Hawaiian Hoary Bat Guidance for Renewable Wind Energy Proponents

Endangered Species Recovery Committee
and
State of Hawaii Department of Land and Natural Resources
Division of Forestry and Wildlife

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Introduction

A. Purpose

The Hawaiian Hoary Bat (*Lasiurus cinereus semotus*) is an endemic subspecies that is listed as an endangered species under state and federal laws. The operation of wind turbines in Hawaiʻi may result in take of the Hawaiian Hoary Bat. Under state law, take of endangered species is prohibited, but may be permitted by the Board of Land and Natural Resources (BLNR; the board) under certain conditions if the take is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity, and when accompanied by an approved Habitat Conservation Plan (HCP). The Department of Land and Natural Resources, Division of Forestry and Wildlife (DOFAW) provides technical assistance to landowners in developing, reviewing, and monitoring Habitat Conservation Plans.

The Endangered Species Recovery Committee (ESRC) is established under Hawaii Revised Statutes, Chapter 195D (HRS 195D) in section 195D-25 (§195D-25) to serve as a consultant to the board and the Department of Land and Natural Resources (the department) on matters relating to endangered, threatened, proposed, and candidate species. Among the ESRC's required duties are to review all applications and proposals for Habitat Conservation Plans and Incidental Take Licenses (ITLs) and make recommendations, based on a full review of the best available scientific and other reliable data, and in consideration of the cumulative impacts of the proposed action on the recovery potential of the endangered, threatened, proposed, or candidate species, to the department and the board as to whether or not they should be approved, amended, or rejected. The ESRC is also required to consult with persons possessing expertise in such areas as the Committee may deem appropriate and necessary in the course of exercising its duties.

The purpose of this guidance document is to provide advice and assistance to the board, department, and applicants for the development, review, and monitoring of Habitat Conservation Plans that accompany ITLs that are proposed or approved for the incidental take of Hawaiian Hoary Bats resulting from the operation of wind turbines. This document provides guidance on selected issues related to the development of HCPs for the Hawaiian Hoary Bat, including, but not limited to the assessment of impacts to Hawaiian Hoary Bats and the avoidance, minimization, and mitigation of those impacts. It does not supersede a detailed analysis of take, avoidance or minimization measures, or mitigation under state (or federal) criteria, nor does it constitute state (or federal) rule-making. Information is provided for clarity and to assist in informing recommendations but may change based on in-progress or future research on the species.

A complete account of requirements for the issuance of an Incidental Take License under state law is provided in HRS 195D. This guidance does not serve as a comprehensive guide to all of the requirements contained in HRS 195D. The purpose of this document is to provide detailed guidance on selected statutory requirements identified in HRS 195D that warrant particular consideration for the issuance of ITLs for the Hawaiian Hoary Bat.

HRS Chapter 195D requires generally that all HCPs describe the activities contemplated to be undertaken within 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 within the plan area that are the focus of the plan (§195D-21(b)(2)(B)). The statute provides further that HCPs 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 Endangered Species Recovery Committee, or both; and provisions for evaluating progress in achieving the goals quantitatively and qualitatively (§195D-21(b)(2)(G)). The HCP shall provide for an adaptive management strategy that specifies the actions to be taken periodically if the plan is not achieving its goals (§195D-21(b)(2)(H)).

Specific requirements for approval include further that the HCP shall:

1) Minimize and mitigate impacts of take, such that:
    a) The applicant, to the maximum extent practicable, shall minimize and mitigate the impacts of the take (§195D-4(g)(1)); and
    b) The HCP shall 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 take can be adequately assessed (§195D-21(b)(2)(C)).

2) Ascertain impacts, so that the plan will:
    a) Contain sufficient information for the board to ascertain with reasonable certainty the likely effect of the plan upon any endangered, threatened, proposed, or candidate species in the plan area and throughout its habitat range (§195D-21(c));
    b) Identify 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 take can be adequately assessed (§195D-21(b)(2)(C)); and
    c) Take into consideration the full range of the species on the island so that the cumulative impacts associated with the take can be adequately assessed (§195D-4(g)(5)).

3) Provide benefits, such that:
    a) The plan will increase the likelihood that the covered species will survive and recover (§195D-4(g)(4));
    b) The cumulative impact of the activity, which is permitted and facilitated by the license, provides net environmental benefits (§195D-4(g)(8)); and
    c) The HCP is designed to result in an overall net gain in the recovery of Hawaiʻi's threatened and endangered species (§195D-30).

4) Avoid specific impacts so that:
    a) Take is not likely to cause the loss of genetic representation of an affected population of any endangered, threatened, proposed, or candidate plant species (§195D-4(g)(9)); or
    b) The cumulative activities within the areas covered by the plan do not reach the level that they cannot be environmentally beneficial (§195D-21(c)(1)); or
    c) Implementation of the plan is not likely to jeopardize the continued existence of any endangered, threatened, proposed, or candidate species identified in the plan area (§195D-21(c)(1)).

A checklist of HCP requirements pursuant to HRS 195D is provided in Appendix 3.

B. Need

The state of Hawaiʻi has established ambitious renewable energy goals with the adoption of Act 97 in 2015 requiring "each electric utility company that sells electricity for consumption in the State" to establish a renewable energy portfolio standard of 100 percent of its net electricity sales by 2045. Wind energy generation is expected to be one of the largest sources of renewable energy to meet this goal. From 2006 to 2012, eight wind energy production facilities were constructed and became operational to provide approximately 200 megawatts (MW) of renewable energy potential in Hawaiʻi, with a ninth wind farm due for completion in 2020. On August 22, 2019, Hawaiian Electric Company, Inc. issued a request for proposals for the generation of up to 250 MW of additional renewable energy on Hawaiʻi Island, Maui, and Oʻahu, much of which is expected to be proposed through the construction and operation of additional wind energy facilities (Hawaiian Electric 2019). A request for proposals for Molokaʻi on August 6, 2019 specified wind turbines of 100 kW or less as a potential option for renewable energy development (Maui Electric 2019).

Monitoring of wind energy facilities in Hawaiʻi to date has shown that their operation during nighttime hours results in take of Hawaiian Hoary Bats, and that the numbers killed by those facilities are higher than was expected during the initial review of the applications for incidental take of the species. Between 2014 and 2017 several of the authorized wind projects exceeded approved take levels. Based on fatality monitoring and the application of the Evidence of Absence (EoA) model at the 80% credibility level for the assessment of unobserved and indirect take, the calculated take as of June 30, 2019 is 190 bats and the current permitted take for all HCPs in Hawaiʻi is 334.

In order to lawfully operate a commercial wind farm in Hawaiʻi, state and federal incidental take authorizations are required, among other environmental compliance measures. All projects which may result in incidental take under HRS 195D are required to develop and implement an approved HCP and obtain an associated Incidental Take License that specifies their permitted level of incidental take. HCPs integrate development activities with conservation and must be designed to ensure that licensed activities do not appreciably reduce the likelihood of the survival and recovery of at-risk species through establishment of impact avoidance and minimization measures, as well as mitigation efforts to offset take. Mitigation required under HRS 195D must be consistent with established recovery goals, must provide a net environmental benefit, and must increase the likelihood that the affected species will survive and recover from its reduced state.

Development of HCPs for the Hawaiian Hoary Bat is problematic because much of the basic information on ecology and life history of the species that is essential for designing an HCP to meet the requirements under HRS 195D is limited or lacking. Among the six HCPs that have been approved for take of Hawaiian Hoary Bats by wind energy projects, guidance provided, and terms and conditions approved for essential components of the HCPs have varied considerably. Recommended and approved mitigation, minimization, and monitoring requirements, for example, have changed among HCPs as new ecological information has become available. As a result, scale and cost of mitigation has been inconsistent, adding to the challenges faced by applicants seeking to develop HCPs that will meet the requirements for approval by the state. Those challenges are unparalleled among the numerous endangered species for which incidental take is currently authorized or requested in Hawaiʻi, and are a clear indication of the need for consistent guidance developed for Hawaiian Hoary Bats through a scientifically rigorous and publicly transparent process.

C. Process

The ESRC, advisory to the BLNR and the department regarding HCP approval and management, has acknowledged the challenges and inconsistencies regarding HCPs and the Hawaiian Hoary Bat. At the request of the ESRC, a Hawaiian Hoary Bat workshop was held April 14 and 15, 2015 in Honolulu, Hawaiʻi to discuss issues related to Hawaiian Hoary Bat conservation with particular reference to guidance for agencies and applicants seeking to develop and secure approval of HCPs. Participants included Hawaiian Hoary Bat researchers from DOFAW, U.S. Geological Survey (USGS), U.S. Forest Service, University of Hawaiʻi, Pacific Cooperative Studies Unit, and U.S. Fish and Wildlife Service (USFWS), as well as government regulators, consultants, stakeholders, and the public.

This guidance document was developed from the outcome of that workshop and is meant to serve as a "living document" to be revisited and updated by DOFAW staff, with ESRC review and input, at least every five years, or as significant advancements are made in the understanding of Hawaiian Hoary Bat ecology and management. The 2020 version of the Hawaiian Hoary Bat guidance document includes the following additions and modifications from the original guidance document of 2015, in addition to numerous lesser changes:

- Revises Section III, Assessment of Take and Impacts for HCPs;
- Adds additional discussion to Section IV, Hawaiian Hoary Bat Take Avoidance and Minimization Measures, and Section V, Mitigation;
- Updates research on Low Wind Speed Curtailment;
- Adds new Section VI, Adaptive Management;
- Summarizes the research initiatives currently underway in Appendix 1; and
- Provides a checklist of HCP requirements pursuant to HRS 195D in Appendix 3.

This document provides assistance to wind energy project proponents to develop HCPs in compliance with HRS 195D, with discussions on topics related to assessment of take and measures to avoid, minimize, and mitigate effects to Hawaiian Hoary Bats during the development of new HCPs and HCP amendments. It should be supplemented with other guidance, in particular the U.S. Fish and Wildlife Service HCP Handbook (https://www.fws.gov/endangered/what-we-do/hcp_handbook-chapters.html).

A key element for the ongoing evaluation of Hawaiian Hoary Bat issues and updates to this guidance document are annual reports provided by ITL license-holders. Given the importance of these documents, uniformity of reporting is essential. Therefore, a template has been provided for annual reports in Appendix 2.

II. Background

A. Ecology and Status of the Hawaiian Hoary Bat

The Hawaiian Hoary Bat, also known as the ʻōpeʻapeʻa, is an endemic subspecies of the North American Hoary Bat (*L. c. cinereus*) and is listed as endangered under both the federal and state endangered species laws. The Hawaiian Hoary Bat has not been evaluated as a distinct subspecies by the International Union for Conservation of Nature (IUCN), but the subspecies is listed as imperiled by NatureServe. Recent genetic research indicates that hoary bats in Hawaiʻi likely colonized the Hawaiian Islands in multiple events and that there may be two distinct subspecies of Hawaiian Hoary Bats present (Baird et al. 2015, Russel et al. 2015, and Baird et al. 2017). Baird et al. (2015) proposed, and Baird et al. (2017) further argued, that red, yellow, and hoary bats should be placed in separate genera (*Lasiurus*, *Dasypterus*, and *Aeorestes*, respectively) and proposed full species status for the Hawaiian Hoary Bat as *Aeorestes semotus*. Federal and state regulatory agencies may make a listing determination in the future in light of new information but at the present time only one bat species is considered present in Hawaiʻi. In April 2015 the Hawaiian Hoary Bat was officially designated as the state land mammal, and it is in fact the only extant native terrestrial mammal in the Hawaiian Islands.

Due largely to the cryptic and solitary nature of the Hawaiian Hoary Bat, knowledge of its ecology, life history, and population constraints is limited. It is known that the Hawaiian Hoary Bat occurs on all of the main Hawaiian Islands, and breeding populations have been documented on all of the main Hawaiian Islands except for Niʻihau and Kahoʻolawe. Recent studies suggest Hawaiian Hoary Bats roost primarily in woody vegetation exceeding 15 feet in height (Bonaccorso et al. 2015), their diet consists principally of nocturnal aerial beetles and moths (Jacobs 1999 and Todd 2012), and they may use several distinct core use areas, each with a mean size of about 63 acres (25.5 hectares) with little to no overlap (Bonaccorso et al. 2015). Hawaiian Hoary Bats may travel as far as six to eight miles (11 to 13 kilometers) one-way in a night to forage (Jacobs 1994 and Bonaccorso et al. 2015). Additional discussion on core use area is provided in Section IV B.

Hawaiian Hoary Bat population sizes are unknown, and it is generally accepted that it is not feasible at this point in time to ascertain an actual population estimate for a single island or the entire state. Understanding population status and specific habitat requirements of the species has been identified as a primary data need for species recovery (USFWS 1998 and Gorresen et al. 2013). Occupancy models and genetic studies have been and continue to be conducted to attempt to come up with population indices and effective population sizes, although effective population does not necessarily equate to actual population size (Gorresen 2008 and Gorresen et al. 2013). Although population estimates are not currently available, studies suggest that the Hawaiian Hoary Bat population on Hawaiʻi Island may be stable and potentially increasing (Gorresen et al. 2013).

B. Bats and Wind Energy

With the increasing development of wind energy facilities, the number of bat fatalities due to collisions with wind turbines has continued to grow to the point that hundreds of thousands of bats are killed each year nationwide, making wind power a significant threat to the continued survival of these species (Cryan 2011).

Bat collisions and mortality at wind facilities are well-documented throughout the U.S., mostly involving migratory tree-roosting bat species such as silver-haired, hoary, and eastern red bats (Johnson and Strickland 2003, Kunz et al. 2007, Arnett et al. 2008, and Cryan 2011). Arnett and Baerwald (2013) estimated that from 2000 to 2011, between 650,000 and 1,300,000 bats were killed at wind facilities in the U.S. and Canada. Hoary bats have been documented to have the highest proportion of fatalities at most continental U.S. wind energy facilities, ranging from nine to 88 percent of all bat fatalities (Arnett et al. 2008). The national average is about 50 percent, with the majority of collisions occurring between July and September during fall migration, with another smaller peak of fatalities documented during spring migration (Cryan 2011).

Fatality rates vary by facility and the national average has been estimated at approximately 12.5 bats per MW per year (Arnett et al. 2008). It is unclear exactly what is driving these fatalities but factors that may influence bat mortality at wind facilities include bat distribution, behavior (e.g. attraction to turbines), weather, turbine height, habitat degradation or loss, and/or siting near certain topographic or landscape features (e.g. proximity to forest or wetlands). Studies have indicated that tree-roosting bats may be attracted to turbines, potentially due to the resemblance of these structures to tall trees and/or the expectation of resources, such as insect prey or potential mates (Kunz et al. 2007, Cryan et al. 2014, and Gorresen et al. 2015c). Other research has shown bats at wind turbines engaging in flight patterns that resemble those of bats swooping down to drink water, indicating that perhaps bats perceive the smooth surface of the turbine as resembling water (McAlexander 2013).

C. Hawaiian Hoary Bats and Wind Energy in Hawai'i

Take records suggest there may be a seasonal pattern for Hawaiian Hoary Bat collision fatalities, although it is not as pronounced as on the continental U.S. (Figure 1). While it is thought that the Hawaiian Hoary Bat completes a seasonal altitudinal migration on a similar time frame, there are still many questions surrounding timing, and whether bats migrate on all islands regardless of maximum elevation, or perhaps migrate to a lesser extent or not at all on lower elevation islands.

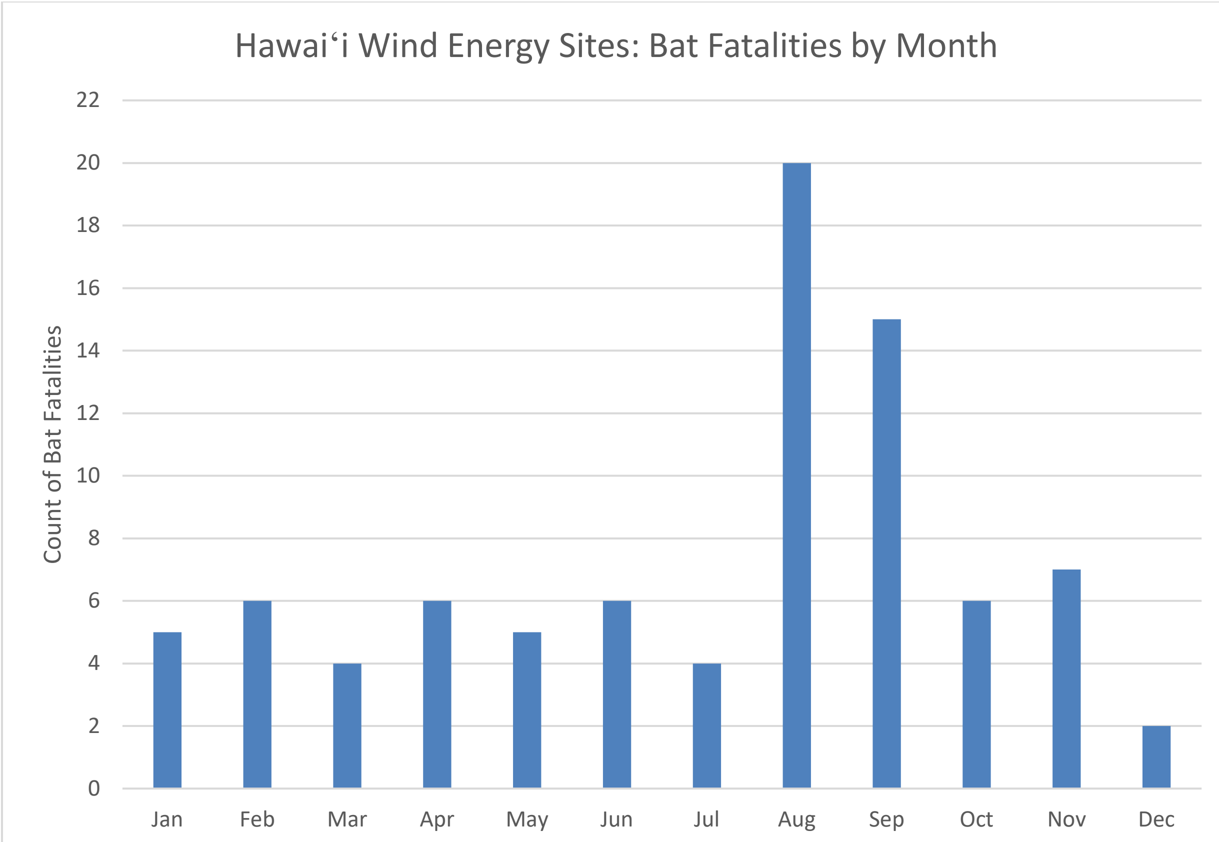

Figure 1. Observed bat fatalities by month across all wind facilities with approved ITLs in Hawaiʻi as of June 30, 2019.

III. Assessment of Take and Impacts for HCPs

A. Overview

Pursuant to statutory requirements in HRS 195D, HCPs should include measures to employ the best available data and methods to determine the number of individuals of the covered species that are expected to be taken during the term of the ITL in order to establish a credible estimated maximum take limit for that license. During the implementation of the HCP, the applicant should conduct appropriate, quantitative field methods to monitor the project for any observed take and employ appropriate analytical techniques and models to assess the calculated actual number taken annually and during the full term of the ITL. To assess potential impacts on endangered species resulting from the take, the HCP should provide for field surveys and monitoring of those species and employ the best available science to assess the full extent of impacts of the take on Hawaiian Hoary Bats in the plan area, on the island, and throughout its range. Resolving those impacts, including cumulative impacts, should result in net recovery benefits for the species, and should not cause the loss of genetic representation or jeopardize the continued existence of any endangered species. Guidance on the development of these measures for HCPs is provided in this section.

B. *Take Calculations*

For wind energy sites to obtain an ITL, a maximum take limit must be identified. For proposed new sites or sites with minimal or no existing Hawaiian Hoary Bat monitoring data, the recommended process for determining the appropriate requested bat take is as follows:

1. Use information from the most comparable wind energy site(s) currently permitted with take data available as a baseline.
2. Adjust the take level based on specific conditions at the proposed new site, including but not limited to: size of turbines and rotors (including tower height and maximum height of blade), wind speeds, results of local or regional Hawaiian Hoary Bat studies, site-specific monitoring (with a minimum of one year of acoustic monitoring in all months, supplemented by thermal imagery monitoring, to gauge the effectiveness of the acoustic monitoring), and ecologic and landscape considerations.
3. Adjust the estimated maximum take, with justification, based on the implementation of any avoidance/minimization proposed.

For existing wind energy facilities with at least several years of monitoring data, a requested take limit should be determined using results of take calculated using Evidence of Absence (EoA) indirect take guidance that has been provided by the USFWS in a separate guidance document (Appendix 4), and bullet 3 above, also adjusting for any factors in bullet 2 that may have changed and that could affect take. For all sites, regardless of prior history, requested take levels should be thoroughly justified with detailed documentation.

Currently, the EoA model developed by statisticians at USGS (Dalthorp et al. 2014, or as updated) for determining incidental take is the model recommended by the agencies and in use by all wind energy projects with permits in Hawaiʻi. This model is designed to estimate take in situations when very few actual observed take events are recorded, as is the case in Hawaiʻi, and is used to project future take and to calculate take at any point in time. The model accounts for both observed and unobserved takes. It incorporates the spatial distribution of the location of carcasses found during monitoring to estimate the fraction of carcasses landing outside the searched area, and includes correction factors for searcher efficiency and carcass removal estimates based on field trials (see Section II C for detailed information on fatality monitoring). With this information the model is then used to calculate a maximum credible number of fatalities. Both DOFAW and USFWS specify the use of 80% credibility levels for a conservative estimate of take. If, for example, 25 bats is the direct take value calculated by the model at the 80% credibility level it can be stated with 80% certainty that the actual amount of take is 25 bats or less.

When using the EoA model to calculate the ongoing take, a *rho* value (when used as a factor by which an adaptive management action may change the fatality rate) should not be applied unless a baseline from site-specific monitoring is first established at a site. To justify the use of a *rho* factor in the EoA calculation, information should be provided on how site-specific or other data were used to determine requested take; specific topics include: average wind speed at site, pre-operational monitoring of bat activity, rotor diameter, nacelle height, and minimization methods (i.e., low wind speed curtailment and/or deterrents).

Annual reports should provide outputs from the EoA model and include a graphical representation of estimated and projected take over the authorized life of the ITL (Figure 2).

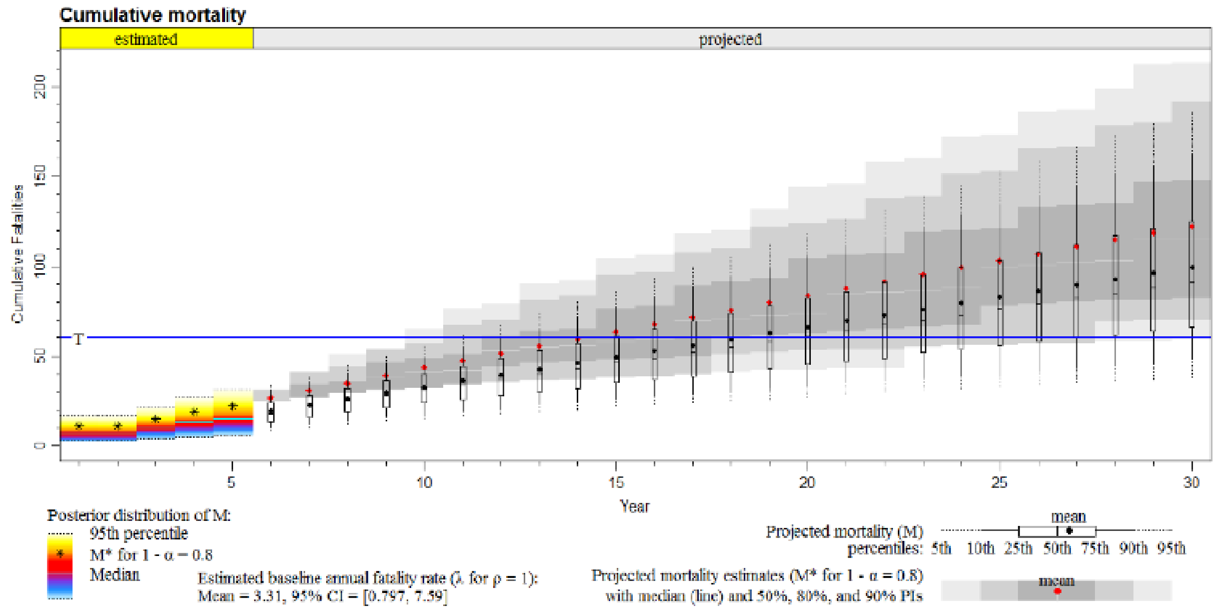

Figure 2. Example of graphic representation of estimated take that should be provided in annual reports. From Evidence of Absence modeling.

Demographic data to calculate indirect take for Hawaiian Hoary Bats are currently limited. Hawaiian Hoary Bat data should foremost be used for analytical purposes; where Hawaiian Hoary Bat data are not available, demographic data from the mainland hoary bat can be used as an appropriate surrogate. Calculations are recommended as described below. Indirect take assessed should follow USFWS guidance (Appendix 4).

C. Fatality Monitoring

Determination of the numbers of Hawaiian Hoary Bats taken under an ITL is essential for compliance with legal requirements under HRS 195D .

Obligations under an HCP include monitoring impacts caused by project activities to ensure compliance with authorized take limitations. For wind farms, a post-construction monitoring plan is designed by the licensee/permittee and must be approved by the wildlife agencies. The method, frequency, size of search plots, number of turbines, and monitoring period are project-specific and dependent on carcass persistence at the site, as well as effectiveness of the searcher.

Fatality monitoring may not represent all individuals killed as some carcasses may 1) fall outside the searched area, 2) be removed by scavengers, 3) deteriorate beyond recognition prior to detection, or 4) remain undiscovered by searchers even when present. Current protocols involve routine searches within a specified distance from the turbine. Hull and Muir (2010) and current findings should be used to determine the fall-out pattern for the fatalities. The maximum height of blade tip and wind direction should be considered when determining the maximum area in which fatalities may fall. A 20% buffer should be added to the outer area during the first few monitoring years to assure coverage is adequate. This is especially important at sites with high wind. There is new data showing that impacted bats fall farther from wind turbines at higher wind speeds (Hein 2017) which has implications for Hawaiʻi wind energy facilities that should be evaluated.

Independent searcher efficiency (SEEF) and carcass removal trials (CARE) are conducted parallel to the search process to estimate probability that a carcass persists until the next search and to estimate the probability that it is then discovered by a searcher. Details of these trials should be provided in HCPs, describing how and when they are to be conducted at a specific site during the year. Treatment of carcasses found during fatality monitoring, or incidental to the regular monitoring, should follow the most current standardized protocol provided by the agencies (Appendix 5). Canine-assisted searches have been demonstrated to provide cost effective and highly efficient searching (e.g. 80-90% of bat trials found, and 97-100% of bird trials found, SunEdison 2014 and 2015) and should be used for all Hawaiian Hoary Bat fatality monitoring and SEEF trials.

Downed wildlife reports for bats should follow the recommended format and content in the most recent Downed Wildlife Protocol (Appendix 5). For bat fatalities the information recorded should include wind speeds, wind directions, temperature, precipitation, moon phase, acoustic detector results (including temporal aspects and call types), and turbine activity for the period between the date the fatality was found and the date of the previous fatality search and, separately, for the fatality search period before that (total of two search periods analyzed). Location of any open water in the area, including watering troughs, should be provided due to the potential to attract bats. Ungulate grazing activity or other relevant land uses in the project area and distances involved should also be provided as there is potential for a relationship with bat activity (Todd et al. 2016). If deterrent devices are installed their operational status during the search period should be reported.

§195D-4(g)(3) provides that the applicant shall cover all costs to monitor the species. To ensure transparency and avoid conflicts of interests, perceived or real, the ESRC recommends that fatality monitoring, SEEF, and CARE trials be carried out by an independent, qualified, third party entity approved by the agencies. Alternatively, for consistency and efficiency of statewide monitoring of Hawaiian Hoary Bat HCPs, DOFAW may wish to procure the appropriate services through a request for proposals process consistent with state procurement rules to carry out those monitoring functions, with the costs to be borne by the applicants.

D. Bat Activity Monitoring

Bat acoustic monitoring at and in the vicinity of wind facilities is necessary to document bat occurrence, habitat preferences at the project site, and seasonal and temporal activity changes that may be associated with take. Monitoring results are expected to help with the development of avoidance and minimization strategies at wind facilities by helping to design smart curtailment regimes or assess the effectiveness of installed deterrent devices.

HCPs should include a description of the experimental design to be employed to monitor Hawaiian Hoary Bat activity in the project area. The description should specify the number and types of devices to be used, the spatial configuration, and the analytical techniques to be used.

The design should be informed by a statistical analysis of the sample size required to detect a given level of change with known level of confidence. The recommended objective is to detect a 20% change in activity in the project area with >80% confidence. The design and methods used should be adaptive, with the results analyzed annually and any modifications employed to achieve the desired level of power to detect the target change.

Acoustic monitoring of bat activity at the site should occur throughout the permit period. Intensive monitoring after the early years of a project may be scaled back if reduced monitoring levels can be demonstrated to maintain acceptable power to establish temporal trends in bat activity through the permit period as well the ability to evaluate bat interactions with wind turbines, to develop methods to more accurately document downed wildlife incidents, and to evaluate adjustment of curtailment protocols. Effective monitoring may also provide information on correlations to other factors that will better inform management decisions. Activity monitoring is recommended at both nacelle and ground levels.

Project proponents should enhance techniques to monitor bat activity at their facilities as new methods become available in order to better understand the impacts of the project on the Hawaiian Hoary Bat, and to potentially reduce impacts by adjusting curtailment protocols based on monitoring results. Research on new monitoring technology could be very beneficial, both to analyze bat interactions with wind turbines as well as to develop methods to more accurately capture downed wildlife incidents.

Newer technologies such as thermal infrared and near-infrared cameras have been used in three studies at wind facilities on the continental U.S. and in Hawaiʻi to observe interactions between bats and wind turbines at night (Horn et al. 2008, Gorresen et al. 2015c, and Cryan et al. 2014). Thermal imaging provides more detailed information about bat behaviors as compared to other monitoring techniques. In Hawaiʻi, during a USGS six-month video surveillance study at the Kawailoa Wind Farm, over 3,000 bat events were observed in almost four thousand hours of video, which was nearly 75% more than detections obtained only with concurrent acoustic monitoring. Bat interactions including chasing blades, investigating nacelles, blade bouncing, foraging near turbines, and some additional unexplained behaviors were documented.

Although video imaging can uncover many interactions between bats and wind turbines, it is not an effective substitute for conducting regular carcass searches at wind energy facilities. The field of view from thermal and infrared cameras is limited; therefore, multiple cameras would be required to adequately monitor each turbine. Furthermore, finding rare events such as bat strikes at wind turbines in Hawaiʻi requires sifting through many hours of data causing a lag time from the time the event occurred to the identification of the event. Due to this lag time, it is unlikely that carcasses would be found to confirm sex, or gather other information, if the monitoring only relied on this search method.

In addition to acoustic or thermal bat activity monitoring, monitoring other weather-related variables such as temperature, wind speed, wind direction, or changing barometric pressure may also be important in determining patterns of observed mortality (Baerwald and Barclay 2011). Moon phase may be important as there is some indication that moon phase may affect how much Hawaiian Hoary Bats use echolocation (Gorresen et al. 2017).

E. Impacts of Take

HRS 195D requires that HCPs include mitigation that will compensate for individuals of a species impacted by the project actions, increase the likelihood that the covered species will recover, contain sufficient information to ascertain with reasonable certainty the likely effect of the plan on the covered species in the plan area and throughout its habitat range, and adequately assess the cumulative impacts associated with the take on the island. The preferred strategy to meet these requirements is to implement mitigation actions designed to offset take of the affected population through enhancement of survival or reproductive success, or both, and to monitor the results of that mitigation to quantitatively confirm its success. Where the impacts of mitigation can be quantitatively assessed with confidence, the impacts of take on the population may be ascertained with reasonable certainty. For the Hawaiian Hoary Bat however, this approach poses significant challenges because of practical and technical limitations associated with quantitative assessment of demographic and population level benefits of mitigation.

Where the impacts of mitigation on take cannot be assessed with reasonable certainty, it is appropriate to explore other approaches to improve understanding of how take may affect the covered species. For example, population models may be used to predict the impact of a given level of take on a population, providing an additional tool to aid planning. Population models may be used to identify levels of take that are likely to cause a population decline, and can be useful to guide HCP planning by allowing the applicant or agency to establish a take limit that is not likely to cause a decline in the population in the event that the effectiveness of mitigation is not known. Population models have been used recently to examine the potential population impacts of take of several mainland species (Frick et al. 2017). Those models were used to predict population responses to mortality resulting from take by wind turbines and to assess the sensitivity of model inputs on the outcomes of the simulations.

Population models for the Hawaiian Hoary Bat are expected to be considerably less robust than those reported by Frick et al. (2017) for mainland species because the demographic information needed to inform those models is poorly known and imprecise for Hawaiian Hoary Bats. While this currently limits the predictive ability of the models, useful results and insights may nevertheless be gained from their development. The ESRC conducted preliminary population viability assessments using Vortex to identify (1) specific population dynamics parameters that are needed to conduct an acceptable population viability analysis (PVA), (2) particularly impactful parameters that should be prioritized for research, and (3) general trends or outcomes that could inform discussions on the impacts of wind projects on the Hawaiian Hoary Bat. Those models used plausible values for demographic inputs based on best available data to explore potential impacts on Hawaiian Hoary Bat populations, examining how impacts would differ for Hawaiian Hoary Bat populations depending on the starting size of a population, whether suitable habitat is limited, and whether that population was stable, increasing, or decreasing at the onset of take. While the models are not meant to predict the outcome of take for any given application, they do suggest what scenarios may be expected under certain circumstances. A detailed account of those exploratory efforts is provided in Appendix 6.

Based on the preliminary models explored by the ESRC, the following recommendations are provided:

1. That additional research is supported to improve estimation of life history and demographic variables that inform the population models.
2. That additional efforts are supported to explore population models for the Hawaiian Hoary Bat that employ alternative assumptions and approaches.
3. That applicants and agencies, in assessing cumulative impacts to Hawaiian Hoary Bat populations resulting from take, should, until such time as the best available science informs otherwise, adopt prudent and relatively conservative assumptions regarding Hawaiian Hoary Bat populations. Until data to the contrary are obtained, analyses should, as a minimum, include the following conservative assumptions:
    a. that Hawaiian Hoary Bat populations on each island are stable or slightly increasing (i.e., a 0 to 1 percent annual population increase as found by Gorresen et al. (2013)),
    b. that compensatory reproduction is not occurring (because no studies have shown that compensatory reproduction is occurring), and
    c. that an annual rate of take that exceeds the annual rate of increase of a population is likely to cause a decline in the population. For example, if the pre-project population is thought to increase by one percent annually then the take of more than one percent of the population annually would be expected to cause a declining population; similarly, if a population is stable, then any take would be expected to result in a comparable population decline.
4. That applicants and agencies should assume, until such time as the best available science informs otherwise, that the Hawaiian Hoary Bat populations on Oʻahu, Maui, and Hawaiʻi are not more than 1,000, 1,500, and 5,000 bats, respectively.
5. That cumulative levels of take exceeding the annual rate of growth of the assumed population sizes for each island should not be authorized unless the expected net benefits to Hawaiian Hoary Bat recovery outweigh the potential losses from take.

Additional details of the exploratory models employed are provided in Appendix 6.

F. *Use of Tiers*

From 2006 to 2018, the BLNR and the USFWS approved six HCPs for wind energy projects that included authorization for incidental take of Hawaiian Hoary Bats. Due to high levels of uncertainty regarding the levels of take projected, unknown effectiveness of projects approved as compensatory mitigation, and the expectation that the results from ongoing research would provide improved guidance for HCP development and implementation, the approved HCPs structured take levels into sequential tiers, each with associated plans and conservation measures. The tiered approach was meant to provide the HCPs with flexibility to implement the appropriate suites of conservation measures in the face of unknown take probabilities and uncertainties in the effectiveness of the minimization measures to be employed.

The ESRC acknowledges the rationale and utility of this approach for early HCPs. In and of itself, the use of tiers to define an incremental approach to the implementation of conservation measures, as part of an otherwise effective and compliant HCP that authorizes an appropriate level of take, may serve a functional purpose. However, the ESRC cautions that the use of tiers may not be consistent with state law and that the use of tiers may have negative outcomes. Inappropriate uses of tiers may include:

- Use of tiers to avoid financial assurances. HRS 195D requires that the applicant identify an adequate funding source (i.e., bond, irrevocable letter of credit, insurance, or surety bond, or provide other similar financial tools) to ensure that the HCP will be implemented in accordance with the schedule, and that the applicant guarantee that those funds will be available. These assurances are required for all authorized take, including all tiers.
- Establishment of tiers that are unjustifiably low. If the initial tier levels are lower than the expected or actual take levels, the project may not be able to meet its statutory requirements during the permit period. For example, use of a tier that is well below the actual take will effectively delay the implementation of the mitigation measures that are ultimately required to compensate for that take, jeopardizing the effectiveness of mitigation, and placing the covered species at risk.
- Establishment of tiers that effectively create a "pay as you take" situation. Establishing tiers that simply keep pace with estimations of take are likely to have tiers triggered late in the permit period. These late triggers will have limited mitigation options and may result in the selection of less desirable conservation actions. For example, habitat restoration may take over a decade to be realized. Tiers that are triggered within a decade of permit expiration are not likely to be able to use restoration as a mitigation tool.

While tiers may theoretically be an incentive for the adoption of more effective minimization and mitigation efforts, tiers can also be a disincentive. This is of particular concern if the total authorized take is not minimized to the maximum extent practicable. Incidental take licenses are intended to identify, and then authorize, the amount of take that an approved activity is likely to have after take has been minimized to the maximum extent practicable. The authorization of take levels that are either excessive or deflated is inappropriate. Underestimating a project's take negatively impacts endangered species, while overestimating take reduces the flexibility of future projects and unnecessarily burdens the current HCP, unless tiers are used to reduce financial assurances or expenditures. In addition, if the requested level of take is higher than the take level that can be achieved by effective minimization the HCP may be inconsistent with statutory requirements to minimize to the maximum extent practicable. Authorized take that is higher than what can be achieved through minimization may also compromise regulatory provisions to ensure that the minimization measures are employed to the maximum extent practicable and that adaptive management is diligently applied to enhance the effectiveness of those measures.

For these reasons, the ESRC recommends that tiers are not used.

IV. Hawaiian Hoary Bat Take Avoidance and Minimization Measures

A. Overview

State law requires that any incidental take authorized as part of an approved HCP is minimized to the maximum extent practicable (§195D-4-(g)(1)), and that any approved HCP identifies the steps that will be taken to minimize take (§195D-21(b)(2)(C)). Pursuant to this section, HCPs submitted for consideration for approval are expected to contain a description of all measures that will be employed to minimize take to the maximum extent practicable and an analysis to demonstrate how those measures constitute the maximum practicable extent of minimization. The data and information that justify the basis for the determination of the maximum practicable extent of the minimization should be provided, including, but not limited to, energetic and economic thresholds that may be impacted by the potential minimization measures, as may be appropriate.

The discussion below provides guidance for the inclusion of selected considerations, practices, or tools that may be employed to reduce take resulting from the operation of wind turbines. The basic principles to be considered for avoidance and minimization are as follows:

- Take should be minimized to the maximum extent practicable. A range of alternatives should be presented that evaluate projected take and are supported with detailed data and reasoning.
- Given the unknown effectiveness of compensatory mitigation measures to offset take, ceasing operations and feathering of rotors from one hour before sunset to one hour after sunrise should be considered to avoid take of Hawaiian Hoary Bats.
- Avoidance and minimization efforts should have a robust adaptive management strategy to ensure that changes and adjustments are employed to increase effectiveness when minimization targets are not being met or when new tools and methods become available.

B. Project Siting

An important consideration during the planning phase for a wind energy project is the siting of the facility. Records available for Hawaiian Hoary Bat strikes by wind turbines in Hawaiʻi suggest significant differences in collision rates among sites. However, the environmental correlates or causes of these differences are currently not well understood. Additional research is needed to understand why some sites are likely to result in higher take so that predictive models can be developed at landscape scales to guide siting decisions. Pending those improved decision tools, applicants for HCPs/ITLs should demonstrate that they have considered various locations and turbine layout configurations and evaluated in detail the advantages and disadvantages of each when considering the potential effect on the Hawaiian Hoary Bat. Some of the factors that should be considered when siting wind energy projects include the following:

- Wind characteristics including a determination of how much a facility can minimize Hawaiian Hoary Bat incidental take through curtailment.
- Proximity to habitat suitable for listed endangered species including Hawaiian Hoary Bats.
- Monitoring to assess Hawaiian Hoary Bats and other listed species presence, activity, and use of the potential project areas based on prior research and project-specific monitoring (minimum acoustic monitoring of one year in all months and supplemented with thermal imaging during high activity months).
- Topographic and habitat features that may be suitable for the Hawaiian Hoary Bat.
- Land use adjacent to the proposed project area, including proximity to federal, state, and private reserves and conservation areas.
- Restoration in the area which could attract bats.

- Vegetation types.
- Presence of water features.
- Climate records.

Other concerns are related to the foraging behavior of hoary bats. Cattle grazing and the resulting manure attracts dung beetles. A large portion of the Hawaiian Hoary Bat diet is comprised of beetles. There is anecdotal evidence that the presence of dung beetles in the vicinity of a wind facility may create an attractive nuisance and draw in foraging bats, putting them at risk of collision with turbine blades. A review of bat fatalities at the Auwahi wind farm on Maui did not find a relationship between fatalities and grazing (Auwahi Wind 2019). Researchers with USGS are currently investigating the possibility of a link between grazing and bat activity.

C. Turbine Specifications

Bat foraging behavior may be influenced by the turbines themselves because of 1) an attraction of bats to the turbine for various reasons, most unknown, 2) attraction of insects to the turbine, or 3) perceived insect source by the bat, regardless of insect availability. Turbine design may help reduce attractiveness.

Barclay et al. (2007) found that fatality rates of bats were relatively low at short turbines (less than 65 meters high), but bat fatalities increased exponentially with turbine height. The range of tower heights examined varied from 25 to 80 meters. The highest bat fatality rates occurred at turbines with towers 65 meters or taller, with the potential explanation being higher towers elevated turbines into altitudes with more migrating bats. It is not clear if Hawaiian Hoary Bats fly at high altitudes when they move from site to site and could be impacted similarly.

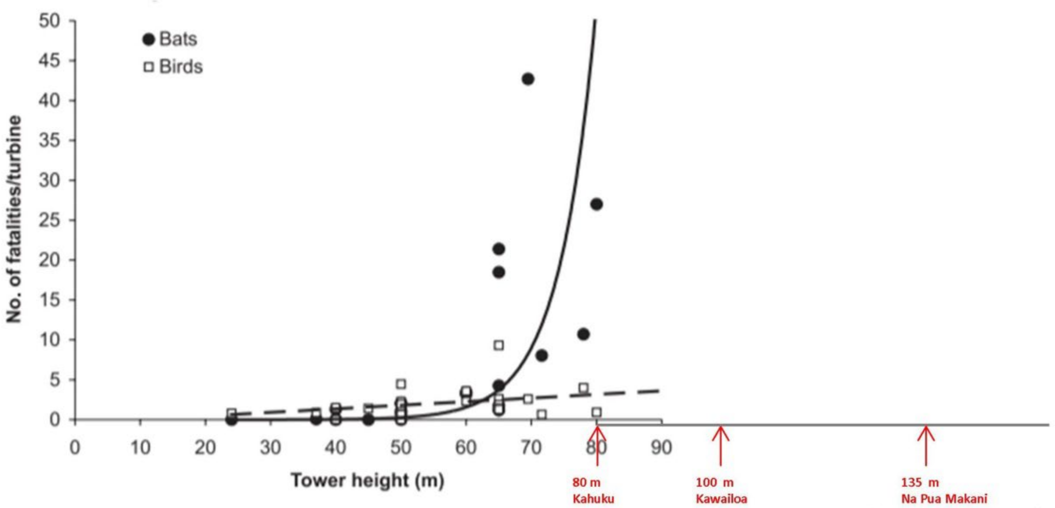

Figure 3. Adapted from Figure 1 in Barclay et al. 2007 and modified to show tower heights for existing (Kahuku and Kawailoa) and under construction (Na Pua Makani) wind farms on Oʻahu.

A more recent study (Zimmerling and Francis 2016) found no relationship between turbine height and bat fatalities for the very narrow range of turbine heights examined, which only varied by 37 meters (99 meters to 136 meters). Importantly, Zimmerling and Francis's (2016) definition of turbine height included the height of the blades, whereas Barclay et al. (2007) examined just tower height. On Oʻahu, this narrow range would only capture the Kahuku wind farm turbines at 127 meters turbine height including the blades. The turbines at the Kawailoa wind farm and those approved for the Na Pua Makani wind farm are significantly above the range examined by Zimmerling and Francis (2016). Kawailoa's turbine height including blades is 150 meters and Na Pua Makani's will be approximately 173 meters.

The Barclay et al. (2007) study also looked at rotor size, but did not find a relationship between mortality and turbine rotor diameter. However, a series of studies at the Fowler Ridge wind farm (Good et al. 2011, 2012, 2018, and 2019) found higher bat mortality at Siemens and Clipper turbines than at GE and Vestas turbines which had smaller rotors. This pattern was thought to potentially be a function of increasing rotor swept area among the different turbines and/or variation in the spin-up and spin-down behavior of turbines from the different manufacturers. The follow-up studies in 2017 and 2018 (Good et al. 2018 and 2019) provided data that show a pattern of turbines with increased rotor size progressively killing more bats (Figure 4). It should be noted that the authors in these later studies did not identify a causal factor for these patterns. Additional studies are needed that include comparing the impacts of different rotor sizes from a single manufacturer and from sites that have a more random distribution of turbines across the landscape. However, based on evaluation of these recent data (e.g., Good et al. 2018 and 2019), estimated take could be expected to be greater for turbines with larger rotors in Hawaiʻi.

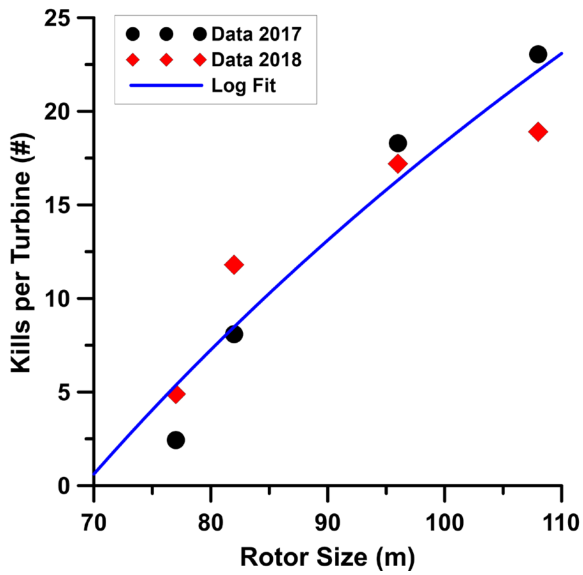

Figure 4. Rotor size and associated bat fatalities. Fatalities over two years for four different rotor sizes (from four different manufacturers) employed at the same nacelle height and under the same experimental treatments. Data from Good et al. (2018 and 2019).

D. Turbine Operations

1. Curtailment

Operational adjustments that curtail the time that turbines are rotating may reduce the number of bats struck by those turbines. Timing of curtailment may be designed to take advantage of known factors that may influence the probability of bats striking particular turbines. Known factors may include time of night, weather, wind speed, location, or seasonality of bat activity. Hawaiian Hoary Bats are nocturnal so curtailment of turbines during night time hours is expected to reduce take. Additional factors to guide curtailment are discussed below.

2. Low Wind Speed Curtailment

Low wind speed curtailment (LWSC) is a twofold strategy of raising the wind speed at which the blades begin spinning and generating electricity, also known as the cut-in speed, and feathering turbine blades (i.e., positioning the blades parallel to the wind) to slow or stop rotation. Under LWSC, wind capable of producing energy is available, but is not being converted to electricity and supplied to the grid. Curtailment can be imposed on a wind energy facility by the receiving utility company if the grid has reached capacity, or can be implemented by the wind facility operator, for instance, to minimize risk of incidental take. For the purposes of this guidance document, we use the term LWSC to refer to facility operator-imposed curtailment of blade rotation. Although LWSC reduces energy output, there is strong scientific evidence that bat fatalities, especially fatalities of migratory bats, are reduced on the U.S. mainland when LWSC is implemented compared to bat fatalities at facilities with no LWSC. Curtailment is currently the primary minimization measure implemented by wind farms in the U.S., including those in Hawaiʻi.

Various studies in the U.S. and Canada have attempted to assess the relationship between wind turbine cut-in speeds and the number of bat fatalities. Results from studies conducted across numerous ecosystems and facilities have consistently shown a decrease in fatalities of over 50 percent once cut-in speeds are equal to or greater than 5.0 meters per second (m/s). Based on these and other published data, curtailment with feathering has been implemented at all wind facilities with federal and state incidental take permits in Hawaiʻi either from the outset of operation as a minimization measure, or as an adaptive management response to higher than expected levels of take. Below is a summary of mainland studies on LWSC, including some newer studies not considered in the previous version of this guidance.

Baerwald et al. (2009) conducted a study during the peak period of migration (August 1–September 7, 2007) for hoary bats (*Lasiurus cinereus*) and silver-haired bats (*Lasionycteris noctivagans*) at a wind energy installation in southwestern Alberta, Canada, where the two bat species accounted for the majority of turbine-related fatalities. They tested three treatment groups: control turbines, treatment turbines with an increased cut-in speed (5.5 m/s), and experimental idling turbines with the blades manipulated to be motionless during low wind speeds. When the group combined the two experimental treatment results and compared them to control turbines, they concluded that the experimental turbines had lower fatality rates for each species.

The Fowler Ridge wind facility in Indiana has conducted a large number of important studies on LWSC. These studies have reported statistically significant reductions in bat casualty rates (bats per turbine per season) for sets of turbines curtailed at 3.5 m/s, 5.0 m/s, and 6.5 m/s, respectively (Good et al. 2011) and at 3.5 m/s, 4.5 m/s, and 5.5 m/s (Good et al. 2012). These studies have shown the value of feathering turbines when they are not generating power (Good et al. 2012). The two other wind farms, Casselman and Pinnacle, that have compared LWSC at both 5.0 m/s and 6.5 m/s also generally found increasing benefit from curtailing at 6.5 m/s versus 5.0 m/s, but the differences were not statistically significant (Arnett et al. 2010 and Schirmacher et al. 2018). Hein et al. (2013 and 2014) proposed that a lack of wind speeds between the 5.0 m/s and 6.5 m/s treatments may have made it difficult for the Casselman and Pinnacle studies to differentiate between those treatments. In contrast, the Fowler Ridge study had a good set of wind speeds with which to differentiate treatments, with the 5.0 m/s treatment operating 21.6 percent less than the fully operational turbines and the 6.5 m/s treatment operating 42 percent less than fully operational turbines.

Young et al. (2011) found that feathering the blades to reduce the rotational speed of turbine blades at or under the manufacturer's cut-in speed of 4.0 m/s significantly reduced bat fatalities. Young et al. (2013) saw a 62% reduction in bat fatalities when feathering was implemented at 5.0 m/s and below, though the study was a comparison made across two years—2011 (no feathering) and 2012 (with feathering)—and assumes that other factors that may influence bat fatalities were the same in years 2011 and 2012. In the feathering study at Fowler Ridge, Good et al. (2012) found that turbines that feathered at 3.5 m/s, 4.5 m/s, or 5.5 m/s had significantly fewer fatalities than turbines that were not feathered. Fatalities decreased with each feathering increment.

At Casselman Wind Project, Arnett et al. (2009, 2010, and 2011) showed an average reduction in bat fatalities of 72 to 82%, depending on year, with the implementation of curtailment and blade feathering when compared to no curtailment. Hein et al. (2014) reported a 54.4% and 76.1% reduction in bat fatalities from a base cut-in of 3.0 m/s for the 5.0 m/s and 6.5 m/s curtailment treatments, respectively, although the two treatments were not shown to be statistically different from each other.

Arnett et al. (2013a) synthesized the results of ten wind energy projects in North America and identified only one study in Sheffield, Vermont that found increasing cut-in speeds to 6.0 m/s resulted in a 60% reduction in bat fatalities relative to that observed at turbines with a cut-in speed of 4.0 m/s. A study conducted at Beech Ridge, West Virginia, found a bat fatality reduction of approximately 89% when all turbines were curtailed at 6.9 m/s for the study, but the reduction was based on a comparison with other facilities, Mount Storm and Mountaineer, that were not curtailing. The study was not a comparison with other turbines at the Beech Ridge site, nor were other cut-in speeds evaluated (Tidhar et al. 2013). Arnett et al. (2013b) also reported the results from a wind farm in USFWS Region 8. Compared to the bat fatalities at turbines set to a cut-in speed of 3.0 m/s, the following reductions in bat fatalities were obtained: 34.5% at 5.0 m/s, and 38.1% at 6.0 m/s during the first four hours after dark, neither of which were statistically significant.

Good and Adachi (2014) reported that the effectiveness of curtailment speeds can depend on the deceleration and acceleration profile of the specific turbine model.

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. They found that wind speed and blade rotation speed influence the way that bats approached turbines. Bats approached turbines less frequently when their blades were spinning fast, and the prevalence of leeward versus windward approaches to the nacelle increased with wind speed at turbines with slow-moving or stationary blades. Leeward approaches declined when the blades were rotating. They also observed that tree bats show a tendency to closely investigate curtailed or feathered turbines and sometimes linger for minutes to hours. This observation suggests the possibility that bats are drawn toward turbines in low winds, but sometimes remain long enough to be put at risk when wind picks up and blades reach higher speeds. Therefore, the frequency of intermittent, blade-spinning wind gusts within such low-wind periods might be an important predictor of fatality risk; fatalities may occur more often when turbine blades are transitioning from potentially attractive (stationary or slow) to lethal (fast) speeds.

Curtailed wind turbines typically use a 10-minute rolling average to determine mean wind speed and trigger rotation, feathering, or curtailment. Schirmacher et al. (2016) evaluated increasing the length of time used for determining the average wind speed from 10 minutes to 20 minutes. The premise behind increasing the rolling average to a longer period of time was that it would decrease the number of turbine starts and stops and thereby decrease the number of bat fatalities associated with bats being in the presence of non-moving or slowing rotating feathered blades when they unfeather and begin to rotate rapidly in higher winds. Schirmacher et al. (2016) reported fewer bat fatalities were observed with a 20-minute rolling average based on wind speed at the meteorological tower anemometer though they were not able to separate fatality risk due to low wind speeds (5.0 m/s) verse risk at start up. Their results also suggested that using average wind speeds from anemometers located at the meteorological towers rather than on turbine nacelles may reduce bat fatalities. Efforts to minimize bat fatalities at wind facilities might benefit by averaging wind speed curtailment thresholds over longer periods of time (e.g., less 10 minutes) to prevent gusts from intermittently pushing blades to lethal speed during low wind periods.

Foo et al. (2017) provided evidence that some species of bats, including hoary bats, do forage at wind turbines. Insects often accumulate on the downwind sides of natural and artificial windbreaks, and tend to increase in number and density with wind speed (Lewis 1965 and 1969).

3. *Summary of Curtailment of Wind Turbines*

The effect of cut-in speeds higher than the 6.5 m/s are difficult to assess in Hawaiʻi because of the 1) large uncertainty associated with estimating fatalities for a rare event, 2) lack of surrogate species that can be used in Hawaiʻi for estimating take of the bat and demonstrating real treatment differences, 3) lack of statistical power because of small project size and high site variability, 4) unknowns surrounding Hawaiian Hoary Bat flight behavior, 5) existing power purchase agreements already in place, and 6) the impacts of an increased cut-in speed on reduction in renewable power production.

Although no studies on the effectiveness of curtailment have been conducted in Hawaiʻi, there is sufficient evidence from research conducted across multiple ecosystems in the continental U.S. that support its use as a minimization measure. An overall comparison of curtailment results shows that there is a general increase in benefit (i.e., a decrease in mortality) as curtailment wind speed increases (Figure 5). Paired results from mainland studies are summarized in Figure 6.

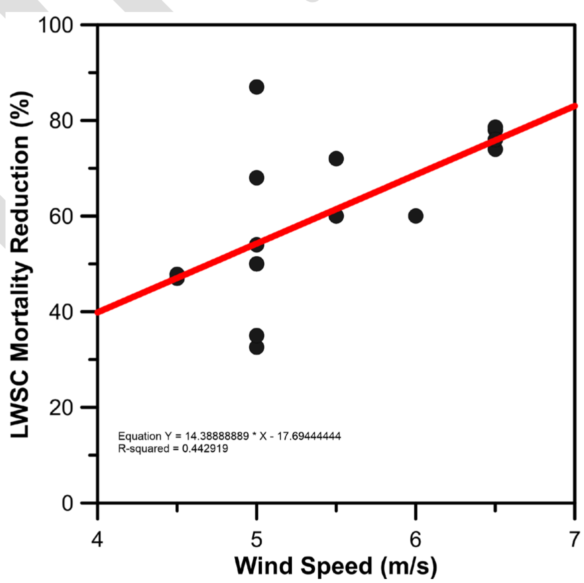

Figure 5. The relationship between curtailment wind speed and bat mortality. There is a general increase in mortality reduction as curtailment wind speed increases.

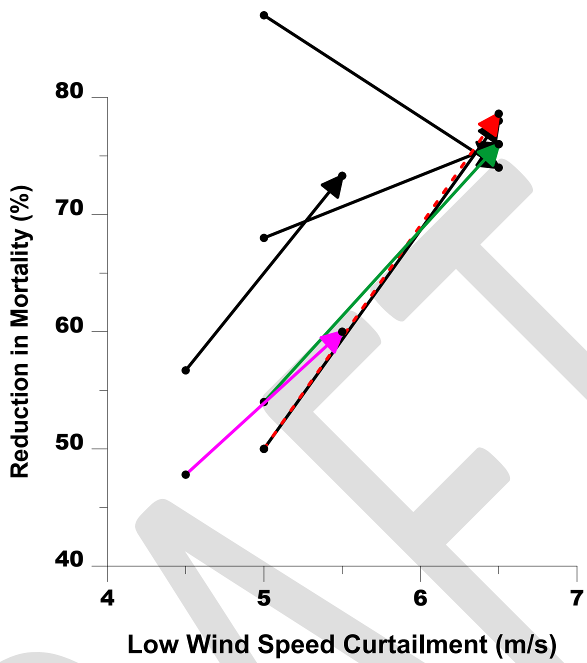

Figure 6. Project trends for eight mainland U.S. studies with incremental increases in LWSC. Seven of the eight studies showed increasing trends as LWSC increases. One study did not.

Based on these findings, LWSC should be a part of every wind facility's minimization strategy to the maximum extent practicable. HCPs should describe in detail the considerations used to develop a cut-in speed for LWSC, including economic considerations. A cut-in speed of 6.5 m/s is suggested based on the mainland studies. With a minimum cut-in speed of 6.5 m/s, a reduced take request may be justified with a detailed rationale. In any case, given the status of the Hawaiian Hoary Bat in Hawaiʻi and the studies available, a minimum cut-in speed of 5.0 m/s should be implemented, with higher cut-in speeds up to or exceeding 6.5 m/s implemented when the cumulative take of Hawaiian Hoary Bats poses a risk to island populations. Higher curtailment speeds have already been implemented by several wind projects in Hawaiʻi as part of adaptive management actions aimed at reducing higher-than-anticipated rates of take. Such adaptive management responses should be continued.

If deterrence technology becomes more effective and available, the need for curtailment efforts may be reduced. The permittees should collect, analyze, and report data on the effectiveness of curtailment practices in their annual reports.

Curtailment protocols and triggers for increasing curtailment are included below in the adaptive management section of this guidance document and should be specified in detail in all HCPs.

Unlike the seasonal-related vulnerability associated with migratory bats on the U.S. mainland, Hawaiian Hoary Bats may transgress or be active around turbines at Hawaii-based wind farms year-round, thus curtailment should be deployed year-round at the permitted wind facilities in Hawaiʻi, unless it can be clearly shown that bats are less active at a particular site during certain months and no takes have previously occurred in those months. This creates a larger loss of renewable energy per turbine than wind farms operating on the U.S. mainland when considering the typical 20-year term of an ITL and/or ITP.

4. *Other Operational Factors*

Other important operational factors that may affect bat mortality and that should be described and analyzed in HCPs for proposed wind turbines:

- Turbine manufacturer.
- Turbine height.
- Rotor size and sweep area. Feathering of rotors when not generating power should be a standard minimization action for all wind projects.
- Turbine behavior prior to reaching cut-in speeds, including specific cut-in speeds, acceleration, deceleration, and free-wheeling rates. Nacelle wind meters should be calibrated to reflect actual wind speeds at the turbine site.
- Criteria used to determine that wind speed has reached cut-in speed to include wind speed measurement location and trigger (e.g. rolling average time used in calculation of wind speed).
- Daily times of cut-in/out and average daily time in feathering mode by season for turbines already in operation.
- Wind speeds and relationship to bat activity as measured by acoustic or thermal sensors.
- Siting considerations as specified above in Section III B.
- A discussion of minimization of Hawaiian Hoary Bat take through optimizing turbine manufacturer, rotor size, turbine power output, and number of turbines needed to reach the power production target.

For existing wind turbines with Hawaiian Hoary Bat take a thorough analysis of previous take is required to determine any patterns that might be affecting take and that could provide opportunities for minimization. These should include the following:

- Spatial considerations (specific locations/turbines where fatalities were found) and temporal considerations (patterns related to time of year).
- Weather (wind speeds and other weather prior to take) and lunar phases.
- Acoustic monitoring results prior to take.
- Operational characteristics of turbines in periods prior to take (number of turbine starts and stops and how the trigger is determined for starts and stops; whether blades are completely stopped during curtailment; specific start and stop times for curtailment and how related to measured bat acoustic activity and the area).

- Surrounding area practices that may influence bat activity (description and location of any grazing within, for instance, one mile of the turbines; location and description of any open water such as cattle troughs that may have been brought into the area; and any other recent activities and changes in the vicinity of the turbines).

E. Bat Deterrence Technology

Bat deterrence technology refers to any device, feature, or modification that uses visual or acoustic means to reduce the numbers of bats that are struck by wind turbine blades. Technologies currently in research and development that hold promise to serve as cost effective tools in reducing the numbers of bats killed by wind turbines include ultrasonic acoustic deterrents and ultra violet (UV) light deterrents. Deterrence provides an alternative approach to reduce take that may not require curtailment of operations and associated impacts to energy production. However, while a number of new technologies have emerged designed to deter bats from coming in close proximity to turbines, additional testing and development are needed to inform planning and deployment for the Hawaiian Hoary Bat.

Acoustic deterrents have been in development and testing since 2006 and have shown generally positive results thus far. A description of bat acoustics and acoustic deterrent technology is summarized in a workshop document: Acoustic Deterrent Workshop National Wind Technology Center, Louisville, CO, August 26, 2013 https://www.energy.gov/sites/prod/files/2015/03/f20/Deterrent-Workshop-Proceedings_Final.pdf. The acoustic deterrents are devices that emit continuous high frequency sounds. The workshop document describes a fundamental impediment to acoustic deterrents which is the short distance that acoustic signals at the needed frequencies will travel. Attenuation due to higher humidity was also an issue noted. For Hawaiian Hoary Bats, Gorresen et al. (2017) recorded that the range of calls in their study was a mean of 29.3 kHz and the 95th percentile of peak frequency was at 38.1 kHz. Acoustic deterrent signals must be well above those frequencies to "jam" bat signals and deter bats, rather that attract them to the source to investigate.

Arnett et al. (2013b) conducted two trials at a wind facility in Pennsylvania, with results the first year showing 21 to 51 percent fewer bat fatalities when deterrents were deployed, and results the second year showing 18 to 62 percent fewer fatalities. Weaver et al. (2019) found a 78 percent reduction in hoary bat mortality over two years for an acoustic deterrent system. This system was recently deployed at the Kawailoa wind farm on O'ahu, with deterrent units installed on all 30 turbines in 2019. Kawailoa is the first wind facility employing the use of commercial acoustic bat deterrents as a minimization strategy not only in Hawai'i, but in the U.S.

Additional current and ongoing deterrence research coordinated by the Bats and Wind Energy Cooperative and funded by various partners is summarized in presentations given in March 2018 and available at the following website: https://www.nationalwind.org/status-findings-developing-technologies-bat-detection-deterrence-wind-facilities. The studies included the following:

- Rotor-mounted, Ultrasonic Bat Impact Mitigation System study;
- Rotor-mounted Biomimetic Ultrasonic Whistle;

- Ultrasonic Acoustic Deterrent using a High Speed Jet Device;
- Testing and Comparability Studies at two facilities (Ohio and Texas) with various treatments; and
- Texturizing Wind Turbine Towers to Reduce Bat Mortality.

The only acoustic deterrent study conducted in Hawaiʻi was at a macadamia nut farm on Hawaiʻi Island by Hein and Schirmacher (2013). This study found a significant decrease in bat acoustic detections when the deterrents were operating (a reduction from 3,814 calls to 10), with activity levels returning to pre-treatment levels immediately following the removal of the deterrent devices. There was also no indication of habituation found in any of the studies.

Based on previous studies demonstrating that some species of bats can perceive bright UV light, two studies by Gorresen et al. (2015a and 2015b) were conducted in the western U.S. to determine if 1) dim UV light was perceptible to bats and 2) if bat flight behavior would be impacted by UV light. The first study demonstrated that multiple genera of bats can perceive dim UV light, at levels imperceptible to humans and many avian species. The second study was conducted at the same macadamia nut farm on Hawaiʻi Island where the aforementioned acoustic deterrent surveys took place. Although not all analysis results were statistically significant, bat calls, bat feeding buzzes, and visual observations of bats at treatment sites declined by 25 to 44 percent as compared to control sites, despite the fact that insect abundance increased. The researchers noted that bat activity was not highly associated with insect abundance, and bats did not appear to have been drawn in by the insects attracted by UV illumination. They hypothesized that the insects were dispersed within the treated airspace to a degree that may not draw the attention of foraging bats. These results indicate that the technology is promising and warrants further study.

Finally, physical modifications to the turbine towers and blades (modifying surface texture) has also been evaluated in a preliminary study as a technique to make turbine towers less attractive to bats based on unpublished research by researchers at Texas Christian University. The work to date has been inconclusive.

Given the relatively high levels of take projected for Hawaiian Hoary Bats in Hawaiʻi, and the uncertainties regarding the effectiveness of mitigation to compensate for that take, research, testing, and deployment of effective deterrents are a high priority. This should be accomplished by 1) including the use of deterrents as part of all HCPs, and 2) investing in deterrent research to support the development and improvement of effectiveness. Agencies should aggressively pursue funding opportunities to support development of deterrents, including application for state and federal grants, such as the HCP planning grants offered under the Cooperative Endangered Species Conservation Fund (https://www.fws.gov/endangered/grants/index.html).

V. Mitigation

A. Overview

HRS 195D requires that each HCP include mitigation measures that result in an overall net gain in the recovery of any species for which take cannot be avoided, the measures that will be implemented to achieve those benefits, and a justification for how the proposal will achieve net recovery benefits. In general, the net benefit requirement is best achieved through the implementation of conservation measures for which quantitative monitoring demonstrates that individuals of the covered species have been effectively added to the population, and that the number added exceeds the number taken. The conservation measures employed may target threats or limiting factors with the objective to increase survival or reproductive success above a known level that would be expected in the absence of mitigation.

Identification of mitigation actions to offset take as described above are challenging for the Hawaiian Hoary Bat because threats and factors that limit the bat population are unknown. Specifically, at the present time, there are no data to infer with statistical confidence an effect on Hawaiian Hoary Bat population dynamics resulting from implementation of conservation measures to address a threat or limiting factor. These challenges are compounded by the limitations inherent in the tools available for the detection of changes in population demographics. As a result, interim mitigation approaches must be identified that comply with applicable sections in HRS 195D.

The discussion below provides guidance for the development of mitigation plans for the Hawaiian Hoary Bat in light of the challenges and uncertainties described above. The overall approach integrates best available science and management practice to enhance efficacy, research to improve understanding of threats and limiting factors, biological monitoring to measure and track success, and adaptive management to improve effectiveness as new information becomes available.

B. Mitigation Planning Framework

The recommended framework for mitigation plans includes the following elements:

- Biological goals and objectives that establish specific, measurable outcomes that describe the targets that the mitigation is expected to achieve and serve as the measures of success.
- Implementation plans that specify how the work will be accomplished to reach the targets and include a schedule of activities.
- Monitoring plans that establish schedules of activities designed to assess progress toward goals and objectives, with time-specific targets that will provide a meaningful indication of whether the implementation is successfully on track to achieve success.
- Adaptive management approaches that are based on the results of monitoring and describe alternative actions that will be implemented if mitigation targets aren't being reached by the proposed implementation actions.

Additional guidance on compensatory mitigation is provided by the USFWS in their 2016 Endangered Species Act Compensatory Mitigation Policy (81 Federal Register 248, pp. 95316-95348).

C. Mitigation Recommendations

It is expected that Hawaiian Hoary Bats are adapted to habitats that support natural complements of species composition, richness, and diversity. There are also data to indicate that Hawaiian Hoary Bats may use habitats and species that are not indigenous to the Hawaiian Islands for foraging, roosting, and breeding. Based on these assumptions and observations, the following framework is recommended:

- Protection of currently suitable, predominantly native forest habitat that is threatened with loss or degradation;
- Restoration of degraded habitats to predominantly native forest habitat;
- Inclusion or incorporation of non-native species or habitat features only when they have been demonstrated to provide recovery benefits into a predominantly native forest restoration project;
- Monitoring of the response by the Hawaiian Hoary Bat population to the mitigation action using the best available methods for the detection of Hawaiian Hoary Bat occupancy, presence, distribution, or abundance; and
- An iterative and structured process for the identification of and support for scientific research to improve understanding of population dynamics, threats, and limiting factors to improve the effectiveness of mitigation efforts designed to provide recovery benefits.

Selection of mitigation projects may be informed by its timing in relation to take. Habitat restoration may require many years of effort before suitable habitat is achieved and therefore may not be appropriate for projects or take authorizations of shorter duration.

The recommendations provided here are interim guidance that will be reviewed and revised as new information becomes available to inform planning. Recommendations are expected to be updated as more research on Hawaiian Hoary Bats is completed and as more specific management actions for the species are identified. These recommendations and guidance will be revised a minimum of every five years.

1. *Habitat Restoration*

a) Biological Goals and Objectives

For many threatened or endangered species, habitat loss is one of the primary threats to their existence. For the Hawaiian Hoary Bat, we lack even basic information on the bat's limiting factors. The federal recovery plan for the Hawaiian Hoary Bat assumed that habitat was limiting. However, there are no studies documenting that habitat is indeed limiting.

The most prudent course of action is to first avoid and minimize take instead of seeking to mitigate or offset take through habitat restoration. Then, if some amount of take cannot be avoided or minimized, mitigation should focus on strategic island wide habitat protection and restoration efforts aimed at maintaining the viability of the native ecosystems that can provide needed resources for the Hawaiian Hoary Bat. Ideally, restoration efforts for HCPs would be coordinated island wide and with other organizations in order to provide Hawaiian Hoary Bat habitat that is well distributed throughout the island, spans a range of elevations, and that complements the recovery of other Hawaiian species.

The goal of a habitat restoration project should be to restore habitat that is currently unsuitable for foraging, roosting, and breeding to conditions that improve suitability for those purposes. While much is unknown concerning the attributes that comprise suitable habitat for the Hawaiian Hoary Bat, native forests represent the natural habitats to which Hawaiian Hoary Bats are adapted and should make up the core of restoration goals, in the absence of compelling information otherwise. Habitat restoration should employ a landscape level strategy incorporating restoration of native forest habitat with natural assemblages of forest canopy, understory, and ground cover species that include natural levels of species richness and diversity, to the greatest degree practicable. Restoration efforts should include controlling the impacts of ungulates (e.g. fencing), removing key invasive species, and planting or enhancing native vegetation, if needed.

Several mitigation projects approved for take of Hawaiian Hoary Bats to date have implemented habitat restoration efforts on native forest and wetland habitats. Studies on Hawaiian Hoary Bat activity and presence have shown that forested areas are positively associated with bat occupancy, though native- versus alien-dominated areas has not yet been determined to be a significant factor tied to occupancy (Gorresen et al. 2013). Bat activity also appears to be high around open canopy areas interspersed with wetlands based on studies in the mainland U.S. (Grindal et al. 1999 and Brooks and Ford 2005). One study in Hawaiʻi conducted by SunEdison (SWCA 2011) suggested that ponds and wetlands could serve as important foraging grounds for the Hawaiian Hoary Bat. Observation of bats frequenting ponds has also been documented during studies at a restoration site on Maui, as reported in the Auwahi Wind Farm Fiscal Year 2018 Annual Report (Auwahi Wind 2018).

Concurrent with the habitat restoration mitigation projects in progress for bats, USGS researchers have increased the understanding of aspects of Hawaiian Hoary Bat distribution, habitat use, prey consumption, and occupancy (Bonaccorso et al. 2015, Bonaccorso et al. 2016, Gorresen et al. 2013, Gorresen et al. 2015a, 2015b, and 2015c, Pinzari et al. 2014, Todd 2012, and Todd et al. 2016). These and other research findings are used to inform habitat-based mitigation actions to further benefit the bats and aid in identifying appropriate mitigation sites to support foraging, pupping, and roosting needs. Surveys have been conducted in Kahikinui Forest Reserve and Nakula Natural Area Reserve on Maui (KFR-NNAR; Todd et al. 2016). The baseline information from those surveys indicated detection probabilities, mean pulses per night, percentage of nights with feeding activity, and acoustic detections are greater in recovering forest areas than in unrestored shrublands (Todd et al. 2016).

Gorresen et al. (2013) found a significant association between occupancy and the prevalence of mature forest cover, indicating this should be a consideration for habitat management. The Gorresen et al. (2013) study also reported the Koa (*Acacia koa*) tree, although abundant in habitats used by bats, was not significantly associated with bat occupancy in their models, and suggested that finding may be the due to Koa supporting little shade cover for day roosts, having limited influence on overall prey availability, and the availability of a wide variety of other food sources that are used opportunistically.

Bonaccorso et al. (2015) tracked 28 Hawaiian Hoary Bats on the windward side of the island of Hawaiʻi. The average size of an individual bat's foraging area was 230 hectares (568 acres) and its average core use area (CUA)—areas where an individual spends 50 percent of its time—was 25.5 hectares (63 acres). There were no significant differences in the size of foraging areas or core use areas based on sex or age. However, adult bats on average had core use areas of 19.64 hectares (48.5 acres), juvenile females had smaller CUAs at 12.2 hectares (30 acres), and juvenile males had larger CUAs of 56.7 hectares (140 acres). There was no overlap in CUAs among adult male bats and limited overlap (less than eight percent in total) among all bats. Unpublished studies by H.T. Harvey (2019) conducted on Maui found much larger CUAs, with bats regularly foraging areas in the order of 3,000 acres. It is currently unclear how to reconcile the vastly different CUA sizes found in the two studies.

In the past, federal and state agencies have used estimates of CUA sizes as surrogates for the habitat needs of the Hawaiian Hoary Bat. These habitat estimates were then used to determine mitigation for the take of Hawaiian Hoary Bats. The amount of habitat recommended to offset the take of one bat has ranged from 20 to 40 acres, depending on the rationale in place at the time.

There are multiple issues with the use of CUAs to determine the size of habitat mitigation areas for the Hawaiian Hoary Bat. The most significant issue is that, as mentioned above, it is not known if habitat is a limiting factor. If habitat is not a key limiting factor, then habitat restoration as an offset to take is not only a waste of resources, but it also generates a false assumption, or sense of security, that bat populations are benefitting from the mitigation. If habitat is limiting, then the restoration of habitat may be an important benefit to Hawaiian Hoary Bat populations. The issues of concern then become how much habitat is needed to increase a bat population and what are the characterizes quality habitat.

Until the H.T. Harvey (2019) study is better understood, the Bonaccorso et al. (2015) study provides the best information on habitat use by Hawaiian Hoary Bats.

Using Bonaccorso et al. (2015) as a starting point, it is recommended that habitat restoration focus on providing:

1. A mix of foraging and roosting/pupping habitat (such as forest and forest edge habitat);
2. Habitat that is predominantly native; and
3. An adequate amount of habitat for each bat being offset. The typical unit of Hawaiian Hoary Bat take is one adult bat, which had a mean CUA of 48.5 acres in the study by Bonaccorso et al. (2015). The CUA is presumably high quality habitat since 50 percent of a bat's time is spent there, with a high level of feeding activity. The restoration of this acreage would be expected to add enough habitat value to provide for half a bat. Doubling the acreage could provide the other half of a bat's habitat need, if it was of high quality. Compensatory mitigation is recommended to consist of 97 acres of high quality predominantly native habitat (i.e., CUA quality).

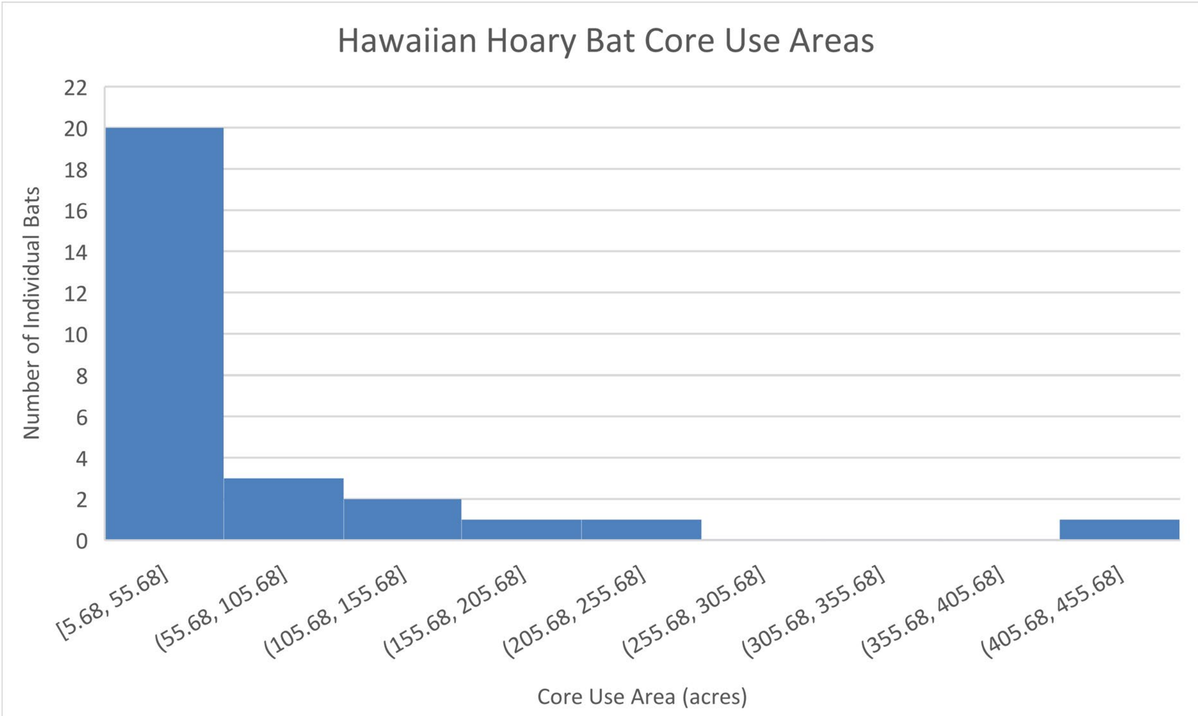

Figure 7. Bat core use area from 28 bats (both adults and subadults) on Hawaiʻi Island (Bonaccorso et al. 2015).

b) Incorporation of Other Habitat Features

Wetlands also have been used as mitigation sites for many plant and animal species. On the continental U.S., restoration efforts at wetlands have demonstrated increased bat activity (Menzel et al. 2005). Only one state-approved HCP in Hawaiʻi includes mitigation for Hawaiian Hoary Bats through wetland restoration. Data collected by SunEdison demonstrated that bat activity rates measured through acoustic detectors are seven times higher at small irrigation ponds near the Kawailoa Wind Farm than at other vegetated areas nearby (SWCA 2011). It is not clear if these water features are increasing the number of bats that can successfully occupy the area, or if they simply represent sites where bats that are foraging over this landscape are concentrated by the water feature and are thus easier to detect. Mitigation through restoration at the ʻUkoʻa wetland on Oʻahu is underway and is intended to provide increased bat foraging habitat. Monitoring efforts will help evaluate the efficacy of wetland management for Hawaiian Hoary Bat mitigation. Although not yet confirmed with data collected in Hawaiʻi, wetland restoration projects could also provide important foraging habitat for Hawaiian Hoary Bats. Studies conducted by USGS at the Koloko-Honokōhau National Historical Park on the island of Hawaiʻi suggest that wetland habitats provide suitable insect prey for the bat (Pinzari et al. 2014).

Research also indicates that Hawaiian Hoary Bats may use some non-native habitat features and that those features may contribute to suitable habitat. Restoration may incorporate habitat features other than those described above where justified by applicable scientific information and after analysis and assessment of any unintended impacts. Examples may include edges or other approaches to create canopy openings, water features, and particular tree species with special attributes. These elements may be appropriate when incorporated into an overall restoration plan predominantly consistent with native habitat restoration. Incorporation of these elements should include a well-reasoned and detailed analysis of how the landscape would support the Hawaiian Hoary Bat and a likelihood of providing a net recovery benefit for the species given the level of take requested.

c) <u>Siting and Legal Considerations</u>

Mitigation should occur on the island where the impact is occurring. However, mitigation projects should also evaluate the proximity to the wind turbine impact area and how that could negatively affect take.

Habitat restoration projects to serve as mitigation should be conducted on lands for which those benefits will receive long term or perpetual protection and management. When private lands are used for restoration there should be a documented commitment, preferably a conservation easement that confers long term or perpetual protection. If a conservation easement is not feasible, a memorandum of agreement with the landowner is recommended. Projects for which there is no assurance for the long term protection of the restored habitat are not recommended.

Public lands should be used for restoration only when funding for restoration by an HCP will enhance and supplement public efforts, especially in the case of acquisition or management of large tracts of land. HCP mitigation funds should in no case replace or displace public funds available for the same work. If the restoration occurs on public lands, additional mitigation may be appropriate since no private land would need to be encumbered. Clear responsibilities of the parties should be specified and a memorandum of agreement with the public land manager should be in place prior to issuance of the ITL.

d) <u>Measures of Success</u>

Monitoring is expected to provide a quantitative assessment of whether the project is on track to meet its mitigation goals. Monitoring for habitat restoration may include assessment of relevant measures such as survival, canopy cover, species richness and diversity, prey abundance, and other features identified as goals and objectives. Monitoring Hawaiian Hoary Bats should employ best available methods, including acoustic monitors, thermal imaging, and methods to assess the abundance of preferred insect prey types. Monitoring should occur prior to restoration to establish a baseline and continue with frequency to ensure robust statistical inference. Surveys should be repeated at specified intervals throughout the life of the project to provide an index of change and to gather information on preferred bat habitat characteristics, limiting factors and threats, or if monitoring techniques are refined, to enable quantification of bat population and productivity.

Measures of success and a detailed schedule showing restoration actions and monitoring are key considerations for inclusion in the mitigation plan. A measure of success must be a metric (quantitative/qualitative or some observable phenomena) that is monitored, and connected back to the mitigation biological goals and objectives. Habitat improvement for bats should result in a statistically documented increase of bat habitat and/or quality of habitat as measured over an established baseline condition. Measures of success should also include data that demonstrate an increase in measures of Hawaiian Hoary Bat use of the area, such as presence, occupancy, or activity. Methods used to detect Hawaiian Hoary Bat use should be designed to detect increased use with robust statistical inference and should include an analysis of statistical power to do so. While it is understood that it is not practicable at this time to estimate the net recovery benefit of habitat restoration as the increased absolute number of bats occupying a core use area, the measures of success should include a quantitative increase in one or more measures of Hawaiian Hoary Bat use of the area inferred with statistical confidence.

2. *Land Acquisition*

Land acquisition may be desirable as mitigation when the benefits of the acquisition to the bat population in the project area can be assessed with reasonable certainty. Circumstances that contribute to the assessment of benefits may include, but not be limited to, lands that presently support bats that are in some way threatened in a manner that would render the habitat no longer suitable for bats. This alternative provides benefits when the acquisition safeguards the land from future development, protects existing habitat, and/or provides a clearly documented opportunity for restoration/creation of habitat.

Proposals to acquire lands to serve as mitigation should include documentation that the habitat to be acquired currently supports bats, such as robust surveys that have documented presence or occupancy over the area for a specified time, presence of suitable habitat such as intact native forest or other habitats that are known to be used by Hawaiian Hoary Bats for foraging, roosting, or breeding, or other indicators of conservation value, such as size, location, proximity to protected public lands, or landscape setting. Larger parcels are typically preferable to smaller parcels; however, the location of a smaller parcel (e.g., adjacent to another larger area that supports bats or is being restored to support bats) could make it more attractive as a mitigation site.

The proposal should provide a documentation of the nature and urgency of threats to the lands and habitats to be acquired. The documentation should show that there is a reasonable expectation that the subject lands will be modified in the foreseeable future such that suitable habitat will be degraded or destroyed, resulting in the absence of Hawaiian Hoary Bats on those lands and the lands no longer providing habitat for Hawaiian Hoary Bats.

The acreage of the proposed acquisition should include an acreage of suitable Hawaiian Hoary Bat habitat (as determined by other considerations in this guidance) for each bat for which the acquisition is proposed to serve as mitigation. If partnering with other entities for a larger acquisition, the prorated share of funds provided for the mitigation should be used to calculate credit at a rate of 97 acres per bat for either existing CUA habitat quality or for proposed areas of restoration and acquisition, as discussed in the habitat restoration section.

Proposals to acquire lands to serve as mitigation should be accompanied by documentation to ensure that once acquired, the habitat will not degrade or lose its suitability as bat habitat into the future in perpetuity. Documentation may include transfer to conservation agencies, management plans, conservation easements, or other assurances. Any planned activities or uses of the lands should be consistent with, and not detrimental to (e.g. timber harvesting, fencing with barbed wire, etc.), protection of bats and suitable habitat.

3. *Research as Mitigation*

During the April 2015 ESRC Bat Workshop and subsequently, experts recognized that current mitigation guidance for the Hawaiian Hoary Bat was based on an incomplete understanding of the species biology and its recovery needs. Filling key information gaps was identified at that time as a priority need to inform better mitigation actions, thereby reducing uncertainty in mitigation effectiveness. After thorough consideration by the ESRC and agencies, research was accepted as a mitigation option for take of Hawaiian Hoary Bats in the near term. Research is not a preferred mitigation strategy for most species, but can be and has been used in instances when there is a paucity of information on the species and where research can enable better management of the species; such as is the case for the Hawaiian Hoary Bat.

Bat research is intended to result in a better understanding of the Hawaiian Hoary Bat and its recovery requirements but the benefits for bats are not readily assessed for any individual HCP and therefore the level of effort required cannot be determined without a monetary value assigned. The cost associated with research should be similar to a value associated with known habitat restoration costs so that research costs are roughly comparable to the cost of restoration mitigation. Given 97 acres per bat as a recommended restoration target, the cost for research is estimated based on cost estimates to maintain and/or restore native forested areas and wetland habitats by the state and other partner organizations. In Hawaiʻi, bat mitigation has varied extensively. DOFAW staff who developed the State of Hawaii Rain Follows the Forest Initiative estimated a range of costs to manage and restore key watershed areas (E. Yuen 2015 pers. comm.). The cost ranged from $35,708 - $68,415 per 40 acres depending on the condition of the forest and management needs, such as the amount of fencing and invasive species control needed. Costs associated with management actions in the State of Hawaii Forest Reserves, Natural Area Reserves, and wetlands range widely with an average cost for 40 acres of $79,220.51 ± $47,366.45. Based on the high standard deviation and wide range in costs of the different managed areas described above, the figure of $50,000 to restore an area of 40 acres is currently considered to be a reasonable cost estimate. Therefore, an appropriate cost for research mitigation is $125,000 per bat.

In order for research to be credited as mitigation, research projects should be designed to provide information applicable to improving mitigation and planning during the period of the HCP or should provide information on better management actions for Hawaiian Hoary Bats that will lead to promoting the recovery of the species. To determine which research questions and projects were recommended, the ESRC established a task force to conduct a thorough assessment of research and information needs, to identify and prioritize those needs, to issue a request for proposals from qualified entities to carry out research projects to address those needs, to review, evaluate, and rank all proposals received, and to recommend to the ESRC which of those research proposals should be supported.

In 2017, the Bat Task Force reported its findings to the ESRC, with a recommendation to support research projects at a total cost of $4M. Those research projects subsequently became a part of the mitigation plans for several HCPs that were pending approval. The research projects were initiated in early 2018 and are expected to continue for 3-5 years. Upon review of the results of those research projects, the ESRC will conduct an assessment of future research needs and make its recommendations through its regular meetings pursuant to HRS Chapter 92. It is expected that further research will be recommended in order to obtain biological information essential to meet statutory requirements of HCPs to provide net recovery benefits to Hawaiian Hoary Bats as part of their ITLs. A description of research priorities and research conducted is provided in Appendix 1.

4. *In-lieu Fee Approaches*

Given the significant challenges and uncertainties in regard to Hawaiian Hoary Bat mitigation, the agencies should consider development of an in-lieu fee framework for an interim period of time as another mitigation option. In an in-lieu fee system, applicants deposit funds into an agency account to serve as their mitigation, and the agencies develop and implement the recommended mitigation actions, as described above. This approach has a number of advantages for species for which the success of compensatory mitigation is highly uncertain, including simplifying the process for applicants, whose mitigation will be deemed successful upon the deposit of the funds, and enhancing the ability of the agencies to direct the funds to specific needs, such as research and habitat management. HCPs may allow direct payments in this manner under State of Hawaii law pursuant to §195D-21(b)(1), if and when at such time the mechanism exists.

VI. Adaptive Management

Adaptive management is a framework to address uncertainty in the conservation of a species covered by an HCP and is a required component of HCPs. USFWS in its HCP Handbook (USFWS and NOAA 2016) outlines an adaptive management program for an HCP as follows:

- Define goals.
- Develop conceptual models to serve as hypotheses for how the system works and to identify key uncertainties.
- Evaluate management options.
- Develop a monitoring and evaluation program that can answer questions to reduce uncertainty.
- Implement management actions and monitoring.
- Evaluate information and incorporate it into decisions to improve system models, if needed.
- Use updated system models for directing future management and monitoring decisions.

An adaptive management framework is built on biological goals and objectives, monitoring, success criteria, and adaptive management triggers and strategy pathways. It allows for flexibility over time during the implementation of the HCP as new information is gained relative to calculated take and mitigation options, and uses monitoring and evaluation to adjust management strategies. An adaptive management strategy is essential in HCPs for the Hawaiian Hoary Bat due to significant data and information gaps that result in uncertainties and/or risk to Hawaiian Hoary Bats under an approved HCP. The HCP should have a trigger for specific actions that must be taken. Each HCP should adhere to the following principles for adaptive management:

- Adaptive management triggers and responses are needed, as a minimum, for the overall rate of take, the rate of take within a tier, CARE/SEEF monitoring, mitigation targets, and the implementation rates (e.g., percentage of time deterrence equipment is operational).
- Triggers for action should be clearly defined. The initial or default responses planned for exceedance of each trigger point should be clearly defined; in some cases, a decision tree may be appropriate.
- An HCP should provide a clear description of the range of adjustments to the management actions that will be required as a result of any adaptive management provisions and those that may be implemented so that all parties understand what can be considered under adaptive management.
- Additional curtailment and bat deterrence technology should be strongly considered as responses to adaptive management trigger(s) for rate of take.

To develop a metric for rate of take to evaluate under adaptive management, methodology using EoA modeling can be used. Dalthorp and Huso (2015) describe a method that calculates a moving-average take rate that is tracked through the years. When the average take rate is determined to be clearly above the permitted level, a short-term trigger is activated that can be used as a check against excessive take over the span of a few years, signaling that the long-term take limit is likely to be exceeded unless conditions change.

If the short-term trigger threshold is exceeded, responses may include 1) curtailment with higher cut-in speed or other operating adjustments for wind turbines if studies available at the time show those measures are likely to reduce take, 2) some form of deterrence if technologically feasible, or 3) some other specific means of minimizing take.

HCPs submitted for consideration are expected to include explicit and clear criteria for levels or rates of take that will trigger a response that is likely to be effective to reduce the rate of take in the foreseeable future. Those responses may include curtailment or other measures. Since bats are nearly exclusively nocturnal, HCPs should consider trigger scenarios for which the response is to curtail during all night time hours.

Adaptive management should include the provision that if authorized take is exceeded, turbines will not operate during times when bat take is possible.

All adaptive management decisions should be documented in each HCP annual report and tracked to allow a thorough review of the full effect of all adaptive management decisions for an HCP. This should include results of monitoring, adherence to the schedule, and overall success, and should be reviewed annually with respect to established success criteria. Annual reporting should follow the recommended HCP annual report template provided by the agencies (Appendix 2).

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Appendix 1. Hawaiian Hoary Bat Research

Research Priorities Identified in 2016

The list of priority research questions from the Hawaiian Hoary Bat workshop was further outlined and then refined by a subcommittee of the ESRC that was established in 2016, the Bat Task Force, to develop a request for proposal (RFP) for research projects based on these research priorities and that could be recommended to HCP applicants. The result was included in the RFP and is reproduced below.

Goal 1: Basic research
Conduct basic research to obtain information that will guide and assist conservation efforts. Objectives include:

a. **Document distribution**. Conduct island-wide surveys on Maui and Oʻahu using replicable methods to document distribution. Document seasonal changes in spatial occupancy. This information may inform efforts to evaluate risk associated with proposed actions and inform management decisions for conservation benefit and provide baseline information needed to understand the potential role of habitat suitability in limiting populations of the bat. (1)
b. **Document demographic information**. Conduct research to determine basic demography, such as annual survival, reproductive success, maximum lifespan, age of 1st breeding, % of breeding females, number of broods per year, mating system, etc. (1)
c. **Document home range and movements**. Conduct radio-telemetry experiments to better elucidate how nightly movements and home range may differ on different islands, in different habitats, or seasonally. (1)
d. **Document genetic variability.** Collect genetic data to document variability, population structure, estimate effective population size, and provide information about population dynamics. (1)
e. **Conduct population modeling**. Obtain and use demographic information to develop population models, including population viability analyses. (2)

Goal 2: Identify limiting factors.
Understanding the factors that limit the survival and reproductive success of individuals, and therefore determine the distribution, abundance, and growth of populations, is essential for planning conservation actions designed to increase bat population sizes and create net recovery benefits. Potential factors that may limit bat populations include:

a. **Suitable habitat**. Bats require suitable habitat for foraging, roosting, and breeding. Studies indicate that bats use a wide range of habitats for foraging, but that mature trees may be important for breeding and roosting. Recent studies have documented aspects of habitat use for breeding and roosting, including tree species and architecture. The following research is needed to improve our understanding of suitable habitat. This information will shed light on the question of whether or not bats are habitat limited. Findings that suitable habitat remains unoccupied would suggest that bats are not habitat limited, that habitat management and restoration would not necessarily result in net recovery benefits, and that other factors may be limiting bat populations. Objectives include, but may not be limited to:

i. **<u>Define suitable habitat.</u>** Document aspects of habitat used for foraging, breeding, and roosting, including vegetation community structure, physical attributes, vegetation species used, and tree architecture. (1)
ii. **<u>Determine relationship of distribution to suitable habitat.</u>** Document bat distribution and presence or absence in suitable habitat to determine whether suitable habitat is unoccupied. (1)
iii. **<u>Determine relationship of abundance to suitable habitat.</u>** Determine whether aspects of suitable habitat are associated with demography and home range such that bat population densities or growth rates are associated with habitat features. (1)
iv. **<u>Conduct experimental treatments.</u>** Conduct long term experimental studies (e.g. up to 20 years) in which bat occupancy or abundance is measured in treatment plots designed to increase suitable habitat. Research designed to employ this approach would be expected to require a study of considerable duration, given the long time frames inherent in habitat management and restoration efforts. Several habitat management projects are currently underway, in some cases in which Hawaiian Hoary Bat occupancy was assessed prior to the initiation of management efforts, that may provide opportunities for research consistent with the goals and objectives sought here. Applicants are encouraged to coordinate with current and potential licensees that may have opportunities for such long term research as part of their current mitigation requirements. (1)

b. <u>Food availability</u>

Populations may be limited if food resources are variable, scarce, or widely dispersed. Food limitation may impact survival and reproductive success to the degree that populations remain stable or decrease despite the availability of suitable habitat and lack of other threats. The following research objectives may contribute to a better understanding of food limitation.

i. **<u>Identify diet</u>**. Understand food habits by analyzing fecal samples to provide information on foraging ecology, nutritional needs, and population ecology. (1)
ii. **<u>Document prey selection</u>**. Determine which prey taxa are selected or preferred by comparison of diet to food availability. (1)
iii. **<u>Determine relationship of home range to food availability</u>**. Conduct studies in which food availability is measured within the home ranges of bats and determine whether a correlation exists. (2)
iv. **<u>Document relationship of food availability to survival and reproductive success</u>**. Conduct studies in which food availability is monitored within and among years to determine whether survival and reproductive success are correlated with food availability. (2)
v. **<u>Conduct experimental treatments</u>**. Conduct experimental studies in which bat demography, occupancy, or abundance is estimated in treatment plots designed to increase food availability. As with objective 2.a.iv. above, this research may require a study of considerable duration, and may be carried out as a part of a study pursuant to that objective, in order to explore the potential relationship between habitat suitability, food availability, and bat population dynamics. (2)

c. **<u>Pesticides</u>** Pesticide use in agricultural or other areas may place bats at risk to exposure, with resulting impacts on impact growth, survival, or reproductive success.
   i. **<u>Survey and analyze contaminate loads in bats.</u>** <u>(1)</u>
   ii. **<u>Conduct surveys for chemical residues on bat prey</u>**. (2)
   iii. **<u>Determine whether demographic variables are correlated with pesticide loads</u>**. (2)
   iv. **<u>Determine whether high pesticide use areas are associated with low bat occupancy.</u>** (2)

d. <u>Predators</u>

Predation may limit populations if bat pups or adults are subject to frequent predation events and high predator populations. Predator impacts on Hawaiian Hoary Bats are largely unknown. The following research may contribute to a better understanding of predatory relationships to bat populations.
   i. **<u>Bat breeding roost monitoring</u>**. Conduct intensive monitoring at roost sites to observe the outcome of pups during the period they are non-volant. (2)
   ii. **<u>Investigation of potential predator's food preferences (e.g. barn owl)</u>**. Analyze potential predators' consumed prey items through analyzing pellets, stomach contents, etc. (2)

Goal 3: Research and development

a. **<u>Develop methods for assessing long term population trends</u>**. Statistically robust methods for the detection of long term population trends are currently thought to be cost-prohibitive at relevant spatial scales. Efforts are needed to develop more cost effective methods to carry out state-wide long term population monitoring. (1)
b. **<u>Develop methods for the estimation of abundance</u>**. Methods for the estimation of bat population levels are currently not available. Efforts are needed to develop and implement such methods in order to inform population models that can be used to understand population status, risk, and sensitivity to incidental take and other threats. (2)

<u>Research Initiated Subsequent to the 2015 Guidance Document</u>

Five research projects were selected as meeting identified research needs as well as other scientific criteria and were recommended for consideration for funding to HCP (new or amended) applicants. All five projects are now underway. Goals and objectives for each are described below and summarized in Table 2.

Hawaiian Hoary Bat conservation genetics

Research components related to Objectives for Goal 1, Basic Research:
- Quantify levels of genetic variation and population structure throughout Hawaiʻi
- Determine if distinct population boundaries exist among islands
- Estimate effective population size(s)
- Determine sex of bats collected and carcasses

Modeling foraging habitat suitability of the Hawaiian Hoary Bat

Research components related to Objectives for Goal 1, Basic Research:
- Echolocation, videography, and insect trapping

- Power analysis to estimate sampling effort for future studies of response to habitat restoration

Research components related to Objectives for Goal 2, Limiting Factors:
- Develop and test a technique that combines multiple sampling methods to specifically assess foraging habitat suitability
- Echolocation, videography, and insect trapping
- Power analysis to estimate sampling effort for future studies of response to habitat restoration

Hawaiian Hoary Bat conservation biology: movements, roosting behavior, and diet
Research components related to Objectives for Goal 1, Basic Research:
- Home range size– seasonality; three annual cycles
- Habitat use– foraging, roosting, and breeding
- Roost fidelity and roost tree characteristics
- Mother-pup behavior at roosts
- Movement patterns and food availability
- Tissue and fecal collection bank– genetic, diet and pesticide studies

Research components related to Objectives for Goal 2, Limiting Factors:
- Habitat use– foraging, roosting, and breeding
- Roost fidelity and roost tree characteristics
- Movement patterns and food availability
- Insect prey-host plant associations
- Diet analysis– insect prey selection and availability using molecular bar-coding techniques
- Tissue and fecal collection bank– genetic, diet, and pesticide studies

Hawaiian Hoary Bat home ranges, seasonal movements, habitat utilization, diet, and prey availability (Maui)
Research components related to Objectives for Goal 1, Basic Research:
- Determine home range and nightly and seasonal movements
- Evaluate foraging and roosting behavior
- Document the seasonal movements of bats

Research components related to Objectives for Goal 2, Limiting Factors:
- Define suitable habitat with acoustic sampling and radio-telemetry
- Assess risk of predation at maternity roosts through monitoring

Analysis of Hawaiian Hoary Bat occupancy, distribution, and habitat use (Oʻahu)
Research components related to Objectives for Goal 1, Basic Research:
- Document distribution
- Estimate occupancy rates, detection probabilities, and covariate relationships
- Estimate seasonal changes in occupancy

Research components related to Objectives for Goal 2, Limiting Factors:

- Determine habitat suitability and characteristics to include vegetation community data, physical attributes, tree architecture, temperature, distance from water and forest, and other relevant variables
- Resource selection modeling

Table 2. Summary of Research in Progress and Associated Goals and Objectives
Note: X indicates primary contributor, x indicates indirect contributor

Goals and Objectives	**Research Studies in Progress**						**Complete d Studies**
	Conserva-tion genetics (USGS)	Modeling foraging habitat suitability (USGS)	Movement , roosting behavior, diet (USGS)	Home range, movement, habitat util., diet, prey avail. (HT Harvey)	Occupancy , distributio n habitat use (West)	Non-RFP research projects in HI (ongoing)	Various
Goal 1 Basic Research							
a. Distribution					X		
b. Demography	x		x				
c. Home range and movements			X	X		x	X
d. Genetic variability	X		x	x		x	
e. Population modeling	x		x	x	x		X
Goal 2 Identify Limiting Factors							
a. Suitable habitat							
a.i. Define suitable habitat		X	X	X	X	X	X
a.ii. Relationship to distribution		X	X	X	X	X	X
a.iii Relationship to abundance		x	x	x	x	x	x
a.iv. Experimental treatments							
b. Food availability							
b.i. Diet	x		X	X		X	X
b.ii. Prey selection		X	X	X			X
b.iii. Relationship to home range			x	x			x
b.iv. Relationship to success			x				
b.v. Experimental treatments							
b.vi. Food availability habitat type							
c. Pesticides							
c.i. Contaminant loads							
c.ii. Contaminants in prey							
c.iii. Correlation of loads-demography							
c.iv. Correlation of loads-occupancy							
d. Predators							
d.i. Bat reproductive success		x	x	x			x
d.ii. Bat predator food preference (cats, barn owls scat study)							
Goal 3 Research and Development							
a. Population trend methods							
b. Estimate of abundance methods							
c. Deterrent research							

Appendix 2. Habitat Conservation Plan Annual Report Template

Appendix 3. HCP Requirements per HRS 195D

<u>HCP Checklist for Key Components</u>

Project Description and Covered Activities
☐ Project description
☐ Purpose and need: clear and detailed
☐ Specific discussion of power purchase agreements (PPAs) and implications for turbine operation details for wind energy
☐ Geographic plan area (includes mitigation areas)/Permit area (covered activities)
  ☐ Description and maps of both plan area to include mitigation program areas, and area covered by Incidental Take License/Incidental Take Permit. Include Tax Map Keys (TMKs).
  ☐ Permits/approvals required
☐ Description of covered activities that may result in take
☐ Alternative actions to the taking, as applicable (not an HRS 195D requirement but needed for an EA/EIS and Federal regulations)

Environmental Setting and Biological Resources
☐ Existing land use
☐ Ecosystem and vegetation for permit and plan areas
☐ Fauna for permit and plan areas

Covered Species
☐ Status and distribution of endangered, threatened, proposed, and candidate species (collectively covered species) with supporting studies
☐ Species description including life history
☐ Habitats/ccosystems used by the covered species
☐ Species use of the area
☐ Species in plan area that don't need coverage and why

Potential Biological Impacts and Take Assessment
☐ Anticipated take of each covered species
  ☐ Direct take; lifecycle considerations; breeding, feeding, shelter
  ☐ Specific causes or components of covered activities associated with take and duration of the take
  ☐ Evidence of Absence (EoA) and 80% credibility used for unobserved direct take
  ☐ Type of take (e.g., injury, mortality, harm, harassment)
  ☐ Indirect take (use USFWS guidance for Hawaiian Hoary Bats)
  ☐ Tiers if any and rationale
  ☐ Lost productivity
☐ Anticipated impacts of the take/effect analysis
  ☐ Resources required by species to fulfill lifecycle needs that may be affected by stressor
  ☐ Identify the resource need affected (breeding, feeding, shelter) by stressor
  ☐ Identify behavioral or physical response associated with each stressor (e.g., stress, displacement, lack of foraging ability, mortality)
☐ Cumulative effects: demographic consequence at population and species levels, both island-specific and Hawaiʻi-wide
  ☐ Identify all other authorized take for each species, both on the project island and Hawaiʻi-wide
  ☐ Demographic consequence at population and species levels, both island-specific and Hawaiʻi-wide
☐ Anticipated impacts of take on Critical Habitat

Conservation Program: Avoidance, Minimization, and Mitigation

☐ Biological goals
☐ Biological objectives
  ☐ SMART: ○ Specific ○ Measurable ○ Achievable ○ Result-oriented ○ Time-fixed
  ☐ Temporal and geographic scope of affected area (e.g., permit area, plan area)
  ☐ Uncertainties
☐ Conservation measures to avoid and minimize take
  ☐ Curtailment cut-in speed and justification
  ☐ Curtailment seasonal and daily timing and justification
  ☐ Details of turbine rotor speeds below manufacturer cut-in speed for the specific turbine models used
  ☐ Details of operation for the specific curtailment cut-in speed proposed: rotor speeds, rolling average times, and wind speed measurement location to stop feathering
  ☐ Deterrence research status and plans for the HCP
  ☐ Description of potential avoidance and minimization that will be employed under adaptive management
☐ Measures to mitigate unavoidable take
  ☐ Specific mitigation proposed including separate implementation plans
  ☐ Ensure HCP minimizes and mitigates impacts to the maximum extent practicable and provides reasoning for the determination
  ☐ Detailed, measurable mitigation success criteria during the permit term
  ☐ Net environmental benefit and recovery analysis
  ☐ Description of potential mitigation that might be employed under adaptive management
☐ A schedule for implementation of the proposed measures and actions

Monitoring and Reporting

☐ Avoidance, minimization, and observation training program for construction and operation staff
☐ Fatality monitoring
  ☐ SEEF and CARE trial specifics and justifications
  ☐ Bats to be sent to USGS for sex determination
  ☐ Third party monitoring and proctoring
  ☐ Notification requirements for downed wildlife and reference to state protocol
☐ Mitigation monitoring including analysis of success criteria and net benefit
☐ Migratory Bird Treaty Act (MBTA) monitoring and reporting
☐ Ecosystem, community, and habitat monitoring per requirement of 195D-21
☐ Reporting and meetings
  ☐ Annual report contents: all monitoring results, direct and indirect take for fiscal year, take since permit start, mitigation progress, adaptive management, minor amendments, expenditures
  ☐ Frequency of interim reports depending on complexity of the project and mitigation, e.g. quarterly
  ☐ Annual and interim reports to include an estimate of total direct and indirect fatalities
  ☐ Wind energy sites use 80% credibility limit to identify tier triggers (if any), and assess compliance with tier limits (if any) and the authorized take limit
  ☐ Annual reports include calculation of lost productivity
  ☐ Annual report recommendations
  ☐ Frequency of update meetings depending on complexity of the project and mitigation

Adaptive Management

☐ Adaptive management strategy
  ☐ Specific actions that may require adaptive management, e.g. take rate; new research or other information that shows that take minimization is available and practicable; mitigation success

- ☐ Triggers set for each action
- ☐ Specific analysis of defined objectives and success criteria, and process and timelines if triggers exceeded

Funding

☐ Budget includes monitoring, minimization, mitigation, contingency, funds for state compliance monitoring
☐ Description specifies that if a tier limit is reached mitigation for that tier must be fully funded and the next tier will not be authorized until mitigation is underway for that tier
☐ Funding assurance includes mitigation, contingency (or termed as adaptive management), and cost for state to take over management of mitigation if needed
☐ Inflation adjustments

Changed and Unforeseen Circumstances

☐ Changed circumstances
- ☐ Identify all changed circumstances (per USFWS regulations)
- ☐ Research or other information that shows an avoidance or minimization measure is likely to reduce take and is practicable
- ☐ Develop thresholds for clearly identifying when circumstances are changed versus unforeseen
- ☐ Develop responses for each circumstance: what will be the response to ensure goals and objectives are met if circumstance X happens to Y degree?

☐ No surprises description

Amendments

☐ In the event of a need for a formal amendment the applicant will work with the agencies to follow the most current agency regulations and policies
☐ Amendments
- ☐ Minor Amendment
  - ☐ Circumstances requiring a minor amendment, e.g. reduce take, increase mitigation
  - ☐ Procedures for a minor amendment
- ☐ Major Amendment
  - ☐ Circumstances requiring a major amendment
  - ☐ Specific trigger for when an amendment is needed when permitted take could be exceeded
  - ☐ Timelines for development of a major amendment

☐ Permit transfer (state ITL runs with the land)

Appendix 4. Evidence of Absence Indirect Take USFWS Guidance

Wildlife Agency Guidance for Calculation of Hawaiian Hoary Bat Indirect Take

In June 2016, the wildlife agencies discussed the possibility for standardizing the incidental take calculations for Hawaiian hoary bat for projects that have incidental take permits or incidental take licenses. As a result of that discussion we are recommending that proponents and their consultants consider using the following time periods and biological factors in their calculation of indirect take for observed Hawaiian hoary bat fatalities and for indirect take of unobserved Hawaiian hoary bats. Most of you will see very little change in the estimated take for your projects simply because the methods being used by everyone where somewhat similar. The only changes are really in the way the indirect is calculated and by the time the juveniles are converted to adults, there is only minor changes in total take estimation.

Calculation of Observed and Unobserved take will continue to be conducted with the Evidence of Absence software (Dalthorp et al. 2014 and Dalthorp and Huso 2015). The 80% credibility output will be used as a *general* guide for what the agencies are 80% confident has not been exceeded. This output plus the indirect take converted to adult bats will represent total take that we are 80% confident has not been exceeded. This total take at the 80% confidence level will also be used as the value to guide the triggering of the next tier level. The next tier level is currently triggered when 75% of the estimated take of the existing tier is reached or exceeded based on the output at the 80% credibility level plus indirect take.

Female Hawaiian hoary bats may be pregnant or supporting dependent young from April 1 through September 15 (Tomich 1986ab; Menard 2001; Uyehara and Wiles 2009; C. Pinzari, pers. comm. 2015). This is based on best science for the Hawaiian hoary bats or North American hoary bat surrogates and information in our files. The wildlife agencies understand that exceptions to this range can occur. However, the need to be conservative on the side of the species is primary. Second, the use of lactation to determine whether or not a female had dependent pups has been challenging, given the condition of the carcasses that are found. Thus, for these reasons, the Service recommends using April 1 through September 15 as a period in which a female bat taken may have been pregnant or lactating and will result in indirect take assessment on the direct take during this time period. This range would apply to all female observed carcasses. The determination of the sex of all carcasses found will be conducted through genetic testing by USGS.

The average number of pups attributed to a female that survive to weaning is unchanged and is assumed to be 1.8 which is based on Bogan, 1972 and Koehler & Barclay, 2000.

The sex ratio of bats taken through unobserved direct take will be assumed to be 50% female, unless there is substantial evidence to indicate a different sex ratio. Substantial evidence would need to be based on at least 10 or more bats.

The assessment of indirect take to a modeled unobserved direct bat take accounts for the fact that we do not know when the unobserved fatality may have occurred. The period of time from pregnancy to end of pup dependency for any individual bat is estimated to be 3 months. Thus the probability of taking a female bat that is pregnant or has dependent young is 25%, or 0.25.

The conversion of juveniles to adults has generally been 1 juvenile to 0.3 adults, though it has varied slightly from project to project. This was loosely based on the estimated survival of the little brown bat (*Myotis lucifugus*) which ranges from 20-48% (Humphrey & Cope 1976). The Service recognizes that this is a less than ideal surrogate for estimating Hawaiian hoary bat survival of a weaned pup to adult, but we have little other scientific evidence to base survival on, until it is established for the Hawaiian hoary bat. Thus, indirect take will be converted from juvenile to adult equivalency using the 0.3 conversion.

Based on the rationale presented above, the wildlife agencies recommend estimated total take be calculated as such:

Observed and Unobserved direct take calculated with Evidence of Absence and the output at 80% credibility used for calculating indirect take.

Indirect take assessed for females taken between April 1 and September 15:
The number of observed female bats taken between April 1 and September 15 x the average number of pups estimated at 1.8

Indirect take assessed for observed males taken at any time or females taken from September 16 through March 31 would be 0.

Indirect take assessed for unobserved take would be:
The estimated number of unobserved bats taken x the proportion of unobserved take that is female, which is assumed to be 0.50 x the proportion of the calendar year in which a female may be pregnant or have dependent young which is 0.25 x the average number of pups estimated at 1.8

Then to convert the indirect (juvenile) take to adults:
(Total indirect take based on observed take + Total indirect take based on unobserved take) x the conversion of juveniles to adults, 0.30.

Example using the above equations:

Observed take 5 bats. Assume Evidence of Absence output at 80% for the 5 observed bats is 13. This means 8 unobserved bats.

	Indirect take
2 of the observed bats were females taken between April 1 and September 15:	2 x 1.8 = 3.6
1 of the observed bats was a female taken between September 16 and March 31:	0
2 of the observed bats were males:	0
We assume 4 of the 8 unobserved bats taken were female:	4 x 0.25 x 1.8 = 1.8
Total indirect take of juveniles	3.6 + 0 + 0 + 1.8 = 5.4
Conversion of juveniles to adults	5.4 x 0.3 = 1.62
Total take based on 80% credibility basis:	**13 +1.6 = 14.6 rounded up to 15 bats.**

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Appendix 5. Downed Wildlife Protocol 2019

Contact the agencies for the most current version of the Downed Wildlife Protocol.

Appendix 6. Exploratory Population Viability Assessments (PVA) on the Hawaiian Hoary Bat v2.0

Introduction

Hawaiian Hoary Bats are listed as an endangered species at both the Federal and State levels. Because we lack good estimates of the numbers of bats found statewide and on individual islands, it has been difficult to assess population-level impacts of wind power projects on this species. Most early estimates of take at wind projects were significantly underestimated. Some recent estimates of cumulative take have ranged up to 30 or more bats per year, with the potential for increases in wind projects to result in a doubling or tripling of take in the future. These increased levels of take have been concerning to the ESRC. Hence, the ESRC's Hawaiian Hoary Bat Task Force was asked to explore the use of population viability analyses (PVA) to identify:

1. Specific population dynamics parameters that are needed to conduct an acceptable PVA,
2. Particularly impactful parameters that should be prioritized for research, and
3. General trends or results that might inform conservation decisions or provide management sideboards for wind projects.

A goal of the State endangered species statute is to ensure that projects will not jeopardize the continued existence of impacted species, are consistent with recovery plan goals, and will increase the likelihood of the recovery of those species. Currently, the 20-year old Federal recovery goal for Hawaiian Hoary Bats is to have stable or increasing populations on the islands of Hawaiʻi, Maui, and Kauaʻi. This recovery plan was written before it was known that Oʻahu had a breeding bat population.

General Methods

Population models are typically used to provide estimates of the likelihood of populations becoming extinct (e.g., probability of extinction), provide estimates of future population size, explore the impact of population parameters on model outcomes, and to compare the qualitative effects of different management options or regimes. Recent population modeling of hoary bats on the mainland provide an example of how to undertake modeling on the Hawaiian Hoary Bat (Frick et al. 2017, Friedenberg and Frick 2019).

Hawaiʻi-specific population parameters were used when available and a range of published parameters on other bats was used when Hawaiʻi data were not available. While data on Hawaiian Hoary Bats are indeed limited, there was more data available than expected. It should be noted, though, that particularly important data like juvenile and adult mortality estimates or population sizes are not currently available for Hawaiian Hoary Bats. Mortality data is available for some other bat species and data from those species were useable for at least exploratory modeling.

Vortex 10.3.60 (April 3, 2019) was used for all population modeling and sensitivity analyses.

Results

Sensitivity Analyses

Five model input parameters were subjected to sensitivity analyses in order to identify key research needs or to help inform the use of population models.

a. Adult mortality rates: ranging from 20-50 percent annual mortality. Model outcomes were very sensitive to changes in the value of adult mortality (see purple line in Figure 1).

b. Juvenile mortality rates: ranging from 30-60 percent annual mortality. Model outcomes were very sensitive to changes in the value of juvenile mortality (see green line in Figure 1).

c. Percentage of females breeding in the population: values based on estimates of 80% (from Tomich's captures of Hawaiian bats; see Menard 2001), 88% (estimate from Druecker 1972 on mainland hoary bats), and 90% (average of Tomich, Druecker, and Jones 1964 for Hawaiʻi and mainland hoary bats). Model outcomes were very sensitive to changes in the percentage of breeding females (see red line in Figure 1).

d. Percentage of broods with only one offspring: values based on 8% (Koehler 1991), 4% (average of Koehler 1991, Druecker 1972, and Tomich for Hawaiʻi and mainland hoary bats), and 0% (Hawaiian Hoary Bat estimate from Tomich; see Menard 2001). Model outcomes were less sensitive to changes in this value than the other parameters (see black line in Figure 1).

e. Maximum reproductive age was assessed by manually running a base PVA using 4 years (from Barclay; see Koehler 1991), 5 years (our best guess used in the baseline PVA), 6 years, 7 years, and 8 years of age. Model outcome appears to be sensitive to changes in this value, with a set PVA with a starting population of 1,000 bats resulting in populations after 20 years of 562, 1228, 1808, 2279, and 2626 bats for the five values.

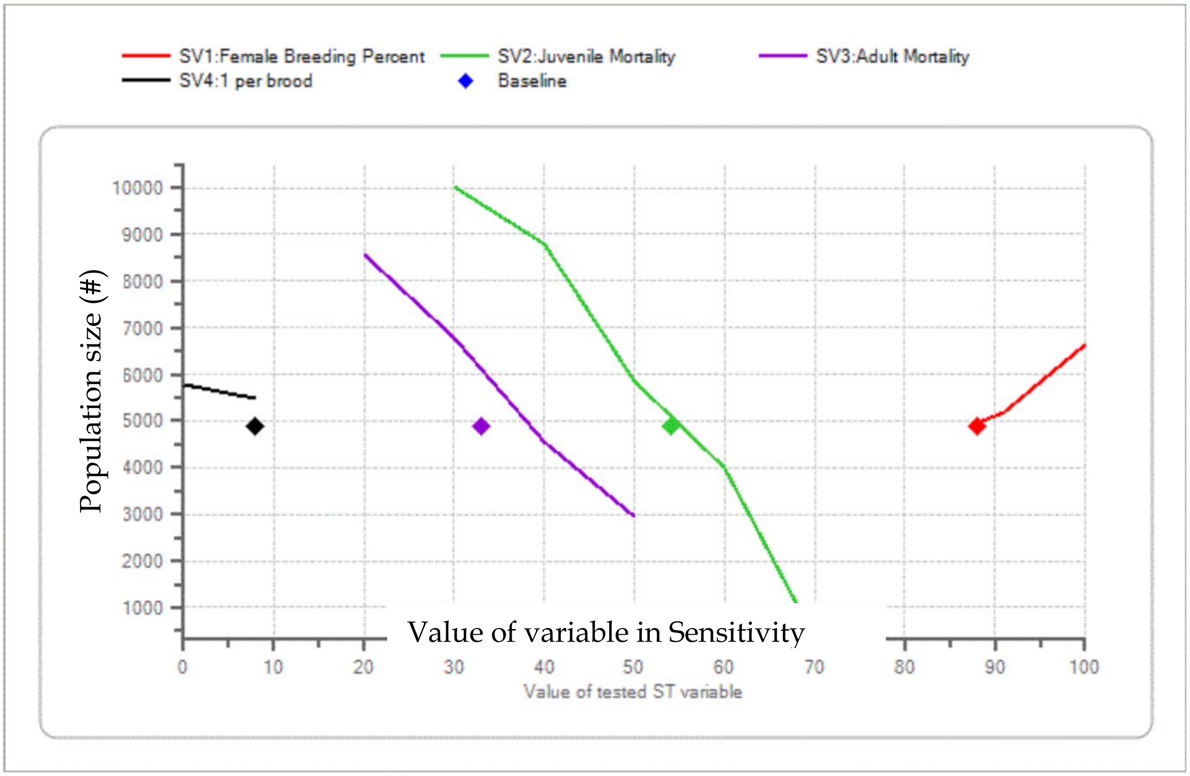

Figure 1. Output of sensitivity analysis for population parameters. The steeper the line, the more sensitive the variable to change. Parameters: percent of females breeding (red), juvenile mortality (green), adult mortality (purple), and the percent of broods with only one offspring (black).

We also looked at how carrying capacity influenced modeling. Frick et al. (2017) set an upper bound on population growth at ten times the initial population size in order to strike a balance between unbounded and overly constrained population growth. We ran models with populations at two times, five times, and ten times carrying capacity. In general, the closer the initial population was to carrying capacity, the smaller its potential growth. Because we found no studies showing that Hawaiian Hoary Bats are habitat limited, we did not undertake extensive exploration of how creating new bat habitat could offset take. Carrying capacity and the impact of creating new habitat are complex modeling issues and need more intensive efforts.

Population Modeling

We started exploratory modeling using available Hawaiian Hoary Bat data, then augmenting that with data from other bat species. Five different models were initially used which spanned a range of different mortality rates in order to see which, if any, models produced stable or increasing populations. Those models (Figure 2) were:

1. Low adult mortality: resulting in a strongly increasing population (+5% annual growth).

2. Low to moderate mortality: resulting in a modestly increasing population (+3.5% annual growth).
3. Moderate mortality: resulting in a stable or slightly increasing population (<+1% annual growth).
4. Lowest mortality estimates for mainland hoary bats: resulting in a declining population (-1% annual growth).
5. Most likely estimated mortality for mainland hoary bats: resulting in a steeply declining population (-15% annual growth).

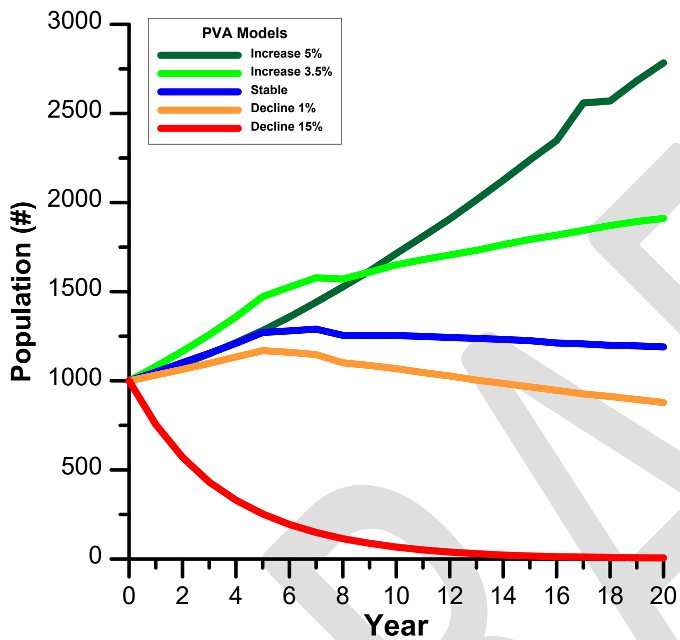

Figure 2. Population trends for an array of Hawaiian Hoary Bat PVA models without take. See text for explanations of models.

Gorressen et al. (2013; p.20) estimated a "stable to slightly increasing" population trend for a Hawaii Island population of Hawaiian Hoary Bats (Figure 3). This is the only published trend we know of for the Hawaiʻi subspecies.

The Task Force decided to focus on developing models that produced "stable to slightly increasing" population trends and assumed populations were not habitat limited. This is somewhat similar to what Friedenberg and Frick (2019) did, although they assumed stability only.

Three PVA models were produced under these narrowed conditions and run with a range of take levels to assess potential impacts to bat populations. When well documented data on Hawaiian Hoary Bats were lacking, parameters were used that were consistent with the literature for similar bat species (see Appendix 1A) and that produced a population trend that was stable or slightly increasing over a 20 year period (i.e., an increase of no more than approximately one percent (1%) annual growth). One PVA was developed to reflect a best guess model (Model A), another model used available Hawaiʻi data over mainland hoary bat data (Model B), and a third model pooled all hoary bat data from both Hawaiʻi and the mainland (Model C). The parameters used in each model can be found in Appendix 2A. A brief description of differences in the models follows.

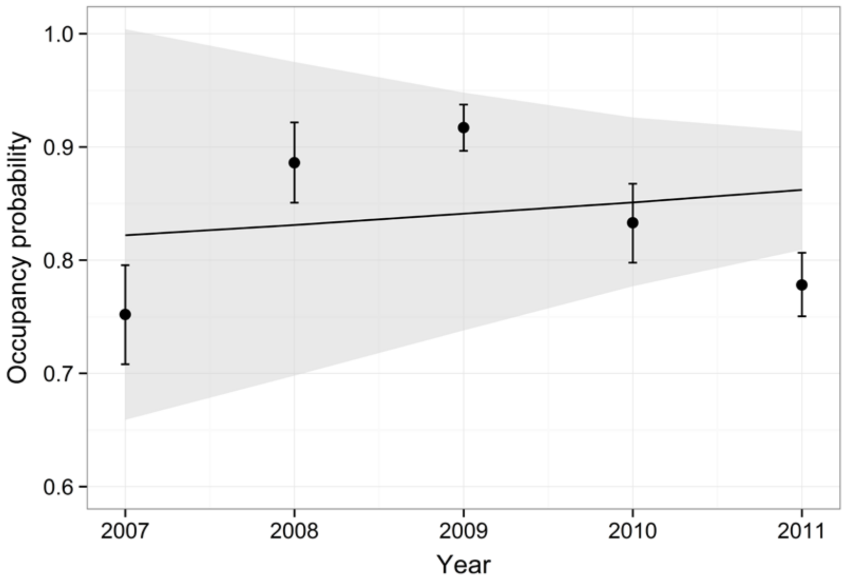

Figure 3. Trend in Hawaiian Hoary Bat occupancy on Hawaiʻi Island from 2007 to 2011 during the period of relatively high detection probability (June to October). Points depict mean annual survey area occupancy (± SE) for all survey areas. Mean trend (black line) and 95% CI (shaded band) were obtained from Bayesian log-linear regression of the annual estimates of occupancy for each survey area. From Gorressen et al. (2013; p. 18).

1. Model A: Best Guess. This model represents a collective best guess as to model parameters. This model produced a stable to slightly increasing population trend with the exponential rate of increase (r) = 0.0082 and the annual rate of change (lambda) = 1.0186. The annual take of up to 1% of the population seems to maintain a stable population. Annual take greater than 1% results in a declining population (Figure 4).

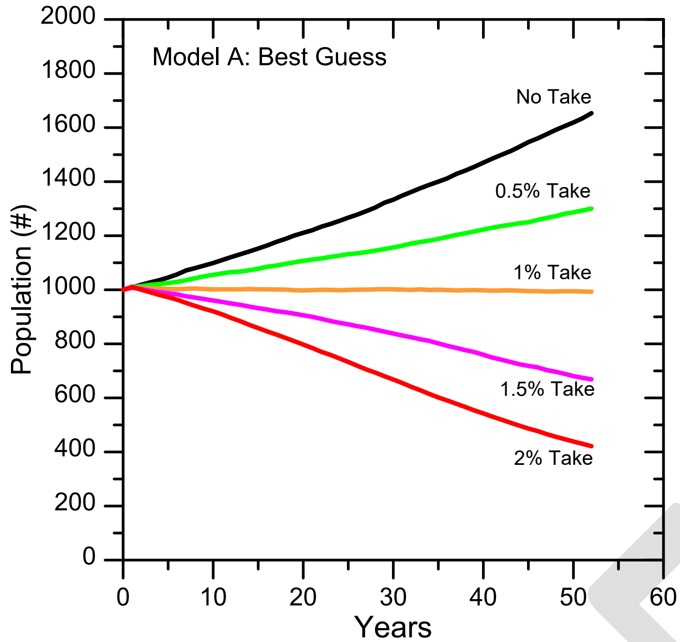

Figure 4. Population trend for Model A: Best Guess under different annual take regimes. Take begins in year 2 and continues to year 52.

2. Model B: Hawaiian Priority. This model prioritized Hawaiʻi data over mainland hoary bat data. This model produced a stable to slightly increasing population trend with the exponential rate of increase (r) = 0.0029 and the annual rate of change (lambda) = 1.0029. The annual take of 0.5% of the population results in a slightly declining population. Annual take greater than 0.5% results in a declining population (Figure 5).

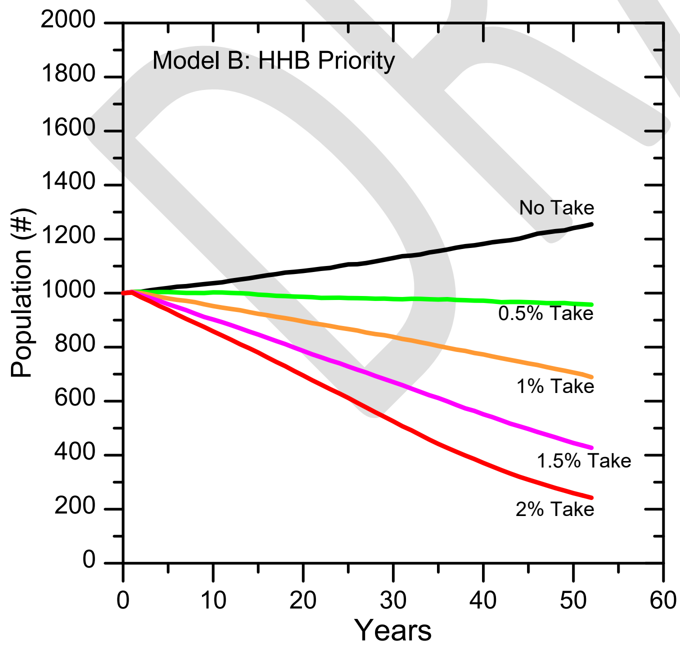

Figure 5. Population trend for Model B: Hawaiian Hoary Bat Data Priority under different annual take regimes. Take begins in year 2 and continues to year 52. This model uses Hawaiʻi data when it is available, even if other data is available.

3. Model C: Averaged Data. This model averaged all hoary bat data, from both Hawai'i and the mainland. This model produced a stable to slightly increasing population trend with the exponential rate of increase (r) = 0.0094 and the annual rate of change (lambda) = 1.0095. The annual take of up to 1% of the population seems to maintain a stable population. Take greater than 1.2% annually results in a declining population (Figure 6).

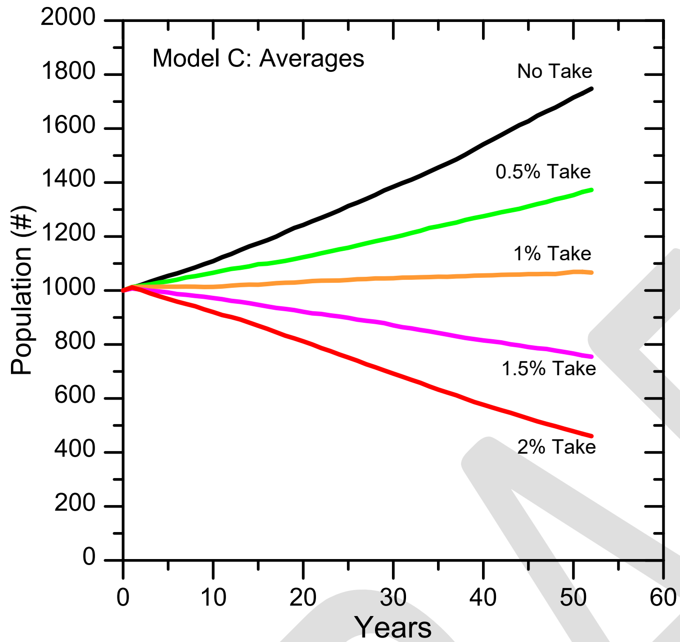

Figure 6. Population trend for Model C: Averages under different annual take regimes. Take begins in year 2 and continues to year 52. This model uses the average of Hawai'i and mainland hoary bat data when both are available.

We also looked at how population size and total annual take might factor into population trends. We used our Model A: Best Guess to explore how population size might interact with take and influence population trends. This model produces a stable to slightly increasing pre-take trend that is similar in scale to the trend reported by Gorressen et al. (2013) and showed very different outcomes to take levels based upon differing initial population sizes (Figure 7). While all populations showed some effects from take, larger populations (> 5,000 bats) showed much less impact than small populations.

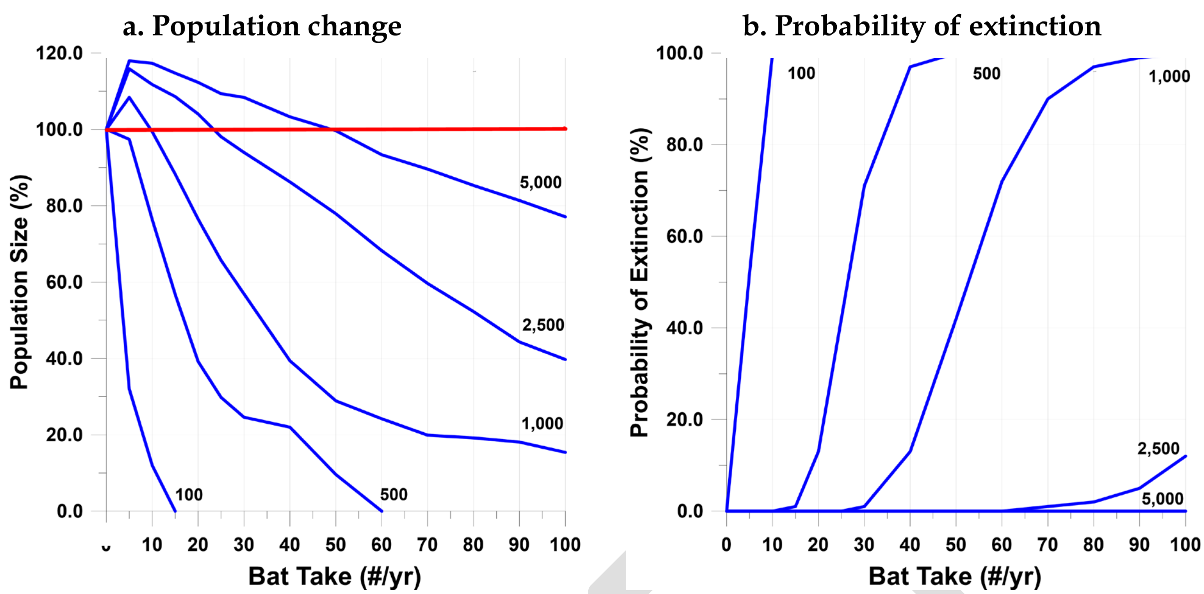

Figure 7. How mortality levels interact with gross take to impact population size and the probability of extinction at the end of 20 years of the specified level of take. A model producing a stable population showed different patterns of (a) population change and (b) extinction probability at various initial population sizes. Note that the point where take approximately equals one percent of the population size is the point where this model indicate that the population will drop below its pre-take population level (red line).

Summary: All three models started with population parameters resulting in slightly increasing populations (approximately a 0.4% to 1.0% annual growth rates). Under all three modeled scenarios, the annual take of bats has a negative impact on population growth; even a 0.5% level of annual take reduces population growth. When modeled annual take exceeded the annual growth rate, modeled population numbers declined.

Preliminary Conclusions

The exploratory PVA efforts provided some insights into research priorities as well as information that may inform conservation decisions. This is our first effort at modeling Hawaiian Hoary Bats; a much more sophisticated and more intensive modeling effort is needed before relying heavily on this effort.

Research priorities

It is well recognized that many important population parameters remain unknown for the Hawaiian Hoary Bat. From the perspective of Habitat Conservation Plans, the following research needs should be prioritized:

1. Determine the current bat population trend on Oʻahu.
2. Determine the current bat population trend on Maui.
3. Determine if past habitat restoration projects have increased bat populations.
4. Determine the size of bat populations on Oʻahu, Maui, and Hawaiʻi.
5. Determine if bat populations are habitat limited.
6. Determine adult bat mortality.
7. Determine juvenile bat mortality.
8. Determine the maximum age of bat reproduction.

Population modeling and take

These modeling efforts do not provide definitive determinations as to how much take should be allowed by specific wind projects. They do, however, provide information useful to conservation decisions and assessments on an island-wide basis. Specifically:

1. One study has estimated population trends for the Hawaiian Hoary Bat (Gorressen et al. 2013). That report stated that the study population on the island of Hawaiʻi was either "stable or slightly increasing." Similar studies on Oʻahu and Maui would help clarify the situation on those islands. Until field studies provide better data, modeling and impact assessment efforts should be consistent with this finding of no more than a 0 to 1 percent annual increase (in populations without wind project take).
2. No studies have shown that compensatory reproduction is occurring in Hawaiian Hoary Bats (or mainland hoary bats). The incorporation of compensatory reproduction in take modeling is currently not warranted.
3. To date, there are no studies that have shown an increase in Hawaiian Hoary Bat populations as a result of mitigation offsets. It is not prudent at this time to expect that habitat restoration will successfully offset large levels of bat take that might cause steep population declines.
4. In general, for models that are stable to slightly increasing and not limited by carrying capacity, an annual rate of take that exceeds the annual rate of increase of a population is likely to cause a decline in that population. For example, if a population has a one percent annual rate of increase without wind project take, a take level in excess of one percent would be expected to result in a declining population. For a stable population, all take would be expected to cause a decline in the population. Friedenberg and Frick (2019) came to a similar conclusion in their report. The significance of these declines would be dependent on the size of the population. If a population is declining prior to take, any take will further the population's decline.
5. These models indicate that projected levels of take may pose a relatively low risk to large Hawaiian Hoary Bat populations. For example, if the proposed annual take of bats for the island of Hawaiʻi was 10 bats/year and the bat population is expected to be over 5,000, there may be low risk to the population. Conversely, an island with under 1,000 bats may not be able to sustain the loss of 10 bats/year.

6. Population modeling can incorporate basic population parameters, take levels, habitat carrying capacity, and increases to carrying capacity via habitat restoration. These entities are all linked; they should not be assessed independently from one another. They should all use the same population trend estimates, core use areas, carrying capacities, population parameters, and other assumptions. Similarly, efforts to estimate bat population sizes using the amounts of suitable habitat should incorporate inputs consistent with population models and observed population trends.

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<u>Appendix 1A. Required information to run Vortex modeling (Vortex 10.2.17.0, a stochastic simulation of the extinction process).</u>

Model Input	Choice	Hawaiian Hoary	Mainland Hoary	Other Bats
Reproductive System				
• Choose one: monogamous, polygynous, hermaphroditic, long-term monogamy, long-term polygyny.	Polygynous			Assumed
• Age at first offspring females	1		Based on Druecker (1972): "Most males and female *L. cinereus [cinereus]* apparently mature sexually during their first summer." Druecker examined by sectioning reproductive tracts of 8 females (7 of 8 breeding).	
• Age at first offspring males	1	Tomich reported for *L.c.s.* (see Menard 2001 thesis Appendix B): "Do young breed in first season: it would seem so because of scrotal testes in this	Based on Druecker (1972): "Most males and female *L. cinereus [cinereus]* apparently mature sexually during their first summer." Druecker examined by sectioning testes of 27	

		juvenile [2784 was caught 9-14-64].”	males (26 of 27 breeding).	
• Maximum lifespan	8		Tuttle (1995) article said about 6 or 7 years based on reproductive rates. Increased to 8 because of online sources giving higher estimates (like 14 years found online at http://www.worldlifeexpectancy.com/mammal-life-expectancy-hawaiian-hoary-bat).	
• Maximum number of broods per year	1	Well known to be 1. See Menard thesis.		
• Maximum number of progeny per brood	2	Tomich field notes (Menard thesis);	Koehler 1991; Druecker 1972.	
• Sex ratio at birth – in % males	50%		Koehler (1991): Thesis reported 10 females to 11 male pups for *L.c.c.*	
• Maximum age of female reproduction	5		Koehler (1991), p 7, said Barclay had 4 year old females. We added a year.	
• Maximum age of male reproduction	5		A guess based on females	
• Density dependent reproduction?	No			No documentation
Reproductive Rates				
% adults females breeding	80, 88, 95	Tomich dissected 15 *L.c.s.*: **80%** were	Druecker (1972), p. 42, caught 8 females from	

		breeding & 20% not (Menard thesis Appendix A).	April to June, of which 7 (**88%**) had embryos; the other one had no embryos but did have sperm. Druecker cites Jones (1964) to report that 38 of 40 females in spring/summer were pregnant. (**95%**).	
SD in % breeding due to EV	5			Guess
Distribution of broods per year:				
0 Broods	0			
1 Broods	100%			We have never heard of breeding females having more than 1 brood per year.
Specify exact distribution (enter as percents)		Tomich dissected 4 pregnant *L.c.s*. and 100% had two embryos (Menard thesis Appendix A).	Koehler (1991) followed 13 families of *L.c.c.* and had 12 families with twins (92%) and 1 family with a singleton (8%). Druecker (1972) dissected 7 female *L.c.c.* and 100% had two embryos.	
1 Offspring	0,4,8%		As per Koehler 91	
2 Offspring	92,96,100		As per Koehler 91	
Mortality Rates				
Mortality from age 0 to 1	52,54,55			
SD in 0 to 1 mortality due to EV	5			

Annual mortality after age 1	33,34			Lentini (2015) study of several microbat studies concluded about 77% adult female bat survival (**23% mortality**) and 66% adult female survival (**33% mortality**) for species that produce more young.
SD in mortality after age 1	5			
Mate Monopolization				
% Males in breeding pool	20%			This low value didn't seem to matter too much since the population is polygynous.
Initial Population Size & Carrying Capacity				
Initial Population Size	100, 300,500,1000, 2500,5000			1,000 was the base size
Carrying Capacity	1000,2000, 5000, 10000			10,000 was base size. Frick (2017): "We fixed a ceiling on population growth at 10 times the initial population size to account for carrying capacity and to balance between unbounded and overly constrained population growth."
Harvest				
First year of harvest	2			
Last year of harvest	52			Modeled 52 years …
Interval between harvests	1			

Number of females harvested	0-200			Base was 10 per year
Number of males harvested	0-200			Base was 10 per year

Appendix 2A. A comparison of variables for Model runs A, B, and C.

Input	Description	A	B	C
1	Populations: 1 island population	Same	Same	Same
2	Duration of 20 years to determine baseline trend (no take)	Same	Same	Same
3	Duration of 52 years to determine overall trends (take and no take)	Same	Same	Same
4	Take starts in year 2 and runs through year 52	Same	Same	Same
5	Extinction defined as no males or no females	Same	Same	Same
6	Reproductive system is polygyny, new mates each year	Same	Same	Same
7	Max age of survival is 8 years	Same	Same	Same
8	Beginning age of breeding is age 1	Same	Same	Same
9	Max age of breeding is age 5	Same	Same	Same
10	Sex ratio at birth is 50 - 50	Same	Same	Same
11	Reproduction is not density-dependent	Same	Same	Same
12	Correlation of environmental variation of 0.5 between repro and survival	Same	Same	Same
13	**Percentage of adult females breeding each year**	**88%**	**80%**	**90%**
14	Breeding environmental variation (SD) is 5%	Same	Same	Same
15	Percent of adult males breeding is 20%	Same	Same	Same
16	**Percentage of broods with 1 pup**	**8%**	**0%**	**4%**
17	**Percentage of broods with 2 pups**	**92%**	**100%**	**96%**
18	**Annual juvenile mortality**	**54%**	**52%**	**55%**
19	Juvenile mortality environmental variation (SD) is 5%	Same	Same	Same
20	**Annual adult mortality**	**33%**	**33%**	**34%**
21	Adult mortality environmental variation (SD) is 3%	Same	Same	Same
22	Initial population size is 1,000	Same	Same	Same
23	Carrying Capacity 10,000	Same	Same	Same
24	Harvest (e.g. take) ranges from 0 to 2%	Same	Same	Same
25	Model iterations: 5,000	Same	Same	Same

A Best Guess Scenario
B Priority to Hawaiian Hoary Bat data
C Averaged data from all Hawaiʻi and mainland hoary bat data