**Endangered Species Recovery Committee**
**Hawaiian Hoary Bat Guidance Document**

State of Hawaiʻi Department of Land and Natural Resources
Division of Forestry and Wildlife
July 2015



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# 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). 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. 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-nose syndrome (WNS) has wiped out an estimated 5.7 to 6.7 million bats (USFWS News Release 2012). WNS has not yet reached Hawaiʻi, and there are no other known diseases which are significant sources of Hawaiian hoary bat mortality, but the potential for WNS or another disease to spread to Hawaiʻi is a possibility. DOFAW has sought competitive grant monies in the past to survey high elevation caves on Hawaiʻi Island for evidence of WNS, and will continue to monitor the situation in the future.

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, making wind power a significant threat to the continued survival of these species (Cryan 2011). Under Hawaiʻi Revised Statutes (HRS) §195D, these fatalities are referred to as incidental take and can be permitted with issuance of Incidental Take Licenses (ITLs) which are 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 Hawai'i 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 as a result of renewable energy projects, especially wind farms, are well-documented on the continental U.S. (Johnson & Strickland 2003, Kunz et al. 2007, Arnett et al. 2008, Cryan 2011) and, as more facilities come online in Hawai'i, have become increasingly more apparent. While the continental US migratory tree-roosting bats are not listed as threatened or endangered, although the spread of white nose syndrome (WNS) may influence that in the near future, Hawai'i is home to a single subspecies of bat and that species is endangered. As of June 29, 2015, 44 Hawaiian hoary bat fatalities have been observed on wind farm facilities in Hawai'i., This number is likely much higher when incidental take is estimated via fatality estimation protocols that incorporate unobserved take, indirect take, and lost productivity. This high level of take makes avoidance, minimization, and mitigation of impacts to this species critical to its persistence and recovery.

### *c. Purpose and Need*

All requests for ITLs, as defined under HRS §195D, must be accompanied by Habitat Conservation Plans (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 under HCPs up until now has been generally inconsistent as new information arises and leads to changes in the approach to mitigation planning. This presents a challenge because scale and cost of mitigation is unpredictable, making it difficult to measure the impact on species recovery across a large number of disparate projects. It also leads to discontent among applicants, complicated planning, lack of predictability, and confusion about the process. For example, there are currently five approved HCPs and two 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 for the take of one bat, and costs ranged from $10,000 to $87,000 for the take of one 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), the advisory committee to the Board of Land and Natural Resources (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, Hawai'i 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 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 in the understanding of Hawaiian hoary bat ecology and management are achieved. It is intended to serve as a guide during the development of new HCPs and the oversight and adaptive management of existing HCPs. It 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 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 (Bonaccorso 2015). Their diet consists primarily of nocturnal aerial beetles and moths (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 2015), but may travel as far as 11 to 13 km one-way in a night to forage (Jacobs 1994, Bonaccorso 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 an exact population number, 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 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 equate to actual population size (Gorresen 2008, Gorresen 2013). Although population estimates are not currently available, studies have shown 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 US 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.

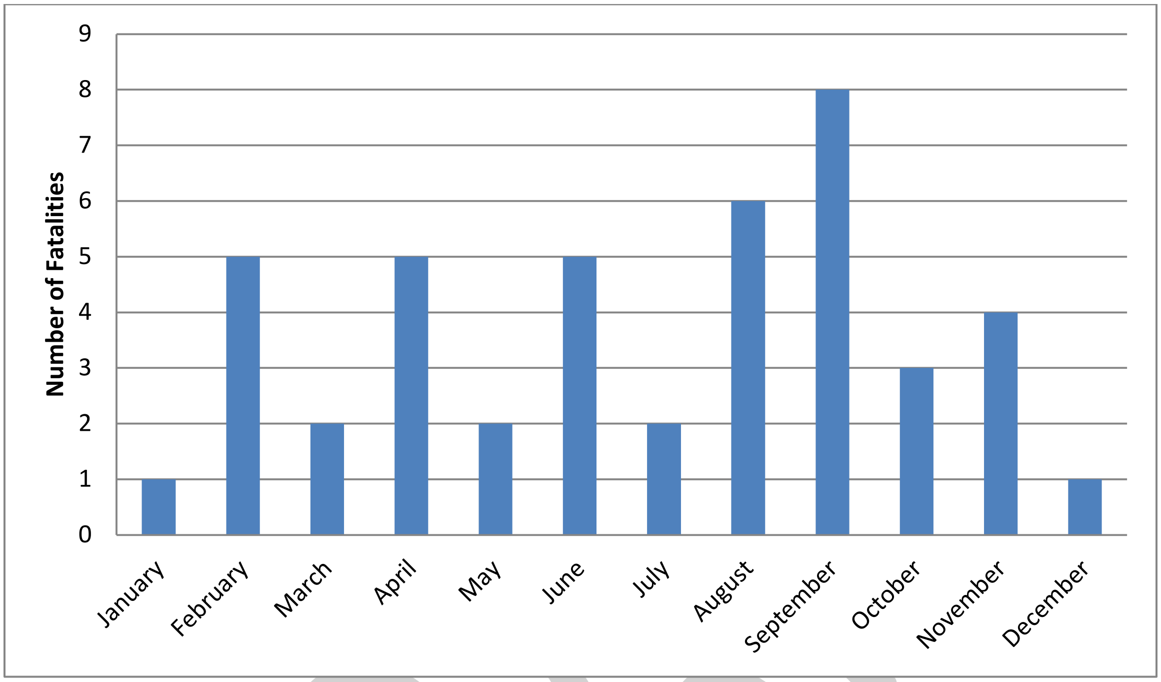



Figure 1. Bat fatalities by month across all wind facilities with approved ITLs in Hawaiʻi as of June 29, 2015.

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 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, NRCS 2009). 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 are unable to fly away from a tree when it is cut or disturbed. For this reason, standard guidance from DOFAW and 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

### *a. Wind Energy*

Curtailment refers to a situation 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, Hein & Schirmacher 2013, 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. Blades may still rotate very slowly while feathered (called free-wheeling), or may be locked in place. Curtailment is currently the primary minimization measure implemented by wind farms in the US, including those here in Hawaiʻi.

Various studies in the US 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 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. Table 1 provides information on the date curtailment was first implemented, cut-in speed, and numbers of bat fatalities that have occurred during active curtailment for each wind facility with an approved ITL.

Recommendations

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 curtailment is a part of every wind facility's minimization strategy to the maximum extent practicable. DOFAW staff 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. 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.

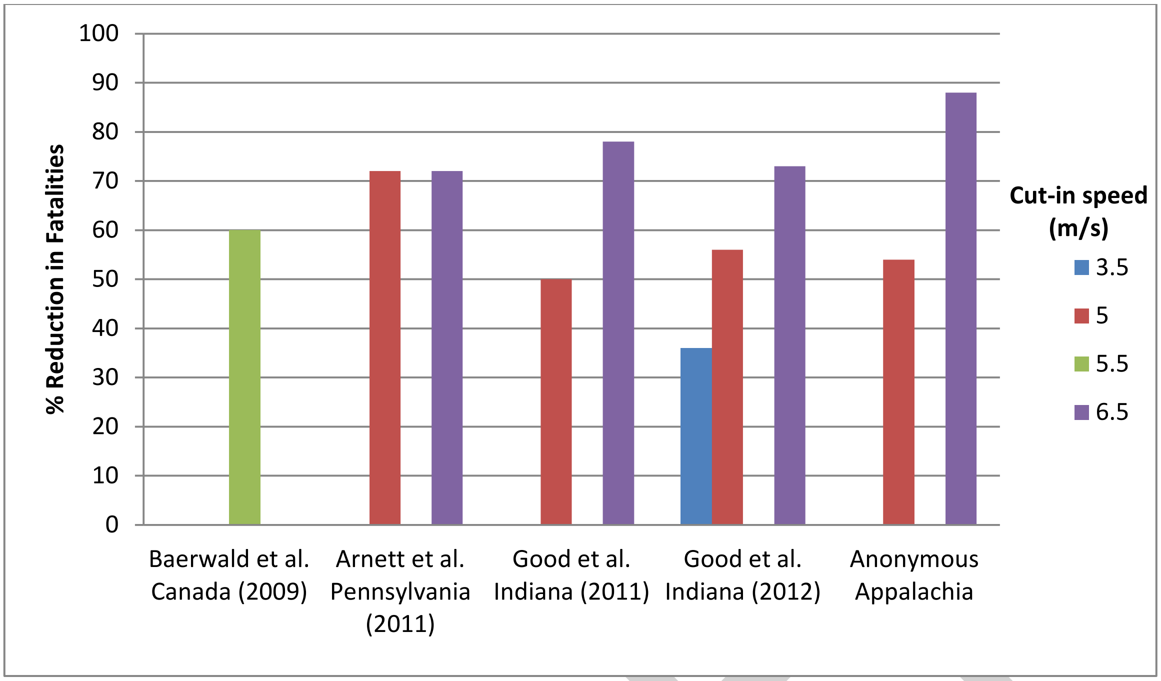



Figure 2. Reduction in fatalities under different curtailment regimes at five wind farms in the continental U.S.

Table 1. Summary of curtailment at wind facilities in Hawaiʻi

| Site | Speed | Date of initial curtailment[1] | Take with curtailment | Take w/o curtailment |
|---|---|---|---|---|
| Auwahi | 5.0 m/s | 2015 | 0 | 5 |
| Kaheawa I | 5.5 m/s | 2014 | 0 | 8 |
| Kaheawa II | 5.0 m/s | start of operation | 1 | 2 |
| | 5.5 m/s | 2014 | 0 | 0 |
| Kahuku | 5.0 m/s | start of operation | 1 | 3 |
| Kawailoa | 5.0 m/s | start of operation | 24 | 0 |

[1] Note that the portion of the year in which curtailment is implemented is not reflected in this table. A fatality that occurred without curtailment either occurred prior to implementation of any curtailment protocol, or during a month when curtailment protocols were not active.

### *b. 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, variety of new technologies have emerged designed to deter bats from coming in close proximity with 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 fewer fatalities. However, factoring in a 9 percent inherent difference between the treatment and control turbines yielded a result of 2 percent more to 64 percent fewer fatalities the second year. Again, the 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 US 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 all declined by 25-44 percent from control to treatment 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 worthy of mitigation credit, and deterrent research can potentially count for mitigation on a case by case basis (see Section VI). It is important to note, however, that USFWS will not accept operational minimization or deterrent research as mitigation. With or without mitigation credit, the ESRC encourages applicants to pursue research and eventual implementation of deterrent devices.

### c. *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 Hawai'i has led to a demand for harvesting timber during the bat pupping season (June 1 – September 15, see Section III.b). The Hawai'i Forest Industry Association (HFIA), Kaua'i Island Utilities Cooperative (KIUC), and other entities have begun to look for ways to detect roosting bats in order to avoid impacting them and thus avoid the need for an ITL and HCP.

Given that Hawaiian hoary bats are small, dark colored, and may be roosting in trees with dense canopies they are extremely difficult to detect visually. 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. By using mice raised up into the trees in cages, searcher efficiency trails have been conducted with trained crew members, and thus far 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. Acoustic detections can be used to determine initially if bats are utilizing an area but do not always indicate that a bat is roosting in an area, simply that is has foraged or traversed that space (D. Johnston 2016 pers comm). Zero acoustic detections may not indicate that bats are not present but could, when combined with proven foliage density indices and other ecological measures, indicate an 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).

<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. 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 at some facilities have produced higher searcher efficiency results (90% of bat trials found and 100% of bird trials found) than humans alone (SunEdison 2014).

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 and help in designing 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.

<u>Recommendations</u>
The ESRC concluded that current protocols for monitoring downed wildlife should continue, and encourages the use of canine-assisted searches where possible. The ESRC would 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. Though not identified as a priority research endeavor, the ESRC encourages research on new monitoring technology with the potential for applicants to receive mitigation credit.

***b. Resource Equivalency Analysis – should this be used in Hawaii***

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); and no economic discounting rate was applied, as has been done in other applications of REA, an approach not favored by all users of this type of modeling, due to potential violations of the ESA. Figure 3 depicts the schematic of the Indiana bat REA model.

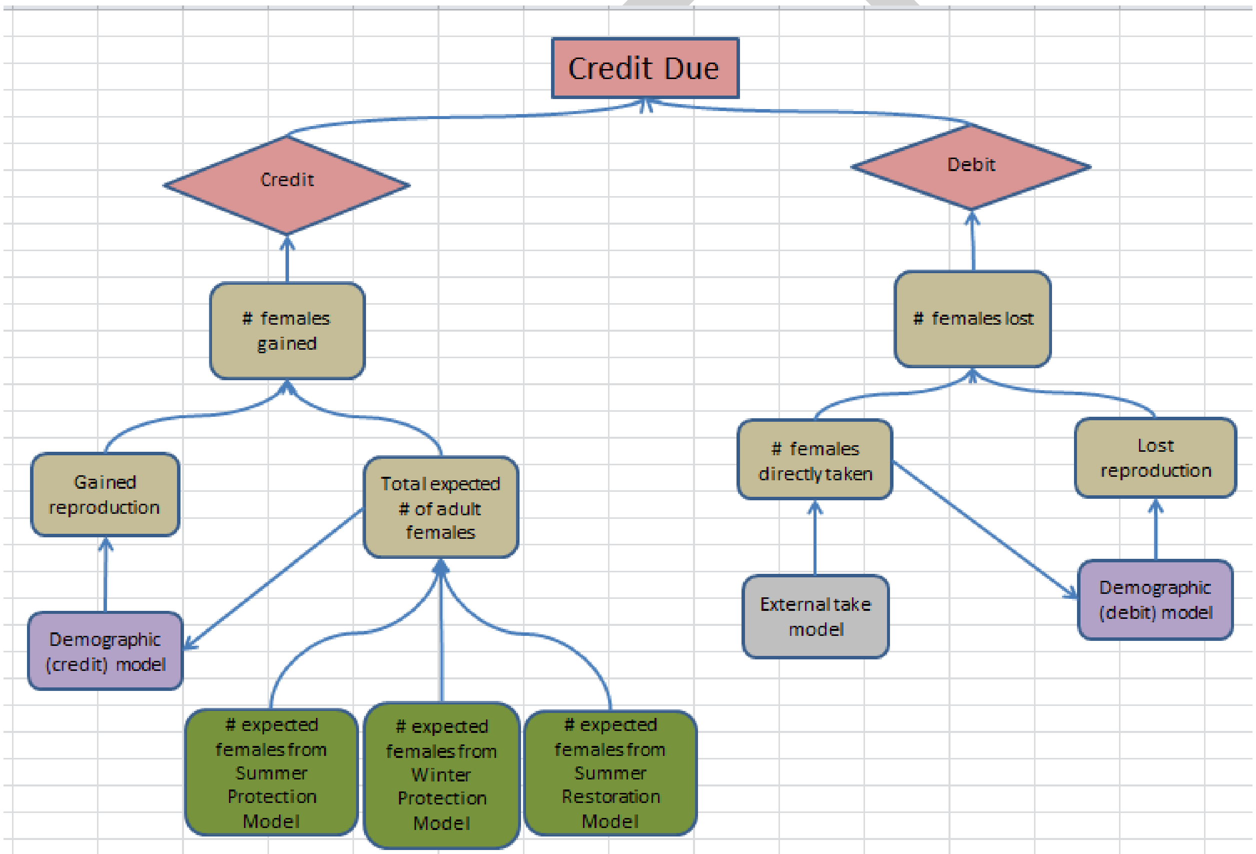


Figure 3. Indiana bat Resource Equivalency Analysis model, USFWS Region 3

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 highly 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.

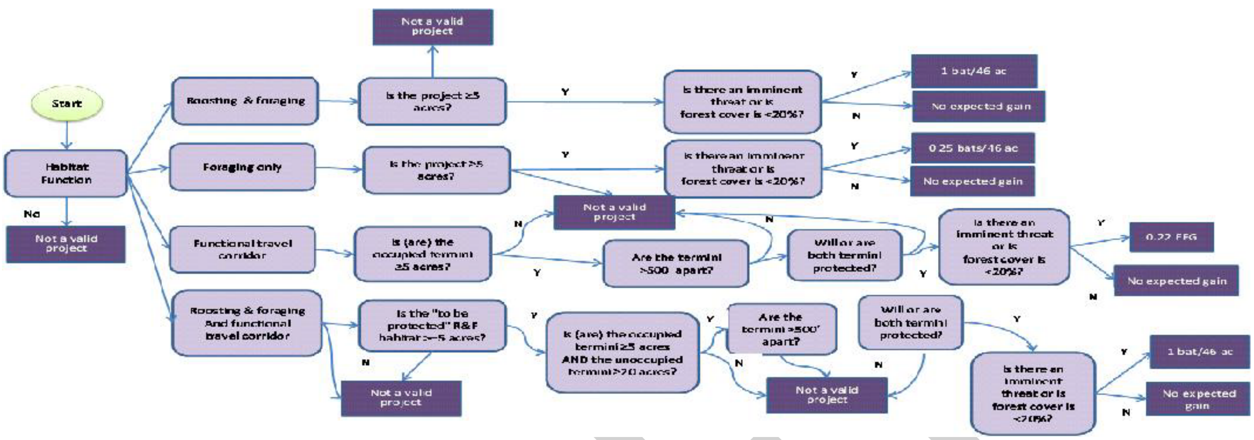



Figure 4. Indiana bat Resource Equivalency Analysis: Summer Habitat Protection Module

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 Hawai'i. 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.

<u>Recommendations</u>
Though the use of the REA model may be possible in the future and is supported by the ESRC in concept, the high degree of uncertainty in the model makes it unusable at this time 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.

### *c. 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 promulgated 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.

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 (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 the 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).

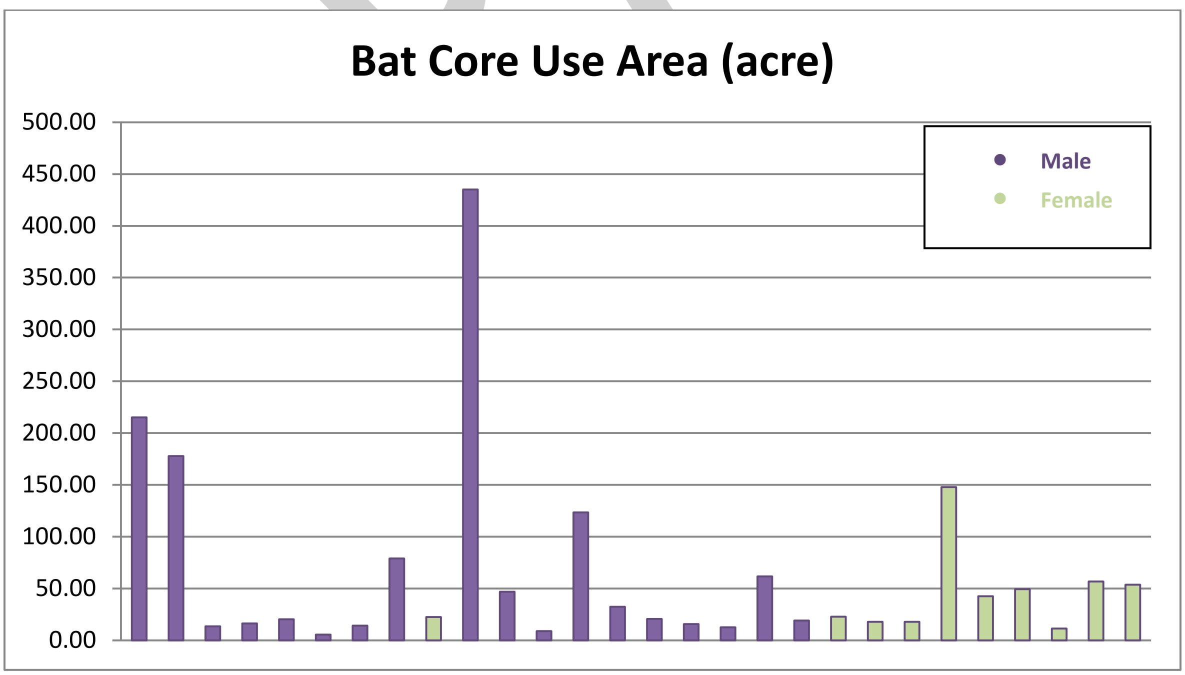



Figure 4. Bat core use area from 28 bats on the Big Island (Bonaccorso, 2015).

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 | KWP II | Kahuku | Kawailoa | Auwahi |
|---|---|---|---|---|---|
| Requested Take by Tiers | 20 | 7 | 12 adults / 9 juveniles | 20 | 5 adults / 2 juveniles |
| | | | | 40 | 10 adults / 4 juveniles |
| | | 11 | 13-18 adults / 9-14 juveniles | | |
| | | | | 60 | 19 adults / 8 juveniles |
| Acreage Required by HCP (Actual) | N/A | 338 (340) | 200 (254) | None specified (80 wetland, 40 upland) | 126.5 (155) |
| Tier 1 Cost | $20,000 | $250,000 | $150,000 | $1,291,000 | $522,000 |
| Cost per acre | N/A | $735.30 | $590.55 | $2,934.09 | $3,367.74 |
| Cost per adult bat | $1,000 | $35,714 | $10,000 | $64,550 | $87,000 |
| Average cost per bat from all HCP | $49,500 | | | | |

In 2015, Bonaccorso published a final 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 on the ground 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 on-the-ground forest restoration, credit should be calculated based on a rate of 40 acres per bat. Bonaccorso noted that the mean core use area was approximately 65 acres and suggested that agencies should use this value as the acreage for bat mitigation and that mitigation should focus on bat pupping elevations below 1,000 meters in elevation (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. Mitigation success will continue to be measured indirectly 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 numbers.

### d. *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 mixture 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.

Note that the options described below 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. *On-the-ground*

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 irrigation areas based on one study conducted by SunEdison (SWCA 2011) indicating that ponds and wetlands could serve as important foraging grounds for the Hawaiian hoary Bat.

Forest restoration projects need to consider the following information:

1) Hawaiian hoary bat pupping habitat occurs below 1,000 meters (Bonaccorso 2015, pers. comm.);
2) Core use area for one Hawaiian hoary bat is considered by DOFAW to be 40 acres;

3) Mitigation projects should not occur in close proximity to the impact area (within the average foraging distance for one bat, i.e., approximately 3 km);
4) Mitigation should occur on the island where the impact is occurring;
5) Restoration efforts should focus on restoring native habitats;
6) Acoustic monitoring or other bat monitoring techniques must occur for the duration of the mitigation project; and
7) Habitat improvement for bats must be measured over an established baseline condition.

Although not yet supported 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.

Another on-the-ground 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. In order for the land acquisition alternative to be used for bat mitigation, several conditions must be met:

1) The land to be acquired must be demonstrated to be under some threat of future development and cannot be zoned conservation district by the State Board of Land and Natural Resources.
2) If an applicant proposes acquisition of a parcel that is designated by more than one zone and one of the zones is conservation district, the parcel can still qualify for mitigation credit if it is demonstrated that the parcel has a high likelihood of being developed.
3) A minimum of 400 acres must be proposed for acquisition. This will ensure at least ten bat core use areas are protected and minimize small and separated ‘postage stamp’ size mitigation projects.
4) The acquisition must be assessed as good quality bat habitat through consultation with bat experts and the land acquisition must be protected in perpetuity (i.e., fee simple, conservation easement, or other arrangement agreed upon by the applicant and the agencies).

*2. 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.

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 must 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.

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. In order to provide a consistent and standard mitigation value for research as mitigation, a cost per bat was determined based on an evaluation of the cost of existing, approved mitigation projects and on-the-ground management costs in the state of Hawaiʻi (See Item 3 below for details). The cost for mitigating for one bat was determined to be $50,000.

3. *Proposed mitigation credit ($50,000/bat) rationale*

As stated above, the cost to mitigate for one bat is determined to be $50,000.

This cost was calculated 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, the price of $50,000 per bat was determined to be a reasonable value in light of the average cost for bat mitigation from state-approved HCPs (average cost is $49,500, Table 2). Furthermore, 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 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.

## VI. Research and conservation priorities

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 eligible for mitigation funding and offsetting incidental take of Hawaiian hoary bats.

1. *Population size and trends on each island.* Although there are potential developments in this area on the horizon, given current best available science it is not currently feasible to determine an actual population size in the state of Hawaiʻi. However, there is a significant amount of research that could be undertaken that will provide information on occupancy, distribution, activity levels, and general population trends that will hopefully lead to an eventual determination of overall bat population size. One example of this type of research would be setting up an island-wide grid of acoustic detectors and conducting a multi-year study to monitor detection frequency and patterns.

2. *Habitat selection and suitability for roosting, foraging, and breeding.* It is unclear at this time what the limiting factors are that prevent the bat population from increasing. Understanding which habitat types bats are occupying, and how and when they use those habitats, would provide a strong indicator for the types of habitat to target for restoration. Or, conversely, could provide data to demonstrate that habitat availability of any kind is not a limiting factor for bats, and would enable mitigation and management funding to be directed toward more appropriate measures.

3. *Diet studies: prey presence, absence, and availability*. Another possible limiting factor for bats could be prey availability and distribution. Studies to determine which prey species bats prefer, where those species are located, and, if they are a limiting factor, how their populations can be increased, would allow for targeted mitigation efforts that could significantly enhance the prey base. Studies of this type are best conducted in areas where the bat population is considered stable, such as currently thought to be the case on the Big Island (F. Bonaccorso, pers. comm), whereas focusing on alleviating or eliminating threats is more important in areas where the population is decreasing.

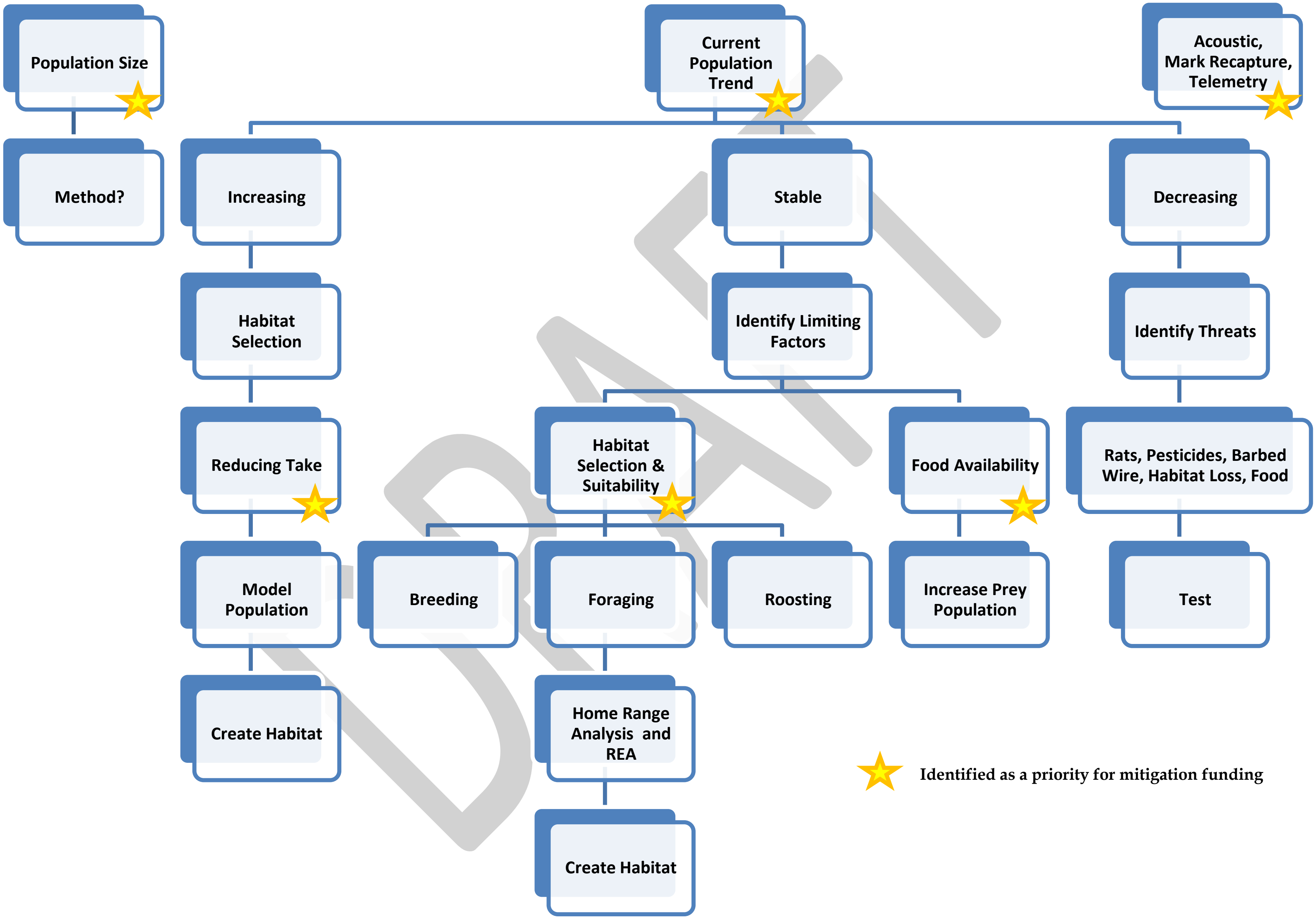
4. *Operational minimization, deterrents, and behavior.* Research into how bats interact with turbines, and potential ways to deter bats or minimize collisions via operational controls have the potential to significantly reduce take and ensure that alternative energy goals can also be met.[1] Given that addressing immediate threats should take priority over take reduction research, the ESRC will approve this research on a case by case basis, as depicted in Figure 5. This research does not necessarily need to take place on the island where impact is occurring, and may even potentially occur on the continental U.S. should the ESRC determine that it has the potential to benefit Hawaiian hoary bats.

5. *Monitoring of existing projects.* Monitoring is required at all projects that involve a restoration component (see Section V). As described here, the intention is to fund monitoring above and beyond the typical acoustic detection and forest structure monitoring that is included in each restoration project. For example, funding an effort to mist-net and radio tag bats, conducting diet studies, or comparing impacts of different restoration methods within an existing restoration project site.



[1] Note that DLNR-DOFAW supports research into bat deterrent mechanisms and other operation minimization measures, but the USFWS considers these avoidance/minimization measures, and will not provide mitigation credit for this research.

Figure 5. Flow chart providing guidance for research project selection.



## VII. Conclusion

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.

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