Endangered Species Recovery Committee
Hawaiian Hoary Bat Guidance Document

State of Hawaiʻi Department of Land and Natural Resources
Division of Forestry and Wildlife

September 2015

Prepared by Angela Amlin and Afsheen Siddiqi
Cover Photo by Corinna Pinzari

Table of Contents

I. Introduction 2

a. Conservation Status of the Species 2

b. Development and Wind Energy Goals 2

c. Purpose and Need 3

II. Ecology and status of the Hawaiian hoary bat 4

III. Anthropogenic Sources of Hawaiian hoary bat take 4

a. Wind Energy 4

b. Tree Trimming and Harvesting 5

IV. Hawaiian hoary bat take avoidance and minimization measures 6

c. Wind Energy 6

d. Bat Deterrent Technology 7

e. Tree Trimming and Harvesting 8

V. Monitoring protocols and new technology 10

a. Wind Energy 10

VI. Mitigation 11

a. Resource Equivalency Analysis 11

b. Bat mitigation projects to date 15

c. Mitigation strategy moving forward 18

1. Habitat management 19

2. Research as mitigation 20

VII. Research and conservation priorities 21

a. Ecological framework 21

b. Implementation plan 27

VIII. Conclusion 27

IX. References 27

I. Introduction

a. Conservation Status of the Species

The Hawaiian hoary bat (*Lasiurus cinereus semotus*), also known as ʻōpeʻapeʻa, is a subspecies of the North American hoary bat (*L. c. cinereus*), and is listed as endangered under both the Federal Endangered Species Act (ESA) and Hawaiʻi endangered species laws (Hawaiʻi Administrative Rules 13-124, Exhibit 2 and Hawaiʻi Revised Statutes (HRS) §195D). It has not been evaluated as a distinct subspecies by the International Union for Conservation of Nature (IUCN), but is listed as globally imperiled by NatureServe. Recent genetic research indicates that the hoary bat in Hawaiʻi likely colonized the islands in multiple events and that there could be two distinct species present (Baird et al., 2015, Russel et al., 2015). 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 Hawaiʻ i and is listed as endangered. As of April 2015, the Hawaiian hoary bat has been officially designated as the state land mammal, and is in fact the only extant native terrestrial mammal in the Hawaiian Islands.

b. Development and Wind Energy Goals

The state Department of Business, Economic Development, and Tourism (DBEDT) produced a report in 2012 entitled *Population and Economic Projections for the State of Hawaii to 2040*. According to the data collected by the report, Hawai´i is a rapidly growing state that experienced a total population increase of about 30 percent and an average annual increase of 1.2 percent between 1980 and 2010, when the U.S. Census Bureau reported a statewide population of 1,363,621. The state also has a large population of military personnel and their families, which has increased in recent years. Although the majority of residents reside in Honolulu County (about 70 percent), population growth rates are higher in Maui, Kauaʻi, and Hawaiʻi Counties. The population is predicted to grow to more than 1.7 million by 2040, with a larger proportion of residents living outside of Honolulu County, and a smaller percentage of residents affiliated with the military.

Growth of this magnitude means that one of the greatest pressures on threatened and endangered species in Hawaiʻi is habitat loss and, in the case of the Hawaiian hoary bat, is thought to be the loss of roosting habitat in particular (USFWS 1998, Mitchel et al. 2005). Pesticides, predation, and roost disturbance are also threats to bat populations (USFWS 1998, Mitchell et al. 2005). On the continental U.S., white-noise syndrome (WNS) has wiped out an estimated 5.7 to 6.7 million bats (USFWS News Release 2012). WNS has not been documented in Hawaiʻi, and there are no other known diseases that are significant sources of Hawaiian hoary bat mortality, but it remains a possibility for WNS or another disease to spread to Hawaiʻi. The State Division of Forestry and Wildlife (DOFAW) has sought competitive grant monies in the past to survey high elevation caves where bats are known to forage on Hawaiʻi Island for evidence of WNS, and will continue to monitor the situation in the future (Bonaccorso in prep.).

Unlike avian species, migratory tree-roosting bats, such as the hoary bat, do not frequently collide with man-made structures such as powerlines and buildings. However, with the increasing development of wind energy facilities, the number of bat fatalities due to collision continues to grow to the point where 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). Under HRS §195D, these fatalities are referred to as incidental take and can be permitted with issuance of Incidental Take Licenses (ITLs) which may be approved by the Board of Land and Natural Resources (BLNR). Take, as defined by the statute means, "…to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect endangered or threatened species of aquatic life or wildlife." The BLNR can only approve an ITL if the requested take is "…incidental to, and not the purpose of, the carrying out of an otherwise lawful activity" (HRS §195D-4(g)).

The State of Hawaiʻi has established ambitious renewable energy goals with the passing of HB623, a bill requiring 100 percent of the state's electricity to come from renewable sources by 2045. Impacts to bats, particularly migratory tree-roosting bats, as a result of collision with wind turbines are well-documented in the continental U.S. (Johnson & Strickland 2003, Kunz et al. 2007, Arnett et al. 2008, Cryan 2011) and, as more facilities come online, are increasingly apparent in Hawaiʻi. While the continental U.S. tree-roosting bats are not currently listed as threatened or endangered, Hawai'i is home to a single endangered subspecies of tree-roosting bat. As of August 25, 2015, 46 Hawaiian hoary bat fatalities have been observed at wind facilities in Hawaiʻi. Actual take is likely much higher when adjusted for unobserved take, indirect take, and lost productivity.

c. Purpose and Need

All requests for ITLs, as defined under HRS §195D-21, must be accompanied by HCPs. HCPs integrate development activities with conservation, and 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 and must provide a net recovery benefit to the affected species.

Mitigation implemented in Hawai´i to date has been generally inconsistent among HCPs as new ecological information has come to light and lead to changes in the approach to mitigation planning. This results in an unpredictable scale and cost of mitigation, making it difficult to measure the impact on species recovery across a large number of disparate projects. It may also lead to frustration among applicants, complicated planning, lack of predictability, and confusion about the process. For example, there are currently five approved HCPs and three HCPs in development associated with wind energy projects covering take of the Hawaiian hoary bat. Restoration efforts in these HCPs ranged from 13 acres to 40 acres per bat, and costs ranged from $10,000 to $87,000 per bat. One HCP mitigated by providing funding for research at a cost of $1,000 per bat. Up to this point, there has not been a robust way of demonstrating that these projects have offset the take requested under the HCPs, or if the net benefit requirement has been met.

The Endangered Species Recovery Committee (ESRC), advisor to the BLNR regarding HCP approval and management, has acknowledged the challenges and inconsistencies regarding HCPs and Hawaiian hoary bats. The ESRC therefore requested a workshop to bring together the appropriate stakeholders to discuss issues ranging from take avoidance, to research priorities, to future mitigation strategies. DOFAW staff coordinated a workshop held in Honolulu, Hawaiʻi on April 14-15, 2015, that brought together government regulators, ecological researchers, consultants, industry personnel, and members of the public. The overarching goal of the workshop was to develop cohesive, consistent guidelines for project proponents attempting to avoid, minimize, and mitigate for incidental bat take, and for the regulators tasked with overseeing those projects.

This white paper is the outcome of that workshop, and is meant to serve as a "living document" that will be revisited and updated by DOFAW staff, under the guidance of the ESRC, at least every five years, or as significant advancements are made in the understanding of Hawaiian hoary bat ecology and management. It is intended to serve as a guide during the development of new HCPs and the oversight and adaptive management of existing HCPs. The ESRC suggests that the recommendations contained herein will be addressed as appropriate in any HCP requesting take of the Hawaiian hoary bat submitted for review, and the applicant may be asked to discuss these topics with the ESRC including any recommendation deemed not applicable or inappropriate for a particular project. This document does not constitute agency approval of any particular measure or project. Should well-supported information come to light that differs from statements or advice provided in this document, the newly acquired information should take precedence and should be included in the next white paper revision.

II. Ecology and status of the Hawaiian hoary bat

Due largely to the cryptic and solitary nature of the Hawaiian hoary bat, knowledge of its ecology and life history is limited. As recently as 2005, it was thought that the bat was likely extirpated on Molokaʻi and Oʻahu, and breeding was limited to the islands of Kauaʻi and Hawaiʻi (Mitchel et al. 2005). We know now that bats occur on all the main Hawaiian islands, and breeding populations occur on all of the main Hawaiian islands except for Niʻihau and Kahoʻolawe, and roost primarily in woody vegetation exceeding 15 feet in height (Bonaccorso et al. 2015). Their diet consists primarily of nocturnal aerial beetles and moths (Jacobs 1999, Todd 2012). Hawaiian hoary bats have distinct core-use areas with a mean size of about 63 acres (25.5. hectares) with little to no overlap (Bonaccorso et al. 2015), but may travel as far as 6 – 8 miles (11 to 13 km) one-way in a night to forage (Jacobs 1994, Bonaccorso et al. 2015). Hawaiian hoary bat population estimates have ranged from a few hundred to a few thousand (Mitchell et al. 2005); however, it is generally accepted that it is not feasible at this point in time to ascertain a population estimate, although understanding population status and specific habitat requirements of the species have been identified as the primary data needs for species recovery (USFWS 1998, 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, Gorresen et al. 2013). Although population estimates are not currently available, studies indicate that the bat population on Hawai´i Island is stable and potentially increasing (Gorresen et al. 2013).

III. Anthropogenic Sources of Hawaiian hoary bat take

a. Wind Energy

Bat collisions and mortality at wind facilities are well-documented throughout the US, mostly involving migratory tree-roosting bat species such as silver-haired, hoary, and eastern red bats (Johnson & Strickland 2003, Kunz et al. 2007, Arnett et al. 2008, Cryan 2011). Arnett and Baerwald (2013) estimated that between 2000 and 2011, between 650,000 and 1,300,000 bats were killed at wind facilities in the U.S. and Canada. Hoary bats have constituted the highest proportions of fatalities at most continental U.S. facilities, ranging from 9 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 during spring migration (Cryan 2011). This seasonal pattern, although not as pronounced as on the continental U.S., is apparent in Hawaiian hoary bat collision fatalities as well (Figure 1). While it is thought that Hawaiian hoary bats complete a seasonal altitudinal migration on a similar time frame, there are still many questions surrounding timing, 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.

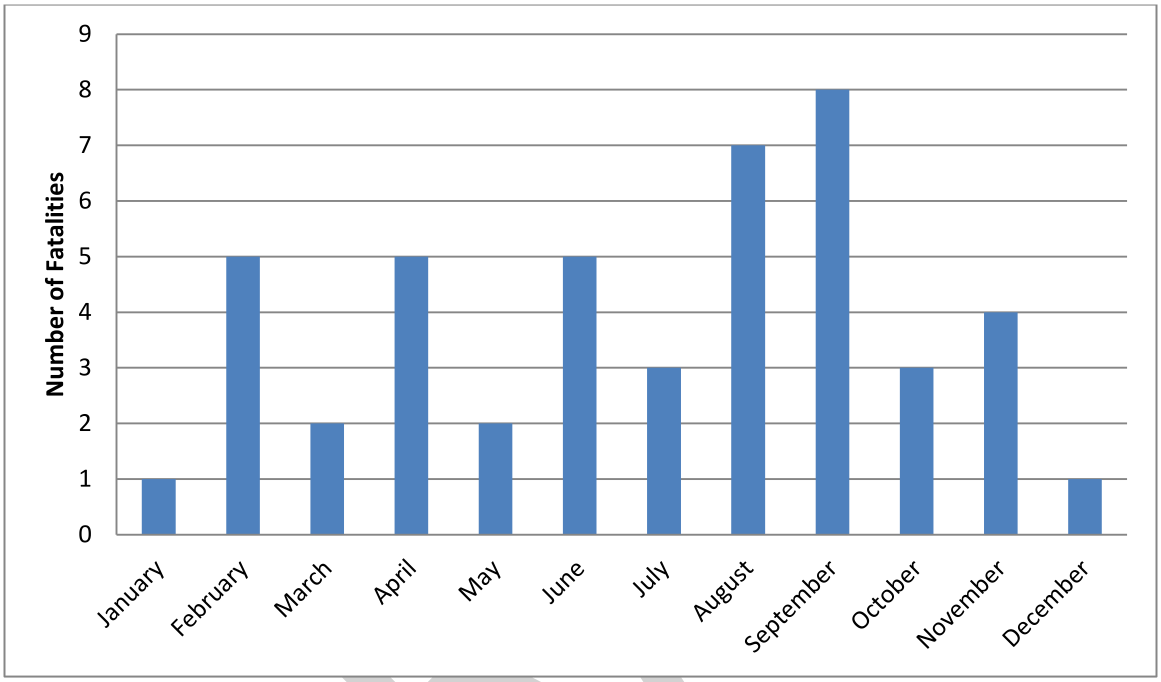


Figure 1. Bat fatalities by month across all wind facilities with approved ITLs in Hawai'i as of August 25, 2015.

Fatality rates vary by facility, and studies have documented fatality rates as high as 41.6 bats per MW per year at a facility in Tennessee (Kunz et al. 2007). However, the national average has been estimated to be closer to 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 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 are actually attracted to turbines, potentially due to the resemblance to tall trees and/or expectation of resources, such as insect prey or potential mates (Kunz et al. 2007, Cryan et al. in prep). 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).

b. Tree Trimming and Harvesting

Female Hawaiian hoary bats give birth to two pups, or occasionally one, in mid-June and the pups are typically dependent on their mother and are unable to fly (non-volant) until late August/early September (USFWS 1998). While tree trimming and harvesting activities are not necessarily incompatible with bat habitat needs (Patriquin & Barclay 2003, Johnson & Strickland 2003), they have the potential to impact juvenile bats because they may be unable to fly away from a tree when it is cut or disturbed. For this reason, guidance from DOFAW and the U.S. Fish and Wildlife Service (USFWS) is that harvesting or trimming of woody plants more than 15 feet tall should not occur between June 1 and September 15 without prior consultation with agency biologists. It is not known exactly how much bat take occurs nationwide or statewide as a result of tree trimming and harvesting.

IV. Hawaiian hoary bat take avoidance and minimization measures

c. Wind Energy

Curtailment refers to a practice in which wind energy is available, but is not being collected and supplied to the grid. Curtailment can be imposed on a facility by the receiving utility company if the grid has reached capacity, or can be implemented by the wind operator. In this paper, when we use the term curtailment we refer to the case of the latter, specifically when curtailment is used as an operational minimization measure. This involves increasing the wind speed at which turbines will “cut-in” and start producing power, as bat collisions happen at a much higher rate when wind speeds are low (Arnett 2005, Cryan et al. in prep). Although wind turbines do not generate power below the cut-in speed, turbine blades continue spinning and therefore still pose a collision risk to wildlife. To combat this risk, blades are often feathered, which means they are turned parallel to the wind and therefore will not spin below the cut-in speed, although they may still rotate very slowly (called free-wheeling). Curtailment is currently the primary minimization measure implemented by wind farms in the U.S., including those here in Hawaiʻi.

Various studies in the U.S. and Canada have looked at the impacts of raising cut-in speeds on number of bat fatalities. Result from studies conducted across numerous ecosystems and facilities, have consistently shown a decrease in fatalities of about 50 percent or more once cut-in speeds are equal to or greater than 5.0 meters per second (m/s). Results of some of these studies are depicted in Figure 2. 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. Benefits of curtailment practices in Hawaiʻi are still being evaluated for their effectiveness. Based on mainland data and curtailment practices in Hawaii, applicants seeking incidental take authorizations for the Hawaiian hoary bat assume a reduction to the impact to the species based on curtailment practices that is proposed.

<u>Recommendations</u>

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. However, it must be noted that due to the small sample size in Hawaiʻi and various other factors, these data cannot be considered statistically significant. The ESRC recommends that low wind speed curtailment is a part of every wind facility’s minimization strategy to the maximum extent practicable, and recommends a minimum cut-in speed of 5.0 m/s, increasing to a higher cut-in speed through adaptive management if the rate of bat take is higher than initially expected. If future deterrence technology becomes available the need for curtailment may no longer be needed. The ESRC recommends that permittees collect, analyze, and report data on the effectiveness of curtailment practices. The ESRC also recommends the inclusion of specific triggers for increasing curtailment be included in HCPs (e.g., exceedance of a certain level of overall take or annual running average). Curtailment protocols should also be modified and addressed within the adaptive management protocol for each facility, and as new information arises that demonstrates ways to more effectively minimize or avoid impacts to bats.

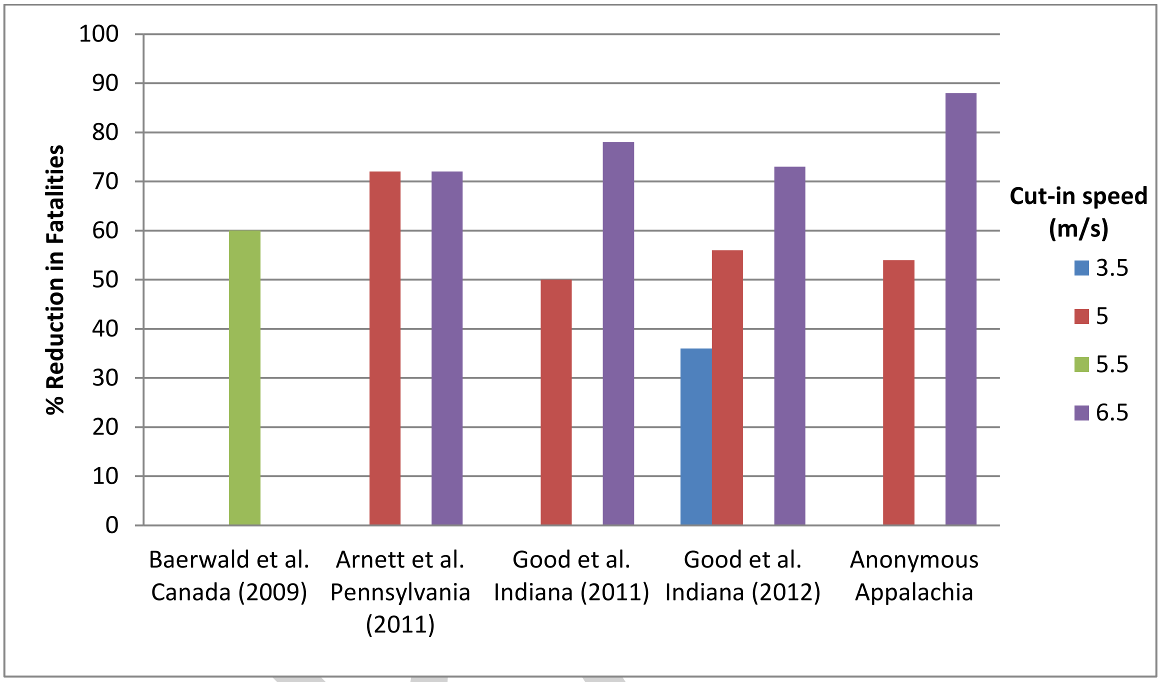


Figure 2. Reduction in fatalities under different curtailment regimes at five wind farms in the continental U.S.

d. Bat Deterrent Technology

Given the high number of bat fatalities at wind facilities and the body of evidence suggesting that bats are attracted to turbines, a variety of new technologies have emerged designed to deter bats from coming in close proximity to turbines. These technologies include ultrasonic acoustic deterrents, ultra violet (UV) light deterrents, and physical modifications to the turbines (e.g. painting blades).

Acoustic deterrents have been in development and testing since 2006, and have shown generally positive results thus far. Initial studies found that bats in flight were never able to capture a suspended mealworm when ultrasonic deterrents were operating (Spanjer 2006), and found a 90 percent reduction of bat activity within 12 m of deterrents set up near ponds (Szewczak and Arnett 2007). The first deterrents designed for use at commercial wind farms were tested by Horn et al. (2008) at a wind facility in New York State, with mixed results. The researchers hypothesized that the mixed results were due to the ultrasound from the deterrent attenuating quickly and not encompassing the entire rotor-swept area of the turbine. Johnson et al. (2012) found that bat activity at four weir ponds in West Virginia was reduced by 17.1 percent when the acoustic detectors were deployed. Arnett et al. (2013) conducted two trials at a wind facility in Pennsylvania, with results the first year showing 21-51 percent fewer bat fatalities when deterrents were deployed, and results the second year showing an 18 to 62 percent fewer fatalities. However, factoring in a nine percent inherent difference between the treatment and control turbines yielded a result of two percent more to 64 percent fewer fatalities the second year. Researchers suspected that distance was a factor, as well as high humidity which also causes high frequency sounds to attenuate.

Unlike curtailment studies, which have not been conducted in Hawaiʻi, an acoustic deterrent study was conducted at a macadamia nut farm on Hawaiʻi Island in 2013 by Hein and Schirmacher of Bat Conservation International. This study found a significant decrease in activity when the deterrents were operating (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. (in review) 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 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 25-44 percent as compared to control sites, despite the fact that insect abundance increased by nearly 500 percent. These results indicate that the technology is promising, and warrants further study.

<u>Recommendations</u>
Both acoustic and UV deterrents have the potential to reduce the number of bat fatalities at wind energy facilities, and the USFWS and DOFAW have strongly encouraged ITL applicants to invest in deterrent research. However, given that the technology is unproven and currently expensive, applicants have been reluctant to do so without receiving credit for mitigation. The ESRC has identified that take reduction is a priority research topic. However, under the Federal ESA and associated regulations, measures to avoid and minimize take cannot be substituted as mitigation for take that is anticipated to occur under an Incidental Take Permit. Permitees are required to minimize take to the "Maximum Extent Practicable," as defined in the ESA regulations. Given that that federal regulations will not allow this type of research to serve as mitigation, the ESRC is not likely to recommend approval of an HCP that includes such provisions. Therefore, the ESRC encourages agencies, applicants, and other interested parties to pursue such research independently. If in the future federal regulations change to allow for such research to receive mitigation credit, the ESRC may consider changes to this guidance.

e. ***Tree Trimming and Harvesting***

In addition to tree trimming needs associated with utility lines and road clearing, increasing pressure to develop a sustainable timber industry in Hawaiʻi has led to a demand for harvesting timber during the bat pupping season (June 1 – September 15, see Section III.b). The Hawaiʻi Forest Industry Association (HFIA), Kauaʻi Island Utilities Cooperative (KIUC), and other entities have begun to look for ways to detect breeding bats in order to avoid impacting them and thus avoid the need for an ITL and HCP.

Given that Hawaiian hoary bats are small and dark colored, they are extremely difficult to detect visually while roosting, especially in trees with dense canopy. While still challenging to find in a large forested area, methodology being implemented by KIUC involves using forward-looking infrared (FLIR) systems to look at individual trees or smaller areas of forested roadsides to determine if bats are present. Apart from emergency situations, KIUC only trims densely vegetated areas outside of the bat pupping season. Some initial searcher efficiency trials have been conducted with trained tree trimmers by using mice raised up into the trees in cages and using FLIR to spot the mice. Although data have thus far not been formally analyzed or published, it has been anecdotally reported that 100 percent of the mice have been located (R. David 2015 pers comm).

When looking at larger patches of potential habitat, the HFIA has supported efforts to categorize habitat by ecological characteristics to determine likely presence/absence of roosting bats. These efforts have relied on the use of acoustic monitoring to detect bats in different habitat types. Although, acoustic detections can be used to determine if bats are utilizing an area they do not necessarily indicate whether a bat is roosting in an area, foraging, or simply traversing that space (D. Johnston 2016 pers comm). Zero acoustic detections may not indicate that bats are absent, but could, when combined with proven foliage density indices and other ecological measures, provide a probability of absence of bats in a particular area. Although not a useful tool for searching through large expanses of trees, FLIR technology and methodology could be incorporated if a particular area of concern had been identified (R. David 2015 pers comm). Potentially, an additional method could be to capture and tag females during the breeding season and then track them back to their roosting trees to study their behaviors and characteristics of their roosting habitat (F. Bonaccorso 2015 pers comm).

It is as yet unclear how best to monitor for bat fatalities as a result of large-scale tree trimming or timber harvesting. It has been proposed that using the aforementioned characterization of bat pupping habitat quality may be an effective avoidance measure (H.T. Harvey, 2014). Scientifically robust sampling indicating bat absence from a particular type of stand would be needed to conclude bats don't use stands with particular characteristics for pupping. The number of acres that would need to be surveyed without finding any roosting bats, or the number of years such results would be needed has yet to be determined, but this type of confirmation could require survey of a few thousand acres of a particular stand class. Similar information would be needed to enable stand characteristics to be used as apractical way to estimate take, given the widespread, low density bat population on the Hawaiian Islands (D. Johnston 2015 pers comm). By determining a likely density of breeding bats based on assigned habitat value, a reasonable estimate of take could potentially be derived based on the number of acres of each habitat category trimmed or harvested. Studies to determine if this method is effective and how best to implement it are ongoing.

<u>Recommendations</u>

The ESRC has found that current suggested protocols for using acoustic detections, habitat indices, or other indirect measures to determine that bats are absent from an area are insufficient, and need further development before they can be approved and implemented as a tool to avoid impacts to the species from tree harvesting during the pupping season. Project proponents should work with agency staff to develop protocols and practices for approval by the ESRC that will inform the potential for harvesting during the pupping season without the need for an ITL. Methods targeted at individual trees, such as FLIR, appear to be successful on their current scale and could potentially be scaled up for use in timber harvest activities. For now, the current guidance of not cutting from June 1 to September 15 without an ITL and associated HCP remains in place.

V. Monitoring protocols and new technology

a. Wind Energy

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 and implemented by the permit holder. The method, frequency, size of search plots, number of turbines, and monitoring period are project-specific and often dependent on carcass persistence at the site. All post-construction monitoring data must be analyzed via statistical methods that provide scientifically robust assessment of take. Accurate take assessment is complicated by the fact that many animals killed at a facility may go undetected. When conducting post-construction surveys, researchers collect a time series of the number of individuals detected during each search. It has long been recognized that the counts do not represent all individuals 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. Models of carcass spatial distribution can be used to estimate the fraction of carcasses landing outside the searched area (Huso and Dalthorp 2014). Independent searcher efficiency and carcass removal trials 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. All estimators of wind turbine-caused bird and bat fatality must account for these primary sources of imperfect detection, each of which will lead to an underestimate of fatality if ignored, or a biased estimate if incorrectly modeled. If detection probability was constant, there would be no need to develop an estimator that adjusts observed counts for imperfect detectability; observed counts could be used as a simple index of fatality (Huso 2011). Because proposed methods vary with time, searcher, weather conditions, season, and other factors, direct estimates of take are not possible; statistical analysis of the fatality data, in light of scavenger removal, carcass deterioration, and searcher efficiency raw data must be completed to allow meaningful assessment of take.

Currently, the Evidence of Absence model developed by statisticians at the U.S. Geological Survey (Dalthorp et al. 2014), is the model recommended by the agencies and in use by all wind facilities in Hawai´i. The model takes into account the aforementioned factors, and applies a site-specific overall probability of detection to fatalities at a given facility, and generates a maximum credible number of estimated fatalities. Generally, monitoring at Hawaiʻi wind farms takes the form of standardized carcass searches by technicians walking transects within a search plot. Additional search methods that have been employed include searching from an all-terrain vehicle and canine-assisted searching. Canine-assisted searches have consistently produced higher search efficiency results. For example, at some facilities have produced higher searcher efficiency results (80-90% of bat trials found and 97-100% of bird trials found) than humans alone (SunEdison 2014, 2015).

Additionally, bat acoustic monitoring at and in the vicinity of wind facilities has been conducted to document bat occurrence, habitat preferences on site, and seasonal and temporal activity changes. Monitoring results are expected to advance avoidance and minimization strategies at wind facilities by helping to design smart curtailment regimes.

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. 2015, 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 SunEdison's Kawailoa Wind Farm, over 3,000 bat events were observed in almost four thousand hours of video. 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 may not be an appropriate tool for take monitoring at wind energy facilities. Namely, the field of view from thermal and infrared cameras is limited, therefore multiple cameras would be required for each turbine. Furthermore, finding rare events such as bat strikes at wind turbines in Hawaiʻi would require 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.

Recommendations

The ESRC concluded that current protocols for monitoring downed wildlife should continue, and encourages the use of canine-assisted searches where possible. Current protocols involve routine searches within a specified distance from the turbine, and analysis of this data via a fatality estimation model that provides a take estimate with a measure of statistical confidence. Currently, the Evidence of Absence model is the preferred mode of take estimation, but as new models arise or current models are perfected, this recommendation may change.

The ESRC would also like project proponents to continue to enhance techniques to monitor bat activity at their facilities 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. Though not identified as a priority research endeavor, the ESRC encourages research on new monitoring technology, both to analyze bat interactions with wind turbines, as well as to develop methods to more accurately capture downed wildlife incidents.

VI. Mitigation

a. Resource Equivalency Analysis

A Resource Equivalency Analysis (REA) is an environmental economics model used to quantify the loss of natural resources and calculate the gain required to offset and mitigate for those losses. REA was developed by the National Oceanic Atmospheric Administration as a tool to enable fair comparison between lost resources and resources gained through compensatory mitigation. It provides a framework by which losses and gains can be quantified into units of resource services (e.g., bat years) and has been used by the U.S. Department of Interior's Natural Resources Damage Assessment. More recently, the REA model was applied under the ESA for wind energy projects on the continental U.S. to evaluate proposed mitigation projects required to offset take of endangered eagles and Indiana bats.

The REA model for the Indiana bat was developed by the USFWS to evaluate the extent and type of mitigation appropriate to compensate for take of Indiana bats from wind energy projects. The model requires specific inputs on the biology (e.g., species life history traits, survival rates, etc.) of the Indiana bat and uses bat years as the unit of measure. The model developed for the Indiana bat only accounts for lost/gained reproductive services; debits and credits are based on the median breeding lifespan of an individual (rather than full lifespan).

Mitigation or credit due depends on the debits (take estimate) due to project actions and is identified via a complex decision making paradigm (see example in Figure 4 for the Summer Habitat Protection Module). As stated above, these models require extensive knowledge of life history parameters, behavior, threats, and survival of the species. The model is fairly robust given the uncertainty surrounding the parameters and errs on the side of conservation of the species. A conservative approach is further realized with defined minimum criteria for mitigation. These include requirements that (1) the habitat restored must be demonstrated to be under threat, (2) protection of the habitat will prevent loss of habitat wthin the bats' home ranges, (3) a minimum of 5 acres will be protected, (4) a summer component must be included with a 46-acre minimum requirement, (5) corridors must be greater than 500 feet and at least 30 feet wide, and (6) protection must be in perpetuity.

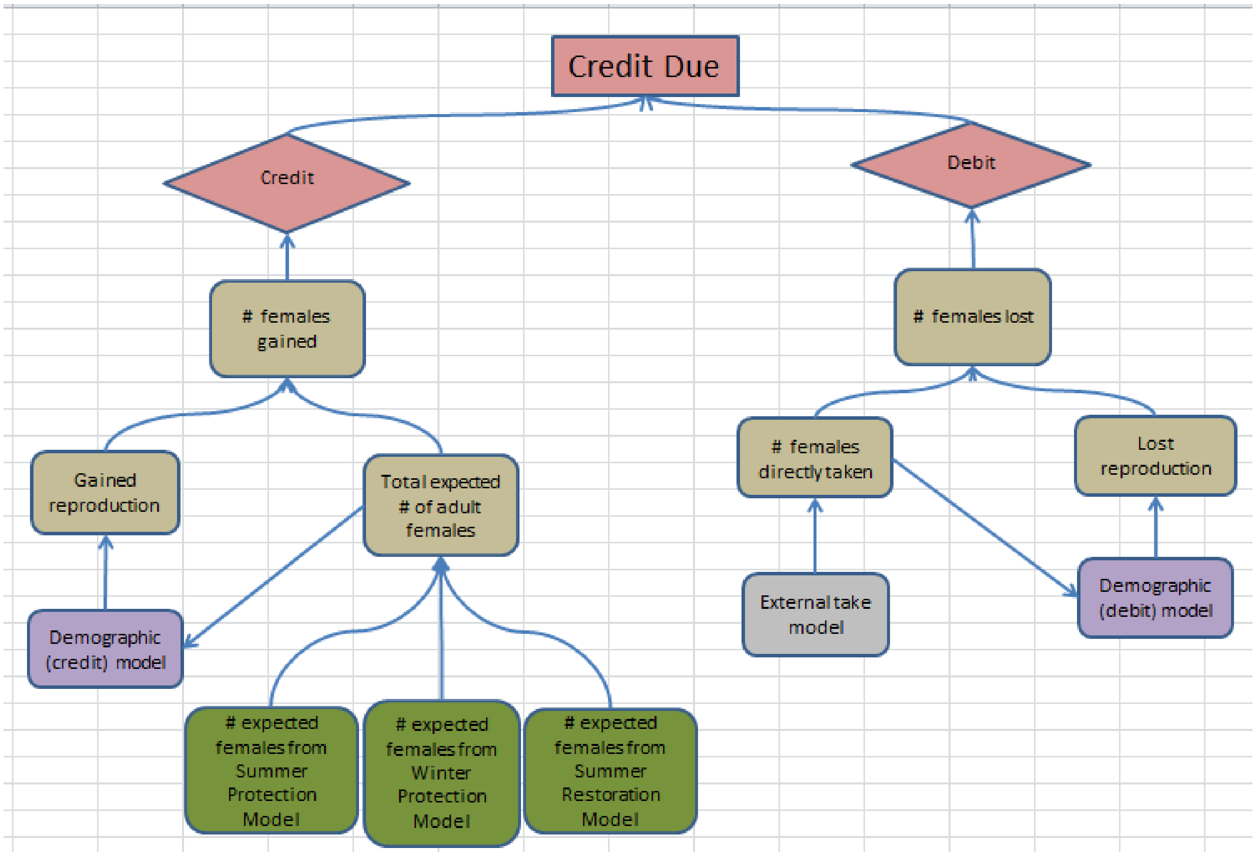


Figure 3. Indiana bat Resource Equivalency Analysis model, USFWS Region 3

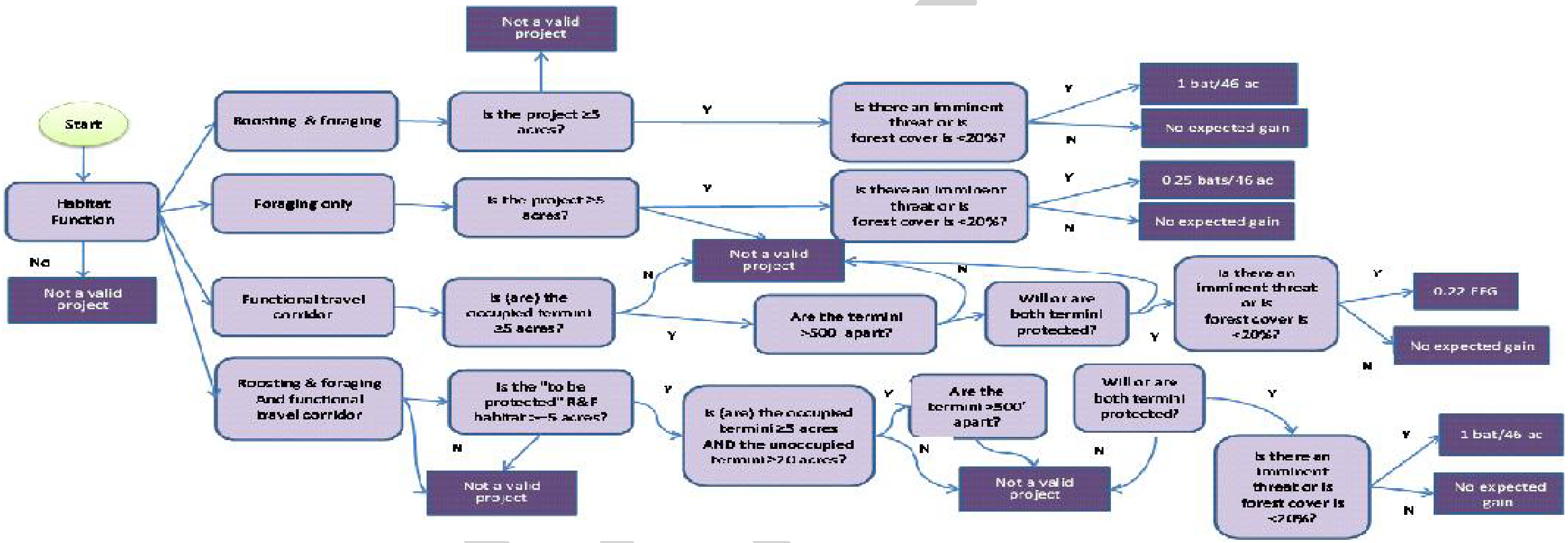


Figure 4. Indiana bat Resource Equivalency Analysis: Summer Habitat Protection Module

Most recently, the mitigation requirement advised by DOFAW and USFWS to offset take of the Hawaiian hoary bat has been 40 acres of forest restoration per pair of bats. A proposal has been put forward to adapt the Indiana bat REA model for the Hawaiian hoary bat in order to gain more flexibility as opposed to the current mitigation guidance. Use of the model could determine what mitigation actions should be implemented with consideration of the type of action, location, duration, and baseline quality of the habitat. Currency in their proposed model is measured in bat years, with gains in bat years assumed to be a result of habitat improvement. Similar to the Indiana bat model, inputs require knowledge of life history characteristics, survival rate, and age distribution of the population. Data on the Hawaiian hoary bat for many of these inputs is currently lacking, therefore the proponent used information from studies of other species as surrogates where available. Using values from surrogates, and especially species not as closely related to the Hawaiian species, brings to question the validity of the model. Furthermore, in some cases, data required for the model are extremely difficult to obtain even for more common species in the continental U.S. Information on Hawaiian hoary bat population growth rates and carrying capacity, both of which are unknown, would increase the robustness of the use of the REA model in Hawaiʻi. The proposed REA model also used a 3 percent discounting rate to incentivize early mitigation. As noted above, some REA users have asserted that the discount rate is a violation of the ESA as the value of a listed animal does not decrease over time.

<u>Recommendations</u>
The use of the REA model as a tool for evaluating mitigation is supported by the ESRC in concept. However, the high degree of uncertainty with regards to the Hawaiian hoary bat inputs in the model raises questions about its efficacy at this time, for this species, and as presented. Research projects could be conducted to improve the inputs of the model to make it more robust in the future, or highly conservative estimates could be proposed for current use while research is undertaken. Research to elucidate demographic information, growth rates, survival, breeding rates, and carrying capacity are needed. The ESRC therefore recommends that the agencies, applicants, and other interested parties continue work to better estimate model inputs and continue development of this type of model based on improved data.

b. Bat mitigation projects to date

As of June 2015, five HCPs with incidental take authorization of the Hawaiian hoary bat are currently operating under the authority established in HRS §195D. Each HCP must describe measures to avoid and minimize the taking of endangered species and must design mitigative measures that result in an overall net gain in the recovery of any species for which take cannot be avoided.

Mitigation efforts that provide commensurate measures for take of bats has proven to be challenging because threats and factors that limit the bat population are unknown. Most projects to date have founded mitigation goals on habitat protection and restoration. However, population monitoring to determine whether such measures meet the net benefit objective laid out in HRS §195D has not yet been implemented. Thus, the challenge is in developing mitigation measures that provide scientifically justifiable and quantifiable benefits for a species that is elusive and fairly unknown. To date, on-the-ground mitigation measures have relied on best available science and credited via habitat as a proxy. Based on preliminary information gathered by the U.S. Geological Survey, the agencies established mitigation based on a male bat mean core use area at 84.3 acres and female core use area, which was interpreted by agency personnel as overlapping with male territories, at 41.2 acres. Applicants seeking incidental take licenses utilized this information to calculate mitigation required to offset the loss of one bat. Assuming that bats live 10 years, restoration of 40 acres of bat habitat would support a pair of bats (male and female) over a 10 year period and four bats over a 20 year period (e.g. Kaheawa Wind Power II HCP).

In 2014, agency staff reinterpreted the data. Data from 28 bats tracked by the Bonnacorso et al. (2015) study revealed a wide range in core use areas by both male and female bats, and one outlier male bat having a very large core use area (Figure 4). The reinterpretation used the *median* bat core use areas for males (20.3 acres; excluding one extreme outlier male) to calculate the required mitigation acreage. Since the median represented half of the bats in the data set, the acreage was doubled, and assuming that females overlapped with males, the agency guidance for mitigation acreage was determined to be 40 acres per pair of bat (20.3 median male core use area rounded to 20, then multiplied by 2).

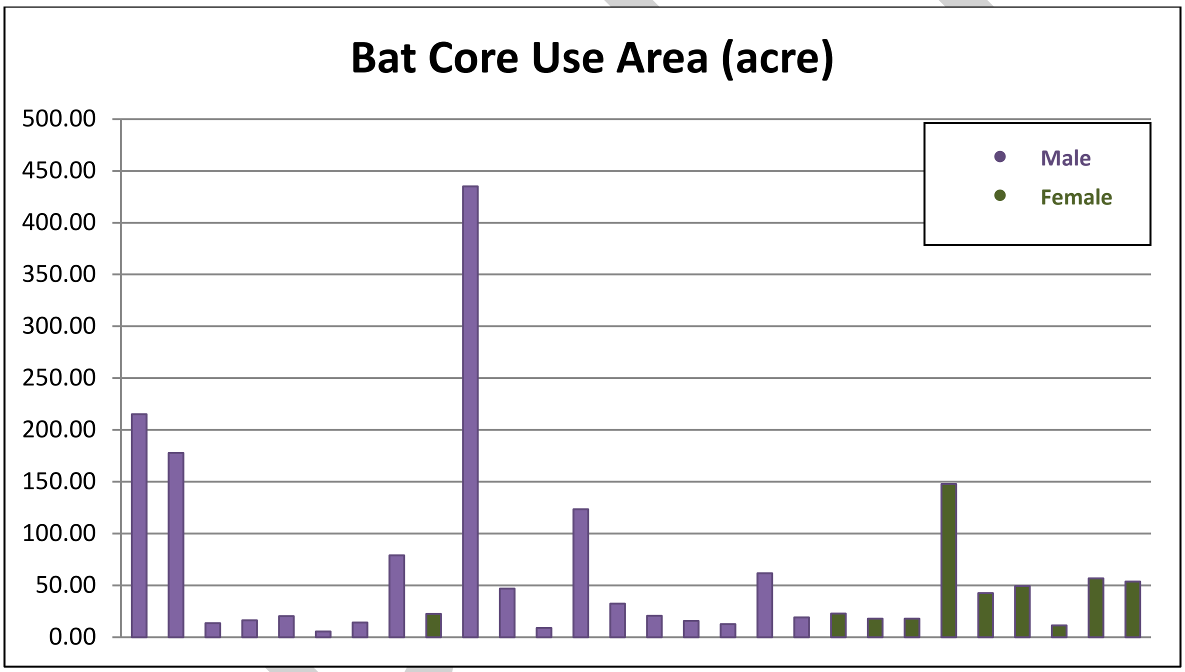


Figure 4. Bat core use area from 28 bats on Hawai´i Island (Bonaccorso et al. 2015).

Mitigation projects for the Hawaiian hoary bat have varied significantly by project type and cost (see Table 2) and have included research, forest restoration, and wetland restoration projects. Measures of success for both forest and wetland restoration have included ungulate removal, invasive species control, fencing, and acoustic monitoring.

Table 2. Hawaiian hoary bat mitigation project comparison across five wind facilities.

	KWP I	Kahuku	Kawailoa	KWP II	Auwahi
Requested Take by Tiers	20	12 adults / 9 juveniles	20 40	7	5 adults
		13-18 adults / 9-14 juveniles	60	11	11 adults
					21 adults
Acreage Required by HCP (Actual)	N/A	200 (254)	None specified (80 wetland, 40 upland)	338 (340)	126.5 (155)
Tier 1 Cost	$20,000	$150,000	$1,291,000	$250,000	$522,000
Cost per acre	N/A	$590.55	$2,934.09	$735.30	$3,367.74
Cost per adult bat	$1,000	$10,000	$64,550	$35,714	$87,000
Average cost per bat from all HCP	$49,500				

In 2015, Bonaccorso et al. published a paper showing the results of the bat home range and core use area study. Based on this new data, DOFAW staff determined that guidance for habitat management mitigation acreages needed to be revised due to the lack of evidence that male and female mean core use area overlap (Bonaccorso et al. 2015). The 40 acres as calculated above would only support one bat over one lifetime, which is assumed to be 10 years. If mitigation projects proceed as forest restoration, credit should be calculated based on a rate of 40 acres per bat. Bonaccorso noted during the April 2015 workshop that the mean core use area was approximately 65 acres and suggested that agencies should use this value as the acreage for bat mitigation (Bonaccorso pers. comm. 2015).

Wetlands 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 the Hawaiian hoary bat through wetland restoration. Data collected by SunEdison has demonstrated that bat activity rates measured through acoustic detectors is seven-fold higher at small irrigation ponds near the Kawailoa Wind Farm as compared to other vegetated areas nearby (SWCA 2011). Further, SunEdison, through their Kawailoa Wind Farm HCP, has observed bat activity at the ʻUkoʻa wetland on Oʻahu and believes that restoration efforts at the wetland will provide increased foraging habitat and result in increased bat activity. Mitigation efforts at ʻUkoʻa wetland are underway and monitoring efforts will help determine the efficacy of wetland mitigation for the Hawaiian hoary bat.

Measures of success in habitat restoration projects have been primarily based on completion of specific actions (e.g., fence building, ungulate removal), forest structure (e.g., canopy height, native versus non-native plant cover), and/or funding spent. Bat acoustic monitoring has also been a major component of mitigation projects as a measure of activity. Although acoustic data can measure bat presence and potentially type of behavior based on call signature, this data does not translate to bat numbers, therefore acoustic data has not been tied to specific quantitative goals or measures. However, baseline acoustic and habitat surveys do exist for current restoration projects, and should be conducted for future projects. These surveys should be repeated at specified intervals throughout the life of the project to provide an index of change. Mitigation success will continue to be measured in this manner until further information is gathered on preferred bat habitat characteristics, limiting factors and threats, or if monitoring techniques are refined to enable quantification of bat population and productivity.

c. Mitigation strategy moving forward

Lack of information on the Hawaiian hoary bat leaves regulatory agencies with the challenging task of determining how best to mitigate for the species. Furthermore, HRS Chapter 195D requires that any HCP or ITL must provide for a net recovery benefit to the species. Given the best available science, and information discussed at the April 2015 ESRC bat workshop, the following mitigation options are described as guidance from the ESRC to applicants seeking to mitigate for take of Hawaiian hoary bats. Currently, filling knowledge gaps remains a priority in order to inform better management thereby increasing the likelihood of recovery for the species. Mitigation for Hawaiian hoary bat take is expected to comprise a combination of funding research priorities and implementing on-the-ground restoration efforts. Specific research and restoration projects required to offset Hawaiian hoary bat take will be based on project-specific impacts and will be evaluated by the regulatory agencies and the ESRC.

The best available information to date indicates that habitat restoration that enhances or increases forested and foraging areas for bats is an optimum mitigation approach as demonstrated in approved HCPs to date. The cost of such mitigation actions can be estimated based on the current cost of mitigation projects and average cost 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 (see Table 2 above) and costs have ranged from $1,000 to $84,000 for the take of one bat. The State of Hawaiʻi 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 (amount of fencing and invasive species control needed). Costs associated with management actions in the State of Hawaiʻi Forest Reserves, Natural Area Reserves and wetlands range widely with an average per bat cost of $79,220.51 ± $47,366.45 (assuming 40 acres per bat for forest projects). Based on the high standard deviation and wide range in costs of the different managed areas described above, the price of $50,000 per enhanced management area for one bat is a reasonable expected cost. Furthermore, the average cost for bat mitigation in the form of habitat management from state-approved HCPs is currently $49,500 (Table 2). Therefore, the ESRC suggests that an appropriate estimated cost for mitigating take of one bat is $50,000. This may be applied to different types of mitigation options outlined below and will be reviewed by the ESRC.

Current mitigation guidance for the species is surrounded by a high degree of uncertainty. Research supported as mitigation could elucidate a completely new strategy for bat mitigation in the future; the cost of which remains to be seen. Through upcoming mitigation funding, it is expected that significant information gaps will be filled in the next 5 years. After this time period, the ESRC will reconvene a bat workshop to reassess mitigation strategies for the following years. This guidance document provides a short-term per-bat mitigation suggested cost of $50,000 with the caveat that this cost estimate is likely to change in the future, and mitigation will be tied directly to specific actions known to benefit the species as opposed to specific dollar amounts, or may occur through contributions to conservation banks, which are not currently established in the state of Hawaiʻi.

Note that the options described below (not in order of priority) are expected to be updated as more knowledge of the species is revealed and as key management actions for the species are identified. These recommendations and guidance will be re-visited approximately every five years.

1. *Habitat management*

Mitigation projects on the ground have thus far taken two forms: forest restoration or wetland restoration. 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 are not a significant factor tied to occupancy (Gorresen et al., 2013). As stated above, bat activity appears to be high around open canopy areas interspersed with wetlands based on studies in the Continental U.S. (Grindal et al. 1999, Brooks & Ford 2005) and one study in Hawai´i conducted by SunEdison (SWCA 2011) indicating that ponds and wetlands could serve as important foraging grounds for the Hawaiian hoary Bat.

Forest restoration projects should consider the following information:

1) Core use area for one Hawaiian hoary bat is considered by the ESRC to be 40 acres;
2) Mitigation projects should avoid close proximity to the impact area;
3) Mitigation should occur on the island where the impact is occurring, as much as it is possible;
4) Restoration efforts should focus on restoring native habitats so as to provide net environmental benefits;
5) Acoustic monitoring or other bat monitoring techniques should occur for the duration of the mitigation project and in a manner that can statistically detect changes in activity;
6) Habitat improvement for bats should be measured over an established baseline condition and result in an increase of bat habitat; and
7) Habitat management or population monitoring projects should also serve as research projects to document whether the management results in an increase in bat activity/occupancy.

Although not yet informed by data collected in Hawaiʻi, wetland restoration projects could provide important foraging habitat for the Hawaiian hoary bat. Studies conducted by USGS at the Koloko-Honokōhau NHP on the island of Hawaiʻi suggest that wetland habitats provide suitable insect prey for the bat (Pinzari et al. 2014). Wetland restoration projects for mitigation should include an extensive monitoring program to compare before and after restoration efforts, prey availability, and should be conducted on the island of impact.

2. *Land Acquisition*

Another compensatory mitigation option that has been proposed more recently by HCP applicants is land acquisition. This alternative provides benefits when the acquisition safeguards the land from future development, protects existing habitat, or provides an opportunity for restoration/creation of habitat. Proposals for land acquisition as mitigation will be evaluated based on the following:

1) Does the proposal include land acquisition alone, or land acquisition plus a management plan?
2) What is the current status of the parcel (e.g., level of protection, intact versus degraded habitat, etc.) and what are the threats?
3) What is the size of the parcel? 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.
4) The acquisition should be protected in perpetuity (i.e., fee simple, conservation easement, or other arrangement agreed upon by the applicant and the agencies).

3. *Research as mitigation*

During the April 2015 ESRC Bat Workshop, experts recognized that current mitigation guidance for the Hawaiian hoary bat was not based on a solid foundation of our understanding of the species and its recovery needs. Filling key information gaps was identified as a priority need to inform better mitigation actions, thereby reducing uncertainty in mitigation effectiveness. After thorough consideration by the ESRC, research was acknowledged as a justifiable mitigation option for offsetting take of the Hawaiian hoary bat in the near term. Research is not generally a preferred mitigation strategy, 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. In order for research to be credited as mitigation, research projects should be targeted to provide information on better management actions for the Hawaiian hoary bat that will lead to increasing the recovery of the species.

Research priorities identified by the ESRC are provided in Section VII. Research and conservation priorities. While research as mitigation has been identified as a top priority, a component of on-the-ground mitigation should be part of the overall mitigation package for the project. Research is encouraged that coincides with on-the-ground restoration/conservation actions or informs future management actions by the permit holder and should result in a peer-reviewed publication. Research associated with on-the-ground restoration/conservation efforts are in addition to, and are not in-lieu of, mitigation efficacy monitoring and take monitoring, which are required.

The challenge with mitigation in the form of research is in translating the value of the research to credit or offset of the take of the species. For example, how many bat credits would a research project to assess the current bat population trends on the island of Maui provide? These important questions are not easily addressed, but the ESRC can provide suggestions for valuing mitigation projects based on our current approach.

VII. Research and conservation priorities

a. Ecological framework

Based on the best available science and the input from workshop attendees, a list of priority research questions was developed. Research efforts that contribute to addressing the following are considered to be priority information needs that may be eligible for mitigation funding to offset incidental take of Hawaiian hoary bats.

1. Population dynamics
   Basic information on bat population dynamics is essential for understanding the status of bat populations, risk of extinction, and potential impacts of incidental take.
   a. Distribution and trends. Conduct island-wide surveys using replicable methods to document distribution and long-term population trends. The findings from this work will provide a baseline for monitoring that can be used to detect changes in future population status and trends and allow the ESRC to evaluate risk associated with proposed actions and inform decisions.
   b. Demography. Conduct studies to document survival and reproductive success and ecological correlates. This information will inform inference on population status and can inform population models designed to infer impacts of incidental take.
   c. Abundance. 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. Limiting factors
   Understanding the ecological 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 thereby create net recovery benefits. Potential factors that 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 are required 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.

i. Habitat selection and preferences. Document aspects of habitat used for foraging, breeding, and roosting, including community structure, physical attributes, vegetation species used, and tree architecture.
ii. Distribution. Document bat distribution and presence or absence in suitable habitat to determine whether suitable habitat is unoccupied.
iii. Experimental treatments. Conduct experimental studies, such as Before-After-Control-Impact (BACI) designs, in which bat occupancy or abundance is measured before and after treatment(s) in plots designed to increase suitable habitat.

b. Food availability

Food availability may limit populations 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 may contribute to a better understanding of food limitation.

i. Relation of home range to food availability. Conduct studies in which food availability is measured within the home ranges of bats and determine whether a correlation exists.
ii. Relation of food availability to survival and reproductive success. Conduct studies in which food availability is monitored within and among years to determine whether survival and reproductive success are correlated with food availability.
iii. Experimental treatment. Conduct experimental studies, such as BACI designs, in which bat demographic variables are estimated before and after treatments in which food availability is manipulated by treatment.
iv. Diet Studies. Understand food habits by analyzing fecal pellets samples to provide information on foraging ecology, nutritional needs, and population ecology.
v. Pesticides. Pesticide use in agriculture areas may also serve as bat foraging areas. Examine secondary effects on bat feeding on prey item where pesticide use is prevalent.

c. Predators

Predation may limit populations if bat pups or adults are subject to frequent predation events and high predator populations. Predator impacts on Hawaiian hoary bat are largely unknown. The following research may contribute to a better understanding of predatory relationships to bat populations.

i. Bat breeding roost monitoring. Conduct intensive monitoring at roost sites to observe the outcome of pups during the period they are non-volant.
ii. Investigation of potential predator's food preferences (e.g. barn owl). Analyze potential predators' congested prey items through analyzing pellets, stomach contents, etc.

d. Disease

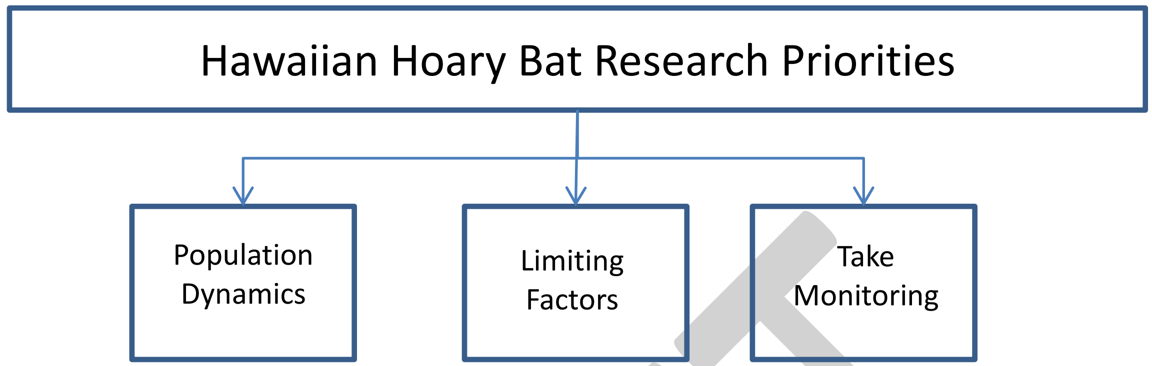
Diseases affecting bats in Hawaiʻi have thus far not been observed; mainland bats are extremely vulnerable to 'white-noise syndrome' which has resulted in significant declines in some species. Arrival of such a disease to the Hawaiian Islands could have serious implications to the Hawaiian hoary bat populations.

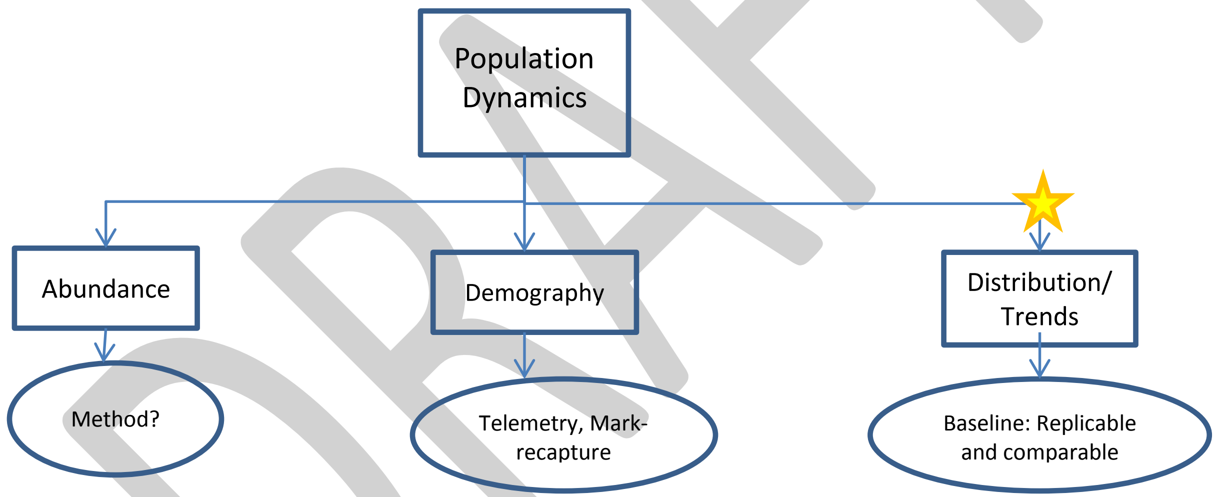
3. Take monitoring[1]

Monitoring of take at project sites is required per approval of incidental take authorizations, but methods for monitoring may vary based on the applicant proposal, site factors, environmental conditions, and new information and techniques. Though not identified as a high priority research endeavor (Section V. Mitigation), the ESRC encourages research on new monitoring technology, both to analyze bat interactions with wind turbines, as well as to develop methods to more accurately capture downed wildlife incidents. Effective monitoring can elucidate information regarding bat behavior with project components and provide useful information on take occurrence, frequency, correlations to other factors that will inform better management decisions.

a. Behavior studies. Conduct research on bat behaviors near project components such as wind turbines to inform better management practices.
b. Research on novel monitoring techniques. Conduct studies on monitoring techniques such as video, audio, FLIR, and canine-assisted monitoring to inform better management practices.

[1] Note that the USFWS considers these avoidance/minimization measures, and Federal regulations do not allow for mitigation credit for this research.


Hawaiian Hoary Bat Research Priorities
Population Dynamics
Limiting Factors
Take Monitoring


Population Dynamics
Abundance
Demography
Distribution/ Trends
Method?
Telemetry, Mark-recapture
Baseline: Replicable and comparable

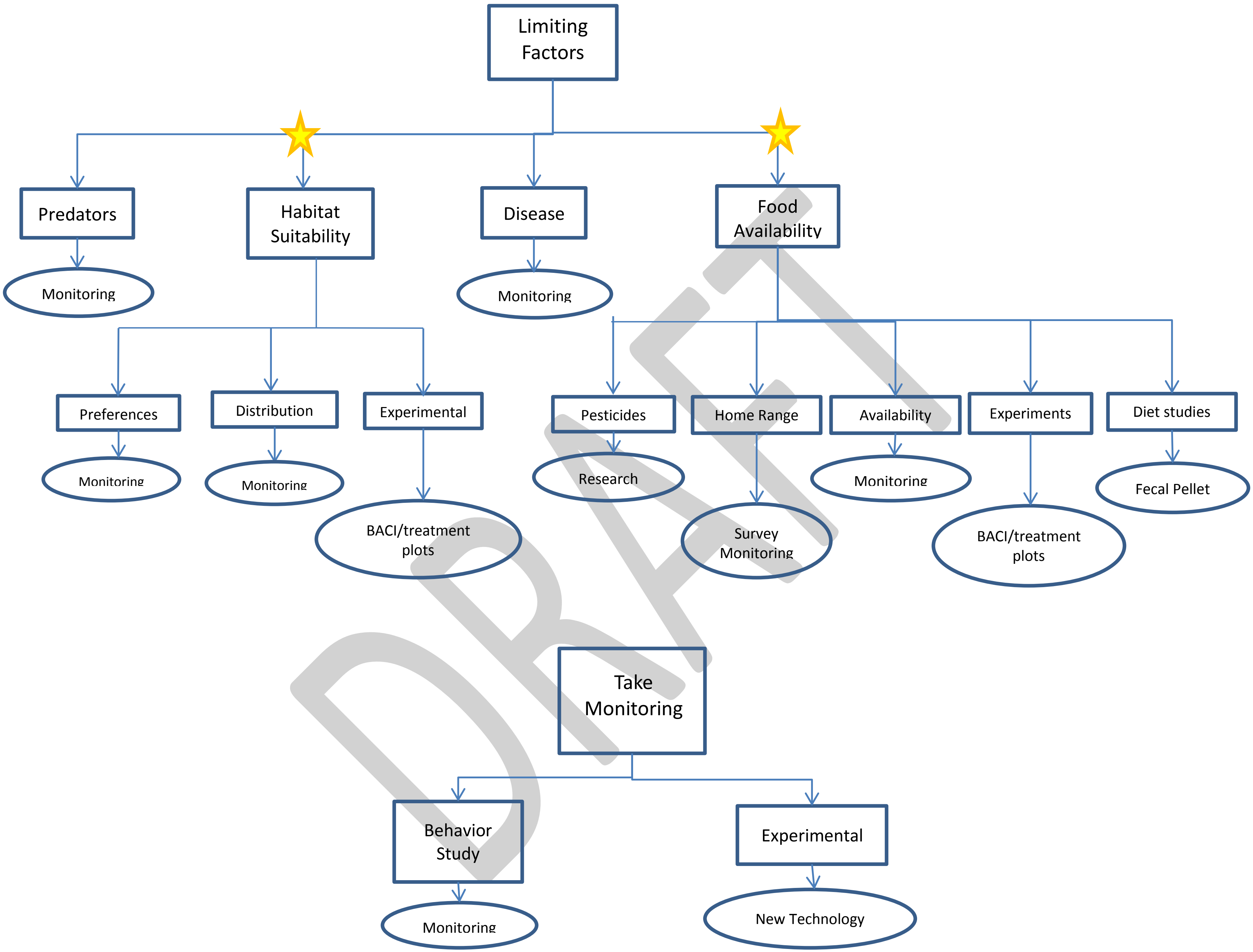

Limiting Factors
Predators
Habitat Suitability
Disease
Food Availability
Monitoring
Monitoring
Preferences
Distribution
Experimental
Pesticides
Home Range
Availability
Experiments
Diet studies
Monitoring
Monitoring
BACI/treatment plots
Research
Survey Monitoring
Monitoring
BACI/treatment plots
Fecal Pellet
Take Monitoring
Behavior Study
Experimental
Monitoring
New Technology
DRAFT

Table 3. Research and conservation priorities for bat research.

GOAL	Questions and Activities				Outcome/Success Factors
Population Dynamics	★ **Distribution and Trends**: Island-wide survey monitoring designed to serve as a baseline population assessment	**Demography**. Intensive monitoring to determine survival and reproductive success rates.	**Abundance.** Methods to estimate population of bats in Hawaii?	**Genetics.** Genetic analysis to clarify taxonomic status.	Understand bat population levels and distribution to better inform management, project siting, potential risk of projects to bats, and cumulative impacts of multiple projects.
Limiting Factors	★ **Habitat Suitability.** Document aspects of habitat for foraging, breeding, and roosting via intensive monitoring and surveying	★ **Food availability.** Diet analysis studies and experimental studies on food availability associated with home ranges, survival, reproductive success and pesticide secondary effects.	**Predators**. Intensive monitoring at roost sites and radio tagged bats to determine predatory relationships.	**Disease.** Monitor bats for evidence of disease.	Understand bat threats and limiting factors to identify management actions with greatest benefit to the species
Take Monitoring	**Behavior** Research bat behavior around project components such as wind turbines	**New Monitoring Techniques.** Research new monitoring for downed wildlife such as video, audio, etc.			Understand bat behavior and take to inform better management practices.

★ Identified as priority for mitigation funding

b. *Implementation plan*

Implementation of the above research priorities requires close coordination between the applicants/permit holders and agency staff (DOFAW and USFWS). Applicants seeking take authorization should consider the research priorities listed above and in Table 3 as part of proposed mitigation packages. Agency staff can help guide research project selection and coordination if multiple license holders pool mitigation funds to complete one of the listed priority projects. Measures of success for research projects will be tied to project completion, annual status updates and a final report detailing results and management recommendations gained from the research endeavor. Project updates will also be provided annually to the ESRC or more frequently if needed.

The ESRC will provide recommendations and revisions to this document based on the research gained from the conservation projects prioritized. Research gained in the next five years from the completion of these projects should inform new management strategies that demonstrate net benefit to the Hawaiian hoary bat.

VIII. Conclusion

Research on the Hawaiian hoary bat has been identified as a priority need to inform best management actions for the species and to provide a demonstrated net benefit under the mitigation actions covered under an HCP. Current and upcoming projects should immediately implement the research priority projects identified in this document.

This white paper guidance document aims to provide clear and consistent policy guidelines for project proponents attempting to avoid, minimize, and mitigate for incidental take of the Hawaiian hoary bat. This outcome is a result of information exchange from bat experts, state and federal agencies, biologists, environmental consultants, license holders, and applicants during the ESRC bat workshop convened in April 2015. Pursuant to HRS Chapter 195D-21, habitat conservation plans shall be based on the best available scientific and reliable data at the time of approval. This document serves as the current guidance for the Hawaiian hoary bat based on the best available science, but must be revised at least once every 5 years, or more frequently as deemed necessary.

IX. References

Arnett, E. B. 2005. Relationships between bats and wind turbines in Pennsylvania and West Virginia: an assessment of bat fatality search protocols, patterns of fatality, and behavioral interactions with wind turbines. A final report submitted to the bats and wind energy cooperative. Bat Conservation International, Austin, Texas, USA.

Arnett, E.B., W.K. Brown, W.P. Erickson, J.K. Fielder, B.L. Hamilton, T.H. Henry, A. Jain, G.D. Johnson, J. Kerns, R.R. Koford, C.P. Nicholson, T.J. O'Connell, M.D. Piorkowski, and R.D.

Tankersley, Jr. 2008. Patterns of Bat Fatalities at Wind Energy Facilities in North America. The Journal of Wildlife Management 72(1):61-78.

Arnett, E.B. and E.F. Baerwald. 2013. Impacts of Wind Energy Development on Bat: Implications for Conservation. Bat Evolution, Ecology, and Conservation 2013, pp 435-456.

Arnett, E.B., C.D. Hein, M.R. Schirmacher, M.M.P. Huso, and J.M. Szewczak. 2013. Evaluating the effectiveness of an ultrasonic acoustic deterrent for reducing bat fatalities at wind turbines. PLoS ONE 8(6):e65794.

Baerwald, E.F., J. Edworthy, M. Holder, and R.M.R. Barclay. 2009. A Large-Scale Mitigation Experiment to Reduce Bat Fatalities at Wind Energy Facilities. The Journal of Wildlife Management 73(7): 1077-1081.

Baird, A.B., Braun, J.K., Mares, M.A., Morales, J.C., Patton, J.C., Tran, C.Q. 2015. Molecular systematic revision of tree bats (Lasiurini): doubling the native mammals of the Hawaiian Islands. Journal of Mammology 96(5):1-20.

Bonaccorso, F.J., C.M. Todd, A.C. Miles, and P.M. Gorresen. 2015. Foraging Range Movements of the Endangered Hawaiian Hoary Bat, *Lasiurus cinereus semotus*. Journal of Mammalogy 96(1):64-71.

Brooks, R.T. and W.M. Ford. 2005. Bat activity in a forest landscape of central Massachusetts. Northeastern Naturalist 12(4): 447-462.

Cryan, P.M. 2011. Wind Turbines as Landscape Impediments to the Migratory Connectivity of Bats. Environmental Law 41:355.

Cryan, P. M., P. M. Gorresen, C. D. Hein, M. R. Schirmacher, R. Diehl, M. Huso, D. T. S. Hayman, P. Fricker, F. Bonaccorso, D. H. Johnson, K. Heist, and D. Dalton. 2014a. Behavior of bats at wind turbines. Proceedings of the National Academy of Sciences 111:15126–15131.

Dalthorp D., M. Huso, D. Dail and J. Kenyon. 2014. Evidence of Absence Users Guide: U.S. Geological Survey Data Series 881, 34 p., http://dx.doi.org/10.3133/ds881.

Good, R. E., W. Erickson, A. Merrill, S. Simon, K. Murray, K. Bay, and C. Fritchman. 2011. Bat Monitoring Studies at the Fowler Ridge Wind Energy Facility Benton County, Indiana, April 13–October 15, 2010. Prepared for: Fowler Ridge Wind Farm. Prepared by Western EcoSystems Technology. Inc., Cheyenne, Wyoming.

Good, R. E., A. Merrill, S. Simon, K. Murray, and K. Bay. 2012. Bat monitoring studies at the Fowler Ridge Wind Farm, Benton County, Indiana. An unpublished report submitted to the Fowler Ridge Wind Farm by WEST. Inc., Cheyenne, WY, USA.

Gorresen, M.P., A.C. Miles, C.M. Todd, F.J. Bonaccorso, and T.J. Weller. 2008. Assessing Bat Detectability and Occupancy with Multiple Automated Echolocation Detectors. Journal of Mammalogy 89(1): 11-17.

Gorresen, M.P., F.J. Bonaccorso, C.A. Pinzari, C.M. Todd, K. Montoya-Aiona, and K. Brinck. 2013. A Five-Year Study of Hawaiian Hoary Bat (*Lasiurus cinereus semotus*) Occupancy on the Island of Hawai`i. Technical Report HCSU-041.

Gorresen, M.P., P.M. Cryan, M.M. Huso, C.D. Hein, M.R. Schirmacher, J.A. Johnson, K.M. Montoya-Aiona, K.W. Brinck, and F.J. Bonaccorso. 2015. Behavior of the Hawaiian Hoary Bat (*Lasiurus cinereus semotus*) at Wind Turbines and its Distribution Across the North Ko´olau Mountains, O´ahu. Technical Report HCSU-064.

Grindal, S.D., J.L. Morisette, and R.M. Brigham. 1999. Concentration of bat activity in riparian habitats over an elevational gradient. Canadian Journal of Zoology 77:972-977

Horn, J.W., E.B. Arnett, M. Jensen, and T.H. Kunz. 2008. Testing the Effectiveness of an Experimental Acoustic Bat Deterrent at the Maple Ridge Wind Farm. A report submitted to the Bats and Wind Energy Cooperative and Bat Conservation International. Bat Conservation International. Austin, Texas, USA.

H.T. Harvey and Associates. 2014. Best Management Practices and Flow Charts to Avoid Take of the Hawaiian Hoary Bat during non-native Commercial Timber Harvest Operations. Final Report 19 September 2014.

Jacobs, D.S. 1994. Distribution and Abundance of the Endangered Hawaiian Hoary Bat, *Lasiurus cinereus semotus*, on the Island of Hawai`i. Pacific Science 48(2): 193-200.

Jacobs, D.S. 1999. The diet of the insectivorous Hawaiian hoary bat (*Lasiurus cinereus semotus*). Canadian Journal of Zoology 77:1603-1607.

Johnson, G.D. and M.D. Strickland. 2003. Biological Assessment for the Federally Endangered Indiana Bat (*Myotis sodalis*) and Virginia Big-eared Bat (*Corynorhinus townsendii virginianus*). Prepared for NedPower Mount Storm LLC.

Johnson, J.B., W.M. Ford, J.L. Rodrigue, and J.W. Edwards. 2012. Effects of Acoustic Deterrents on Foraging Bats. Res. Note NRS-129. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 5p.

Kunz, T.H., E.B. Arnett, W.P. Erickson, A.R. Hoar, G.D. Johnson, R.P. Larkin, M.D. Strickland, R.W. Thresher, and M.D.Tuttle. 2007. Ecological Impacts of Wind Energy Development on Bats: Questions, Research Needs, and Hypotheses. Frontiers in Ecology and the Environment 5(6):315-324.

McAlexander, A. 2013. Evidence that Bats Perceive Wind Turbine Surfaces to be Water. Masters Thesis, Texas Christian University.

Menzel, J.M., M.A. Menzel, J.C. Kilgo, W.M. Ford, and J.W. Edwards. 2005. Bat response to Carolina bays and wetland restoration in the southeastern U.S. coastal plain. Wetlands 25(3): 542-550.

Mitchell, C., C. Ogura, D.W. Meadows, A. Kane, L. Strommer, S. Fretz, D. Leonard, and A. McClung. October 2005. Hawaii's Comprehensive Wildlife Conservation Strategy. Department of Land and Natural Resources. Honolulu, Hawai'i. 722 pp.

Patriquin, K.J. and R.M. Barclay. 2003. Foraging by Bats in Cleared, Thinned, and Unharvested Boreal Forest. Journal of Applied Ecology 40: 646-657.

Pinzari, C., F. Bonaccorso, and K. Montoya-Aiona. 2014. Hawaiian Hoary Bat Occupancy at Kaloko-Honokōhau National Historical Park. Technical Report HCSU-051.

Russell, A.L, Pinzari, C.A., Vonhof, M.J., Olival, K.J., Bonaccorso, F.J. 2015. Two Tickets to Paradise: Multiple Dispersal Events in the Foundinggg of thhhe Hoary Bat Populations in Hawai'i. PLoS ONE 10(6).

Spanjer, G. R. 2006. Responses of the big brown bat, Eptesicus fuscus, to a proposed acoustic deterrent device in a lab setting. A report submitted to the Bats and Wind Energy Cooperative and the Maryland Department of Natural Resources. Bat Conservation International. Austin, Texas, USA.

SWCA. 2011. Kawailoa Wind Power Final Habitat Conservation Plan. Prepared for Kawailoa Wind Power, LLC. by SWCA Environmental Consultants. October 2011.

Szewczak, J.M. and E.B. Arnett. 2007. Field Test Results of a Potential Acoustic Deterrent to Reduce Bat Mortality from Wind Turbines. Unpublished report. Bat Conservation International. Austin, Texas, USA.

SunEdison. 2014. Kawailoa Habitat Conservation Plan FY 2014 Annual Report Year 2.

SunEdison. 2015. Kaheawa I Habitat Conservation Plan Annual Report: FY 2015.

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

U.S. Fish & Wildlife Service. 1998. Recovery Plan for the Hawaiian Hoary Bat. U.S. Fish & Wildlife Service, Portland, OR. 50pp.

U.S. Fish & Wildlife Service. 2012. News Release: North American bat death toll exceeds 5.5 million from white-noise syndrome. U.S. Fish & Wildlife Service, Fairfax, VA. January 17, 2012.