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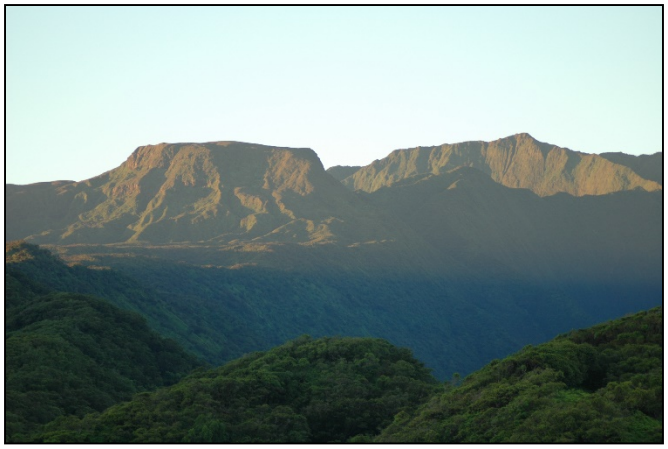

Hawaiian Hoary Bat Mitigation Monitoring at the West Maui Mountains Watershed Partnership Project Site, Lahaina, Maui

Proposal #8019

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Section 1. Proposed Scope of Services

Kaheawa Wind Power Phase II (KWP II), which is owned and operated by SunEdison, is implementing a state and federally approved Habitat Conservation Plan for its 21 megawatt wind energy facility on the island of Maui. KWP II, has proposed to amend its permitted incidental take of the Hawaiian hoary bat (*Lasiurus cinereus semotus*) from 11 bats to an additional 69 bats, which would increase the total projected incidental take to 80 bats for a 20-year period. As mitigation for this additional requested take, KWP II is negotiating an agreement with the West Maui Mountains Watershed Partnership (WMMWP) to fund the conservation and restoration of 1,600 acres of habitat that might be suitable for the recovery (repopulation) of Hawaiian hoary bats in the West Maui Mountains (Figure 1). In addition to conservation measures such as fence construction, management of ungulates, habitat enhancements, and monitoring that are planned at the mitigation site, the U.S. Fish and Wildlife Service (USFWS) requires acoustic monitoring for a minimum three-month period in the first year and then every fifth year thereafter. The purpose of this monitoring is to assess changes in bat activity as a result of habitat restoration, and the growth of vegetation and prey in the restored areas. Per your request, H. T. Harvey & Associates is proposing to conduct the baseline acoustic monitoring study that would comply with the USFWS's minimum mitigation requirement for Hawaiian hoary bats at KWP II (Task 1).

In addition to the minimum mitigation requirement described above, we understand that the Service and SunEdison are interested in implementing additional research that addresses other aspects of Hawaiian hoary bat ecology. These research topics include the distribution and seasonal occupancy of bats in various habitats, the relationship between activity and environmental characteristics, roost fidelity including the conditions causing roost abandonment and the behavior of mothers and pups at tree roosts and other reproductive ecology, and foraging ecology including a better understanding of the predator-prey dynamics. These topics suggest the need for more intensive acoustic monitoring, radio-telemetry studies, available prey studies, and other topics described below. Implementing these supplemental research efforts would exceed the minimum mitigation monitoring requirements described above but would also provide needed information on the ecological requirements of bats in Hawai'i. Moreover, if begun before implementation of the restoration plans, it will provide (in the long run) a measure of the success of the restoration efforts. This will greatly facilitate the development of practicable mitigation opportunities in the future. To provide the support necessary to meet some of these objectives, H.T. Harvey & Associates is also proposing three supplemental tasks (Tasks 2-4) which would more closely examine the behavior and ecology of Hawaiian hoary bats

These supplemental tasks are as follows:

- Task 2 – Conduct an acoustic monitoring study that broadens spatial representation of bat activity by including areas upslope of the mitigation lands within the same watersheds and increases the sampling effort from approximately three months to one full year. This effort should help establish the utilization

of various high altitude and low altitude habitats over the course of a one-year cycle. As a part of Task 2, we believe a reconnaissance-level visit of up to eight person days is needed to meet with the MMWP staff to determine access and understand the site, to determine the efficacy of the equipment, and to determine the locations of the ten monitoring stations within the mitigation site, and up to 10 additional sites in the watersheds above.

- Task 3 - Prey availability study, 7 consecutive days every other month for one full year (this effort should help determine how the prey base responds to restoration efforts, and if patterns of bat activity are driven by prey dynamics).
- Task 4 – Radio-telemetry to assess roosting ecology for one month (this effort should increase our understanding of fine scale maternity roosting habitat, to help focus restoration actions to improve roosting habitat, and help understand potential risks to pups at maternity roosts).

Budget:

Each Task is designed to stand alone and is separately budgeted so that SunEdison and the agencies can decide upon which Tasks they want implemented. Our budget for Task 1 is $115,658 (or discounted to $108,602 if SunEdison or MWWMP staff retrieve data cards from units). Task 2's budget, which is an expansion of Task 1, is $299,742 (or discounted to $266,518 if SunEdison or MWWMP staff retrieve data cards from units). Because the requirements for Task 1 would be met under Task 2, Task 1 would be replaced by Task 2 if SunEdison decides to move forward with this expanded version of acoustic monitoring. Task 3's budget is $179,658 (or discounted to $163,194 if SunEdison or MWWMP staff retrieve insect samples), and Task 4's budget is $135,113. The total budget for Tasks 2, 3, and 4 is $614,513 without the field help from SunEdison or MWWMP staff for retrieval of data and samples, and with field help the budget is $565,121. The following is a detailed description of each of the proposed tasks.

Task 1. Short-term Acoustic Monitoring

To sufficiently address the USFWS guidance on mitigation monitoring procedures for the Hawaiian hoary bat under the KWP II HCP, we will deploy a network of acoustic detectors across the 1600-acre Project site to establish a baseline of bat activity levels across the restoration site. We will first carefully review and investigate access across the 1600-acre WMMWP Project site to inform the site selection process then select a minimum of 10 additional sites that allow even sampling of elevations (i.e., approximately half in higher and half in lower elevation areas) and to the extent possible, their generalized even spatial distribution. While the overall elevation range within the project site is not great, there is a general upslope trend to all the habitats, and there are three major watershed valleys that comprise the site. Project ecologists will deploy the detectors in May 2016 and record data for the maternity season (1 June – 15 September 2016) and an additional two weeks (16 – 31 September), to include this peak activity period for Hawaiian hoary bats.

The first year will focus on establishing baseline activity levels and patterns at the site; results may yield general patterns in activity by elevation, and habitat. We will use the Gap analysis habitat maps to help inform our site selection, and work closely with WWMWP to select appropriate accessible sites. Continuation of these efforts in one or more subsequent periods may provide a more robust capacity to detect significant differences in bat activity between sampling periods.

Equipment:

We will deploy 10 Song Meter SM4BAT units (Wildlife Acoustics, Concord, Massachusetts) powered by solar panels. Song Meters record ultrasonic calls using full-spectrum technology and are durable, weather-proof, and record with reasonably good microphones. Recording ranges among bat detectors vary, so results among sites may not be compatible if different technologies or detectors are used (Adams et al. 2012). While there is a general consensus among Hawaiian hoary bat researchers that full spectrum detectors have better sensitivity than zero-cross technology, the U.S. Geological Survey (USGS) is comparing the efficacy of Song Meters (older generation SM2s versus new generation SM4s). For the WMMWP Project we selected SM4 detectors because of their advertised endurance and reliability and to align with the likely choice of detectors for other SunEdison bat monitoring projects. Otherwise, we will conform to whatever bat detector SunEdison chooses for Hawaiian projects.

Deployment of acoustic detectors requires that the units themselves or microphones be placed off the ground so that sound absorption and echoes from the ground do not interfere with recording. Therefore, we propose to deploy bat detector microphones on the top of 6-foot galvanized steel poles. Detectors will be set to record from sunset to sunrise, based on the latitude and longitude.

Despite advancements that include increased data storage capacity and less frequent download requirements, working on long-term acoustic monitoring programs in the past has demonstrated that checking detectors, retrieving data, and inspecting system components to ensure proper function on a routine basis is important. Therefore, two weeks after being deployed, detectors will be checked to ensure each unit is are working properly, and data checks will occur every other month thereafter. During monitoring checks, SD-high capacity data storage cards will be swapped out with new SD cards so that data down loading is not needed in the field. Two sets of replacement supplies (e.g., detector or power cords, etc.) will be kept on hand. This will enable minor repairs or component replacements to be performed efficiently and should prevent long gaps in recording should equipment failure occur.

Data Analysis and Report:

We will analyze calls using callviewer v.18 (Skowronski and Fenton 2008) and Sonobat v.3.2 (Szewczak 2015). To characterize foraging activity within the site, we will label files with feeding buzzes. We will report the number of minutes of activity detected per night and number of feeding buzzes detected per night. We will

analyze activity in R (v. 3.2.0; R Development Core Team 2015). Detections will be analyzed as binary daily data (i.e., presence / absence of at least one bat recording per night). The first year will simply be to establish baseline activity levels at the site. Subsequent years will help determine trends.

We will provide monthly progress reports of our efforts. Our year one draft report will comprise an analysis of our baseline data with maps and other figures that explain the spatial distribution of the bats over time. We will prepare a final year one report that will respond to any comments made by SunEdison.

Supplemental Task 2. Reconnaissance-level Visit and Long-term Acoustic Monitoring

Although the first year of data will be used to gather baseline data, we propose deployment of 20 acoustic monitoring sites across the WMMWP Project site and the watershed lands above the project site, to allow us to discriminate differences in bat activity and occupancy among finer scale habitat differences (e.g., elevation, forest cover, understory growth) in subsequent monitoring periods. As described above, the first year will be to establish the baseline, but may yield some trends in activity by elevation and/or by insect abundance. Subsequent years will attempt to detect significant differences between sampling periods. We will use the same equipment and data downloading scheduling as described in Task 1, except that we will deploy 20 Song Meter SM4BAT units (Wildlife Acoustics, Concord, Massachusetts). Prior to establishing the 20 monitoring stations, an eight-person day reconnaissance-level visit is needed to meet with the WMMWP staff to determine access and better understand the site, determine the efficacy of the equipment, and to determine the locations of the twenty monitoring stations. We propose to begin in late October 2015 with the reconnaissance-level visit and the deployment of equipment.

Data Analysis and Report:

We will analyze calls using the same methodology described in Task 1 (i.e., the first year will establish the baseline in activity levels, but may yield some differences in activity by season and elevation) and we will add the analyses of bat activity and insect abundance (if insect monitoring is conducted). Subsequent years will test for significant differences between sampling periods.

To analyze bat activity in relation to weather conditions we will conduct a logistic regression of presence of bat over 10-minute intervals in R (R core team 2013). Weather variables will be collected by selecting a weather station in closest proximity to the area of bat site use and foraging. We will analyze presence of the bat over 10-minute intervals in relation to wind speed, temperature, humidity, precipitation, moon illumination, and wind direction. If no weather station is adequate, then we will install a data logging weather station at the project site (MK-III RTI-LR Sensor Assembly, Rainwise Inc., Trenton, Maine).

We will provide monthly progress reports of our efforts and a draft year one report summarizing our findings. The annual report will include our statistical analyses and a discussion of spatial distribution of the bats over time. We will prepare a final report that will respond to any comments made by SunEdison.

Supplemental Task 3. Prey Availability Monitoring

To help determine how prey availability varies spatially and temporally across the site and responds to restoration efforts, we will sample the availability of prey with methods modified from Todd (2012). We will be using Universal black light traps (Bioquip Products, Inc. Rancho Dominquez, California) comprising a 22-watt U-shaped fluorescent black light tube, a 30.5 cm diameter lid, and an aluminum funnel for insects to fall into a collecting bucket with ethylene glycol. Light traps will be switched on and off with photoelectric switches. A light trap will be deployed with each bat detector for seven consecutive nights once every other month in order to adequately sample all flying insects (Hirao *et al.*, 2008) for a trial run of one year. At the end of the first year of collecting insect data, a power analysis of the data will be performed to determine if the sampling regime is appropriate for the questions asked. Light traps will be placed between 200 - 300 m away from each bat detector to avoid attracting insects and bats to the detectors. The direction of the light trap from the bat detector will be chosen by random means.

Additionally we will use Flight Interception Traps (FIT) to collect nocturnal flying insects that may not be attracted to light as suggested by Christopher Todd (pers. comm.). Because Hawaiian hoary bats are obligate aerial foragers, we will not use other traditional methods of insect sampling, such as sweep nets and sticky (Tanglefoot) traps that primarily collect insects from vegetation. Further, light trap sampling is relatively unbiased and more efficient than other sampling methods (Raimondo *et al.*, 2004). As suggested in Todd 2012, we believe any effects from sampling during full moons will be minimal because of the robust sample size. We plan on testing the efficacy of insect collecting equipment during our reconnaissance-level survey and begin collecting data in October 2015.

Data Analysis and Report:

We will analyze spatial and temporal variation of insect abundance and diversity, and how bat activity responds to overall prey abundance, as well as abundance of specific insect guilds. Additionally, we will evaluate the efficacy of using the timed light traps and FIT and the taxa-based biases associated with each sampling device.

We will provide monthly progress reports of our efforts and a draft year one report summarizing our findings. The report will include a statistical analysis of our data including a power analysis to determine if we have an adequate sample size to compare values. The report will include a discussion of the temporal and spatial

distribution of the prey availability compared with bat activity. We will prepare a final report that will respond to any comments made by SunEdison.

Supplemental Task 4. Radio Telemetry - Roosting Ecology and Diet Analysis:

While acoustic monitoring can provide measures of activity, as well as foraging activity from recordings of feeding buzzes, we will attach radio transmitters to bats as the primary method of assessing bat roosting behaviors and roosting habitats. The goal of these studies is to understand Hawaiian hoary bat roost characteristics and roosting patterns at the WMMWP. The specific objectives include determining the habitat characteristics of roost sites (height, tree species, diameter at breast height, distance to water, aspect, number of radio tagged conspecifics in close proximity) and the roosting patterns (number of days in each roost site, times for departures). Because of access issues and the extremely rough terrain, we will not attempt to radio-track bats during the night to delineate foraging areas.

Capture Methods:

Netting and radio telemetry will start in June 2016 and continue for up to 30 days. We will capture bats using mist nets, and a combination of acoustic lures (Reyes 2015). Rather than restricting capture sites to the restoration sites and the watersheds above the restoration, we will conduct netting in any suitable areas in the general vicinity of Lahaina. This could lead to higher capture rates, while still meeting the objective of studying bat activity patterns in and around the restoration site. At least two trained ecologists will operate up to 5 mist nets including macro nets sized at 6m and 9m x 30m (Johnston 2000) that will be placed across or along fly-ways or over water to capture flying bats. Nets will be deployed along movement corridors to increase the chance of capture (Palmeirim and Etheridge 1985), and the nets will be checked no less frequently than every 20 minutes. Use of an acoustic lure has been shown to increase capture rates in difficult capture locations for hoary bats in mainland North America (Reyes 2015), and functions in a similar capacity with Hawaiian hoary bats (Reyes, pers. obs). Mist nets to be used with acoustic lures will be placed out of direct flyways, against vegetation or hidden under trees, with an Ultrasoundgate Player BL Pro broadcasters using Avisoft-SASLab software (Avisoft Bioacoustics, Glienicke, Germany), a laptop computer, powered by an external 12V battery. Hoary bat social calls will be broadcast until 2:00 AM on most nights.

When bats are captured we will collapse all nets to focus on data collection from our captured bat. We will record sex, age, reproductive condition, forearm length (mm), and weight (g). We will also mark bats with an identifying split wing band. We will collect 2 tissue samples from biopsy wing punches and attach a radio transmitter and micro LED to the intrascapular area of the bat's back and release it on site. We will collect guano samples left in the bag for diet analysis. All capture, handling, and telemetry methods will be performed in accordance with special conditions stated in the USFWS Permit issued to H. T. Harvey & Associates #

TE80538A-0 and in the Hawaii Division of Forestry and Wildlife (DOFAW) permit issued to David S. Johnston.

Tracking Methods:

We will use mobile receivers (Telecommunications specialists or Lotek) to read temperature sensitive transmitters, and a Yagi antennae to triangulate the location of roosting bats. On the subsequent morning of capture, we will search for the bats' radio tag signal until the roost is located and confirmed by visually observing the bat in its roost location or emerging from the roost.

Roost Observations:

When a maternity roost is located we will place a bat detector at the base of the tree to monitor vocalizations that will help identify timing of arousals, emergence and returns, and behavior at the roost. If a maternity roost is found, we will record roost behavior with low cost security camera technology. Because we will be able to get relatively close to the roost, the much more expensive near infrared and thermal imaging cameras are not likely needed. To assess microclimate of hoary bat roosts we will replicate a study conducted by Willis and Brigham (2005) on the roost selection of mainland hoary bats.

Once we can visually locate a hoary bat maternity roost in a tree we will record: tree species; tree diameter at breast height (DBH); height of bat in tree; aspect of roost tree branch; forest cover over and under roost location; and the locations of all trees in the surrounding .045 hectare plot. We will place an iButton temperature logger on the roost branch with the roosting bat. We will then randomly select a tree within one hectare distance from the roost tree and record all identical information as the roost tree.

Dietary Analysis

Bat guano will be stored in individual vials containing desiccant, and labeled with a unique identifier for each bat, date, and location of capture. We plan to employ DNA barcoding to help determine bats' diets. DNA barcoding is a method of DNA sequencing used to identify species or to a certain level of taxa from biological tissue samples. If we cannot secure a molecular geneticist to proceed with a DNA barcoding analysis of the bats' fecal pellets, we will follow methods outlined in Whitaker et al. (2009), to identify insect parts to the highest level of taxonomy possible, comparing parts to reference samples from local insect collections and the contents of our insect traps. This will allow us to examine the local contents of the diet, and compare to available insect taxa.

Data Analysis and Report:

If we achieve a sufficient sample size of roost locations for a statistical analysis, we will use the Akaike information criterion, with a second order correction for small sample sizes (AICc) and an information theoretic approach to compare roost locations to randomly selected roost sites, to compare physical and microclimate

conditions that influence preferences (Burnham and Anderson 2002, Willis and Brigham 2005). We will construct a set of candidate models representing a range of hypotheses for factors that influence roost selection by bats. We will rank these models according to AICc. We will report favorable roost conditions for all important variables, as these data can be used to inform mitigation and habitat augmentation to develop favorable roosting habitat. Given the short duration of Task 4, our progress report will comprise our results and then our year one report will include our statistical analyses of the bat roost characteristics and roosting patterns.

Section 2. Highlighted Publications

Adams, A.M, M.K. Jantzen, R. M. Hamilton, and M.B. Fenton. 2012. Do you hear what I hear? Implications for detector selection for acoustic monitoring of bats. *Methods in Ecology and Evolution*, 3(6), 992-998.

Burnham, K., and D. Anderson. 2002. Model selection and inference: a practical information-theoretic approach. Springer Verlag, New York.

Hirao, T., M. Murakami, and A. Kashizaki. 2008. Effects of mobility on daily attraction to light traps: comparison between lepidopteran and coleopteran communities. Insect Conservation and Diversity. 1: 32-39.

Johnston, D. S. 2000. An improved technique to capture bats using macro mist nets. Bat Research News.

Palmeirim, J. M., and K. Etheridge. 1985. The influence of man-made trails on foraging by tropical frugivorous bats. *Biotropica*, *17*(1), 82-83.

Raimondo, S., J. S. Strazanac, & L. Butler. 2004 Comparison of sampling techniques used in studying Lepidoptera population dynamics. Environmental Entomology, 33, 418–425.

Reyes, G.A. 2015. The behavioral function of social calls in the migratory hoary bat (*Lasiurus cinereus).* Master's thesis. Humboldt State University, Arcata, CA.

Todd, C.M. 2012. Effects of prey abundance on seasonal movements of the Hawaiian hoary bat (*Lasiurus cinereus semotus*). M.Sc. thesis, University of Hawaii at Hilo.

Willis, C. K., and R. M. Brigham. 2005. Physiological and ecological aspects of roost selection by reproductive female hoary bats (*Lasiurus cinereus*). *Journal of Mammalogy*, *86*(1), 85-94.