reports. Unpublished field reports.
- Telfer, T.C., J.L. Sincock, G.V. Byrd, and J.R. Reed. 1987. Attraction of Hawaiian Seabirds to Lights: Conservation Efforts and Effects of Moon Phase. *Wildlife Society Bulletin* 15:406–413.
- Tetra Tech. 2008. *Final Habitat Conservation Plan for the Construction and Operation of the Lāna'i Meteorological Towers*. Prepared for Castle & Cooke, Division of Forestry and Wildlife and U.S. Fish and Wildlife Service, Lāna'i, Maui County, Hawai'i.


- . 2018. *Auwahi Wind Farm Habitat Conservation Plan FY 2018 Annual Report*. Prepared for Auwahi Wind Farm and Sempra Renewables. Available at: https://dlnr.hawaii.gov/wildlife/files/2019/02/Auwahi-HCP-Draft-FY18-Annual-Report_1-24-2019_FINAL.pdf. Accessed May 6, 2019.
- . 2019. *Kawailoa Wind Project Habitat Conservation Plan FY 2018 Annual Report*. Revised report. Prepared for Kawailoa Wind, LLC. Available at: https://dlnr.hawaii.gov/wildlife/files/2019/05/Kawailoa-HCP-FY-2018-Annual-Report_REVISIED_26Feb2019.pdf. Accessed May 6, 2019.
- Tomich, P.Q. 1986. Endangered Species Information System Species Workbook. Part II – Species Biology. Unpublished U.S. Fish and Wildlife Service report.
- Travers, M., A. Raine, and M. McKown. 2014. Acoustic Detections of Avian Power Line Collisions: A Novel Monitoring Solution for a Global Problem. 2014 Hawai‘i Conservation Conference abstract. Hawai‘i Convention Center, Honolulu.
- U.S. Fish and Wildlife Service (USFWS). 1998. *Recovery Plan for the Hawaiian Hoary Bat (Lasiurus cinereus semotus)*. U.S. Fish and Wildlife Service, Portland, Oregon.
- . 2004. *Draft Revised Recovery Plan for the Nēnē or Hawaiian Goose (Branta sandvicensis)*. U.S. Fish and Wildlife Service, Portland, Oregon.
- . 2005a. Regional Seabird Conservation Plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region, Portland, Oregon.
- . 2005b. *‘Ake‘ake or Band-Rumped Storm-Petrel (Oceanodroma castro)*. U.S. Fish and Wildlife Service. Honolulu, Hawai‘i.
- . 2005c. Hawaiian Dark-rumped Petrel (*Pterodroma phaeopygia sandwichensis*) 5-Year Review Summary and Evaluation. Available at: http://ecos.fws.gov/docs/five_year_review/doc3866.pdf. Accessed June 4, 2015.
- . 2011. Nēnē or Hawaiian Goose (*Branta sandvicensis*) 5-Year Review Summary and Evaluation. Available at: http://ecos.fws.gov/docs/five_year_review/doc3864.pdf. Accessed May 28, 2015.
- . 2012a. *Land-Based Wind Energy Guidelines*. Available at: http://www.fws.gov/windenergy/docs/WEG_final.pdf. Accessed May 27, 2015.
- . 2012b. Endangered Species in the Pacific Islands: Hawaiian Hoary Bat. Available at <http://www.fws.gov/pacificislands/fauna/HIhoarybat.html>. Accessed January 27, 2016.
- . 2012c. Species Assessment and Listing Priority Assignment Form: *Oceanodroma castro*. Available at: http://ecos.fws.gov/docs/candidate/assessments/2013/r1/B08V_V01.pdf. Accessed July 18, 2013.
- . 2016. *Wildlife agency guidance for calculation of Hawaiian hoary bat indirect take*. U.S. Fish and Wildlife Service, Pacific Islands Field Office, Honolulu, Hawai‘i.
- Warner, R.E. 1968. The Role of Introduced Diseases in the Extinction of the Endemic Hawaiian Avifauna. *Condor* 70(2): 10–120.

- Whitaker, J.O., and P.Q. Tomich. 1983. Food Habits of the Hoary Bat, *Lasiurus cinereus*, from Hawai‘i. *Journal of Mammalogy* 64:151–152.
- Widmer, A. 2018. Meeting notes regarding the bat fatality analysis for Tawhiri’s Habitat Conservation Plan application revisions for Pakini Nui Wind Farm. April 24. Copies available at SWCA, Honolulu, Hawai‘i.
- Wilkinson, G.S., and J.M. South. 2002. Life History, Ecology and Longevity in Bats. *Aging Cell* 1:124–131.
- Winter, L. 2003. Popoki and Hawai‘i’s Native Birds. *‘Elepaio* 63:43–46.
- Wood, K. R., D. Boynton, E. VanderWerf, L. Arnold, M. LeGrande, J. W. Slotterback, and D. Kuhn. 2002. *The distribution and abundance of the Band-rumped Storm-Petrel (Oceanodroma castro): A Preliminary Survey on Kaua‘i, Hawai‘i*. Report to the U.S. Fish and Wildlife Service, Pacific Islands Office, Honolulu, Hawai‘i.
- Woog, F., and J.M. Black. 2001. Foraging Behavior and the Temporal Use of Grasslands by Nēnē: Implications for Management. *Studies in Avian Biology* 22:319–328.
- Work, T. M. J. Dagenais, R. Rameyer, and R. Breeden. 2015. Mortality Patterns in Endangered Hawaiian Geese (Nene; *Branta sandvicensis*). *Journal of Wildlife Diseases* 51(3).
- Young, D.P. Jr., S. Nomani, W. Tidhar, and K. Bay. 2012. NedPower Mount Storm Wind Energy Facility, Post-Construction Avian and Bat Monitoring: Fall 2011. Prepared for NedPower Mount Storm, LLC, Houston, Texas. Prepared by Western EcoSystems Technology, Inc., Cheyenne, Wyoming.
- Young, L.C., E.A. VanderWerf, M.T. Lohr, C.J. Miller, A.J. Titmus, D. Peters, and L. Wilson. 2013. Multi-Species Predator Eradication within a Predator-proof Fence at Ka‘ena Point, Hawaii. *Biological Invasions* 15(12):2627–2638.
- Zimpfer, J., and F. Bonaccorso. 2010. Barbed Wire Fences and Hawaiian Hoary Bats: What We Know. 2010 Hawai‘i Conservation Conference abstract. Hawai‘i Convention Center, Honolulu.

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Appendix A

Hawaiian Hoary Bat Mitigation Resource Equivalency Analysis



RESOURCE EQUIVALENCY ANALYSIS FOR
PAKINI NUI WIND FARM TO MITIGATE FOR
TAKE OF THE HAWAIIAN HOARY BAT

SEPTEMBER 2019

PREPARED FOR
Tawhiri Power LLC

PREPARED BY
SWCA Environmental Consultants

**RESOURCE EQUIVALENCY ANALYSIS
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Prepared for

Tawhiri Power LLC
551 Pilgrim Drive, Suite C
Foster City, California 94404
Attn: Steven Pace
(650) 358-1550, ext. 11

Prepared by

SWCA Environmental Consultants
1001 Bishop Street
ASB Tower, Suite 2800
Honolulu, Hawai'i 96813
(808) 548-7922
www.swca.com

SWCA Project No. 28683

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INTRODUCTION

Pakini Nui Wind Farm, located near South Point on the Island of Hawai'i, is a 21-megawatt (MW) operating wind energy facility (Project). Construction of the Project began in August 2006 and was completed in April 2007. The Project, consisting of 14 General Electric 1.5-MW SE turbines, began operations on April 3, 2007. Tawhiri Power LLC (Tawhiri) owns and operates the Project.

SWCA Environmental Consultants (SWCA) conducted a resource equivalency analysis (REA), an environmental economic model frequently used in damage assessments and mitigation planning, to determine the size of mitigation project that would fully offset the anticipated level of take for the endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*) at the Pakini Nui Wind Farm.

Overview of Project and Mitigation Need

Tawhiri is in the process of drafting a Habitat Conservation Plan (HCP) and obtaining an incidental take permit/incidental take license (ITP/ITL) in accordance with the Endangered Species Act of 1973, as amended, and §195D of Hawai'i Revised Statutes. Take of 26 Hawaiian hoary bats will be covered under the ITP/ITL, once approved, with a permit duration of 10 years (8 years of operation, 2 years of decommissioning). An integral part of the HCP process is proposing a mitigation project that will fully offset the impacts of the proposed taking. Tawhiri is currently in discussion with Hawai'i Volcanoes National Park (HVNP) to define the parameters of a habitat restoration project that would be carried out in the Kahuku Unit of HVNP and would create and/or enhance foraging and pupping habitat for the Hawaiian hoary bat. The purpose of this REA is to provide biologically sound logic to assist Tawhiri in determining the appropriate size of this project to ensure that the impacts of the authorized taking through an ITP/ITL are fully offset.

Resource Equivalency Analysis

An REA is an economic model that provides a science-based, peer-reviewed method of quantifying interim and permanent resource losses (i.e., losses of animals) associated with an environmental disturbance and scaling compensatory mitigation to offset those losses (Allen et al. 2005; Dunford et al. 2004; King 1997). An REA quantifies and balances losses (take due to Project operation) and gains (benefits of compensatory mitigation) in animal-years.

An REA quantifies take in animal-years, which are the additional years the animals would have lived if they had not been killed by the disturbance. For example, the disturbance-related death of an animal that would have lived another 10 years, on average, would result in the loss of 10 animal-years. An REA also quantifies mitigation in animal-years, which often measure improved carrying capacity of newly created or improved habitat or the benefits of eliminating a different source of mortality. For example, a mitigation project that creates an acre of new habitat that supports five individuals annually can be said to produce 5 animal-years/year in mitigation credit. Once the resource losses are known and the mitigation resource gains are known per unit of application, the REA calculates the size of the project needed to offset the resource loss at a ratio of 1:1. In some cases, where the reproductive potential of the animals lost differs from the animals supported by the mitigation project, foregone reproduction (the lives of the offspring of the animal killed, also measured in animal-years) may also be quantified and offset.

Another key element of an REA is that it applies an economic discount rate to resource losses and gains so that they can be traded in present value (PV). A discount rate of 3% is most commonly used in these analyses to account for interest rates, impatience, and risk in planning projects and managing habitat in the future. Application of the discount rate results in resource gains or losses occurring in the future

having less value than those occurring earlier. This motivates early mitigation, as a larger amount of mitigation will be required if it is implemented later in the project than if it is implemented earlier. However, discount rates of even 1–2% per year shift the costs of environmental degradation to later generations and reduce incentives for long-term environmentally favorable projects (Environmental Justice Organizations, Liabilities and Trade 2018). For this reason, some analyses apply a 0% discount rate, such as the U.S. Fish and Wildlife Service’s (USFWS’s) REA for Indiana Bat take mitigation (USFWS 2013a).

Applications and Benefits

REAs were originally developed to quantify mitigation required to offset an environmental injury that had already occurred and REAs have been routinely applied during the Natural Resource Damage Assessment (NRDA) process since the 1990s. In the last several years, REAs have been used to estimate the mitigation needed to offset environmental injuries that are anticipated but have not yet occurred. A current example is the REA developed by the USFWS to estimate the number of power poles that need to be retrofitted to offset the anticipated project-related loss of golden and bald eagles (USFWS 2013b).

The following are benefits of an REA:

- High credibility – the approach has been evaluated and documented in scientific peer-reviewed literature and has held up in numerous court cases.
- Analyses are quantitative rather than qualitative in nature.
- Equations are straightforward but have enough input variables to allow for flexibility in project design.
- Provides a replicable method for negotiation of mitigation ratios, acceptable compensatory restoration, and/or fines.
- Valuable planning tool; can be used to evaluate the cost of multiple compensatory mitigation measures.
- Applicable to any ecosystem type where an appropriate habitat services metric can be defined.
- Currently the most commonly used method by natural resource trustees to assess damages to ecosystems.
- Used by federal regulatory agencies, such as the USFWS, NOAA, the Bureau of Land Management, the Environmental Protection Agency, the Department of the Interior, and the U.S. Army Corps of Engineers.

Data Needs

The following are data needs for an REA:

- The timing and duration of the disturbance (e.g., project construction and/or operation)
- An estimated number of animal fatalities caused by the disturbance
- An estimate of the animal’s normal lifespan and the age distribution of the population so that the average animal-years lost per animal killed can be estimated without knowing the actual ages of the animals killed; age distribution can be estimated from age-specific survival rates if lifespan is known

- A determination of whether foregone reproduction needs to be modeled—that is, whether the reproductive potential of the animals killed is different from the reproductive potential of the animals served by the mitigation
- An estimate of the new resource services produced by the mitigation project per unit of application (e.g., number of animals supported per year per acre of habitat improved)
- The timing and duration of the mitigation project, including the time of implementation and the time to full benefit
- The economic discount rate being used

An REA is an appropriate tool for mitigation planning in advance of resource loss when the resource losses (project impacts) and resource gains (mitigation benefits) can be reasonably estimated. Where there is uncertainty in these estimates, it is appropriate to use conservative estimates that will result in additional mitigation so the project proponent and wildlife agencies can be confident that the full resource loss will be offset.

Hawaiian Hoary Bat

The Hawaiian hoary bat is the only existing native terrestrial mammal from the Hawaiian Archipelago and is endemic to the islands (USFWS 1998). The Hawaiian hoary bat is a subspecies of the hoary bat (*Lasiurus cinereus*) found throughout the Americas. This sub-species has been recorded on Kaua‘i, O‘ahu, Moloka‘i, Maui, and Hawai‘i, but no historical population estimates exist. The Hawaiian hoary bat—and hoary bats in general—are solitary foliage-roosting bats, although mothers and pups roost together (USFWS 1998). Radio telemetry has shown that Hawaiian hoary bats can range widely in a single night, are territorial, and do not congregate to feed. Due to the Hawaiian hoary bat’s solitary habits, conducting research on it (or the hoary bat in the continental United States) is difficult, and little information is available for many basic life history parameters.

Forest Restoration Mitigation Project

The Pakini Nui Project site does not have any roosting or pupping habitat because of a dearth of trees. Furthermore, it is expected there are few native arthropods available for foraging in the predominant invasive plants. It is most likely that any bats frequenting the area are searching for prey in the lee of the nearby cliff and only infrequently enter the area occupied by turbines.

Tawhiri proposes measures that focus on restoring high-quality native habitat in an area that has been historically overgrazed and overrun with non-native plant species. The full description of the forest restoration mitigation project is detailed in Appendix B of the HCP. The methods of the forest restoration mitigation project consist of controlling invasive plants, planting native trees and shrubs, and scarification around existing koa trees to regenerate the existing seed bank. This work will take place in an area where seed supplies for native tree species are limited and competition from invasive or aggressive grasses and woody species inhibits forest recovery. Furthermore, with the potential threat of the spread of rapid ‘ōhi’a death into HVNP, forest restoration projects of this type gain even more importance in maintaining roosting habitat for the Hawaiian hoary bat. The forest restoration mitigation project area, once restored, will provide forested habitat comprised mostly of native species, providing roosting/pupping and improved foraging habitat for Hawaiian hoary bats. The forest restoration mitigation project will mitigate for impacts to low-quality habitat by improving roosting and pupping habitat in a perpetually protected location that currently constitutes low-quality habitat.

HVNP acquired the 150,865-acre Kahuku Unit in 2003 for the preservation of habitat for threatened, endangered, and other rare plants and animals. To this end, HVNP fenced large tracts of land within this unit and removed ungulates to reduce the immediate threat to the preservation of these rare species and their habitat. The forest restoration mitigation project area, which is adjacent to the Ka'ū Forest Preserve, provides habitat for a number of rare, threatened, and endangered species, including the Hawaiian hoary bat and nēnē (*Branta sandvicensis*). Hawaiian hoary bats were detected in the forest restoration mitigation project area year-round (Fraser and HaySmith 2009), although these detections were not associated with a restoration project. Unfortunately, much of the lowland forest (< 1,372 meters [4,500 feet] elevation) is badly degraded by decades of land clearing and destruction by cattle, mouflon sheep, and pigs. Large forest tracts have been converted to alien grass pastures and are invaded by Christmas berry (*Schinus terebinthifolius*), strawberry guava (*Psidium cattleianum*), and kāhili ginger (*Hedychium gardnerianum*). HVNP staff have constructed boundary fences and removed animals (feral pigs and cattle), but additional measures, such as invasive plant control and the planting of native trees, are needed to facilitate forest recovery and restoration of wildlife habitat. Without active restoration, much of the area would remain dominated by non-native pasture grasses and would not provide roosting or pupping habitat for Hawaiian hoary bat.

METHODS

Standard methods for the REA were applied, with resource loss and gain measured in bat-years. The mathematical equations applied in this analysis were adapted for use from the USFWS's REA framework to mitigate the take of eagles from wind power operations (https://www.fws.gov/ecological-services/es-library/pdfs/Technical_Note_on_Avoided_Loss.pdf, accessed 08/25/2019). This stepwise replacement model is calculated as:

$$(1) \quad I = \sum_{t=0} [(NB_t - N_t) \div (1 + r)^t]$$

where I is the resource loss bat-years, NB_t and N_t represent the number of individuals in the population (at time t) under “baseline” and “injured” scenarios, respectively, t indexes time in years, and r is the annual discount rate.

From equation (1), the REA measures I directly as the PV bat-years over the permit term. The process of scaling the mitigation project size (Y , measured in acres) to exactly offset I is:

$$(2) \quad Y = I \div \text{mitigation benefit } (C)$$

The mitigation benefit (C , PV animal-years produced per acre of habitat restored) is calculated as:

$$(3) \quad C = \sum_{t=0} [(N_t - NB_t) \div (1 + r)^t] \div \text{scaling factor}$$

where NB_t and N_t represent the number of individuals in the population (at time t) under “baseline” and “restored” scenarios, respectively, t indexes time in years, r is the annual discount rate, and the *scaling factor* is size of the analysis plot (acres) containing the population described in NB_t and N_t .

The following sections review the assumptions and rationale for the estimates of resource losses and gains used in the REA. These estimates and assumptions are summarized for quick reference in Table 1. For the purposes of the REA, if information on the Hawaiian hoary bat is unknown, available information for the hoary bat in the Americas is used. If that information is also lacking, available information from another lasiurine species is used. If this information is unavailable, information from foliage-roosting bats within the same family (Vespertilionidae) is used.

Although Tawhiri acknowledges that some of the Hawaiian hoary bat life history inputs are not known and must be based on surrogates, the REA is presented as the best available method in the absence of better methods or agency guidance.

Table 1. Data Need, Estimates Used, and Sources for Pakini Nui Hawaiian Hoary Bat Mitigation Resource Equivalency Analysis

Data Need	Estimates Used	Source
The timing and duration of the disturbance and an estimated number of animal fatalities.	Take of 26 bats in 8 years of operation	Section 4.1 of the HCP
An estimate of the animal's normal lifespan and the age distribution of the population so that the average animal-years lost per animal killed can be estimated without knowing the actual ages of the animals killed; age distribution can be estimated from age-specific survival rates if lifespan is known.	Maximum lifespan is 10 years. Assumed annual survival rates of juveniles (30%) and adults (85%) were used to characterize the age distribution of the population.	Lifespan: as noted in Amlin and Siddiqi (2015) Adult survival: O'Shea et al. 2011; Pryde et al. 2006 Juvenile survival: Wildlife agency guidance for calculation of Hawaiian hoary bat indirect take (USFWS 2016)
An estimate of the new resource services produced by the mitigation project per unit of application (e.g., number of animals supported per year per acre of habitat improved).	The forest restoration mitigation project area may currently support limited use by bats. Bats were detected at the project by Fraser and HaySmith 2009), but bat roosting and pupping habitat is limited. Use at baseline is estimated in the model as one bat per 80 acres (0.5 bat per 40 acres) One bat per 80 acres is a conservative assumption that includes the possibility that bats may currently travel through and potentially forage in the mitigation project area. For comparison, two bats per 40 acres is considered full carrying capacity based on mapping core range habitat sizes (Bonaccorso et al. 2015). The model assumes that the forest restoration mitigation project area will support two bats-years per 40 acres in the sixth year following planting in each section (full value).	Professional opinion, Fraser and HaySmith 2009; Bonaccorso et al. 2015
The timing and duration of the mitigation project, including the time of implementation and the time to full benefit.	Funding for the forest restoration mitigation project will be provided in year 1. Noxious and invasive plant removal and the planting of tree seedlings will take place on approximately an eighth (12.5%) of the forest restoration mitigation project area every year for years 2–9 of the mitigation project. Koa, the fastest growing tree species to be planted and/or regenerated, will reach 15 feet in height after about 5 years and will provide roosting habitat 6 years following scarification. Therefore, the creation of pupping habitat will begin on 12.5% of the forest restoration mitigation project area 6 years after planting (year 7 of the forest restoration mitigation project) and expand on an additional 12.5% of the forest restoration mitigation project area until year 14 (final planting in year 9 plus 6 years of growth, including the initial year). High-quality pupping habitat would result following 15–20 years of tree growth.	Professional opinion based on design of project, as described in Appendix B of the HCP

Data Need	Estimates Used	Source
The economic discount rate being used.	0% annual discount rate	The standard rate typically used in REAs (e.g., USFWS eagle take REA) is 3%; however, 0% is consistent with the discount rate used for the Indiana Bat REA.

Maximum Lifespan

A lifespan of 10 years was used in the REA, in alignment with the latest State of Hawai‘i Department of Land and Natural Resources guidance (as noted on pages 15 and 16 of Amlin and Siddiqi 2015).

Annual Adult Survival Rate

No data for adult survival rates of hoary bats or other lasiurine species were available through a literature search; however, information of other foliage roosting vespertilionid bats is as follows:

- Colorado big brown bats (*Eptesicus fuscus*) – Annual adult survival at five maternity colonies monitored from 2001 to 2005 was estimated at 0.79 (95% confidence interval [95% CI] = 0.77–0.82) (O’Shea et al. 2011)
- New Zealand long-tailed bat (*Chalinolobus tuberculatus*) – Annual survival varied from 0.75 (95% CI = 0.54–0.88) to 0.89 (0.48–0.99) at Hanging Rock and 0.55 (0.39–0.71) to 0.91 (0.44–0.99) at Grand Canyon (Pryde et al. 2006).

In this REA, an annual adult survival rate of 85% is used. This is likely an overestimate of survival, which is consistent with the recommended conservative approach to the REA. This overestimate of survival will produce an overestimate of the bat-years lost per bat fatality and result in a higher amount of mitigation due. It is important to note that this survival rate is *not* appropriate for use in a population viability analysis, as it would not be conservative in that context.

Juvenile to Adult Survival Rate

Juveniles are converted to adults by multiplying by 0.3, which is in accordance with the *Wildlife agency guidance for calculation of Hawaiian hoary bat indirect take* (USFWS 2016). This translates to a 30% survival rate for juveniles to adults (juveniles mature at 1 year old) and is used in this REA.

Population Age Distribution

This is currently unknown, and a population age distribution was generated using a 30% juvenile to adult survival rate, an 85% annual adult survival rate and a maximum lifespan of 10 years.

Habitat and Territoriality

Hawaiian hoary bats roost primarily in woody vegetation exceeding 15 feet in height (Bonaccorso et al. 2015, cited in Amlin and Siddiqi 2015). Hawaiian hoary bat roosts are typically in dense canopy foliage or in subcanopy when canopy is sparse, with open access for launching into flight (USDA 2009). A study of a sample of Hawaiian hoary bats (n = 28) on the Island of Hawai‘i estimated a mean foraging range of 391 to 749 acres (230.7 ± 72.3 hectares) and mean core use area of 45 to 79 acres (25.2 ± 6.9 hectares)

(Bonaccorso et al. 2015). The size of home ranges and core areas varied widely between individuals. Core areas included feeding ranges that were actively defended—especially by males—against conspecifics. Female core ranges overlapped with male ranges.

Timing and Duration of the Disturbance

An estimated 26 fatalities are expected over the 10-year permit term (8 years of operation, 2 years of decommissioning).

Simulating Population Structure and Age-Related Fatality

Annual survival rates were used to simulate population structure. The survivorship of a cohort of 100 bats was calculated over the 10-year lifespan. The number surviving in each year was assumed to be representative of the relative number of bats in each age class at any one time (Table 2). This simulation indicated that approximately 75% of bats died by age 2.

Table 2. Simulated Age Distribution of the Population from the Annual Survival Rate and the Estimated Bat Fatalities per Year of Each Age Assuming This Distribution.

Age in years	Assumed Annual Survival Rate (%)	Simulated Survival to Age (100 bats)	Assumed Age Distribution of the Population (%)	Estimated Bat Fatalities per Year
0–1	30	100.00	39.42	1.28
1–2	85	30.00	11.83	0.38
2–3	85	25.50	10.05	0.33
3–4	85	21.68	8.54	0.28
4–5	85	18.42	7.26	0.24
5–6	85	15.66	6.17	0.20
6–7	85	13.31	5.25	0.17
7–8	85	11.31	4.46	0.14
8–9	85	9.62	3.79	0.12
9–10	0	8.17	3.22	0.10
Totals		253.68	100.00	3.25

Estimating Resource Losses

All ages of bat were assumed to be equally vulnerable to Project-related fatality, thus the age distribution of the bats killed is proportional to the simulated age distribution of the bats present. The fatality rate was assumed to be constant over the 8 years of operation. The bat-years lost with every year of Project operation were modeled using a matrix that estimated survival to each successive year for each age cohort of bats that would occur in the absence of the Project.

No economic discount rate was applied, so the rate of PV bat-years lost per year of Project operation did not change over the 8 years of operation modeled. The annual estimates of resource losses were summed over the remaining permit term to produce the total PV bat-years lost that must be offset with mitigation.

Estimating Resource Gains

Mitigation credit is generated by increasing the carrying capacity of the habitat in the forest restoration mitigation project area. The forest restoration mitigation project area is within the known range of the Hawaiian hoary bat and is proposed on lands for which there is currently no management plan nor is there funding for habitat restoration. The methods used by the National Park Service to achieve this restoration are reliable in that Hawaiian hoary bat forage availability is reasonably certain to be improved within the first 6 years because the removal of invasive plants, reintroduction of native plants, and overall increased native biodiversity of the vegetation are expected to boost bat forage biodiversity and availability.

Long-term roosting and potential pupping resources are expected to begin establishing after about 5 years (when koa seedlings should reach 15 feet in height) and would be fully established within 15–20 years. The improved functionality and resources of the forest restoration mitigation project area are expected to continue to provide those resources for the life of each individual tree. Without the forest restoration mitigation project, it is assumed that this forest restoration mitigation project area currently supports one bat per 80 acres to account for the provision of low-quality forage and transitory space. As discussed in the following section, this ratio can be significantly improved as a result of the forest restoration mitigation project.

RESULTS

The resource loss (I , PV bat-years) was divided by the per-acre mitigation resource gain (C , PV bat-years) to estimate the acres of mitigation needed to fully offset the loss. The REA assumes that the forest restoration mitigation project will begin the first permit year. This forest restoration mitigation project is designed such that tree saplings will be planted in dense nodes that should outcompete the invasive grasses for the life of the tree without additional management intervention, which in some cases may be hundreds of years.

The mitigation credit generated by the forest restoration mitigation project depends on the lifetime of the mitigation project (the anticipated duration of increased carrying capacity resulting from habitat improvement). 10 years post-funding was modeled. According to the REA, the total size of the forest restoration mitigation project needed to fully offset the proposed take is 1,074 acres.

LITERATURE CITED

- Allen, P.D. II, D.J. Chapman, and D. Lane. 2005. Scaling environmental restoration to offset injury using habitat equivalency analysis. In *Economics and Ecological Risk Assessment: Applications to Watershed Management*, edited by R.F. Bruins and M.T. Heberling, pp. 165–184. Boca Raton, Florida: CRC Press.
- Amlin, A., and A. Siddiqi. 2015. *Endangered Species Recovery Committee Hawaiian Hoary Bat Guidance Document*. State of Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife, Honolulu, Hawai‘i.
- Bonaccorso, F.J., C.M. Todd, A.C. Miles, and P.M. Gorresen. 2015. Foraging Range Movements of the Endangered Hawaiian Hoary Bat, *Lasiurus cinereus semotus* (Chiroptera: Vespertilionidae). *Journal of Mammalogy* 96(1):64–71.
- Dunford, R.W., T.C. Ginn, and W.H. Desvousges. 2004. The Use of Habitat Equivalency Analysis in Natural Resource Damage Assessments. *Ecological Economics* 48(2004):49–70.
- Environmental Justice Organisations, Liabilities and Trade. 2013 Discounting the Future. Available at: <http://www.ejolt.org/2013/01/discounting-the-future>. Accessed June 20, 2018.
- Fraser, H., and L. HaySmith. 2009. *Hawaiian Hoary Bat Monitoring Protocol*. Pacific Island Network. Natural Resource Report NPS/PWR/PACN/NRR. 2009/DRAFT. National Park Service, Fort Collins, Colorado.
- King, D.M. 1997. *Comparing Ecosystem Services and Values, with Illustrations for Performing Habitat Equivalency Analysis*. Prepared by King and Associates, Inc., Washington, D.C., for the U.S. Department of Commerce, Silver Springs, Maryland.
- National Park Service. 2018. About Us. Available at: <https://www.nps.gov/aboutus/index.htm>. Accessed May 31, 2018.
- O’Shea T.J., L.E. Ellison, and T.R. Stanley. 2011. Adult Survival and Population Growth Rate in Colorado Big Brown Bats (*Eptesicus fuscus*). *Journal of Mammalogy* 92(2):433–443. Available at: <http://dx.doi.org/10.1644/10-MAMM-A-162.1>.
- Pryde, M.A., M. Lettink, and C.F.J. O’Donnell. 2006. Survivorship on Two Populations of Long-tailed Bats (*Chalinolobus tuberculatus*) in New Zealand. *New Zealand Journal of Zoology* 33:85–95.
- U.S. Department of Agriculture. 2009. Bats of the U.S. Pacific Islands. Biology Technical Note No. 20. Natural Resources Conservation Service, Pacific Islands Area.
- U.S. Fish and Wildlife Service (USFWS). 1998. Recovery Plan for the Hawaiian Hoary Bat (*Lasiurus cinereus semotus*). U.S. Fish and Wildlife Service, Portland, Oregon.
- . 2013a. Region 3 Indiana Bat Resource Equivalency Analysis Model for Wind Energy Projects, Draft Version: January 31, 2013. Bloomington, Minnesota.
- . 2013b. Eagle Conservation Plan Guidance, Module 1 – Land-based Wind Energy Version 2: April 2013.

———. 2016. *Wildlife agency guidance for calculation of Hawaiian hoary bat indirect take*. Pacific Islands Field Office, Honolulu, Hawai'i.

Wilkinson, G.S., and J.M. South. 2002. Life History, Ecology and Longevity in Bats. *Aging Cell* 1:124–131.

Appendix B

**A Proposal to Restore 1,200 Acres of
Lowland Mesic-Wet 'Ōhi'a Forest to Benefit
Hawaiian Hoary Bat and Other Threatened and Endangered
Species in Kahuku Unit, Hawai'i Volcanoes National Park**

**A Proposal to Facilitate Forest Recovery Across 1200 acres of Lowland Mesic-Wet 'Ōhi'a Forest to Benefit Hawaiian Hoary Bat and other Threatened and Endangered Species in Kahuku Unit, Hawaii Volcanoes National Park
10 years**

Contact: Sierra McDaniel 808-985-6097
Sierra_McDaniel@nps.gov

Proposed Work

The park will facilitate forest recovery across 1200 acres of degraded forest/pasture in Kahuku. Currently, staff are constructing boundary fences and removing animals, but additional measures, such as invasive plant control and planting of native trees, are needed to facilitate forest recovery and restoration of wildlife habitat. Efforts are focused in areas where a limited seed supply of native tree species, and competition from alien pasture grasses and aggressive woody species inhibits forest recovery. Work crews will sweep and control target weeds, such as kahili ginger (*Hedychium gardnerianum*), blackberry (*Rubus argutus*) christmasberry (*Schinus terebinthifolia*), and strawberry guava (*Psidium cattleianum*), propagate and plant 90,000 seedlings of native trees across 1200 acres of degraded 'ōhi'a forest/pasture (Figure 1). In addition, grasses around select existing koa trees will be removed either with herbicide or mechanical scarification to regenerate koa from the seed bank. The work will benefit the Hawaiian Hoary Bat and at least eight additional listed endangered species, two species of concern, and 17 rare species. The total cost of the project is \$1,463,728 across ten years.

Background

In 2003, Hawaii Volcanoes National Park (HVNP) acquired the 150,865 acres Kahuku Unit. The area provides habitat for a number of rare, threatened and endangered plant and animal species (Benitez et al. 2005, Tweed et al. 2007, Pratt et al. 2011, McDaniel pers. comm.), including the endangered Hawaiian Hoary Bats which have been detected in a variety of forest habitats ranging from 2,000 ft. to 7,400 ft. elevation in Kahuku (Fraser and Haysmith 2009).

Unfortunately, much of the lowland forest (<4,500 ft elevation) is badly degraded by decades of land clearing and impacts by cattle, mouflon and pigs. Large forest tracts have been converted to alien grass pastures with portions invaded by christmasberry and incipient populations of strawberry guava, blackberry and kahili ginger. The park is constructing boundary fences and removing animals, but additional measures, such as invasive plant control and planting of native trees, are needed to facilitate forest recovery and restoration of wildlife habitat. Without active restoration efforts much of the area will remain dominated by nonnative pasture grasses without native forest regeneration.

We propose to actively facilitate forest recovery in a 1200 acre block of degraded ‘ōhi’a forest/pasture (Figure 1).

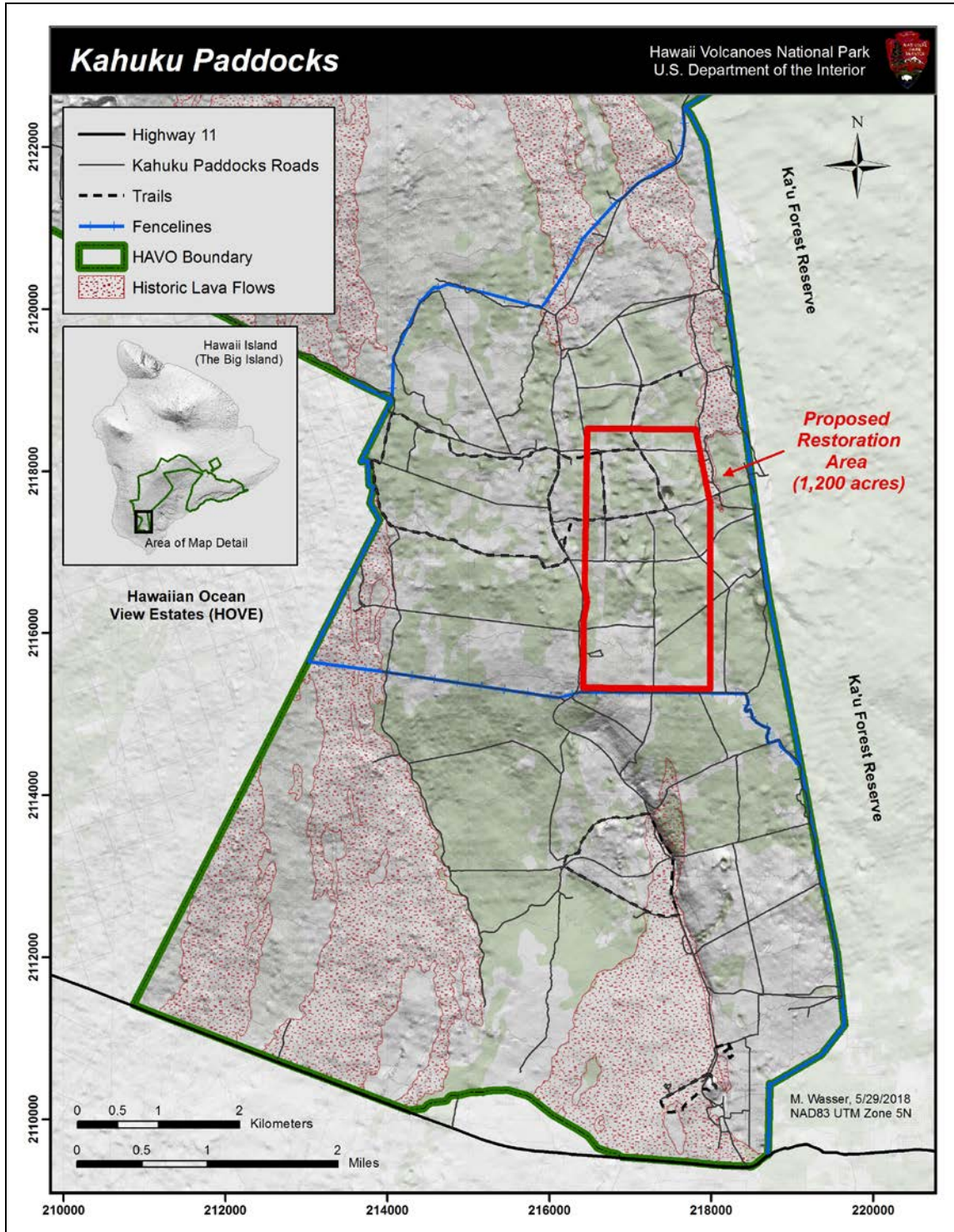


Figure 1. Map lower of Kahuku. Proposed restoration activities would be conducted within a 1200 acre area (red rectangle).

The proposed restoration work would benefit the Hawaiian Hoary Bat along with 8 additional listed endangered species, two SOC, and 17 locally rare species in the area (Table 1). Kahuku is also part of the Ka`ū Forest Complex which is among the priority 1 watersheds by the state of Hawaii because of its high conservation value, unique ecosystems and critically endangered rare plant and wildlife populations. The local community surrounding the park is very interested and eager to learn about and participate in restoration at the park. This restoration project will engage hundreds of community members and students while providing an opportunity to learn about the unique natural resources of Kahuku.

Table 1. Federally-listed endangered, rare and uncommon species that would benefit from active restoration of lower Kahuku

Species	Taxon	Status
<i>Branta sandvicensis</i>	Bird	Endangered
<i>Buteo solitarius</i>	Bird	Endangered
<i>Clermonita lindseyana</i>	Plant	Endangered
<i>Cyanea stictophylla</i>	Plant	Endangered
<i>Drosophila heteroneura</i>	Insect	Endangered
<i>Lasirus cinereus ssp semotus</i>	Mammal	Endangered
<i>Pittosporum hawaiiense</i>	Plant	Endangered
<i>Prichardia lanigera</i>	Plant	Endangered
<i>Vestiaria coccinea</i>	Bird	SOC
<i>Cyrtandra menziesii</i>	Bird	SOC
<i>Trematolobelia wimmeri</i>	Plant	SOC
<i>Antidesma platyphyllum</i>	Plant	Rare
<i>Charpenteria obovata</i>	Plant	Rare
<i>Clermontia clermontioides</i>	Plant	Rare
<i>Clermonita hawaiiensis</i>	Plant	Rare
<i>Clermontia montis-loa</i>	Plant	Rare
<i>Cyanea pilosa</i>	Plant	Rare
<i>Cyrtandra platyphylla</i>	Plant	Rare
<i>Marattia douglasii</i>	Plant	Rare
<i>Melicope radiata</i>	Plant	Rare
<i>Phyllostegia ambigua</i>	Plant	Rare
<i>Phytolacca sandwicensis</i>	Plant	Rare
<i>Pittosporum hosmeri</i>	Plant	Rare
<i>Rumex giganteus</i>	Plant	Rare
<i>Scaevola chamissoniana</i>	Plant	Rare

Species	Taxon	Status
<i>Tetraplasandra hawaiiensis</i>	Plant	Rare
<i>Touchardia latifolia</i>	Plant	Rare
<i>Urera glabra</i>	Plant	Rare

Objective

1. Prevent establishment of target weed species to promote natural recovery across 1200 acres
2. Plant 90,000 nursery reared seedlings of important native species to facilitate forest recovery in nodes across 1200 acres in former pasture in the Kahuku Unit. In addition, grasses around select existing koa trees will be removed either with herbicide or mechanical scarification to regenerate koa from the seed bank.
3. Evaluate community vegetation changes within and outside of the active restoration area.

Methods

1. **Prevent establishment of target weed species.** Work crews will conduct ground searches to locate and target weed species. GPS data will be collected for areas searched and number of plants treated. Target species include blackberry, strawberry guava, kahili ginger, and christmasberry. Control methods will follow established park prescribed treatments for each species (Table 2).
2. **Plant 90,000 nursery reared seedlings and remove grasses from select existing koa trees using herbicide or mechanical scarification.** Seeds of native tree and shrub species will be collected within the local area and processed for propagation. All propagation will be conducted at the HVNP native plant facility. Facilities will be kept free of pest species; individuals will be rigorously monitored and sanitized before planting to avoid contamination of target locations. Techniques for propagating and planting common native species have been developed and applied at HVNP. Prior to planting and seed broadcasting, alien grasses will be temporarily suppressed by applying a 2% solution of imazapyr and glyphosate. In addition, a total of approximately 30 acres of grasses around select existing koa trees will be removed either with herbicide or mechanical scarification to regenerate koa from the seed bank.

Planting and seeding nodes will be strategically placed to link existing forest fragments or build biodiversity around existing solitary trees. Nodes built around scattered tall ‘ōhi‘a and koa trees in the pasture may attract birds to disperse seeds, have higher nutrient inputs because of leaf litter fall and higher moisture levels because of cloud water interception. Planting seedlings in dense nodes will reduce light levels as the canopy develops and suppress the dominate invasive grasses. This will create forest habitat that would be extant for the life of the trees, needing very little long term management.

3. **Monitor project success.** Vegetation monitoring plots will be established both within and outside of the project area to evaluate impacts of management actions on the vegetation community composition and structure. Plots will be established in the first year of the project and read at year 10 to determine if success criteria have been met.
 - Outplanted seedling survival averages 60% across all outplanted species at one year post planting.
 - Native species richness significantly increases over time.
 - The canopy is composed entirely of native tree species

Implementation Schedule

Year 1- Begin project coordination and site visits with work leaders, begin collection of plant material and propagation. Conduct invasive plant sweeps and removal. Establish vegetation monitoring plots.

Year 2-5 - Begin planting of nursery reared seedlings. Complete planting of 45,000 seedlings by year 5 (approximately 11,250 per year).

Year 5-10- Complete planting of 45,000 (approximately 11,250 per year) nursery reared seedlings by year 10. Re-read vegetation plots in year 10.

Table 2. Invasive species targeted for control.

Species	Common Name	Control Method
<i>Cestrum nocturnum</i>	Night cestrum	10% Garlon 3A Cut Stump
<i>Hedychium gardnerianum</i>	Kahili ginger	1.5g/l Escort
<i>Morella faya</i>	Faya tree	10% Garlon 3A cut stump, 50 % Garlon 3A Frill
<i>Psidium cattleianum</i>	Strawberry guava	10% Garlon 3A Cut Stump
<i>Rubus argutus</i>	Blackberry	1% Garlon 3A Foliar
<i>Schinus terebinthifolius</i>	Christmasberry	1% Garlon 4 Diesel

Budget

This project would be carried out over a 10 year period. The park has already significantly invested in this area by constructing fences and removing all of the nonnative ungulates. Matching funds or in-kind support provided by HVNP staff includes overall project coordination (e.g. planning, compliance, logistical support, supervision of collection of plant material, and activities in the nursery and field).

The total requested funding is \$1,463,728 across 10 years. Funding will support a plant propagator or biological science technician to propagate, plant and monitor vegetation changes, pest control workers to remove nonnative vegetation, D6 equipment and operator, project supplies, transportation costs, greenhouse facility cost, and cultural resource survey. An annual inflation rate of 2% is built into the calculations.

		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	total
Pest control worker	270 worker days sweep and remove target weeds from 1200 acres 1x	\$92,259.00	\$0	\$0	\$0	\$0	\$0.00	\$0	\$0	\$0	\$0	\$92,259.00
Pest control worker	site prep (herbicide grasses prior to planting and maintenance of grasses) 35 worker days per year	\$12,198.69	\$12,443	\$12,692	\$12,945	\$13,204	\$13,468.34	\$13,738	\$14,012	\$14,293	\$14,579	\$133,572.25
Plant propagator/biological science technician seed collection, processing, propagation, site prep, planting, monitoring	75% GS-7 step 5 + 45% benefits (from 2018 OPM salary table \$48,123 + \$21,655 = \$69,788 per year)	\$54,456	\$55,545	\$56,656	\$57,789	\$58,944	\$60,123	\$61,326	\$62,552	\$63,803	\$65,079	\$596,273
Planting labor combination of staff and volunteers	50 plants per person per day @ \$200 per day = 225 days per 11250 plants	\$0	\$47,754	\$48,709	\$49,684	\$50,677	\$51,691	\$52,725	\$53,779	\$54,855	\$0	\$409,874
D6 equipment and operator	remove grasses and facilitate seedling recruitment	\$8,323	\$0	\$8,659	\$0	\$9,009	\$0	\$9,373	\$0	\$9,752	\$0	\$45,117
Greenhouse	construction and maintenance	\$15,000	\$0	\$0	\$0	\$0	\$3,000	\$0	\$0	\$0	\$0	\$18,000
Greenhouse	site prep leveling, gravel fill or surface hardening	\$20,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$20,000
Supplies	Propagation supplies, planting tools, herbicide	6,800	3,876	3,954	4,033	4,113	6,196	4,279	4,365	4,452	4,541	\$46,609
Transportation	GSA 12 months per year	\$7,491	\$7,641	\$7,794	\$7,949	\$8,108	\$8,271	\$8,436	\$8,605	\$8,777	\$8,952	\$82,023
Compliance	cultural resource survey	\$20,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$20,000
Project total with 2% inflation		\$236,527	\$127,258	\$138,463	\$132,400	\$144,057	\$142,749	\$149,877	\$143,314	\$155,932	\$93,152	\$1,463,728

References:

Baker, J. K., and D. W. Reeser. 1972. Goat management problems in Hawaii Volcanoes National Park: A history, analysis, and management plan. U.S. Department of the Interior National Park Service Natural Resources Report Number 2. Office of the Chief Scientist, Washington D.C.

Benitez, D. M., T. Belfield, R. Loh, L. Pratt, and A. D. Christie. 2008. Inventory of vascular plants of the Kahuku addition, Hawai'i Volcanoes National Park. Pacific Cooperative Studies Unit Technical Report 157. University of Hawaii at Manoa. Honolulu, Hawai'i.

Fraser, H. and L. Haysmith. 2009. Draft Hawaiian Hoary Bat Monitoring Protocol. Pacific Islands Inventory and Monitoring. Natural Resource Report NPS

Hess, S. C. 2008. Wild sheep and deer in Hawai'i— a threat to fragile ecosystems. USGS Fact Sheet FS 2008-3102. <http://pubs.usgs.gov/fs/2008/3102/>

McDaniel, S., R. Loh, S. Dale, and C. Yanger. 2011. Experimental restoration of mesic and wet forests in former pastureland, Kahuku Unit, Hawaii Volcanoes National Park. Technical Report No. 175. Pacific Cooperative Studies Unit, University of Hawai'i, Honolulu, Hawai'i.

Pratt, L. W., T. K. Pratt, and D. Foote. 2011. Rare and Endangered Species of Hawaii Volcanoes National Park. Hawai'i Cooperative Studies Unit Technical Report HCSU-025. University of Hawai'i at Hilo.

Tweed, E., P.M. Gorresen, R.J. Camp, P.J. Hart and T.K. Pratt. May 2007. Forest Bird Inventory of the Kahuku Unit of Hawai'i Volcanoes National Park. Technical Report No. 143. 175. Pacific Cooperative Studies Unit, University of Hawai'i, Honolulu, Hawai'i.

Appendix C

Mitigation Costs and Funding

Appendix C. Pakini Nui HCP Funding Matrix

Category	Item	10-Year Total	Timing of Expense	Annual Expense	Number of Years
Compliance	Fatality searches, SEEF, and CARE during operations	\$ 480,000	Rolling basis	\$ 60,000	8
DLNR Compliance Audit	Compliance audit	\$ 80,000	Annually	\$ 8,000	10
Hawaiian Hoary Bat	Habitat restoration at HNVP Kahuku Unit (including vegetation monitoring)	\$ 1,463,728	Annually	\$ 146,373	10
	Bat activity and invertebrate monitoring	\$ 50,000	Annual average	\$ 5,000	10
Hawaiian Petrel and Band-rumped Storm Petrel	Colony protection at HVNP	\$ 115,100	One-time Contribution, Year 1	\$ 115,100	1
Nene	Predator control at breeding pen	\$ 30,000	One-time Contribution, Year 1	\$ 30,000	1
Contingencies (Funding Assurances)	10% of compliance and mitigation project totals. Requested by USFWS to assure funds for adaptive management, inflation, and other changed circumstances.	\$ 185,436	On reserve if needed.		
	5% of mitigation project totals. Requested by DOFAW to assure funds for mitigation project management.	\$ 82,941	On reserve if needed.		
Compliance Sub-total		\$ 560,000			
Mitigation Project Sub-total		\$ 1,658,828			
Contingency Sub-total		\$ 268,377			
Grand Total		\$ 2,487,205			

Appendix D

**Assist Recovery of Endangered Seabird Populations on
Mauna Loa in Hawai'i Volcanoes National Park**

Assist Recovery of Endangered Seabird populations on Mauna Loa in Hawaii Volcanoes National Park

Proposed Work

The park constructed a five mile barrier fence encompassing over 600 acres of nesting habitat to protect the largest subcolony of endangered Hawaiian Petrels or 'Ua'u (*Pterodroma sandwichensis*) on Hawai'i Island. Construction began in 2013 and was completed in 2016. The park conducted predator control and surveillance within the fence during the 2016 and 2017 breeding seasons; no cats have been detected and no predation events were documented therefore the area has been deemed free of cats. Funds requested here will augment post-construction management actions for three years including: remote surveillance for ingress predators (due to fence damage, etc.), annual fence inspection and maintenance, replacement of anti-bird strike materials surveys and nest density monitoring to assess bird response to predator removal. Total cost for three years is \$115,100.

Background

The Hawaiian Petrel was once one of the most numerous seabirds in the main Hawaiian Islands. Due to sheer numbers, this and other seabird species likely were ecologically significant as a source of marine nutrients for generally impoverished tropical soils (Loope 1998). Hawaiian Petrels also had an important place in native culture: Hawaiians harvested chicks and adults as a food source. These endangered birds still persist in remnant colonies at the margins of their former range - generally at high elevations or on steep slopes where nesting birds are best able to evade introduced mammalian predators.

On Hawaii Island, the primary known nesting colonies occur in Hawai'i Volcanoes National Park, on the subalpine slopes of Mauna Loa, between 8,000 and 10,000 feet. Even in this extreme environment, predation by feral cats has been documented as the primary threat to the species. To address the primary threat, the park selected a fence design that was developed, tested, and successfully used in Australia (Moseby and Read 2006) and modified this design for high elevation sites. Complimentary research conducted in the park resulted in recommendations to incorporate materials that make fences more visible to flying petrels and thus reduce the risk of fence strike (Swift 2004). After years of planning, the five mile fence was constructed between 2013 and 2016 at a cost of \$1M, including in-kind support and contributions from multiple funders in addition to the NPS.

Funds provided by this proposal would augment the current park management of Hawaiian petrels within the fence. The park conducts one complete fence inspection per year; additional funds would support more frequent fence inspections and to rapidly respond to potentially damaging events, like a significant storm, with a complete inspection and repair as needed, thus minimizing potential impacts to nesting birds, such as predator ingress. Real-time surveillance for predator ingress would be improved with the addition of eight remote texting game cameras; images are sent to park staff via emails, allowing for a rapid response by park staff should ingress be detected. Monitoring for ingress predators within the enclosure is best accomplished by placing cameras at nest sites, as potential routes are excluded by the fence, thus providing additional reproductive data on a subset of nests. This will improve the park's estimate of reproductive success as cameras have proven to provide more accurate information on this cryptic species than human observation of indirect cues (such as guano and the

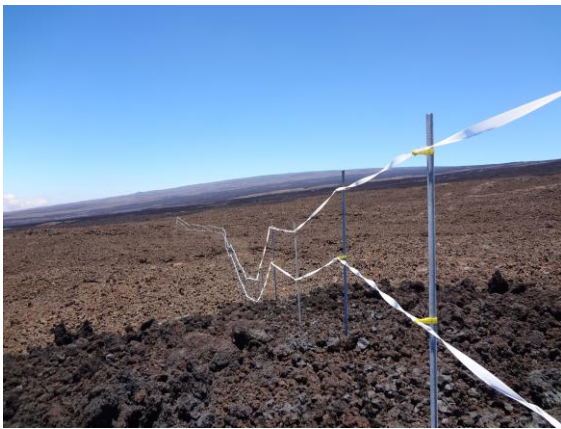
presence of chick down). While the fence was completed in 2016, the strike primary deterrent (two strands of white woven tape) were installed in 2013, when the fence posts were installed, to alert birds to the presence of the poles and to condition them to the coming fence. With additional funds available, the white tape can be replaced efficiently as soon as it is deemed necessary. The park conducted five consecutive years of nest density survey to establish baseline density estimates before and during fence construction and to refine the new monitoring protocol techniques. This level of monitoring is not sustainable given current fiscal uncertainty and will therefore occur only when funding is available. Additional funds will provide the support needed to conduct this systematic monitoring at 5 or 6 years post construction, an appropriate time to expect change given the maturation rate of the species.



Feral cat preying on a chick via remote camera.



Aerial view of the lowest section of the fenced area.



The white visibility tape is beginning to show minor wear.



Assessing nest activity is challenging for this cryptic species; remote cameras can greatly improve monitoring results.

Objectives

Conduct additional fence inspections, to better ensure fence integrity and rapid response to damage. Increase capacity to conduct real time, remote surveillance to detect and respond to any incidents of predator ingress using texting cameras. Ensure integrity of bird deterrent markings on fence by replacing as needed. Monitor the bird response to predator removal at by conducting a follow up systematic survey to detect changes in nest density over time.

Methods

1- Set game cameras (texting) to monitor real time for ingress predators; monitor reproductive success at a subset of nests.

2- Conduct additional fence inspection each year to better ensure integrity of fence. Inspection would be in response to potentially damaging event if one occurs, otherwise would be planned opposite the park's annual inspection.

3- Replace deteriorated anti-strike devices (white marking tape or alternate) to ensure the fence remains visible to transiting birds.

4- Monitor petrel response to removal of predators. Nest surveys will be conducted in 50m x 50 m grids as outlined in the Hawaiian Petrel Monitoring Protocol (Hu et al. 2015). Data collected will be used to calculate nest densities and contribute to the detection of trends over time.

Implementation Schedule

Years 1-3 - Conduct surveillance for ingress predators (via remote cameras) and annual fence inspections.

Year 1, 2 *or* 3 - When needed, replace deteriorated anti-strike devices to ensure the fence remains visible to petrels.

Year 3 - Conduct nest density survey and monitoring to measure bird response to the removal of predators.

Deliverables

- Complete replacement of 10 miles (2 strands) of white tape to ensure the fence remains visible to Hawaiian petrels.
- Reproductive success results for a subset of Hawaiian petrel nests for each of three years.
- Results of consistent, remote surveillance for ingress predators.
- Comprehensive annual fence inspections and repairs.
- Post predator removal nest density estimates, comparable to estimates obtained before and during construction.

Budget

TASK	Item	Description	Y1	Y2	Y3	Total
Surveillance for predator ingress	personnel	3 pp/year	7,500	7,500	7,500	22,500
	helicopter	4 hours	4,000	4,000	4,000	12,000
	remote cameras (texting)	8	3,000	0	0	3,000
	texting camera data package	10 mos/year	2,200	2,200	2,200	6,600
Annual fence inspection/repair	personnel	2 pp/year	5,000	5,000	5,000	15,000
	helicopter	4 hours	4,000	4,000	4,000	12,000
	supplies	lump	500	500	500	1,500
Replace bird deterrents *may occur in a different year	personnel	2 pp	5,000	0	0	5,000
	helicopter	4 hours	4,000	0	0	4,000
	supplies	lump	6500	0	0	6500
Nest density monitoring	personnel	8 pp	0	0	20000	20,000
	helicopter	6 hours	0	0	6000	6000
	supplies	lump	0	0	1000	1000
		Total	41,700	23,200	50,200	115,100

References:

Hu, D., G. E. Ackerman, C. S. N. Bailey, D. C. Duffy, and D. C. Schneider. 2015. Hawaiian petrel monitoring protocol, Pacific Island Network. Natural Resource Report NPS/PACN/NRR. National Park Service, Fort Collins, Colorado.

Loope, L.L. 1998. Hawaii and Pacific islands. Pp 747-774 in M.J. Mac, P.A. Opler, C.E. Puckett Haecker, and P.D. Doran (editors). Status and Trends of the Nation's Biological Resources, Volume 2. U.S. Department of the Interior, U.S. Geological Survey, Reston, VA.

Moseby, K.L. and J.L. Read. 2006. The efficacy of feral cat, fox and rabbit exclusion fence designs for threatened species protection. *Biological Conservation* 127: 429-437.

Swift, R. 2004. Potential Effects of Ungulate Exclusion Fencing on Displaying Hawaiian Petrels at Hawai'i Volcanoes National Park. MS thesis. Oregon State University, Corvallis, OR.

Appendix E

Downed Wildlife Protocol

DOWNED WILDLIFE PROTOCOL

**STANDARD PROTOCOL FOR HOLDERS of a State of Hawai`i
INCIDENTAL TAKE LICENSE and U.S. Fish and Wildlife Service
INCIDENTAL TAKE PERMIT
RESPONDING TO
DEAD OR INJURED BIRDS AND BATS THAT ARE
THREATENED AND ENDANGERED SPECIES OR MBTA SPECIES**

[For species not listed as endangered or threatened or MBTA use the
downed wildlife form at the end of this document]

Do not move wildlife unless in imminent danger.
Call DOFAW immediately for your island using the phone numbers in
Attachment 1

Fill out information on the downed wildlife form using the version with the
same date as this protocol and send as directed later in this protocol

OVERVIEW

The islands of Hawai`i contain numerous native and endemic species of wildlife that are protected by strict state and federal laws. This protocol is geared towards downed (injured or deceased) wildlife and focused on the endangered Hawaiian hoary bat and avian species protected by the Endangered Species and Migratory Bird Treaty Acts. The likelihood of encountering injured or dead wildlife that are protected by state and federal endangered species laws should be considered equal to encountering non-listed species. Therefore, all downed wildlife should be treated with the same safeguards and care to ensure adequate response and documentation according to the following set of guidelines.

Always be prepared for discovery of downed birds and bats. Please ensure that all staff and personnel are trained in this protocol, and that contact information, written protocols, and supplies are ready for response.

The first response for downed birds and bats is to call the local Hawai`i Division of Forestry and Wildlife (DOFAW) Office. The DOFAW staff is generally able to respond by sending someone to the scene to retrieve the injured or deceased wildlife. If DOFAW staff cannot be reached, you must leave a message and call-back number. In the event that DOFAW personnel are reached but not able to respond right away, they may instruct those reporting the incident to provide necessary response. Follow their directions carefully.

If DOFAW staff cannot be contacted, especially if the downed animal is in imminent danger, you should be prepared to handle the animal yourself, following the protocol, and transport them to DOFAW or a permitted wildlife rehabilitator. Again, you should only handle injured wildlife if DOFAW staff cannot be contacted or if the animal is in imminent danger.

DOWNED WILDLIFE PROTOCOL

PREPARING TO RESPOND FOR DOWNED OR INJURED BIRDS AND BATS

In all cases, ensure that all field staff are trained in the response protocol for injured birds and bats. Ensure they have read and understand the protocol, and have the protocol posted (including highlighted contact information) in a prominent location. Make sure that all staff know who to contact, and where supplies for handling injured wildlife are located. Staff should be regularly briefed on protocols, especially at the beginning of each distinct season that might correspond with a heightened likelihood of encountering downed wildlife.

Non-governmental parties should make prior arrangements, including procedures and payments with the rehabilitation or veterinary care facilities that will be used to treat injured animals.

At a minimum, for vehicles or foot patrols where maintaining a wildlife response kit (carrier) may be impractical, keep a copy of the protocol handy and accessible along with a large clean towel, soft cloth such as a t-shirt or flannel, several flags or tent stakes, and a pair of gloves, all of which are to be specifically designated for use in injured wildlife response.

For facilities and dedicated vehicles, please prepare and maintain one or more carriers designated for handling and transporting injured wildlife. This response kit should contain: a large clean towel; soft cloth such as a t-shirt or flannel; several flags or tent stakes; several pairs of gloves (plastic/latex disposable gloves and also heavy duty gloves such as leather or heavy rubber that can be sanitized); eye protection; a ventilated cardboard box, pet carrier, or other non-airtight container; and a copy of the protocol. For larger facilities (managed areas such as wildlife refuges, preserves, wetlands, or conservation areas), or areas where downed birds and bats are likely, please maintain several containers of various sizes. The container must provide enough room for the animal to comfortably move around, but also be sturdy enough to hold active birds or bats.

For small birds or bats, cardboard pet carriers or 'living world' plastic carriers work well as they have many ventilation holes and handles for easy carrying. Waxed pet carriers are preferred because they are sturdier, hold up longer, and can be thoroughly cleaned between uses. Sturdy cardboard boxes with holes punched in them to allow cross ventilation are also good. For birds, holes no wider than one inch in diameter should be punched on all four sides of the box. For bats, holes must be no larger than one-half inch diameter. A minimum of eight holes per side is sufficient. The carrier should be padded inside, well-ventilated and covered (to provide a sense of security).

Plastic dog kennels are recommended for handling larger birds, such as petrels, shearwaters, owls, hawks, ducks, stilts, and geese. All cages must have towels or rags placed in the bottom to help prevent slipping and protect bird feet and keels. The towel or other cushioning material should be sufficient to cover the bottom of the container effectively.

Cardboard boxes that are used for transporting injured wildlife should only be used once then discarded to avoid cross-contamination and/or disease or pathogen transfer. If plastic kennels or waxed pet carriers are used, be sure that they are adequately cleaned or sterilized between uses. Never put two animals in the same container.

Always wear personal protective equipment when handling downed wildlife. Disease and contamination exposure can work in both directions (bird or bat to person, and vice versa); always use protection against direct contact. If it becomes necessary to handle a bird, always wear disposable gloves. If multiple animals are being handled ensure that a new pair of gloves is used between each bird or bat.

Never put birds or bats near your face. When handing a bird or bat to someone else, make sure that the head, neck, and wings are secure and in control first to avoid serious injury to handlers and to minimize

DOWNED WILDLIFE PROTOCOL

injury to the animal. Never allow an alert bird with injuries to move its head freely while being handled – many birds will target eyes and can cause serious injury if not handled properly. Communicate with the person you are working with.

Never feed an injured bird or bat. The dietary needs of most species are more delicately balanced than many people realize. Most injured animals are suffering from dehydration, and attempting to feed or water the animal may kill it, as it is probably not yet able to digest solid food or even plain water. Often, when an injured animal arrives at a veterinary or rehabilitation facility, it is given a special fluid therapy for several days before attempts to feed the animal begin.

Handle wild birds and bats only if it is absolutely necessary. The less contact you have with the animal, the more likely it will survive.

NOTE: For remote sites with spotty coverage, ground staff may need to have a planned communication system with radios, or a cell carrier known to provide adequate coverage, that will allow communication with a designated contact able to relay information to DOFAW island biologist at the appropriate numbers listed in Attachment 1.

IF YOU FIND A LISTED OR MBTA BIRD OR BAT WHICH IS INJURED AND IN IMMINENT DANGER:

1. Do not put yourself in danger. Always wear personal protective equipment and clothing, including gloves and eye protection, to protect yourself when handling injured wildlife.
2. Mark the location with a flag or tent stake. **Record the time and location of the observation including the animal species and its condition, and call the DOFAW island biologist immediately at the number in Attachment 1.** Contact information is in prioritized order; if you don't reach the first person on the list, you must call the next. If possible, have someone stay with the animal while someone else calls. If there is no response from either party the animal may be picked up and transported to a qualified care facility after documenting key information and taking photos. If the animal is in imminent danger and you are able to protect it from further harm, mark the location where it was found with a flag or tent stake.
3. Pick up the bird or bat as safely as possible. Always bear in mind your safety first, and then the injured animal. If picking up a bird, approach and pick up the bird from behind as soon as possible, using a towel, t-shirt, or cloth by gently wrapping it around its back and wings. Gently covering the head (like a tent) and keeping voices down will help the animal remain calm and greatly reduce stress. If picking up a bat, use only a soft light-weight cloth such as a t-shirt or towel (toes can get caught in towel terry loops). Place the cloth completely over the bat and gather up the bat in both hands. You can also use a kitty litter scooper (never used in a litter box before) to gently "scoop" up the bat into a container.
4. Record the date, time, location, condition of the animal, and circumstances concerning the incident as precisely as possible. Place the bird or bat in a ventilated box (as described above) for transport. Never put two animals in the same container. Provide the animal with a calm, quiet environment, but do not keep the animal any longer than is necessary. It is critical to safely transport it to a wildlife official or veterinary professional trained to treat wildlife as soon as possible. While coordinating transport to a facility, keep the injured animal secure in the rescue container in a warm, dark, quiet place. Darkness has a calming effect on birds, and low noise levels are particularly important to help the animal remain calm. Extra care should be taken to keep wildlife away from children and pets.

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5. Transportation of the animal to DOFAW per coordination with DOFAW staff may be required as soon as possible.
6. Notify HCP staff of DOFAW at the Honolulu office and USFWS within 24 hours via email.
7. Fill out a Downed Wildlife Form (use the version with the same date as this protocol) and report to the appropriate official(s) including DOFAW and USFWS HCP staff within 3 days.
 - a. For DOFAW send to the following email addresses: dofaw.hcp@hawaii.gov; glenn.m.metzler@hawaii.gov
 - b. For USFWS send to the following email addresses:
 - i. For O`ahu and Kaua`i: jiny_kim@fws.gov, and cc: diane_sether@fws.gov, jenny_hoskins@fws.gov, Victoria_owens@fws.gov, and keith_swindle@fws.gov
 - ii. For Maui, Moloka`i, Lana`i, and Hawai`i: diane_sether@fws.gov and cc: jenny_hoskins@fws.gov, Victoria_owens@fws.gov, and keith_swindle@fws.gov
8. If you must keep the bird or bat overnight, keep it in a ventilated box with a secure lid. Please keep the animal in a quiet, dark area and do not attempt to feed, handle, or release it. Continue to try to contact DOFAW staff and veterinary care facilities.

IF YOU FIND A LISTED OR MBTA BIRD OR BAT WHICH IS INJURED BUT NOT IN IMMEDIATE DANGER:

9. Do not put yourself in danger. Always wear personal protective equipment and clothing, including gloves and eye protection, to protect yourself when handling injured wildlife.
10. Mark the location with a flag or tent stake. **Record the time and location of the observation including the animal species and its condition, and call the DOFAW island biologist immediately at the number in Attachment 1.** Contact information is in prioritized order; if you don't reach the first person on the list, you must call the next. If possible, have someone stay with the animal while someone else calls. If there is no response from either party the animal may be picked up and transported to a qualified care facility after thoroughly documenting the situation in the downed wildlife form and taking appropriate photos.
11. Usually DOFAW staff will have you leave the animal in place while they come and get the animal, but dependent on the situation they may provide other instructions. Please follow their directions.
12. While waiting for DOFAW staff to arrive, minimize noise and movement in the area around the wildlife. Watch the animal so that its location is not lost if it moves away. If possible, keep sources of additional harassment or harm, such as pets, vehicles, and loud noises, away from the animal. Note any changes in the condition of the animal.
13. Notify HCP staff of DOFAW at the Honolulu office and USFWS within 24 hours of discovery via email.
14. Fill out a Downed Wildlife Form (use the version with the same date as this protocol) and report to the appropriate official(s) including DOFAW and USFWS HCP staff within 3 days.
 - a. For DOFAW send to the following email addresses: dofaw.hcp@hawaii.gov; glenn.m.metzler@hawaii.gov
 - b. For USFWS send to the following email addresses:
 - i. For Oahu and Kauai wildlife: jiny_kim@fws.gov, and cc: diane_sether@fws.gov, jenny_hoskins@fws.gov, Victoria_owens@fws.gov, and keith_swindle@fws.gov
 - ii. For Maui, Molokai, Lanai, and Hawaii wildlife: diane_sether@fws.gov and cc: jenny_hoskins@fws.gov, victoria_owens@fws.gov, and keith_swindle@fws.gov

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Do not attempt to release the bird or bat yourself. Do not move injured wildlife unless explicitly instructed by DOFAW. DOFAW will need to document circumstances associated with the incident. The animal may also have internal injuries or be too tired or weak to survive. Never throw the bird or bat into the air as this could cause more injury or result in death. Let trained staff or veterinary personnel familiar with wildlife rehabilitation and care examine the animal and decide when, where, and how to proceed.

IF YOU FIND A LISTED OR MBTA **DECEASED** BIRD OR BAT:

All listed (MBTA and T&E species) wildlife found deceased must be reported ASAP upon detection to DOFAW and USFWS.

1. Mark the location with a flag or tent stake. **Record the time and location of the observation including the animal species and its condition, include photo documentation.**
2. **Call the DOFAW island biologist immediately at the number in Attachment 1.** Contact information is in prioritized order; if you don't reach the first person on the list, you must call the next. **Do not** move or collect the wildlife unless directed to do so by DOFAW. If necessary place a cover over the wildlife carcass or pieces of carcass *in-situ* (a box or other protecting item) to prevent wind or scavenger access from affecting its (their) position(s). Usually DOFAW staff will have you leave the animal in place while they come and get the animal, but dependent on the situation they may provide other instructions. Please follow their directions carefully.
3. If the DOFAW island biologist primary and secondary contacts (at the numbers in Attachment 1) cannot be reached within 1 hour, the carcass should be double bagged and placed in the refrigerator, not the freezer, until appropriate disposition is determined by the wildlife agencies. However, if the carcass is clearly from a wind energy turbine collision it can be placed directly in the freezer. The island biologist must still be contacted and when reached their instructions followed.
4. Also notify HCP staff of DOFAW at the Honolulu office and USFWS within 24 hours of discovery via email.
5. DOFAW island biologists will determine if the carcass should be submitted to the National Wildlife Health Center Honolulu Field Station (Dr. Thierry Work) for necropsy. The general considerations are as follows: if the fatality appears atypical for the species and situation the carcass may be a candidate for necropsy. If cause of fatality is questionable DOFAW or USFWS HCP biologists should provide instructions on how to proceed.
6. Fill out a Downed Wildlife Form (use the version with the same date as this protocol) and send to the appropriate official(s) including DOFAW and USFWS HCP staff within 3 days.
 - a. For DOFAW send to the following email addresses: dofaw.hcp@hawaii.gov; glenn.m.metzler@hawaii.gov
 - b. For USFWS send to the following email addresses:
 - i. For O`ahu and Kaua`i wildlife: jiny_kim@fws.gov cc: diane_sether@fws.gov, jenny_hoskins@fws.gov, victoria_owens@fws.gov, and keith_swindle@fws.gov
 - ii. Maui, Moloka`i, Lana`i, and Hawai`i wildlife: diane_sether@fws.gov, and cc: jenny_hoskins@fws.gov, victoria_owens@fws.gov, and keith_swindle@fws.gov

Attachment 1. Contact List for Downed Wildlife Protocol for DOFAW Island Biologists

Island	Primary Contact	After business hours/weekends
Maui	(808) 984-8100 (First Primary Contact) [Secondary: (808) 268-5087, (808) 870-6344, (808) 280-4114 (seabirds)]	(808) 870-6344, (808) 268-5087, (808) 280-4114 (seabirds)
Moloka`i	(808) 553-1745, (808) 870-7598	(808) 870-7598
Lana`i	(808) 565-7916, (808) 357-5090	(808) 357-5090
East Hawai`i	(808) 974-4221	(808) 640-3829
West Hawai`i	(808) 887-6063	(808) 339-0983
O`ahu	(808) 973-9786, (808) 295-5896	(808) 295-5896, (808) 226-6050
Kaua`i	(808) 274-3433 (808) 632-0610, (808) 635-5117 [Secondary: (808) 212-5551 for Kaua`i Seabirds HCP and KIUC Short-term HCP]	(808) 645-1576, (808) 635-5117

Downed Wildlife Forms on the following pages:

Downed Wildlife Incident Documentation and Reporting Form for LISTED and MBTA SPECIES
Downed Wildlife Form for Species NOT LISTED or MBTA

Downed Wildlife Incident Documentation and Reporting Form

LISTED and MBTA SPECIES

Facility Name:**Species Common Name:****Species Scientific Name:****Four Letter Code:** [common name, e.g. HOBA for the Hawaiian Hoary Bat; contact DOFAW unsure]:**File Name:** [naming convention: SPECIESCODE_YEAR_MM-DD_FACILITY ABBREVIATION]

Observer Name:	
Report Prepared by:	
Date of Incident:	
Date of report:	
Fatality or Injury:	
Age (Adult/Juvenile), if known:	
Sex (if known):	
Incidental or Routine Search:	
Date Last Surveyed:	
Official Search Dist. and Whether In or Out	
Time Observed (HST):	
Time Initially Reported to DOFAW (HST):	
Time Picked Up and By Who:	
Deceased Animal Sent for Necropsy (Y/N)	
General Location:	
GPS Coordinates units and datum; prefer: GCS WGS84 or NAD83 UTM Zone 4N (specify):	
Closest Turbine #, distance from and bearing:	
Closest structure and distance (non-turbine):	
Ground Cover Type and Height (cm):	
Cloud Cover (%):	
Cloud Deck (m above ground level):	
Precipitation:	
Temperature (°F)	
Wind Direction&Speed for Wind Projects (m/s):	

Details:

Condition of Specimen [include a description of the animal's general condition, as well as any visible injuries, be specific (*e.g.*, large cut on right wing tip)]:

Probable Cause of Injuries and Supportive Evidence [be descriptive, *e.g.*, 'teeth marks visible on upper back', or 'found adjacent to tire marks in mud']:

Action Taken [include names, dates, and times, whether sent for necropsy]:

Additional Comments:

Include the following:

- photos up close and photo with nearest structures or turbines in the background; include a ruler or measuring device to provide scale
- map showing aerial imagery with location of found animal, search area polygon, turbine numbers, and nearby features, roads, and structures labeled where applicable

Additional Information Required for Covered Species at HCP Wind Energy Sites

- For the turbine associated with the fatality, include a figure showing rotor speed, wind-speed, and all weather variables for the time period spanning the last two search periods up to the time the fatality or injury was found.
- Moon phase
- Presence and description of grazing cattle within 1 mile of the turbines (bats only)
- Presence of any standing or flowing water within 1 mile of the turbines (including watering troughs)(bats only)

Downed Wildlife Incident Documentation and Reporting Form

SPECIES NOT LISTED OR MBTA

Facility Name:

Species Common Name:

Species Scientific Name:

Four Letter Code: [common name, e.g. HOBA for the Hawaiian Hoary Bat; contact DOFAW unsure]:

File Name: [naming convention: SPECIESCODE_YEAR_MM-DD_FACILITY ABBREVIATION]

Observer Name:	
Date of Incident:	
Species (common name):	
Age (Adult/Juvenile), if known:	
Sex (if known):	
Incidental or Routine Search:	
Time Observed (HST):	
General Location:	
GPS Coordinates; GCS WGS84 or NAD83 UTM Zone 4N) (specify):	
Closest Turbine #, distance from and bearing:	
Closest structure (e.g., Turbine # or Bldg):	
Distance to Base of closest structure:	
Bearing from Base of closest structure:	
Condition of specimen:	
Action Taken:	
Temperature:	
Precipitation within the past 24 hours	
Wind Direction&Speed for Wind Projects (m/s):	

Probable Cause of Injuries and Supportive Evidence:

Additional Information:

[Photos]

Appendix F

Standardized Protocols for Incidental Finds

Wildlife agency standardized protocols for wildlife fatalities found outside the designated search area or discovered incidentally outside of a routine search

Evidence of Absence software (Dalthorp et al 2017; <https://pubs.er.usgs.gov/publication/ds1055>) utilizes the number of observed carcasses and the detection probability to produce a probability distribution of the number of fatalities that may have occurred based on imperfect detection. The number of carcasses entered as “Observed” assumes that the carcasses were found in the designated search area and during a routine search. In January 2018, the wildlife agencies discussed the need for establishing a standardized protocol for fatalities of protected wildlife species that are modeled with Evidence of Absence Ver. 2.0.6. but fail to meet the input criteria required by the model. Such exceptions may include carcasses found outside of the designated search area during a routine search, or carcasses incidentally discovered outside of a routine search day. “Rules” for treating these exceptions in the Evidence of Absence model should recognize and encumber the best science in order to maintain the validity of the software’s output and not purposefully violate the basic mathematical assumptions that drive the model.

To best accommodate these types of Observed carcasses, the wildlife agencies provide the following standardized guidance. For the purposes of this guidance, assume the carcass found is of the species you are modeling.

Fatality found outside of the designated reduced search area

This situation would only apply to projects that have a carcass search area that has been reduced below where a carcass could potentially fall.

The Downed Wildlife Protocol and accompanying reporting procedures should be followed for carcasses found outside of the reduced routine search area. The carcass will be considered accounted for in the Unobserved take by the Evidence of Absence model. The report should clearly note the measured location of the carcass and relationship to the area searched in addition to the standard data required on the downed wildlife report. Measurements reported in meters will be based on distance from the turbine base or nearest structure. Such measurement should be conducted with a tape measure and with GPS. Project reports should also clearly identify the carcasses that fall in this category.

Fatality found outside of the designated “full” search area.

This situation would imply that the initial monitoring and search area based on turbine height and carcass size may have been undersized and will require expanding the area.

A designated “full” search area is expected to account for all carcasses. The lack of project specific data for small carcass sizes as resulted in the general adoption of the standards presented in Hull and Muir (2010). The wildlife agencies recommend an additional buffer zone of 20% be added to account for the wind effect on carcass fallout and uncertainty until adequate data is gathered for a site. The additional 20% buffer zone would need to be included in the routine searches. The buffer should be located on the down-wind side of the project if the wind is predominantly from one direction. The calculated area based on Hull and Muir plus the buffer area is designated as the “full” search area. Fatalities found during a routine search of the “full” search area (Hull & Muir predicted + 20% buffer zone) would be treated as an Observed fatality in the model.

If the carcass is found beyond this “full” monitoring area, the Downed Wildlife Protocol and accompanying reporting procedures should still be followed. In addition, the permittee should contact the appropriate wildlife agency personnel listed in the Downed Wildlife Protocol to discuss adjusting the size of the fall out area and if expanding the area searched is needed to account for all potential fallout.

Fatality found incidentally (not during a routine scheduled search) in the designated search area

The model takes into account the frequency of searches. If a carcass is found incidentally, then it must be determined if the carcass would have been found on the next routine search day and therefore counted as Observed, or if the carcass would have been missed or be gone on the next routine search and accounted for in the Unobserved portion of fatalities.” The Hawaiian hoary bat carcasses are important to ongoing genetic research, so leaving the listed carcass in place is not in the best interest for the species. If a carcass is found incidentally, in the designated search area the Downed Wildlife Protocol and reporting should be followed. The report should clearly indicate who found the carcass, and under what circumstances (turbine maintenance, weeding, mowing, etc). The report should also indicate the method of determining how to categorize the carcass. The three methods are:

- 1) Permittee chooses to include the carcass as Observed in the model, regardless of searcher efficiency.
- 2) Wildlife agencies will include the carcass as Observed in the model when the documented detection probability is sufficiently high so as to reasonably assume the carcass would have been found on a subsequent scheduled search. Specifically, this method makes the assumption that the search efficiency and k value are such that there is a high probability that the carcass would have been found on a subsequent search. This method will be used for all large and medium carcasses found. This method will also be used for smaller carcasses when it is reasonable to assume the carcass or carcass trace would have been found on a subsequent search. The wildlife agencies will assume a carcass would have been found when the documented searcher efficiency $\geq 75\%$ and k value ≥ 0.7 .

In the case of small carcasses where the searcher efficiency is less than 75% (based on permittee’s documented efficacy), a double-blind search with a replacement surrogate should be conducted to determine how the recovered carcass shall be categorized: Observed or Unobserved. That trial shall include the following criteria:

- a. The surrogate (typically a rat) should be identical to that used for search efficacy trials and similar in size to the carcass found.
- b. The surrogate carcass should be labeled as a surrogate for the specific carcass it is representing, and placed by a third party in the proximity of where the carcass that was recovered was found with label hidden.
- c. The placement of this carcass should be conducted by the same party responsible for placing carcasses for efficiency trials, whenever possible.

- d. Under no circumstances should the searcher conducting the routine search, be the one placing the surrogate or have knowledge of the surrogate's location or the timing of the placement.
- e. Routine fatality searches should be carried out following standard search procedures.
- f. The outcome of the trial should be reported in the compliance report and include the date the surrogate was placed and the date the carcass was found. If the carcass was never found, the third party should check on the status of the carcass. If the carcass is still present, leave it in place for subsequent searches. Include this information in the compliance report.
- g. If the surrogate was found, the original carcass should be reported as Observed. If the surrogate was not found, the original carcass should be reported as Unobserved.

Note: The wildlife agencies expect the permittee's to conduct thorough, fair, and impartial searches and not to purposefully conduct searches for carcasses outside of the scheduled routine fatality searches in an attempt to manipulate fatality documentation or calculation of take. The agencies also acknowledge the amount of effort it takes to conduct the thorough routine fatality searches and trials necessary to measure carcass retention and searcher efficiency. If a carcass is found outside of a routine search and a searcher efficiency trial is scheduled to be conducted within the next 30 days, it may be possible to include option 3 within that searcher efficiency trial. However, you must contact the wildlife agencies for approval.

Literature Cited

Dalthorp, Daniel, Huso, Manuela, and Dail, David, 2017, Evidence of absence (v2.0) software user guide: U.S. Geological Survey Data Series 1055, 109 p., <https://doi.org/10.3133/ds1055>.

Hull, C. L. and S. Muir (2010). Search areas for monitoring bird and bat carcasses at wind farms using a Monte-Carlo model. *Australasian Journal of Environmental Management* 17: 77-87.

Appendix G

Avian Point Count Surveys at Pakini Nui Wind Farm



SWCA[®]

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Avian Point Count Surveys at Pakini Nui Wind Farm

CONFIDENTIAL BUSINESS INFORMATION

Prepared for

Tawhiri Power LLC

Prepared by

SWCA Environmental Consultants

September 25, 2015



**AVIAN POINT COUNT SURVEYS AT
PAKINI NUI WIND FARM**

CONFIDENTIAL BUSINESS INFORMATION

Prepared for

Tawhiri Power LLC
551 Pilgrim Drive, Suite C
Foster City, California 94404
Attn: Steven Pace
(650) 358-1550, ext. 11

Prepared by

SWCA Environmental Consultants
1001 Bishop Street
ASB Tower, Suite 2800
Honolulu, Hawai'i 96813
(808) 548-7922
www.swca.com

September 21, 2015

EXECUTIVE SUMMARY

The purpose of this report is to summarize the results of avian point count surveys that were conducted at the Pakini Nui Wind Farm site from January to December 2014. SWCA conducted these surveys to assess the presence, abundance, and flight behavior of avian species at the wind farm, and to assess the risk of incidental avian mortality of federal- or state-listed threatened or endangered species that may be on-site or that may transit through the site. Six point count stations (four on-site and two off-site) were established for systematic, repeated 15-minute surveys of avian activity in and near the wind farm. Descriptive bird activity data, such as flight directions, altitude, species distribution, and behavior, were recorded.

In all, 19 bird species were recorded both on- and off-site; none of these species are federally listed endangered or threatened species. Most of the flight activity of birds on-site was attributed to small non-native passerine birds. No native birds were observed on-site, but one migratory species, the Pacific golden-plover, was observed. No flocks of birds on-site were observed flying within the rotor swept zone of the turbines. Although not observed in flight on-site, the migratory Pacific golden-plover and the listed species that were not documented may occasionally pass through the rotor swept zone. However, the risk of incidental take is considered to be low.

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1 INTRODUCTION

Pakini Nui Wind Farm on Hawai'i Island is one of seven currently operating wind-generating facilities in Hawai'i. The other wind farms are on O'ahu (Kahuku and Kawailoa), Maui (Kaheawa I and II, and Auwahi), and Hawai'i (Hawi).

SWCA conducted avian point count surveys at the Pakini Nui Wind Farm from January to December 2014 to assess the risk of incidental avian fatalities of federal- or state-listed threatened or endangered species that may be present at, or transit through, the site. The goal of these avian surveys was to quantify the level of bird activity on-site using visual point count surveys, with the emphasis on characterizing the flight patterns and activity of threatened and endangered species.

1.1 Description of Project Site

Tawhiri Power LLC operates the 21-megawatt (MW) Pakini Nui Wind Farm at South Point on Hawai'i Island. Tawhiri Power LLC is a partnership of wholly owned subsidiaries of Apollo Energy Corporation (AEC) and General Electric (GE) Capital Corporation. Construction of the Pakini Nui Wind Farm started in August 2006, and was completed in April 2007. The wind farm, consisting of 14 GE 1.5-MW SE turbines, began operations on April 3, 2007. The project includes approximately 11 kilometers (7 miles) of aboveground tie lines. The turbines have tubular towers with a hub height of approximately 65 meters (m) (213 feet); the rotor blades are approximately 70 m (230 feet) in diameter and reach a maximum height of 100 m (328 feet).

The areas below and near the Pakini Nui turbines are routinely grazed by cattle and feral goats. The vegetation in these areas consists mostly of buffelgrass (*Cenchrus ciliaris*) and is interspersed with an occasional lantana bush (*Lantana camara*) and kiawe tree (*Prosopis pallida*). Depending on the intensity of the grazing at different locations, grass height ranges from ankle to knee high. The cliff to the west of the turbine string has similar vegetation but offers shelter from both wind and ungulates, and therefore there are more and larger-stature kiawe trees. The areas south and east of the site are similar and consist of mostly grazed buffelgrass grasslands with interspersed non-native trees such as kiawe. North of the site, the vegetation gradually becomes more shrubby and woody, with mostly non-native tree and shrub species. At the northernmost portion of the tie line, the vegetation consists of mostly native forest, with 'ōhi'a lehua (*Metrosideros polymorpha*) and pūkiawe (*Leptecophylla tameiameia*) as the dominant species.

Pakini Nui experiences relatively high average wind speeds. Wind direction is predominantly between 70° north and 90° north. Mean annual rainfall for this area is approximately 21.8 inches (554 millimeters [mm]). Rainfall is typically highest in March and lowest in May and June (Giambelluca et al. 2013). The closest rainfall gauge to the site (Kamaoa Puueo) has experienced average rainfall for 2014 through the end of December 2014 (National Oceanic and Atmospheric Administration/National Weather Service, Weather Forecast Office Honolulu 2014) mostly due to the significant rainfall during Hurricane Ana.

2 METHODS

SWCA biologists surveyed six point count stations from January to December 2014. Stations 1, 2, 3, and 4 were on-site and stations 5 and 6 were off-site (Figure 1). The on-site stations were chosen to represent vegetation communities and habitat types at the wind farm, close to the turbine locations (Table 1). Stations 2, 3 and 4 were along the turbine string, and station 1 was between the turbine string and the operations and maintenance building. Off-site stations overlooked the cliff to the south of the turbine string; station 5 looked directly over the ocean, and station 6 had a vantage point over non-native mixed forest and bare lava. The dominant vegetation type within 200 m (656 feet) of each station is listed in Table 1.

Point count stations were typically surveyed diurnally between 0600 and 1100, and 1400 and 1900 during each visit to the wind farm. Each point count was conducted for 15 minutes per station. One to two biologists using 10 × 50 binoculars with a 6.5 degree field of vision were present at each point count, and all birds observed within approximately 200 m from each station were recorded. Time of day, species, size of flock, flight direction, flight altitude, and distance between bird(s) and biologist were recorded. Negative values for flight altitudes were recorded when flight activity occurred at elevations below the observer. Weather conditions were also documented. Wind speed and wind direction were recorded with a Kestrel 4500 (Nielsen Kellerman, USA), and percentage cloud cover and visibility were estimated visually. Precipitation was categorically documented.

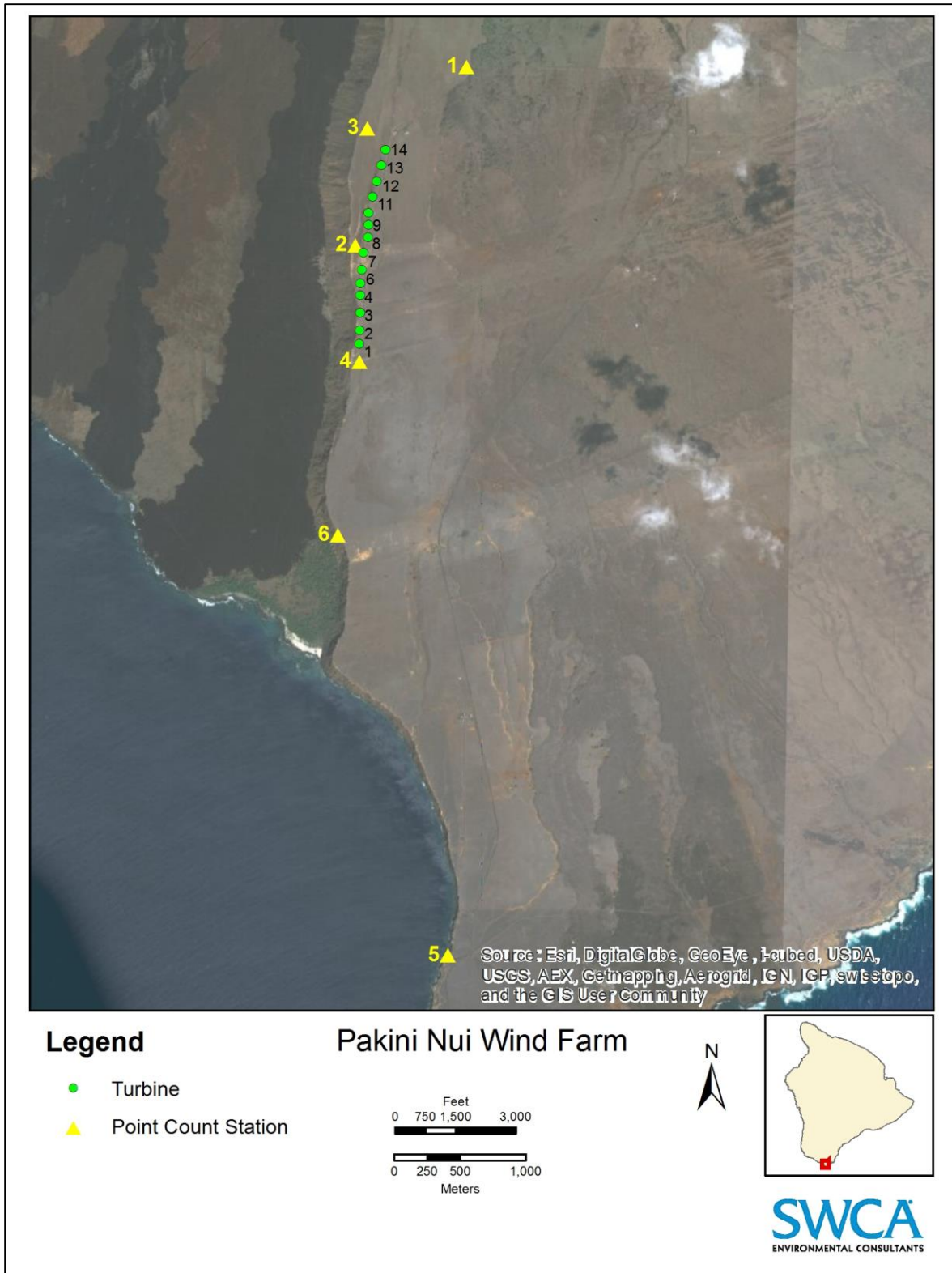


Figure 1. Location of point count stations at Pakini Nui Wind Farm.

Table 1. Dominant Vegetation Cover at Point Count Stations

Point Count Station	Vegetation Cover
1	Shrubby with Christmas berry (<i>Schinus terebinthifolius</i>) dominating
2	Buffelgrass grazed to stubble and interspersed with an occasional lantana bush and kiawe tree
3	Buffelgrass grazed to stubble and interspersed with an occasional lantana bush and kiawe tree
4	Buffelgrass grazed to stubble and interspersed with an occasional lantana bush and kiawe tree
5	Coastal sea cliff with grazed buffelgrass underfoot
6	Cliff overlooking primarily a non-native shrubby vegetation community

3 INCIDENTAL SIGHTINGS

During the January–December 2014 point count surveys, SWCA biologists recorded incidental sightings of native birds on-site and off-site while traveling between point count sites, and when on site for fatality searches, or SEEF and CARE trials.

3.1.1 Data Analysis

All point count data were entered into a Microsoft Access 2007 database. Descriptive bird activity data, including flight direction, altitude, and distribution of species on-site, were recorded in the field for each station. To simplify data analysis, each separate behavioral observation (consisting of solitary or multiple birds) was defined as a ‘flock.’ A list of species most likely to occur in the rotor swept zone (RSZ; from 30 to 100 m in height) was also included. The RSZ occurs from minimum to maximum tip height of tower blades (Table 2).

Table 2. Turbine Specifications

Turbine Specifications	Size (meters)
Tower height	65
Rotor diameter	70
Maximum tip height	100
Minimum tip height	30

4 RESULTS

SWCA biologists conducted bird point count surveys on-site for 22.75 hours (91 individual point counts) within the airspace envelopes from January to December 2014. An additional 11.00 hours (44 individual point counts) were spent at point count stations off-site.

In all, 19 bird species were recorded (Table 3). Ten bird species were observed at the on-site stations, including one migratory species, the winter migrating Pacific golden-plover (*Pluvialis fulva*). Nine species were observed at the off-site stations, including three indigenous sea birds—the greater frigatebird

(*Fregata minor palmerstoni*), red-tailed tropic bird (*Phaethon rubricauda melanorhynchos*), and wedge-tailed shearwater (*Puffinus pacificus*)—and one endemic species, the black noddy (*Anous minutus melanogenys*). Eight of the nineteen species observed are protected under the Migratory Birds Treaty Act of 1978 (see Table 3).

Table 3. Bird Species Recorded at On-Site and Off-Site Point Count Stations

Common Name	Scientific Name	Status*	MBTA	On-Site	Off-Site
African silverbill	<i>Lonchura cantans</i>	NN		X	X
Black francolin	<i>Francolinus</i>	NN			X
Black noddy, noio	<i>Anous minutus melanogenys</i>	En	X		X
Common myna	<i>Acridotheres tristis</i>	NN		X	X
Erckel's francolin	<i>Francolinus erckelii</i>	NN		X	X
Eurasian skylark	<i>Alauda arvensis</i>	NN	X	X	X
Greater frigate bird, 'iwa	<i>Fregata minor palmerstoni</i>	I	X		X
Japanese white eye	<i>Zosterops japonicus</i>	NN			X
Northern cardinal	<i>Cardinalis</i>	NN	X		X
Northern mockingbird	<i>Mimus polyglottos</i>	NN	X	X	X
Nutmeg mannikin	<i>Lonchura punctulata</i>	NN		X	X
Pacific golden-plover, kolea	<i>Pluvialis fulva</i>	M	X	X	X
Red-tailed tropic bird, ko'a'e 'ula	<i>Phaethon rubricauda melanorhynchos</i>	I	X		X
Rock pigeon	<i>Columba livia</i>	NN		X	X
Saffron finch	<i>Sicalis flaveola</i>	NN		X	X
Wedge-tailed shearwater, 'ua'u kani	<i>Puffinus pacificus</i>	I	X		X
Yellow-billed cardinal	<i>Paroaria capitata</i>	NN			X
Yellow-fronted canary	<i>Serinus mozambicus</i>	NN		X	X
Zebra dove	<i>Geopelia striata</i>	NN			X

* En = endemic; I = indigenous; M = migratory; NN = non-native permanent resident.

Of the 360 flocks observed on-site, the large majority of recorded flight activity consisted of introduced passerine bird species. Although the unit for flight activity is flocks, the most common recorded flight activity at the on-site stations consisted of solitary birds. The most common species observed in flight were Eurasian skylarks, common mynas, and African silverbills. Together with other introduced small passerine species, these species accounted for approximately 86% of the observed on-site flight activity. Seventy-five percent of all flights observed (3rd quartile) were at 15 m or less above ground level, and the middle 50% of all flock flight heights (interquartile range) was between 5 and 15 m (Figure 2). The most commonly observed (median) flight altitude was 5 m. Two outlying flocks were observed in flights at 25 m in altitude, both solitary Eurasian skylarks. Concerning the probability of interaction with the turbines, 100% of all flocks observed on-site were below the RSZ, which is from 30 to 100 m above ground level. No flocks were observed flying over the RSZ. Of the 131 flocks observed off-site, only one was within the height of the RSZ (a solitary greater frigatebird observed at an altitude of 50 m).

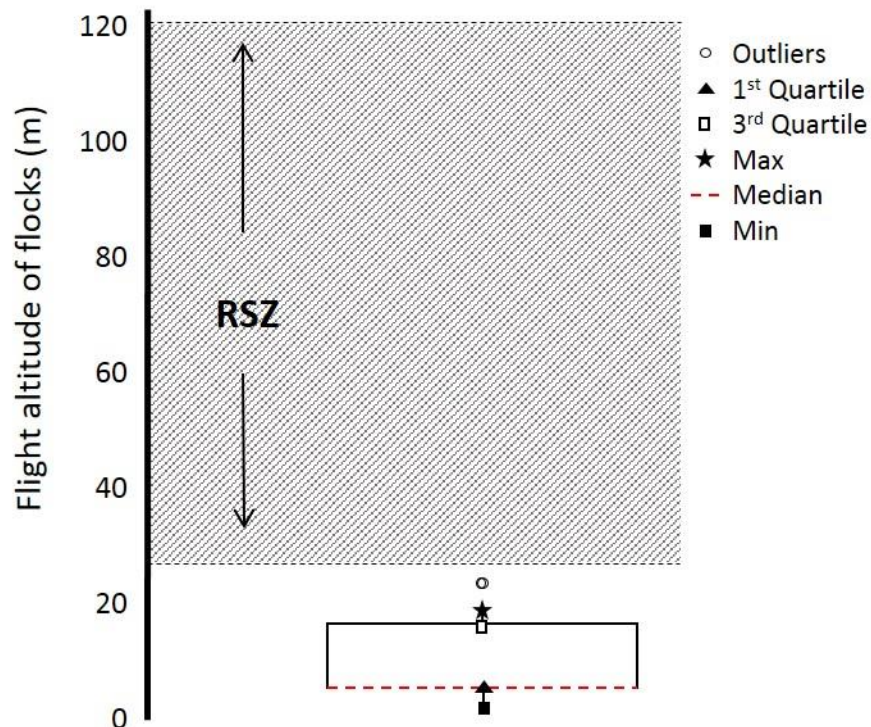


Figure 2. Box plot of flight altitude of flocks observed on-site in the rotor swept zone of the turbine.

4.1.1 Native and Migratory Non-Listed Species

4.1.1.1 ON-SITE

No native birds were documented on-site. Seventeen sightings of the migratory Pacific golden-plover were recorded on-site (see Table 3). Most sightings were of solitary birds, but a flock of four and a flock of nine were documented, once each. Pacific golden-plovers arrived at the site in August and departed in May. These birds were most frequently seen on the roads and in the cleared grassy areas and were not observed flying in the RSZ of the turbines.

4.1.1.2 OFF-SITE

Of the 30 flocks recorded off-site, four native bird species and one migratory non-listed bird species were recorded (see Table 3). Eight flocks of wedge-tailed shearwaters were observed ranging in flock size from one to several hundreds of birds foraging off-shore. Wedge-tailed shearwaters nest along the coast and on offshore islands, and do not often fly further inland. A solitary greater frigate bird and one red-tailed tropic bird were observed at station 5, flying at a distance of 200 m from the station, and 150 m away from the cliff (horizontal distance), respectively. One flock of two black noddies was also observed. Seventeen flocks of Pacific golden-plovers were observed off-site, but none of these were observed in flight.

4.1.2 Threatened and Endangered Species

4.1.2.1 ON-SITE

No listed avian species were detected on-site.

4.1.2.2 OFF-SITE

No listed avian species were detected off-site.

4.1.3 Incidental Sightings

One incidental sighting of a greater frigate bird was made from a vantage at turbine 1 on July 21, 2014. The bird was flying approximately 200 m to the south below the cliff.

5 DISCUSSION AND CONCLUSION

Introduced passerines dominate the bird flight activity at Pakini Nui Wind Farm. No listed species were observed on-site or off-site. The only migratory bird species noted on-site was the Pacific golden-plover. Although migratory Pacific golden-plovers were never observed flying in the RSZ of the turbines, they may be expected to do so on occasion. This species spends much of its time during the day on the ground; therefore, the risk of colliding with a turbine is low. However, this species does occasionally form flocks and has the potential to fly into the RSZ, particularly during their winter migration months (August through April).

The great frigate bird, red-tailed tropic bird, black noddy, and wedge-tailed shearwater may fly near or over the site occasionally. These species are seabirds that typically forage over the ocean, but occasionally soar above land, although none nest at the Pakini Nui Wind Farm. Documented fatalities of greater frigatebirds have been recorded at other operational wind farms on Hawai'i. None of these species are federally listed species; therefore, incidental take permits are not issued.

Although not observed by SWCA biologists, federally listed species may occasionally pass through the RSZ of Pakini Nui Wind Farm, particularly at night. Hawaiian petrels (*Pterodroma sandwichensis*) (Mitchell et al. 2005) and band-rumped storm petrel (*Oceanodroma castro*) (Banko et al. 1991; Slotterback 2002) may transit the site en-route to and from their nesting grounds during their respective breeding seasons. Based on Day et al. 2003, these passage rates are expected to be very low.

Although no endangered Hawaiian Goose or nēnē (*Branta sandwicensis*) were documented, some may show up at the site because of increased movement as a result of the translocation, and an expected increase in population size, in part as a result from the translocation.

6 LITERATURE CITED

- Banko, W.E., P.C. Banko, and R.E. David. 1991. Specimens and probable breeding activity of the Band-rumped Storm-petrel on Hawai'i. *The Wilson Bulletin* 103:650–655.
- Day, R.H., B.A. Cooper, and R.J. Blaha. 2003. Movement patterns of Hawaiian Petrels and Newell's Shearwaters on the island of Hawaii. *Pacific Science* 57:147–160.
- Giambelluca, T.W., Q. Chen, A.G. Frazier, J.P. Price, Y.-L. Chen, P.-S. Chu, J.K. Eischeid, and D.M. Delaporte, 2013: Online Rainfall Atlas of Hawai'i. Bull. Amer. Meteor. Soc. 94, 313-316, doi: 10.1175/BAMS-D-11-00228.1.
- Mitchell, C., C. Ogura, D.W. Meadows, A. Kane, L. Strommer, S. Fretz, D. Leonard, and A. McClung. 2005. Hawaii's Comprehensive Wildlife Conservation Strategy. Department of Land and Natural Resources, Honolulu, Hawaii. Available at: <http://dlnr.hawaii.gov/wildlife/cwcs/hawaii/>. Accessed May 13, 2015.
- Slotterback, J. 2002. Band-rumped Storm-Petrel (*Oceanodroma castro*) and Tristram's Storm- Petrel (*Oceanodroma tristrami*). No. 675 In *The Birds of North America*, edited by A. Poole and F. Gill. Philadelphia, Pennsylvania: The Birds of North America, Inc.

Appendix H

Hawaiian Hoary Bat Surveys at Pakini Nui Wind Farm



Hawaiian Hoary Bat Surveys at Pakini Nui Wind Farm in Years 2014–2017

MAY 2019

PREPARED FOR
Tawhiri Power LLC

PREPARED BY
SWCA Environmental Consultants

**HAWAIIAN HOARY BAT SURVEYS
AT PAKINI NUI WIND FARM IN YEARS 2014–2017**

DRAFT

Prepared for

Tawhiri Power LLC
1291 E. Hillsdale Blvd., Suite 213
Foster City, California 94404
Attn: Steven Pace
(650) 358-1550, ext. 11

Prepared by

SWCA Environmental Consultants
307a Kamani Street
Honolulu, Hawaii 96813
(808) 548-7922
www.swca.com

SWCA Project No. 27319.02

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EXECUTIVE SUMMARY

The purpose of this report is to summarize Hawaiian hoary bat (*Lasiurus cinereus semotus*) activity recorded at or near Pakini Nui Wind Farm over 4 years of monitoring (December 2013 to December 2017; study period). Bat activity was detected using Wildlife Acoustics, Inc. SM2 and SM2+ bat detectors, which record acoustic files of ultrasonic noises emitted by bats while they are navigating, foraging, or socializing. The reported bat activity rates are relative rates rather than absolute measures of bat activity at the site.

The project site is relatively flat with a large cliff that is oriented north-south to the west of the turbine array. Detectors were placed in various locations and distances from the turbines or permanent meteorological (met) tower to ensure good representative coverage of activity across the project site as well as the met tower. Two detectors were placed at the rear of the nacelles in the southern- (Turbine 1) and northern- (Turbine 14) most turbines. Two detectors were placed on the ground, one halfway between Turbine 1 and Turbine 2 and another placed just downwind of Turbine 14. A fifth detector was placed at the base of the met tower. A sixth detector was placed off-site west of Turbine 1 at the lip of the cliff to detect potential bat activity occurring in the lee of this cliff.

Bat activity at Pakini Nui Wind Farm was detected at all locations, during all months of the year, and in all years of the study period. Average on-site bat activity for the study period was 0.43 passes per detector-night (Table ES-1). The highest on-site bat average activity rate occurred in 2016, the third year of study, with an annual mean for the five on-site detectors of 0.60 passes per detector-night. The sampling effort was uneven due to problems with malfunctioning equipment, precluding robust statistical comparisons of activity rates among years and seasons. In addition, no attempt was made to quantitatively analyze bat call amplitude—either a call was observed or it was not—because it is impossible to determine how far from the detector a bat may have been.

Table ES-1. Bat Passes per Detector-Night at Locations On-site

Analysis Year	Detector Nights	Median*	Mean	Standard Deviation	Minimum	Maximum	Total Passes Detected
December 2013– December 2014	1,039	0	0.35	1.19	0	16	359
January 2015– December 2015	1,564	0	0.43	2.02	0	47	665
January 2016– December 2016	1,465	0	0.60	5.73	0	140	882
January 2017– December 2017	869	0	0.24	1.29	0	21	205
Whole study period	4,937	0	0.43	3.41	0	140	2,111

* A median value of 0 indicates that fewer than half of the nights detected any bats.

Bat activity rates peaked in August and September along the turbine string. This seasonality in activity compares well with other Hawaiian hoary bat research, which may indicate that bats on Hawai‘i Island migrate to higher altitudes from the lowlands from September to March (post-lactation and pre-pregnancy time frames) (Menard 2001).

Recorded activity was consistently lower at the nacelle height (0.14 and 0.08 passes per detector-night for the study period) than at ground height (1.60, 0.37, and 0.28 passes per detector-night for the study period). At the vertically paired detectors at Turbine 1, bat activity was, on average, 20 times higher at the ground detector than the nacelle detector over the study period. Bat activity at the vertically paired detectors located at Turbine 14 was 2.5 times higher. Considering data from all the detectors located along the turbine string, bat activity was 6 times higher at ground height than nacelle height.

Bat activity at the detector west of Turbine 1 (located at the cliff edge) recorded over 15 times more passes (nearly 8-1/2 times more passes per detector-night) than at detectors located at ground level along the turbine string or met tower, and some 165 times more passes (nearly 162 times more passes per detector-night) than the highest recording nacelle detector. This difference is most apparent in 2015. It is possible that bats could be flying and feeding in the lee of the cliff where wind speeds can expect to be near zero during normal trade-wind periods, which is more than 95% of the time at Pakini Nui Wind Farm.

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1 INTRODUCTION

Tawhiri Power LLC is the owner/operator of Pakini Nui Wind Farm on Hawai‘i Island. The wind farm is located within the range of the endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*). Tawhiri Power LLC completed 4 years of acoustic surveys beginning in late December 2013 (Table 1) to characterize Hawaiian hoary bat activity at or near the wind farm. The results of these surveys are summarized in this report.

Table 1. Acoustic Survey Years

Survey Year	Date Range
Year 1	December 2013–December 2014
Year 2	January 2015–December 2015
Year 3	January 2016–December 2016
Year 4	January 2017–December 2017
Whole study period	December 2013–December 2017

2 WIND FARM SITE

Pakini Nui Wind Farm is a 20.5-megawatt (MW) facility consisting of 14 General Electric 1.5-MW SE turbines located approximately 4 miles north of South Point on Hawai‘i Island. Construction of the wind farm started in August 2006 and was completed in April 2007. The wind farm began operations on April 3, 2007. The turbines have tubular towers with a nacelle height of approximately 65 meters (m) (213 feet); the rotor diameters are approximately 70 m (230 feet) and reach a maximum height of 100 m (328 feet) aboveground. The project also includes approximately 11 kilometers (km) (7 miles) of aboveground tie-lines and a permanent met tower located approximately 300 m east of Turbine 8. The turbine array runs north-south, parallel to a cliff to the west of the farm. The southernmost turbine is Turbine 1 and the northernmost turbine is Turbine 14.

The areas below and in the vicinity of the turbines are routinely grazed by cattle and feral goats. The vegetation in these areas consists mostly of buffelgrass (*Cenchrus ciliaris*), which is grazed and interspersed with an occasional lantana bush (*Lantana camara*) and kiawe tree (*Prosopis pallida*). Depending on the intensity of grazing at different locations, grass height ranges from ankle high to knee high. The top of the cliff to the west of the turbine string has similar vegetation but offers shelter from the wind and therefore there are more and larger-stature kiawe trees. The other areas of the project site are similar and consist of grazed buffelgrass grasslands with interspersed non-native trees such as kiawe. Several miles to the north of the project site the vegetation gradually becomes more shrubby and woody, with mostly non-native trees and shrub species. At the northernmost portion of the tie-line where the interconnection facility sits across the highway from the entrance to the Kahuku portion of Hawai‘i Volcanoes National Park, the vegetation consists of mostly native forest, with ‘ōhi‘a lehua (*Metrosideros polymorpha*) and pūkiawe (*Leptecophylla tameiameia*) as the dominant species.

Pakini Nui is a Class 1 wind site (average winds are 9 meters per second [m/s] or greater) and thus experiences relatively high average wind speeds. Wind direction is between 70° and 90° north over 95% of the time.

3 HAWAIIAN HOARY BAT

3.1 Population, Biology, and Distribution

The Hawaiian hoary bat is the only native land mammal present in the Hawaiian archipelago. It is a subspecies of the hoary bat (*Lasiurus cinereus*), which occurs across much of North and South America. Both males and females have a wingspan of approximately 0.3 m (1 foot), although females are typically larger bodied than males. Both sexes have a coat of brown and gray fur. Individual hairs are tipped or frosted with white (Mitchell et al. 2005).

Presence of the species has been recorded on all the main Hawaiian Islands (Bonaccorso et al. 2015). Population estimates for all islands in the state in the recent past have ranged from hundreds to a few thousand bats (Menard 2001); however, it is generally accepted that it is not feasible at this point to calculate a population estimate (Amlin and Siddiqi 2015). Studies indicate that the bat population on Hawai‘i Island is stable and possibly increasing (Gorresen et al. 2013). The Hawaiian hoary bat is believed to occur primarily below an elevation of 1,220 m (4,000 feet); however, this subspecies has been recorded between sea level and approximately 3,600 m (11,811 feet) in elevation (Bonaccorso, as cited in Gorresen et al. 2013), with most instances occurring at or below approximately 628 m (2,060 feet) (U.S. Fish and Wildlife Service [USFWS] 1998).

Hawaiian hoary bats roost in native and non-native vegetation from 1 to 9 m (from 3 to 29 feet) above ground level. They have been observed roosting in ‘ōhi‘a lehua, hala (*Pandanus tectorius*), coconut palms (*Cocos nucifera*), kukui (*Aleurites moluccana*), kiawe trees, avocado (*Persea americana*), mango (*Mangifera indica*), shower trees (*Cassia javanica*), pūkiawe, and fern clumps; they are also suspected of roosting in eucalyptus (*Eucalyptus* spp.) and Sugi pine (*Cryptomeria japonica*) stands. The species has been rarely observed using lava tubes, cracks in rocks, or human-made structures for roosting (Bonaccorso et al. 2016). While roosting during the day, Hawaiian hoary bats are solitary, although mothers and pups roost together (USFWS 1998).

A study of a sample of male and female Hawaiian hoary bats (n = 28) on Hawai‘i Island has estimated short-term (1–2 weeks) mean core range habitat sizes of 25.5 hectares (ha) (63.0 acres) (Bonaccorso et al. 2015). The size of home ranges and core areas varied widely among individuals. Core areas included feeding ranges that were actively defended, especially by males, against conspecifics. Female core ranges overlapped with male ranges. Bats typically feed along a line of trees, a forest edge, or a road, and a typical feeding range stretches approximately 275 m (300 yards). Bats will spend 20 to 30 minutes hunting in a feeding range before moving on to another (Bonaccorso et al. 2015).

It is suspected that breeding occurs primarily between April and mid-September. Lactating females have been documented from June to mid-September, indicating that this is the period when nonvolant young are most likely to be present. Breeding populations occur on all the main Hawaiian Islands except for Ni‘ihau and Kahoolawe (Bonaccorso et al. 2015). It is not known whether bats observed on Ni‘ihau and Kahoolawe breed locally or only visit these islands during nonbreeding periods. Seasonal changes in the abundance of Hawaiian hoary bats at different elevations indicate that altitudinal movements occur on Hawai‘i Island. During the breeding period, Hawaiian hoary bat occurrences increase in the lowlands and decrease at high-elevation habitats. In the winter, bat occurrences increase in high-elevation areas (above 1,525 m [5,000 feet]), especially from January through March (Bonaccorso 2011; Menard 2001).

Hawaiian hoary bats feed on a variety of native and non-native night-flying insects, including moths, beetles, crickets, mosquitoes, and termites (Whitaker and Tomich 1983). They appear to prefer moths ranging between 16 and 20 millimeters (0.6 and 0.89 inches) in size (Bellwood and Fullard 1984; Fullard

2001). Koa moths (*Scotorythra paludicola*), which are endemic to the Hawaiian Islands and use koa (*Acacia koa*) as a host plant (Haines et al. 2009), are frequently targeted as a food source (Gorresen et al. 2015). The species locates its prey using echolocation. Watercourses and edges (e.g., coastlines and forest-pasture boundaries) appear to be important foraging areas (Brooks and Ford 2005; Francl et al. 2004; Grindal et al. 1999; Menzel et al. 2002; Morris 2008). In addition, the species is attracted to insects that congregate near lights (Bellwood and Fullard 1984; Mitchell et al. 2005; USFWS 1998). They begin foraging just before or after sunset, depending on the time of year (Mitchell et al. 2005; USFWS 1998).

3.2 Known Occurrences in the Vicinity of the Wind Farm

According to Day and Cooper (2005), Hawaiian hoary bats have been recorded at South Point. Bats have also been detected within the southern portion of the Kahuku section of Hawai'i Volcanoes National Park, where they are widespread and present year-round. The Kahuku section is across the road from the electrical interconnection point of the project, and approximately 12.5 km (7.8 miles) from the turbine string.

Bats have been documented in forests, as well as pastureland, and may use less-forested areas during the nonbreeding season (Gorresen et al. 2013). Gorresen et al. (2013) found that, contrary to expectations, bat occupancy was not greater at less windy sites. Hawaiian hoary bats were as likely to be observed at windy sites as at low-wind sites, although the authors did not directly compare activity levels and wind speeds. The first confirmation of Hawaiian hoary bats at Pakini Nui Wind Farm occurred when a Hawaiian hoary bat carcass was found below wind turbine generator (WTG) 12 on August 31, 2013. Refer to the Year 1 Fatality Monitoring Report (SWCA Environmental Consultants [SWCA] 2015) for details.

4 METHODS

4.1 Acoustic Bat Surveys

Wildlife Acoustics Inc. SM2 and SM2+ bat detectors (detectors) were deployed to quantify Hawaiian hoary bat activity at various locations in the vicinity of Pakini Nui Wind Farm (Figure 1). Wildlife Acoustics bat detectors record ultrasonic sounds, including those emitted by bats. The recorded sonograms were subsequently examined using the Wildlife Acoustics Inc. programs Song Scope 4.1.3A and Kaleidoscope Viewer 3.1.5, which allow for the visualization of ultrasonic echolocation bat calls.

In all, seven locations were sampled over the duration of the study period (Table 2). Detector D1, located relatively far from the wind turbines among scattered trees, was abandoned late in August 2014 because only a few bat passes were recorded during the period it was deployed and the detector was located well off-site. In the 9 months it was deployed north of the array, only 10 total passes were detected (0.07 passes per detector-night). A detector-night is defined as a night when the detector log indicated that the detector was properly functioning, whether or not any acoustic files were recorded for the given night. The sparse survey results from Detector D1 will not be further summarized in this report. The Detector D1 location was replaced with the Detector D2 location in mid-2014. Detector D2 was located on the ground midway between Turbine 1 and Turbine 2 at the same distance from the cliff as the turbines.

Detector F was located right at the edge of the cliff directly west of Turbine 1, where it recorded bat activity occurring out and below the cliff. Because this detector was located in a different habitat and land-use type than that of the detectors located along the turbine array or met tower, results from this detector are reported separately.



Figure 1. Detector locations.

Table 2. Detector Locations and Dates of Operation

Detector	Location Notes	Height Aboveground (m)	Location Characteristics	Dates of Operation	Number of Nights Sampled (number of nights analyzed) [*]
C	Ground level near base of met tower	1.5–3.0	Short grass, met tower	December 19, 2013–November 3, 2017	1,302 (1,295)
D1 [†]	Ground level 1 km north of turbine string	1.5–3.0	Christmas berry trees, long grass	December 19, 2013–August 11, 2014	163 (137)
D2	Ground level halfway between Turbine 1 and Turbine 2	1.5–3.0	Short grass	August 29, 2014–December 7, 2017	747 (694)
E	Ground level downwind of Turbine 14	1.5–3.0	Short grass	December 19, 2013–December 31, 2017	1,238 (1,238)
F	At lip of cliff downwind of Turbine 1	1.5–3.0	Short grass, cliff edge	December 19, 2013–December 31, 2017	1,178 (1,168)
G	In nacelle of Turbine 14 at 65 m	65.0	Turbine 14 nacelle	July 3, 2014–January 3, 2017	598 (570)
H	In nacelle of Turbine 1 at 65° m	65.0	Turbine 1 nacelle	June 30, 2014–September 26, 2017	1,144 (1,140)

^{*} Total excludes survey nights in months with fewer than 10 nights of data collected. These survey nights were censored from further summary because the data were too sparse to characterize the average activity rate for that month.

[†] Results from Detector D1 are not summarized in this report.

Detectors C, D1, D2, E, and F were placed between 1.5 to 3.0 m above ground level (see Table 2). At each site, microphones were placed facing downwind (toward the cliff) to reduce noise interference from the wind and maximize the probability of detecting a bat, which were thought to fly up from the protection of the cliff if and when winds allowed it. Detectors G and H were deployed at the rear of the 65-m-high nacelles of Turbines 14 and 1, respectively (Figure 2; see Table 2). Microphones at Detectors G and H were tie-wrapped to the outside nacelle lid of the turbine and similarly mounted to face downwind of the turbine.

Acoustic files originating from bats were classified as bat call sequences and bat passes. A bat call is a one-frequency, modulated sweep. A call sequence consists of a continuous recording of one or more bat calls. A bat pass is a call sequence consisting of two or more calls (Baerwald and Barclay 2009) and is therefore a subset of the total number of call sequences. Individual call passes were separated by a time interval of more than 1 second between passes (Kunz et al. 2007).

Some detectors malfunctioned periodically. For quality assurance purposes, data summaries exclude survey nights from months with fewer than 10 nights of data. These survey nights were censored because the data were too sparse to reliably characterize the average activity rate for that month (Table 3).



Figure 2. Bat detector microphone mounted on nacelle.

Table 3. Sampling Effort by Month

Location	Analysis Year	Number of Detector-Nights Each Detector Was Operational by Month											
		1	2	3	4	5	6	7	8	9	10	11	12*
C	2014	31	28	31	27	20	30	29	31	30	31	30	44
	2015	31	28	31	30	31	30	31	20	30	31	30	31
	2016	31	29	31	28	31	20	25	31	30	31	30	31
	2017	29	23	31	30	31	17	19	22	4 (C)	29	3 (C)	N
D1	2014	31	9 (C)	29	16	9 (C)	29	19	8 (C)	N	N	N	13
D2	2014	N	N	N	N	N	N	N	3 (C)	30	31	29	29
	2015	29	23	30	28	31	30	26	19	24	22	19	29
	2016	31	13	2 (C)	N	N	9 (C)	N	31	30	27	21	11
	2017	25	14	9 (C)	12	8 (C)	16	8 (C)	16	1 (C)	18	6 (C)	7 (C)
E	2014	31	28	28	16	19	30	25	31	30	22	24	24
	2015	10	28	31	30	31	30	31	31	30	19	29	31
	2016	21	29	31	12	17	21	23	31	30	31	21	20
	2017	31	28	31	30	12	26	31	29	27	14	27	26
F	2014	N	3 (C)	31	27	31	30	18	31	30	31	24	44
	2015	31	28	31	30	31	30	31	31	30	31	30	29
	2016	28	29	31	30	31	30	11	31	24	31	12	31
	2017	31	28	25	14	20	5 (C)	13	11	N	16	2 (C)	31

Location	Analysis Year	Number of Detector-Nights Each Detector Was Operational by Month											
		1	2	3	4	5	6	7	8	9	10	11	12*
G	2014	N	N	N	N	N	N	9 (C)	12	14	23	1 (C)	17
	2015	23	28	31	9 (C)	12	18	31	31	11	19	6 (C)	N
	2016	N	N	25	30	31	30	31	31	30	31	30	31
	2017	3 (C)	N	N	N	N	N	N	N	N	N	N	N
H	2014	N	N	N	N	N	1 (C)	31	31	30	31	30	31
	2015	31	28	31	30	31	30	31	31	30	31	30	31
	2016	31	29	31	30	31	30	31	31	30	31	30	31
	2017	31	28	31	30	3 (C)	17	31	31	26	N	N	N

Note: C = censored data (data censored from analysis because fewer than 10 nights were surveyed this month), Month 1 = January, etc., N = no data (detector was either not deployed or not operational).

* Year 2014 tallies include data collected in December 2013; data from December 2013 was designated as Year 1 data (see Table 1).

4.2 Quantifying Bat Activity

Bat activity was quantified by dividing the number of bat passes recorded by detector-nights (Baerwald and Barclay 2009). Patterns in recorded bat activity were summarized by location, month and year, height, and habitat (i.e., along the turbine string or at the edge of the cliff).

5 ACOUSTIC SURVEY RESULTS

5.1 Bat Activity along the Turbine String (on-site)

Biologists from SWCA acoustically sampled five sites along the turbine string at Pakini Nui Wind Farm during Years 1 to 4. In all, 2,008 bat call sequences resulting in 2,111 passes were recorded from the five locations where the detectors were deployed (Table 4).

Bat activity along the turbine string varied more among months than among years (Figure 3), with peak activity occurring in August and September. Annual patterns in activity varied among locations with no strong trends apparent over the study period. Robust statistical comparisons are not possible with the uneven sampling that resulted from frequent equipment malfunctions. Activity levels were greatest on average at Detector D2, with peak activity levels recorded in August and September of 2016. The lowest activity level was recorded at Detector E throughout 2017; while the detector log indicated that the detector was properly functioning, the fact that no bat passes were recorded at this location in 2017 suggests the detector may not have been working properly.

Bat activity along the turbine string is consistently greater at ground height (Detectors C, D2, and E) than at nacelle height (Detectors G and H) (Figure 4). This difference is particularly noticeable during the period of peak activity in August and September. A relevant comparison can be made between Detector D2, located at ground level, and Detector H, located almost vertically above Detector D2 at nacelle height (65 m). These two detectors are located approximately equidistant from the cliff and were deployed during nearly the same time frame. Over the study period, the average activity rate at Detector D2 (1.60 passes per detector-night, 1,109 passes overall) was twentyfold higher than at Detector H (0.08 passes per detector-night, 694 passes overall). When comparing Detectors D2 and E between September 1, 2014, and December 31, 2016, the fact that Detector D2 recorded more than twice the number of passes as Detector E (1.15 versus 0.48 passes per detector-night, respectively) may be due to Detector D2's relatively close proximity to the cliff.

Table 4. Bat Activity Rate at Locations along the Turbine String (on-site)

Location	Year	Bat Passes Per Detector-Night (passes; detector-nights) by Month												
		1	2	3	4	5	6	7	8	9	10	11	12	Average
C	2014	0.06 (2; 31)	0.00 (0; 28)	0.06 (2; 31)	0.07 (2; 27)	0.25 (5; 20)	0.17 (5; 30)	0.03 (1; 29)	0.61 (19; 31)	1.90 (57; 30)	0.55 (17; 31)	0.03 (1; 30)	0.11 (5; 44)	0.32 (116; 362)
	2015	0.00 (0; 31)	0.04 (1; 28)	0.00 (0; 31)	0.03 (1; 30)	0.13 (4; 31)	0.13 (4; 30)	0.13 (4; 31)	0.30 (6; 20)	1.07 (32; 30)	0.71 (22; 31)	0.07 (2; 30)	0.00 (0; 31)	0.21 (76; 354)
	2016	0.00 (0; 31)	0.00 (0; 29)	0.00 (0; 31)	0.11 (3; 28)	0.26 (8; 31)	0.40 (8; 20)	0.32 (8; 25)	1.26 (39; 31)	1.13 (34; 30)	0.55 (17; 31)	0.00 (0; 30)	0.06 (2; 31)	0.34 (119; 348)
	2017	0.31 (9; 29)	0.00 (0; 23)	0.03 (1; 31)	0.37 (11; 30)	0.16 (5; 31)	0.12 (2; 17)	0.26 (5; 19)	0.55 (12; 22)	C	0.28 (8; 29)	C	C	0.23 (53; 231)
D2	2014	C	C	C	C	C	C	C	C	3.23 (97; 30)	0.23 (7; 31)	0.45 (13; 29)	0.03 (1; 29)	0.99 (118; 119)
	2015	0.14 (4; 29)	0.30 (7; 23)	0.03 (1; 30)	0.00 (0; 28)	1.03 (32; 31)	0.47 (14; 30)	0.00 (0; 26)	4.00 (76; 19)	3.00 (72; 24)	1.05 (23; 22)	0.00 (0; 19)	0.00 (0; 29)	0.74 (229; 310)
	2016	0.06 (2; 31)	0.08 (1; 13)	C	C	C	C	C	10.03 (311; 31)	10.03 (301; 30)	0.22 (6; 27)	0.00 (0; 21)	0.00 (0; 11)	3.79 (621; 164)
	2017	0.20 (5; 25)	0.14 (2; 14)	C	1.42 (17; 12)	C	2.31 (37; 16)	C	3.81 (61; 16)	C	1.06 (19; 18)	C	C	1.40 (141; 101)
E	2014	0.26 (8; 31)	0.04 (1; 28)	0.07 (2; 28)	0.06 (1; 16)	0.05 (1; 19)	0.40 (12; 30)	0.20 (5; 25)	0.52 (16; 31)	0.83 (25; 30)	0.18 (4; 22)	0.00 (0; 24)	0.21 (5; 24)	0.26 (80; 308)
	2015	0.00 (0; 10)	0.07 (2; 28)	0.00 (0; 31)	0.07 (2; 30)	0.26 (8; 31)	0.07 (2; 30)	1.94 (60; 31)	1.68 (52; 31)	3.50 (105; 30)	1.11 (21; 19)	0.03 (1; 29)	0.03 (1; 31)	0.77 (254; 331)
	2016	0.00 (0; 21)	0.03 (1; 29)	0.06 (2; 31)	0.00 (0; 12)	0.88 (15; 17)	0.05 (1; 21)	0.00 (0; 23)	0.84 (26; 31)	2.07 (62; 30)	0.35 (11; 31)	0.29 (6; 21)	0.15 (3; 20)	0.44 (127; 287)
	2017	0.00 (0; 31)	0.00 (0; 28)	0.00 (0; 31)	0.00 (0; 30)	0.00 (0; 12)	0.00 (0; 26)	0.00 (0; 31)	0.00 (0; 29)	0.00 (0; 27)	0.00 (0; 14)	0.00 (0; 27)	0.00 (0; 26)	0.00 (0; 312)
G	2014	C	C	C	C	C	C	C	0.00 (0; 12)	0.07 (1; 14)	0.04 (1; 23)	C	0.00 (0; 17)	0.03 (2; 66)
	2015	0.00 (0; 23)	0.11 (3; 28)	0.06 (2; 31)	C	0.00 (0; 12)	0.11 (2; 18)	0.06 (2; 31)	0.71 (22; 31)	2.45 (27; 11)	1.05 (20; 19)	C	C	0.38 (78; 204)
	2016	C	C	0.00 (0; 25)	0.00 (0; 30)	0.00 (0; 31)	0.03 (1; 30)	0.00 (0; 31)	0.00 (0; 31)	0.03 (1; 30)	0.00 (0; 31)	0.00 (0; 30)	0.00 (0; 31)	0.01 (2; 300)

Hawaiian Hoary Bat Surveys at Pakini Nui Wind Farm in Years 2014–2017
 CONFIDENTIAL BUSINESS INFORMATION

Location	Year	Bat Passes Per Detector-Night (passes; detector-nights) by Month												
		1	2	3	4	5	6	7	8	9	10	11	12	Average
H	2014	C	C	C	C	C	C	0.00 (0; 31)	0.13 (4; 31)	1.07 (32; 30)	0.00 (0; 31)	0.17 (5; 30)	0.06 (2; 31)	0.23 (43; 184)
	2015	0.35 (11; 31)	0.04 (1; 28)	0.03 (1; 31)	0.00 (0; 30)	0.35 (11; 31)	0.00 (0; 30)	0.00 (0; 31)	0.06 (2; 31)	0.00 (0; 30)	0.06 (2; 31)	0.00 (0; 30)	0.00 (0; 31)	0.08 (28; 365)
	2016	0.00 (0; 31)	0.00 (0; 29)	0.00 (0; 31)	0.00 (0; 30)	0.00 (0; 31)	0.00 (0; 30)	0.00 (0; 31)	0.00 (0; 31)	0.00 (0; 30)	0.00 (0; 31)	0.43 (13; 30)	0.00 (0; 31)	0.04 (13; 366)
	2017	0.03 (1; 31)	0.11 (3; 28)	0.03 (1; 31)	0.07 (2; 30)	C	0.00 (0; 17)	0.10 (3; 31)	0.00 (0; 31)	0.04 (1; 26)	C	C	C	0.05 (11; 225)

Note: C = censored data or no data.

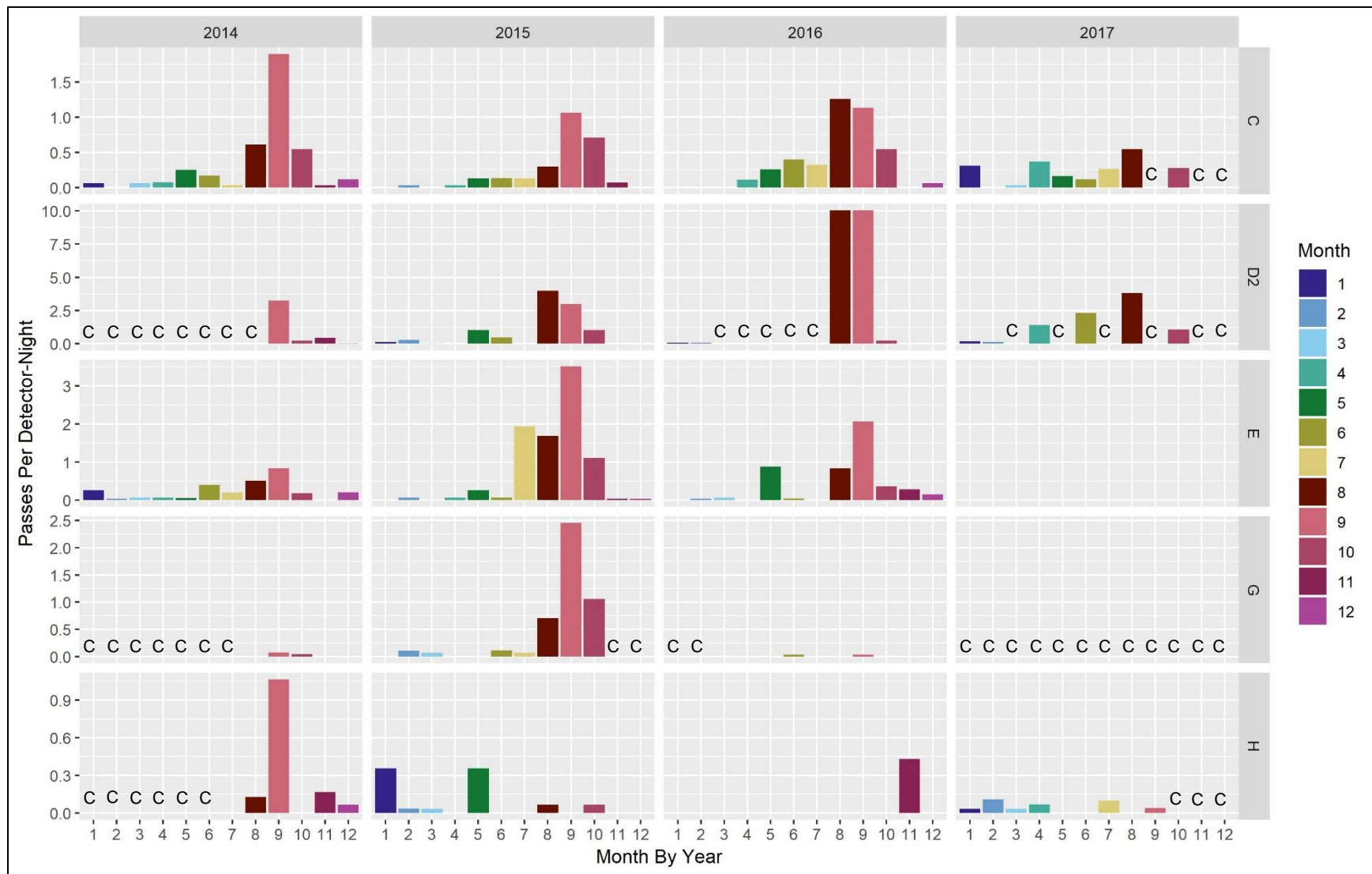


Figure 3. Bat activity rate along the turbine string by month, year, and location. The scale on the y-axis (Passes Per Detector-Night) varies by location to facilitate intra-location comparisons among years. Month 1 = January, etc.; C = censored data or no data (not 0).

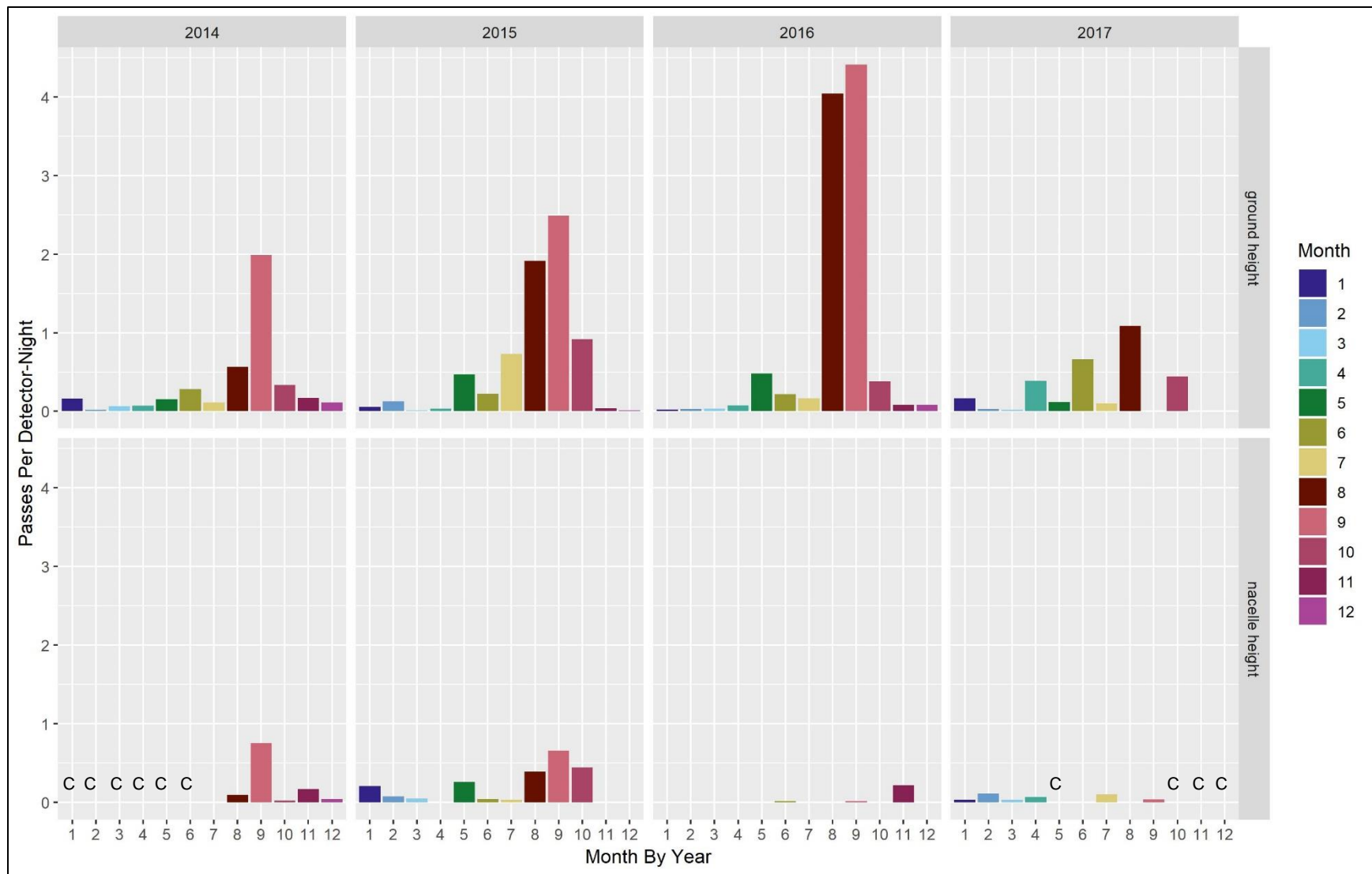


Figure 4. Bat activity rate along the turbine string by month, year, and detector height (ground or nacelle). Month 1 = January, etc.; C = censored data or no data (not 0).

5.2 Bat Activity in the Lee of the Cliff (off-site)

Biologists from SWCA acoustically sampled a location off-site west of Turbine 1 for activity occurring in the lee of the cliff (Detector F); bat activity levels at this location were several orders of magnitude higher than those recorded on-site. In Years 1 through 4, 15,678 bat call sequences resulting in 17,495 passes were recorded at this location (Table 5). Bat activity at this location was particularly high in June and July of 2015, recording an average of 172 and 139 passes per detector night, respectively; this strong seasonal peak is not apparent in other years (Figure 5).

6 DISCUSSION AND CONCLUSIONS

Bat activity at Pakini Nui Wind Farm was detected at all locations, during all months of the year, and in all years throughout the study period. It is important to note that reported bat activity rates are relative rates rather than absolute measures of bat activity at the site. Although the detectors were placed in various locations along the turbine array at ground and nacelle height and at the base of the met tower to ensure good representative coverage of activity across the site, the detectors were not randomly placed at each location. They were instead situated to maximize the probability of detecting a bat near a fixed structure such as a turbine or met tower. Given this, it is possible that the average recorded bat activity of the entire site could be higher or lower than the measured rate.

Activity rates peaked in August and September along the turbine string. Activity in the lee of the cliff (Detector F) peaked between June and July in 2015. This seasonality in activity compares well with other Hawaiian hoary bat research, which may indicate that bats on Hawai'i Island migrate to higher altitudes from the lowlands from September to March (post-lactation and pre-pregnancy time frames) (Menard 2001). The detectors cannot differentiate individual bats, and, as a result, high activity, particularly when looking at detections during any one night, could be a result of many bats being detected or a single bat making multiple passes (Kunz et al. 2007). Consequently, the observed periods of higher bat activity may have resulted from an increase in the number of bats during the higher activity seasons, an increase in the usage of the area by the same number of individuals, or some combination thereof.

Recorded activity was consistently much lower at nacelle height than at ground height. At vertically paired Detectors D2 and H, bat activity was 20 times higher at ground height than at nacelle height over the period of study. Considering data from all the detectors located along the turbine string, bat activity was 6 times higher at ground height (0.599 bat passes per detector-night) than nacelle height (0.104 bat passes per detector-night) over the study period. This calculation assumes that Detector E (at ground height) was accurately recording zero bats in 2017; the difference in bat activity between ground height and nacelle height may be greater if Detector E was malfunctioning during this time.

Bat activity at Detector F, located off-site at the edge of the cliff, was consistently higher (sometimes several orders of magnitude higher) than bat activity along the turbine string or at the met tower. Over the study period, bat activity was, on average, 35 times higher at Detector F (15.0 bat passes per detector-night) than at detectors located along the turbine string or met tower (0.428 bat passes per detector-night). This difference is most apparent in 2015 but still distinct in other years. In Years 1, 3, and 4, bat activity was still 13 times higher at Detector F (average of 5.62 bat passes per detector-night) than at detectors located along the turbine string (average of 0.429 bat passes per detector-night). It is possible that bats could be flying and feeding in the lee of the cliff where wind speeds can expect to be at or near zero when winds are 10 m/s or more along the turbine array.

Table 5. Bat Activity Rate at Detector F in the Lee of the Cliff (off-site)

Location	Year	Bat Passes Per Detector Night (passes; detector-nights) by Month												Average
		1	2	3	4	5	6	7	8	9	10	11	12	
F	2014	C	C	0.29 (9; 31)	0.52 (14; 27)	3.58 (111; 31)	16.50 (495; 30)	28.50 (513; 18)	27.90 (865; 31)	29.03 (871; 30)	0.97 (30; 31)	0.54 (13; 24)	0.55 (24; 44)	9.92 (2,945; 297)
	2015	0.00 (0; 31)	0.00 (0; 28)	4.26 (132; 31)	7.43 (223; 30)	47.71 (1,479; 31)	172.97 (5,189; 30)	139.48 (4,324; 31)	6.42 (199; 31)	41.93 (1,258; 30)	0.00 (0; 31)	5.03 (151; 30)	0.59 (17; 29)	35.74 (12,972; 363)
	2016	0.11 (3; 28)	0.14 (4; 29)	0.35 (11; 31)	3.17 (95; 30)	20.71 (642; 31)	3.00 (90; 30)	1.64 (18; 11)	5.52 (171; 31)	3.08 (74; 24)	0.03 (1; 31)	0.08 (1; 12)	0.13 (4; 31)	3.49 (1,114; 319)
	2017	0.10 (3; 31)	0.00 (0; 28)	0.08 (2; 25)	2.50 (35; 14)	0.00 (0; 20)	C	18.15 (236; 13)	10.45 (115; 11)	C	1.19 (19; 16)	C	1.74 (54; 31)	2.46 (464; 189)

Note: C = censored data or no data, Month 1 = January, etc.

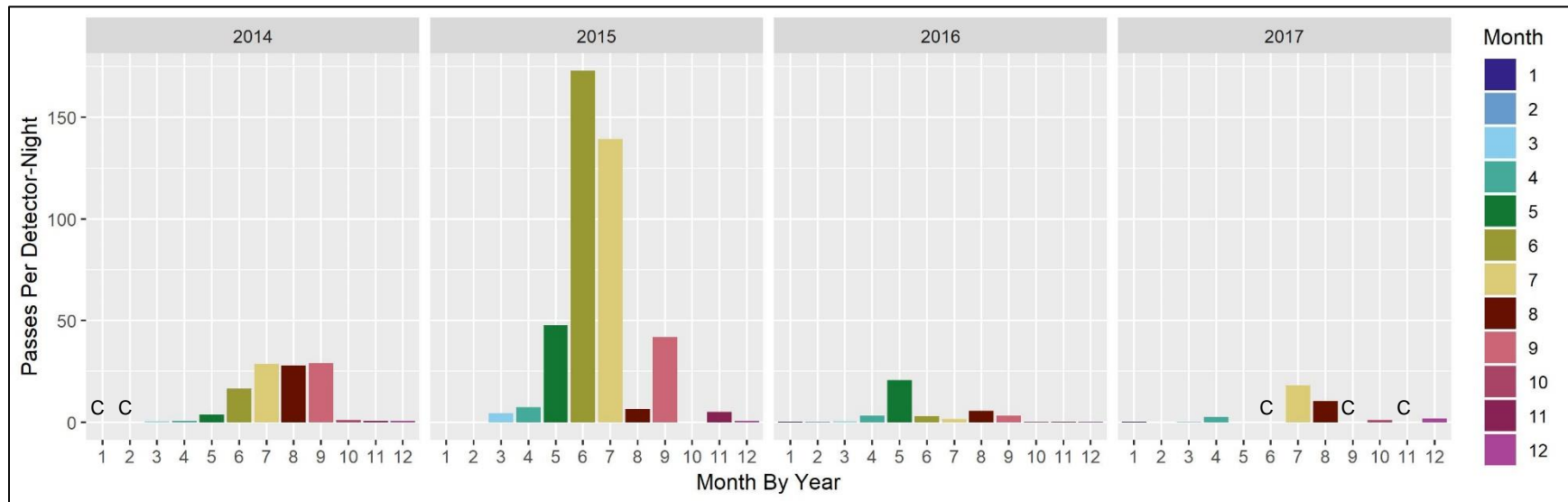


Figure 5. Bat activity rate at Detector F in the lee of the cliff by month and year. Month 1 = January, etc.; C = censored data or no data (not 0).

7 LITERATURE CITED

- Amlin, A., and A. Siddiqi. 2015. *Endangered Species Recovery Committee Hawaiian Hoary Bat Guidance Document*. Honolulu: State of Hawai'i Department of Land and Natural Resources, Division of Forestry and Wildlife. December.
- Baerwald, E.F., and M.R. Barclay. 2009. Geographic variation in activity and fatality of migratory bats at wind energy facilities. *Journal of Mammalogy* 90(6):1341–1349.
- Bellwood, J.J., and J.H. Fullard. 1984. Echolocation and foraging behaviour in the Hawaiian hoary bat, *Lasiurus cinereus semotus*. *Canadian Journal of Zoology* 62:2113–2120.
- Bonaccorso, F.J. 2011. Ope‘ape‘a – solving the puzzles of Hawaii’s only bat. *Bats* 28(4):10–12.
- Bonaccorso, F.J., K. Montoya-Aiona, C.A. Pinzari, and C. Todd. 2016. *Winter Distribution and Use of High Elevation Caves as Foraging Sites by the Endangered Hawaiian Hoary Bat, Lasiurus cinereus semotus*. Technical Report HCSU-068. Hilo, Hawai'i: U.S. Geological Survey.
- Bonaccorso, F.J., C.M. Todd, A.C. Miles, and P.M. Gorresen. 2015. Foraging range movements of the endangered Hawaiian hoary bat, *Lasiurus cinereus semotus*. *Journal of Mammalogy* 96(1):64–71.
- Brooks, R.T., and W.M. Ford. 2005. Bat Activity in a forest landscape of central Massachusetts. *Northeastern Naturalist* 12(4):447–462.
- Day, R.H., and B.A. Cooper. 2005. *Analysis of Bird and Bat Issues Related to the Pakini Nui Wind Farm near South Point, Hawai'i Island*. Prepared for Apollo Energy. ABR, Inc – Environmental Research and Services.
- Francl, K.E., W.M. Ford, and S.B. Castleberry. 2004. Bat activity in central Appalachian wetlands. *Georgia Journal of Science* 62:87–94.
- Fullard, J.H. 2001. Auditory Sensitivity of Hawaiian Moths (Lepidoptera: Noctuidae) and Selective Predation by the Hawaiian Hoary Bat (Chiroptera: *Lasiurus cinereus semotus*). *Proceedings of the Royal Society of London B* 268:1375–1380.
- Gorresen M.P., F.J. Bonaccorso, C.A. Pinzari, C.M. Todd, K. Montoya-Aiona, and K. Brinck. 2013. *A Five-year Study of Hawaiian Hoary Bat (Lasiurus cinereus semotus) Occupancy on the Island of Hawai'i (HSCU-041)*. Hilo: Hawai'i Cooperative Studies Unit, University of Hawai'i at Hilo. Available at: http://hilo.hawaii.edu/hcsu/documents/TR41_Gorresen_Bat_occupancy.pdf. Accessed February 19, 2019.
- Gorresen, M.P., P.M. Cryan, M.M. Huso, C.D. Hein, M.R. Schirmacher, J.A. Johnson, K.M. Montoya-Aiona, K.W. Brinck, and F.J. Bonaccorso. 2015. *Behavior of the Hawaiian Hoary Bat (Lasiurus cinereus semotus) at Wind Turbines and Its Distribution Across the North Ko‘olau Mountains, O‘ahu*. Technical Report HCSU-064. Hilo, Hawai'i Cooperative Studies Unit, University of Hawai'i at Hilo.
- Grindal, S.D., J.L. Morissette, and R.M. Brigham. 1999. Concentration of bat activity in riparian habitats over an elevational gradient. *Canadian Journal of Zoology* 77:972–977.

- Haines, W.P., M.L. Heddle, P. Welton, and D.A. Rubinoff. 2009. Recent outbreak of the Hawaiian koa moth, *Scotorythra paludicola* (Lepidoptera: Geometridae), and a review of outbreaks between 1892 and 2003. *Pacific Science* 63(3):349–369.
- Kunz, T.H., E.B. Arnett, B.M. Cooper, W.P. Erickson, R.P. Larkin, T. Mabee, M.L. Morrison, M.D. Strickland, and J.M. Szewczak. 2007. Assessing impacts of wind-energy development on nocturnally active birds and bats: A guidance document. *Journal of Wildlife Management* 71:2449–2486.
- Menard, T. 2001. Activity patterns of the Hawaiian hoary bat (*Lasiurus cinereus semotus*) in relation to reproductive time periods. Master's thesis, University of Hawai'i at Mānoa.
- Menzel, M.A., T.C. Carter, J.M. Menzel, M.F. Ford, and B.R. Chapman. 2002. Effects of group selection silviculture in bottomland hardwoods on the spatial activity pattern of bats. *Forest Ecology and Management* 162:209–218.
- Mitchell, C., C. Ogura, D.W. Meadows, A. Kane, L. Strommer, S. Fretz, D. Leonard, and A. McClung. 2005. *Hawaii's Comprehensive Wildlife Conservation Strategy*. Honolulu, Hawai'i: Department of Land and Natural Resources. Available at: <https://dlnr.hawaii.gov/wildlife/files/2013/09/CWCS-Full-Document-2005Oct01.pdf>. Accessed February 19, 2019.
- Morris, A.D. 2008. Use of forest edges by bats in a managed pine forest landscape in coastal North Carolina. Master's thesis, University of North Carolina, Chapel Hill.
- SWCA Environmental Consultants (SWCA). 2015. *Fatality Searches, Searcher Efficiency and Carcass Retention Trials at Pakini Nui Wind Farm*. Prepared for Tawhiri Power LLC. SWCA Environmental Consultants. September 25.
- U.S. Fish and Wildlife Service (USFWS). 1998. *Recovery Plan for the Hawaiian Hoary Bat* (*Lasiurus cinereus semotus*). Portland, Oregon: U.S. Fish and Wildlife Service.
- Whitaker, J.O., and P.Q. Tomich. 1983. Food habits of the hoary bat, *Lasiurus cinereus*, from Hawaii. *Journal of Mammalogy* 64:151–152.

Appendix I

Fatality Searches, Searcher Efficiency, and Carcass Retention Trials Report at Pakini Nui Wind Farm

Fatality Searches, Searcher Efficiency and Carcass Retention Trials Report at Pakini Nui Wind Farm

CONFIDENTIAL BUSINESS INFORMATION

Prepared for

Tawhiri Power LLC

Prepared by

SWCA Environmental Consultants

September 25, 2015



FATALITY SEARCHES, SEARCHER EFFICIENCY AND CARCASS RETENTION TRIALS REPORT AT PAKINI NUI WIND FARM

CONFIDENTIAL BUSINESS INFORMATION

Prepared for

Tawhiri Power LLC
551 Pilgrim Drive, Suite C
Foster City, California 94404
Attn: Steven Pace
(650) 358-1550, ext. 11

Prepared by

SWCA Environmental Consultants
Bishop Square ASB Tower
1001 Bishop Street, Suite 2800
Honolulu, Hawai'i
(808) 548-7899
www.swca.com

September 21, 2015

EXECUTIVE SUMMARY

SWCA Environmental Consultants have been conducting fatality monitoring and searcher efficiency (SEEF) trials at the Pakini Nui Wind Farm near South Point on Hawaii Island starting in March, 2014, scavenger trapping starting in November 2014, and carcass removal (CARE) trials starting in January, 2014. Prior to March, 2014 and subsequent to May, 2015, Tawhiri Power LLC (Tawhiri) conducted fatality monitoring using its own employee's. No state- or federally endangered, threatened, or vulnerable listed species fatalities were documented at the site. Carcasses of two size classes representing Hawaiian hoary bats and medium-sized seabirds were used for CARE trials. The average time of carcass retention during CARE trials was approximately 4 days, but varied from 0 to 14 days. CARE trials indicate that medium-sized carcasses were removed more quickly than small carcasses. SEEF trials were 68% successful during the first search attempt, but the second search attempt was considerably less successful at less than 25% of carcasses recovered, due to the fact that carcasses missed during first search attempt were placed in locations where they were inherently more difficult to find. Scavenger trapping resulted in capture of both cats and mongooses near the Pakini Nui Wind Farm.

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1. INTRODUCTION

Pakini Nui Wind Farm, located on Hawaii Island, is one of seven currently operational wind-generating facilities in Hawaii. The other wind farms are located on Oahu (Kahuku and Kawailoa), Maui (Kaheawa I and II, and Auwahi), and Hawaii (Hawi).

An avian and bat survey report was prepared for Tawhiri Power LLC by ABR, Inc., in 2005. This report concluded that endangered bird species and the endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*) could be present at the project site but likely in small numbers. The report recommended field surveys and methods to minimize impacts associated with light attraction and above-ground transmission lines. A fatality monitoring protocol was established for the wind farm, and monthly searches have been conducted for downed wildlife at the wind farm since it started operations on April 3, 2007. The fatality search methods were updated to be consistent with current guidelines in August, 2013. No avian fatalities had been reported at the wind farm until the discovery of a Hawaiian hoary bat carcass at the site on August 31, 2013. This fatality was discovered during a scheduled fatality monitoring event, after weekly monitoring had been initiated by Tawhiri Power LLC staff at the beginning of the month. Tawhiri Power LLC is in the process of applying for incidental take authorizations for species protected under the Endangered Species Act (ESA) of 1973, as amended (16 United States Code [USC] 1531–1544); and Chapter 195D, Hawaii Revised Statutes [HRS]).

In February 2014, Tawhiri Power LLC contracted SWCA Environmental Consultants (SWCA) to conduct fatality monitoring, searcher efficiency (SEEF) trials, and carcass removal (CARE) trials at Pakini Nui Wind Farm near South Point, Hawaii which began in late March 2014. This report summarizes the findings of these trials conducted on-site by SWCA biologists Trice Davis (biological technician), John Polhemus (wildlife biologist), and Corinna Pinzari (wildlife biologist) from March 27, 2014, to May 9 2015.

2. DESCRIPTION OF THE PROJECT SITE

2.1. Location and Vicinity

Tawhiri Power LLC operates the 21-megawatt (MW) Pakini Nui Wind Farm at South Point on Hawaii Island (Figure 1). Tawhiri Power LLC is made up of a partnership of wholly owned subsidiaries of Apollo Energy Corporation and GE Capital Corporation. Construction of the Pakini Nui Wind Farm started in August 2006, and was completed in April 2007. The wind farm, consisting of 14 GE 1.5-MW SE turbines, began operations on April 3, 2007. The project includes approximately 11 kilometers (7 miles) of above-ground tie-lines. The turbines have tubular towers with a hub height of approximately 65 meters (m) (213 feet); the rotor blades are approximately 70 m (230 feet) in diameter, and reach a maximum height of 100 m (328 feet).

The areas below and near the turbines are routinely grazed by cattle and feral goats. The vegetation in these areas consists mostly of buffelgrass (*Cenchrus ciliaris*), which is grazed and interspersed with an occasional lantana bush (*Lantana camara*) and kiawe tree (*Prosopis pallida*). Depending on the intensity of the grazing at different locations, grass height ranges from ankle to knee high. The cliff to the west of the turbine string has similar vegetation but offers shelter from both wind and ungulates, and as a result there are more and larger-stature kiawe trees. The areas south and east of the site are similar, consisting of mostly grazed buffelgrass grasslands with interspersed non-native trees such as kiawe. North of the site, vegetation gradually becomes more shrubby and woody, with mostly non-native tree and shrub species. At the northernmost portion of the tie-line, the vegetation consists of mostly native forest, with ‘ōhi‘a lehua (*Metrosideros polymorpha*) and pūkiawe (*Leptecophylla tameiameia*) as the dominant species.

Pakini Nui experiences relatively high average wind speeds. Wind direction is predominantly between 70 degrees (°) east-northeast and 90° east. Mean annual rainfall for this area is approximately 21.8 inches (554 millimeters [mm]). Rainfall is typically highest in March and lowest in May through June (Giambelluca et al. 2013). The closest rainfall gauge to the site (Kamaoa Puueo) experienced average annual rainfall through the end of December 2014 (National Oceanic and Atmospheric Administration/National Weather Service, Weather Forecast Office Honolulu 2014).

3. METHODS

3.1. Fatality Monitoring

Weekly fatality monitoring searches were conducted at the project site by trained SWCA biologists from March 27, 2014, to March 17, 2015, to document wildlife fatalities at the Pakini Nui Wind Farm. Ellipsoidal-shaped plots were centered on each of the 14 wind turbine generators (WTGs) (Figure 1). For WTGs 1–5, the searchable area was truncated on the western periphery due to their position near the cliff, which limited access of the searchable area.

Hull and Muir (2010) found that for small turbines (65 m [213 feet] hub height and 33 m [108 feet] blade length), 99% of bat fatalities landed within 45 m (147 feet) of the turbine base, and for medium sized carcasses, 99% fall within 108 m (354 feet).

Search plots at wind farms in Hawai‘i are typically 75% of turbine height. However, because of the strong prevailing winds at the Project that blow consistently between 70 and 90 degrees for more than 90% of the time, it was agreed, with USFWS and DLNR concurrence (meeting with USFWS and DLNR dated 2/20/2014), that the upwind portion of the search plot could be reduced to 60% turbine height, whereas the downwind portion could be lengthened to 90% turbine height. The search plot extends 72 m (236 feet) upwind; and 107 m (351 feet) downwind. Because the WTGs are placed close to one another and all individual WTG search areas overlapped, a single final search area was used (Figure 1).

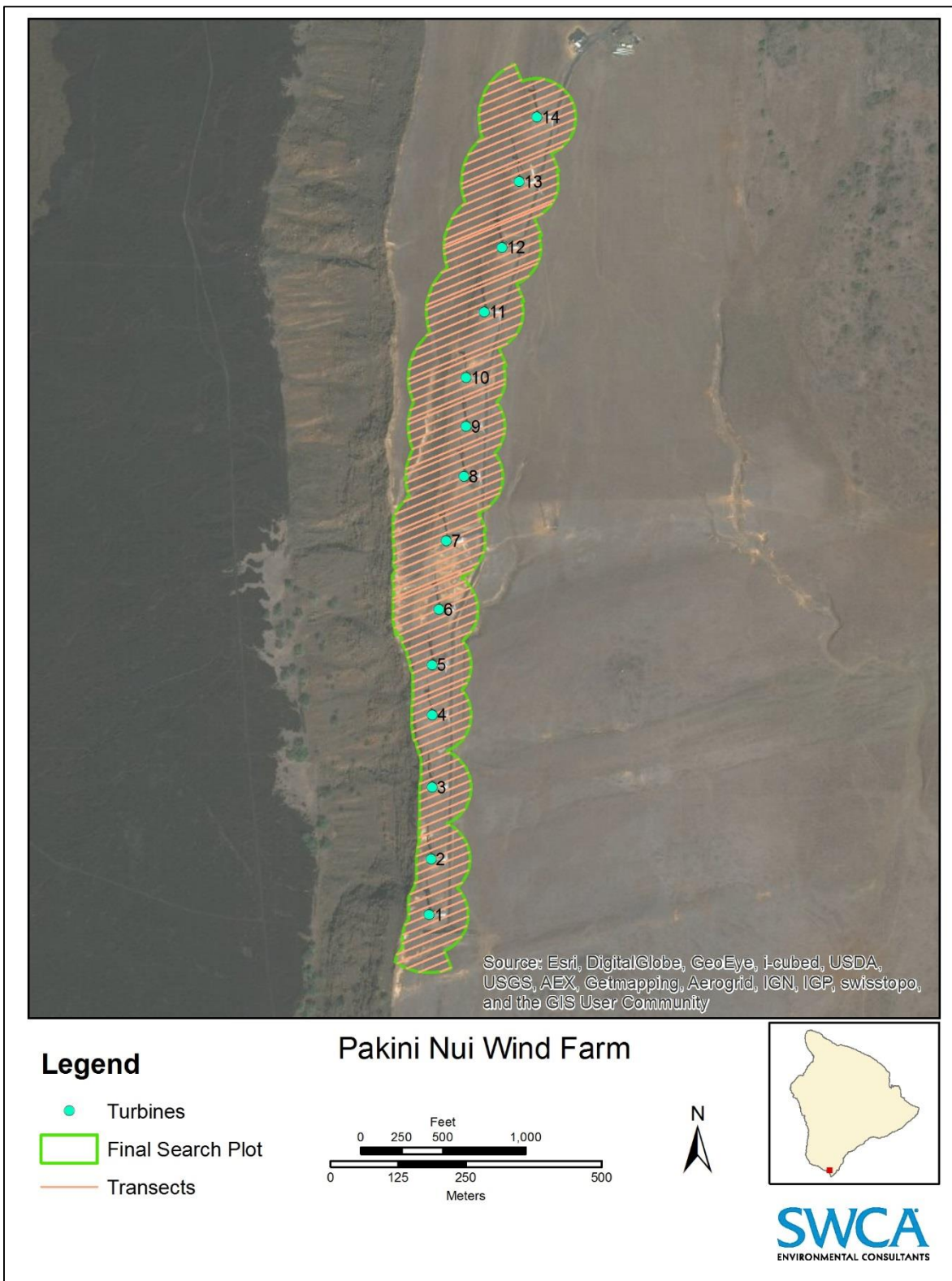


Figure 1. Pakini Nui Wind Farm showing search plot area, search transects, and numbered WTGs.



Figure 2. SWCA biologist next to a white transect marking stake southwest of WTG 1. Additional stakes can be seen in the distance along the top of the cliff, demarcating the western edge of searchable parallel transects.

In all, 90 parallel transects across the search area were staked approximately 15 m (49 feet) apart (Figures 1 and 2). Searchers followed the marked transects, searching 7.5 m (24.6 feet) on either side. Searches were usually conducted by one person on foot. All data collected—including information about any carcasses discovered, WTGs searched, weather conditions, search dates, CARE status, and SEEF status—were digitized into a spreadsheet. Photographs were taken and stored when relevant. Appendix A provides the search dates for each WTG throughout the survey’s duration.

3.2. Carcass Retention Trials

For CARE and SEEF trials, two size classes (small and medium) of surrogate carcasses were used in place of endangered species that are at risk of fatality by WTG activity. Dead rats were used as surrogates for the Hawaiian hoary bat. Rat carcasses were ordered from Layne Labs in California, and were the “Small Frozen Colored Rats” variety, which are various dark colorations with a white stomach. The approximate body size of the rats was 11.5 centimeters (cm) (4.5 inches) long. For the medium size class, dead chickens were used as surrogate carcasses for medium-sized birds such as Hawaiian petrels (*Pterodroma sandwichensis*), etc. Chicken carcasses (XL) were ordered from RodentPro.com, LLC, and were mottled in coloration.

A surrogate carcass was considered taken if fewer than 10 of its body feathers and/or fewer than two wing feathers remained (Young et al. 2012).

Placement of surrogate carcasses by SWCA biologists was chosen randomly from a set of randomly generated global positioning system (GPS) localities using Esri's Arc-GIS software. Surrogate carcasses were placed on-site in the early morning, making sure the searcher had no knowledge of where carcasses were placed. The carcasses were placed by navigating to a random point, then tossing the carcass over the shoulder to further avoid bias in the carcass placement. For rat carcasses with white stomachs, proctors then ensured that rats were placed stomach-down to more closely match the appearance of a dead Hawaiian hoary bat. The number of days that surrogate carcasses remained was recorded either visually by the searcher or by deployed game cameras, which recorded predators near (and potentially removing) the surrogate carcasses via motion-detecting sensors and digital images. Data were summarized for 12 months and calculations made for the number of days and standard deviation (SD) before carcass removal.

3.3. Searcher Efficiency Trials

SEEF trials at Pakini Nui Wind Farm were proctored by SWCA biologists. Trials began in March 2014 and continued through April 2015. Surrogate carcass locations were chosen based on randomly generated GPS point locations within the final search area. Black plastic bats, which were exact model replicas of brown bats, were used as surrogates for the Hawaiian hoary bat. Plastic bats measured 10 cm (3.9 inches) in length with a 22.5-cm (8.8-inch) wingspan, which is comparable to the body and wingspan of the Hawaiian hoary bat. Because the model had rigid plastic wings, the wings were cut in three locations and sewn together with string (Figure 3). This was done when surrogate carcasses were placed on-site during a SEEF trial to create a more natural injured-carcass appearance from a WTG impact. For the medium size class, stuffed dodos and stuffed pigeons closely matching Hawaiian petrels in size and coloration were used in the SEEF trials. Proctors placed carcasses in the same manner as for CARE trials (see section 3.2.) in the early morning and without searcher knowledge of placement. The searcher was unaware of either timing of SEEF trials or of the number of surrogate carcasses placed during SEEF trials. When a carcass was found by the searcher, the approximate location, carcass type, and closest WTG was communicated via email or text to the project coordinator. Efficiency was determined as follows:

Searcher efficiency = number of surrogate carcasses found / total surrogate carcasses

After searches were completed for the day, the searcher notified the proctor of any carcasses discovered during the search. Proctors verified if any undiscovered carcasses were remaining. If so, the carcasses were left in place to determine the likelihood that the searcher would find it the following week. If a carcass had gone missing or was not recovered after the second search attempt, then that specific trial was not counted, because it could not be verified that the carcass was actually in place during the search period. Data were then analyzed to calculate the overall SEEF for the survey period by dividing the number of surrogate carcasses found by the total number of surrogate carcasses placed on-site.



Figure 3. Surrogate carcass plastic bat with cut and sewn wings placed on-site in buffelgrass.

3.4. Scavenger Trapping

Five live traps (Havahart cat rescue kits sized 32 × 10.5 × 12.5 inches) were deployed intermittently from November 19, 2014, through April 2015 near the Pakini Nui Wind Farm using cat food and sardines as bait. Traps were placed outside the search areas, along roads and other pathways likely to be used by cats and mongooses. If an SWCA biologist was unable to check the traps by sundown the following day, the traps were closed and reopened when daily checks were again able to be conducted. This means that traps were open most weekdays. Any animals trapped were picked up by representatives from the Humane Society's Kona shelter and evaluated for adoption. Animals not suitable for adoption were humanely euthanized by the Humane Society.

4. RESULTS

4.1. Fatality Monitoring

No fatalities of listed species were documented during the survey period. A total of one take incident of a listed species (Hawaiian hoary bat; August 31, 2013) has been found at the site since operations began on April 3, 2007. This carcass was found by Tawhiri Power LLC personnel during a weekly fatality search.

Between March 2014 and April 2015, SWCA biologists found zero bird carcasses that were not associated with CARE or SEEF trials.

4.2. Carcass Removal Trials

Thirty-nine CARE trials were conducted over the survey period from January 2014 to January 2015. Some trials resulted in missing data for some carcasses deployed for various reasons (e.g., game camera digital card corrupted, game camera went missing, etc.). Therefore, only 32 trials were successful. CARE

trial data were recorded for 10 medium (chicken) carcasses, and 22 small (rat) carcasses. Game camera images (Figure 4) and animals caught by scavenger trapping indicate that feral cats (*Felis catus*) and to a lesser degree small Asian mongooses (*Herpestes javanicus*) are the most common scavengers present.

The overall average of CARE for both small and medium carcasses combined was 4.19 (\pm 3.42) days. If considered by carcass size only, medium-sized carcasses were on average taken more quickly at 2.80 (\pm 2.64) days compared to small carcasses, which had an average minimum retention time of 4.82 (\pm 3.61) days. The calculated standard deviations were large given the variability of the data.

On six occasions, the minimum retention time of a carcass could have been different than the actual recorded time a carcass was noted as missing (maximum retention time). This was due to the searcher not being able to record data for various reasons (e.g., the carcass was observed on-site on a Friday, but was missing the following Monday; the precise date of CARE was not recorded on camera due to malfunctioning SD card, but the carcass went missing before the next visual search; etc.). Despite these differences, the average minimum and maximum days of CARE were quite comparable (Table 1).

Table 1. Days of Surrogate Carcasses Retained during CARE Trials

Carcasses	Average Minimum Retention Time (days)	SD	Average Maximum Retention Time (days)	SD
Small size	4.82	(3.61)	5.05	(3.66)
Medium size	2.80	(2.64)	3.86	(3.36)
Overall	4.19	(3.42)	4.63	(3.66)



Figure 4. Feral cat photographed by deployed game camera.

4.3. Searcher Efficiency Trials

The overall SEEF trial success rate from March 2014 to April 2015 was 68.38% during the first search attempt, which consisted of 117 trials. For small (N=84) and medium carcasses (N=33), the SEEF success rate for the first search attempt was 66.67% and 72.73%, respectively. The second search attempt SEEF trials (N=19, most carcasses were found during first search) was considerably lower than first search attempts, at 24.32% success. For small carcasses (N=19), SEEF in the second attempt was at 28.57% success, and 11.11% for medium carcasses. For the second search attempt, the probability of finding a medium-sized carcass dropped by 61.62%. Probabilities for finding small carcasses during the second search attempt dropped much less dramatically, by 38.10%. Overall, this equates to a 44.06% decrease in the probability that a carcass of any size would be found during a second search attempt.

Table 2. SEEF Trial Results for Human Visual Searching at Pakini Nui Wind Farm for 2014

Surrogate Carcass Size	Search Attempt 1			Search Attempt 2		
	N	Found	SEEF (%)	N	Found	SEEF (%)
Small	84	56	66.67	28	8	28.57
Medium	33	24	72.73	9	1	11.11
Total	117	80	68.38	37	9	24.32

4.4. Scavenger Trapping

Scavenger traps were deployed intermittently. In all, seven cats and one mongoose were trapped and removed between November 19, 2014 and April 2015.

Table 3. Species and Number of Scavengers Trapped

Date	Number and Species Trapped
12/9/2014	2 cats
12/11/2014	1 mongoose
12/31/2014	1 cat
3/24/2015	1 cat
3/26/2015	1 cat
3/31/2015	1 cat
4/16/2015	1 cat
Total	8

5. DISCUSSION

From January 2014 through April 2015, fatality monitoring, SEEF, and CARE trials as well as scavenger trapping were conducted at Pakini Nui Wind Farm on Hawaii Island. No state- or federally listed endangered, threatened, or vulnerable species were documented as fatalities during the entire survey period.

CARE trials showed a high level of variability (see Table B-1). Overall, the average minimum time before carcass removal occurred was about 4 days. However, the calculated standard deviation indicated that time of average carcass removal varied from less than 1 day to greater than a week. Differences between CARE time for the two size classes show the average time before removal of medium-sized carcasses was quicker, from less than a day to 5 days. Small carcasses had a longer average retention time of approximately 0–14 days.

SEEF trials had a searcher efficiency of approximately 68% success during the first attempt. The searcher efficiency for second search attempts dropped considerably to 24%. More than two-thirds of all medium-sized carcasses were recovered during the first search attempt. However, the second search attempts' likelihood of recovery dropped considerably to 11%. The drop in likelihood of searcher efficiency between searching attempts was less dramatic for small-sized carcasses. This indicates that if a carcass was not found during the first search attempt, it was much less likely to be found at all. Most likely these carcasses were positioned in a location that inherently made them more difficult to find therefore the average likelihood of finding a carcass upon second attempt is lower than that of finding a carcass upon first attempt.

Trapping was successful at removing a number of scavengers near the site. This, in conjunction with game cameras used during the CARE trials, indicates that mongooses and feral cats are the common scavengers removing carcasses on-site. However, CARE times did not show a significant change over time in response to trapping or other potential temporal variables.

6. LITERATURE CITED

- Giambelluca, T.W., Q. Chen, A.G. Frazier, J.P. Price, Y.L. Chen, P.S. Chu, J.K. Eischeid, and D.M. Delaporte. 2013. Online Rainfall Atlas of Hawai'i. *Bull. Amer. Meteor. Soc.* 94, 313–316, doi: 10.1175/BAMS-D-11-00228.1. Available at: <http://rainfall.geography.hawaii.edu>. Accessed on March 18, 2015.
- Young, D.P. Jr., S. Nomani, W. Tidhar, and K. Bay. 2012. *NedPower Mount Storm Wind Energy Facility, Post-Construction Avian and Bat Monitoring: Fall 2011*. Prepared for NedPower Mount Storm, LLC. Prepared by Western EcoSystems Technology (WEST), Inc., Cheyenne, Wyoming. February 27, 2012.

Appendix A.

Fatality Monitoring Plot Search Dates at Pakini Nui Wind Farm in 2014

Appendix A. Fatality Monitoring Plot Search Dates at Pakini Nui Wind Farm in 2014

Table A-1. Fatality Monitoring Plot Search Dates at Pakini Nui Wind Farm in 2014

Turbines	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Searcher	Comments
Date	3/27/14	3/27/14	3/27/14	3/27/14	3/27/14	3/27/14	3/27-28/14	3/27-28/14	3/27-28/14	3/27-28/14	3/27-28/14	3/27-28/14	3/27-28/14	3/27-28/14	OL & TD	
	4/3/14	4/3/14	4/3/14	4/3/14	4/2/14	4/2/14	4/2/14	4/2/14	4/2/14	4/1/14	4/1/14	4/1/14	4/1/14	4/1/14	TD	
	4/10/14	4/10/14	4/10/14	4/10/14	4/9/14	4/9/14	4/9/14	4/9/14	4/9/14	4/8/14	4/8/14	4/8/14	4/8/14	4/8/14	TD	
	4/17/14	4/17/14	4/17/14	4/17/14	4/16/14	4/16/14	4/16/14	4/16/14	4/16/14	4/15/14	4/15/14	4/15/14	4/15/14	4/15/14	TD	
	4/24/14	4/24/14	4/24/14	4/24/14	4/23/14	4/23/14	4/23/14	4/23/14	4/23/14	4/22/14	4/22/14	4/22/14	4/22/14	4/22/14	TD	
	5/2/14	5/2/14	5/2/14	5/2/14	5/1/14	5/1/14	5/1/14	5/1/14	5/1/14	4/29/14	4/29/14	4/29/14	4/29/14	4/29/14	TD	
	5/8/14	5/8/14	5/8/14	5/8/14	5/7/14	5/7/14	5/7/14	5/7/14	5/7/14	5/6/14	5/6/14	5/6/14	5/6/14	5/6/14	TD	
	5/15/14	5/15/14	5/15/14	5/15/14	5/14/14	5/14/14	5/14/14	5/14/14	5/14/14	5/13/14	5/13/14	5/13/14	5/13/14	5/13/14	TD	
	5/22/14	5/22/14	5/22/14	5/22/14	5/21/14	5/21/14	5/21/14	5/21/14	5/21/14	5/20/14	5/20/14	5/20/14	5/20/14	5/20/14	TD	
	5/30/14	5/30/14	5/30/14	5/30/14	5/29/14	5/29/14	5/29/14	5/29/14	5/29/14	5/28/14	5/28/14	5/28/14	5/28/14	5/28/14	TD	Moved by 1 day
	6/6/14	6/6/14	6/6/14	6/6/14	6/5/14	6/5/14	6/5/14	6/5/14	6/5/14	6/4/14	6/4/14	6/4/14	6/4/14	6/4/14	TD	Moved by 1 day
	6/12/14	6/12/14	6/12/14	6/12/14	6/11/14	6/11/14	6/11/14	6/11/14	6/11/14	6/10/14	6/10/14	6/10/14	6/10/14	6/10/14	TD	
	6/19/14	6/19/14	6/19/14	6/19/14	6/18/14	6/18/14	6/18/14	6/18/14	6/18/14	6/17/14	6/17/14	6/17/14	6/17/14	6/17/14	TD	
	6/26/14	6/26/14	6/26/14	6/26/14	6/25/14	6/25/14	6/25/14	6/25/14	6/25/14	6/24/14	6/24/14	6/24/14	6/24/14	6/24/14	TD	
	7/3/14	7/3/14	7/3/14	7/3/14	7/2/14	7/2/14	7/2/14	7/2/14	7/2/14	7/1/14	7/1/14	7/1/14	7/1/14	7/1/14	TD	
	7/10/14	7/10/14	7/10/14	7/10/14	7/9/14	7/9/14	7/9/14	7/9/14	7/9/14	7/8/14	7/8/14	7/8/14	7/8/14	7/8/14	TD	
	7/18/14	7/18/14	7/18/14	7/18/14	7/16/14	7/16/14	7/16/14	7/16/14	7/16/14	7/15/14	7/15/14	7/15/14	7/15/14	7/15/14	TD	Not searched due to jury duty 7/17/14
	7/24/14	7/24/14	7/24/14	7/24/14	7/23/14	7/23/14	7/23/14	7/23/14	7/23/14	7/22/14	7/22/14	7/22/14	7/22/14	7/22/14	TD	
	7/31/14	7/31/14	7/31/14	7/31/14	7/30/14	7/30/14	7/30/14	7/30/14	7/30/14	7/29/14	7/29/14	7/29/14	7/29/14	7/29/14	TD	
					8/6/14	8/6/14	8/6/14	8/6/14	8/6/14	8/5/14	8/5/14	8/5/14	8/5/14	8/5/14	TD	Not searched due to hurricane
	8/15/14	8/15/14	8/15/14	8/15/14	8/14/14	8/14/14	8/14/14	8/14/14	8/14/14	8/12/14	8/12/14	8/12/14	8/12/14	8/12/14	TD	
	8/21/14	8/21/14	8/21/14	8/21/14	8/20/14	8/20/14	8/20/14	8/20/14	8/20/14	8/19/14	8/19/14	8/19/14	8/19/14	8/19/14	TD	
	8/28/14	8/28/14	8/28/14	8/28/14	8/27/14	8/27/14	8/27/14	8/27/14	8/27/14	8/26/14	8/26/14	8/26/14	8/26/14	8/26/14	TD	
	9/4/14	9/4/14	9/4/14	9/4/14	9/3/14	9/3/14	9/3/14	9/3/14	9/3/14	9/2/14	9/2/14	9/2/14	9/2/14	9/2/14	TD	
	9/11/14	9/11/14	9/11/14	9/11/14	9/10/14	9/10/14	9/10/14	9/10/14	9/10/14	9/9/14	9/9/14	9/9/14	9/9/14	9/9/14	TD	
	9/18/14	9/18/14	9/18/14	9/18/14	9/17/14	9/17/14	9/17/14	9/17/14	9/17/14	9/16/14	9/16/14	9/16/14	9/16/14	9/16/14	TD	
	9/25/14	9/25/14	9/25/14	9/25/14	9/24/14	9/24/14	9/24/14	9/24/14	9/24/14	9/23/14	9/23/14	9/23/14	9/23/14	9/23/14	TD	
	10/2/14	10/2/14	10/2/14	10/2/14	10/1/14	10/1/14	10/1/14	10/1/14	10/1/14	9/30/14	9/30/14	9/30/14	9/30/14	9/30/14	TD	
	10/9/14	10/9/14	10/9/14	10/9/14	10/8/14	10/8/14	10/8/14	10/8/14	10/8/14	10/7/14	10/7/14	10/7/14	10/7/14	10/7/14	TD	
	10/16/14	10/16/14	10/16/14	10/16/14	10/15/14	10/15/14	10/15/14	10/15/14	10/15/14	10/14/14	10/14/14	10/14/14	10/14/14	10/14/14	TD	
	10/23/14	10/23/14	10/23/14	10/23/14	10/22/14	10/22/14	10/22/14	10/22/14	10/22/14	10/21/14	10/21/14	10/21/14	10/21/14	10/21/14	TD	
	10/30/14	10/30/14	10/30/14	10/30/14	10/29/14	10/29/14	10/29/14	10/29/14	10/29/14	10/28/14	10/28/14	10/28/14	10/28/14	10/28/14	TD	
	11/6/14	11/6/14	11/6/14	11/6/14	11/5/14	11/5/14	11/5/14	11/5/14	11/5/14	11/4/14	11/4/14	11/4/14	11/4/14	11/4/14	TD	

Appendix A. Fatality Monitoring Plot Search Dates at Pakini Nui Wind Farm in 2014

Table A-1. Fatality Monitoring Plot Search Dates at Pakini Nui Wind Farm in 2014

Turbines	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Searcher	Comments
	11/13/14	11/13/14	11/13/14	11/13/14	11/12/14	11/12/14	11/12/14	11/12/14	11/12/14	11/11/14	11/11/14	11/11/14	11/11/14	11/11/14	TD	
	11/20/14	11/20/14	11/20/14	11/20/14	11/19/14	11/19/14	11/19/14	11/19/14	11/19/14	11/18/14	11/18/14	11/18/14	11/18/14	11/18/14	TD	
	11/26/14	11/26/14	11/26/14	11/26/14	11/25/14	11/25/14	11/25/14	11/25/14	11/25/14	11/24/14	11/24/14	11/24/14	11/24/14	11/24/14	TD	Moved forward one day; Thanksgiving
	12/4/14	12/4/14	12/4/14	12/4/14	12/3/14	12/3/14	12/3/14	12/3/14	12/3/14	12/2/14	12/2/14	12/2/14	12/2/14	12/2/14	TD	
	12/11/14	12/11/14	12/11/14	12/11/14	12/10/14	12/10/14	12/10/14	12/10/14	12/10/14	12/9/14	12/9/14	12/9/14	12/9/14	12/9/14	TD	
	12/17/14	12/17/14	12/17/14	12/17/14	12/16/14	12/16/14	12/16/14	12/16/14	12/16/14	12/15/14	12/15/14	12/15/14	12/15/14	12/15/14	TD	
	12/24/14	12/24/14	12/24/14	12/24/14	12/23/14	12/23/14	12/23/14	12/23/14	12/23/14	12/22/14	12/22/14	12/22/14	12/22/14	12/22/14	TD	
	12/31/14	12/31/14	12/31/14	12/31/14	12/30/14	12/30/14	12/30/14	12/30/14	12/30/14	12/29/14	12/29/14	12/29/14	12/29/14	12/29/14	TD	
					1/8/2015	1/8/2015	1/8/2015	1/8/2015	1/8/2015	1/7/2015	1/7/2015	1/7/2015	1/7/2015	1/7/2015	TD	T1-4 not searched due to searcher illness
																No searches; wind farm maintenance
	1/23/2015	1/23/2015	1/23/2015	1/23/2015	1/21/2015	1/21/2015	1/21/2015	1/21/2015	1/21/2015	1/19/2015	1/19/2015	1/19/2015	1/19/2015	1/19/2015	TD	
	1/29/2015	1/29/2015	1/29/2015	1/29/2015	1/28/2015	1/28/2015	1/28/2015	1/28/2015	1/28/2015	1/27/2015	1/27/2015	1/27/2015	1/27/2015	1/27/2015	TD	
	2/5/2015	2/5/2015	2/5/2015	2/5/2015	2/4/2015	2/4/2015	2/4/2015	2/4/2015	2/4/2015	2/3/2015	2/3/2015	2/3/2015	2/3/2015	2/3/2015	TD	
	2/12/2015	2/12/2015	2/12/2015	2/12/2015	2/11/2015	2/11/2015	2/11/2015	2/11/2015	2/11/2015	2/10/2015	2/10/2015	2/10/2015	2/10/2015	2/10/2015	TD	
	2/19/2015	2/19/2015	2/19/2015	2/19/2015	2/18/2015	2/18/2015	2/18/2015	2/18/2015	2/18/2015	2/17/2015	2/17/2015	2/17/2015	2/17/2015	2/17/2015	TD	
	2/26/2015	2/26/2015	2/26/2015	2/26/2015	2/25/2015	2/25/2015	2/25/2015	2/25/2015	2/25/2015	2/24/2015	2/24/2015	2/24/2015	2/24/2015	2/24/2015	TD	
	3/5/2015	3/5/2015	3/5/2015	3/5/2015	3/4/2015	3/4/2015	3/4/2015	3/4/2015	3/4/2015	3/3/2015	3/3/2015	3/3/2015	3/3/2015	3/3/2015	TD	
	3/12/2015	3/12/2015	3/12/2015	3/12/2015	3/11/2015	3/11/2015	3/11/2015	3/11/2015	3/11/2015	3/10/2015	3/10/2015	3/10/2015	3/10/2015	3/10/2015	TD	
	3/19/2015	3/19/2015	3/19/2015	3/19/2015	3/18/2015	3/18/2015	3/18/2015	3/18/2015	3/18/2015	3/17/2015	3/17/2015	3/17/2015	3/17/2015	3/17/2015	TD	

Appendix B.

Carcass Removal Trial Results during the Survey Period

Table B-1. CARE Trial Results during Reporting Period

Carcass ID	Date Deployed	Waypoint	Turbine	Vegetation Type	Carcass Type	Minimum Retention Time (days)	Maximum Retention Time (days)
1	1/31/2014	2	8	G	R	9	9
2	1/31/2014	3	6	G	R	8	8
3	2/14/2014	1	13	G	R	14	14
4	2/14/2014	4	5	G	R	11	11
6	3/14/2014	9	3	G	C	2	2
5	3/14/2014	5	7	G	R	5	5
7	3/28/2014	6	13	G	C	3	3
8	3/28/2014	8	5	G	R	2	2
9	4/7/2014	12	12	G	R	0	0
10	4/7/2014	15	11	G	R	0	0
11	4/16/2014	21	6	G	R	8	8
12	4/16/2014	22	6	G	R	6	6
13	4/22/2014	18	10	G	C	2	2
14	5/7/2014	7	8	G	R	2	2
15	5/13/2014	14	12	G	R	2	2
16	5/27/2014	13	14	G	C	1	1
17	5/27/2014	35	10	G	R	3	5
18	6/2/2014	34	12	G	R	7	7
20	6/16/14	33	13	G	C	0	0
19	6/16/2014	56	9	G	R	3	3
21	7/21/14	21	12	G	C	3	3
22	7/30/2014	22	3	G	R	4	4
23	8/4/2014	23	13	G	R	1	1
26	9/22/2014	119	7	G	R	5	6
27	10/3/2014	196	1	G	R	6	6
28	10/10/2014	182	1	G	R	2	2
30	11/7/2014	120	12	G	R	6	8
32	11/24/2014	115	14	G	R	2	2
33	12/8/2014	155	2	G	C	1	1
34	12/15/2014	39	11	G	C	2	6
35	1/20/2015	169	6	G	C	4	6
36	1/26/2015	169	6	G	C	10	13
Average overall retention time (days)						4.19	4.63
SD						3.42	3.66
Average rat retention time (days)						4.82	5.05
SD						3.61	3.66
Average chicken retention time (days)						2.80	3.86
SD						2.64	3.63

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Appendix C.

**Searcher Efficiency Trial Results for First and Second Searching Attempts
during the Survey Period**

Table C-1. SEEF Trial Results for First and Second Search Attempts during SWCA Reporting Period

Waypoint	WTG	Vegetation Type	Carcass Type	Search Date	Found First Search Attempt	Search Date	Found Second Search Attempt
21	6	G	R	4/16/2014	N		
22	6	G	R	4/16/2014	N		
26	10	G	PB	4/29/2014	Y		
16	8	G	PB	5/1/2014	Y		
19	5	G	PB	5/2/2014	N		
28	1	G	PB	5/8/2014	Y		
29	7	G	PB	5/7/2014	Y		
43	3	G	PB	5/15/2014	N	5/22/2014	Y
44	8	G	PB	5/14/2014	Y		
11	6	G	PB	5/29/2014	Y		
13	14	G	C	5/28/2014	Y		
31	1	G	PB	5/30/2014	Y		
46	12	G	PB	6/4/2014	Y		
62	7	G	PB	6/5/2014	Y		
95	2	G	PB	6/6/2014	Y		
52	10	G	PB	6/10/2014	Y		
7	8	G	PB	6/11/2014	Y		
63	2	G	PB	6/12/2014	Y		
80	2	G	PB	6/19/2014	Y		
60	13	G	PB	6/17/2014	N		
68	6	G	PB	6/18/2014	Y		
10	11	G	PB	7/1/2014	Y		
48	6	G	PB	7/2/2014	Y		
50	4	G	PB	7/3/2014	N		
78	1	G	PB	7/8/2014	Y		
96	5	G	PB	7/9/2014	Y		
98	14	G	PB	7/10/2014	Y		
73	3	G	PB	7/22/2014	N	7/29/2014	Y
97	12	G	PB	7/22/2014	Y		
99	3	G	PB	7/25/2014	N	7/29/2014	Y
100	13	G	PB	7/25/2014	Y		
57	6	G	PB	7/30/2014	N		
69	4	G	PB	7/31/2014	Y		
81	3	G	PB	7/31/2014	Y		
55	5	G	PB	8/6/2014	Y		
58	8	G	PB	8/6/2014	Y		
64	11	G	PB	8/5/2014	Y		

Table C-1. SEEF Trial Results for First and Second Search Attempts during SWCA Reporting Period

Waypoint	WTG	Vegetation Type	Carcass Type	Search Date	Found First Search Attempt	Search Date	Found Second Search Attempt
82	5	G	PB	8/15/2014	Y		
92	3	G	PB	8/15/2014	Y		
24	9	G	PB	8/14/2014	Y		
61	14	G	PB	8/12/2014	Y	8/19/2014	Y
80	2	G	PB	8/28/2014	Y		
28	1	G	PB	8/28/2014	Y		
75	10	G	PB	9/2/2014	N	9/9/2014	Y
77	6	G	PB	9/3/2014	Y		
85	11	G	PB	9/2/2014	N	9/10/2014	N
91	4	G	SP	9/4/2014	Y		
83	8	G	SP	9/10/2014	Y		
87	4	G	PB	9/11/2014	Y		
89	14	G	PB	9/10/2014	N	9/16/2014	Y
105	2	G	PB	9/11/2014	N	9/18/2014	Y
84	9	G	SP	9/17/2014	Y		
65	9	G	PB	9/24/2014	Y		
67	7	G	PB	9/24/2014	Y		
116	1	G	SD	9/25/2014	Y		
135	9	G	SD	10/8/2014	Y		
176	5	G	SP	10/9/2014	Y		
198	1	G	PB	10/9/2014	Y		
71	11	G	PB	10/13/2014	Y		
72	11	G	SP	10/13/2014	Y		
158	3	G	SD	10/15/2014	Y		
195	1	G	PB	10/15/2014	Y		
101	6	G	PB	10/22/2014	Y		
102	10	G	SP	10/21/2014	Y		
104	13	G	SD	10/21/2014	N	10/28/2014	N
114	3	G	PB	10/23/2014	Y		
108	11	G	SP	11/11/2014	N	11/18/2014	N
110	12	G	PB	11/11/2014	Y		
122	9	G	SD	11/12/2014	N	11/19/2014	N
127	8	G	PB	11/12/2014	N	11/19/2014	N
118	2	G	PB	11/20/2014	Y		
125	6	G	PB	11/19/2014	Y		
121	5	G	PB	11/27/2014	N	12/4/2014	N
107	1	G	PB	11/27/2014	N	12/4/2014	N
166	2	G	SP	12/11/2014	Y		
140	7	G	PB	12/10/2014	Y		

Table C-1. SEEF Trial Results for First and Second Search Attempts during SWCA Reporting Period

Waypoint	WTG	Vegetation Type	Carcass Type	Search Date	Found First Search Attempt	Search Date	Found Second Search Attempt
153	7	G	PB	12/10/2014	Y		
161	13	G	PB	12/9/2014	Y		
163	13	G	SD	12/9/2014	Y		
143	1	G	SP	12/17/2014	Y		
151	3	G	PB	12/17/2014	Y		
128	5	G	PB	12/17/2014	N	12/23/2014	N
131	6	G	PB	12/16/2014	N	12/23/2014	N
117	11	G	SD	12/15/2014	N	12/22/2014	N
132	4	G	SP	1/23/2015	Y		
154	6	G	PB	1/21/2015	Y		
174	4	G	PB	1/29/2015	Y		
199	4	G	PB	1/29/2015	Y		
191	6	G	SP	1/28/2014	Y		
148	5	G	PB	2/11/2015	N	2/18/2015	N
156	5	G	PB	2/11/2015	Y		
168	13	G	SP	2/10/2015	Y		
17	8	G	SP	3/4/2015	Y		
20	11	G	PB	3/3/2015	N	3/10/2015	N
23	11	G	SD	3/3/2015	N	3/10/2015	Y
25	12	G	SP	3/10/2015	Y		
27	10	G	PB	3/10/2015	Y		
30	7	G	PB	3/11/2015	Y		
32	8	G	SP	3/11/2015	Y		
36	12	G	PB	3/17/2015	N	3/24/2015	N
37	8	G	PB	3/18/2015	N	3/25/2015	N
38	14	G	SP	3/17/2015	Y		
40	12	G	PB	3/17/2015	N	3/24/2015	N
41	13	G	PB	3/17/2015	N	3/24/2015	N
42	11	G	SP	3/17/2015	Y		
45	12	G	PB	3/17/2015	Y		
47	12	G	SD	3/17/2015	Y		
49	13	G	SP	3/31/2015	N	4/7/2015	N
54	13	G	SD	3/31/2015	N	4/7/2015	N
74	10	G	SP	3/31/2015	Y		
4	5	G	PB	4/8/2015	Y		
9	3	G	PB	4/9/2015	N	4/15/2015	Y
19	5	G	SP	4/8/2015	Y		
142	1	G	PB	4/9/2015	N	4/16/2015	N

Appendix J

Habitat Conservation Plan Annual Report Template

Project Name
Annual Report
For the Period _____

Prepared for

Prepared by

Month, Year

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EXECUTIVE SUMMARY

Include:

- basic project specifications and schedule
- any changes in management, operations, or ownership
- covered species
- covered activities
- monitoring information summary
- avoidance and minimization measures
- take summary including total take, fiscal year take, permitted take, and evaluation of take rate
- mitigation summary for covered species
- summary of any amendments including approvals
- summary of adaptive management including approvals
- plans for the future

Total observed fatalities and calculated total take since ITL issuance

Species Name	FY ____ Reporting Period	Total Permit Period from ____ through June 30, 20__				Permit/License Take
	Observed Take	Observed Take	Estimated Unobserved Take	Indirect Take using HCP multipliers	Estimated Take	

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ATTACHMENTS

Possible Attachments:

- Details for fatality monitoring, SEEF and CARE
- Fatality/Injury summary for species not covered in HCP and not MBTA
- Raw data for fatality estimator
- Fatality estimation input parameters and outputs
- Details for various take estimates and calculations
- Lost productivity calculations (when required)
- Mitigation reports
- Photographs
- Downed Wildlife Reports

OTHER ENCLOSURES PROVIDED ELECTRONICALLY - SEEF and CARE data files formatted for use in Evidence of Absence

1.0 INTRODUCTION

Include:

- Incidental Take License and Permit numbers
- citation of reporting requirements in HCP and HRS 195D-21(f)
- basic project specifications and schedule
- changes in management, operations, or ownership
- covered species
- covered activities
- list dates and purpose of meetings with regulatory agencies in the FY

Figure 1-1. Project Vicinity Map

2.0 PROJECT MONITORING PROGRAM

2.1 PRESENCE/ABSENCE/ABUNDANCE MONITORING

Acoustic, thermal, other monitoring.

2.2 TAKE MONITORING

2.3 WILDLIFE EDUCATION AND INCIDENTAL REPORTING PROGRAM

2.4 SEARCHER EFFICIENCY (SEEF)

Include type and number of carcasses placed, dates, number found, number removed before first search, whether repeated search was used, interval between searches (if applicable), and efficiency. Provide rationale for timing of SEEF and procedure for placement of carcass. Include vegetation class and map with GPS coordinates. Identify searchers and proctors. Please note—names can be redacted if a public request for the report is made. Include spread sheet with this data formatted for use in Evidence of Absence as an electronic file.

2.5 CARCASS RETENTION (CARE) AND SCAVENGER TRAPPING

Include number and type of carcasses placed, date of placement, method of monitoring (camera or human), scavenger results, and type of scavenger, if known. Include scavenger control measures, procedure, timing, bait, and outcomes. Include spread sheet with this data formatted for use in Evidence of Absence as an electronic file.

2.6 ECOSYSTEM OR VEGETATION MONITORING

Explain any monitoring results that are required in the HCP.

3.0 MBTA SPECIES FATALITIES OR INJURIES

Include fatalities or injuries occurring during the annual reporting period and since issue of permit.

List and summarize the details for each fatality or injury that occurred during the reporting period. Categorize as to covered species, MBTA, or none.

For injuries specify who handled the animal, where it was triaged and rehabbed, and the eventual outcome and all related dates.

Summarize pertinent information from USFWS permit report.

Table 3.1. MBTA species Take Summary

Species Name	Date Observed	Condition (dead, injured, etc.)	Actions taken	Disposition of animal or carcass

4.0 COVERED SPECIES TAKE, AVOIDANCE/MINIMIZATION AND MITIGATION

4.1 TAKE SUMMARY FOR ALL COVERED SPECIES

For injuries specify who handled the animal (e.g. was it DOFAW or if not then the reason and who did handle it), where it was triaged and rehabbed, and the eventual outcome.

Table 4-1. All Covered Species Take Summary

Species Name	FY ____ Reporting Period	Total Permit Period from ____ through June 30, 20__				Permit/License Authorized Take
	Observed Take During this FY	Observed Take	Estimated Unobserved Take	Calculated Indirect Take	Total Estimated Take	

4.2 SPECIES 1 (BATS)

4.2.1 Avoidance and Minimization Measures

Explain how project is meeting avoidance and minimization to the “maximum extent practicable”.

Explain any changes to these measures within the past year and what effect they have had.

For bats include an analysis of factors preceding bat takes that may have influenced takes including acoustic detector results (including temporal aspects and call types), weather (wind speed and direction, precipitation, storms) at or prior to takes, turbine operational details, moon phase, and information related to surrounding land practices such as grazing and cropping that might influence bat presence. All relevant factors that may explain takes should be evaluated and especially preceding periods of multiple HHB takes that occur within a short span of time, or other unusual timing or circumstances.

Summarize curtailment history and dates/hours and evaluation of effectiveness.

4.2.2 Direct Take

Summarize and explain data in tables below.

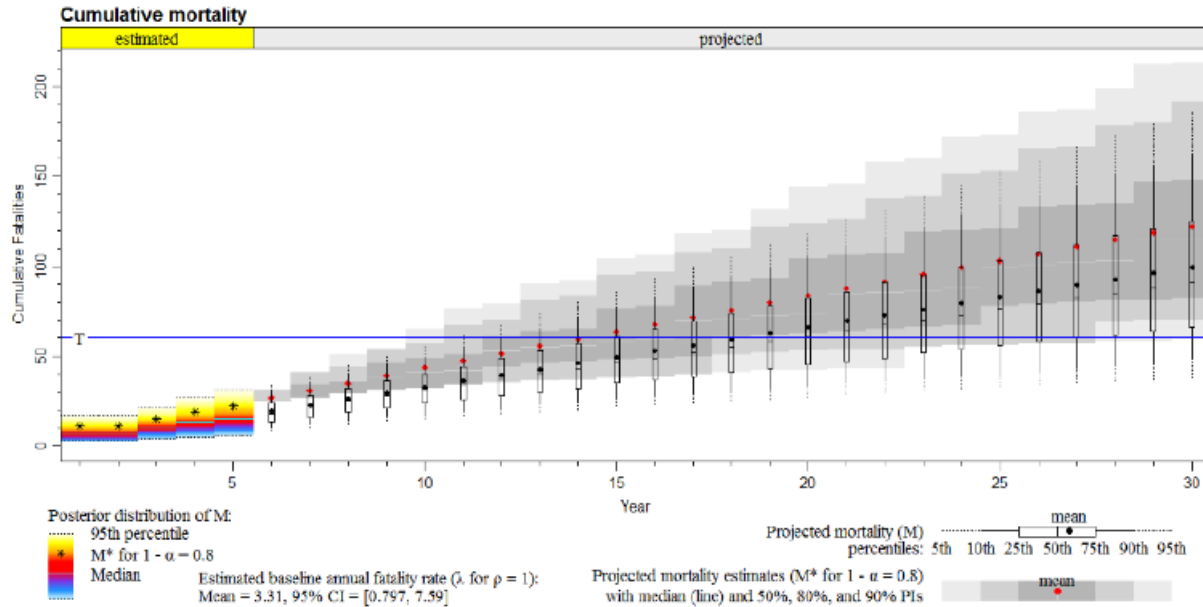
Table 4-2. Species 1 Direct Takes Attributable to the Project Since Permit/License Issue

Discovery Date	State FY	Fatal (yes/no)	Cause	Turbine # and curtail speed (m/s)	Distance from turbine (m)	Explain if not used in unobserved modeling
				only for wind HCPs	only for wind HCPs	only for wind HCPs

Table 4-3. Species 1 Observed Fatalities or Injuries Not Attributable to the Project Since Permit/License Issue

Discovery date	State FY	Fatal (yes/no)	Cause	Reason not attributed to project

Provide outputs from the EoA and include a graphical representation like the one below.



4.2.3 Indirect Take

Cite and use USFWS PIFWO guidance document for bats. to calculate indirect take on observed and unobserved. Please show all calculations including date of observed take, sex, and the number of observed and unobserved take based on the 80% credibility level. Assume a 1:1 female:male ratio for all take observed during the breeding season that were not definitively identified as to gender.

4.2.4 Species 1 Take Summary

Provide text summary and graphical representation showing take rate and include projection graph from EoA model for bats.

Table 4-4. Species 1 Take Summary

FY ____ Reporting Period	Total Permit Period through June 30, 20__				Permit/License Take
Observed Take	Observed Take	Calculated Unobserved Take	Indirect Take	Calculated Take	

4.3 SPECIES 2 [REPEAT SECTIONS .1 - .5 ABOVE FOR EACH SUBSEQUENT SPECIES]

5.0 MITIGATION

5.1 MITIGATION SUMMARY FOR ALL COVERED SPECIES

Include summary of status of meeting goals and objectives and success criteria.

Explain status of achieving net environmental and recovery benefit.

Figure 5-1. Location of mitigation projects

5.2 SPECIES 1 (BATS)

-overall schedule and progress of mitigation

-specific mitigation project(s) with status of meeting success criteria (cite attachments for details)

-progress in net gain of recovery of species

-progress in attainment of net environmental benefit

-reference to attachments if applicable

5.3 SPECIES 2

6.0 ADAPTIVE MANAGEMENT AND AMENDMENTS

6.1 ADAPTIVE MANAGEMENT

Describe problems or issues that required adaptive management.

Describe the evaluation of adaptive management decisions and comparison to triggers.

Evaluate triggers for take rate and mitigation progress and success

Explain what actions were taken if triggers are exceeded and a schedule for implementation

Explain the decision process and interaction/decisions with agencies

6.2 AMENDMENTS

Define minor and major amendments based on the HCP.

Summarize any action taken on major amendments and how documented.

7.0 FUNDING

7.1 EXPENDITURES

Status of funding per HRS 195D-21(f).

Summarize expenditures this fiscal year and project to date

7.2 FUNDING ASSURANCE

List all funding assurances in place and schedules.

Provide justification that the amount of funding assurance is adequate.

8.0 OTHER TOPICS

8.1 PLANS AND MANAGEMENT OBJECTIVES FOR THE NEXT FISCAL YEAR

As required under 195D-21(f). Include “areas needing technical advice”.

Attachments