APPROVED

ENDANGERED SPECIES RECOVERY COMMITTEE

14 APRIL 2014 MEETING MINUTES

Hawaii Department of Land and Natural Resources

Kalanimoku Building; 1151 Punchbowl Street; Room 322B; Honolulu, HI 96813

MEMBERS: Scott Fretz (DLNR-Division of Forestry and Wildlife), John Harrison (At-Large Member), Patrick Hart (At-Large Member), Jim Jacobi (US Geological Survey), Greg Koob (US Fish and Wildlife Service), Gordon Tribble (US Geological Survey; in audience).

SPEAKERS: Angela Amlin (DLNR-Division of Forestry and Wildlife), Frank Bonaccorso (US Geological Survey), Joy Browning (US Fish & Wildlife Service), Dawn Bruns (US Fish & Wildlife Service), Mitchell Craig (SunEdison), Reggie David (Rana Biological), Marcos Gorresen (Hawaii Co-operative Studies Unit - UH Hilo), Cris Hein (Bat Conservation International), Dave Johnston (H.T. Harvey & Associates), Ling Ong (SWCA Environmental Consultants), Corinna Pinzari (Hawaii Co-operative Studies Unit - UH Hilo), Diane Sether (US Fish & Wildlife Service), John Vetter (DLNR-Division of Forestry and Wildlife), Ted Weller (USDA - Forest Service),

AGENCY STAFF: Jodi Charrier (US Fish & Wildlife Service), Kirsty Gallaher (DLNR- Division of Forestry and Wildlife), Leila Gibson (US Fish & Wildlife Service), Afsheen Siddiqi (DLNR-Division of Forestry and Wildlife), Jon Sprague (US Fish & Wildlife Service), Katherine Cullison (DLNR-Division of Forestry and Wildlife).

FACILITATOR: Teya Penniman

OTHERS: Derek Brow (William S. Richardson School of Law - UH Manoa), Matthew Burt (Directorate of Public Works), Paul Conry (H.T. Harvey & Associates), Dave Cowan (SunEdison), Lisa Ferentinos (Ko'olau Mountains Watershed Partnership), Justin Fujimoto (Naval Facilities Engineering Command), Nicholas Koch (Hawaiʻi Forest Industry Association), Michelle Mansker (US Army Garrison Natural Resources), Lisa Munger (Goodsill Anderson), Allan Nakamura (USDA - Wildlife Services), Ben Okimoto (Honolulu Zoo), Gregory Spencer (H.T. Harvey and Associates), Matt Stelmach (SunEdison), Joel Thompson (WEST, Inc.), Carolyn Unser (SunEdison), Johanna Valente (SunEdison), Marie van Zandt (Auwahi Wind), Eric VanderWerf (Pacific Rim Conservation), Karen Wattam (SunEdison), Brita Woeck (Tetra Tech).

ITEM 1. Call to order

Chair Fretz called the meeting of the Endangered Species Recovery Committee (hereinafter referred to as the “ESRC” or “Committee”) to order at 9:05am.

Chair Fretz introduced Teya Penniman, the workshop facilitator.

Fretz stated that the format of the workshop would be an informative discussion and that the purpose was for the committee to get input from the panel, with certain products required from each agenda item. Public comments would be requested before detailed discussions occurred.

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Penniman introduced the first item as an overview of the Hawaiian hoary bats within the regulatory process.

ITEM 2. Overview of current knowledge and status of the Hawaiian hoary bat *(Frank Bonaccorso, US Geological Survey)*

Bonaccorso introduced himself and stated that he had worked in Hawaii for the past 11 years and would highlight the projects that a core group of USGS researchers (based on the Big Island) had conducted over the past few years through a UH Hilo and USGS cooperative, with assistance from many other agencies.

Research projects included the following:

1. Food habits of the Hawaiian hoary bat (in process)

The Hawaiian hoary bat is a solitary roosting species, cryptic, nocturnal, and highly mobile; it feeds heavily on moths and beetles.

This project involved collecting fecal pellets and studying the fragments by microscope. Bats masticate food into 1 – 3 mm fragments. Have been able to identify a dozen species of insects. For example, the Chinese garden beetle, an invasive species, is one of the most common species eaten on the Big Island. Also red-shouldered stink bug. It is easier to undertake studies using this method in Hawai‘i because there are fewer species of nocturnal flying insects (and the bat is an aerial feeder). Data from USGS team member Chris Todd’s Master’s thesis looked at acoustic detectability and periodicity. Bat activity doesn’t appear to be strongly linked to insect biomass data (based on light trapping). At the study site (Wailuku Gorge) Lepidoptera were the most readily available prey species and the most commonly consumed; however, Coleoptera were consumed in a greater proportion than their availability compared to other genera. This suggests that Coleoptera are preferred prey for the Hawaiian hoary bat. There is potential for DNA barcoding to expand knowledge in the future, allowing the identification of soft bodied species which cannot be detected using the current method of analysis.

2. Behavior of the Hawaiian hoary bat at wind turbines and its distribution across the north Ko‘olau Mountains, O‘ahu (Gorresen et al., in review as HCSU Technical Report)

This was a six-month study using infrared/video monitoring and bat carcasses and involved collaboration with Bat Conservation International and the Hawai‘i Cooperative Studies Unit (HCSU). It is currently in review and will likely be available in the following month.

3. Tree bats use air currents and visual cues when approaching wind turbines (Cryan et al.2014)

This study found that bats were detected more frequently at lower wind speeds, and typically approached turbines from downwind. The proportion of downwind approaches increased with wind speed when blades were not turning, but decreased when blades could turn. It was suggested that tree bat fatalities at turbines may be the consequence of behaviors that provide selective advantages when elicited by tall trees, but are maladaptive when elicited by wind turbines.

4. Bats see dim ultraviolet light (Gorresen et al.; submitted to Physiological and Biochemical Zoology)

This study found that seven insectivorous species of bats (five genera and three families) showed ‘escape-toward-the-light’ behavior in a Y-maze with a choice of no light or UV light (peak wavelength 365 nm at an intensity, 1/30th the ambient value at dusk). This provided compelling evidence of widespread dim-light UV vision in bats, which might provide another mechanism for take-avoidance.

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5. Seasonal occupancy at Koloko (Pinzari et al; field components completed, lab analysis underway)

Acoustic detectors were used to survey bat seasonal occupation of the landscape. The study was undertaken at a small park on west coast of the Big Island. Hawaiian hoary bats were present year-round at modest occupancy levels. The highest occupancy was associated with wetland habitats (including old fishing ponds and anchialine pools), and the lowest occupancy with extreme xeric exposed lava beds. Insect prey species were collected with light traps and a prey phenology analysis was currently underway.

6. Foraging range movements of the endangered Hawaiian hoary bat, Lasiurus cinereus semotus *(Bonaccorso et al.2015)*

This study was based on 28 radio-tagged individuals. Data were only available for summer foraging range (unsuccessful at radio tagging bats in winter at high elevations).

Findings included a mean summer foraging range of 231 ha (570 ac), a mean summer core-use area of 25 ha (62.5 ac or 11% of mean foraging range) with almost no overlap in core-use among individuals, and a mean long axis of foraging range of 3,391 ± 754 m (2.1 mi).

Limitations of the study included the limited battery life of the transmitter (two weeks).

Dave Johnston asked if foraging ranges were exclusive of other bats if they overlapped. Bonaccorso replied that there was some overlap, but this was negligible in the core foraging area. Adult males did not overlap at all in core use area, but there was a small overlap between juveniles and adult males.

Fretz asked if it was known how the foraging areas were segregated: through acoustics or chasing other bats out. Bonaccorso replied that anecdotal evidence suggested that both methods were employed, have heard calls and seen chasing behavior.

Johnston asked what kind of habitat was preferred. Bonaccorso replied that there may be up to five or six disjunct core use areas. The long axis of the largest area was 17 km. The bat was a habitat generalist, with habitat including closed canopy forest with gaps, edges and anthropogenic windrows.

Fretz asked if it was safe to assume this information applied to pairs. Bonaccorso could not provide a definitive answer but expected that it might not apply to pairs.

7. Testing the use of ultraviolet light as a means of minimizing bat fatalities at wind turbines (Gorresen et al.; submitted to Endangered Species Research)

This article would be addressed by Gorresen in a talk later in the day.

8. Winter distribution and use of high elevation caves as foraging sites by the endangered Hawaiian hoary bat, Lasiurus cinereus semotus *(Bonaccorso et al.; Manuscript soon ready for review as an HCSU Technical Report)*

This study was undertaken near the Daniel K. Inouye Highway on slopes of Mauna Loa. Acoustic detectors were placed outside lava tube entrances. The caves with the highest number of detections during the winter were those two at the highest elevations. Bat activity appeared to be highest at caves at lower elevation near the beginning of winter, with activity moving upslope. There was no evidence of roosting and there were few trees available apart from dwarf scattered trees downslope. The resource the bats seemed to be following was *Pterydroma* (native species of moth). At the Mauna Loa ice cave there were pictures of moths walking on the ice (year round). The cloud inversion layer was usually present at about

1,700 m. If it was raining, foraging above clouds was preferred as it is not efficient to forage in drizzle, heavy rain, fog or high winds.

9. Acoustic surveys of Hawaiian hoary bats in Kahikinui Forest Reserve on the Island of Maui (Todd et al.; HCSU Technical Report in Draft).

10. Two tickets to paradise: Multiple dispersal events in the founding of Hoary bat populations in Hawaii (Russell et al.; submitted to PLOS One)

This genetic study found that Hawaiian hoary bat populations originated via dispersal from the North American hoary bat species *Lasiurus cinereus cinereus.* There appear to have been at least two dispersal events representing differentiated evolutionary significant units with distinct evolutionary histories. Demographic analyses suggest Hawaiian populations on all main Hawaiian islands were founded no more than 10,000 years ago, with a recent distinct population on O‘ahu and Maui founded ~800 years ago.

ITEM 3. Wind take avoidance

ITEM 3a. Curtailment

Curtailment practices *(Cris Hein, Bat Conservation International)*

Hein provided an overview of terminology associated with curtailment practices. This is also known as operational impact reduction and involves changing turbine operations to reduce fatalities. The cut-in speed is the wind speed at which the generator is connected to the grid and producing electricity, although blades can still spin rapidly below this. Feathering is defined as rotating the blades so that they are parallel to the wind to reduce speeds and doesn’t involve brake application.

In 2003, it was discovered that wind turbines were a threat to bats. A study on the cumulative impacts of wind energy development on bats in the U.S. and Canada was completed in 2013 (Arnett and Baerwald). Between 2000 and 2011, between 840,000 and 1.7 million fatalities were estimated. Between 190,000 and 395,000 were recorded in 2011 alone. In 2012, with a larger capacity installed, cumulative fatalities of between 2 and 4 million fatalities were estimated.

It should be noted that 79% of bat mortalities from wind turbines are migratory tree roosting species (which are considered most likely to be impacted by wind turbines). The mainland hoary bat was the most impacted species of which 38% were hoary bats. It has been suggested that half of all U.S. species had been impacted by wind turbines.

Fatalities on an annual basis based on the amount of installed capacity.

The study found that peak fatalities occurred from late summer to fall and were higher under certain weather conditions (wind speed in particular). No bats had been recorded killed at non-moving turbines.

Because of the relatively well-defined set of conditions under which most fatalities occurred, there are opportunities to alter operations to reduce fatalities, but there may be associated costs to the facility.

Hawaii currently has 206 MW of installed wind energy generating capacity, with 40 recovered bat fatalities and between 210 and 243 bats estimated to have been killed.

The impacts of changing turbine operations were outlined, according to initial research in Canada by Baerwald et al. (2009). Raising the cut-in speed from the normal manufacturer’s cut in speed of 4m/s to

5.5m/s, reduced fatalities by 60%. Making the turbines idle at low wind speeds (changing blade angle and generator speed) resulted in 57.5% fewer fatalities. Chosen cut-in speeds were based on acoustic data showing declines in bat activity around 5 to 6m/s.

Various studies supported these results:

Arnett et al. (2011) found 44-83% fewer bats were killed at lower cut-in speeds and found an annual power loss of between 0.3 and 1% from implementing these cut-in speeds.

Good et al. (2011) used the same cut-in speeds as Arnett et al. (2011) and found similar results.

Good et al. (2012) assessed the impacts of feathering and increasing cut-in speeds at the same site as Good et al. (2011). 36% fewer bats were killed under those conditions. A similar study found a <1% annual production loss during implementation.

Anonymous (2012) in the southwestern United States found that Brazilian freetail bats had the highest fatalities.

Martin et al. (2013) featured a control and 6m/s cut in speed at certain temperatures.

Hale & Bennet (2015) found a significant decrease in fatalities with little economic production loss.

The above studies found a variation in percentage reduction and overlap between different cut-in speeds. It's evident that the cut-in speeds don't necessarily have to be drastically increased to obtain a conservation value. On average there was approximately a 50% reduction in fatalities. Economic costs of implementation appeared to be low, but varied between sites. Feathering and higher cut-in speeds might not work for all species depending on their habits. Turbine technology could advance to be able to spin at lower wind speeds at which point it might cost more to implement these strategies.

Ways to measure cut-in speeds included blade tip speed versus wind speed and the percentage of time that blades spun at any given wind speed.

The studies involved multi-site, landscape level data which was used to develop a cost-benefit ratio.

Refining operational changes included allowing operations in the rain, modelling high fatality events with weather variables and focus on periods of highest risk (for example during migration, reproductive females), investigating the on/off decision framework and rotor speed (to reduce wear and tear on turbines and reduce potential fatality risk during operational transition).

Fatality monitoring was helpful but had limitations; behavioral studies may be expensive but could assist with identifying the exact time and conditions of highest risk.

Smart Curtailment *(Dave Johnston, H.T. Harvey and Associates)*

Johnston introduced the topic of Low Wind Speed Curtailment (LWSC), the most supported management strategy to reduce bat fatalities, but which operates primarily on coarse parameters. Ideally it would have only a minimal impact on power generation. In Hawai‘i, many of the facilities were right on the edge of being profitable.

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Kawailoa Wind (SunEdison) has voluntarily been implementing LWSC, although studies have not yet been done to prove it effective in Hawaiʻi. LWSC was implemented because of the higher than expected bat fatalities during operations.

Studies which detailed curtailment included Arnett et al. (2013) – a review paper detailing the relationships between weather and bat activity; Weller et al. (2012) – weather conditions and bat activity for a site in southern California; Korner-Neivergelt et al. (2013), who determined fatalities on a turbine by turbine basis; and Johnston et al. (2013), who determined wind direction drivers and predictors of fatalities. They were also able to predict 'hotspot turbines' based on the direction to the nearest roosting area.

Kawailoa had implemented acoustic and weather monitoring and had been collecting very specific, turbine by turbine data points (every 10 minutes). Less than 1% of the data included bat activity (resulting in zero-inflated results). The data had therefore been collapsed into a single dataset with 10-minute intervals for seven weather parameters (windspeed, wind direction, temperature, humidity, barometric pressure, moon illumination and rainfall) and four habitat parameters (distance to forest edge, distance to cliff edge, elevation of turbine above sea level and northing).

In the early stages of the research, spatial relationships were a focus but patterns were not detected. There was high confidence in the data for barometric pressure, but no relationship with bat activity was detected. There appeared to be an inverse relationship between temperature and bat activity, but there were too few data points for it to be conclusive.

It had been found that there was lower bat activity during higher wind speeds and certain wind directions. As turbines increased in elevation, collision risk decreased. There had been many correlations between weather variables and bat activity, but there was a need to determine which of these were biologically significant. Only three fatalities had a 24 hour window during which they were known to occur.

Additional considerations for future studies included controlling for the month or season and time of night. Limitations included the fact that many bats were active without being detected. It was difficult to model, and therefore likely to be difficult to implement smart curtailment in Hawaiʻi, when there had been so few fatalities and therefore so little data available.

Mansker asked if anyone had studied the impacts of barbed wire. Fretz replied that this question would be addressed later.

A member of the audience (name unknown) asked about the approach to measure bat activity against conditions, given that it was as yet unclear if mortality was related to activity level. Johnston replied that the approach essentially involved modelling risk. There was the assumption that there was a tight relationship between activity and fatalities, but it appears that this might not be the case.

Hein suggested that thermal imagery could be used to determine precise information about the bat interactions with the turbines which could be linked to weather. Johnston replied that the disadvantage was the expense per turbine, which would limit the number of turbines for which data could be determined. This could result in a lot being learned about individual bat behavior but less about the broader system.

VanderWerf added that the approach seemed promising, as some conditions that resulted in lower or higher activity levels had been identified. Johnston replied that more information would be required to assess this with a higher level of certainty. No studies in Hawaiʻi on whether curtailment would decrease mortality.

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Fretz stated that although number of bats being killed was low, it was a large proportion of the small population, and there was therefore an obligation to decrease it. He asked if the committee felt that curtailment should be required, perhaps in an experimental way to gather data. Curtailment had not been written into the first wind Habitat Conservation Plan (HCP) in Hawaiʻi for the bat, but was implemented later once the take reached a certain level. The applicant had proposed to do a lot of curtailment based on self-monitoring and projected take being higher than expected.

Craig added that curtailment had been implemented from the beginning of SunEdison operations. Some of the studies on the mainland had been based on different species behaviors, for example migration, whereas the Hawaiian hoary bat has limited migration. The bat may be able to roost in trees while wind speeds are high, thereby decreasing the risk of fatalities.

Weller mentioned that the studies that Hein had described depended on conducting daily surveys and know exactly which nights bats had been killed. He asked how often daily surveys had been conducted in Hawaii. Craig replied that USGS and BCI had conducted daily searches over six months at four turbines and had found one fatality. Searches by SunEdison had therefore been reduced to twice a week.

Charrier noted that currently all facilities in Hawaii are curtailing and using feathering.

Johnston asked if there was any reason why curtailment should not be considered as part of the protocol. He gave an example of Mexican freetailed bats, where take showed no relationship with wind, and suggested there was a need to do similar pairwise studies in Hawaiʻi.

Harrison asked if there would be further discussion during the workshop about UV sensitivity and the possibility of applying additional strategies to mitigate take. It was suggested that that curtailment would likely continue to be a solution as more information was determined through research.

Fretz suggested applicants could be asked to include curtailment and propose a course of action to the committee.

Hart noted that there were insufficient numbers of bats to determine parameters and asked if studies had been done on Maui where there were more bats. Craig replied that there might be insufficient fatality data for many analyses but there were other sources of data. An advantage of acoustic data was that it could be used as indicator of bats flying at a particular time of night. At certain turbines there may be higher fatalities and an experimental approach would be required to understand the reasons for this.

Penniman suggested that it would be helpful to have the staff provide guidelines based on the presentations.

Amlin added that the curtailment windspeeds had been based on many of the studies discussed by Hein. Although they were mainland studies, a general decrease in take based on decreased cut-in speeds was considered applicable to Hawaiʻi. The Division of Forestry and Wildlife (DOFAW) staff, in conjunction with US Fish and Wildlife Service (USFWS), had therefore used this information when formulating their recommendations. Originally, curtailment had been requested during peak breeding season but due to fatalities outside this timeframe, the length of time was extended.

Cowan said it would be important to have something that could be tailored for each site. Johnston added that the next step might be to look at groups of turbines. If differences were detected, it might be worth allowing a change in the curtailment requirements in the HCPs based on low take. Penniman noted that staff were already working with applicants to develop site-specific curtailment procedures and would continue to develop this.

Amlin stated that wind speed parameters had been based on mainland studies which showed a general decrease in take with an increase in the cut-in speed. The plans had originally only called for curtailment within peak breeding season, but based on fatalities the spread of time was increased. This is an evolving process and is being implemented in collaboration with USFWS.

Cowan added that the potential for before and after studies was very limited due to a small sample size. Fretz asked whether this was related to a small sample size versus detectability. Craig suggested that acoustic detectability determined general patterns and not individual bat activity. A future approach would be visual detection which could improve the resolution of the data. It had been observed that bats did fly at speeds greater than 5 m/s but generally flew more when wind speeds were lower. Studies related to wind speeds would be therefore be useful. Penniman added that one of the outputs of this workshop would be recommendations for additional studies.

Johnston mentioned that sample sizes in Hawaiʻi would always be low; and that there was a need to base data on activity rather than fatalities. Craig added that certain turbines had higher fatalities and that curtailment could perhaps be balanced at turbines with high versus low fatalities.

Weller suggested the time of year and side of the island were also important determinants. A database of fatalities and what variables should be collected in future would be important to build if it were not already in existence. Amlin added that DOFAW staff maintain a database of fatalities including the location and detection date. This could be combined with other variables such as the average windspeed. Weller added that general information about the site would also be important data to collect. Fretz stated that one of the main outputs of the workshop would be to focus on what information would be required for reports going to staff for monitoring. Conry emphasized the need for adaptive research and management.

ITEM 3b. Bat Deterrent Technology

Effectiveness and timeline *(Cris Hein, Bat Conservation International)*

Hein outlined the need to develop other mutually beneficial strategies for curtailing take, one of which was the use of ultrasonic acoustic deterrents. They have been in use since 2006, and interfere with bats ability to orient and find prey. The devices require minimal maintenance but are still a relatively unproven technology due to a dearth of studies and the physical limitations of projecting sound. For example, high frequency sounds attenuate relatively quickly in the atmosphere, and there have been challenges such as an increase in the length of turbine blades.

In controlled tests, it was found that bats were not at all able to catch prey. In the field, a 90% reduction in activity was recorded and found to be sustained over a week (bats had not become habituated).

Arnett et al. (2012) had placed deterrents on wind turbines in Pennsylvania. They operated at 122db Sound Pressure Level (logarithmic measure of the effective pressure of a sound relative to a reference value; in this case equivalent to that of a jet engine), with a range from 20 to 100 kHz. This was measured at the standard distance of 1m from the device, They were placed on the nacelle with two devices directing sound upwards and six directing sound toward the ground. Of the six, three were on each side of the nacelle: two pointing toward the blades, two pointing straight down, and two pointing toward the end of the nacelle. There was a reduction in take of between 21 and 51%, with a 9% inherent variation within the first year of study. When this variation was applied to the following year of study, they found between 2% more fatalities and 64% fewer fatalities. Unfortunately the devices experienced a number of failures due to high temperatures and water entry. They also tended to work better for bats with lower frequency calls as they were able to encounter and react to the sounds from further away.

In 2013, a deterrent test was performed for the Hawaiian hoary bat. Hawaiʻi is a highly humid environment, which was a limiting factor. The study site was the Island Princess Macadamia estate on the Big Island. Deterrent and control sites were switched across the landscape over the course of the study to eliminate bias. Thermal camera and acoustic detectors had been placed 35 m away from the deterrents. The acoustic detectors were used to measure bat activity before the deterrent was placed at site and the night after the deterrent was removed (could not be run concurrently with the deterrent due to the sound interference). Thermal cameras were, however, used while deterrents were active. A significant difference between controls and deterrents had been found in paired tests, with lower variation in activity when the deterrents were active. It was also established that once the deterrents were moved, bats reoccupied the areas. The results from the thermal cameras showed little bat activity (bats leaving airspace and turning around) when deterrents were on, compared to high bat focal activity on control nights. The effective range of the deterrence tested was 30 meters in high humidity (around 80% humidity).

A comparison of Operational Minimization (OM) and Acoustic Deterrents (AD) was provided. At this stage, there have been few studies on AD compared to OM. The main differences include the following: OM impacts power production and purchase agreements (even though this appears to be minimal), while AD required upfront and maintenance costs, research and development. On the mainland, where bats were migrating, these technologies were unlikely to have a problem with sustained effect, but in Hawaiʻi the bats might become habituated. AD, however, had the capability to pulse using a broad range of frequencies, which makes it less likely that bats will become habituated. Mounting designs have improved where electronic components can be placed inside nacelles to make the devices more weatherproof, and better seals and more robust equipment are promising trends.

Human-safe ultraviolet light deterrence *(Marcos Gorresen, Hawaii Cooperative Studies Unit – UH Hilo)*

Gorresen stated that, in general, bats use vision to navigate across landscapes. It is believed that under low light conditions, bats can see emergent structures in the landscape which might be cues for resources such as roost sites, social opportunities and insect aggregations. A few bats are known to see in UV spectrum. It was desired to know how widespread UV vision was in bats and whether this could be used as a deterrent to ensure bats do not perceive turbines as trees (as mostly tree-roosting species are killed). Another requirement was to ensure this could be done at sufficiently low levels to avoid impacting humans and other species, such as birds.

A Y-maze light experiment had been conducted. The light was invisible to people because of a low illumination level (<1/30th of ambient light levels at dusk). It had been tested on seven species of bats on the mainland (not including hoary bats as they are difficult to capture). Unlike tree bats, these species occupied enclosed structures.

Within each species, bats showed evidence of moving towards low level UV light (statistically significant). This was the first demonstration that a diverse group of bats could see dim UV light. Light cues might be advantageous for bats to utilize, for example, those that emerge from caves. The study is currently in review.

Following this, a field experiment was conducted to determine if the Hawaiian hoary bat would respond in the same way. Thermal cameras and acoustic detection were utilized at 10 sites and available insect prey measured during periods when UV deterrents were present and absent. Gorresen showed a video with three bats interacting on a control night and pointed out the behavioral differences in near range versus further away and the duration of the event. Data collected included approximate distance from the camera, duration of the event (nearby bats will pass through the field of view more quickly, so would expect the duration of the event to increase if bats were being deterred), and acoustic data including the number of pulses and frequency of feeding buzzes.

When the UV deterrents were on, the following results were obtained: acoustic detections and calls declined, thermal imagery showed a 25- 38% drop in detections and increase in the duration of events as more bats were flying further away. These results were set against the marked increase in insect prey biomass (five-fold increase). Bats were not completely eliminated from the area, suggesting a combination of deterrent methods would be most effective. This research was also in review.

A thorough review of the literature was done to determine if birds were likely to be affected. Nocturnal birds don't have the UV sensitive cones / photoreceptors and yet most birds have UV transmissive lens and corneas, so some birds can likely perceive UV. This has actually been shown for certain groups of birds including passerines. There is some concern that migratory passerines could be impacted. However, birds as a whole have very low refractive power in their eyes and therefore don't gather as much light. Keeping the illumination level of UV deterrents very low would likely decrease the possible impacts on birds.

Bonaccorso suggested a study testing the combined impacts of UV and acoustic, while Ong suggested looking at the difference between bats which appeared to move towards the light versus those which avoided it.

Gorresen mentioned that initial tests were on cave-dwelling bats which would use this ability to locate the entrances. Vegetation has very low reflectance of UV light so the potential response by bats to UV deterrence on turbines may be greater. A study using red lighting with low illumination levels showed decreased bat fatalities; UV was likely to have the same effects but would be less visually intrusive. Fretz enquired about the costs of such a system. Gorresen replied that a prototype had cost $500 for the LEDs and $500 for the machine. Advantages included that it was a passive cue and that LEDs are low energy. The effects of acoustic deterrents were more dramatic, a combined deterrent might be the most effective.

Hein added that the cost of acoustic deterrents was $13,000 per turbine. But prices could drop by 50 to 75% once they become commercially available. General Electric is also currently developing its own deterrent. Because of the difficulties with small sample sizes in Hawai‘i, it was important to combine fatalities, acoustic and camera data.

Hart asked if there had been any indications of whether birds were impacted by acoustics. Hein stated that no differences in bird fatalities had been detected. The aim had been to maintain the frequency above human audible levels, but the sound was still isolated around turbines. If the frequency range was lowered, the sound could travel over a greater distance. Pulsing frequencies and sweeps also helped to project sound and prevent habituation by randomizing patterns.

Johnston stated that dropping the frequency below 20Khz in order to project the sound further was a good idea. Most bats could hear down to 4 kHz, so the sound could be dropped to below 20 kHz. VanderWerf noted that effects to pueo needed to be considered to determine if this was an attractive nuisance. If the frequency was too low it might have the risk of attracting owls (which might mistake it for the sounds of prey).

Cowan mentioned that he was aware of UV lights being used as a strobe as a deterrent. Gorreson added that radar had been used to deter bats. At the military installation, the bats were attracted to the immediate area around the radar, then left. It was hypothesized that the reasons for this were that the bats were initially attracted to the radar frequency until it became too uncomfortable.

One of the main outcomes DOFAW staff hoped to get from the workshop included:

Amlin added that research priorities were important and mentioned that there had been internal disagreements within DOFAW and USFWS (and policy differences) on whether or not research into deterrents could be considered mitigation. This is because deterrents themselves were an avoidance measure but the research into deterrents (in Hawaiʻi) might be classified differently. DOFAW staff wanted to obtain the opinion of the ESRC on whether this was a valid way to spend mitigation money. Fretz replied that a case by case approach was required because of the different kinds of information that would need to be addressed. The decision on whether the money could be used to fund this research would depend on what the question was. There were a few entities currently engaged in research projects and they should be allowed to finish them before the ESRC determined whether funding should be assigned. In his opinion, research could count towards mitigation.

Penniman added that both of the technologies seemed promising but perhaps still challenging in their application to Hawaiʻi due to the small sample sizes and asked the Committee's opinion.

Amlin added that both agencies (DOFAW and USFWS) had encouraged applicants to support deterrent research, but given that it might not result in actual mitigation credit, applicants had been reluctant to spend the money. The question was whether research into effectiveness of deterrents could be added to the list of research priorities. Johnston agreed that deterrent research should be considered as the goal was ultimately trying to reduce / deter fatalities. Hart agreed with this sentiment. Craig added that because of the low number of fatalities, visual cues should also be used for studies. Cowan noted that decreasing mortality was cheaper than replacing bats, while Ong suggested that research didn't necessarily need to be done in Hawaiʻi. The committee members agreed. Fretz added his support for deterrent research being included in the guidelines for HCPs and that this research could be done on the mainland. Penniman concluded by stating that research on deterrents could count as mitigation on a case by case basis. It would be added to the list of options and this could include research on the mainland.

ITEM 4. Wind take monitoring

Post construction monitoring protocols and acoustic monitoring at four wind farms in Hawaiʻi
(Mitchell Craig, SunEdison)

Craig discussed ongoing post-construction monitoring and acoustic monitoring at four wind farms in Hawaiʻi. Results from Kawailoa Wind Farm were discussed as an example.

Transects are generally five to seven meters apart. There were some unsearchable sections of the facilities due to the terrain. Vegetation management is undertaken to increase searcher efficiency (SEEF). ATVs and canine-assisted searching have also been employed to improve efficiency, with dogs used at all four sites but especially at Kahuku and Kawailoa. GPS tracking devices are placed on the dogs to ensure the search area is covered. Trials have been conducted, with as high as a 90% SEEF for bats using dogs, versus about 60 to 70% SEEF for bats with humans alone. The methods used depended on wind and temperature conditions.

Carcass persistence trials had been undertaken using rats to simulate bat carcasses. Six 30-day trials had been undertaken, with a minimum of six trials per year. SEEF trials had used a minimum of 30 carcasses per size and vegetation class per year.

Predator control was being undertaken at all sites to allow carcasses to persist long enough to be recovered. For example, it had been discovered that mongoose had been removing carcasses within two days at Kahuku, so monitoring had been increased to three times a week until mongoose control became more effective. Similar interventions had been implemented for feral pigs and cats. Vegetation management included mowing, conducted immediately after searches.

Of the species mitigated for on Oahu, only the Hawaiian hoary bat had been found. On Maui, all of the species mitigated for had been found, except Newell's Shearwater. Search plots are between 50% and 75% of the maximum Rotor Swept Zone on Oahu and 75% on Maui. On Oahu the 50% area (where most bat fatalities are likely to fall) is searched twice a week, while the 50 to 75% area (more likely to be birds, which persist longer) is searched every two weeks. On Maui, the searches are conducted every week, based on carcass persistence which is different to that on Oahu.

Seven or eight people were involved in monitoring activities at Kawailoa, with another six or seven people at the facilities on Maui.

The HCPs for SunEdison have required acoustic monitoring. Ninety detectors have been placed at Kawailoa, with nacelle detectors and ground detectors being placed at every turbine, and 12 additional detectors in nearby gulches. This was due to bat take being higher than expected. At Kahuku there are 12 ground detectors and 12 nacelle detectors, at KWP I there are nine ground detectors and six nacelle detectors, and at KWP II there are eight ground detectors and seven nacelle detectors. All of the microphones had recently been replaced with newer versions which were much less susceptible to water and weather. All ground detectors had been mounted on 20 foot poles, apart from those in the gulches. At Kahuku they had found extremely low activity (detected on fewer than 5% of nights per month), although bats had been detected all year. Detections were recorded all year at KWPI and KWPII with the highest activity between August and November. At Kawailoa each turbine had a different activity level with a general peak between May and October. Fatalities were observed at every month on O´ahu except for January, and every month except January, June, July, August, and October on Maui.

Generally bat activity and fatalities (which were more common during the summer months) peak at the same time on O´ahu, but not on Maui. A similar pattern was detected in the gulches at Kawailoa. Fatalities have also been concentrated at certain turbines.

New technology including video, infrared and thermal imaging *(Marcos Gorresen, Hawaii Cooperative Studies Unit – UH Hilo)*

Gorresen introduced the first study which had been undertaken using thermal cameras (Horn et al. 2008). Researchers did observe certain behaviors such as chasing blades, but the cameras utilized were very expensive and resolutions poor. Near infrared had been used at first, but had been replaced by weatherproof thermal cameras although they generated a lot of data.

About 8,000 hours of video data had been recorded in Hawai‘i, and due to higher levels of bat activity than expected, the data was subsampled for analysis. Algorithms had been developed to detect bat motion, with proofing required to confirm bat observations. Many behavioral observations had been obtained, including investigating the nacelle and blade bouncing. This supported the findings of an Indiana study, which had also suggested that bats regularly approached wind turbines, with little evidence of foraging behavior. Focal behaviors included what appeared to be bats investigating the nacelles. It had been hypothesized that bats could be mistaking stationery and slow moving turbines with trees.

The Hawaii study had found 3,400 high confidence bat detections in 4,000 hours of footage that was subsampled from the total of 8,000 hours recorded. Bat detections were infrequent (0.5 to 1 per hour per turbine), but increased through the year from summer to winter. This was different than what had been detected using acoustics. Weather variables such as barometric pressure and wind speed had also been obtained. Contrast between Indiana and Hawaiʻi was that foraging had been observed in Hawaiʻi, and seemed to show more resident local bats encountering familiar structures as opposed to simply migrating through as they may be doing in Indiana.

Hart wondered if bat populations were declining over time given the rates of fatalities or if bats might be moving into the area (thereby forming sink areas).

Gorresen was unsure of the proportion of bat activity which had been recorded when the blades were moving. Behaviors did change in that bat detections decreased as wind speeds increased. There was the possibility that intermediate speeds might catch bats by surprise.

Hein mentioned that in the future, if cameras and data processing abilities were improved, they could be used to estimate take. He added that some groups were investigating this for offshore windfarm applications but that it would need to be groundtruthed using carcasses (i.e. on land). Craig stated that the cost of effective on the ground monitoring were large, and suggested that having six people watching video footage every day could end up being more efficient and exact than searching for fatalities. This could also potentially be confined to focal turbines.

Johnston asked how much further thermal imagery needed to be developed before it could be used effectively. Gorresen replied that the tools were already available but that there were tradeoffs between camera cost, quality, and the amount of data and locations sampled. There was currently a significant delay between data being captured, downloaded off the cameras and processed, which would not be quick enough to retrieve carcasses for groundtruthing.

Penniman mentioned that current technology including the ability to detect fatalities as well as post construction monitoring including acoustic. She asked the ESRC members for guidance on what tools yhey would like applicants to use.

Fretz added that take was estimated using Huso’s evidence of absence model, which included search efficiency and confidence intervals. In light of this, he wondered how much difference it made detecting only 50% of the carcasses versus the 90% target search efficiency. Sether stated that it depended on many factors: if there was good predator control and longer persistence then it was not as important to find carcasses early. Craig cautioned that the lower the SEEF, the higher the risk of estimates being inflated if more fatalities than expected were found. Weller added that there were ancillary benefits of higher SEEF, including being able to link fatalities to weather and sex the bats. Craig added that it was also dependent upon the numbers: if there was only one fatality a year and the SEEF was low, then there would be a good chance of not finding the carcass. The higher the number of fatalities, the lower the SEEF could be while still obtaining accurate results.

Cowan stated that more intensive monitoring was being undertaken in Hawaiʻi than anywhere else in the country, and it was one of the few places where canine assisted searches were used. Monitoring twice a week is intensive for year round monitoring.

Amlin asked if the Committee could think of any missing components that could be added to the recommendations presented, and whether research into these types of monitoring technologies could be used for mitigation credit. Most HCP projects in the state are currently moving out of the intensive post-construction monitoring period and into interim monitoring period.

Craig added that there was uncertainty in monitoring which was driven by uncertainty about the status and drivers of mortality for the bats. Johnston noted that he would like to see dog monitoring continued.

Fretz said that additional information could inform issues like curtailment. For example, if the use of dogs for monitoring required more or less resources overall. Craig replied that dog monitoring resulted in higher efficiency, but they could survey fewer turbines in a day. Vegetation management was the most time consuming, with slightly less required if dogs were used. Johnston added that the use of dogs resulted in a smaller area being required to be searched to obtain the same level of confidence, thereby increasing efficiency. Charrier noted that dogs could not be used at every site due to safety issues, heat issues etc.)

It was concluded that monitoring using the current approach would remain and that the ESRC was open to the idea of research on new monitoring technology as a mitigation option.

ITEM 5. Tree trimming / harvesting bat take avoidance and monitoring

Use of Forward-Looking Infrared (FLIR) systems *(Reggie David, Rana Biological Consulting)*

David spoke about the work being done for Kauai Island Utility Cooperative (KIUC). On Kauai, the vegetation needs to be trimmed by the utility cooperative year round to ensure it doesn't interfere with powerlines. Some of the vegetation is considered to be suitable roosting sites for the Hawaiian hoary bat, and KIUC is in the process of developing tree-trimming protocols to avoid impacting roosting bats.

Challenges includ the lack of audio detection for roosting bats, the use of unwieldy bucket trucks, and the need to search multiple sites in a single day. They tested a series of portable Forward-Looking Infrared (FLIR) devices that could find small mammals in vegetation during bat pupping season. They tried to trap bats to obtain test images but were unsuccessful, so small mice placed in cages in the treetops were used as surrogate targets. Many units had to be tested before one was consistently effective (Fluke devices). Telephoto lenses had been added to the FLIR to increase the ability to accurately identify bats (as opposed to birds or rodents) from the ground. Limitations included dense vegetation, the need for searching to be done early in the morning (bat body temperatures are not very high, making it more difficult to detect them in dense vegetation), and the difficulties in detecting bats versus other small mammals or birds.

KIUC decided to take a precautionary approach which involved only trimming densely vegetated sites outside of bat pupping season (except in emergencies). The influence of high temperatures was an issue, and trimming had to be postponed (sometimes for a few days at a time) in such circumstances.

There has been an extensive hands on training program for the KIUC staff involved. Staff are routinely tested with random searcher efficiency trials, which involved hiding mice in vegetation. So far searcher efficiency has been 100%.

Crew training was the most critical element for success of this project. Although whole teams were trained, a 'bat man' had been selected from each crew for more specialized training. Staff had been given a briefing on native / endangered species – the 'original Hawaiians.' Apart from it being the right thing to do, the searches were a legal requirement.

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Status of development of FLIR protocol to survey timber for bats prior to harvest *(Dawn Bruns, US Fish and Wildlife Service)*

Bruns introduced a new forestry project where the timber industry (and perhaps biofuels industry on Kauai) was interested in developing a method to ensure that bat take could be avoided. Nicholas Koch of the Hawaiʻi Forest Industry Association (HFIA) added that they were looking to harvest trees during the Hawaiian hoary bat pupping season because of the difficulties in halting operations for three months of the year. This would create a legal pathway for landowners to harvest trees, as sustainable forestry benefitted many, potentially including the bat.

Bruns had been working with HFIA for a year and a half. This project would be initiated with young eucalyptus trees less than 15 years old. HFIA had collected money from members and hired H.T. Harvey and Associates to develop a draft protocol to avoid/minimize impacts to roosting bats. Sheri Mann from DOFAW had also sourced some funding to support these efforts.

A preliminary DOFAW-funded study is planned for 2015. The study aimed to confirm that mice were a good surrogate for bat pups (pups would be the main target as the parents would be off foraging in summer). There was a lack of funding to study the temperature signatures of bat pups but data for lactating females would be welcomed instead if this was available from other studies. The study would also look at what type of FLIR equip to use and at what angle, and if there is a detection temperature cut-off.

The timber harvesting would be done using feller bunchers and would not involve clearing large acreages. There might be a need to develop an HCP for the timber industry, including HCP planning assistance.

Pinzari asked if the study would involve using a different device from that used by the KIUC as she was unsure if it had the capability to reach into dense vegetation / treetops. David replied that it would require looking at the branches from 4 to 6 different angles due to the device not being able to be seen through dense vegetation. Johnston suggested that testing be started at known roosts, using different temperatures and at different times of the day.

Estimating take based on habitat characterization *(Dave Johnston, H.T. Harvey and Associates)*

Johnston introduced the concept of "take", which in the context of this discussion refers to the loss of individuals during the breeding season as it relates to roosting habitat (the concept can also incorporate foraging habitat hence the need for the distinction). Information was needed to determine if there were certain ecological characteristics that could be identified and used to predict habitat quality, and areas of higher and lower bat population densities, as had been achieved for the salt marsh harvest mouse on the mainland, for example. Individual detections of bats don't necessarily indicate that the bat had been roosting in the location where it was detected. Multiple detections of bats might suggest a roost nearby. The roosts could then be detected upon closer inspection. The Hawaiian hoary bat is a foliage roosting species which often uses Eucalyptus trees. However, it could not be assumed that a bat was roosting in a tree in which it was seen. If there was a possibility of a roost being nearby, the tree would be observed using night vision goggles. In all of the cases in which Johnston had done this, not only the tree but the exact roosting cavity had been identified. About 10 years ago, he had been asked to survey 2 miles of potential bat habitat on the mainland. A scoring system of 0 to 3 had been utilized for each tree / cluster of trees, with 3 being the best potential habitat. A number of roosts were discovered, and buffers set around them.

Based on the inability to use FLIR for tall, dense forests, Johnston asked if it might be worth developing a roosting habitat value assessment for the Hawaiian hoary bat. He showed an example of dense forest which was unlikely to be suitable bat habitat because it was too cluttered. Another example of a group of trees on a ridgetop was suitable in that it was open habitat, but it was likely to be too windy. A final example of open forest habitat revealed slightly more structure, a clustering of vegetation in the canopy and more open habitat beneath, which was considered moderately good habitat for the bat. It was noted that Hawaiian hoary bats sometimes preferred alien / invasive trees for roosting, such as the African tulip tree or Eucalyptus species. A 2015 study by Bonaccorso et al. had recorded the nighttime movements of the Hawaiian hoary bat and was a good starting point for understanding more about habitat preferences.

Penniman summarized the discussion about the requirements for determining presence or absence of bats in trees during the pupping season. The first level of assessment should involve the identification of unsuitable habitat using a foliage density or similar index / habitat suitability score, followed by no bat detection for 30 days using acoustics, followed by the use of FLIR where there might be bats.

Conry mentioned that there was a need for the Hawaii Forest industry to get started, and that they were looking for protocols to use. If the bat was present and a buffer around known roost trees was implemented, he asked if the ESRC would consider it to be safe to harvest nearby. It needed to be verified if there would be a chance of take in these areas.

Johnston suggested that it would help to employ many of those tools to conclude that bats were not present in an area. Echolocation is used even in open air space, and detectors could be used to first determine if bats were utilizing the area. Upon further inspection it could be determined if bats were roosting there.

Koch added that based on the need to plan tree harvests, over the longer-term it would be good to have a vegetation proxy which would allow checking for bats prior to harvesting and improve the chances of detecting bats. For example a leaf-area index or equivalent measure could be investigated, even though it was acknowledged that it might be infeasible.

Conry suggested that guidance would be required on whether harvesting could occur during pupping season if FLIR imagery was unclear or not able to be used. He asked if visual and acoustic information could provide sufficient confidence to conclude no bats were present in the area.

Johnston didn't expect that a source of funding could be obtained in time to complete the study to determine accuracy before harvesting was required. Bruns added that there was prospective HCP funding which could be applied for in 2016.

Bonaccorso added that zero detection over long periods could be combined with a foliage density index to support the assessment and increase confidence in the absence of bats in certain areas. Amlin suggested that detections of bats in Eucalyptus species, which theoretically shouldn't be suitable habitat, showed that habitat assessments had inherent issues.

Weller suggested that the habitat suitability scores suggested by Johnston could be calibrated using acoustic detectors. If zero detections were obtained in 30 days (for example), the area could be considered unsuitable habitat. According to Bruns, the HCP planning grant program could potentially fund such research, based on the submission of a joint proposal. Amlin stated that if the goal of the timber industry would be to avoid HCPs, then HCP funding couldn't be used to develop these initiatives. Fretz added that the HCP grant was competitive, with shrinking funds.

David mentioned that FLIR would not be a useful tool for searching 1,000 acres of trees, but could be useful once the search area had been narrowed down. Bonaccorso added that bats often used the same tree for roosting, although backup trees could be utilized. Johnston couldn't imagine a bat not echolocating in a forest and suggested that it could be assumed that bats were not roosting in a forested area if no echolocation was detected.

Penniman stated that the current protocol was to avoid harvests during pupping season, but it appeared that other techniques could be used to inform harvesting during this period. Fretz added that applicants should submit proposals with details on such things for vetting.

Conry suggested first doing habitat assessments followed by detection studies.

Johnston didn't recall the topic ever being presented to the ESRC, and thought it might still be under agency review. Fretz recalled that the information required to conclude that bats were absent was not sufficient and encouraged Bruns to provide a proposal to the committee with specifics when available.

Bruns asked about the requirements for concluding with a high degree of confidence that bats were not present in an area. She gave an example of bat detectors being left out for 30 days at a density of 30 per acre. If no bats were detected, would this be an acceptably low risk of a false negative. She added that it had been a little unnerving seeing the number of bats present in thermal imaging videos taken at wind farms, many of which had not been picked up by acoustic detection (although wind farm and forest conditions are different). Bonaccorso suggested that in his experience, it would be acceptable to conclude that bats were absent in such a case.

Hein stated that it was unusual to rely on the proponent to determine an appropriate study design. Amlin added that typically an applicant would come forward and consult with DOFAW and USFWS, present a protocol which would be reviewed by and receive input from agency staff, and eventually would be referred to the committee. Currently there was limited knowledge and guidance available. If a protocol that worked was proposed, then it could be adopted. Fretz added that in such case this could be turned into general guidance.

Penniman asked how big the HFIA was (i.e. how many times it was likely to come to the ESRC). Koch stated that the forest industry in Hawai'i was not very big; there were currently two operations which used machines to harvest. HFIA in Hawaii was hoping for large amount of data to be gathered in the future to better manage the process.Mansker added that there were potentially many others who would be affected (those who needed to cut trees greater than 15 feet in height during pupping season, for example).

Fretz wondered about other data that could come from intensive acoustic surveys and whether it had the potential to determine other habitat preferences. Browning added that for USFWS, proposals for research had to show how the data collected would directly benefit the recovery of the species. There was a need to obtain data to start building a dataset and USFWS was trying to obtain as much as possible.

Bonaccorso suggested that a possible approach could be to capture females during the breeding season, track them to their roosts, and use thermal cameras to observe behaviors. A lot of information on the needs for successful breeding could be obtained through this method. There are many simple studies which could be implemented but just hadn't been attempted yet.

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Penniman summarized some of the key outputs of the day's discussions as being the need for applicants to determine that bats weren't present before felling trees, as well as the need to continue research into habitat characterization in the future. She thanked the presenters for their input and adjourned the meeting at approximately 5:00pm.