Appendix 1

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GOVERNOR OF HAWAII

ALLAN A. SMITH
INTERIM CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
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HISTORIC PRESERVATION
KAHOOLAWE ISLAND RESERVE COMMISSION
LAND
STATE PARKS

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES

Office of Conservation and Coastal Lands
POST OFFICE BOX 621
HONOLULU, HAWAII 96809

REF:OCCL:TM

CDUP: MA-3380

Perry White
Planning Solutions
Ward Plaza, Suite 330
210 Ward Avenue
Honolulu, Hawaii 96814-4012

JUL 20 2007

Dear Mr. White,

SUBJECT: Conservation District Use Permit (CDUP) MA-3380

This letter is to inform you that on July 20, 2007, the Chairperson of the Board of Land and Natural Resources, pursuant to Chapter 13-5, Hawaii Administrative Rules, approved Conservation District Use Application MA-3380 for Meteorological Measurement Towers Located at Located at Olowalu-Ukumehame, Lahaina/Wailuku, Maui, portions of TMK: (2) 4-8-001:001 and (2) 3-6-001:014 subject to the following conditions:

1. The applicant shall comply with all applicable statutes, ordinances, rules, and regulations of the Federal, State and County governments, and the applicable parts of Section 13-5-42, Hawaii Administrative Rules;

2. The applicant, its successors and assigns, shall indemnify and hold the State of Hawaii harmless from and against any loss, liability, claim or demand for property damage, personal injury or death arising out of any act or omission of the applicant, its successors, assigns, officers, employees, contractors and agents for any interference, nuisance, harm or hazard relating to or connected with the implementation of corrective measures to minimize or eliminate the interference, nuisance, harm or hazard;

3. The applicant shall comply with all applicable Department of Health administrative rules;

4. Where any interference, nuisance, or harm may be caused, or hazard established by the use the applicant shall be required to take measures to minimize or eliminate the interference, nuisance, harm, or hazard within a time frame and manner prescribed by the Chairperson;

5. Any work done on the land shall be initiated within one year of the approval of such use, and unless otherwise authorized be completed within three years of the approval. The applicant shall notify the Department in writing when construction activity is initiated and when it is completed;

6. Should an impact with flying wildlife occur, KWP II shall remove the tower(s) until such time as the tower(s) are covered by an Incidental Take License and accompanying (amended) Habitat Conservation Plan;

7. Before proceeding with any work authorized by the Board, the applicant shall submit four (4) copies of the construction and grading plans and specifications to the Chairperson or his authorized representative for approval for consistency with the conditions of the permit and the declarations set forth in the permit application. Three (3) of the copies will be returned to the applicant. Plan approval by the Chairperson does not constitute approval required from other agencies;

8. The applicant shall obtain a land disposition from the Land Division for the proposed use;

9. In issuing this permit, the Department has relied on the information and data that the applicant has provided in connection with this permit application. If, subsequent to the issuance of this permit, such information and data prove to be false, incomplete or inaccurate, this permit may be modified, suspended or revoked, in whole or in part, and/or the Department may, in addition, institute appropriate legal proceedings;

10. Should historic remains such as artifacts, burials or concentration of charcoal be encountered during construction activities, work shall cease immediately in the vicinity of the find, and the find shall be protected from further damage. The contractor shall immediately contact SHPD (692-8015), which will assess the significance of the find and recommend an appropriate mitigation measure, if necessary;

11. The applicant understands and agrees that this permit does not convey any vested rights or exclusive privilege;

12. Best management practices for prevention of introducing exotic species to the site shall be observed;

13. Upon the end of the duration of data collection or the end of the equipment lifecycle or within three years, all equipment shall be removed and the land shall be restored to its original condition;

14. The applicant acknowledges that the approved work shall not hamper, impede or otherwise limit the exercise of traditional, customary or religious practices in the immediate area, to the extent such practices are provided for by the Constitution of the State of Hawaii, and by Hawaii statutory and case law;

15. Other terms and conditions as may be prescribed by the Chairperson; and

16. Failure to comply with any of these conditions shall render this Conservation District Use Permit null and void.

Please acknowledge receipt of this approval, with the above noted conditions, in the space provided below. Please have an authorized signature sign two copies. Retain one and return the other within thirty (30) days. A copy of the Staff report is included for your information. Should you have any questions on any of these conditions, please feel free to contact Tiger Mills at 587-0382.

Aloha,

Samuel J. Lemmo, Administrator
Office of Conservation and Coastal Lands

Receipt acknowledged:

____
Applicant's Signature

Date__________________

c: Chairperson
Maui Board Member
Maui District Land Office
County of Maui, Department of Planning

Appendix 2

Proposed KWP II Post-Construction Monitoring Protocol

Sampling to estimate the mortality occurring at a wind energy facility must consider spatial and temporal factors at different scales. At the scale of the individual turbine, the area searched should encompass the majority of where expected mortalities will fall; in addition, the search interval has to be of a frequency where most carcasses will be discovered before they are scavenged. When spatial and temporal variation within a site are considered, individual turbines within a site should be sampled sufficiently to account for the spatial variation that exists among turbines, as well as across seasons of the year when species of interest are at the greatest risk of turbine collision.

The accuracy of a mortality estimate itself depends on several factors. The probability of finding a carcass depends on the search interval and scavenging rates at the site. Scavenging rates are typically estimated by conducting trials to yield representative carcass retention times and search intervals are then adjusted accordingly. Another factor that determines the probability of finding a carcass is searcher efficiency. Searcher efficiency will account for individuals that may be killed by collision with project components but that are not found by searchers for various reasons, such as heavy vegetation cover.

This monitoring protocol outlines the scavenger and searcher efficiency trials that KWP II will conduct as well as the search methods that will be used to locate carcasses impacted by the operation of the wind facility.

EARLY POST-CONSTRUCTION STUDIES

The field methods proposed below are based primarily on a refinement of the methods that have been used at KWP since operations began in June 2006 (Kaheawa Wind Power 2006). Other recent studies of bird and bat fatalities at wind power projects in the U.S. and Europe were also reviewed to develop and refine previously-approved methods and search techniques (e.g., Kerns and Kerlinger 2004, Pennsylvania Game Commission 2007, Stantec 2008, Stantec 2009, Arnett 2005, Jain et al. 2007, Fiedler et al. 2007).

The initial period of fatality monitoring at KWPII will entail frequent, systematic searches of the area beneath each turbine by trained technicians. Carcass removal and searcher efficiency trials will be conducted within this period. Subsequently, intensive sampling at a pre-determined reduced effort will be conducted for one year at 5-year intervals with attendant SEEF trials and carcass removal trials. A regular rapid assessment technique will be developed for the interim years to determine direct take occurring between years of intensive monitoring.

<u>Factors Considered for Scavenger and Searcher Efficiency (SEEF) Trials</u>

Factors that may affect the results of scavenger and SEEF trials include seasonal differences, vegetation types and carcass sizes.

Seasonal differences are presumed to affect the outcome of scavenger trials. The rate of carcass retention may vary due to seasonal changes in density of predators on site, or seasonal changes in predator behavior. For the monitoring protocol at KWP II, the year is divided into two seasons, the winter/spring season (December – May) and summer/fall (June – November). Scavenger trials already conducted at the adjacent KWP facility have suggested that scavenging rates vary with the two seasons identified above (Kaheawa Wind Power 2008). The outcome of SEEF trials are not expected to vary with season.

Different vegetation types are likely to affect the outcome of both scavenger and SEEF trials. It is anticipated that more complex vegetation structures will result in lower scavenging rates and lower searcher efficiency. Search plots at KWPII will consist either of bare ground or short stature grass and will be maintained throughout the life of the project.

Carcass sizes will also likely affect the outcome of both scavenger and SEEF trials. Three size classes have been established to reflect the size classes of the Covered Species: bat size, medium birds (seabirds) and large birds (nēnē). Based on studies conducted at KWP and elsewhere, it is expected that as size increases, both carcass retention times and searcher efficiency will increase.

Placement of Carcasses for Searcher Efficiency and Carcass Removal Trials

Each carcass used in searcher efficiency or carcass removal trials will be placed randomly within the search plots. These points will be generated within each identified vegetation zone using ArcView 9x with the Generate Random Points tool in Hawth's Analysis Tools 3.27. Parameters that will be specified for each randomly chosen location will include the minimum distance between random points and minimum distance of the point from the vegetation zone boundary. Minimum distances between random points will ensure that carcasses are not placed too close together. This will maintain the independence of the samples and prevent predator swamping. The distance of each point from the boundary of the vegetation zone will ensure that carcasses will be within the specified vegetation zone and not be placed on edges or within transition zones. These points will subsequently be loaded into a GPS as waypoints to allow the accurate placement of the carcasses.

Carcass Removal Trials

The objective of performing carcass removal studies at KWP II will be to determine the average amount of time an avian or bat carcass remains visible to searchers before being removed by scavengers or otherwise rendered undetectable. Carcass removal trials have been ongoing at the KWP facility since November, 2005. To date a total of 27 trials have been conducted using a variety of species and numbers of specimens. Carcass retention times average 6.6 days for small (n=7) carcasses and 10.3 days for medium sized carcasses (n=59), while large birds typically remain visible to observers for the standard two week duration of trials or longer (Kaheawa Wind Power, 2008b, 2009, 2010a,b). Similar but more frequent trials will be conducted at KWP II with the purpose of maintaining an ongoing record of scavenging rates at different times of year, and among different vegetation and ground cover types, that will best reflect site-specific conditions in the event that a take does occur. Eight to twelve carcass removal trials will be conducted during the initial survey year, designed to enable four to six trials within a corresponding season (summer/fall and winter/spring) and will be used to adjust the number of estimated direct takes of covered species observed by correcting for carcass removal bias.

Each carcass removal trial will consist of placing a pre-determined number of carcasses (up to a maximum of nine specimens) of varying size classes on the ground at random locations within representative vegetation classes. The carcass will be placed such that it approximates what would be expected if a bird/bat came to rest on the ground after having collided with an overhead structure. The intent will be to distribute trials along the length of the project area to represent a range of elevations, habitat conditions, vegetation cover types, and seasonal variability. Fresh carcasses will be used whenever available, if frozen carcasses are used, all carcasses will be thawed before being deployed. An example of a possible sampling design is presented in Table 1.

All carcasses will be checked on days daily for up to 30 days or until all evidence of the carcass is absent. On day 30, all remaining materials, feathers or parts will be retrieved and properly discarded. Results of trials provide a basis for determining the search frequency necessary to ensure that birds and bats are not scavenged before they can be detected by searchers (see Barrios and Rodriguez 2004 and Kaheawa Wind Power 2008). In some instances, carcasses may be monitored beyond the 30 day survey duration if the information being gathered substantially informs the conclusions of the monitoring exercise. Data will be analyzed by season, and according to vegetation and carcass size classifications.

Table 1. Possible Sampling Scheme for KWP II Scavenger Trials for One Season

Vegetation types	Season	Size class	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Total sample size
Bare ground	Winter / Spring	Bats	2		2		2		2		8
		Med birds	2		2		2		2		8
		Large birds		2		1		2		1	6
Grass	Winter / Spring	Bats	2		2		2		2		8
		Med birds	2		2		2		2		8
		Large birds		1		2		1		2	6
		Total	**8**	**3**	**8**	**3**	**8**	**3**	**8**	**3**	**44**

Searcher Efficiency Trials (SEEF)

Searcher Efficiency (SEEF) Studies represent an important component of downed wildlife monitoring and provide an estimate of carcass detection probability. As with SEEF trials at KWP, trials will be conducted in association with the regular search effort to estimate the percentage of avian/bat fatalities that are found by searchers. Searcher efficiency will be evaluated according to vegetation classification and differences in carcass detection rates for different sized birds and for bats. Estimates of searcher efficiency will be used to adjust estimates of direct take by accounting for carcass detection bias.

Personnel conducting carcass searches will not be told when or where trials will be conducted. Trials will be administered during the twice weekly monitoring period but dates will be chosen randomly, as far as practicable. Each trial will consist of 3 - 8 bird carcasses and/or bats or bat surrogates. Prior to a search commencing, each carcass will be placed within chosen vegetation zones, as described above, at randomly selected locations that will be searched on the same day. Each trial carcass will be discreetly marked and located by GPS so it can be relocated and identified when found. If carcasses of the covered species are not available, carcasses of surrogate species will be used as previously described. Data will be analyzed according to vegetation and carcass size classifications. More trials will be conducted if analyses indicate that more trials are needed to provide statistical confidence in the resultant values and enable mean searcher detection probabilities to be ascertained for the project site.

Searcher efficiency rates at KWP using Wedge-tailed Shearwaters as surrogates for the two Covered seabird species have ranged from an average of 64 -70% in shrubs (n=90), 78 - 81%% in grass (n=145) to 97 - 100% detectability on bare ground (n=51). Using house sparrows and Zebra doves as surrogates for bats at KWP, the average searcher efficiency rates ranged from 33 - 42% in shrubs (n=15), to 36 – 50% in grass (n=20), and 67 – 97% detection on bare ground (n=30) (Kaheawa Wind Power 2009, 2010a). Using carcasses of bats (if available), small mammals, seabirds and geese as surrogates for each Covered Species in SEEF trials performed during the initial three years of study will provide a better representation of detection variability among differing vegetation and terrain conditions for the different sized Covered Species, resulting in greater confidence in this species-specific adjustment variable.

Procurement of Carcasses for Trials

If using state or federally protected species as surrogates for trials, all state and federal laws pertaining to transport, possession, and permitted use of these species along with appropriate animal use protocols will be followed. A scientific permit will be obtained for all species that may be used in trials. Carcasses used in the trials will be selected to best represent the size, mass, coloration, and if possible should be closely related to or roughly the same proportions as the four Covered Species. For example, Wedge-tailed shearwaters and Lesser Canada Goose (*Branta canadensis parvipes*) both exhibit close taxonomic resemblance to the two covered seabird species and nēnē, respectively, and have been used successfully at KWP in carcass removal trials. All carcasses used for the trials will be fresh or freshly thawed. Dark colored mammals (e.g., small rats, mice) and small passerines (e.g. house finch, house sparrow) may be used as surrogates for bats. Other types of avian carcasses that may prove useful for trials include locally-obtained road kills, downed seabirds, owls, and waterbirds, or species not protected under the MBTA such as pheasant (*Phasianus colchicus*) and rock dove (*Columba livia*). Nēnē mortalities that occur elsewhere but render the carcasses available for these studies would provide an important opportunity to learn how long nēnē remain visible to searchers at KWP II. Use of species protected under ESA or MBTA will require permission from DLNR and USFWS.

Search Intervals

The search interval will initially consist of once weekly searches. Consultation with the Endangered Species Recovery Committee (ESRC) and DLNR has indicated a preference for a search interval that is equal to the time interval where approximately 90% of all carcasses are retained. KWP II will be conduct its own carcass removal trials, and search intervals may be adjusted to more accurately reflect seasonal carcass removal rates by size class. The actual search interval and target carcass retention rates will be decided with the concurrence of the agencies.

Should SEEF trials indicate that mean carcass retention times are less than 7 days, trapping may be conducted to depress scavenger populations and increase carcass retention times. All applicable permits will be obtained.

Search Areas Beneath Meteorological Towers

The search area beneath the temporary met towers will be circular and extend 10 m beyond the supporting guy wires. The search area beneath the permanent unguyed met tower (80 m) will also be circular and be half the height of the tower at 40 m search radius.

Search Areas Beneath Individual Turbines

Several studies of small-bodied animals (songbirds and bats), with adequate sample sizes (n = 69 – 466), have shown that the majority of carcasses are found within a search area of less than 50% of the maximum turbine height (Arnett 2005, Jain et al. 2007, Fiedler et al. 2007; see Fig. 1a, b, 2a, b, c, d, e). Most of the carcass distributions (% fatalities vs. distance from turbine) appear to be well described by 2nd degree polynomials, with most fatalities found at approximately 25% of the distance of turbine height, then decreasing with few fatalities occurring beyond 50% of the maximum turbine height (Fig 2a, b, c).

These data are also supported by the distribution of carcasses that have been found at the operating KWP facility. To date, after more than 3000 turbine plot searches conducted during the four years operation at KWP, only seven carcasses have been found that are clearly attributable to collisions with the turbines. The carcasses consist of one Hawaiian hoary bat, one Hawaiian petrel, four nēnē, one barn owl, one Hawaiian short-eared owl, nine introduced game birds (ring-necked pheasant, Black francolin) two white-tailed tropicbirds, and one Great frigatebird with carcass distances from the turbine ranging from 1 – 67.6 m (75% of maximum turbine height at 90 m). Search plots for KWP are of 90 m radius (100% turbine height) and no intact carcasses were found beyond a distance of 50% turbine height, with the exception of one white-tailed tropicbird and one Hawaiian short-eared owl where the main carcasses were found at 75% and 67% maximum turbine height, respectively. In both cases, portions of the wing were discovered downwind of the carcass. The partially intact white-tailed tropicbird wing was measured a distance of 170 m from the nearest turbine, probably blown across the bare and recently burned slope below the substation facility by steady moderate to strong winds from the NE. The Hawaiian short-eared owl wing section was found at a distance of 87 m (97% maximium turbine height) (Kaheawa Wind Power, 2010a). It should not be ruled out that carcass materials documented in these cases may have been manipulation or moved by scavengers.

Most of these studies have concentrated on the fatality distributions of small birds and bats. However, these fatality distributions are also expected to apply to larger bodied birds, though it is expected that larger-bodied birds, because of their greater weight, they will likely be found closer to the base of the turbines.

Given the considerations detailed above, it is proposed that search areas beneath individual turbines for KWP II will consist of searches to 75% turbine height (75 m radii), a search area which encompasses the distribution of all the carcasses found to date attributable to turbine collisions at KWP.

Spatial and Temporal Sampling Scheme During the First Year of Intensive Sampling

Frequency of Sampling

Sampling at KWP II will consist of once weekly carcass searches to 75% turbine height. The actual search intervals will be adjusted based on the results of the seasonal carcass removal trials as they become available. The search intervals will be determined in consultation with DLNR and USFWS.

Plot Maintenance

All search plots will be maintained as bare ground or short stature grass (less than 24") for the life of the project.

Determining Spatial and Temporal Variation on Site

The weekly search frequency is anticipated to accurately describe variation in mortality rates at different turbines within the site, as well as identify periods when Covered Species that potentially occur year round on site (nēnē and Hawaiian hoary bat) are at greater risk of collision. Each turbine will be sampled 54 times a year, resulting in a total of 756 turbine searches per year for the entire facility.

Intensive Sampling During the Second Year

If sufficient data is collected in the first year, search plots and search frequencies may be adjusted to enable the most efficient sampling regime. The change in sampling regime will be determined by KWP II in consultation with DLNR, USFWS and members of the ESRC .

However, the same sampling regime as Year 1 will be continued if data indicates that more sampling is needed before any change can be made.

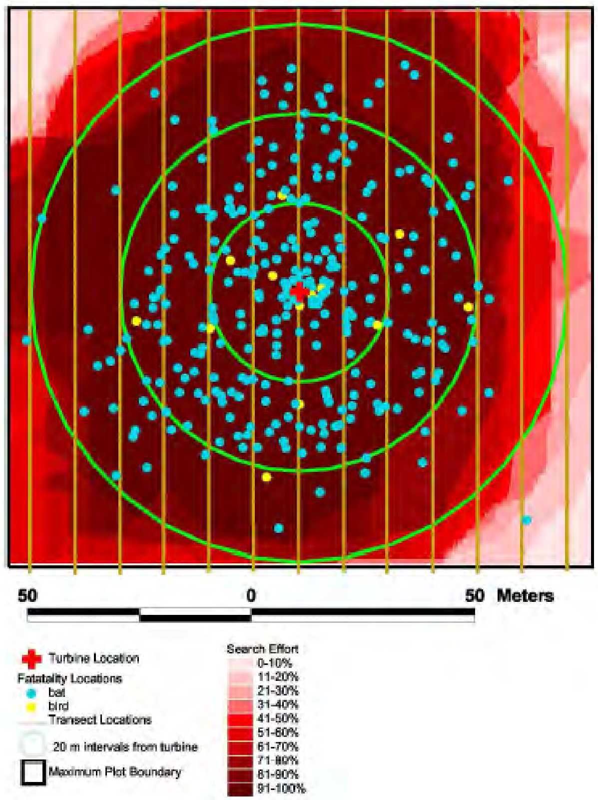


Figure 1a. Bat and bird fatalities (n=466 bats) at all turbines combined at Meyersdale Wind Energy Center in Pennsylvania, 2 August to 13 September 2004 (Arnett 2005). The maximum turbine height was 115 m.

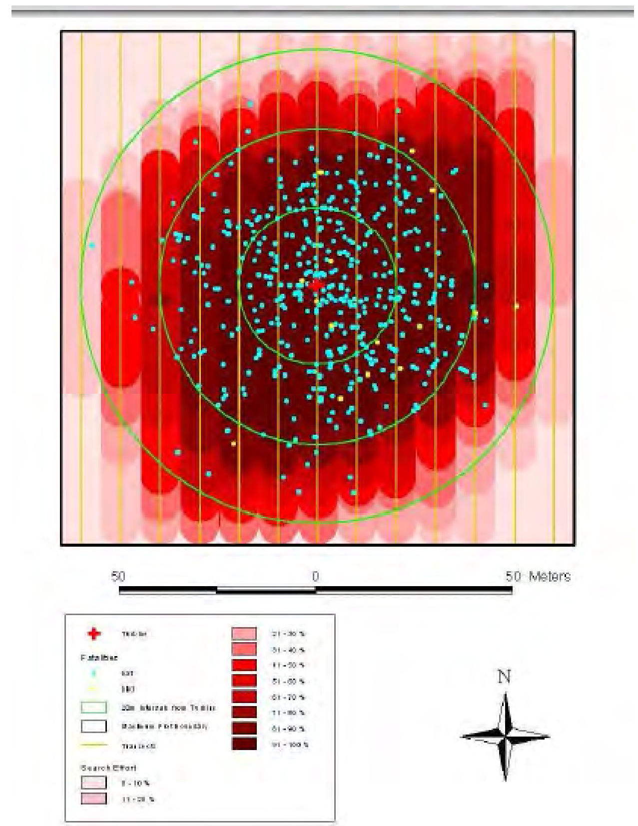
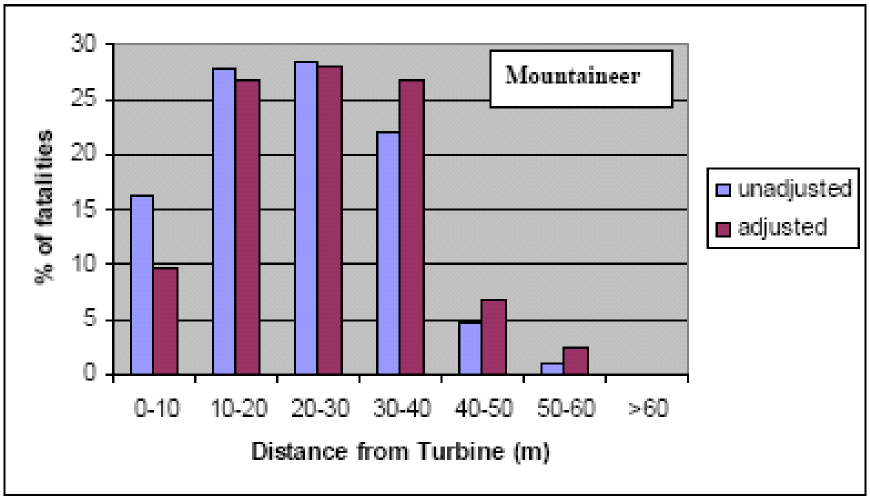


Figure 1b. Bat and bird fatalities (n=499 bats) at all turbines combined at Mountaineer Wind Energy Center in West Virginia, 31 August to 11 September 2004 (Arnett 2005). The maximum turbine height was 104.5 m.



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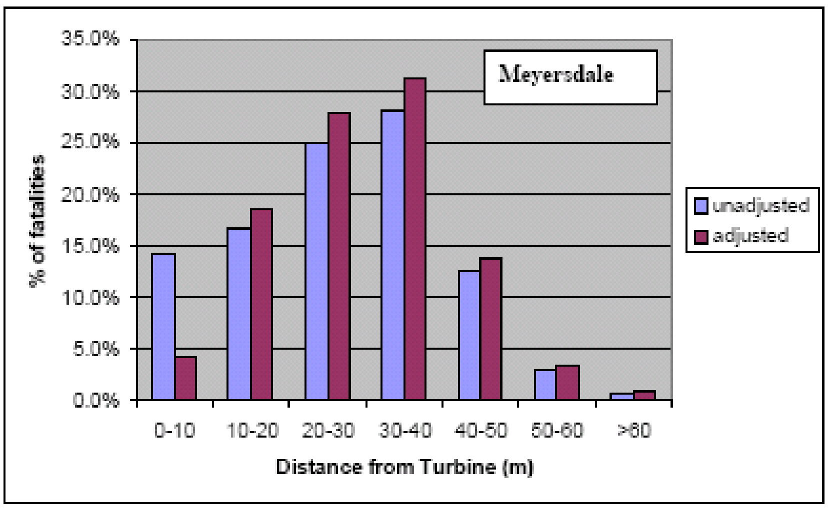
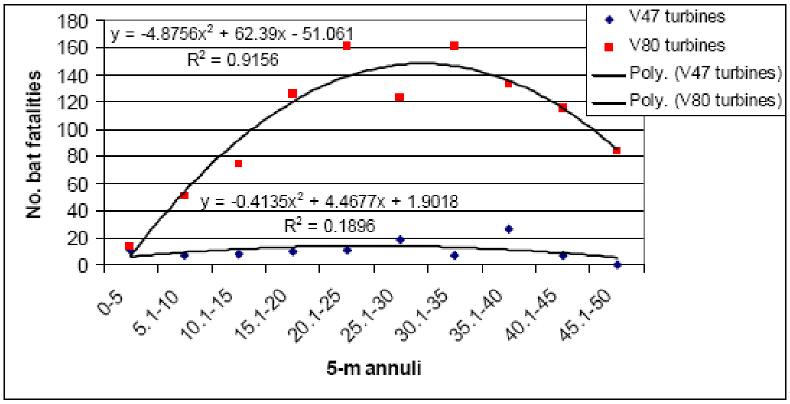


b

Figure 2a, b. Distribution of fatalities (birds and bats) as a function of distance from a turbine for Mountaineer and Meyersdale sites based on unadjusted counts, and counts adjusted for searcher detection and sampling effort (figures from Arnett 2005). The maximum turbine height was 104.5 m.



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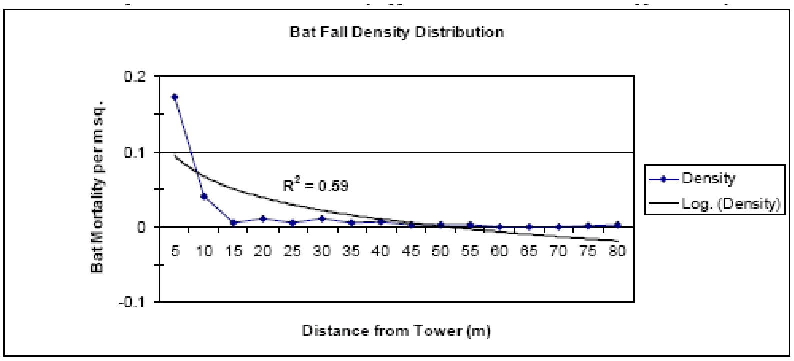

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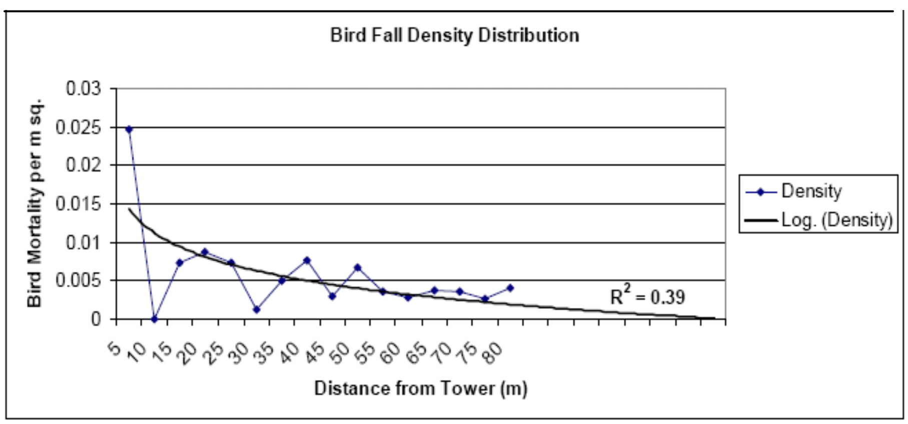

e

Figure 2c. Number of bats found within 5m annuli around V47 turbines (n = 20) and V80 turbine (n=243) from 5 April to 20 December 2005 and associated trend line for Buffalo Mountain, Tennessee (figure from Fielder et al 2007). The trend line for the V80 predicts that bat fatalities would reach zero at 59.6 m from the turbine (maximum turbine height is 120m). Data from the V47 is not considered in this report due to small sample sizes.

Figure 2d,e. Maple Ridge Wind Power, New York bat and bird fatality density distributions from September 1 to November 15, 2006, in relation to distance from towers with associated trend lines. The maximum turbine heights were 122 m (figures from Jain et al 2007). The trend lines predict that bird carcass densities approximate zero at 110m and at 45m for bats. The maximum turbine height was 122 m.

Post Three-Year Intensive Sampling Period

Spatial and temporal trends on site should also be well understood at the end of the three-year intensive sampling period, enabling correction factors to be appropriately applied. Depending on findings, the correction factors may enable a decrease or modification of sampling effort (e.g. increase in search intervals or decrease in the number of turbines searched), identify specific turbines or times of the year when sampling effort should be concentrated, and inform adaptive management considerations. Discussion with ESRC, USFWS and DLNR has indicated a preference for the reallocation of effort whereby mitigation efforts are increased in exchange for a reduction in fatality monitoring. It is expected that the intensive monitoring effort will be scaled back by about 50%. It is also proposed that intensive fatality monitoring after the post three-year intensive sampling period be conducted at the beginning of 5-year bins; years 6, 11 and 16, resulting in a total of 6 years of intensive monitoring during the life of the project (Table 2). SEEF trials and carcass removal trials will be repeated during these years to determine if any of the variables have changed over time (Table 2). All adjustments to direct take will use the most recent estimates from the SEEF and carcass removal trials.

In addition to this reduced monitoring effort, regular rapid assessment (RRA) of each search plot will be conducted in the interim years. This may consist of personnel searching each plot to 75% turbine height on an ATV (all terrain vehicle). The frequency at which the surveys take place will be determined at the conclusion of the carcass removal trials for that 5-year period. SEEF trials will also be conducted to determine the searcher efficiency of the chosen RRA method. All adjustments to direct take found in the interim years will use the estimates from the SEEF and carcass removal trials for that 5-year time period.

The intensive monitoring during the first year of the 5-year period and the subsequent 4-year rapid assessment is designed to inform the Applicant if the take is still occurring at Tier 1 levels or whether take has moved to a Tier 2 or Lower tier based on 5-year and 20-year take limits outlined in the HCP. Five-year total direct take levels will be determined for each 5-year bin while 20-year total direct take levels will be a cumulative total from the start of project operation.

This long-term sampling regime will be refined by KWPII in consultation with ESRC, USFWS, DLNR, statisticians and wind energy experts after the initial 2-year intensive sampling period.

Years

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
IM	IM	IM	RRA	RRA	IM	RRA	RRA	RRA	RRA	IM	RRA	RRA	RRA	RRA	IM	RRA	RRA	RRA	RRA
SEEF trials	SEEF trials		SEEF trials		SEEF trials	SEEF trials				SEEF trials	SEEF trials				SEEF trials	SEEF trials			
CRT	CRT				CRT					CRT					CRT				
1st 5-year bin					2nd 5-year bin					3rd 5-year bin					4th 5-year bin				

IM = intensive monitoring; RRA = regular rapid assessment; CRT= carcass removal trials

Total direct take for 5-year bin = total direct take for IM + total direct take for RRA years

Table 2. Timetable for SEEF and scavenger removal trials and search techniques

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Appendix 3

FINAL REPORT

RADAR AND VISUAL STUDIES OF SEABIRDS AT THE PROPOSED KWP II DOWN-ROAD ALTERNATIVE WIND ENERGY FACILITY, MAUI ISLAND, HAWAII, SUMMER 2009

BRIAN A. COOPER AND ROBERT H. DAY

PREPARED FOR

FIRSTWIND, LLC
NEWTON, MA

PREPARED BY

ABR, INC.–ENVIRONMENTAL RESEARCH AND SERVICES
FOREST GROVE, OREGON ♦ FAIRBANKS, ALASKA

RADAR AND VISUAL STUDIES OF SEABIRDS AT THE PROPOSED KWP II DOWN-ROAD ALTERNATIVE WIND ENERGY FACILITY, MAUI ISLAND, HAWAII, SUMMER 2009

FINAL REPORT

Prepared for

FIRSTWIND, LLC
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and

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EXECUTIVE SUMMARY

- We used radar and audiovisual methods to collect data on movements of endangered Hawaiian Petrels (*Pterodroma sandwichensis*) and threatened Newell's (Townsend's) Shearwaters (*Puffinus auricularis newelli*) at the proposed Kaheawa Wind Power II Down-road Alternative wind energy generation facility, on Maui Island during summer 2009. We conducted evening and morning surveys during 20–24 July 2009.
- The objectives of the study were to: (1) document movement rates of Hawaiian Petrels and Newell's Shearwaters at the proposed KWP II Down-road Alternative facility; (2) estimate the daily number of petrels/ shearwaters that fly within areas that would be occupied by wind turbines at the proposed facility; and (3) estimate annual fatality rates of petrels/shearwaters at proposed turbines and meteorological (met) tower.
- We recorded 37 radar targets that fit our criteria for petrels and shearwaters.
- The mean movement rate across all nights was 1.78 ± 0.14 targets/h. After adjusting our sampling results for hours of the night that we did not sample (i.e., non-peak periods), we estimated a mean movement rate of 10.0 petrel-like/shearwater-like targets/night during summer 2009.
- We recorded one Hawaiian Petrel during visual sampling. This bird was heading east (i.e., toward Haleakala) at 40 m agl at 2126 on 24 July.
- To determine the risk of collision-caused mortality, we used petrel/shearwater movement rates observed on radar in summer 2009, petrel/shearwater flight altitudes from previous studies, and dimensions and characteristics of the proposed turbines and met towers to generate an estimate of exposure risk. We then applied estimates of the fatality probability (i.e., the probability of collision with a portion of the turbine or tower and dying while in the airspace occupied by the structure) and a range of estimated avoidance probabilities (i.e., the probability that a bird will detect and avoid entering the airspace containing the turbine or tower) to this estimate of exposure to calculate annual fatality rates that could be expected at the proposed turbines and met tower.
- We estimate that ~1,607 Hawaiian Petrels and 882 Newell's Shearwaters pass over the 1.5-km-radius radar sampling area in an average year (including birds at all altitudes).
- We estimated annual fatality rates at wind turbines and met towers by assuming that 90%, 95%, or 99% of all petrels/shearwaters flying near a turbine/tower will see and avoid the structure. Based on these scenarios, annual fatality rates for wind turbines ranged from 0.016–0.217 Hawaiian Petrel/turbine/yr and 0.009–0.119 Newell's Shearwaters/turbine/yr. For the 65-m met tower, we estimated a fatality of 0.008–0.081 Hawaiian Petrel/tower/yr and 0.004–0.044 Newell's Shearwaters/tower/year. Although the range of assumed avoidance rates of wind turbines and met towers (90–99%) is not fully supported by empirical data at this time we speculate that avoidance rates of petrels and shearwaters at wind farm structures (e.g., wind turbines and met towers) potentially are ≥95%, based upon fatality rates at existing windfarms and avoidance behavior of petrels observed at other structures (e.g., powerlines and communication towers); thus, we believe that fatality rates will be within the lower half of the range of estimates.

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We thank FirstWind for funding this study and for providing the ornithological radar used for sampling. We thank Greg Spencer and Dave Cowan (FirstWind) for help with logistics and thank Greg Spencer and Ian Bordenave (FirstWind) for their assistance with the visual sampling. At ABR, Rich Blaha and Dorte Dissing produced study figures and Alice Stickney and Pam Odom assisted with report production.

INTRODUCTION

First Wind, LLC, formerly UPC Wind Management, LLC, operates the 30-MW Kaheawa Pastures Wind Energy Generation Facility, referred to as Kaheawa Wind Power I (KWP I), on the island of Maui (Figure 1). A new wind project adjacent to the existing facility is being considered for development by FirstWind and will be operated as Kaheawa Wind Power II (i.e., the KWP II Down-road Alternative). Two federally-listed seabird species occur on Maui: the endangered Hawaiian Petrel (*Pterodroma sandwichensis*; Hawaiian name 'Ua'u) and the threatened Newell's (Townsend's) Shearwater (*Puffinus auricularis newelli*; Hawaiian name 'A'o). Ornithological radar and night-vision techniques have been shown to be successful in assessing numbers and movement rates of these petrels and shearwaters on the Hawaiian Islands (e.g., Kaua'i [Cooper and Day 1995, 1998; Day and Cooper 1995, Day et al. 2003b], Maui [Cooper and Day 2003], Moloka'i [Day and Cooper 2002], and Hawai'i [Day et al. 2003a]). Previous radar and visual studies documented the presence of petrel/shearwater targets, including visual observations of Hawaiian Petrels, in the vicinity of the existing KWP I project site (Day and Cooper 1999, Cooper and Day 2004a). These data were used to model the potential number of annual fatalities at the KWP I development (Cooper and Day 2004b). In addition, radar studies were conducted in 2008 (Sanzenbacher and Cooper 2008, 2009) to model the potential number of fatalities in a nearby portion of an alternate KWP II site that was located just upslope of the KWP II Down-road Alternative.

The currently operational KWP I wind-energy facility consists of an articulated row of 20 1.5-MW turbines (GE 1.5se) with a hub height of ~55 m and a rotor diameter of 70.5 m, plus one 30-m-high, guyed NRG monopole meteorological (met) tower and two 55-m-high, guyed lattice met towers (Figure 2). The proposed KWP II Down-road Alternative project would consist of ~14 additional 1.5-MW turbines (GE 1.5se), each with a hub height of ~65 m and a rotor diameter of 70.5 m, plus one 65-m-high, free-standing met tower.

ABR conducted additional radar and visual studies on Maui in July 2009 with a specific focus on an area proposed for the KWP II Down-road Alternative. The objectives of the study were to: (1) document movement rates of Hawaiian Petrels and Newell's Shearwaters at the proposed KWP II Down-road Alternative facility; (2) estimate the daily number of petrels/shearwaters that fly within areas that would be occupied by wind turbines or met towers at the proposed facility; and (3) estimate annual fatality rates of petrels/shearwaters at proposed turbines and meteorological (met) tower.

Background

Two seabird species that are protected under the Endangered Species Act (ESA) are likely and/or known to occur in the KWP II Down-road Alternative project area: the endangered Hawaiian Petrel and the threatened Newell's (Townsend's) Shearwater. The Hawaiian Petrel and the Newell's Shearwater are forms of tropical Pacific species that nest only on the Hawaiian Islands (American Ornithologists' Union 1998). Both species are Hawaiian endemics whose populations have declined significantly in historical times: they formerly nested widely over all of the Main Islands but now are restricted in most cases to scattered colonies in more inaccessible locations (Ainley et al. 1997b, Simons and Hodges 1998). The one exception is Kaua'i Island, where colonies still are widespread and populations are substantial in size. Of note, Kaua'i (along with Lana'i) also has no introduced Indian Mongooses (*Herpestes auropunctatus*) which prey on these seabirds.

The Hawaiian Petrel nests primarily on Maui (Richardson and Woodside 1954, Banko 1980a; Simons 1984, 1985; Simons and Hodges 1998, Cooper and Day 2003), Kaua'i (Telfer et al. 1987, Gon 1988, Day and Cooper 1995; Ainley et al. 1995, 1997a, 1997b; Day et al. 2003a), Hawai'i (Banko 1980a, Conant 1980, Hu et al. 2001, Day et al. 2003a), Lana'i (Shallenberger 1974; Hirai 1978a, 1978b; Conant 1980; G. Spencer and J. Penniman, pers. comm.), and Moloka'i (Simons and Hodges 1998, Day and Cooper 2002). On Maui, these petrels are known to nest on Haleakala Crater (Brandt et al. 1995, Simons and Hodges 1998) and are believed to nest in West Maui (Cooper and Day 2003), with recent observations of birds calling and exhibiting aerial displays consistent with breeding behavior, despite the

Figure 1. Maui Island, Hawaii, with approximate location of the Kaheawa Pastures Wind Energy Facilities (KWP I and KWP II).

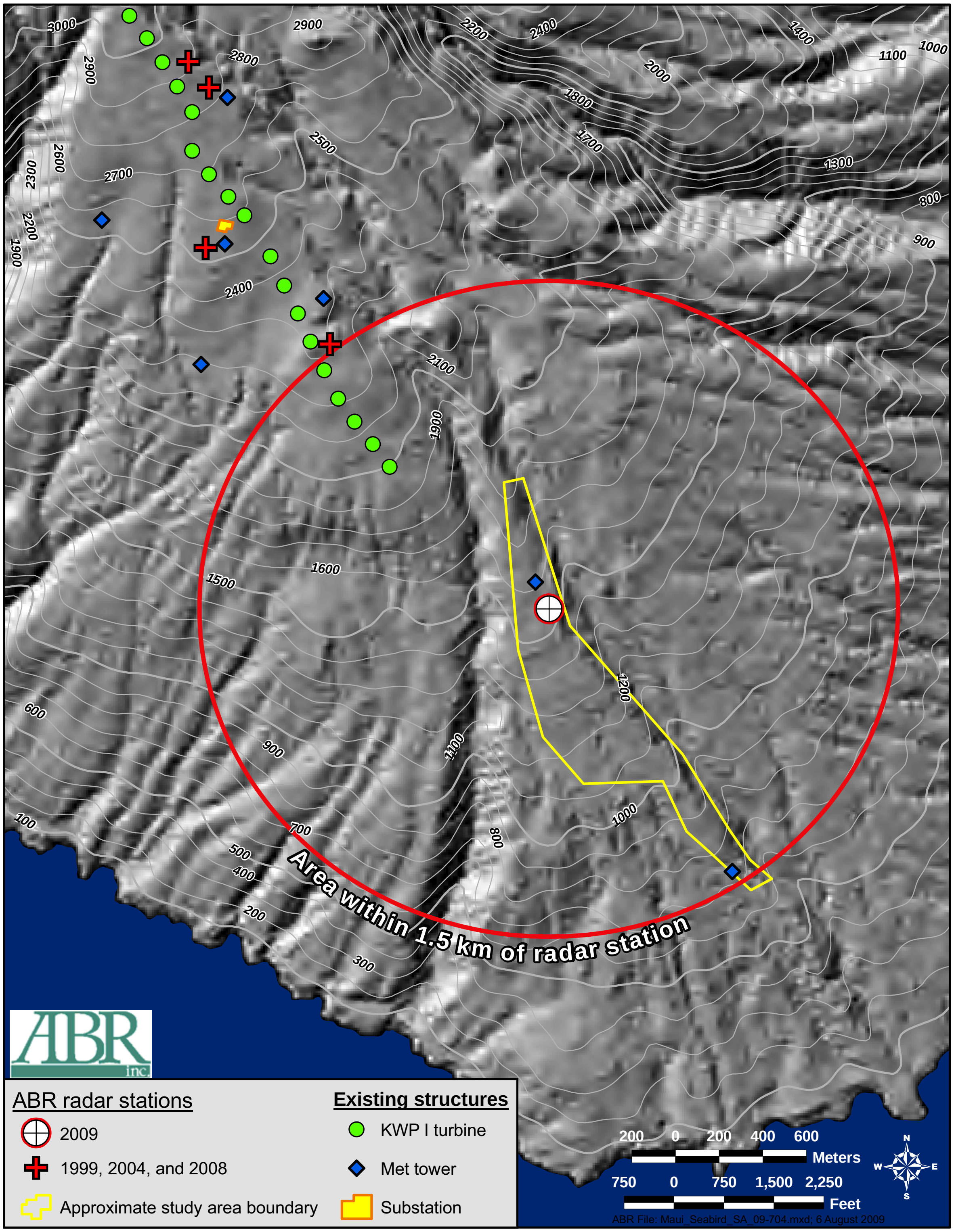

Figure 2. Location of 2009 radar sampling stations relative to sampling stations from previous studies (Day and Cooper 1999, Cooper and Day 2004a; Sanzenbacher and Cooper 2008, 2009) and areas under consideration for siting of wind turbines at the proposed KWP II Down-road Alternative wind energy facility, Maui, Hawaii.

minimal historical evidence and introduction of Indian Mongoose on Maui. For example, on 16 June 1999, a Hawaiian Petrel was heard calling from a bed of uluhe ferns (*Dicranopteris linearis*) at 3,300 ft (~1,000 m) elevation in the Kapunakea Preserve, which lies on the northwestern slope of the West Maui Natural Area Reserve (A. Lyons, *fide* C. Bailey). In addition, recent observations of consistent calling from a single location suggests that there is another small colony of Hawaiian Petrels in the West Maui Mountains ~14 km north of the KWP project areas (G. Spencer, FirstWind, pers. comm.). On the other hand, daily movement rates of Hawaiian Petrels near KWP I and II (i.e., on the southern slope of West Maui Mountain; Day and Cooper 1999, Cooper and Day 2004a, Sanzenbacher and Cooper 2008 and 2009) are much lower than those over the eastern and northern sides of Maui (Cooper and Day 2003), suggesting that few birds use that area.

Newell’s Shearwaters nest on several of the main Hawaiian Islands, with the largest numbers clearly occurring on Kaua’i (Telfer et al. 1987, Day and Cooper 1995; Ainley et al. 1995, 1997b; Day et al. 2003b). These birds also nest on Hawai’i (Reynolds and Richotte 1997, Reynolds et al. 1997, Day et al. 2003a), almost certainly nest on Moloka’i (Pratt 1988, Day and Cooper 2002), and may still nest on Oahu (Sincock and Swedberg 1969, Banko 1980b, Conant 1980, Pyle 1983; but see Ainley et al. 1997b). On Maui, recent auditory observations suggest that a small colony of Newell’s Shearwaters is present in the west Maui Mountains ~14 km north of the KWP project areas (G. Spencer, FirstWind, pers. comm.), matching a prediction of their occurrence there by Cooper and Day (2003). Newell’s Shearwaters typically nest on steep slopes that are vegetated by uluhe fern (*Dicranopteris linearis*) undergrowth and scattered o'hia trees (*Metrosideros polymorpha*).

There is interest in studying these two species because of concerns regarding collisions with structures such as met towers and turbines. To date, there is documented mortality of only one Hawaiian Petrel at a wind turbine and zero Newell’s Shearwaters at wind-energy facilities (wind turbines or met towers) within the Hawaiian Islands (G. Spencer, FirstWind, pers. comm.). Note, however, that fatality studies have been conducted only for 3.5 yr at one wind-energy location in the Hawaiian Islands (KWP I, Maui) and 3 mo at six met towers at the same site prior to operation. Hence, there have not been enough studies of adequate duration or geographic scope to answer the question definitively of whether these species are prone to collisions at these types of structures. There has, however, been well-documented petrel and shearwater mortality because of collisions with other human-made objects (e.g., transmission lines, communication towers) on Kaua’i (Telfer et al. 1987, Cooper and Day 1998, Podolsky et al. 1998) and Maui (Hodges 1992), and there have been collision-caused fatalities of other seabirds at other Hawaiian Islands (Fisher 1966).

STUDY AREA

The operational KWP I windfarm and proposed KWP II Down-road Alternative expansion are located on the southern slope of West Maui Mountain, in an area called Kaheawa Pastures (Figure 1). These sites lie on a moderately sloping portion of West Maui Mountain, ~1–6 km inland from McGregor Point. Vegetation at the site consists of non-native grasslands at lower elevations and a mixture of grasslands and scattered shrubs at moderate to higher elevations. Although the KWP II Down-road Alternative area consists of a dry Mediterranean habitat, vegetation becomes much wetter upland, toward the summit of West Maui Mountain. Presumably, vegetation communities also are dominated by native species in these higher, wetter areas. These upland habitats may provide suitable nesting habitat for Newell's Shearwaters, based on our experience on Kaua’i and other sites. In addition to the vegetation, the steepness of the land at higher elevations on West Maui Mountain also suggests that suitable nesting habitat exists for Hawaiian Petrels, as it does on Haleakala (Brandt et al. 1995), Kaua’i (Telfer, pers. comm.), and Lana’i (Hirai 1978b).

In previous studies at the KWP I and KWP II sites (Day and Cooper 1999, Cooper and Day 2004a; Sanzenbacher and Cooper 2008, 2009), sampling was conducted at four other stations; however, for the current study, we established a new sampling station with a focus on providing maximal radar coverage of potential siting areas for the proposed KWP II Down-road Alternative development (Figure 2). The study area is situated in lower elevations slightly to the east and south of the existing KWP I turbine string, and our 2009 sampling station was located adjacent to the existing KWP I access road, just south of the Lahaina Pali trail (20° 47'52.6" N, 156° 32'16.5" W; elevation ~490 m).

METHODS

We used marine radar and visual equipment to collect data on the movements, flight behaviors, and flight altitudes of petrels and shearwaters at a single sampling station during summer (20–24 July) 2009 (Table 1). The daily sampling effort consisted of 3 h each evening (1900–2200 h) and 2 h each morning (0400–0600 h). These sampling periods were selected to correspond to the evening and morning peaks of movement of petrels and shearwaters, as described near breeding colonies on Kaua'i (Day and Cooper 1995). During sampling, we collected radar and audiovisual data concurrently so the radar operator could help the audiovisual observer locate birds for species identification and data collection. In return, the audiovisual observer provided information to the radar operator on the identity and flight altitude of individual targets (whenever possible). For the purpose of recording data, a calendar day began at 0700 and ended at 0659 the following morning; that way, an evening and the following morning were classified as occurring on the same day.

The ornithological radar used in this study was a Furuno (Model FCR-1510) X-band radar transmitting at 9.410 GHz through a slotted wave guide with a peak power output of 12 kW; a similar radar unit is described in Cooper et al. (1991) and Mabee et al. (2006). The antenna face was tilted upward by ~10°, and we operated the radar at a range setting of 1.5 km and a pulse-length of 0.07 μsec.

Issues associated with radar sampling include ground clutter and shadow zones. Whenever energy is reflected from the ground, surrounding vegetation, and other objects around the radar unit, a ground-clutter echo that can obscure targets of interest (i.e., birds) appears on the radar's display screen. Shadow zones are areas of the screen where birds can fly at an altitude that potentially would

Table 1. Sampling dates and number of inbound and outbound seabird radar targets and number of audio-visual observations of species of interest at the proposed KWP II Down-road Alternative wind-energy site, Maui, Hawaii, July 2009.

			Number of radar targets			Number of audio-visual
Date	Site	Period	Inbound[1]	Outbound[1]	Total	detections[2]
20 July	Lower	Eve	0	7	7	0
		Morn	0	1	1	0
21 July	Lower	Eve	0	5	5	0
		Morn	1	2	3	0
22 July	Lower	Eve	4	0	4	3 SEOW
		Morn	1	0	1	1 TROP
23 July	Lower	Eve	6	1	7	3 SEOW
		Morn	1	0	1	2 SEOW, 1 BAOW, 1 UNOW
24 July	Lower	Eve	6	0	6	1 HAPE, 1 BAOW, 1 UNOW
		Morn	1	1	2	1 SEOW

[1] Flight direction categories for landward and seaward categories included all birds flying toward and away, respectively, from either the colonies located on the opposite end of west Maui to the north of the study site or colonies on Haleakala.
[2] HAPE = Hawaiian Petrel; HOBA = Hoary Bat; NESH = Newell's Shearwater; SEOW = Short-eared Owl; BAOW = Barn Owl: TROP = unidentified Tropicbird; UNOW = Unidentified owl.

put them behind a hill or row of vegetation where they could not be detected because the radar operates only on line-of-sight. We attempted to minimize ground clutter and shadow zones during the selection of radar sampling stations; various structures and landscape features visible on radar indicated that our sampling stations provided good coverage of the study area.

We sampled for six 25-min sessions during each evening and for four 25-min sessions each morning (Table 1). Each 25-min sampling session was separated by a 5-min break for collecting weather data. To help eliminate non-target species, we collected data only for those targets that met a suite of selection criteria, following methods developed by Day and Cooper (1995), that included appropriate flight characteristics and flight speeds (≥30 mi/h [≥50 km/h]). We also removed radar targets identified by flight characteristics or visual observers as being of other bird species.

We conducted audiovisual sampling for birds and bats concurrently with the radar sampling to help identify targets observed on radar and to obtain flight-altitude information. During this sampling, we used 10X binoculars during crepuscular periods and Generation 3 night-vision goggles (Model ATN-PVS7; American Technologies Network Corporation, San Francisco, CA) during nocturnal periods. The magnification of the night-vision goggles was 1X, and their performance was enhanced with the use of a 3-million-Cp floodlight that was fitted with an IR filter to avoid blinding and/or attracting birds. Audiovisual observations were conducted within 25 m of the radar to facilitate coordination between observers, and we also listened for petrel and shearwater vocalizations.

Before each 25-min sampling session, we also collected environmental and weather data, including:

- wind speed (to the nearest 1.6 km/h [1 mi/h]);
- wind direction (to the nearest 1°);
- percent cloud cover (to the nearest 5%);
- cloud ceiling height, in meters above ground level (agl; in several height categories);
- visibility (maximal distance we could see, in categories);
- light condition (daylight, crepuscular, or nocturnal, and with or without precipitation)
- precipitation type; and
- moon phase/position (lunar phase and whether the moon was above or below the horizon in the night sky).

For each appropriate radar target, we recorded the following data:

- species (if identified by visual observer);
- number of birds (if identified by visual observer);
- time;
- direction of flight (to the nearest 1°);
- cardinal transect crossed (000°, 090°, 180°, or 270°);
- tangential range (the minimal perpendicular distance to the target when it passed closest to the radar; used in reconstructing actual flight paths, if necessary);
- flight behavior (straight, erratic, circling);
- velocity (to the nearest 5 mi/h [8 km/h]); and
- flight altitude (meters agl, if identified by visual observer).

For each bird (or bat) recorded during audiovisual sampling, we recorded:

- time;
- species (to the lowest practical taxonomic unit [e.g., Hawaiian Petrel, unidentified petrel/shearwater]);
- number of individuals composing each target;
- ordinal flight direction (000°, 045°, 090°, 135°, 180°, 225°, 270°, 315°); and
- flight altitude (meters agl).

For any birds heard but not observed, we recorded species, number of calls, direction of calls, and approximate distance.

DATA ANALYSIS

We entered all radar and visual data into Microsoft Excel databases. Data files were checked visually for errors after each night's sampling, then were checked electronically for irregularities at the end of the field season, prior to data analyses. In addition, radar data were filtered to remove non-target species, and only known petrel/shearwater targets or unknown targets with appropriate characteristics (i.e., target size, flight characteristics, and airspeeds ≥30 mi/h) were included in data analyses. Airspeeds were calculated by correcting observed target flight speeds (groundspeeds) for speed and relative direction of wind, as measured each half-hour at the radar station (Mabee et al. 2006).

We tabulated counts of numbers of radar targets of petrels and shearwaters recorded during each sampling session, then converted those counts to estimates of movement rates of birds (radar targets/h), based on the number of minutes sampled. No sampling time was lost to rain or other factors; we standardized estimates by actual minutes of sampling effort each half hour. We used all of the estimated movement rates across sampling sessions at a station to calculate the mean ± 1 standard error (SE) nightly movement rate of petrels and shearwaters by station and pooled data across nights to derive an overall hourly movement rate for the study.

We also classified general flight directions of each radar target as landward or seaward and summarized those directional categories by station, date, and time period. To categorize the general flight direction of each target, we defined a landward flight as a radar target flying toward the West Maui Mountains or Haleakala (on East Maui) and classified targets flying in the opposite directions as seaward targets.

MODELING FATALITY RATES

The risk-assessment technique that we have developed involves the use of radar data for estimating the fatality rates for petrels and shearwaters near structures in the Hawaiian Islands. This modeling technique uses the radar data on seasonal movement rates to estimate numbers of birds flying over the area of interest (sampling station) across a 255-d year (for Hawaiian Petrels) or a 210-d year (for Newell's Shearwater) when breeding birds are present on the island. The model then uses information on the physical characteristics of the structures (e.g., wind turbines or met towers) themselves to estimate horizontal and vertical interaction probabilities and combines these interaction probabilities with the movement rates to generate exposure rates (Figure 3). These rates represent the estimated numbers of petrels/shearwaters that pass within the airspace occupied by a proposed wind turbine or within the airspace occupied by a met tower and its associated guy wires each year. We then combine these exposure rates with (1) the probability that an interaction results in fatality, and (2) the probability that birds detect structures and avoid interactions, to estimate fatality rates.

We calculate an exposure rate by multiplying the seabird movement rate observed on radar by horizontal- and vertical-interaction probabilities. The movement rate is an estimate of the average number of birds passing in the vicinity of the proposed turbines/towers in a day, as indicated by numbers of targets on the radar screen and the mean flock size/target. It is generated from the radar data by: (1) multiplying the average movement rates by 5.0 h to estimate the number of targets moving over the radar site in the first 3 h and last 2 h of the night (i.e., during the peak movement periods of petrel/shearwaters); (2) adjusting the sum of those evening and morning counts to account for the estimated percentage of movement that occurs during the middle of the night (when we did not sample); and (3) multiplying that total number of targets/night by the mean number of seabirds/target to generate an estimate of the number of petrel/shearwaters passing in the vicinity of the proposed met towers/turbines during an average day.

We used the radar-based movement data from our current study at the proposed KWP II Down-road Alternative development to estimate seabird movement-rates in summer and assumed that those rates represented average rates observed in an average year. We used data from all-night sampling sessions on Kaua'i (Day and Cooper 1995) to estimate movement rates occurring during the hours between our evening and morning sampling periods. These data suggested that an additional 12.6% of the total combined evening

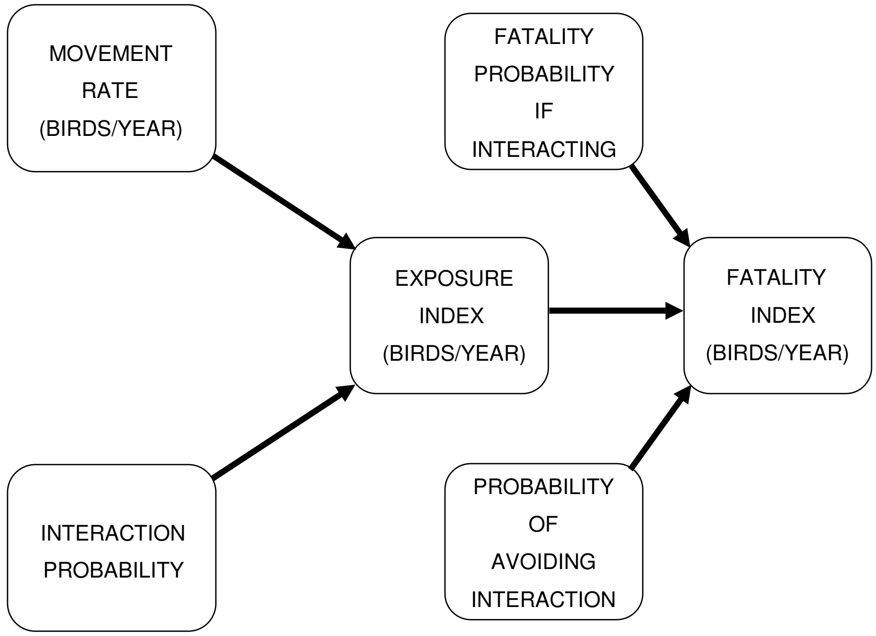

Figure 3. Major variables used in estimating possible fatalities of Hawaiian Petrels and Newell's Shearwaters at wind turbines at the proposed KWP II Down-wind Alternative wind energy facility, Maui, Hawaii. See Tables 2 and 3 for details on calculations.

landward movements and seaward morning movements occurred between the evening and morning peak-movement periods (Day and Cooper, unpubl. data). We also corrected the number of targets for flock size: mean flock sizes of petrels and shearwaters combined in Hawai'i are 1.05 ± SE 0.01 birds/flock (*n* = 2,062 flocks; Day and Cooper, unpubl. data). In addition, we used the timing of inland flights at the nearby Ukumehame site from Cooper and Day (2003) to correct for proportions of targets that were Hawaiian Petrels and those that were Newell's Shearwaters; those data suggested that 60% of the targets were Hawaiian Petrels and 40% of the targets were Newell's Shearwaters.

The number of petrels visiting breeding colonies tends to decline from summer to fall because attendance at colonies by nonbreeders and failed breeders declines as chick-rearing progresses (Serventy et al. 1971, Warham 1990, Ainley et al. 1997b, Simons and Hodges 1998). Although we do not yet have fall data for the site, we split the 255-d breeding season for Hawaiian Petrels (Simons and Hodges 1998) and 210-d breeding season for Newell's Shearwaters (Ainley et al. 1997b) into a spring/summer period of 180 days and 150 days for petrels and shearwaters, respectively, and a fall period of 75 days and 60 days for petrels and shearwaters, respectively. We corrected the seasonal estimates of nightly movement rates by the numbers of days for the spring/summer and fall seasons to generate estimates of movements for each season and species. We assume that the sum of these two estimates represents estimated movement rates for an entire breeding season (i.e., an average year).

Because the resulting estimate of the number of birds/yr is not an integer, we then round it upward to the next whole number to generate an estimate of the average number of birds passing within 1.5 km of the radar site during a year. This rounding technique results in slightly-inflated fatality estimates, but we choose to take a conservative approach in these studies associated with endangered species.

INTERACTION PROBABILITIES

Horizontal

Interaction probabilities consist of horizontal and vertical components. The horizontal-interaction probability is the probability that a bird seen on radar will pass through or over the airspace occupied by a met tower or turbine located somewhere on the radar screen. This probability is calculated from information on the two-dimensional area (side view) of the tower/turbine and the two-dimensional area sampled by the radar screen to determine the interaction probability. The 65-m, free-standing met-tower system consists of a central lattice tower without any supporting guy wires. The tower is 65 m high with a width at the base of ~6 m and a width at the top of ~0.5 m. The proposed wind turbines have ~65-m monopole towers and 35.25-m-long blades. Two calculations of area were made for turbines because of the large differences in area of the structure that depended on the orientation of the blades relative to the flight path of an approaching bird: a minimal area occupied by each proposed turbine if a bird approaches it from the side (i.e., side profile) and a maximal area occupied by each turbine if a bird approaches it from the front (i.e., front profile, including the rotor-swept area). The ensuing ratio of cross-sectional area of the proposed tower/turbine to the cross-sectional area sampled by the radar (1.5 km) indicates the probability of interacting with (i.e., flying over or through the airspace occupied by) the proposed tower or turbine.

Vertical

The vertical-interaction probability is the probability that a bird seen on radar will be flying at an altitude low enough that it might pass through the airspace occupied by a proposed met tower/turbine located somewhere on the radar screen. This probability is calculated from data on flight altitudes and from information on the proposed turbine heights. We used data from throughout the Hawaiian Islands (n = 2,010 birds; Cooper and Day, unpubl. data) to calculate the percentage of petrels/shearwaters with flight altitudes at or below the maximal height of the turbines (i.e., 51.0% ≤100 m agl) and met towers (i.e., 33.0% ≤65 m agl). We would have preferred to use flight-altitude data from the project area for the flight-altitude computations, but adequate sample sizes do not currently exist to do so.

FATALITY RATES

The annual estimated fatality rate is calculated as the product of: (1) the exposure rate (i.e., the number of birds that might fly within the airspace occupied by a tower/turbine); (2) the fatality probability (i.e., the probability of collision with a portion of the tower/turbine and dying while in the airspace occupied by the structure); and (3) the avoidance probability (i.e., the probability that a bird will detect and avoid entering the airspace containing the tower/turbine). The annual fatality rate is generated as an estimate of the number of birds killed/yr as a result of collisions with the tower/turbine, based on a 255-d breeding season for Hawaiian Petrels and a 210-d breeding season for Newell’s Shearwaters.

Fatality Probability

The estimate of the fatality-probability portion of the fatality rate formula is derived as the product of: (1) the probability of dying if a bird collides with a tower/turbine; and (2) the probability of colliding with a turbine if the bird enters the airspace occupied by the structure (i.e., are there gaps big enough for birds to fly through the structure without hitting any part of it). Because any collision with a wind turbine or tower falls under the ESA definition of “take” we used an estimate of 100% for the first fatality-probability parameter. Note that the actual probability of fatality resulting from a collision is less than 100% because of the potential for a bird to hit a turbine component and not die (e.g., a bird could brush a wingtip but avoid injury/death). The second probability (i.e., striking the structure) needs to be calculated differently for met towers and turbines. In the met-tower design, the tower frame is a lattice structure, so we conservatively estimated the probability of hitting the tower if the bird enters the airspace at 100%. Similarly, a bird approaching a wind turbine from the side has essentially a 100% probability of getting hit by a blade; in contrast, a bird approaching from the back or front of a turbine may pass through the rotor-swept area without colliding with a blade, if it is flying fast enough. We calculated the probability of collision for the “frontal” bird approach based upon the length of a petrel (43 cm; Simons and Hodges 1998); the average groundspeed of petrels on Maui (mean velocity = 42.5 mi/h; *n* = 347 probable petrel targets; Cooper and Day, unpubl. data) and the time that it would take a 43-cm-long petrel to travel completely through a 2-m-wide turbine blade spinning at its maximal rotor speed (22 revolutions/min); also see Tucker (1996). These calculations indicated that 19.5% of the disk of the rotor-swept area would be occupied by a blade sometime during the length of time (i.e., 0.13 sec) that it would take a petrel to fly completely past a rotor blade (i.e., to fly 2.43 m).

Avoidance Probability

The final parameter is the avoidance probability, which is the probability that a bird will see the turbine and change flight direction, flight altitude, or both, so that it completely avoids flying through the space occupied by a met tower/turbine. Because avoidance probabilities are largely unknown, we present fatality estimates for a range of probabilities of collision avoidance by these birds by assuming that 90%, 95%, or 99% of all petrels or shearwaters flying near a tower/turbine structure will detect and avoid it. See discussion for explanation of avoidance rates used.

RESULTS

VISUAL OBSERVATIONS

One Hawaiian Petrel was detected by visual observers (Table 1). This bird was heading eastward toward Haleakala at 40 m agl at 2126 on 24 July. That bird also was observed on radar. In addition, we had numerous observations of Short-eared Owls (*Asio flammeus sandwichensis;* Pueo), plus a few Barn Owls (*Tyto alba*), and one unidentified tropicbird (at 0542 on 22 July). No Hawaiian Hoary Bats (*Lasiurus cinereus semotus*; 'Ope'ape'a) were recorded.

MOVEMENT RATES

We recorded 37 radar targets during 25.0 h of sampling in summer 2009 that fit our criteria for petrels and shearwaters (Table 1). Passage rates tended to be higher in the evening than in the morning: only 8 (21.6%) of the 37 targets were recorded during the morning sampling period. Mean nightly movement rates during summer 2009 were 1.78 ± 0.14 targets/h. After adjusting our sampling results for hours of the night that we did not sample (i.e., non-peak periods), we estimated a mean movement rate of 10.0 petrel-like targets/night during summer 2009 (Table 2).

We observed two different patterns of movement that depended on wind strength. During 20 and 21 July, there were strong Trade Winds (i.e., with average wind speeds mostly 20–35 mi/h), and we observed a pattern of 5–7 outbound targets in the evening followed by lower numbers of outbound targets in the morning (Table 1; Figure 4). During the final three nights of sampling, the winds were light (i.e., with average wind speeds mostly 0–5 mi/h [i.e., below turbine cut-in speed, since the KWP I turbine blades were not spinning]) and we observed a pattern of 4–6 inbound targets in the evening and lower numbers of targets in the morning (Table 1; Figure 5). Further, there appeared to be a shift in the spatial distribution of birds during low wind conditions that was not seen during strong winds: during the low winds, the majority of the inbound targets flew over the lower half of the proposed turbine string, and all were heading in the general direction of breeding colonies on Haleakala—not West Maui Mountain.

EXPOSURE RATES

The exposure rate is calculated as the product of three variables: annual movement rate, horizontal-interaction probability, and vertical-interaction probability. As such, it is an estimate of the number of birds flying in the vicinity of the wind turbine/met tower (i.e., crossing the radar screen) that could fly in a horizontal location and at a low-enough altitude that they could interact with a tower/turbine. Based on our summer 2009 movement rate data, we estimate that ~1,607 Hawaiian Petrels and 882 Newell’s Shearwaters pass over the 1.5-km-radius radar sampling area in an average year (including birds at all altitudes; Tables 2 and 3). To generate annual exposure rates of birds exposed to each turbine or met tower (e.g., birds/tower/yr), we then multiplied the annual movement rate by the horizontal-interaction probability and the vertical-interaction probability. By applying those proportions to our data (and

Table 2. Estimated average exposure rates and fatality rates of Hawaiian Petrels (HAPE) and Newell's Shearwaters (NESH) at GE 1.5se wind turbines at the proposed KWP II Down-road Alternative wind-energy site, Maui, Hawaii, based on radar data collected in July 2009. Values of particular importance are in boxes.

Variable/parameter	HAPE		NESH	
	Minimum	Maximum	Minimum	Maximum
MOVEMENT RATE (MVR)				
A) Mean movement rate (targets/h)				
A1) Mean rate during nightly peak movement periods in spring/summer based on July 2009 data (targets/h)	1.776	1.776	1.776	1.776
A2) Mean rate during nightly peak movement periods in fall based on July 2009 data (targets/h)	1.776	1.776	1.776	1.776
B) Number of hours of evening and morning peak-period sampling	5	5	5	5
C) Mean number of targets during evening and morning peak-movement periods				
C1) Spring/summer (A1 * B)	8.88	8.88	8.88	8.88
C2) Fall (A2 * B)	8.88	8.88	8.88	8.88
D) Mean proportion of birds moving during off-peak h of night	0.126	0.126	0.126	0.126
E) Seasonal movement rate (targets/night) = ([C * D] + C)				
e1) Spring/summer	10.0	10.0	10.0	10.0
e2) Fall	10.0	10.0	10.0	10.0
F) Mean number of birds/target	1.05	1.05	1.05	1.05
G) Estimated proportion of each species	0.60	0.60	0.40	0.40
H) Daily movement rate (birds/day; = E * F * G)				
H1) Spring/summer	6.30	6.30	4.20	4.20
H2) Fall	6.30	6.30	4.20	4.20
I) Fatality domain (days/year)				
I1) Spring/summer	180	180	150	150
I2) Fall	75	75	60	60
J) Annual movement rate (birds/year; = ([H1 * I1] + [H2 * I2]), rounded to next whole number)	1,607	1,607	882	882
HORIZONTAL INTERACTION PROBABILITY (IPH)				
K) Turbine height (m)	100	100	100	100
L) Blade radius (m)	35.25	35.25	35.25	35.25
M) Height below blade (m)	29.5	29.5	29.5	29.5
N) Front-to-back width (m)	6	6	6	6
O) Minimal side profile area (m²; = K * N)	600		600	
P) Maximal front profile area (m²; = [M * N] + [π * L²])		4,081		4,081
Q) Cross-sectional sampling area of radar at or below 100 m turbine height (= 3000 m * 100 m = 300,000 m²)	300,000	300,000	300,000	300,000
R) Minimal horizontal interaction probability (= O/Q)	0.00200000		0.00200000	
S) Maximal horizontal interaction probability (= P/Q)		0.01360211		0.01360211
VERTICAL INTERACTION PROBABILITY (IPV)				
T) Proportion of petrels flying ≤ turbine height)	0.51	0.51	0.51	0.51

Table 2. Continued.

Variable/parameter	HAPE		NESH	
	Minimum	Maximum	Minimum	Maximum
EXPOSURE INDEX (ER = MVR * IPH * IPV)				
U) Daily exposure index (birds/turbine/day; = H * (R or S) * T; rounded to 8 decimal places)				
U1) Spring/summer	0.00642528	0.04369870	0.00428352	0.02913247
U2) Fall	0.00642528	0.04369870	0.00428352	0.02913247
V) Annual exposure index (birds/turbine/year; = J * (R or S) * T; rounded to 8 decimal places	1.63914000	11.14788498	0.89964000	6.11850314
FATALITY PROBABILITY (MP)				
W) Probability of striking turbine if in airspace on side approach	1.00	1.00	1.00	1.00
X) Probability of striking turbine if in airspace on frontal approach	0.20	0.20	0.20	0.20
Y) Probability of fatality if striking turbine[1]	1.00	1.00	1.00	1.00
Z1) Probability of fatality if an interaction on side approach (= W * Y)	1.00000		1.00000	
Z2) Probability of fatality if an interaction on frontal approach (= X * Y)		0.19500		0.19500
FATALITY INDEX (= ER * MP)				
Annual fatality rate with 90% exhibiting collision avoidance (birds/turbine/year; = V * (Z1 or Z2) * 0.1)	0.16391	0.21738	0.08996	0.11931
Annual fatality rate with 95% exhibiting collision avoidance (birds/turbine/year; = V * (Z1 or Z2) * 0.05)	0.08196	0.10869	0.04498	0.05966
Annual fatality rate with 99% exhibiting collision avoidance (birds/turbine/year; = V *(Z1 or Z2) * 0.01)	0.01639	0.02174	0.00900	0.01193

[1] Used 100% fatality probability due to ESA definition of "take"; however, actual probability of fatality with collision <100% (see methods).

rounding up to the nearest whole number), we estimate that 2–12 Hawaiian Petrels and 1–7 Newell's Shearwater fly within the space occupied by each wind turbine in an average year (Tables 2 and 4) and estimate that 1 Hawaiian Petrel and 1 Newell's Shearwater fly within the space occupied by the 65-m-high met tower in an average year (Tables 3 and 4). Note that all these calculations are exposure rates and, thus, include an unknown proportion of birds that would detect and avoid the turbines and met towers. Hence, exposure rates estimate how many times/year a petrel or shearwater would be exposed to wind turbines or met towers and not necessarily the number that actually would collide with those structures.

FATALITY MODELING

The individual steps and estimates involved in calculating fatality rates are shown in Table 2 (turbines) and Table 3 (met tower). We speculate that the proportions of birds that detect and avoid turbines and towers is substantial (see Discussion), but limited petrel- or shearwater-specific data are available to use for an estimate of the avoidance rates for those types of structures. Because it is necessary to estimate the fatality of petrels and shearwaters at the proposed project, however, we assumed that 90%, 95%, or 99% of all birds will be able to detect and avoid the towers and turbines. If we also assume that 100% of the birds colliding with a turbine/tower die (although see above), the ranges of annual fatalities are 0.016–0.217 Hawaiian Petrel/turbine/yr and 0.009–0.119 Newell's Shearwaters/turbine/year (Table 2). For the 65-m met tower, we estimate a fatality rate of 0.008–0.081 Hawaiian Petrel/tower/yr and 0.004–0.044 Newell's Shearwaters/tower/year (Table 3). For cumulative annual fatalities, the

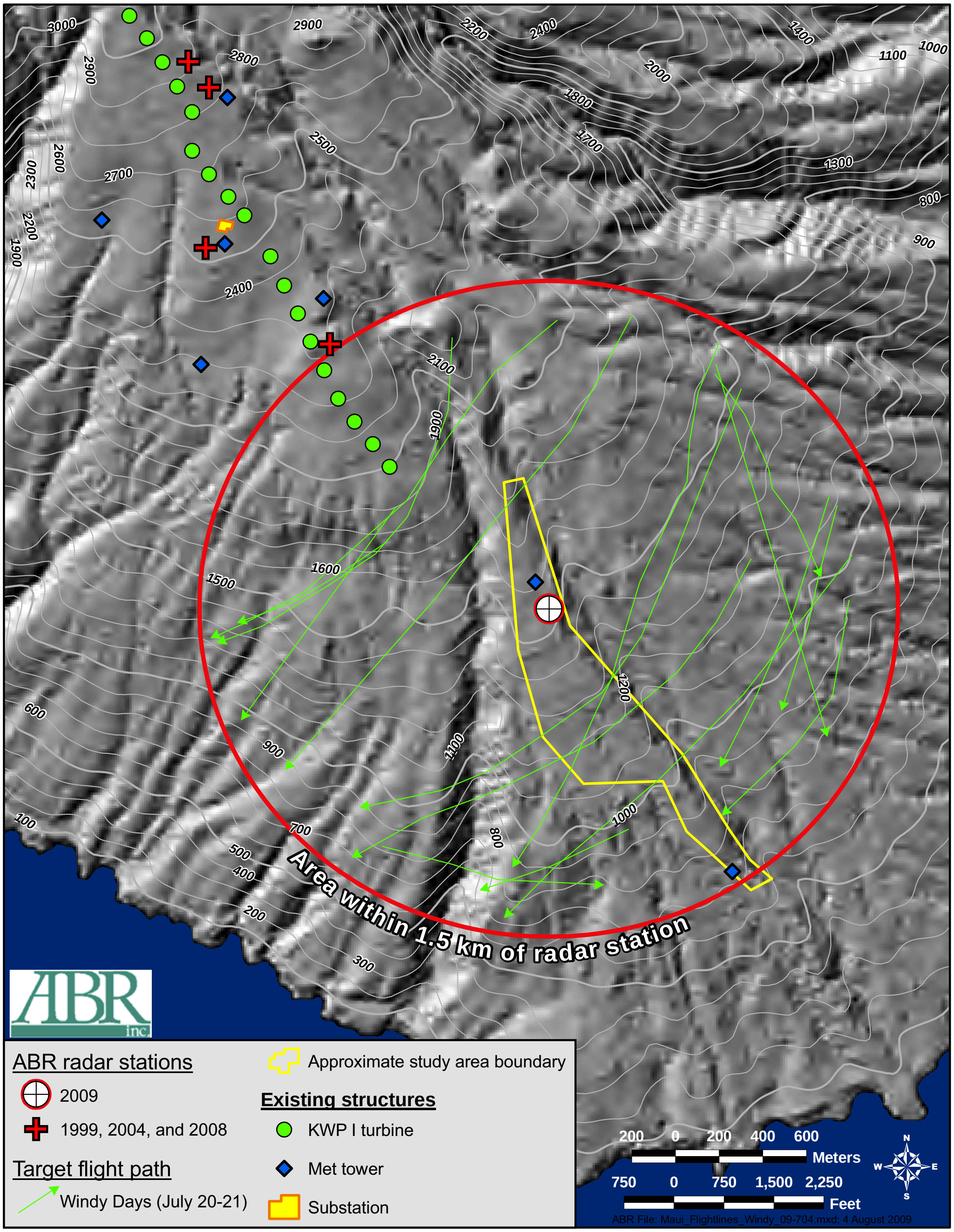

Figure 4. Location of flight paths of petrel-like radar targets observed during the strong wind conditions of 20–21 July 2009, at the KWP II Down-road Alternative wind energy facility, Maui, Hawaii.

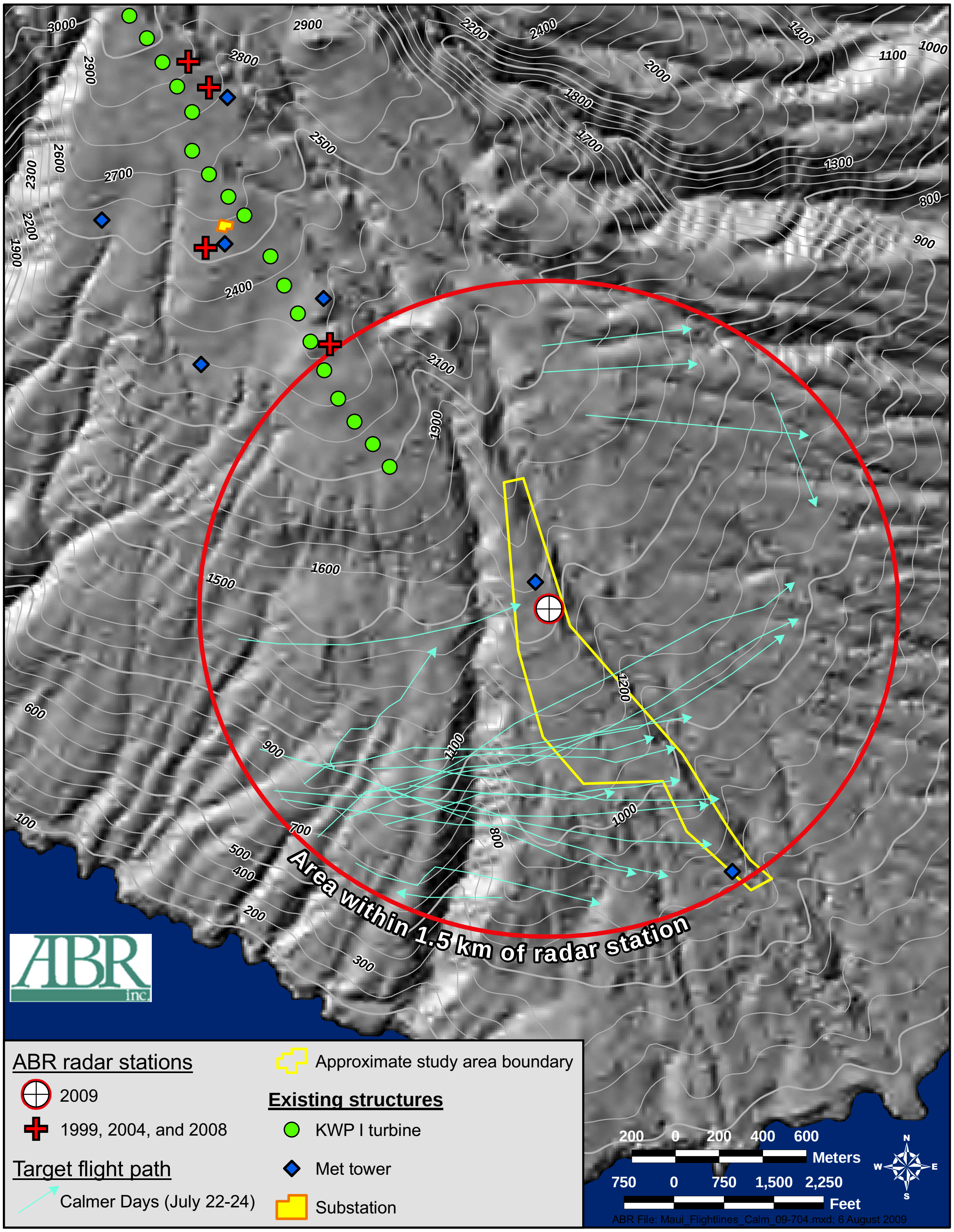

Figure 5. Location of flight paths of petrel-like radar targets observed during the light and variable wind conditions of 22–24 July 2009, at the KWP II Down-road Alternative wind energy facility, Maui, Hawaii.

Table 3. Estimated average exposure rates and fatality rates of Hawaiian Petrels (HAPE) and Newell's Shearwaters (NESH) at the proposed free-standing 65-m-tall met tower at the KWP II Down-road alternative wind-energy site, Maui, Hawaii, based on radar data collected in July 2009. Values of particular importance are in boxes.

Variable/parameter	HAPE	NESH
MOVEMENT RATE (MVR)		
A) Mean movement rate (targets/h)		
A1) Mean rate during nightly peak movement periods in spring/summer based on July 2009 data (targets/h)	1.776	1.776
A2) Mean rate during nightly peak movement periods in fall based on July 2009 data (targets/h)	1.776	1.776
B) Number of hours of evening and morning peak-period sampling	5	5
C) Mean number of targets during evening and morning peak-movement periods		
C1) Spring/summer (A1 * B)	8.88	8.88
C2) Fall (A2 * B)	8.88	8.88
D) Mean proportion of birds moving during off-peak h of night	0.126	0.126
E) Seasonal movement rate (targets/night) = ((C * D)+ C)		
e1) Spring/summer	10.0	10.0
e2) Fall	10.0	10.0
F) Mean number of birds/target	1.05	1.05
G) Estimated proportion of each species	0.60	0.40
H) Daily movement rate (birds/day =E*F*G)		
h1) Spring/summer	6.30	4.20
h2) Fall	6.30	4.20
I) Fatality domain (days/year)		
i1) Spring/summer	180	150
i2) Fall	75	60
J) Annual movement rate (birds/year; = ((H1*I1) + (H2*I2)), rounded to next whole number)	1,607	882
HORIZONTAL INTERACTION PROBABILITY (IPH)		
K) Maximal cross-sectional area of tower (side view =297 m²)	297.0	297.0
L) Cross-sectional sampling area of radar at or below 50 m tower height (= 3000 m * 65 m = 195,000 m²)	195000.000	195000.000
M) Average probability of radar target intersecting the met tower (= K/L, rounded to 8 decimal places)	0.00152308	0.00152308
VERTICAL INTERACTION PROBABILITY (IPV)		
N) Proportion of petrels flying ≤ tower height)	0.33	0.33
EXPOSURE INDEX (ER = MVR*IPH*IPV)		
O) Daily exposure index (birds/tower/day = H*M*N, rounded to 8 decimal places)		
O1) Spring/summer	0.00316612	0.00211075
O2) Fall	0.00316612	0.00211075
P) Annual exposure index (birds/tower/year = J*M*N, rounded to 8 decimal places)	0.80770292	0.44330677
FATALITY PROBABILITY (MP)		
Q) Probability of striking tower if in airspace	1.00	1.00
R) Probability of fatality if striking tower[1]	1.00	1.00
S) Probability of fatality if an interaction (= Q*R)	1.00000	1.00000
FATALITY INDEX (= ER*MP)		
T) Annual fatality rate with 90% exhibiting collision avoidance (birds/tower/year = P*S*0.1)	0.08077	0.04433
U) Annual fatality rate with 95% exhibiting collision avoidance (birds/tower/year = P*S*0.05)	0.04039	0.02217
V) Annual fatality rate with 99% exhibiting collision avoidance (birds/tower/year = P*S*0.01)	0.00808	0.00443

[1] Used 100% fatality probability due to ESA definition of "take", however actual probability of fatality with collision <100% (see methods).

annual fatality rate would be 0.229–3.043 Hawaiian Petrels/yr and 0.126–1.670 Newell's Shearwaters/yr for all 14 proposed wind turbines combined (Table 4). The cumulative annual fatalities at the one proposed met tower would be 0.008–0.081 Hawaiian Petrels/yr and 0.004–0.044 Newell's Shearwaters/yr (Table 4). We caution again, however, that the range of assumed avoidance rates of seabirds and turbines/towers (90–99%) is not fully supported by empirical data at this time.

DISCUSSION

MOVEMENT RATES AND FLIGHT BEHAVIOR

Within KWP, there has been some variation in mean movement rates among years and studies (Table 5), but all estimated rates have been low (i.e., between 0.5 and 1.8 targets/h). Thus, mean movement rates of Hawaiian Petrels recorded in the KWP study areas (i.e., ~1–2 targets/h; this study; Day and Cooper 1999, Cooper and Day 2004; Sanzenbacher and Cooper 2008, 2009) are much lower than those over the eastern and northern sides of Maui (Cooper and Day 2003).

Our limited data (i.e., five sampling nights) from the current study suggest that patterns of movement may have been affected by the wind regime. We found that shearwater/petrels mostly flew in an outbound movement towards the southwest during strong Trade Winds and flew inbound toward the east during light and variable winds (i.e., at wind speeds that apparently were below the cut-in speed of the KWP I turbines that were not spinning at the time). Our limited data also suggested that the passage rates might be higher over the lower (southern) end of the study area than elsewhere during calm conditions, though, again note that we only had two nights of sampling during strong winds and three nights during light winds. The flight directions of the targets observed during light winds suggest that they were birds approaching Maui from the west and "cutting the corner" of West Maui on their way to breeding colonies on Haleakala.

VISUAL OBSERVATIONS OF PETRELS AND SHEARWATERS

In total, we have had three visual observations of Hawaiian Petrels and two observations of unidentified shearwaters/petrels over the KWP study areas during 1999–2009 (Table 6; Day and Cooper 1999, Cooper and Day 2004a; Sanzenbacher and Cooper 2008, 2009; this study). The birds observed in the evening period were headed easterly or northeasterly, and the birds observed in the morning were heading southeasterly or southwesterly. These directions fit a pattern of inbound movements toward Haleakala in the evening and outbound movements from Haleakala and/or West Maui in the morning.

Flight altitudes of the two birds that we observed over the proposed turbine-string ridges were within turbine heights (i.e., one was at 40 m agl and the other was at 65 m agl; Table 6). The flight altitudes of the other three birds were much higher (i.e., 300–500 m agl), but they were measured over the valley to the east; hence, we not know what their flight altitudes were as they flew over the ridges on which the turbine strings lie. Thus, it is possible that visual altitude data is biased to detecting lower-flying birds, the very limited data that we have for known flight altitudes (n = 2) suggest that a substantial proportion of petrels may have flown within the turbine-height zone.

In our fatality models, we used the timing of inland flights at the nearby Ukumehame site from Cooper and Day (2003) to correct for proportions of targets that were Hawaiian Petrels and those that were Newell's Shearwaters; those data suggested that 60% of the targets were Hawaiian Petrels and 40% of the targets were Newell's Shearwaters. However, the timing of two of the three Hawaiian Petrels that we saw over the site (Table 6) occurred during the late evening, a period when Cooper and Day (2003) assumed that only Newell's Shearwaters would occur. Thus, these visual observations suggest the possibility that more than 60% of the radar targets we observed in the current study could have been Hawaiian Petrels. We do not recommend changing the relative proportions of Hawaiian Petrels vs. Newell's Shearwaters in the fatality model, however, unless further data are collected to confirm this pattern.

Table 4. Summary of exposure rates, fatality rates, and cumulative fatality rates for Hawaiian Petrels (HAPE) and Newell's Shearwaters (NESH) at wind turbines and meteorological (met) towers at the proposed KWP II Down-road Alternative wind-energy site, Maui, Hawaii, based on radar data collected in July 2009.

	Exposure rate/structure (birds/structure/yr)			Fatality rate/structure (birds/structure/yr)			Cumulative fatality rate (birds/yr)	
Structure type	HAPE	NESH	Avoidance rate	HAPE	NESH	No. structures	HAPE	NESH
GE 1.5 MW turbine	1.639 (min)	0.900 (min)	0.90 (min)	0.164	0.090	14.00	2.295	1.259
	11.148 (max)	6.119 (max)	0.90 (max)	0.217	0.119	14.00	3.043	1.670
			0.95 (min)	0.082	0.045	14.00	1.147	0.630
			0.95 (max)	0.109	0.060	14.00	1.522	0.835
			0.99 (min)	0.016	0.009	14.00	0.229	0.126
			0.99 (max)	0.022	0.012	14.00	0.304	0.167
65-m free-standing met tower	0.808	0.443	0.90	0.081	0.044	1.00	0.081	0.044
			0.95	0.040	0.022	1.00	0.040	0.022
			0.99	0.008	0.004	1.00	0.008	0.004

Table 5. Mean (± SE) movement rates of petrel-like targets measured with radar at the KWP wind-energy site and proposed KWP II wind-energy sites, Maui, Hawaii, during 1999–2009 studies.

Year	Site	Movement rate (targets/h) Summer	Movement rate (targets/h) Fall	Source
1999	KWP I	1.2 ± 0.3	–	Day and Cooper (1999)
2004	KWP I	–	1.0 ± 0.2	Cooper and Day (2004)
2008	KWP II	0.46 ± 0.15	0.09 ± 0.07	Sanzenbacher and Cooper (2008. 2009)
2009	KWP II Alternate	1.78 ± 0.14	–	current study

Table 6. Records of Hawaiian Petrels and unidentified shearwaters/petrels at the proposed KWP II wind-energy site and nearby KWP I wind-energy site, Maui, Hawaii, during 1999–2009 studies.

Date	Time	Species[1]	Number	Altitude (m agl)	Flight direction
28 May 1999	2150	HAPE	1	300[2]	NE
28 May 1999	0608	UNSP	2	500[2]	SE
12 October 2004	0608	HAPE	1	500[2]	SE
15 October 2004	0454	UNSP	1	65	SW
24 July 2009	2126	HAPE	1	40	E

[1] HAPE = Hawaiian Petrel; UNSP = unidentified shearwater/petrel.
[2] Flight altitude measured over the valley to east of the proposed turbine string ridge, not over the proposed turbine string ridge itself; measurements were done that way because that is where birds were first seen.

EXPOSURE RATES AND FATALITY ESTIMATES

We estimated that 2–12 Hawaiian Petrels and 1–7 Newell’s Shearwater would fly within the space occupied by each wind turbine in an average year and estimated that 1 Hawaiian Petrel and 1 Newell’s Shearwater would fly within the space occupied by the 65-m-high met tower in an average year (Table 4). We used these estimated exposure rates as a starting point for developing a complete avian risk assessment; however, we emphasize that it currently is unknown whether bird use (i.e., exposure) and fatality at windfarm structures are strongly correlated. For example, Cooper and Day (1998) found no relationship between movement rates and fatality rates of Hawaiian Petrels and Newell’s Shearwaters at powerlines on Kaua’i, indicating that other factors had a much greater effect on causing fatality than movement rates did. For example, other factors such as proximity to the ocean or poor weather could be more highly correlated with fatality rates than is bird abundance. As an example, collisions of Laysan Albatross with a large array of communication-tower antenna wires and guy wires adjacent to large, high-density albatross breeding colonies on Midway Atoll occurred at a far higher rate during periods of high winds, rain, and poor visibility than during periods of better weather: 838 (>25%) of the 2,901 birds killed during the study were killed during two storms (Fisher 1966). To determine which factors are most relevant, future studies that collect concurrent data on movement rates, weather, and fatality rates would be useful to begin to determine whether movement rates and/or weather conditions can be used to predict the likelihood of petrel fatalities at wind turbines and other structures across the entire proposed windfarm.

In addition, few data are available on the proportion of petrels and shearwaters that do not collide with wind turbines or met towers because of collision-avoidance behavior (i.e., birds that completely alter their flight paths horizontally and/or vertically to avoid flying through the space occupied by a turbine/tower). Clearly, the detection of wind turbines or other structures could result in collision-avoidance behavior by these birds and reduce the likelihood of collision. There also appear to be differences between petrels and shearwaters in their ability to avoid obstacles. For example, Cooper and Day (1998) indicated that Hawaiian Petrels have flight characteristics that make them more adept at avoiding powerlines than Newell’s Shearwaters, suggesting that Hawaiian Petrels might also be more likely to avoid collisions with other structures such as wind turbines. These authors also suggested that the tendency for Hawaiian Petrels to approach and leave nesting colonies primarily during crepuscular periods enables these birds to see and avoid structures (e.g., wind turbines) more easily than do Newell’s Shearwaters that approach and leave nesting colonies primarily during nocturnal periods.

Some collision-avoidance information is available on petrels and shearwaters from earlier work that we conducted on Kaua’i (Cooper and Day 1998; Day et al., *In review*). In summary, those data suggest that the behavioral-avoidance rate of Hawaiian Petrels and Newell’s Shearwaters near powerlines is high. For example, across all 207 Hawaiian Petrels observed flying within 150 m of transmission lines on Kauai, 40 exhibited behavioral responses; of those 40 birds that exhibited collision-avoidance responses, none (0%) collided with a transmission line. Thus, the collision-avoidance rate for Hawaiian Petrels was 100% (i.e., 40 of 40 interactions). Across all 392 Newell’s Shearwaters observed flying within 150 m of transmission lines, 29 exhibited behavioral responses; of those 29 birds that exhibited collision-avoidance responses, none (0%) collided with a transmission line. However, one Newell's Shearwater that did not exhibit a collision-avoidance response hit a transmission line. Thus, the collision-avoidance rate for Newell’s Shearwaters was 97% (i.e., 29 of 30 interactions).

There also is some information available on collision-avoidance of Hawaiian Petrels on Lana’i, where the behavior of petrels was studied as they approached large communication towers near the breeding colony (TetraTech 2008; Day et al., *In review*). In that study, all 20 (100%) of the Hawaiian Petrels seen on a collision-course toward communication towers exhibited avoidance behavior and avoided collision.

Additional data that provides some insight on collision-avoidance behavior of petrels and shearwaters at windfarm structures (e.g., wind turbines and met towers) are available from other studies associated with the operational KWP I wind facility. There was 1 Hawaiian Petrel fatality and 0 Newell’s Shearwater fatalities observed at the 20-turbines and three met towers in the first 3.5 years of operation (G. Spencer, FirstWind, pers. comm.). Calculations using data for scavenging bias and searcher efficiency collected at the KWP I wind facility indicate that the one observed fatality equates to a corrected direct take of 0.5 Hawaiian Petrels/yr and 0 Newell’s Shearwaters/yr (Kaheawa Wind Power LLC 2009, *in prep*). Cooper and Day (2004b) modeled seabird fatality for the KWP I wind turbines, based on movement rates from radar studies at the site (Day and Cooper 1999; Cooper and Day 2004a, 2004b), and estimated that the combined annual fatality of Hawaiian Petrels and Newell’s Shearwaters at the KWP I turbines would be ~3–18 birds/yr with a 50% avoidance rate, ~1–2 birds/yr with a 95% avoidance rate, and <1 bird/yr with a 99% avoidance rate. Thus, the fatality model that used a 99% avoidance value was a closer fit with the measured fatality rates than was the fatality models that used a 50% or 95% avoidance rate.

In summary, currently available data from Kaua’i, Lana’i, and Maui suggest that the avoidance rate of petrels and shearwaters at transmission lines and communications towers is high and approaches 100% (Day et al., *in review*). Data from the fatality searches at turbines and met towers on Maui are more difficult to interpret because they suggest high avoidance but are not a direct measure of avoidance; however those data also suggest that avoidance of those structures must be occurring because only one Hawaiian

Petrel has been found during regular fatality searches of those structures over a 3.5-year period. Thus, the overall body of evidence, while incomplete, is consistent with the hypothesis that the average avoidance rate of wind turbines and met towers is substantial and potentially is ≥95%. The ability of Hawaiian Petrels and Newell's Shearwater to detect and avoid most objects under low-light conditions makes sense from a life-history standpoint, in that they forage extensively at night and are adept at flying through forests near their nests during low light conditions.

In addition to the limited data available for Hawaiian Petrels and Newell's Shearwaters, there is evidence that many other species of birds detect and avoid structures (e.g., wind turbines, met towers) during low-light conditions (Winkelman 1995, Dirksen et al. 1998, Desholm and Kahlert 2005, Desholm et al. 2006). For example, seaducks in Europe have been found to detect and avoid wind turbines >95% of the time (Desholm 2006). Further, natural anti-collision behavior (especially alteration of flight directions) is seen in migrating Common and King eiders (*Somateria mollissima* and *S. fischeri*) approaching human-made structures in the Beaufort Sea off of Alaska (Day et al. 2005) and in diving ducks approaching offshore windfarms in Europe (Dirksen et al. 1998). Collision-avoidance rates around wind turbines are high for Common Eiders in the daytime (Desholm and Kahlert 2005), gulls (*Larus* spp.) in the daytime (>99%; Painter et al. 1999, cited in Chamberlain et al. 2006), Golden Eagles (*Aquila chrysaetos*) in the daytime (>99%; Madders 2004, cited in Chamberlain et al. 2006), American Kestrels (*Falco sparverius*) in the daytime (87%, Whitfield and Band [in prep.], cited in Chamberlain et al. 2005), and passerines during both the day and night (>99%; Winkelman 1992, cited in Chamberlain et al. 2006).

We agree with others (Chamberlain et al. 2006, Fox et al. 2006) that species-specific, weather-specific, and site-specific avoidance data are needed in models to estimate fatality rates accurately. However, the currently available avoidance data from Kaua'i and Lana'i for Hawaiian Petrels and Newell's Shearwaters and the petrel fatality data at KWP I wind turbines and met towers while incomplete, is consistent with the notion that a substantial proportion of petrels detect and avoid wind turbines, marked met towers, communication towers, and powerlines under normal ranges of weather conditions and visibility (but note that avoidance rates could be lower under inclement conditions). Until further petrel- and shearwater-specific data on the relationship between exposure and fatality rates are available for structures at windfarms, we continue to provide a range of assumptions for avoidance rates in our fatality models (i.e., 90%, 95%, and 99% avoidance), along with a discussion of the body of evidence that, while incomplete at this time, is consistent with the notion that the average avoidance-rate value is substantial and potentially is ≥95%. With an assumption of a 95% avoidance rate, the estimated average annual take at the KWP II Downroad Alternative would be ≤0.1 Hawaiian Petrel/turbine/yr and ≤0.06 Newell's Shearwaters/turbine/yr and, for met towers, fatality would be 0.04 Hawaiian Petrel/tower/yr and 0.02 Newell's Shearwaters/tower/yr.

Other factors could affect our estimates of fatality in either a positive or a negative direction. One factor that would have created a positive bias was the inclusion of targets that were not petrels or shearwaters. Our visual observations of several other species with similar target characteristics to petrels (especially during crepuscular periods, when we could use binoculars) helped to minimize the inclusion of these non-target species, but it is possible (especially during nocturnal conditions) that some of our radar targets were other fast-flying species that were active during the sampling period (e.g., Pacific Golden-Plover [*Pluvialis fulva*]). A second positive bias in our fatality model is our simplistic assumption that movement rates of seabirds do not fall as individual fatalities occurred (i.e., we assumed sampling with replacement for fatalities). Given the low movement rates observed in this study, it is likely that the fatality of just a single bird would substantially reduce the average nightly movement rates. A third positive bias is the assumption that turbines are operating at maximal rotor speed; this assumption clearly is incorrect because of variability in winds, but using it results in maximal estimates of collision rates for birds flying through the turbine rotors.

There also are factors that could create a negative bias in our fatality estimates. One example would be if targets were missed because they flew within radar shadows. Because the sampling stations provided good coverage of the surrounding area, we believe that the proportion of targets that was missed because they passed through the entire area of coverage of the study area within a radar shadow was minimal.

A factor that could affect the predictive value of our fatality estimates in either direction is interannual variation in the number of birds visiting nesting colonies on Maui. Average hourly movement rates for the current study (= ~1.8 targets/h), from 2004 (summer = ~0.5 targets/h; fall = ~0.1 targets/h; Sanzenbacher and Cooper 2008, 2009), from summer 1999 (1.2 targets/h; Day and Cooper 1999), and from fall 2004 (1.0 targets/h; Cooper and Day 2004a) all suggest that rates are consistently low at the KWP project areas relative to other areas on Mauai, and that interannual variation in that overall level of bird use of the area is minimal. Some caution in extrapolation of movement rates across years is still warranted, however, because there are examples of other sites with high interannual variation in counts, such as the three sites on Kaua'i where counts were ~100–300 birds/hr lower (~four times lower) in fall 1992 than in fall 1993; the lower counts in 1992 were attributed to the effects of Hurricane Iniki (Day and Cooper 1995). Oceanographic factors (e.g., El Niño–Southern Oscillation events) also vary among years and are known to affect the distribution, abundance, and reproduction of seabirds (e.g., Ainley et al. 1994, Oedekoven et al. 2001). Another factor that could cause interannual variation in counts in either direction is overall population increases or declines. For example, there was a ~60% decline in radar counts on Kaua'i between 1993 and 1999–2001 that was attributed to population declines of Newell's Shearwaters (Day et al. 2003b).

CONCLUSIONS

We used our risk-assessment model to estimate the number of Hawaiian Petrels and Newell's Shearwaters that might be killed by collisions with wind turbines and met towers at the proposed KWP II Down-road Alternative facility. The model is affected by several input variables, including the collision-avoidance rate. The absence behavioral studies to fully quantify avoidance rates at wind turbines and met towers precludes determination of actual avoidance rates; however, a growing body of evidence suggests that a high percentage of petrels and shearwaters detect and avoid structures such as communication towers, transmission lines, and wind turbines (see above). We also suspect high rates of anti-collision behaviors because petrels must rely upon acute nocturnal vision for foraging and other flight activities under varying weather conditions. In conclusion, we believe that the proportion of petrels that would see and avoid proposed wind turbines at the KWP II Down-road Alternative will be high, but until studies are conducted to quantify avoidance behavior at wind turbines and met towers, we provide a range of assumptions for avoidance rates in our fatality models (i.e., 90%, 95%, and 99% avoidance rates) along with a discussion of the body of evidence that is consistent with the hypothesis that the average avoidance-rate value is substantial and potentially ≥95%. With an assumption of 95% avoidance, the estimated average annual take at the proposed KWP II Down-road Alternative wind turbines would be ≤0.1 Hawaiian Petrel/turbine/yr and ≤0.06 Newell's Shearwaters/turbine/yr. The estimated average annual take at the proposed KWP II Down-road Alternative met tower (with an assumption of 95% avoidance) would be 0.04 Hawaiian Petrel/tower/yr and 0.02 Newell's Shearwaters/tower/yr.

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Appendix 4

Wildlife Education and Observation Program

Purpose	To educate project employees and other on-site personnel in the observation, identification and treatment of wildlife
Approach	In conjunction with regular assigned duties, all personnel will: ⅄ attend wildlife education briefings conducted in cooperation with DOFAW and USFWS; ⅄ monitor wildlife activity while on the site; ⅄ identify key species when possible (Hawaiian Petrel, Newell's Shearwater, Nene and Hawaiian Hoary Bat); ⅄ document specific observations with the filing of a Wildlife Observation Form; ⅄ identify, report and handle any downed wildlife in accordance with the Downed Wildlife Protocol, including filing a Downed Wildlife Monitoring Form – Incidence Report; ⅄ respond and treat wildlife appropriately under all circumstances.
Notes	All personnel will avoid approaching any wildlife other than downed wildlife; avoid any behavior that would startle or harass any wildlife; and not feed any wildlife.

Descriptions and Photographs
Follow

Hawaiian Petrel	
Description	16 inches, 36-inch wingspan. Head, wings and tail are sooty-colored, contrasting with slightly paler back. Forehead and underparts are white; tail is short. Feet are bi-colored pink and black. Downy chicks are charcoal gray.
Voice	Distinctive call heard at breeding colonies is a repeated moaning "ooh-ah-ooh." At their burrows, birds also produce a variety of yaps, barks and squeals.
Habits	The Hawaiian Petrel is generally seen close to the main Hawaiian islands during breeding season; otherwise, it is a pelagic species. The flight is characterized by high, steeply-banked arcs and glides; the wings are long and narrow. Breeding extends from March to October. One white egg is laid within deep burrows or under rocks. Adults arrive in colonies well after dark. As the chicks develop, parental care becomes less frequent and adults leave the colony each year two to three weeks before the chicks. Adults feed on squid, fish and crustaceans, and pass food to chicks by regurgitation. Predation by introduced rats, cats and mongooses is a serious threat to this species.

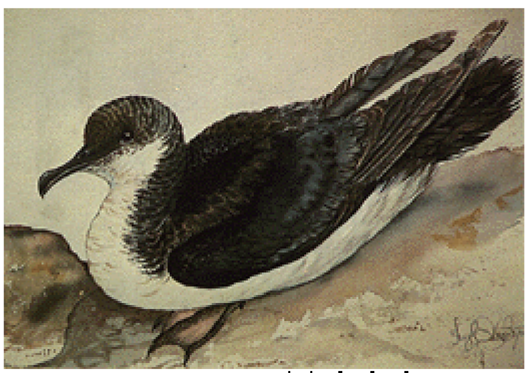
HNP/C. Hodges

HVNP/W. Banko

source: http://pacificislands.fws.gov/wesa/uau.html

source: http://www.birdinghawaii.co.uk/xHawaiianPetrel2.htm

Newell’s Shearwater	
Description	12 – 14 inches, 30 – 35-inch wingspan. Black above and white below. The white extends from the throat to the black undertail coverts. Sharp contrast of dorsal/ventral color is more distinct than in larger, more common Wedge-tailed Shearwater. Bill, legs and toes are dark; webbing between toes is pink.
Voice	Around nesting colony, a variable, jackass-like braying and crow-like calling.
Habits	The flight of the Newell’s Shearwater is characterized by rapid, stiff wingbeats and short glides. This species occurs in Hawaiian waters during the breeding season (April to November); it flies to nesting colonies only after dark, departing before dawn. Birds are highly vulnerable to predation by rats and cats. Many fledglings departing the colonies in late fall are attracted to urban lights and fall on highways or other brightly-lit areas.



Painting by Sheryl Ives Boynton

source: http://pacificislands.fws.gov/wesa/ao.html

source: http://audubon2.org/webapp/watchlist/viewSpecies.jsp?id=141

source: http://www.birdinghawaii.co.uk/XNewells2.htm

Nene	
Description	22 – 26 inches, sexes similar. A medium-sized goose with black head and nape that contrasts with yellow-buff cheek. Neck is also buffy but with dark brown furrows. Heavily barred gray-brown above; lighter barrel below. Bill and partially-webbed feet are black. Adults weigh approximately 4 pounds, males are larger.
Voice	Call is a loud "haw" or "haw-ah," resembling honking of the Canada Goose. Also gives a variety of muted calls, often resembling the "moo" of a cow.
Habits	Nene frequent scrubland, grassland, golf courses, and sparsely-vegetated slopes and, on Kaua`i, open lowland country. They feed on a variety of native and introduced plants. The breeding season extends from November to June. The nest is a down-lined bowl usually well-concealed under bushes; two to five white eggs are laid. Approximately 85 Nene have been released at Hanaula since 1995 as part of DOFAW's propagation and recovery program. Predation by introduced mongooses and feral cats on eggs, goslings and brooding adults inhibits population increases.

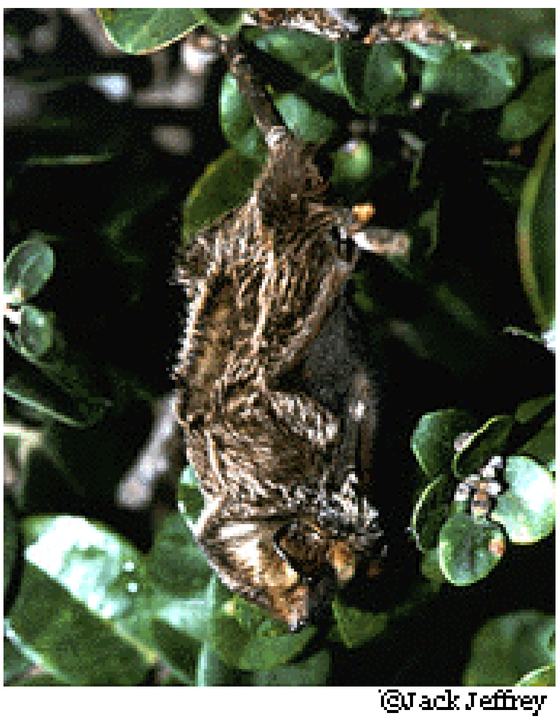
source: http://www.aloha-hawaii.com/hawaii/nene

source: http://www.50states.com/bird/nene.htm

source: http://www.thewildones.org/Animals/nene.html

source: http://www.coffeetimes.com/nene.htm

Hawaiian Hoary Bat	
Description	Weighs 5 to 8 ounces, has a 10.5 – 13.5-inch wingspan. Females are larger than males. It has a heavy fur coat that is brown and gray, and ears tinged with white, giving it a frosted or "hoary" look.
Voice	Like most insectivorous bats, this bat emits high frequency (ultrasonic) echolocation calls that detect its flying prey. These calls generally range from 15 – 30 KHz. Their lower frequency social calls may be audible to humans. These low frequency "chirps" are used to warn other bats away from their feeding territory.
Habits	The Hawaiian Hoary Bat is nocturnal to crepuscular and eats insects. Little is known about its biology, distribution, or habitat use on the Hawaiian islands, though it is thought to be most abundant on the Big Island. It occurs primarily below 4,000 feet elevation, although it commonly is seen at 7,000 to 8,000 feet on Hawai`i and at 10,000 feet on Haleakala. On Maui, this bat is believed to primarily occur in moist, forested areas. In spite of this preference, though, it has been seen in Lahaina and near Mopua, both of which are dry, and on the dry, treeless crest of Haleakala. During the day, this bat roosts in a variety of tree species and occasionally in rock crevices and buildings; it even has been recorded hanging from wire fences on Kaua`i and has been seen leaving and entering caves and lava tubes on Hawai`i.



source: http://pacificislands.fws.gov/wesa/hrybatindex.html

source: http://www.honoluluzoo.org/hawaiian_bat.htm

SAMPLE

Wildlife Education and Observation Program
KWP II
Observation Form

Observer's Name:			**Date:**	
Temperature:	**Wind Direction:**	**Wind Speed:**	**Precipitation:**	**Cloud Cover:**

Species Observed	
Location	
Proximity to Turbine	
Approximate Altitude	
Direction Traveling	
Other Species in Area	
Comments	

Appendix 5

Life History Information on

Newell's Shearwater (*Puffinus newelli*), Hawaiian Petrel (*Pterodroma sandwichensis*), Hawaiian Goose (*Branta sandvicensis*)
and
Hawaiian Hoary Bat (*Lasiurus cinereus semotus*)

Compiled by:
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Honolulu, HI 96813

1.1 INTRODUCTION

Demographic factors were used to assess indirect take and loss of productivity in section 5.0 (Potential Impacts) and 6.0 (Mitigation) of the HCP. Indirect take and loss of productivity are defined as follows:

> Indirect Take - These are individuals that suffer mortality as the result of a direct take of another individual. For example, the loss of a parent may also result in the loss of eggs or young.
>
> Loss of Productivity - Productivity can be assessed in terms of chicks or fledglings produced per breeding adult per year or the number of fledglings that survive to adulthood per breeding adult per year. When a direct take occurs, loss of productivity can occur between the time the direct take occurs and the time that mitigation is provided. Productivity may also be lost if a juvenile is used as a replacement for the take of a breeding age adult. Factors that need to be taken into consideration when accounting for loss of productivity include demographic factors such as the age and sex of the individuals taken, the time of year the take occurs, and the type of mitigation provided.

Demographic factors for each species covered by the HCP were determined using existing literature. Preference was given to life history information available from Hawai‘i, followed by information available for the same species on the North American continent or other areas of the world. If specific information was lacking for any species, life history information for a closely related species was used as a surrogate.

The life history information for the Newell’s shearwater (*Puffinus newelli*), Hawaiian petrel (*Pterodroma sandwichensis*), Hawaiian goose (*Branta sandvicensis*) and Hawaiian hoary bat (*Lasiurus cinereus semotus*) follow in the sections below.

1.2 Seabirds

1.2.1 Newell’s Shearwater

The following demographic factors and assumptions (from Ainley et al. 1997 and as otherwise noted) were used to assess indirect take and loss of productivity of the Newell’s shearwater.

Breeding Season: The breeding season lasts from June to October each year.

Age at First Breeding: Assumed age 6.

Adults Breeding/Year: On the basis of estimates made by Telfer (1986), incidence of non- breeding is high for Newell’s Shearwater on Kaua‘i. Only 46% of pairs that actively use a burrow actually breed in a given year (range 30–62 %, n = 5 yr, 36–47 burrows monitored/yr).

Reproductive Success: 66.0% ± 6.4 SD (range 49–75) of nests in which eggs are laid fledge young. Manx Shearwater populations have similar fledging rates (Brooke 1990). For the purposes of the HCP, a 70% average fledging rate is assumed.

Survival: Annual adult survivorship of Newell’s Shearwater was estimated to be 0.904 ± 0.017 SE, on the basis of allometric equation relating survivorship to body mass in procellariiforms. This figure approximates that estimated for Manx Shearwater by more conventional means (Brooke 1990). For the purposes of the HCP, it is assumed that 50% of fledged young survive to breeding age.

Number of Broods: One per year.

Clutch Size: One.

Relative Productivity of Males vs. Females: Relative productivity of males and females is assumed to be similar, as with the Hawaiian petrel described below. For the purposes of estimating lost productivity and indirect take, it is assumed that males and females each contribute 50% towards indirect take and the average annual productivity.

1.2.2 Hawaiian Petrel

The following demographic factors and assumptions (from Simons and Hodges 1998 and as otherwise noted) were used to assess indirect take and loss of productivity of the Hawaiian petrel:

Breeding Season: The breeding season lasts from May to October each year.

Age at First Breeding: Unknown, but population data suggests breeding starts at age 5-6. Age 5 is assumed for purposes of estimating indirect take and lost productivity.

Adults Breeding/Year: Estimated at 89%.

Reproductive Success: Estimates of annual reproductive success (chicks fledged/eggs laid) at Haleakala, Maui from 1979–1981 (Simons 1985) and 1993 (Hodges 1994) averaged 63.4 % ± 16.0 SD (range 38–82, n = 128). For the purpose of the HCP, the average annual reproductive success of 70% is assumed.

Survival: In an analysis of life history by Simons (1984), survival to breeding age was estimated to be 27%. For the purpose of the HCP, it is assumed that 30% of fledged young survive to breeding age. Yearly adult survivorship was estimated to be 93%.

Number of Broods: One per year.

Clutch Size: One.

Relative Productivity of Males vs. Females: Breeding Hawaiian petrels are apparently monogamous and show a high degree of mate fidelity over subsequent years. Pairs may exhibit courtship behavior that may last one or more seasons prior to breeding. Thus the loss of a male could cause a breeding hiatus for a female even if in pre-breeding condition. Both males and females incubate eggs and provide food for nestlings. For the purposes of estimating lost productivity and indirect take, it is assumed that males and females each contribute ~~equa~~lly towards indirect take and the average annual productivity.

Sex Ratio: Similar adult male and female survival rates in related species (Warham 1996) suggest a balanced sex ratio, but no published data is available.

Based on these assumptions the following approach is proposed for adjusting each take of a Hawaiian Petrel or Newell's Shearwater that occurs to account for lost productivity:

1. No adjustment if in-kind mitigation (i.e., replacement with same-age individual) occurs during same year as take.

2. Increase mitigation for each year that replacement lags behind. Compound adjustments

annually to account for lost productivity of offspring. Loss of productivity accrual ends for an adult take once an adult replaces it. If fledglings are used to replace adult take the adult take continues to accrue loss of productivity until the fledglings survive and mature to reproduce. A fledgling that could have been produced from an adult take can be directly replaced by a fledgling produced through mitigation.

3. Replacements that occur in advance of take may offset adjustments for lagging replacements as long as the advance replacement is in-kind or survival to adult age is accounted for when fledglings are intended to replace adults.

4. Lagging and advanced replacements may result from, (a) replacement with an individual from the same age class at a different time, (b) replacement with an individual from a different age class during the same year as take, or (c) replacement with an individual from a different age class at a different time.

1.2 Hawaiian Goose, Nēnē

Adjustments to the take of Nene were developed based on the following demographic factors and assumptions (from Banko et al. 1999 and USFWS 2004 and as otherwise noted):

Breeding Season: The nēnē has an extended breeding season with eggs reported from all months except May, June, and July, although the majority of birds in the wild nest during the rainy (winter) season between October and March.

Age at First Breeding: Female nēnē mature at age three and males at age two. For the purposes of this HCP, it is assumed that both genders of nēnē mature at age three.

Adults Breeding/Year: Estimated at 60%.

Clutch Size: A clutch typically contains 3 to 5 eggs (mean 3.13 ± 1.07, range 1 to 6, n = 552 nests in the wild

Number of Broods: One per year.

Reproductive Success: During 4 seasons (1978–1981) mostly in highland habitat on Hawaiʻi and Maui, eggs hatched in at least 36 % (n=50) of 140 observed breeding attempts, and goslings fledged in 7 % (n=10; Banko 1992). During 1994– 1996 at Hawaiʻi Volcanoes National Park, eggs hatched in 58 % (21) of 36 nests with known outcomes, resulting in 42 goslings (2.0 goslings/successful pair) and 6 fledglings (0.29 fledgling/successful pair; Hu 1998). For the purposes of this HCP, it is assumed that adults have an average of 0.3 fledglings per pair.

Survival to breeding age: The mortality rate of captive-reared released goslings to Year 1 was reported to be 16.8% for females and 3% for males. For the purposes of this HCP, a conservative annual mortality rate of 20% is assumed for both genders of geese and this rate is assumed constant through maturity (age three).

Relative Productivity of Males vs. Females: Nēnē are highly territorial during the breeding season and males are likely to be defending nesting territories while the females are incubating. Family groups often forage together. For the purposes of estimating lost productivity and indirect take, it is assumed that males and females each contribute ~~equally~~ equally towards indirect take and the average annual productivity.

Based on these assumptions the following adjustments are proposed for each take of a Nene to account for lost productivity:

Take of Gosling	Take of Immature/Juvenile (Post-fledging, pre-nesting)	Take of Adult
No adjustment if replacement gosling propagated in same year as take.	No adjustment if release of juvenile occurs same year as take.	Assume loss of 3 years productivity (conservative age to first breeding) if release of juvenile occurs concurrent with take.
Increase replacement ratio by 10 % for each year release lags behind take.	Increase replacement ratio by 10 % for each year release lags behind take.	Assume loss of 10 % productivity per year, compounded annually to account for productivity of offspring.
Replacements that occur in advance of take may offset adjustments for lagging replacements.	Replacements that occur in advance of take may offset adjustments for lagging replacements.	Replacements that occur in advance of take may offset adjustments for lagging replacements.
Compound annually to account for productivity of offspring.	Compound annually to account for productivity of offspring.	Adjust for assumed 90 % survival to adulthood of released juvenile birds.

1.3 Hawaiian Hoary Bat

Little life history information exists for the hoary bat (*Lasiurus cinereus cinereus*) found on continental America. Because these bats are migratory, do not hibernate and are not colonial, they are difficult to study. Even less life history information is available for the Hawaiian hoary bat. Hence, adjustments to the take of the Hawaiian hoary bat to account for lost productivity were developed based on the following demographic factors and assumptions using information from the hoary bat from continental America or other bat species when necessary:

Breeding Season: The pregnancy and lactating period for the female Hawaiian hoary bat occurs from April to August each year. The breeding lasts approximately four months, with a three month gestation period followed by parental care of one month (NatureServe 2008).

Age at First Breeding: Hoary bats on the continental US breed at age one (Gannon 2003, Koehler and Barclay 2000)

Adults Breeding/Year: Estimated at 100% for colonial bats (Gannon 2003), no data available for the hoary bat. Adults breeding/year is assumed to be 100 % for the Hawaiian hoary bat for purposes of this HCP.

Reproductive Success: A study following young of the hoary bat in Manitoba, Canada records that 23 out of 25 young fledged, resulting in a reproductive success of 92% (Koehler and Barclay 2000). Reproductive success is typically high for bats as they have a life history strategy where they have few young, low reproductive rates and are long lived compared to mammals of equivalent size (Kunz et al. 2005).

Survival to breeding age: No data exists for the Hawaiian hoary bat or the hoary bat on the American continent. However, survival is low for female little brown bats (*Myotis lucifugus* 20.4-47.2%) and female big brown bats (*Eptesicus fuscus*, 10.5-31.9%, Humphrey 1982). Survival rates of Hawaiian hoary bats probably approximate those of the big brown bat more closely than the little brown bat, given that they similar life history strategies such foliage roosting and the ability to commonly have two young at a time. The survival rate of Hawaiian hoary bats is estimated to be 30%.

Number of Broods: One per year.

Litter Size: Both Bogan (1972) and Koehler and Barclay (2000) in separate observations record that 6 females located before parturition gave birth to a total of 11 young, resulting in an average litter size of 1.83.

Relative Productivity of Males vs. Females: Male hoary bats only contribute sperm to the breeding process. Females are solely responsible caring and feeding the young till fledging. For the purposes of estimating indirect take, it is assumed that males contribute nothing to indirect take and females 100%.

Sex Ratio: Sex ratios of Hawaiian hoary bats inferred from samples obtained during different seasons indicate that during the pre-pregnancy and breeding season (April to August), sex ratios in the lowlands are approximately 1:1. During the post-lactation period (September to December) the sex ratio of females to males in the lowlands increases to 4:1 (Menard 2001). Sex of each take will be determined genetically if not clearly determined visually.

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Funding Matrix- KWP II

	Item / Activity	One-time Cost	Annual Cost	Years 1-5	Remaining 15 Years	20-year Permit Duration
General Measures	Preconstruction surveys for nene and nests	$5,000				$5,000
	Daily search and documentation of nene and nests during construction	$25,000				$25,000
	Invasive species avoidance and minimization	$30,000	$5,000	$50,000	$15,000	$95,000
	Wildlife Education and Observation Program (WEOP)		$1,500	$7,500	$25,000	$32,500
	Hawaiian short-eared owl mitigation	$25,000				$25,000
	Sub-Total	**$85,000**	**$6,500**	**$57,500**	**$40,000**	**$182,500**
Minimization Tier 2 Rates of Take	Radar studies to characterize seabird interactions at facility				$50,000	$50,000
	Increased site-specific bat studies using enhanced audio-visual technologies to characterize activity levels and document bat interactions at facility		$10,000	$50,000	$50,000	$100,000
	Sub-Total	**$0**	**$10,000**	**$50,000**	**$100,000**	**$150,000**
Seabird mitigation (Tier 1)	Makamakaole fencing and social attraction option	$300,000		$100,000	$600,000	$1,000,000
	Exploring Maui mitigation alternatives KWPII portion			$56,000		$56,000
	Subtotal	**$300,000**	**$0**	**$156,000**	**$600,000**	**$1,056,000**
Tier 2 (NESH), or insufficient credit accrual at Tier 1.	Alt 2a Increase seabird colony size and productivity within fenced area, habitat enhancement and social attraction	$50,000	$10,000	$50,000	$150,000	$250,000
	Alt 2b Project at scale similar to Alt 1 at alternative location on Maui	$390,000	$0	$0	$0	$390,000
	Alt 2c: In situ predator proof fence in West Maui	$220,760	$36,642	$36,642	$549,623	$807,024
	Maximum sub-total	**$390,000**	**$36,642**	**$36,642**	**$549,623**	**$807,024**
Additional Measures for Tier 2 rates of take (HAPE)	Increased mitigation efforts at the same site or mitgation at another seabird site		$30,000	$150,000	$100,000	$250,000
	Sub-Total	**$0**	**$30,000**	**$150,000**	**$100,000**	**$250,000**
Lower rates of Take	Same as Baseline					
Nene Mitigation (Tier 1)	Staffing for monitoring and predator trapping at nesting locations on Maui			$162,500	$237,500	$400,000
	Sub-Total	**$0**	**$0**	**$162,500**	**$237,500**	**$400,000**

Additional Measures	Systematic observations of nene at the KWP II site		$2,000	$10,000	$30,000	$40,000
	Sub-Total	**$0**	**$2,000**	**$10,000**	**$30,000**	**$40,000**
Tier 2	Staffing for monitoring and predator trapping at nesting locations on Maui				$150,000	$150,000
	Sub-Total	**$0**	**$0**	**$0**	**$150,000**	**$150,000**
Tier 3	Staffing for monitoring and predator trapping at nesting locations on Maui	$0			$300,000	$300,000
	Sub-Total	**$0**	**$0**	**$0**	**$300,000**	**$300,000**
Lower rates of take	Same as Tier 1					
Additional Measures if Hanaula population declines or reintroduction efforts fail	New release pen if required	$150,000				$150,000
	Partial purchase of truck	$10,000				$10,000
	Staffing for on-site monitoring		$20,000	$80,000		$80,000
	Helicopter transport of nene to release site		$2,000	$6,000		$6,000
	Sub-Total	**$160,000**	**$22,000**	**$86,000**	**$0**	**$246,000**
Bat mitigation (Tier 1)	Management			$250,000		**$250,000**
	Bat monitoring at KWP II and vicinity for 5 years		$12,500	$25,000	$37,500	$62,500
	Sub-Total	**$0**	**$12,500**	**$275,000**	**$37,500**	**$312,500**
Tier 2	Increased management			$125,000		$125,000
	Increased site-specific bat studies using enhanced audio-visual technologies to characterize activity levels and document bat interactions at facility	$50,000	$10,000		$50,000	$100,000
	Sub-Total	**$50,000**	**$10,000**	**$125,000**	**$50,000**	**$225,000**
Tier 3	Research				$950,000	$950,000
	Sub-Total	**$0**	**$0**	**$0**	**$950,000**	**$950,000**
Tier 4	Land Protection	$0	$0	$0	$450,000	$450,000
	Sub-Total	**$0**	**$0**	**$0**	**$450,000**	**$450,000**
Measures for Lower Rates of Take	Same as Baseline					
Downed Wildlife Monitoring	Downed wildlife monitoring, oversight and reporting			$525,000	$1,050,000	$1,575,000
	3rd party Proctoring of Searcher Efficiency Trials and QA/QC of take calculations and reporting.			$53,000		$53,000

	Sub-Total	$0	$0	$578,000	$1,050,000	$1,628,000
State Compliance Monitoring	Sub-Total	$0	$12,000	$60,000	$180,000	$240,000
3rd Party Monitoring Contingency	Sub-Total	$0	$0	$525,000	$1,050,000	$1,575,000

Estimated Project Sub-Totals

	Item / Activity	One time Cost	Years 1-5	Remaining 15 Years	20-year Permit Duration
Tier 1	Minimization and General Measures	$85,000	$57,500	$40,000	$182,500
	Seabird Mitigation (Maximum)	$300,000	$156,000	$600,000	$1,056,000
	Nene Mitigation	$0	$172,500	$267,500	$440,000
	Hawaiian Hoary Bat	$0	$275,000	$37,500	$312,500
	Sub-Total	$385,000	$661,000	$945,000	$1,991,000
Tier 2	Minimization	$0	$50,000	$100,000	$150,000
	Seabird Mitigation (Maximum)	$390,000	$186,642	$649,623	$1,057,024
	Nene Mitigation	$0	$0	$150,000	$150,000
	Hawaiian Hoary Bat	$50,000	$125,000	$50,000	$225,000
	Sub-Total	$440,000	$361,642	$949,623	$1,582,024
Tier 3	Nene Mitigation	$0	$0	$300,000	$300,000
	Hawaiian Hoary Bat	$0	$0	$950,000	$950,000
	Sub-Total	$0	$0	$1,250,000	$1,250,000
Tier 4	Hawaiian Hoary Bat	$0	$0	$450,000	$450,000
	Sub-Total	$0	$0	$450,000	$450,000
Contingency Measures	Contingency Measures if Hanaula Nene Population exhibits failure	$160,000	$86,000	$0	$246,000
	3rd Party Monitoring Contingency	$0	$525,000	$1,050,000	$1,575,000
	Sub-Total	$160,000	$611,000	$1,050,000	$1,821,000
Other	Downed Wildlife Monitoring	$0	$578,000	$1,050,000	$1,628,000
	State Compliance Monitoring	$0	$60,000	$180,000	$240,000
	Sub-Total	$0	$638,000	$1,230,000	$1,868,000

Total Including Maximum Cost for Tier 1 Mitigation	$1,991,000
Total Tier 1 + Contingency Measures + Other	$5,680,000
Total for Tier 1+ Tier 2 Take Level of Mitigation+ Contingency Measures+ Other	$7,262,024
Total for Tier 1+ Tier 2+Tier 3+Tier 4 Take Level of Mitigation+ Contingency Measures+ Other	$8,962,024

Appendix 7

BOTANICAL RESOURCES SURVEY

for the

KAHEAWA PASTURES ENERGY PROJECT

UKUMEHAME, MAUI, HAWAII

by

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August 2009

Prepared for:
First Wind Energy, LLC

BOTANICAL RESOURCES SURVEY
Kaheawa Pastures Wind Energy Project

INTRODUCTION

The Kaheawa Pastures Wind Energy Project area lies on lower Kealaloloa Ridge on the southern tip of West Maui between Manawainui Gulch on the west and Malalowaia'ole Gulch on the east. The project area is approximately 276 acres in size TMK (2) 3-6-01:14 (por.). This study has been initiated by First Wind Energy LLC to assess the botanical resources in the area in fulfillment of environmental requirements of the planning process.

SITE DESCRIPTION

Kealaloloa Ridge is a very evenly sloping ridge descending from Hanaula Peak to the sea at a 16% grade. Vegetation is mostly open windblown grasslands with scattered shrubs and trees in gullies. Soils are exclusively characterized as Rocklands (rRK) by the National Resource Conservation Service (Foote et al, 1972). This substrate consists of thin soils formed from gray trachyte lavas of the Honolua Series which overlay the foundational lavas of the West Maui volcano. These lavas weather to platy gray blocks that extend across the entire ridge. This area is quite arid with annual rainfall totaling only about 12 to 20 inches per year (Armstrong, 1983).

BIOLOGICAL HISTORY

In pre-contact times this part of the mountain slope was entirely covered with native vegetation of low stature with dry grass and shrub lands and with a few trees in the gullies. The Hawaiians made some uses of forest resources here and had a cross-island trail cresting the ridge at 1600 ft. elevation. This trail was upgraded during the mid-1800s and used as a horse trail to Lahaina. It was resurrected to use in recent years and is the present Lahaina Pali Trail.

Cattle ranching began in the late 1800s and continued for over 100 years. During this time the grazing animals consumed most of the native vegetation which was gradually replaced by hardy weed species.

During the 1950s high voltage power lines were installed across the mountain along with access roads through this area. Increased traffic brought more disturbances and weeds. Fires became more frequent, further eliminating remnant native vegetation.

With the cessation of cattle grazing a number of grass and weed species have proliferated, creating a heightened fire hazard. Large fires have swept across the mountain consuming thousands of acres including the entire project area several times.

DESCRIPTION OF THE VEGETATION

The vegetation within the project area is a diverse array of grasses and low shrubs with a scattering of small trees in gullies. The most abundant species is buffelgrass (*Cenchrus ciliaris*) which has proliferated following the fires. Also common are Natal redtop (*Melinis repens*), ‘ilima (*Sida fallax*), ‘uhaloa (*Waltheria indica*), lesser snapdragon (*Antirrhinum orontium*) and Jamaica vervain (*Stachytarpheta jamaicensis*). A total of 62 species were recorded during the survey.

Fifteen species of native plants were found on the project area: kumuniu (*Doryopteris decipiens*), (*Cyperus phleoides* var *phleoides*) no common name, kalamalö (*Eragrostis deflexa*), ‘äheahea (*Chenopodium oahuense*), nehe (*Lipochaeta lobata* var. *lobata*), nehe (*Melanthera lavarum*), puakala (*Argemone glauca*), ‘akia (*Wikstroemia oahuensis*), pili grass (*Heteropogon contortus*), koali awahia (*Ipomoea indica*), ‘ilima, ‘uhaloa, naio (*Myoporum sandwicense*), ‘ulei (*Osteomeles anthyllidifoli*a) and ‘a’ali’i (*Dodonaea viscosa*). The remaining 47 plant species were non-native grasses, shrubs and trees.

SURVEY OBJECTIVES

This report summarizes the findings of a botanical survey of the Kaheawa Pastures Wind Energy Project which was conducted in August, 2009.
The objectives of the survey were to:

1. Document what plant species occur on the property or may likely occur in the existing habitat.

2. Document the status and abundance of each species.

3. Determine the presence or likely occurrence of any native plant species, particularly any that are federally listed as Threatened or Endangered. If such occur, identify what features of the habitat may be essential for these species.

4. Determine if the project area contains any special habitats which if lost or altered might result in a significant negative impact on the flora in this part of the island.

5. Note which aspects of the proposed development pose significant concerns for plants and recommend measures that would mitigate or avoid these problems.

SURVEY METHODS

The entire project area was surveyed on foot. Areas on rocky gully slopes and the steep cliffs at the edges of the two large bordering gulches were examined more intensively as these were the places where the most native plants survived both the grazing of cattle and the effects of wildfires. Notes were made on plant species, distribution and abundance as well as on terrain and substrate.

PLANT SPECIES LIST

Following is a checklist of all those vascular plant species inventoried during the field studies. Plant families are arranged alphabetically within three groups: Ferns, Monocots and Dicots. Taxonomy and nomenclature of the ferns are in accordance with Palmer (2003) and the flowering plants are in accordance with Wagner et al. (1999) and Staples and Herbst (2005).

For each species, the following information is provided:

1. Scientific name with author citation

2. Common English or Hawaiian name.

3. Bio-geographical status. The following symbols are used:

   endemic = native only to the Hawaiian Islands; not naturally occurring anywhere else in the world.
   indigenous = native to the Hawaiian Islands and also to one or more other geographic area(s).
   Polynesian introduction = plants introduced to Hawai'i in the course of Polynesian migrations and prior to western contact.
   non-native = all those plants brought to the islands intentionally or accidentally after western contact.

4. Abundance of each species within the project area:

   abundant = forming a major part of the vegetation within the project area.
   common = widely scattered throughout the area or locally abundant within a portion of it.
   uncommon = scattered sparsely throughout the area or occurring in a few small patches.
   rare = only a few isolated individuals within the project area.

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
FERNS			
NEPHROLEPIDACEAE (Sword Fern Family)			
Nephrolepis brownii (Desv.) Hovencamp & Miyam.	Asian sword fern	non-native	rare
PTERIDACEAE (Brake Fern Family)			
Doryopteris decipiens (Hook.) J.Sm.	kumuniu	endemic	rare
Pityrogramma austroamericana Domin	gold fern	non-native	rare
MONOCOTS			
CYPERACEAE (Sedge Family)			
Cyperus phleoides Nees ex Kunth subsp. *phleoides*	-----------------	endemic	rare
POACEAE (Grass Family)			
Andropogon virginicus L.	broomsedge	non-native	rare
Cenchrus ciliaris L.	buffelgrass	non-native	abundant
Cynodon dactylon (L.) Pers.	Bermuda grass	non-native	rare
Eragrostis deflexa Hitchc.	kalamalö	endemic	rare
Heteropogon contortus (L.) P. Beauv. ex Roem & Schult.	pili grass	indigenous	uncommon
Melinis minutiflora P. Beauv.	molasses grass	non-native	rare
Melinis repens (Willd.) Zizka	Natal red-top	non-native	common
Panicum maximum Jacq.	Guinea grass	non-native	rare
Sporobolus africanus (Poir.) Robyns & Tournay	smutgrass	non-native	rare
DICOTS			
AMARANTHACEAE (Amaranth Family)			
Amaranthus spinosus L.	spiny amaranth	non-native	rare
Amaranthus viridis L.	slender amaranth	non-native	rare
Atriplex semibaccata R. Br.	Australian saltbush	non-native	rare
Chenopodium murale L.	'äheahea	non-native	rare

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
Chenopodium oahuense (Meyen) Aellen	'äheahea	endemic	rare
APOCYNACEAE (Dogbane Family)			
Calotropis procera (Aiton) W.T. Aiton	small crown flower	non-native	rare
ASTERACEAE (Sunflower Family)			
Conyza bonariensis (L.) Cronq.	hairy horseweed	non-native	uncommon
Emilia fosbergii Nicolson	red pualele	non-native	uncommon
Lactuca sativa L.	prickly lettuce	non-native	rare
Lipochaeta lobata (Gaud.) DC. var. lobata	nehe	endemic	rare
Melanthera lavarum (Gaud.) Wagner & Rob.	nehe	endemic	uncommon
Senecio madagascariensis Poir.	fireweed	non-native	rare
Sonchus oleraceus L.	pualele	non-native	rare
Tridax procumbens L.	coat buttons	non-native	uncommon
Xanthium strumarium L.	kikania	non-native	rare
Zinnia peruviana L.	zinnia	non-native	rare
BRASSICACEAE (Mustard Family)			
Sisymbrium altissimum L.	tumble mustard	non-native	uncommon
CACTACEAE (Cactus Family)			
Opuntia ficus-indica (L.) Mill.	panini	non-native	rare
CONVOLVULACAE (Morning Glory Family)			
Ipomoea indica (J. Burm.) Merr.	koali awahia	indigenous	rare
EUPHORBIACEAE (Spurge Family)			
Chamaesyce hirta (L.) Millsp.	hairy spurge	non-native	rare
FABACEAE (Pea Family)			
Acacia farnesiana (L.) Willd.	klu	non-native	rare
Chamaecrista nictitans (L.) Moench	partridge pea	non-native	uncommon
Crotalaria incana L.	fuzzy rattlepod	non-native	uncommon

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
Desmanthus pernambucanus (L.) Thellung	slender mimosa	non-native	uncommon
Desmodium incanum DC.	kaimi clover	non-native	rare
Desmodium tortuosum (Sw.) DC.	Florida beggarweed	non-native	rare
Indigofera suffruticosa Mill.	'inikö	non-native	uncommon
Leucaena leucocephala (Lam.) de Wit	koa haole	non-native	uncommon
Macroptilium lathryroides (L.) Urb.	wild bean	non-native	uncommon
Pithecellobium dulce (Roxb.) Benth.	'opiuma	non-native	rare
Prosopis pallida (Humb. & Bonpl. ex Willd.) Kunth	kiawe	non-native	uncommon
GENTIANACEAE (Gentian Family)			
Centaurium erythraea Raf.	bitter herb	non-native	rare
LAMIACEAE (Mint Family)			
Leonotis nepetifolia (L.) R. Br.	lion's ear	non-native	rare
MALVACEAE (Mallow Family)			
Abutilon incanum (Link) Sweet	hoary abutilon	non-native	rare
Sida fallax Walp.	'ilima	indigenous	common
Waltheria indica L.	'uhaloa	indigenous	common
MYOPORACEAE (Myoporum Family)			
Myoporum sandwicense A. Gray	naio	indigenous	rare
PAPAVERACEAE (Poppy Family)			
Argemone glauca (Nutt. ex Prain) Pope	puakala	endemic	rare
PLANTAGINACEAE (Plantain Family)			
Antirrhinum orontium L.	lesser snapdragon	non-native	common
Plantago lanceolata L.	narrow-leaved plantain	non-native	uncommon
PORTULACACEAE (Purslane Family)			
Portulaca oleracea L.	pigweed	non-native	rare

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
Portulaca pilosa L.	------------------	non-native	rare
PROTEACEAE (Protea Family)			
Grevillea robusta A. Cunn. ex R. Br.	silk oak	non-native	rare
ROSACEAE (Rose Family)			
Osteomeles anthyllidifolia	ūlei	indigenous	uncommon
SAPINDACEAE (Soapberry Family)			
Dodonaea viscosa Jacq.	'a'ali'i	indigenous	uncommon
SOLANACEAE (Nightshade Family)			
Solanum lycopersicum L.	cherry tomato	non-native	rare
THYMELAEACEAE ('Akia Family)			
Wikstroemia oahuensis (A. Gray) Rock	'akia	endemic	rare
VERBENACEAE (Verbena Family)			
Lantana camara L.	lantana	non-native	uncommon
Stachytarpheta jamaicensis (L.) Vahl.	Jamaica vervain	non-native	common

DISCUSSION

The construction of additional wind turbines will require the development of additional access roads and the clearing and leveling of construction pads within the 276 acre project area. This will result in the loss of vegetation where these occur. The area in general has experienced a dramatic loss of native plant communities over the last century and there is concern that further losses of rare species and special habitats be avoided. The proposed project was analyzed with these concerns in mind.

Of the 15 native plant species identified on the property none were found to be federally listed as Threatened or Endangered species (USFWS, 2009), nor were any found that are candidates for such status. All but two are widespread and fairly common in Hawaii. (*Lipocheata lobata*) has one Endangered variety from Oahu and one commoner variety (L.l. *var lobata*) known from Niihau, O'ahu and West Maui. The one found in the project area is the commoner variety that has no federal status. (*Eragrostis deflexa*) is a native grass that was presumed to be extinct in the early 1990s. Recent collections, some quite extensive, from West Maui, Lana'i and Kaho'olawe, however, have been identified as (*Eragrostis deflexa*) and this species is not likely to be listed as Endangered. Six populations of this grass were found within the project area along the rocky edges of the two large gulches.

Of the 15 native plant species found in the project area were most prevalent in the rocky habitat bordering Manawainui and Malalowaia'ole Gulches. This is due to the fact that these area were less accessible to grazing cattle over the years, and to the fact that these rather barren, rocky area are less susceptible to the effects of fires. The three hardiest native species 'ilima, 'uhaloa and 'a'ali'i that are more prevalent on the flatter grassy ridge tops, are the most likely to be impacted by road construction and the leveling of tower pads. These are three of the commonest native dryland plants in all of Hawaii.

It is likely that periodic fires will continue to be a problem into the forseeable future. The area has been nearly completely overtaken by buffelgrass, a highly flammable, fire-adapted species that is quick to recover following wildfires. Meanwhile, each fire destroys more and more of even the hardiest native plants. Unless land management practices change dramatically across this dry mountain slope, little improvement in this prognosis is likely.

Previous botanical surveys on this southern tip for West Maui have identified a few Endangered species growing in gulches about two miles upslope of this project area. This area is remote from these populations and is in a habitat completely unsuitable for their growth and survival. This project is not expected to negatively impact any of these species.

Due to the general condition of the habitat and the specific lack of any environmentally sensitive native plant species or habitats on or near the project area, the proposed development work is not expected to result in any significant negative impact on the botanical resources in this part of Maui.

RECOMMENDATIONS

The quality of the roads created will have a long term effect on surrounding habitat. Poorly engineered roads in this entire project area quickly erode causing downslope disturbances from moving water and road materials. They have the added effect of necessitating frequent maintenance work resulting in further disturbances. It is recommended that the road surfaces be crowned and rolled with stable material, and that swales, drains and culverts be engineered to channel water from the roadway quickly and effectively.

It is desirable that the incidence of wildfires be minimized because of their devastating long term effects on native plant resources. Fuels in this area are highly flammable. One way to minimize fire here is to limit human access along the road corridor to only those with management or other legitimate functions.

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Appendix 8

KAHEAWA WIND POWER II:
POST-CONSTRUCTION REVEGETATION/RESTORATION PLAN

April 2010

I. Introduction

Kaheawa Wind Power II, LLC (KWP II) proposes to construct and operate a new 21-megawatt (MW) wind energy generation facility at Kaheawa Pastures above Mā‛alaea in the southwestern portion of the Island of Maui, Hawai‛i. The proposed project is situated on approximately 143 acres (58 ha) of State Conservation District Land southeast of the existing 30-MW Kaheawa Wind Power (KWP) project operated and owned by Kaheawa Wind Power LLC (KWP LLC) (KWP II 2009). The proposed project location is referred to as the Downroad Siting Area (Planning Solutions, Inc. 2009).

The area to be disturbed during construction of the KWP II facility is former pasture that was converted from native plant communities well over 100 years ago, and is currently dominated by a mixture of native and non-native grasses and low shrubs with scattered small trees. The area is prone to periodic wildfires, which suppress native plants and favor the spread of non-native, fire-tolerant grasses. Several native plant species are widely scattered throughout the project area, mixed among the non-native grasses (Hobdy 2009b). Native plants are more prevalent at higher elevations of Kaheawa Pastures and in the rocky habitat bordering Manawainui and Malalowaiaole Gulches (Hobdy 2009a, 2009b, 2010).

Construction of the proposed KWP II facility will disturb approximately 43 ac (17 ha) of land. Approximately one third of the disturbed area will be revegetated upon completion of earthwork. Areas suitable for stabilization by revegetation include cut and fill slopes and road cuts. Turbine pads, as well as some portion of the road cuts, will be stabilized with hard materials (e.g., rip-rap and compacted gravel) rather than vegetation in order to ensure stability or increase searchability of turbine plots for downed wildlife.

This plan describes the goals, methods, monitoring, and success criteria for revegetation of areas temporarily disturbed during the construction of KWP II. This plan is intended to meet the dual goals of 1) stabilizing disturbed areas immediately following construction, and 2) re-introducing and establishing several native plant species throughout the site as a longer-term effort. Most elements of this plan involve the application of Best Management Practices (BMPs) and are derived from experiences and lessons learned at the adjacent KWP project site, which underwent construction in early 2006, and which has a comparable plant ecological history.

II. Existing Conditions

The proposed KWP II project area is located in an area known locally as Kaheawa Pastures, on the southern slope of the West Maui Mountains between 695 and 1,825 ft elevation (212 and 556 m). The project area is approximately 4 miles (6.4 km) mauka (inland) of McGregor Point. It is located in the General subzone of the State Conservation District to the southeast of the existing 30-MW KWP facility along the existing access road (Downroad Siting Area). Kealaloloa Ridge, situated immediately northeast of Malalowaiaole Gulch, separates the project area from the isthmus of Maui to the east.

Average annual rainfall at the proposed project area ranges from less than 15 inches (38 cm) per year at the Honoapi‛ilani Highway/site access road intersection to slightly over 40 inches (102 cm) per year at the uppermost portion of the existing wind facility (3,200 ft or 975 m). Most of the rainfall occurs during winter months (80+ percent from November through April).

Botanical surveys of the proposed KWP II area were conducted by Robert Hobdy in August 2009 and January 2010. The vegetation is mostly grasses and low-growing shrubs, with occasional small trees in the wetter gullies. The most abundant species in the project area is non-native buffelgrass (*Cenchrus ciliaris*), which proliferated after the fires in 1999 (Hobdy 2009a). Hobdy identified a total of 24 plants native to the Hawaiian Islands, which are widely scattered throughout the area. No state or federally threatened, endangered, or candidate species were found during his surveys.

III. Background of Revegetation Efforts at KWP

Because of the proximity and similarity of the landscape at the two facilities, the proposed KWP II facility will rely heavily on the lessons learned at KWP. The amended Conservation District Use Permit (CDUP MA-3103) granted to KWP by the Board of Land and Natural Resources (BLNR) on 24 June 2005 contained the following conditions related to revegetation:

20. *"All cleared areas shall be revegetated in a manner consistent with other permit conditions, with specific consideration given to the fire contingency plan and the Habitat Conservation Plan. Any necessary revegetation shall be completed within thirty days of the completion of specific project components that resulted in ground clearing, using native species found in the area;"*

37. *"The applicant shall ensure that operations and maintenance staff do not damage native plants. If construction or operation required the removal of native plants, the plants will be removed, relocated and replanted. The applicant shall pay for the cost of this effort;"*

38. *"The applicant shall work with plant experts to introduce appropriate native plant species back into the Kaheawa Pastures;"*

Similar conditions were required in the National Pollutant Discharge Elimination System (NPDES) General Permit for the KWP project area:

- *"Temporary soil stabilization with appropriate vegetation will be applied to areas remaining unfinished for more than 30 days; and*

- *Permanent soil stabilization will be applied as soon as practical after final grading. Contractor will coordinate with the Department of Land and Natural Resources (DLNR) regarding selection of appropriate vegetation as a condition of the Conservation District Use Permit."*

After extensive research and efforts at seeking source materials, KWP biologists concluded that establishing vegetation within 30 days by seeding with native species (per Condition 20) was not feasible due to the unavailability of native species in sufficient commercial quantities. Currently, the Hawaiʻi Department of Transportation is working with the Federal Highway Administration on a three-year research project to develop native grass mixes and hydro-seeding techniques for use on civil projects in Hawaiʻi (Dacus, pers. comm.). However, techniques have not yet been developed in Hawaiʻi for hydro-seeding or broadcasting with native seed mixes on a large scale.

In the *Response to October 27, 2005 Letter Regarding the Establishment of Stabilizing Vegetation Cover for Erosion and Sediment Control Related to Wind Farm Access Road Construction*, the State of Hawaiʻi Department of Land and Natural Resources (DLNR) authorized KWP's request to apply commercially available annual ryegrass (*Lolium multiflorum*) in order to comply with permit conditions of the CDUP and the NPDES permit, given the following conditions:

1. *"The permittee shall acquire commercial quantities of native pili grass bundles or other native species as soon as possible to substitute the annual rye; and*

2. *The permittee is responsible for controlling the annual rye if it starts invading adjacent State lands."*

KWP subsequently established a conservation partnership with the USDA/NRCS to obtain native pili grass (*Heteropogon contortus*) from the U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS) Plant Materials Center on Molokaʻi. This partnership resulted in field trials to test the ability to establish pili grass at KWP using seed and bales. Following several treatments, it was determined that while it is possible to establish pili grass in limited quantities, and over several months, it probably cannot be expected to meet rapid, site-wide ground cover re-establishment requirements.

Following the trials with pili grass, KWP petitioned DLNR and the Office of Conservation of Coastal Lands (OCCL) to consider allowing manual application and hydro-seeding with a grass seed mixture to accomplish site revegetation goals. DLNR officials in the Division of Forestry and Wildlife (DOFAW) provided comments on this proposal, citing that annual ryegrass is expected to die off and provide a more suitable environment for recruitment by adjacent species. DOFAW expressed interest in limiting the amount of emergent grass in the immediate vicinity of turbines, a recommendation intended to minimize the attraction of Nēnē, which are common in the area and browse on a wide range of emergent vegetation types. KWP biologists have documented that Nēnē are prevalent in the area and currently use the areas in proximity to the existing turbines on a regular (i.e., almost daily) basis. Thus, revegetating bare areas with grasses is not expected to pose an additional risk of bird collisions.

At the same time, KWP biologists have had considerable success at re-introducing native plants grown in the nursery at various locations throughout the site, including along cut and fill slopes and other open earth portions of the roadsides and turbine pads. Although these plantings do not provide a uniform stabilizing cover *per se*, it does appear that they will, over several seasons, come to dominate the areas treated. Between July 2007 and June 2008, approximately 7,500 young a‘ali‘i (*Dodonaea viscosa*) were propagated from seed collected at Kaheawa and planted along cut and fill slopes and other open earth portions of the roadsides and turbine pads. An intensive outplanting effort comprising nearly 16,000 individual plants of several key native species occurred during the winter and spring of 2009 at KWP.

IV. Revegetation Goals

The goals of the revegetation plan for KWP II are based on the relevant CDUP and NPDES permit conditions for KWP, as well as experiences and lessons learned at KWP.

The proposed revegetation strategy for KWP II has two goals:

1. Address the immediate requirement of stabilizing exposed soils following construction activities at KWP II, in accordance with erosion and sedimentation control BMPs and NPDES stormwater discharge permitting requirements; and

2. Re-introduce native plant species in selected areas throughout the site over several years, with the goal of re-establishing native plant species in areas that have been overgrown with non-native species for a century or more.

V. Revegetation Methods

KWP II biologists will work alongside the DLNR-DOFAW specialists to ensure that revegetation methods consider and incorporate all wildlife, forestry, fire, and rangeland concerns and are in alignment with the management provisions of the Conservation District. All revegetation material brought to the project area (e.g. seed mixes, sand, gravel, rock, and mulch) will be certified as weed free by the Hawai‘i Department of Agriculture (HDOA) prior to entering the project area.

KWP II will work with construction contractors to ensure that slopes are not excessively compacted so as to inhibit establishment of vegetation. No other site preparation (e.g. weeding, adding soil amendments, etc.) is anticipated to be necessary prior to revegetation.

<u>Hydroseeding (*Goal 1*):</u>

KWP II biologists propose to hydroseed disturbed areas along the edges of turbine pads and along road cuts and fill slopes with annual ryegrass to establish an initial cover of vegetation after ground shaping and grading activities have been completed (Figure 1). Annual ryegrass was selected for erosion control because it provides rapid initial vegetation cover and forms an extensive, dense root system (Valenzuela and Smith 2002). This species is expected to gradually die back and allow natural recruitment of neighboring species or species present in the seed bank (DOFAW, personal communication). Hydroseeding with annual ryegrass will require supplemental irrigation for a 90-day period and monitoring to ensure establishment of stabilizing cover.

<u>Erosion Mats and Hard Materials (*Goal 1*):</u>

Excessively steep areas may require additional erosion control to achieve the immediate goal of stabilizing exposed soils and preventing erosion. For example, certain sections of the site may require the use of organic coir or jute mats and/or coir logs to reduce water flow velocity and capture sediments and seed material during periods of seasonal rainfall. The mats or logs will be secured in place along steep fill slopes and grades to provide temporary erosion control during the initial establishment period and further contribute to ground cover establishment. In addition, some portion of the disturbed area (particularly the turbine pads) will be stabilized with hard materials (e.g., rip-rap, compacted gravel) rather than vegetation in order to ensure stability and facilitate monitoring of turbine plots for downed wildlife. The use of these materials will be evaluated in consultation with DLNR and the U.S. Fish and Wildlife Service (USFWS), and implemented according to site-specific considerations.

<u>Outplanting (*Goal 2*):</u>

To accomplish the long-term goal, KWP II biologists propose to re-introduce native plants in discrete locations over several years, with the intent of eventually re-establishing some of the key elements of the plant communities that historically existed on the site (Figure 2). This phase will involve collecting native seeds and cuttings in the area, propagating these species at local nurseries, and subsequently outplanting these species at the site.

Native species that may potentially be used during this phase include ʽaʽaliʽi (*Dodonaea viscosa*), pili grass (*Heteropogon contortus*), ʽūlei (*Osteomeles anthyllidifolia*), and ʽilima (*Sida fallax*). These relatively fast-growing and easily propagated species provide excellent root structure for maintaining surface substrate retention, as well as provide a native seed source for the project area. Pili grass and ʽaʽaliʽi are particularly appropriate for Kaheawa Pastures because these species area among the few native Hawaiian plants shown to be fire tolerant (Tunison et al. 1994, Loh et al. 2009).

The specific species, sizes, densities, and location of native outplantings will be determined based on site-specific factors such as slope, erosion potential, and substrate. Due to physical constraints of the site (i.e. the presence of surface bedrock material), KWP II LLC may concentrate native outplants outside of the area disturbed during construction (i.e. near the puʽu). This location will be determined in consultation with DLNR, USFWS, and a revegetation/restoration specialist.

Because this phase will occur after the immediate revegetation phase, many of these plantings will be installed in or adjacent to areas that were previously stabilized with the annual ryegrass mixture and temporary measures (e.g., coir mats and logs). In certain cases, it may be necessary to remove or control undesirable non-native species, either manually or with the assistance of an approved herbicide. Any use of herbicides will be done only in consultation with DLNR, and only in accordance with applicable restrictions on handling and use.

KWP II biologists plan to approach this phase of the site revegetation plan in a manner that emulates the successful native plant reintroduction efforts at KWP. KWP II will work in collaboration with KWP to share resources and coordinate logistics.

VI. Timeline

Construction of the access roads and turbine foundations is anticipated to begin shortly after issuance of the Federal Incidental Take Permit (ITP) and State Incidental Take License (ITL). Revegetation of temporarily disturbed area with annual ryegrass will begin as soon as possible immediately after construction of the access roads and turbine foundations. Outplanting with native species will occur during the first several years of the project. Some species will be outplanted immediately after hydroseeding with annual ryegrass to take advantage of irrigation.

VII. Monitoring and Success Criteria

Regular irrigation and monitoring will be necessary at KWP II to ensure that immediate revegetation measures are successful. Young grasses and seedlings are especially vulnerable to root damage in the absence of rain or watering. All hydroseeded areas will be monitored and irrigated for a 90-day period following hydroseeding. The revegetation/restoration contractor shall provide sufficient irrigation during this period to assure adequate survival.

This phase of the project will be considered successful if it can be demonstrated that >75% of the bare areas, fill slopes, and road cut segments that receive treatment have established cover within one year following treatment. If initial applications appear to be only partially successful, subsequent hand and/or hydro-seeding applications or additional temporary measures (e.g., matting or logs) may be installed to ensure adequate coverage and erosion control.

The longer term revegetation efforts at KWP II are expected to be very successful given the success at KWP. A well-established seed collection and propagation program exists in cooperation with local nurseries, other native plant specialists, contract landscape specialists, and volunteers. Plants will be outplanted and maintained, monitored, and documented using resources available at KWP II and in collaboration with community and conservation groups. This effort will be considered to be successful if a minimum of 5,000 individual plants are installed during the first three years following construction, with an average survival rate of greater than 75% (i.e., a minimum of 3,750 surviving plants), for all plants one year after installation, as determined by representative sampling of planted areas. If mortality exceeds 25%, replacement plantings will be installed as needed to achieve the 75% minimum.

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Figure 1. Mechanized hydroseeding along a bare road cut during immediate site revegetation and soil stabilization efforts following construction at KWP.

Figure 2. Several native plant species successfully outplanted at KWP as part of long-term revegetation efforts.

Appendix 9

An Assessment of Hawaiian Native Molluscan Fauna of the lower Kaheawa Pasture, West Maui, Hawai‘i

TMK (2) 3-6-01 : 14

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Introduction:

The terrestrial molluscan fauna of Hawai‘i is in a state of catastrophic decline in which hundreds of species and an endemic family are in danger of extinction. Hawai‘i's molluscs evolved in isolation with an ecological naivety that has left them extremely vulnerable to environmental change, and a low fecundity that has not allowed them to recover from the pressures exerted by introduced predators. During the late 20th century perhaps as many as two-thirds of the living species described in the 19th and early 20th centuries became rare or extinct.

This survey was commissioned by First Wind to determine if any species of native Hawaiian snails, particularly those species listed by federal or state agencies as threatened, endangered, or of substantial conservation concern, remain within or along the borders of the lower Kaheawa Pasture, and if so what steps should be taken to insure their continued survival.

During the survey rock talus and grasses were searched for living snails, and soil samples were screened for living and dead snails to 1 mm in diameter. Two species of extant snails were located representing two families – one, an undescribed species of Vertiginidae, the other a species of Succinidae.

Site Description:

The lower Kaheawa Pasture lies in the Lahaina District in the ahupua‘a of Ukumehame and is defined by the upper reaches of Manawainui Gulch on the southwest and by Malalowaia‘ole Gulch on the north. The area surveyed was located between these two gulches and consisted of a gently undulating pasture with a slight slope of 17 degrees and the upper edges of the gulches themselves. The elevation range was approximately 258 - 577 meters. Much of the pasture was burned in 2006 in the most recent of many wind-driven fires that consumed the vegetation on the gulch slopes and the flat, grass-covered pasture.

Remnants of an old road snake up the pasture on the southwest side of the First Wind access road which lies to the north of the approximate center of much of the survey area. Along the upper edges of the gulches that define the survey area are periodic rock outcroppings, low rock cliffs and rock talus, the latter being generally overgrown with taller grass than that seen in the pasture. These talus areas are of particular interest because they form good dryland snail habitat as well as offer the potential to find semi-fossil snail shells, which might indicate the presence of species not encountered alive during the survey or species that may have existed in the survey area prior to the activity of First Wind.

At the time of the survey the top of the pasture was covered with a knee-high grass and sporadic woody shrubs, many of which were blackened and appeared to be recovering from the last fire in 2006. The substrate is a hard packed sun-dried soil covered with loose rocks. Occasional rock outcroppings are scattered throughout the pasture and appear to be remnants of the volcanic flows that cap what is now the ridge.

Biological History and Potential:

Prior to European contact much of the pasture was probably covered in woody shrubs and trees of the Hawaiian low elevation dryland forest; grasses; and occasional ferns, with the horizontally growing uluhe fern probably being found in the highest elevation surveyed. Little or no habitat would have been available for arboreal snails; however, ground-dwelling snails were found in similar dryland habitats statewide and some are still extant in other such areas on Maui.

There is no record of land snails having been found in the area of the survey; however, based on previous collections of Hawaiian dryland snails, species of the following four families might have been present at one time.

Species of the family Succinidae are known from similar dryland habitat on the lower western slopes of Haleakala; a species of Endodontidae is known from fresh dead shells collected in a small gulch on the Lahaina side of West Maui several miles from the survey area; species of ground-dwelling Achatinellidae are known to exist at the base of grasses on some of the dry, remnant islands of the northwestern Hawaiian chain and were no doubt found in similar habitat throughout the Hawaiian Islands; and species of Vertiginidae are known to have inhabited grass and leaf litter in dryland areas throughout the island chain.

An extensive search of the literature, however, showed no indication that species from these families have ever been collected from the survey area. If snails had been collected in the survey area they were probably species already known to early collectors from other areas and thus were not considered of interest.

Survey Objectives:

This survey and report were initiated out of concern that there may be native snail populations within, or reasonably close to, the lower Kaheawa Pasture region and proposed Kaheawa Wind Power facility. The objectives were to determine if any native land snail species were present in the survey area, to identify them and to try to determine their habitat. Another objective was to look for semi-fossil shells protected beneath rocks or buried in the soil, which could indicate what species might have been present in the area at one time.

Habitat Requirements:

The habitats preferred by the Hawaiian lowland molluscan fauna are determined by available vegetation and moisture. Considering the sparse vegetation and dry conditions of the survey area the search for living land snails was restricted to rock talus, rock cliffs and other rocky features scattered in the pasture where the roots of grasses help maintain moisture beneath the rocks and deep in cracks. This kind of habitat is common along the upper edges of the defining gulches but uncommon in the open pasture.

Method:

A preliminary examination and initial survey of the area showed that the best habitat existed along the edge of the gulch on the windward side of the survey area. A series of stations was established based on available habitat along the upper edge of the gulch and a transect determined by the elevational contour of each station was followed horizontally across the pasture, as Hawaiian snails are known to be sensitive to elevation on the steep slopes of West Maui.

Species Discovered:

Of the four potential families expected to be found in the survey area, two families had living representatives and two families did not. As expected, both species were found in protected, moist habitat beneath rocks.

The Succinid, ***Succinea mauiensis*** Ancey, 1889, is present throughout the pasture within undisturbed rock outcroppings where it attaches to the moist undersides of closely-packed rocks or in the root mat of grasses beneath the rocks. It was not found beneath the loose surface rocks which litter the pasture but have no root mat.

This species is known to have a wide range in dry habitat on East and West Maui. The *S. mauiensis* present in the survey area were uncommon in the pasture compared to the upper edges of the gulches. One live specimen was collected and preserved in an RNA/Later solution for further study, and dead specimens were collected when encountered for identification purposes.

In addition to the Succinid, an undescribed species of Vertiginidae of the genus ***Nesopupa*** was discovered in similar habitat. This new species was seen in only one location along the upper edge of Malalowaiaʻole Gulch at an elevation of 446 meters and represents a fifth species of the genus to be found on Maui.

After the initial discovery of the first specimen a one-square-meter area was examined closely on two occasions. A total of 9 *Nesopupa* specimens were collected including four fresh fragments, four intact dead shells and one live specimen. The live specimen was collected for descriptive purposes. One other live specimen was noted and left.

Conservation Relevance:

In general dryland species appear to have an advantage in surviving the introduced predatory snails which have devastated the native molluscan fauna because their preferred habitat is too dry for these predators to survive. In addition, the habitat of the two living species found within the survey area has proven to be resilient, as it has apparently survived 100 years of grazing cattle and periodic fires.

Discussion:

Finding lowland snails in the survey area was not a surprise, though finding an undescribed species of ***Nesopupa*** was, and indicated that the area has never been thoroughly explored for Hawaiian snails.

The two species found in the survey area are numerous when located. Thus, there is reason to believe that both species may exist in similar habitats beyond the boundaries of the property surveyed on neighboring ridges and in neighboring gulches.

Of the two species located during the survey, only ***Succinea mauiensis*** is found in the area proposed to be developed, and then only in several rock outcroppings associated with small ravines scattered within the pasture. The undescribed ***Nesopupa sp.*** is found in an area not scheduled to be developed.

For these reasons careful planning and caution should suffice to protect these species. In fact, they may eventually prosper as the use of the pasture becomes stabilized, is protected more vigorously from fires and is regulated by First Wind.

The attention First Wind has given to this important but devastated aspect of Hawaiian biology is commendable, but it appears that years of abuse of the land prior to First Wind has destroyed much of the habitat available to these snails, reducing the potential habitat for living snails to islands of rock outcroppings. More than 99% of the land within the survey area is now completely devoid of snails and their habitat.

Conclusion:

First Wind has shown by this survey that the degradation of an area through decades of grazing and periodic fires was no reason to ignore the possibility that endemic Hawaiian snails and their micro-habitat might yet survive. This prudence has not only demonstrated snails can and do survive in extreme conditions, but that new species may yet be discovered where least expected, adding more to our knowledge of this fragile fauna.

GPS Coordinates:

GPS coordinates are given here for the five stations along Malalowaiaʻole Gulch and the species found at each.

20˚48.224 – 156˚32.409 No snails present. Elevation 577 meters.
20˚47.706 – 156˚32.145 ***Nesopupa n. sp.*** and ***Succinea mauiensis*** Ancey, 1889. Elevation 446 meters.
20˚47.537 – 156˚31.996 ***Succinea mauiensis*** Ancey, 1889. Elevation 350 meters.
20˚47.335 – 156˚31.855 No snails present. Elevation 282 meters.
20˚47.275 – 156˚31.832 meters. ***Succinea mauiensis*** Ancey, 1889. Elevation 256 meters.

Species Analysis:

Family Succinidae
Succinea mauiensis Ancey, 1889 was compared with an image of a specimen from the Museum of Comparative Zoology at Harvard, MCZ# 039616 (possible lectotype).

Family Vertiginidae
Nesopupa n. sp. was compared with the following Nesopupa which represent all the known species from Maui, Kahoʻolawe, Lanaʻi and Molokaʻi.

Nesopupa (Nesopupilla) baldwini Ancey, 1904
1.2 mm. Maui. MCZ 078790 Paratype.

Nesopupa (Nesopupilla) baldwini lanaiensis Pilsbry & Cooke, 1920
1.6 mm. Lanaʻi. MCZ 078778 Paratype.

Nesopupa (Nesopupilla) baldwini subcostata Pilsbry & Cooke, 1920
1.5 mm. Molokaʻi. MCZ 180174.

Nesopupa (Infranesopupa) bishopi Cooke & Pilsbry, 1920
2.15 mm. Maui. BPBM 12465 Holotype.

Nesopupa (Nesopupilla) dispersa Cooke & Pilsbry, 1920
1.4 mm. Kahoʻolawe. MCZ 078785 Paratype.

Nesopupa (Infranesopupa) dubitabilis Cooke & Pilsbry, 1920
1.2 mm. Molokaʻi. MCZ 078797 Paratype.

Nesopupa (Limbatipupa) newcombi (Pfeiffer, 1853)
1.3 mm. Lanaʻi. MCZ 045244 Lectotype.

Nesopupa (Limbatipupa) newcombi seminulum (Boettger, 1881)
1.2 mm. Molokaʻi. MCZ 180179.

Nesopupa (Infranesopupa) limatula Cooke & Pilsbry, 1920
1 mm. Maui. ANSP 44692 Paratype.

Nesopupa (Limbatipupa) singularis Cooke & Pilsbry, 1920
1.0 mm. Maui. ANSP 44697.

Nesopupa (Nesodagys) wesleyana rhadina Cooke & Pilsbry, 1920
2 mm. Molokaʻi. MCZ 078793 Paratype.

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Appendix 10

Calculating Total Direct Take

Monitoring efforts at KWP II as prescribed in the KWP II HCP will result in identification of "observed" mortality, which is a statistical sampling of all mortality directly attributable to project operations. Identifying the total mortality (or "total direct take") requires accounting for individuals that may be killed by collision with project components but that are not found by searchers for various reasons, including heavy vegetation cover and scavenging. The calculation for estimating total direct take is:

Total Direct Take = Observed Direct Take + Unobserved Direct Take

Searcher efficiency (SEEF) trials and scavenger trials are conducted to arrive at estimates of unobserved direct take (See Appendix 2). SEEF trials measure how effective searchers are in finding carcasses within the search areas and scavenger trials measure the length of time carcasses remain in the field before being removed by scavengers. Scavenger trials are often used to determine the frequency at which turbines and met towers can be searched to maximize the likelihood of searchers detecting carcasses while maintaining a cost-effective survey schedule. Factors to be considered for SEEF trials and scavenger trials for KWP II include season, carcass size, and vegetation type.

Numerous estimators have been developed for the calculation of unobserved direct take. The variables these estimators often include are SEEF, search intervals, and carcass retention rates within the search intervals. Newer estimators are frequently incremental improvements over older estimators as biases and deficiencies of each estimator become clearer as data accumulates. KWP II, LLC examined three estimators, Shoenfeld (2004), Jain (2007), and Huso (2008), in the development of the calculation to be used for determination of total direct take for its project.

The estimators are presented below:

Estimator by Shoenfeld (2004)

$$m = \left(\frac{N * I * C}{k * t * p}\right)\left(\frac{e^{I/t} - 1 + p}{e^{I/t} - 1}\right)$$

N= total number of turbines
I = interval between searches in days
C = total number of carcasses detected for the period of study (total direct take)
k= number of turbines sampled
t = mean carcass removal time in days
p = searcher efficiency (proportion of carcasses found)
e = natural log

Shoenfeld (2004) and its derivatives were found to bias total direct take calculations low as carcass retention rates (t) increased, particularly when search intervals (I) were small (Smallwood 2007, Huso 2008a, b). The weakness of the estimator resulted from the t/I not being a good estimate of scavenger efficiency (or proportion of carcasses remaining) and this bias also became more pronounced as searcher efficiency (p) became low (Huso 2008a, b).

Estimator by Jain (2007)

$$`C = \frac{C}{S_c \times S_e \times P_s}$$

`C = total number of carcasses for the period of study (total direct take)

C = number of carcasses found

S_c = scavenger efficiency (proportion of carcasses remaining)

S_e = searcher efficiency (proportion of carcasses found)

P_s = proportion of towers searched

Jain (2007) tried to avoid the bias present in the Shoenfeld (2004) estimator by directly incorporating scavenger efficiency or proportion of carcasses remaining (S_e) into his proposed estimator. Jain (2007) assumed that carcasses had equal probability of occurring on any day between search intervals, thus the average number of days a carcass was present was half the number of days between searches and S_e was determined empirically in scavenger trials for a specified time period (in this case half the search interval). This method proposed for determining S_e is fairly simplistic as scavenger efficiency is non-linear but approximates a logarithmic function (Smallwood 2007). Methods to estimate S_e have subsequently been improved on by Huso (2008a, b).

Estimator by Huso (2008)

$$\hat{m}_{ij} = \frac{c_{ij}}{\hat{r}_{ij}\hat{p}_{ij}\hat{e}_{ij}}$$

$\mathbf{m_{ij}}$ = estimated total direct take at turbine *i* over interval *j*

$\mathbf{c_{ij}}$ = observed direct take

$\mathbf{r_{ij}}$ = estimated proportion of carcasses remaining after scavenging

$\mathbf{p_{ij}}$ = estimated searcher efficiency (proportion of carcasses found)

$\mathbf{e_{ij}}$ = effective search interval

The recently introduced estimator by Huso (2008a, b) has several improvements over the previous two estimators. For estimating the scavenger efficiency or the proportion of carcasses remaining within a specified search interval (r_{ij}), Huso (2008a, b) accounts for the logarithmic nature of carcass removal, and also accounts for the removal of older carcasses over time while newer carcasses are being simultaneously deposited during the search interval. Huso (2008) has further developed methods to determine effective search intervals (e_{ij}) for cases where search intervals are much longer than the estimated carcass retention times (i.e. carcasses deposited early on in the search interval are 99% removed by scavengers before the subsequent search). Simulations run to determine the degree of bias for the different estimators has shown that the Huso (2008a, b) estimator is the least susceptible to bias over a wide range of values for each variable and is currently the most precise of the commonly used estimators (Huso 2008a, b).

Estimating Total Direct Take at KWP II

In the light of the recent improvements to estimators for calculating total direct take, KWP II, LLC proposes to apply the Huso (2008a, b) estimator to the monitoring protocol proposed for KWP II in Appendix 2. Three factors will be considered for scavenger trials and SEEF trials - season, carcass size, and vegetation type. The values obtained from the scavenger and SEEF trials will then be applied to the Huso (2008a, b) estimator using the following protocol:

1. Determine proportion of different vegetation types (bare ground, grass) under all turbines combined for search area less than 75% turbine height. Please see Appendix 2 for the definition of search areas.

2. Conduct SEEF trials for each vegetation type. Calculate variances for SEEF trials for each vegetation type per season. Conduct statistical tests to determine if searcher efficiency varies with vegetation type. Pool SEEF values for vegetation types that are not significantly different.

3. Determine mean carcass removal time for each vegetation type. Calculate variances for carcass removal time for each vegetation type per season. Conduct statistical tests to determine if carcass removal rates vary with vegetation type. Pool carcass removal rates for vegetation types that are not significantly different.

4. Determine effective search interval for each carcass size for each vegetation type.

5. Apply values to Huso (2008a, b) formula for 75% search areas (see example).

6. Methods to determine variances and confidence intervals for total direct take are currently being developed by M. Huso (Huso 2008a, Huso pers. comm.). When such methods become available, KWP II will apply confidence intervals to the estimated total direct take.

An example of using Huso (2008) to calculate total direct take of a medium-sized bird (Hawaiian petrel) for one season (Summer and Fall combined, June - November) is presented. For illustrative purposes, an observed take of two petrels within the 75% search area. The theoretical search protocol is as follows:

All 14 turbines on site will be searched weekly (7-day intervals) to 75% turbine height.

Example of Calculation of Direct Take Using Huso (2009) for Hawaiian Petrel in Summer

Main equation

$$\hat{m}_{ij} = \frac{c_{ij}}{\hat{r}_{ij}\hat{p}_{ij}\hat{e}_{ij}}$$

Eq 1

$$If\ f(x) = \lambda e^{-\lambda x};\ S(x) = e^{-\lambda x}$$

Eq 2

$$d_{99} = \min(x : S(x) = 0.01, I),\ \hat{e} = \frac{d_{99}}{I}$$

Eq 3

$$\hat{\lambda} = 1/\bar{t};$$

Eq 4

$$\hat{r} = \frac{\int_0^{d_{99}} e^{-\lambda x} dx}{d_{99}} = \frac{(1 - e^{-\lambda d_{99}})}{\lambda d_{99}}$$

m_{ij}	estimated mortality
r_{ij}	estimated proportion of carcasses remaining after scavenging
p_{ij}	estimated searcher efficiency
c_{ij}	observed take
I	search interval
e_{ij}	effective search interval
d_{99}	days to 99% of carcasses removed
t	mean carcass retention time (scavengers)

Example of Calculation of Direct Take Using Huso (2009) for Hawaiian Petrel in Summer

Season	**Winter**		
Search area	**75% turbine height**		
Vegetation type	**bare ground**	**grass**	**unsearchable**
Proportion	0.75	0.20	0.05
Petrel Size (SEEF) likelihood of detection (p_{ij})	1.00	0.81	
Mean Carcass removal time (t) (days)	11	11	
No of carcasses (c_{ij})	1	1	
λ (Eq3)	0.09	0.09	
d_{99}	49.28	49.28	
I	7	7	
d_{99} (Eq 2 applied)	7	7	
e_{ij}	1	1	
Eq4			
λd_{99}	0.63	0.63	
r_{ij}	0.74	0.74	
m_{ij}	1.34	1.66	
total mortality	3.01		
total mortaity including unsearchable areas (= total mortality + (total mortality x 0.05))	3.16		

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Appendix 11

Seabird Mitigation:

Makamakaʻole Seabird Mitigation and Management Plan (with KWP and KWP II)

Calendar Year	Task/Item	By	Estimated Cost ($1,000s)	Project Share	
				KWP	**KWP II**
2011	• Permit application review and processing • Solicit bids/select contractor • Follow-up reconnaissance/construction planning	Project Staff/ Consultant	50	25	25
2012	• Fence construction • Intensive predator trapping/bait boxes • Social attraction and artificial burrows • Monitoring • Field investigation for contingencies	Project Staff/ Interns	260	130	130
2013	• Continue bait boxes • Social attraction and artificial burrows • Monitoring • Field investigation for contingencies	Project Staff/ Interns	48	24	24
2014	• Inspections (fence/predator) • Bait boxes • Social attraction and artificial burrows • Monitoring • Field investigation for contingencies	Project Staff/ Interns	48	24	24
2015	• Inspections (fence/predator) • Bait boxes • Social attraction and artificial burrows • Monitoring • Field investigation for contingencies	Project Staff/ Interns	48	24	24
2016	• Inspections (fence/predator) • Bait boxes • Social attraction and artificial burrows • Monitoring • Field investigation for contingencies • Assessment of first five years, projection of expected credit accrual	Project Staff/ Interns	48	24	24
2017-2031 *(KWP permit expires 2026)*	• Social attraction continues • Inspections (fence/predator) • Bait boxes • $30,000/yr for 15 years	Project Staff/ Interns	450	225	225
		Totals	**952**	**476**	**476**

Seabird Mitigation Alternative :
Multi-Project Plan for Hawaiian Petrel at Haleakala National Park and Newell's Shearwater on Maui/Molokai/Lanai

Calendar Year	Task/Item	By	Estimated Cost ($1,000s)	Project Share	
				KWP	KWP II

2017	• If Makamaka`ole is not meeting mitigation goals proceed with Haleakala/alternative Maui/Molokai/Lanai options
	• Haleakala Petrel Colony:
	  ○ Coordinate with National Park Service, define Haleakala colony management area, prepare draft plan, submit for agency review
	  ○ Execute necessary agreements with NPS, obtain necessary permits and authorizations
	• Newell's Shearwater:
	  ○ Fence construction
	  ○ Intensive predator trapping/bait boxes
	  ○ Social attraction and artificial burrows
	  ○ Monitoring
		Project Staff/ Consultant Support	334	167	167

2018	• Haleakala Petrel Colony:
	  ○ Complete final plan, complete permits, authorizations and agreements
	  ○ Solicit resumes/select field staff, procure equipment and materials
	  ○ Lay out management area and trapping array
	  ○ Commence trapping in accordance with approved plan
	• Newell's Shearwater:
	  ○ Continue trapping and baiting
	  ○ Social attraction and artificial burrows
	  ○ Monitoring
		Project Staff/Consultant Support	60	30	30

2019	• Haleakala Petrel Colony:
	  ○ Continue trapping in accordance with approved plan
	  ○ Work out bugs in program
	• Newell's Shearwater:
	  ○ Inspections (fence/predator)
	  ○ Trapping and baiting
	  ○ Social attraction and artificial burrows
	  ○ Monitoring
		Project Staff/ Interns	60	30	30

2020	• Haleakala Petrel Colony:
	  ○ Continue trapping in accordance with approved plan
	• Newell's shearwater:
	  ○ Inspections (fence/predator)
	  ○ Trapping and baiting
	  ○ Social attraction and artificial burrows
	  ○ Monitoring
		Project Staff/ Interns	60	30	30

2021	• Haleakala Petrel Colony:
	  ○ Continue trapping in accordance with approved plan
	• Newell's shearwater:
	  ○ Inspections (fence/predator)
	  ○ Trapping and baiting
	  ○ Social attraction and artificial burrows
	  ○ Monitoring
	  ○ Assessment of first five years, projection of expected credit accrual
		Project Staff/ Interns	60	30	30

2017-2031 *(KWP permit expires 2026)*	• Haleakala Petrel Colony:
	  ○ Continue trapping @ $30K/yr for 8 yrs in accordance with approved plan (assumes 8 add'l years needed to fulfill mitigation obligations)
	• Newell's shearwater:
	  ○ Continue trapping/mgmt @ $30K/yr for 11 yrs in accordance with approved plan
		Project Staff/ Interns	570	285	285

		Totals	**1145**	**572**	**572**

Appendix 12

Kaheawa Wind Power II
Habitat Conservation Plan

Construction Phase Nēnē and Nest Survey Protocol

INTRODUCTION

Surveys for nēnē and nēnē nests will be conducted by a qualified biologist, ornithologist, field ecologist or similarly experienced professional, prior to any clearing, grading, selected drill-and-shoot dense substrate fracturing, or construction of project roadways, turbines and accessory facilities. These surveys will be conducted as avoidance and minimization measures as prescribed in the project's Habitat Conservation Plan and are a requirement of the Conservation District Use Permit issued to Kaheawa Wind Power II (KWP II) by the DLNR.

Section 9 of the Endangered Species Act (ESA) prohibits the "take" of any endangered or threatened species of fish or wildlife listed under the ESA. Under the ESA, the term "take" means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect species listed as endangered or threatened, or to attempt to engage in any such conduct. "Harm" in the definition of "take" in the ESA means an act which actually kills or injures wildlife, and may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering (50 CFR 17.3). "Harass" in the definition of take in the ESA means an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding or sheltering (50 CFR 17.3).

Section 195D-4, Hawai`i Revised Statutes, states that any endangered or threatened species of fish or wildlife recognized by the ESA shall be so deemed by State statute. Like the ESA, the "take" of such endangered or threatened species is prohibited [Section 195D-4(e)]. The definition of "take" in Section 195D-2 mirrors the definition of the ESA: "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect endangered or threatened species of aquatic life or wildlife...or to attempt to engage in any such conduct."

The nēnē nesting season typically begins in October and ends in April. Although nēnē are not believed to use the KWP II project area as preferred nesting habitat, they may still be present in the project area during the nesting and non-nesting season. Therefore, construction activities occurring from May through September would typically be the least likely to encounter nēnē nesting in the project vicinity.

FIELD METHODS

Timing Surveys for Optimal Reliability

Surveys to identify nēnē or nēnē nests in project construction areas should be conducted in a timeframe as close as possible to anticipated construction activities in order for the survey to accurately represent the occurrence of birds or newly established nests in proximity to these areas. Because nēnē are mobile and have the ability to readily move among different portions of the project area, the reliability of a survey depends largely on it being performed immediately before construction activities are expected to commence.

The timing and protocol for conducting pre-construction surveys during the nesting season will be confirmed through consultation with DOFAW and USFWS prior to surveys being conducted to ensure that there is confidence in the survey methods and results such that the subsequent proposed construction activity can be safely undertaken.

DOFAW and Kaheawa Wind Power biologists have agreed to work in close collaboration during construction phase nēnē monitoring at KWP II.

Search Area

The area surveyed for Nene presence or nesting activity should cover the entire area where such construction activity will occur, and will extend a distance of 100-200 meters (328-656 feet) further on either side of these areas, depending on the specific type of construction activity being performed. For example, if roadway construction on a turn will involve cut-and-fill in an area that is 50 feet wide, this area plus 100 meters on either side must be searched. Similarly, if drill-and-shoot charge detonations are required to loosen dense rock and substrate prior to excavation, the area that will be searched may extend 200 meters. The size of the search area on any given day will depend on which areas are planned for construction activities and what specific construction activities are planned, while spacing and configuration of transects will be dependent upon topography and vegetation in the area, and subject to the surveyor's qualified opinion..

Construction Monitoring

KWP II will provide a biologist who will inspect areas of proposed active construction for evidence of nests, adult birds and/or young, for a period leading up to and immediately prior (same day) to construction work proceeding. During the nesting period, once an area is searched and determined to be "cleared" (of nene nests and or family groups with un-flighted goslings), KWP II biologists may, where practicable and warranted, place a temporary orange construction fence or similar barrier at the edge of the surveyed area to designate the limits of the area that has been "cleared". This temporary fence material may be moved and re-used as surveying and construction proceeds, but will not be left in the field indefinitely.

If nests or birds are found, the discovery protocol provided in the following section will be followed.

DISCOVERY PROTOCOL

Discovery During Clearing Surveys

Should any nēnē or nests be found during a survey, DOFAW and USFWS will be contacted and will advise the on-site biologist in-charge of monitoring at KWP II how to proceed, on a case-by-case basis, depending on the location and status of the birds or nest. It is important to note the case-by-case nature of this protocol, as there are many factors that DOFAW, USFWS, and KWP II will consider if birds and/or nests are discovered in the project area, including: topography and terrain; vegetation and adjacent habitat; recent weather; proximity to proposed construction activity; status of nest and eggs and the age, health and behavior of goslings and/or adults.

If a nest is found during pre-construction clearing surveys, the following measures will likely be required, in varying degrees:

- Construction will likely be prohibited from commencing within a certain perimeter of the nest for an appropriate period of time;
- Subsequent monitoring of the nest may be required to ensure that the nest, eggs, chicks and adults are not disturbed by project activities nearby and elsewhere;
- Temporary fencing or other protection barrier, where specifically warranted may be required to protect the nest from nearby activity; or the nest may be relocated by agency officials.

DOFAW and USFWS will likewise advise KWP II on appropriate measures to avoid any inadvertent harm or harassment of non-nesting birds, family groups, and individuals or flocks that are discovered during the clearing surveys.

Discovery During Construction

Even with timely surveys, it is possible that construction activities could encounter birds or nests that were not discovered during an initial clearing survey. If a nest or evidence of nēnē nesting activity is discovered during construction, all work in the vicinity of the discovery shall cease immediately and DOFAW and USFWS shall be contacted.

Thereafter, the same case-by-case protocol as described in the section above (Discovery During Clearing Surveys) will be followed. Construction may be allowed to resume in adjacent areas beyond the established nest protection bufferbuffer if agreed by DLNR, USFWS, and KWP II that such activity is not expected to result in adverse impacts or disturbance; temporary fencing, other protective barrier, or suitable marking strategy may be required along with subsequent monitoring; or, the nest may be relocated by agency officials.

Education

DOFAW and Kaheawa Wind Power II have agreed that it would be beneficial to coordinate pre-construction educational and training sessions with all construction workers, inspectors, and site managers to provide information about nēnē , with an emphasis on their nesting and foraging habits, general disposition and behavior, and overall ecology in the Kaheawa Pastures region. Kaheawa Wind Power II is also implementing a Wildlife Education and Observation Program (WEOP) under the HCP that ensures each individual contractor and their designees are provided with the necessary information on the occurrence and behavior, guidelines for reporting observations and occurrences of birds around work areas and roads of nēnē while working and traveling I

REPORTING

Kaheawa Wind Power II will present written results of daily surveys performed throughout the construction phase of the project to DOFAW and USFWS on a weekly and as-requested basis to ensure steady and useful exchange of information on the status of monitoring efforts and levels of nēnē interaction with construction activities. A final report summaring the results of construction phase nēnē monitoring will be prepared and presented to DOFAW and USFWS when construction activities are complete.

Appendix 13

RADAR AND VISUAL STUDIES OF SEABIRDS AT THE PROPOSED KWP II DOWN-ROAD ALTERNATIVE WIND ENERGY FACILITY, MAUI ISLAND, HAWAII, FALL 2009

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RADAR AND VISUAL STUDIES OF SEABIRDS AT THE PROPOSED KWP II DOWN-ROAD ALTERNATIVE WIND ENERGY FACILITY, MAUI ISLAND, HAWAII, FALL 2009

FINAL REPORT

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EXECUTIVE SUMMARY

- We used radar and audiovisual methods to collect data on movements of endangered Hawaiian Petrels (*Pterodroma sandwichensis*) and threatened Newell's (Townsend's) Shearwaters (*Puffinus auricularis newelli*) at the proposed Kaheawa Wind Power II Down-road Alternative (KWP II) wind energy generation facility, on Maui Island during fall 2009. We conducted evening and morning surveys during 25–29 October 2009.
- The objectives of the study were to: (1) document movement rates of Hawaiian Petrels and Newell's Shearwaters at the proposed KWP II facility; (2) estimate the daily number of petrels/shearwaters that fly within areas that would be occupied by wind turbines and a meteorological (met) tower at the proposed facility; and (3) estimate annual fatality rates of petrels/shearwaters at proposed turbines and a met tower.
- We recorded 24 radar targets that fit our criteria for petrels and shearwaters.
- The mean movement rate across all nights was 1.16 ± 0.17 targets/h. After adjusting our sampling results for hours of the night that we did not sample (i.e., non-peak periods), we estimated a mean movement rate of 6.5 petrel-like/shearwater-like targets/night during fall 2009.
- No Hawaiian Petrels or Newell's Shearwaters were detected by visual observers. We also did not visually observe any Hawaiian Hoary Bats, but had one auditory detection on the evening of 27 October.
- To determine the risk of collision-caused mortality, we used petrel/shearwater movement rates observed on radar in summer and fall 2009, petrel/shearwater flight altitudes from previous studies, and dimensions and characteristics of the proposed turbines and met towers to generate an estimate of exposure risk. We then applied estimates of the fatality probability (i.e., the probability of collision with a portion of the turbine or tower and dying while in the airspace occupied by the structure) and a range of estimated avoidance probabilities (i.e., the probability that a bird will detect and avoid entering the airspace containing the turbine or tower) to this estimate of exposure to calculate annual fatality rates that could be expected at the proposed turbines and met tower.
- We estimated that 2–11 Hawaiian Petrels and 1–6 Newell's Shearwater fly within the space occupied by each wind turbine in an average year and estimated that 1 Hawaiian Petrel and 1 Newell's Shearwater fly within the space occupied by the 65-m-high met tower in an average year. Note that all these calculations are exposure rates and, thus, include an unknown proportion of birds that would detect and avoid the turbines and met towers. Hence, exposure rates estimate how many times/year a petrel or shearwater would be exposed to wind turbines or met towers and not necessarily the number that actually would collide with those structures.
- We provide a range of assumptions for avoidance rates in our fatality models (i.e., 90%, 95%, and 99% avoidance rates) along with a discussion of the body of evidence that is consistent with the hypothesis that the average avoidance-rate value is substantial and potentially ≥95%. With an assumption of ≥95% avoidance, the estimated average annual number of fatalities at the proposed KWP II wind turbines would be 0.015–0.098 Hawaiian Petrel/turbine/yr and 0.008–0.054 Newell's Shearwaters/turbine/yr. The estimated average annual number of fatalities at the proposed KWP II met tower (with an assumption of ≥95% avoidance) would be 0.007–0.036 Hawaiian Petrel/tower/yr and 0.004–0.020 Newell's Shearwaters/tower/yr.

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ACKNOWLEDGMENTS

We thank First Wind for funding this study and for providing the ornithological radar used for sampling. We thank Greg Spencer and Dave Cowan (First Wind) for help with logistics and thank Greg Spencer, Bob Roy, and Ian Bordenave (First Wind) for their assistance with the visual sampling. At ABR, Rich Blaha and Dorte Dissing produced study figures and Alice Stickney and Pam Odom assisted with report production.

INTRODUCTION

First Wind, LLC, formerly UPC Wind Management, LLC, operates the 30-MW Kaheawa Pastures Wind Energy Generation Facility, referred to as Kaheawa Wind Power I (KWP I), on the island of Maui (Figure 1). A new wind project adjacent to the existing facility is being considered for development by First Wind and will be operated as Kaheawa Wind Power II (i.e., the KWP II Down-road Alternative [KWP II]). Two federally-listed seabird species occur on Maui: the endangered Hawaiian Petrel (*Pterodroma sandwichensis*; Hawaiian name ’Ua’u) and the threatened Newell’s (Townsend’s) Shearwater (*Puffinus auricularis newelli*; Hawaiian name ’A’o). Ornithological radar and night-vision techniques have been shown to be successful in assessing numbers and movement rates of these petrels and shearwaters on the Hawaiian Islands (e.g., Kaua’i [Cooper and Day 1995, 1998; Day and Cooper 1995, Day et al. 2003b], Maui [Cooper and Day 2003], Moloka’i [Day and Cooper 2002], and Hawai’i [Day et al. 2003a]). Previous radar and visual studies documented the presence of petrel/shearwater targets, including visual observations of Hawaiian Petrels, in the vicinity of the existing KWP I project site (Day and Cooper 1999, Cooper and Day 2004a). These data were used to model the potential number of annual fatalities at the KWP I development (Cooper and Day 2004b). In addition, radar studies were conducted in 2008 (Sanzenbacher and Cooper 2008, 2009) to model the potential number of fatalities in a nearby portion of a previous KWP II site that was located just upslope of the KWP II Down-road alternative.

The currently operational KWP I windfarm consists of an articulated row of 20 1.5-MW turbines (GE 1.5se) with a hub height of ~55 m and a rotor diameter of 70.5 m, plus one 30-m-high, guyed NRG monopole meteorological (met) tower and two 55-m-high, guyed lattice met towers (Figure 2). The proposed KWP II project would consist of ~14 additional 1.5-MW turbines (GE 1.5se), each with a hub height of ~65 m and a rotor diameter of 70.5 m, plus one 65-m-high, free-standing met tower.

ABR conducted additional radar and visual studies on Maui in July 2009 (Cooper and Day 2009) and fall 2009 (this study) with a specific focus on an area proposed for the KWP II facility. The objectives of the studies were to: (1) document movement rates of Hawaiian Petrels and Newell’s Shearwaters at the proposed KWP II facility; (2) estimate the daily number of petrels/shearwaters that fly within areas that would be occupied by wind turbines or met towers at the proposed facility; and (3) estimate annual fatality rates of petrels/shearwaters at the proposed turbines and meteorological (met) tower.

Background

Two seabird species that are protected under the Endangered Species Act (ESA) are likely and/or known to occur in the KWP II project area: the endangered Hawaiian Petrel and the threatened Newell’s (Townsend’s) Shearwater. The Hawaiian Petrel and the Newell’s Shearwater are forms of tropical Pacific species that nest only on the Hawaiian Islands (American Ornithologists’ Union 1998). Both species are Hawaiian endemics whose populations have declined significantly in historical times: they formerly nested widely over all of the Main Islands but now are restricted in most cases to scattered colonies in more inaccessible locations (Ainley et al. 1997b, Simons and Hodges 1998). The one exception is Kaua’i Island, where colonies still are widespread and populations are substantial in size. Of note, Kaua’i (along with Lana’i) also has no introduced Indian Mongooses (*Herpestes auropunctatus*) which prey on these seabirds.

The Hawaiian Petrel nests primarily on Maui (Richardson and Woodside 1954, Banko 1980a; Simons 1984, 1985; Simons and Hodges 1998, Cooper and Day 2003), Kaua’i (Telfer et al. 1987, Gon 1988, Day and Cooper 1995; Ainley et al. 1995, 1997a, 1997b; Day et al. 2003a), Hawai’i (Banko 1980a, Conant 1980, Hu et al. 2001, Day et al. 2003a), Lana’i (Shallenberger 1974; Hirai 1978a, 1978b; Conant 1980; G. Spencer and J. Penniman, pers. comm.), and Moloka’i (Simons and Hodges 1998, Day and Cooper 2002). On Maui, these petrels are known to nest on Haleakala Crater (Brandt et al. 1995, Simons and Hodges 1998) and are believed to nest in West Maui (Cooper and Day 2003, Kaheawa Wind Power 2009), with recent observations of birds calling and exhibiting aerial displays consistent with breeding

Figure 1. Maui Island, Hawaii, with approximate location of the Kaheawa Pastures Wind Energy Facilities (KWP I and KWP II).

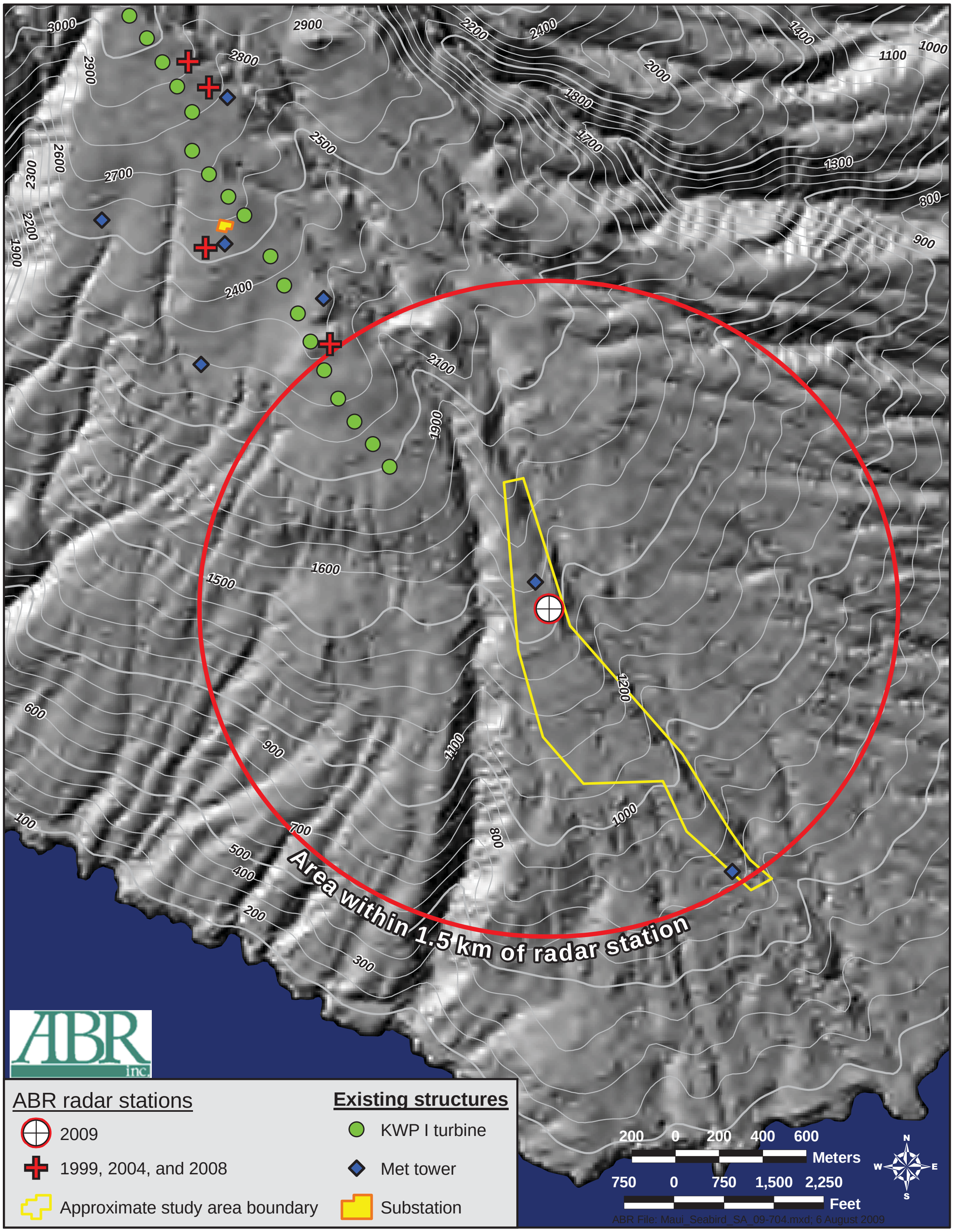

Figure 2. Location of 2009 radar sampling stations relative to sampling stations from previous studies (Day and Cooper 1999, Cooper and Day 2004a; Sanzenbacher and Cooper 2008, 2009) and areas under consideration for siting of wind turbines at the proposed KWP II Down-road Alternative (KWP II) wind energy facility, Maui, Hawaii.

behavior, despite the minimal historical evidence and introduction of Indian Mongoose on Maui. For example, on 16 June 1999, a Hawaiian Petrel was heard calling from a bed of uluhe ferns (*Dicranopteris linearis*) at 3,300 ft (~1,000 m) elevation in the Kapunakea Preserve, which lies on the northwestern slope of the West Maui Natural Area Reserve (A. Lyons, *fide* C. Bailey). In addition, recent observations of consistent calling from a single location suggests that there is another small colony of Hawaiian Petrels in the West Maui Mountains ~14 km north of the KWP project areas (G. Spencer, First Wind, pers. comm.). On the other hand, daily movement rates of Hawaiian Petrels near KWP I and II (i.e., on the southern slope of the West Maui Mountains; Day and Cooper 1999, Cooper and Day 2004a, Sanzenbacher and Cooper 2008 and 2009) are much lower than those over the eastern and northern sides of Maui (Cooper and Day 2003), suggesting that few birds use that area.

Newell's Shearwaters nest on several of the main Hawaiian Islands, with the largest numbers clearly occurring on Kaua'i (Telfer et al. 1987, Day and Cooper 1995; Ainley et al. 1995, 1997b; Day et al. 2003b). These birds also nest on Hawai'i (Reynolds and Richotte 1997, Reynolds et al. 1997, Day et al. 2003a), almost certainly nest on Moloka'i (Pratt 1988, Day and Cooper 2002), and may still nest on Oahu (Sincock and Swedberg 1969, Banko 1980b, Conant 1980, Pyle 1983; but see Ainley et al. 1997b). On Maui, recent auditory observations suggest that a small colony of Newell's Shearwaters is present in the West Maui Mountains ~14 km north of the KWP project areas (G. Spencer, First Wind, pers. comm.), matching a prediction of their occurrence there by Cooper and Day (2003). Newell's Shearwaters typically nest on steep slopes that are vegetated by uluhe fern undergrowth and scattered o'hia trees (*Metrosideros polymorpha*).

There is interest in studying these two species because of concerns regarding collisions with structures such as met towers and turbines. To date, there has been only one documented fatality of a single Hawaiian Petrel and zero Newell's Shearwaters during the past four years at KWP (G. Spencer, First Wind, pers. comm.). In addition, zero fatalities of either species were observed at six met towers that were monitored on the island of Lana'i during 2008 (TetraTech 2008a). Though several additional entities operate other wind turbine and/or met tower facilities within the Hawaiian Islands, it is unknown whether these other facilities have incurred take of either species. Hence, there still are not enough reported studies of adequate duration or geographic scope to answer the question definitively of whether these species are prone to collisions at wind turbines and met towers. There has, however, been well-documented petrel and shearwater mortality because of collisions with other human-made objects (e.g., transmission lines, communication towers) on Kaua'i (Telfer et al. 1987, Cooper and Day 1998, Podolsky et al. 1998) and Maui (Hodges 1992), and there have been collision-caused fatalities of other seabirds at other Hawaiian Islands (Fisher 1966).

STUDY AREA

The operational KWP I windfarm and proposed KWP II expansion are located on the southern slope of the West Maui Mountains, in an area called Kaheawa Pastures (Figure 1). These sites lie on a moderately sloping portion of West Maui Mountain, ~1–6 km inland from McGregor Point. Vegetation at the site consists of non-native grasslands at lower elevations and a mixture of grasslands and scattered shrubs at moderate to higher elevations. Although the KWP II area consists of a dry Mediterranean habitat, vegetation becomes much wetter upland, toward the summit of West Maui Mountain. Presumably, vegetation communities also are dominated by native species in these higher, wetter areas. These upland habitats may provide suitable nesting habitat for Newell's Shearwaters, based on our experience on Kaua'i and other sites. In addition to the vegetation, the steepness of the land at higher elevations on West Maui Mountain also suggests that suitable nesting habitat exists for Hawaiian Petrels, as it does on Haleakala (Brandt et al. 1995), Kaua'i (Telfer, pers. comm.), and Lana'i (Hirai 1978b).

In previous studies at the KWP I and KWP II sites (Day and Cooper 1999, Cooper and Day 2004a; Sanzenbacher and Cooper 2008, 2009; Cooper and Day 2009), sampling was conducted at four other stations; however, for the current study, we established a new sampling station with a focus on providing maximal radar coverage of potential siting areas for the proposed KWP II Down-road Alternative development (Figure 2). The study area is situated in lower elevations slightly to the east and south of the existing KWP I turbine string, and our 2009 sampling station was located adjacent to the existing KWP I access road, just south of the Lahaina Pali trail (20° 47'52.6" N, 156° 32'16.5" W; elevation ~490 m).

METHODS

We used marine radar and visual equipment to collect data on the movements, flight behaviors, and flight altitudes of petrels and shearwaters at a single sampling station during fall (25–29 October) 2009 (Table 1). The daily sampling effort consisted of 3 h each evening (1800–2100 h) and 2 h each morning (0430–0630 h). These sampling periods were selected to correspond to the evening and morning peaks of movement of petrels and shearwaters, as described near breeding colonies on Kaua'i (Day and Cooper 1995). During sampling, we collected radar and audiovisual data concurrently so the radar operator could help the audiovisual observer locate birds for species identification and data collection. In return, the audiovisual observer provided information to the radar operator on the identity and flight altitude of individual targets (whenever possible). For the purpose of recording data, a calendar day began at 0700 and ended at 0659 the following morning; that way, an evening and the following morning were classified as occurring on the same day.

The ornithological radar used in this study was a Furuno (Model FCR-1510) X-band radar transmitting at 9.410 GHz through a slotted wave guide with a peak power output of 12 kW; a similar radar unit is described in Cooper et al. (1991) and Mabee et al. (2006). The antenna face was tilted upward by ~10°, and we operated the radar at a range setting of 1.5 km and a pulse-length of 0.07 μsec.

Issues associated with radar sampling include ground clutter and shadow zones. Whenever

Table 1. Sampling dates and number of inbound and outbound seabird radar targets and number of audiovisual observations of species of interest observed at the proposed KWP II Down-road Alternative (KWP II) wind-energy site, Maui Island, Hawaii, October 2009.

			Number of radar targets			
Date	Site	Period	Inbound[1]	Outbound[1]	Total	Number of audio-visual Detections[2]
25 Oct	Lower KWP	Eve	0	1	1	1 SEOW
		Morn	3	0	3	0
26 Oct	Lower KWP	Eve	1	1	2	0
		Morn	2	1	3	2 NENE
27 Oct	Lower KWP	Eve	2	0	2	1 PGPL, 1 HOBA (acoustic)
		Morn	5	0	5	0
28 Oct	Lower KWP	Eve	2	0	2	4 SEOW
		Morn	1	0	1	1 SEOW
29 Oct	Lower KWP	Eve	2	2	4	1 BAOW
		Morn	1	0	1	0
TOTAL		Eve	7	4	11	
		Morn	12	1	13	
		Total	19	5	24	

[1] Flight direction categories for inbound and outbound categories included all birds flying toward/away from either the colonies located on west Maui (north of the study site) or colonies located on Haleakala (i.e., Inbound = 316–135° and Outbound = 136–315°).

[2] NENE = Nene; HOBA = Hoary Bat; SEOW = Short-eared Owl; BAOW = Barn Owl: PGPL = Pacific Golden-plover.

energy is reflected from the ground, surrounding vegetation and other objects around the radar unit, a ground-clutter echo that can obscure targets of interest (i.e., birds) appears on the radar's display screen. Shadow zones are areas of the screen where birds can fly at an altitude that potentially would put them behind a hill or row of vegetation where they could not be detected because the radar operates only on line-of-sight. We attempted to minimize ground clutter and shadow zones during the selection of radar sampling stations; various structures and landscape features visible on radar indicated that our sampling stations provided good coverage of the study area.

We sampled for six 25-min sessions during each evening and for four 25-min sessions each morning (Table 1). Each 25-min sampling session was separated by a 5-min break for collecting weather data. To help eliminate non-target species, we collected data only for those targets that met a suite of selection criteria, following methods developed by Day and Cooper (1995), that included appropriate flight characteristics and flight speeds (≥30 mi/h [≥50 km/h]). We also removed radar targets identified by flight characteristics or visual observers as being of other bird species.

We conducted audiovisual sampling for birds and bats concurrently with the radar sampling to help identify targets observed on radar and to obtain flight-altitude information. During this sampling, we used 10X binoculars during crepuscular periods and Generation 3 night-vision goggles (Model ATN-PVS7; American Technologies Network Corporation, San Francisco, CA) during nocturnal periods. The magnification of the night-vision goggles was 1X, and their performance was enhanced with the use of a 3-million-Cp floodlight that was fitted with an IR filter to avoid blinding and/or attracting birds. Audiovisual observations were conducted within 25 m of the radar to facilitate coordination between observers, and we also listened for petrel and shearwater vocalizations. In addition, we opportunistically used an Anabat SDI ultrasonic detector (Titley Electronics) to listen for bat vocalizations in the immediate vicinity during our sampling.

Before each 25-min sampling session, we also collected environmental and weather data, including:

- wind speed (to the nearest 1.6 km/h [1 mi/h]);
- wind direction (to the nearest 1°);
- percent cloud cover (to the nearest 5%);
- cloud ceiling height, in meters above ground level (agl; in several height categories);
- visibility (maximal distance we could see, in categories);
- light condition (daylight, crepuscular, or nocturnal, and with or without precipitation)
- precipitation type; and
- moon phase/position (lunar phase and whether the moon was above or below the horizon in the night sky).

For each appropriate radar target, we recorded the following data:

- species (if identified by visual observer);
- number of birds (if identified by visual observer);
- time;
- direction of flight (to the nearest 1°);
- cardinal transect crossed (000°, 090°, 180°, or 270°);
- tangential range (the minimal perpendicular distance to the target when it passed closest to the radar; used in reconstructing actual flight paths, if necessary);
- flight behavior (straight, erratic, circling);
- velocity (to the nearest 5 mi/h [8 km/h]); and
- flight altitude (meters agl, if identified by visual observer).

For each bird (or bat) recorded during audiovisual sampling, we recorded:

- time;
- species (to the lowest practical taxonomic unit [e.g., Hawaiian Petrel, unidentified petrel/shearwater]);
- number of individuals composing each target;
- ordinal flight direction (000°, 045°, 090°, 135°, 180°, 225°, 270°, 315°); and
- flight altitude (meters agl).

For any birds heard but not observed, we recorded species, number of calls, direction of calls, and approximate distance.

DATA ANALYSIS

We entered all radar and visual data into Microsoft Excel databases. Data files were checked visually for errors after each night's sampling, then were checked electronically for irregularities at the end of the field season, prior to data analyses. In addition, radar data were filtered to remove non-target species, and only known petrel/shearwater targets or unknown targets with appropriate characteristics (i.e., target size, flight characteristics, and airspeeds ≥30 mi/h) were included in data analyses. Airspeeds were calculated by correcting observed target flight speeds (groundspeeds) for speed and relative direction of wind, as measured each half-hour at the radar station (Mabee et al. 2006).

We tabulated counts of numbers of radar targets of petrels and shearwaters recorded during each sampling session, then converted those counts to estimates of movement rates of birds (radar targets/h), based on the number of minutes sampled. Only 25 min of sampling time was lost to rain or other factors during the fall sampling period; we standardized estimates by actual minutes of sampling effort each half hour. We used all of the estimated movement rates across sampling sessions at a station to calculate the mean ± 1 standard error (SE) nightly movement rate of petrels and shearwaters by station and pooled data across nights to derive an overall hourly movement rate for the study.

We also classified general flight directions of each radar target as inbound or outbound and summarized those directional categories by station, date, and time period. To categorize the general flight direction of each target, we defined an inbound flight as a radar target flying toward 316–135° (i.e., toward breeding colonies in the West Maui Mountains or on Haleakala) and classified targets flying in the opposite directions (i.e., toward 136–315°) as outbound targets.

MODELING FATALITY RATES

The risk-assessment technique that we have developed involves the use of radar data for estimating the fatality rates for petrels and shearwaters near structures in the Hawaiian Islands. This modeling technique uses the radar data on seasonal movement rates to estimate numbers of birds flying over the area of interest (sampling station) across a 255-d year (for Hawaiian Petrels) or a 210-d year (for Newell's Shearwater) when breeding birds are present on the island. The model then uses information on the physical characteristics of the structures (e.g., wind turbines or met towers) themselves to estimate horizontal and vertical interaction probabilities and combines these interaction probabilities with the movement rates to generate exposure rates (Figure 3). These rates represent the estimated numbers of petrels/shearwaters that pass within the airspace occupied by a proposed wind turbine or within the airspace occupied by a met tower and its associated guy wires each year. We then combine these exposure rates with (1) the probability that an interaction results in fatality, and (2) the probability that birds detect structures and avoid interactions, to estimate fatality rates.

We calculate an exposure rate by multiplying the seabird movement rate observed on radar by horizontal- and vertical-interaction probabilities. The movement rate is an estimate of the average number of birds passing in the vicinity of the proposed turbines/towers in a day, as indicated by numbers of targets on the radar screen and the mean flock size/target. It is generated from the radar data by: (1) multiplying the average movement rates by 5.0 h to estimate the number of targets moving over the radar site in the first 3 h and last 2 h of the night (i.e., during the peak movement periods of petrel/shearwaters); (2) adjusting the sum of those evening and morning counts to account for the estimated percentage of

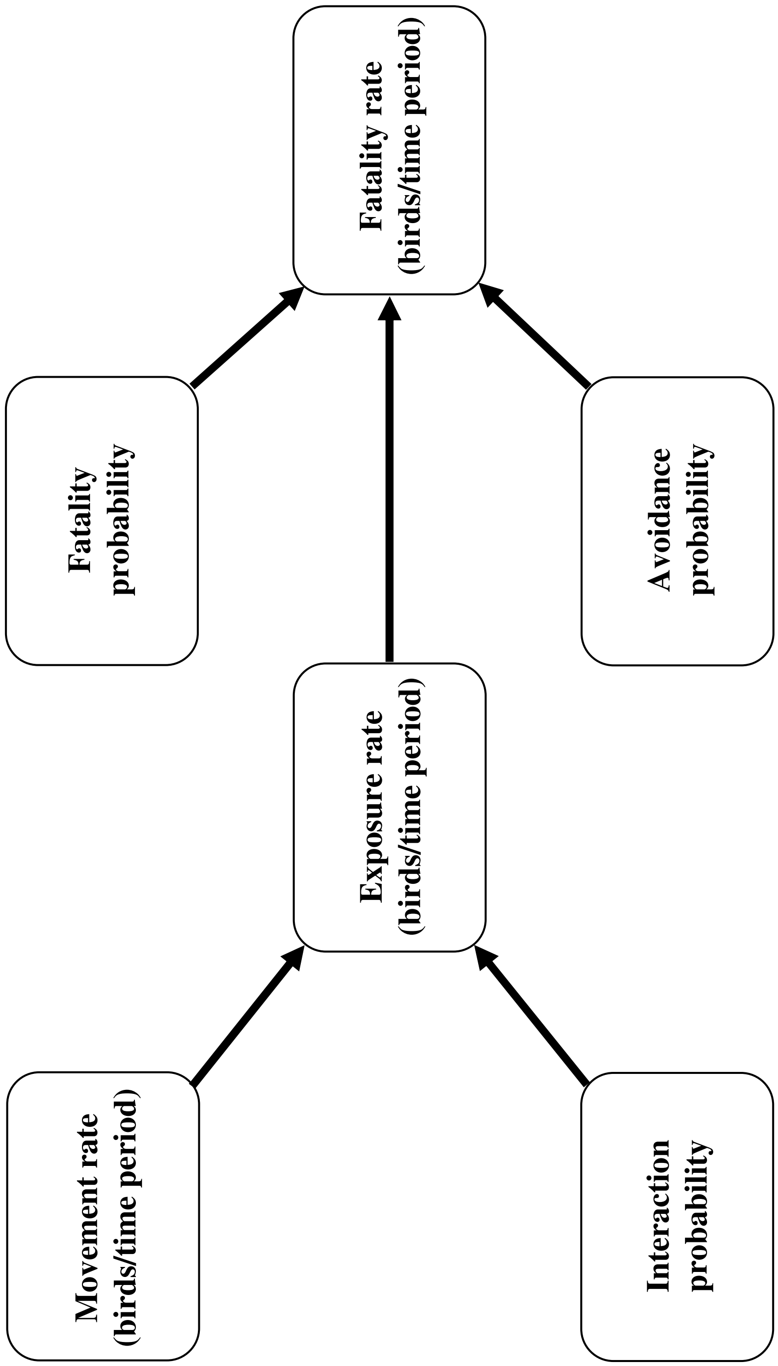

Figure 3. Major variables used in estimating possible fatalities of Hawaiian Petrels and Newell's Shearwaters at wind turbines at the proposed KWP II Down-road Alternative (KWP II) wind energy facility, Maui, Hawaii. See Tables 2 and 3 for details on calculations.

movement that occurs during the middle of the night (when we did not sample); and (3) multiplying that total number of targets/night by the mean number of seabirds/target to generate an estimate of the number of petrel/shearwaters passing in the vicinity of the proposed met towers/turbines during an average day.

We used the radar-based movement data from our summer 2009 (Cooper and Day 2009) and fall studies (this study) at the proposed KWP II development to estimate seabird movement-rates and assumed that those rates represented average rates observed in an average year. We used data from all-night sampling sessions on Kaua'i (Day and Cooper 1995) to estimate movement rates occurring during the hours between our evening and morning sampling periods. These data suggested that an additional 12.6% of the total combined evening inbound movements and outbound morning movements occurred between the evening and morning peak-movement periods (Day and Cooper, unpubl. data). We also corrected the number of targets for flock size: mean flock sizes of petrels and shearwaters combined in Hawai'i are 1.05 ± SE 0.01 birds/flock (*n* = 2,062 flocks; Day and Cooper, unpubl. data). In addition, we used the timing of inland flights at the nearby Ukumehame site from Cooper and Day (2003) to correct for proportions of targets that were Hawaiian Petrels and those that were Newell's Shearwaters; those data suggested that 60% of the targets were Hawaiian Petrels and 40% of the targets were Newell's Shearwaters.

The number of petrels visiting breeding colonies generally tends to decline from summer to fall because attendance at colonies by nonbreeders and failed breeders declines as chick-rearing progresses (Serventy et al. 1971, Warham 1990, Ainley et al. 1997b, Simons and Hodges 1998). Thus, we split the 255-d breeding season for Hawaiian Petrels (Simons and Hodges 1998) and 210-d breeding season for Newell's Shearwaters (Ainley et al. 1997b) into a spring/summer period of 180 days and 150 days for petrels and shearwaters, respectively and a fall period of 75 days and 60 days for petrels and shearwaters, respectively. We corrected the summer 2009 (from Cooper and Day 2009) and fall 2009 seasonal estimates of nightly movement rates by the numbers of days for the spring/summer and fall seasons, to generate estimates of movements for each season and species. We assume that the sum of these two estimates represents estimated movement rates for an entire breeding season (i.e., an average year).

Because the resulting estimate of the number of birds/yr is not an integer, we then round it upward to the next whole number to generate an estimate of the average number of birds passing within 1.5 km of the radar site during a year. This rounding technique results in slightly-inflated fatality estimates, but we choose to take a conservative approach in these studies associated with endangered species.

INTERACTION PROBABILITIES

Horizontal

Interaction probabilities consist of horizontal and vertical components. The horizontal-interaction probability is the probability that a bird seen on radar will pass through or over the airspace occupied by a met tower or turbine located somewhere on the radar screen. This probability is calculated from information on the two-dimensional area (side view) of the tower/turbine and the two-dimensional area sampled by the radar screen to determine the interaction probability. The 65-m, free-standing met-tower system consists of a central lattice tower without any supporting guy wires. The tower is 65 m high with a width at the base of ~6 m and a width at the top of ~0.5 m. The proposed wind turbines have ~65-m monopole towers and 35.25-m-long blades. Two calculations of area were made for turbines because of the large differences in area of the structure that depended on the orientation of the blades relative to the flight path of an approaching bird: a minimal area occupied by each proposed turbine if a bird approaches it from the side (i.e., side profile) and a maximal area occupied by each turbine if a bird approaches it from the front (i.e., front profile, including the rotor-swept area). The ensuing ratio of cross-sectional area of the proposed tower/turbine to the cross-sectional area sampled by the radar (1.5 km) indicates the probability of interacting with (i.e., flying over or through the airspace occupied by) the proposed tower or turbine.

Vertical

The vertical-interaction probability is the probability that a bird seen on radar will be flying at an altitude low enough that it might pass through the airspace occupied by a proposed met tower/turbine located somewhere on the radar screen. This probability is calculated from data on flight altitudes and from information on the proposed turbine heights. We used data from throughout the Hawaiian Islands (n = 2,010 birds; Cooper and Day, unpubl. data) to calculate the percentage of petrels/shearwaters with flight altitudes at or below the maximal height of the turbines (i.e., 51.0% ≤100 m agl) and met towers (i.e., 33.0% ≤65 m agl). We would have preferred to use flight-altitude data from the project area for the flight-altitude computations, but adequate sample sizes do not currently exist to do so.

FATALITY RATES

The annual estimated fatality rate is calculated as the product of: (1) the exposure rate (i.e., the number of birds that might fly within the airspace occupied by a tower/turbine); (2) the fatality probability (i.e., the probability of collision with a portion of the tower/turbine and dying while in the airspace occupied by the structure); and (3) the avoidance probability (i.e., the probability that a bird will detect and avoid entering the airspace containing the tower/turbine). The annual fatality rate is generated as an estimate of the number of birds killed/yr as a result of collisions with the tower/turbine, based on a 255-d breeding season for Hawaiian Petrels and a 210-d breeding season for Newell's Shearwaters.

Fatality Probability

The estimate of the fatality-probability portion of the fatality rate formula is derived as the product of: (1) the probability of dying if a bird collides with a tower/turbine; and (2) the probability of colliding with a turbine if the bird enters the airspace occupied by the structure (i.e., are there gaps big enough for birds to fly through the structure without hitting any part of it). Because any collision with a wind turbine or tower falls under the ESA definition of "take" we used an estimate of 100% for the first fatality-probability parameter. Note that the actual probability of fatality resulting from a collision is less than 100% because of the potential for a bird to hit a turbine component and not die (e.g., a bird could brush a wingtip but avoid injury/death). The second probability (i.e., striking the structure) needs to be calculated differently for met towers and turbines. In the met-tower design, the tower frame is a lattice structure, so we conservatively estimated the probability of hitting the tower if the bird enters the airspace at 100%. Similarly, a bird approaching a wind turbine from the side has essentially a 100% probability of getting hit by a blade; in contrast, a bird approaching from the back or front of a turbine may pass through the rotor-swept area without colliding with a blade, if it is flying fast enough. We calculated the probability of collision for the "frontal" bird approach based upon the length of a petrel (43 cm; Simons and Hodges 1998); the average groundspeed of petrels on Maui (mean velocity = 42.5 mi/h; n = 347 probable petrel targets; Cooper and Day, unpubl. data) and the time that it would take a 43-cm-long petrel to travel completely through a 2-m-wide turbine blade spinning at its maximal rotor speed (22 revolutions/min); also see Tucker (1996). These calculations indicated that 19.5% of the disk of the rotor-swept area would be occupied by a blade sometime during the length of time (i.e., 0.13 sec) that it would take a petrel to fly completely past a rotor blade (i.e., to fly 2.43 m).

Avoidance Probability

The final parameter is the avoidance probability, which is the probability that a bird will see the turbine and change flight direction, flight altitude, or both, so that it completely avoids flying through the space occupied by a met tower/turbine. Because avoidance probabilities are largely unknown, we present fatality estimates for a range of probabilities of collision avoidance by these birds by assuming that 90%, 95%, or 99% of all petrels or shearwaters flying near a tower/turbine structure will detect and avoid it. See discussion for explanation of avoidance rates used.

RESULTS

VISUAL OBSERVATIONS

No Hawaiian Petrels or Newell's Shearwaters were detected by visual observers (Table 1). We did have numerous observations of Short-eared Owls (*Asio flammeus sandwichensis;* Pueo), one Barn Owl (*Tyto alba*), a flock of two Nene (*Branta sandvicensis*) at 0612 h on 26 October, and one Pacific Golden-Plover (*Pluvialis fulva*) at 1812 h on 27 October. No Hawaiian Hoary Bats (*Lasiurus cinereus semotus*; 'Ope'ape'a) were seen, but one was detected on the ultrasonic device on the evening of 27 October.

MOVEMENT RATES

We recorded 24 radar targets during 25.0 h of sampling in fall 2009 that fit our criteria for petrels and shearwaters (Table 1). Passage rates were similar between the evening and morning: 11 (46%) of the 24 targets were recorded during the evening sampling period. Mean nightly movement rates during fall 2009 were 1.16 ± 0.17 targets/h. After adjusting our sampling results for hours of the night that we did not sample (i.e., non-peak periods), we estimated a mean movement rate of 6.5 petrel-like targets/night during fall 2009 (Table 2).

Flight paths generally were similar between evening and morning, with widely dispersed movements across the entire proposed wind facility (Table 1; Figures 4 and 5). The majority of targets were heading toward the general direction of breeding colonies on Haleakala—not West Maui Mountain.

EXPOSURE RATES

The exposure rate is calculated as the product of three variables: annual movement rate, horizontal-interaction probability, and vertical-interaction probability. As such, it is an estimate of the number of birds flying in the vicinity of the wind turbine/met tower (i.e., crossing the radar screen) that could fly in a horizontal location and at a low-enough altitude that they could interact with a tower/turbine. Based on our summer and fall 2009 movement rate data, we estimate that ~1,443 Hawaiian Petrels and 795 Newell's Shearwaters pass over the 1.5-km-radius radar sampling area in an average year (including birds at all altitudes; Tables 2 and 3). To generate annual exposure rates of birds exposed to each turbine or met tower (e.g., bird passes/tower/yr), we then multiplied the annual movement rate by the horizontal-interaction probability and the vertical-interaction probability. By applying those proportions to our data (and rounding up to the nearest whole number), we estimate that 2–11 Hawaiian Petrels and 1–6 Newell's Shearwater fly within the space occupied by each wind turbine in an average year (Tables 2 and 4) and estimate that 1 Hawaiian Petrel and 1 Newell's Shearwater fly within the space occupied by the 65-m-high met tower in an average year (Tables 3 and 4). Note that all these calculations are exposure rates and, thus, include an unknown proportion of birds that would detect and avoid the turbines and met towers. Hence, exposure rates estimate how many times/year a petrel or shearwater would be exposed to wind turbines or met towers and not necessarily the number that actually would collide with those structures.

FATALITY MODELING

The individual steps and estimates involved in calculating fatality rates are shown in Table 2 (turbines) and Table 3 (met tower). We speculate that the proportions of birds that detect and avoid turbines and towers is substantial (see Discussion), but limited petrel- or shearwater-specific data are available to use for an estimate of the avoidance rates for those types of structures. Because it is necessary to estimate the fatality of petrels and shearwaters at the proposed project, however, we assumed that 90%, 95%, or 99% of all birds will be able to detect and avoid the towers and turbines. If we also assume that 100% of the birds colliding with a turbine/tower die (although see above), the annual fatality rates are 0.015–0.195 Hawaiian Petrel/turbine/yr and 0.008–0.108 Newell's Shearwaters/turbine/year (Table 2). For the 65-m met tower, we estimate a fatality rate of 0.007–0.073 Hawaiian Petrel/tower/yr and 0.004–0.040 Newell's Shearwaters/tower/year (Table 3). For cumulative annual fatalities, the annual fatality rate would be 0.206–2.733 Hawaiian Petrels/yr and 0.114–1.506 Newell's Shearwaters/yr for all 14 proposed wind turbines combined (Table 4). The cumulative annual fatalities at the one proposed met tower would be 0.007–0.073 Hawaiian Petrels/yr and 0.004–0.040 Newell's Shearwaters/yr (Table 4). We caution

Table 2. Estimated average exposure rates and fatality rates of Hawaiian Petrels (HAPE) and Newell's Shearwaters (NESH) at GE 1.5se wind turbines at the proposed KWP II Down-road Alternative (KWP II) wind-energy site, Maui, Hawaii, based on radar data collected in July and October 2009. Values of particular importance are in boxes.

Variable/parameter	HAPE		NESH	
	Minimum	Maximum	Minimum	Maximum
MOVEMENT RATE (MVR)				
A) Mean movement rate (targets/h)				
A1) Mean rate during nightly peak movement periods in spring/summer based on July 2009 data (targets/h)	1.776	1.776	1.776	1.776
A2) Mean rate during nightly peak movement periods in fall based on October 2009 data (targets/h)	1.161	1.161	1.161	1.161
B) Number of hours of evening and morning peak-period sampling	5	5	5	5
C) Mean number of targets during evening and morning peak-movement periods				
C1) Spring/summer (A1*B)	8.88	8.88	8.88	8.88
C2) Fall (A2*B)	5.805	5.805	5.805	5.805
D) Mean proportion of birds moving during off-peak h of night	0.126	0.126	0.126	0.126
E) Seasonal movement rate (targets/night) = ((C*D)+ C)				
E1) Spring/summer	10.0	10.0	10.0	10.0
E2) Fall	6.5	6.5	6.5	6.5
F) Mean number of birds/target	1.05	1.05	1.05	1.05
G) Estimated proportion of each species	0.60	0.60	0.40	0.40
H) Daily movement rate (bird passes/day =E*F*G)				
H1) Spring/summer	6.30	6.30	4.20	4.20
H2) Fall	4.12	4.12	2.75	2.75
I) Fatality domain (days/year)				
I1) Spring/summer	180	180	150	150
I2) Fall	75	75	60	60
J) Annual movement rate (bird passes/year; = ((H1*I1) + (H2*I2)), rounded to next whole number)	1,443	1,443	795	795
HORIZONTAL INTERACTION PROBABILITY (IPH)				
K) Turbine height (m)	100	100	100	100
L) Blade radius (m)	35.25	35.25	35.25	35.25
M) Height below blade (m)	29.5	29.5	29.5	29.5
N) Front to back width (m)	6	6	6	6
O) Minimal side profile area (m²) = (K*N)	600		600	
P) Maximal front profile area (m²) = (M*N) + (π x L²)		4081		4081
Q) Cross-sectional sampling area of radar at or below 100 m turbine height (= 3,000 m * 100 m = 300,000 m²)	300,000.0	300,000.0	300,000.0	300,000.0
R) Minimal horizontal interaction probability (= O/Q)	0.00200000		0.00200000	
S) Maximal horizontal interaction probability (= P/Q)		0.01360211		0.01360211
VERTICAL INTERACTION PROBABILITY (IPV)				
T) Proportion of petrels flying ≤ turbine height)	0.51	0.51	0.51	0.51

Table 2. Continued.

Variable/parameter	HAPE Minimum	HAPE Maximum	NESH Minimum	NESH Maximum
EXPOSURE INDEX (ER = MVR*IPH*IPV)				
U) Daily exposure index (bird passes/turbine/day = H*(R or S)*T, rounded to 8 decimal places)				
U1) Spring/summer	0.00642528	0.04369870	0.00428352	0.02913247
U2) Fall	0.00420031	0.02856655	0.00280021	0.01904437
V) Annual exposure index (bird passes/turbine/year = J*(R or S)*T, rounded to 8 decimal places	1.47186000	10.01020412	0.81090000	5.51497732
FATALITY PROBABILITY (MP)				
W) Probability of striking turbine if in airspace on a side approach	1.00		1.00	
X) Probability of striking turbine if in airspace on frontal approach		0.20		0.20
Y) Probability of fatality if striking turbine[1]	1.00	1.00	1.00	1.00
Z1) Probability of fatality if an interaction on side approach (= W*Y)	1.00000		1.00000	
Z2) Probability of fatality if an interaction on frontal approach (= X*Y)		0.19500		0.19500
FATALITY INDEX (= ER*MP)				
Annual fatality rate with 90% exhibiting collision avoidance (birds/turbine/year = V*(Z1 or Z2)*0.1)	0.14719	0.19520	0.08109	0.10754
Annual fatality rate with 95% exhibiting collision avoidance (birds/turbine/year =V*(Z1 or Z2)*0.05)	0.07359	0.09760	0.04055	0.05377
Annual fatality rate with 99% exhibiting collision avoidance (birds/turbine/year =V*(Z1 or Z2)*0.01)	0.01472	0.01952	0.00811	0.01075

[1] Used 100% fatality probability due to ESA definition of "take"; however, actual probability of fatality with collision <100% (see methods).

again, however, that the range of assumed avoidance rates of seabirds and turbines/towers (90–99%) is not fully supported by empirical data at this time.

DISCUSSION

MOVEMENT RATES AND FLIGHT BEHAVIOR

Within KWP, there has been some variation in mean movement rates among years and studies (Table 5), but all estimated rates have been low (i.e., between 0.5 and 1.8 targets/h). Thus, mean movement rates of Hawaiian Petrels recorded in the KWP study areas (i.e., ~1–2 targets/h; this study; Day and Cooper 1999, Cooper and Day 2004; Sanzenbacher and Cooper 2008, 2009; Cooper and Day 2009) all are much lower than those over the eastern and northern sides of Maui (Cooper and Day 2003).

Our limited data in summer (i.e., five sampling nights; Cooper and Day 2009) suggested that patterns of movement may have been affected by the wind regime. For instance, in summer we found that shearwater/petrels mostly flew in an outbound movement towards the southwest during strong Trade Winds and flew inbound toward the east during light and variable winds. Further, those limited data also suggested that summer passage rates might be higher over the lower (southern) end of the study area than elsewhere during calm conditions, though, again note that we only had two nights of sampling during strong winds and three nights during light winds.

We did not experience any high wind conditions during fall; average wind speeds ranged between 0–8 mph. Thus, we did not have high wind conditions for comparison to summer movement patterns under those conditions, but during the low wind conditions, we did observe similar directionality as in summer, with most birds

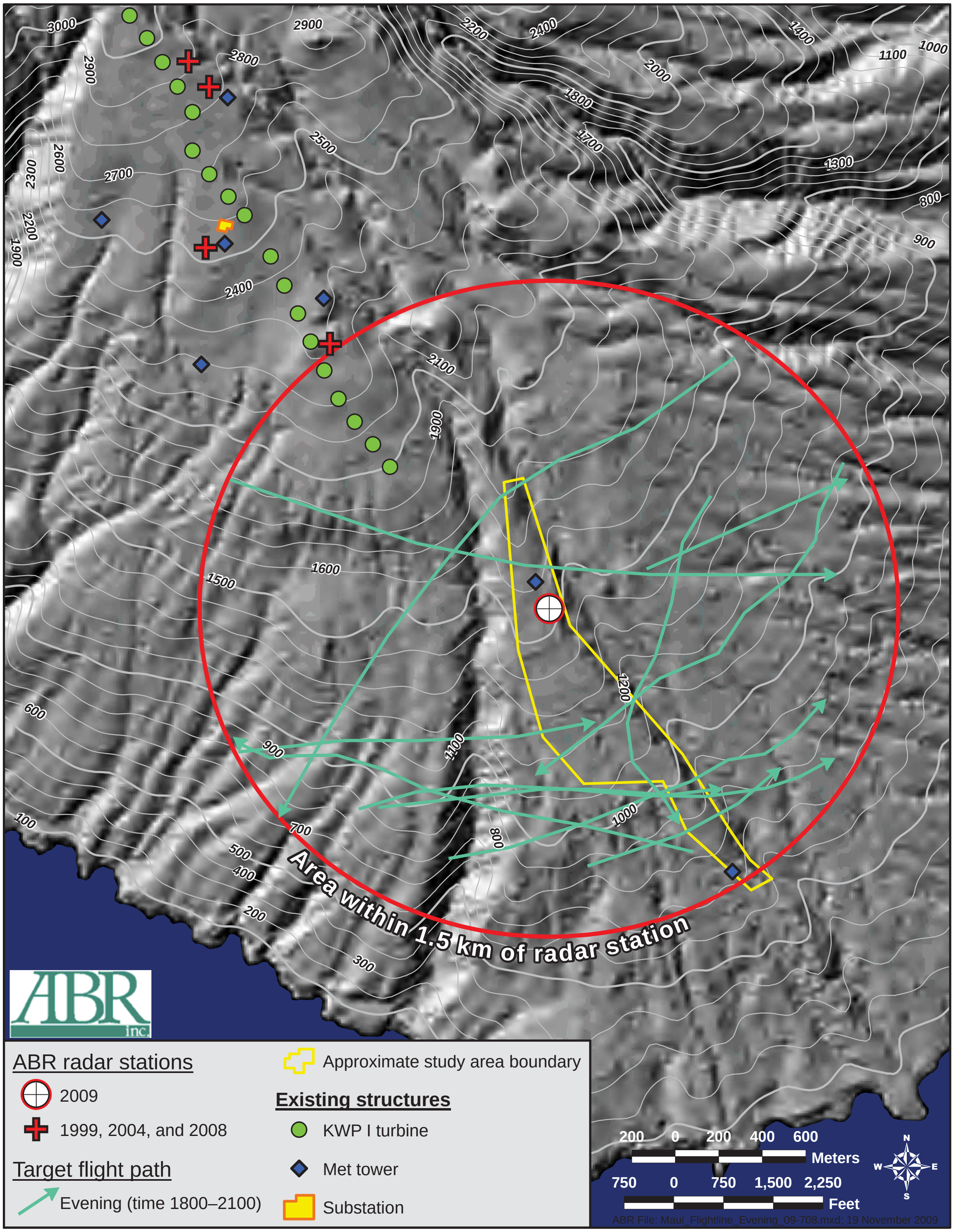

Figure 4. Location of flight paths of petrel-like radar targets observed during the evening sampling period (1800–2100 h) in October 2009 at the KWP II Down-road Alternative (KWP II) wind energy facility, Maui, Hawaii.

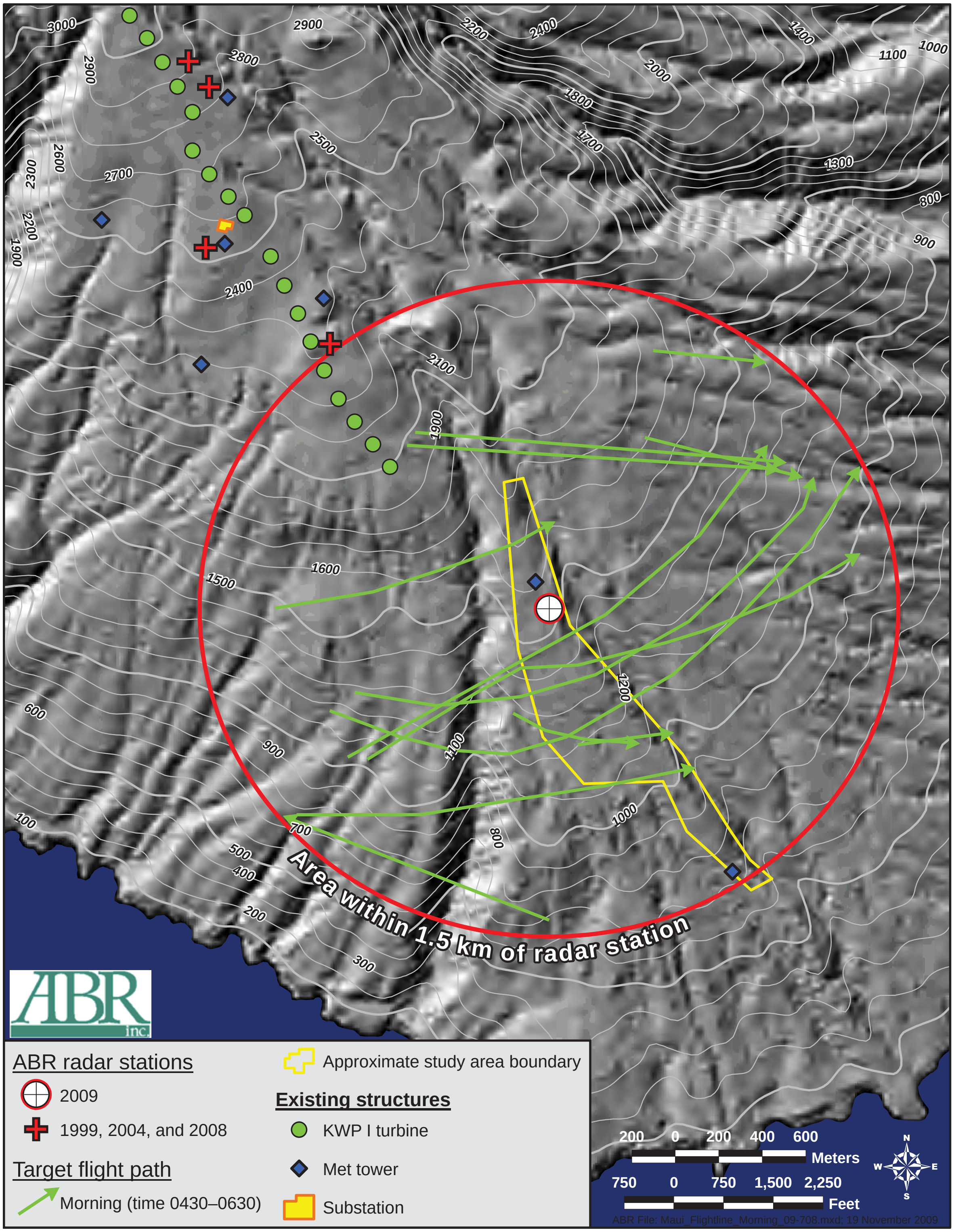

Figure 5. Location of flight paths of petrel-like radar targets observed during the morning sampling period (0430–0630 h) in October 2009 at the KWP II Down-road Alternative (KWP II) wind energy facility, Maui, Hawaii.

Table 3. Estimated average exposure rates and fatality rates of Hawaiian Petrels (HAPE) and Newell's Shearwaters (NESH) at the proposed free-standing 65-m-tall met tower at the KWP II Down-road Alternative (KWP II) wind-energy site, Maui, Hawaii, based on radar data collected in July and October 2009. Values of particular importance are in boxes.

Variable/parameter	HAPE	NESH
MOVEMENT RATE (MVR)		
A) Mean movement rate (targets/h)		
A1) Mean rate during nightly peak movement periods in spring/summer based on July 2009 data (targets/h)	1.776	1.776
A2) Mean rate during nightly peak movement periods in fall based on October 2009 data (targets/h)	1.161	1.161
B) Number of hours of evening and morning peak-period sampling	5	5
C) Mean number of targets during evening and morning peak-movement periods		
C1) Spring/summer (A1 * B)	8.88	8.88
C2) Fall (A2 * B)	5.805	5.805
D) Mean proportion of birds moving during off-peak h of night	0.126	0.126
E) Seasonal movement rate (targets/night) = ((C * D)+ C)		
E1) Spring/summer	10.0	10.0
E2) Fall	6.5	6.5
F) Mean number of birds/target	1.05	1.05
G) Estimated proportion of each species	0.60	0.40
H) Daily movement rate (bird passes/day =E*F*G)		
H1) Spring/summer	6.30	4.20
H2) Fall	4.12	2.75
I) Fatality domain (days/year)		
I1) Spring/summer	180	150
I2) Fall	75	60
J) Annual movement rate (bird passes/year; = ((H1*I1) + (H2*I2)), rounded to next whole number)	1,443	795
HORIZONTAL INTERACTION PROBABILITY (IPH)		
K) Maximal cross-sectional area of tower (side view = 297 m²)	297.0	297.0
L) Cross-sectional sampling area of radar at or below 65 m tower height (= 3,000 m * 65 m = 195,000 m²)	195,000.000	195,000.000
M) Average probability of radar target intersecting the met tower (= K/L, rounded to 8 decimal places)	0.00152308	0.00152308
VERTICAL INTERACTION PROBABILITY (IPV)		
N) Proportion of petrels flying ≤ tower height)	0.33	0.33
EXPOSURE INDEX (ER = MVR*IPH*IPV)		
O) Daily exposure index (bird passes/tower/day = H*M*N, rounded to 8 decimal places)		
O1) Spring/summer	0.00316612	0.00211075
O2) Fall	0.00206975	0.00137983
P) Annual exposure index (bird passes/tower/year = J*M*N, rounded to 8 decimal places)	0.72527400	0.39957923
FATALITY PROBABILITY (MP)		
Q) Probability of striking tower if in airspace	1.00	1.00
R) Probability of fatality if striking tower[1]	1.00	1.00
S) Probability of fatality if an interaction (= Q*R)	1.00000	1.00000
FATALITY INDEX (= ER*MP)		
T) Annual fatality rate with 90% exhibiting collision avoidance (birds/tower/year = P*S*0.1)	0.07253	0.03996
U) Annual fatality rate with 95% exhibiting collision avoidance (birds/tower/year = P*S*0.05)	0.03626	0.01998
V) Annual fatality rate with 99% exhibiting collision avoidance (birds/tower/year = P*S*0.01)	0.00725	0.00400

[1] Used 100% fatality probability due to ESA definition of "take", however actual probability of fatality with collision <100% (see methods).

Table 4. Summary of exposure rates, fatality rates, and cumulative fatality rates for Hawaiian Petrels (HAPE) and Newell's Shearwaters (NESH) at wind turbines and meteorological (met) towers at the proposed KWP II Down-road Alternative (KWP II) wind-energy site, Maui, Hawaii, based on radar data collected in July and October 2009

	Exposure rate/structure (bird passes/structure/yr)			Fatality rate/structure (birds/structure/yr)			Cumulative fatality rate (birds/yr)	
Structure type	HAPE	NESH	Avoidance rate	HAPE	NESH	No. structures	HAPE	NESH
GE 1.5 MW turbine	1.472 (min)	0.811 (min)	0.90 (min)	0.147	0.081	14.00	2.061	1.135
	10.010 (max)	5.515 (max)	0.90 (max)	0.195	0.108	14.00	2.733	1.506
			0.95 (min)	0.074	0.041	14.00	1.030	0.568
			0.95 (max)	0.098	0.054	14.00	1.366	0.753
			0.99 (min)	0.015	0.008	14.00	0.206	0.114
			0.99 (max)	0.020	0.011	14.00	0.273	0.151
65-m free-standing met tower	0.725	0.400	0.90	0.073	0.040	1.00	0.073	0.040
			0.95	0.036	0.020	1.00	0.036	0.020
			0.99	0.007	0.004	1.00	0.007	0.004

Table 5. Mean (± SE) movement rates of petrel-like targets measured with radar at the KWP wind-energy site and proposed KWP II wind-energy sites, Maui, Hawaii, during 1999–2009 studies.

Year	Site	Movement rate (targets/h)		Source
		Summer	Fall	
1999	KWP I	1.2 ± 0.3	–	Day and Cooper (1999)
2004	KWP I	–	1.0 ± 0.2	Cooper and Day (2004)
2008	KWP II	0.46 ± 0.15	0.09 ± 0.07	Sanzenbacher and Cooper (2008. 2009)
2009	KWP II	1.78 ± 0.14	1.16 ± 0.17	Cooper and Day (2009); current study

flying inbound towards the east. In contrast, we did not see as strong a pattern of higher passage rates over the lower (southern) end of the study during fall as in summer. Thus, the consistent flight directions of the targets observed during light winds in summer and fall suggest that they were birds approaching Maui from the west and "cutting the corner" of West Maui on their way to breeding colonies on Haleakala, but it is unknown whether the lower, southern half of the study area consistently has higher passage rates than the northern half during low wind conditions.

VISUAL OBSERVATIONS OF PETRELS AND SHEARWATERS

In total, we have had three visual observations of Hawaiian Petrels and two observations of unidentified shearwaters/petrels over the KWP study areas during 1999–2009 (Table 6; Day and Cooper 1999, Cooper and Day 2004a; Sanzenbacher and Cooper 2008, 2009; this study). The birds observed in the evening period were headed easterly or northeasterly, and the birds observed in the morning were heading southeasterly or southwesterly. These directions fit a pattern of inbound movements toward Haleakala in the evening and outbound movements from Haleakala and/or West Maui in the morning.

Flight altitudes of the two birds that we observed over the proposed turbine-string ridges were within turbine heights (i.e., one was at 40 m agl and the other was at 65 m agl; Table 6). The flight altitudes of the other three birds were much higher (i.e., 300–500 m agl), but they were measured over the valley to the east; hence, we do not know what their flight altitudes were as they flew over the ridges on which the turbine strings lie. Thus, the very limited data that we have for known flight altitudes at this site (n = 2) suggests that at least some petrels flew within the turbine-height zone.

In our fatality models, we used the timing of inland flights at the nearby Ukumehame site from Cooper and Day (2003) to correct for proportions of targets that were Hawaiian Petrels and those that were Newell's Shearwaters; those data suggested that 60% of the targets were Hawaiian Petrels and 40% of the targets were Newell's Shearwaters. However, the timing of two of the three Hawaiian Petrels that we saw over the site (Table 6) occurred during the late evening, a period when Cooper and Day (2003) assumed that only Newell's Shearwaters would occur. These visual observations suggest the possibility that more than 60% of the radar targets we observed in the current study could have been Hawaiian Petrels. We do not recommend changing the relative proportions of Hawaiian Petrels vs. Newell's Shearwaters used for the fatality model, however, unless further data are collected to confirm this pattern.

EXPOSURE RATES AND FATALITY ESTIMATES

We estimated that 2–11 Hawaiian Petrels and 1–6 Newell's Shearwater would fly within the space occupied by each wind turbine in an average

Table 6. Records of visual observations of Hawaiian Petrels and unidentified shearwaters/petrels at the proposed KWP II wind-energy site and nearby KWP I wind-energy site, Maui, Hawaii, during 1999–2009 studies.

Date	Time	Species[1]	Number	Altitude (m agl)	Flight direction
28 May 1999	2150	HAPE	1	300[2]	NE
28 May 1999	0608	UNSP	2	500[2]	SE
12 October 2004	0608	HAPE	1	500[2]	SE
15 October 2004	0454	UNSP	1	65	SW
24 July 2009	2126	HAPE	1	40	E

[1] HAPE = Hawaiian Petrel; UNSP = unidentified shearwater/petrel.

[2] Flight altitude measured over the valley to east of the proposed turbine string ridge, not over the proposed turbine string ridge itself; measurements were done that way because that is where birds were first seen.

year and estimated that 1 Hawaiian Petrel and 1 Newell's Shearwater would fly within the space occupied by the 65-m-high met tower in an average year (Table 4). We used these estimated exposure rates as a starting point for developing a complete avian risk assessment; however, we emphasize that it currently is unknown whether bird use (i.e., exposure) and fatality at windfarm structures are strongly correlated. For example, Cooper and Day (1998) found no relationship between movement rates and fatality rates of Hawaiian Petrels and Newell's Shearwaters at powerlines on Kaua'i, indicating that other factors had a much greater effect on causing fatality than movement rates did. For example, other factors such as proximity to the ocean or poor weather could be more highly correlated with fatality rates than is bird abundance. As an example, collisions of Laysan Albatross with a large array of communication-tower antenna wires and guy wires adjacent to large, high-density albatross breeding colonies on Midway Atoll occurred at a far higher rate during periods of high winds, rain, and poor visibility than during periods of better weather: 838 (>25%) of the 2,901 birds killed during the study were killed during two storms (Fisher 1966). To determine which factors are most relevant, future studies that collect concurrent data on movement rates, weather, and fatality rates would be useful to begin to determine whether movement rates and/or weather conditions can be used to predict the likelihood of petrel fatalities at wind turbines and other structures across the entire proposed windfarm.

In addition, few data are available on the proportion of petrels and shearwaters that do not collide with wind turbines or met towers because of collision-avoidance behavior (i.e., birds that completely alter their flight paths horizontally and/or vertically to avoid flying through the space occupied by a turbine/tower). Clearly, the detection of wind turbines or other structures could result in collision-avoidance behavior by these birds and reduce the likelihood of collision. There also appear to be differences between petrels and shearwaters in their ability to avoid obstacles. For example, Cooper and Day (1998) indicated that Hawaiian Petrels have flight characteristics that make them more adept at avoiding powerlines than Newell's Shearwaters, suggesting that Hawaiian Petrels might also be more likely to avoid collisions with other structures such as wind turbines. These authors also suggested that the tendency for Hawaiian Petrels to approach and leave nesting colonies primarily during crepuscular periods enables these birds to see and avoid structures (e.g., wind turbines) more easily than do Newell's Shearwaters that approach and leave nesting colonies primarily during nocturnal periods.

Some collision-avoidance information is available on petrels and shearwaters from earlier work that we conducted on Kaua'i (Cooper and Day 1998; Day et al., *In prep*). In summary, those data suggest that the behavioral-avoidance rate of Hawaiian Petrels and Newell's Shearwaters near powerlines is high. For example, across all 207 Hawaiian Petrels observed flying within 150 m of transmission lines on Kauai, 40 exhibited behavioral responses; of those 40 birds that exhibited collision-avoidance responses, none (0%) collided with a transmission line. Thus, the collision-avoidance rate for Hawaiian Petrels was 100% (i.e., 40 of 40 interactions). Across all 392 Newell’s Shearwaters observed flying within 150 m of transmission lines, 29 exhibited behavioral responses; of those 29 birds that exhibited collision-avoidance responses, none (0%) collided with a transmission line. However, one Newell's Shearwater that did not exhibit a collision-avoidance response hit a transmission line. Thus, the collision-avoidance rate for Newell’s Shearwaters was 97% (i.e., 29 of 30 interactions).

There also is some information available on collision-avoidance of Hawaiian Petrels on Lana’i, where the behavior of petrels was studied as they approached large communication towers near the breeding colony (TetraTech 2008b; Day et al., *In prep*). In those studies, all 26 (100%) of the Hawaiian Petrels seen on a collision-course toward communication towers exhibited avoidance behavior and avoided collision. In addition, zero fatalities of Hawaiian Petrels were observed at six met towers that were monitored on the island of Lana’i during 2008 (TetraTech 2008a).

Additional data that provides some insight on collision-avoidance behavior of petrels and shearwaters at windfarm structures (e.g., wind turbines and met towers) are available from other studies associated with the operational KWP I wind facility. There was 1 Hawaiian Petrel fatality and 0 Newell’s Shearwater fatalities observed at the 20-turbines and three met towers in the first ~four years of operation (G. Spencer, First Wind, pers. comm.). Calculations using data for scavenging bias and searcher efficiency collected at the KWP I wind facility indicate that the one observed fatality equates to a corrected direct take of 0.5 Hawaiian Petrels/yr and 0 Newell’s Shearwaters/yr (Kaheawa Wind Power LLC 2009, *in prep*). Cooper and Day (2004b) modeled seabird fatality for the KWP I wind turbines, based on movement rates from radar studies at the site (Day and Cooper 1999; Cooper and Day 2004a, 2004b), and estimated that the combined annual fatality of Hawaiian Petrels and Newell’s Shearwaters at the KWP I turbines would be ~3–18 birds/yr with a 50% avoidance rate, ~1–2 birds/yr with a 95% avoidance rate, and <1 bird/yr with a 99% avoidance rate. Thus, the fatality model that used a 99% avoidance value was a closer fit with the measured fatality rates than was the fatality models that used a 50% or 95% avoidance rate.

In summary, currently available data from Kaua’i, Lana’i, and Maui suggest that the avoidance rate of petrels and shearwaters at transmission lines and communications towers is high and approaches 100% (Day et al., *in prep*). Data from the fatality searches at turbines and met towers on Maui are more difficult to interpret because they suggest high avoidance but are not a direct measure of avoidance; however those data also suggest that avoidance of those structures must be occurring because only one Hawaiian Petrel has been found during regular fatality searches of those structures over a four-year period. Thus, the overall body of evidence, while incomplete, is consistent with the hypothesis that the average avoidance rate of wind turbines and met towers is substantial and potentially is ≥95%. The ability of Hawaiian Petrels and Newell’s Shearwater to detect and avoid most objects under low-light conditions makes sense from a life-history standpoint, in that they forage extensively at night and are adept at flying through forests near their nests during low light conditions (Ainley et al. 1997b, Simons and Hodges 1998).

In addition to the limited data available for Hawaiian Petrels and Newell’s Shearwaters, there is evidence that many other species of birds detect and avoid structures (e.g., wind turbines, met towers) during low-light conditions (Winkelman 1995, Dirksen et al. 1998, Desholm and Kahlert 2005, Desholm et al. 2006). For example, seaducks in Europe have been found to detect and avoid wind turbines >95% of the time (Desholm 2006). Further, natural anti-collision behavior (especially alteration of flight directions) is seen in migrating Common and King eiders (*Somateria mollissima* and *S. fischeri*) approaching human-made structures in the Beaufort Sea off of Alaska (Day et al. 2005) and in diving ducks approaching offshore windfarms in Europe (Dirksen et al. 1998). Collision-avoidance rates around wind turbines are high for Common Eiders in the daytime (Desholm and Kahlert 2005), Common Terns (*Sterna hirundo*) and Sandwich Terns (*Sterna* *sandvicensis*) during the daytime (>99%, Everaert and Stienen 2007), gulls (*Larus* spp.) in the daytime (>99%; Painter et al. 1999, cited in Chamberlain et al. 2006), Golden Eagles (*Aquila chrysaetos*) in the daytime (>99%; Madders 2004, cited in Chamberlain et al. 2006), American Kestrels (*Falco sparverius*) in the daytime (87%, Whitfield and Band [in prep.], cited in Chamberlain et al. 2005), and passerines during both the day and night (>99%; Winkelman 1992, cited in Chamberlain et al. 2006).

We agree with others (Chamberlain et al. 2006, Fox et al. 2006) that species-specific, weather-specific, and site-specific avoidance data are needed in models to estimate fatality rates accurately. However, the currently available avoidance data from Kaua'i and Lana'i for Hawaiian Petrels and Newell's Shearwaters and the petrel fatality data at KWP I wind turbines and met towers while limited, is consistent with the notion that a substantial proportion of petrels detect and avoid wind turbines, marked met towers, communication towers, and powerlines. Until further petrel- and shearwater-specific data on the relationship between exposure and fatality rates are available for structures at windfarms, we continue to provide a range of assumptions for avoidance rates in our fatality models (i.e., 90%, 95%, and 99% avoidance), along with a discussion of the body of evidence that, while incomplete at this time, is consistent with the notion that the average avoidance-rate value is substantial and potentially is ≥95%. With an assumption of a 95% avoidance rate, the estimated average annual fatality rate at the KWP II would be ≤0.10 Hawaiian Petrel/turbine/yr and ≤0.05 Newell's Shearwaters/turbine/yr and, for met towers, the average annual fatality rate would be 0.04 Hawaiian Petrel/tower/yr and 0.02 Newell's Shearwaters/tower/yr.

Other factors could affect our estimates of fatality in either a positive or a negative direction. One factor that would have created a positive bias was the inclusion of targets that were not petrels or shearwaters. Our visual observations of several other species with similar target characteristics to petrels (especially during crepuscular periods, when we could use binoculars) helped to minimize the inclusion of these non-target species, but it is likely (especially during nocturnal conditions) that some of our radar targets were other fast-flying species that were active during the sampling period (e.g., Pacific Golden-Plover). A second positive bias in our fatality model is our simplistic assumption that movement rates of seabirds do not fall as individual fatalities occurred (i.e., we assumed sampling with replacement for fatalities). Given the low movement rates observed in this study, it is likely that the fatality of just a single bird would substantially reduce the average nightly movement rates. A third positive bias is the assumption that turbines are operating at maximal rotor speed; this assumption clearly is incorrect because of variability in winds, but using it results in maximal estimates of collision rates for birds flying through the turbine rotors.

There also are factors that could create a negative bias in our fatality estimates. One example would be if targets were missed because they flew within radar shadows. Because the sampling stations provided good coverage of the surrounding area, we believe that the proportion of targets that was missed because they passed through the entire area of coverage of the study area within a radar shadow was minimal.

A factor that could affect the predictive value of our fatality estimates in either direction is interannual variation in the number of birds visiting nesting colonies on Maui. The average hourly movement rates in summer (~1.8 targets/h), and fall (~1.2 targets/h) 2009 were slightly higher than rates from previous years (Table 5). However, all those studies suggest that rates are consistently low at the KWP project areas relative to other areas on Maui, and that interannual variation in the overall level of bird use of the area is minimal (i.e., < 1 target/h difference among studies). Some caution in extrapolation of movement rates across years is still warranted, however, because there are examples of other sites with high interannual variation in counts, such as the three sites on Kaua'i where counts were ~100–300 birds/hr lower (~four times lower) in fall 1992 than in fall 1993; the lower counts in 1992 were attributed to the effects of Hurricane Iniki (Day and Cooper 1995). Oceanographic factors (e.g., El Niño–Southern Oscillation events) also vary among years and are known to affect the distribution, abundance, and reproduction of seabirds (e.g., Ainley et al. 1994, Oedekoven et al.

2001). There was a moderate El Niño–Southern Oscillation event that began in April 2009 and was still developing when our summer study occurred in July 2009 (NOAA 2009). We speculate that it is unlikely that El Niño-related oceanographic effects were large enough by July 2009 to have significantly affected seabird movement rates during our summer study period, but it is possible that fall rates could have been affected (however, note that this is unlikely, given that fall 2009 rates were higher than rates in both fall 2004 and fall 2008; Table 5). Another factor that could cause interannual variation in counts in either direction is overall population increases or declines. For example, there was a ~60% decline in radar counts on Kaua'i between 1993 and 1999–2001 that was attributed to population declines of Newell's Shearwaters (Day et al. 2003b).

CONCLUSIONS

We used our risk-assessment model to estimate the number of Hawaiian Petrels and Newell's Shearwaters that might be killed by collisions with wind turbines and met towers at the proposed KWP II facility. The model is affected by several input variables, including the collision-avoidance rate. The absence of behavioral studies to fully quantify avoidance rates at wind turbines and met towers precludes determination of actual avoidance rates; however, a growing body of evidence suggests that a high percentage of petrels and shearwaters detect and avoid structures such as communication towers, transmission lines, and wind turbines (see above). We also suspect high rates of anti-collision behaviors because petrels must rely upon acute nocturnal vision for foraging and other flight activities under varying weather conditions. In conclusion, we believe that the proportion of petrels that would see and avoid proposed wind turbines at the KWP II will be high, but until studies are conducted to quantify avoidance behavior at wind turbines and met towers, we provide a range of assumptions for avoidance rates in our fatality models (i.e., 90%, 95%, and 99% avoidance rates) along with a discussion of the body of evidence that is consistent with the hypothesis that the average avoidance-rate value is substantial and potentially ≥95%. With an assumption of ≥95% avoidance, the estimated average annual number of fatalities at the proposed KWP II wind turbines would be 0.015–0.098 Hawaiian Petrel/turbine/yr and 0.008–0.054 Newell's Shearwaters/turbine/yr. The estimated average annual number of fatalities at the proposed KWP II met tower (with an assumption of ≥95% avoidance) would be 0.007–0.036 Hawaiian Petrel/tower/yr and 0.004–0.020 Newell's Shearwaters/tower/yr.

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Appendix 14

Downed Wildlife Protocol

Kaheawa Wind Power II

Habitat Conservation Plan

Purpose	To identify and document any wildlife injury or fatality incident that involves Covered and MBTA Species at the Kaheawa Wind Power II site incidental to and during regular monitoring.
Applicability	This protocol applies to all employees of Kaheawa Wind Power II and its affiliates, and extends to all consultants, contractors, or other personnel who work on the site.
Covered Species	Covered Species include the federally *endangered* Hawaiian Petrel, Hawaiian goose, Hawaiian Hoary Bat, and the federally *threatened* Newell's Shearwater. MBTA species include all species covered under the provisions of the federal Migratory Bird Treaty Act.
Overall Approach	Downed wildlife may be located during the course of regular monitoring or opportunistically during routine site work. In addition to the project's monitoring program, which is a component of the project's Habitat Conservation Plan, project consultants and personnel will routinely look for and exhibit awareness of the potential to encounter downed wildlife when working at individual turbine sites, when traveling along site roads by vehicle, and when traveling the site on foot. Should any downed wildlife be found or reported, the responsible party (Senior Wildlife Biologist, Site Compliance Officer, or their official designee) shall contact Maui DLNR Forestry and Wildlife Division and USFWS immediately to initiate response coordination: Maui Wildlife Program Manager at 808-873-3510 (John Medeiros) or 808-873-3502 (Fern Duvall). USFWS Wildlife Biologist at 808-792-9433 (James Kwon) A written report that provides documentation and details of the incident will be submitted to DLNR/DOFAW and USFWS within 3 business days following the incident. All downed wildlife will be left in place until agency personnel arrive or unless directed by USFWS or DLNR personnel. Injured wildlife may require, if instructed directly by DLNR or USFWS, that the responsible party transport the downed individual in an appropriate container (e.g. ventilated pet carrier) either to a qualified veterinarian or other facility specified by DLNR or USFWS, as described below, as soon as possible and appropriate (e.g., if the individual is alive, it shall be transported immediately). The responsible party will also complete a Downed Wildlife Monitoring Form and an official Incident Report will be submitted to DLNR and USFWS within 3 business days following the incident.
Facility Information	TBD Phone:
Kaheawa Wind Power II Contact Information	Gregory Spencer, Senior Wildlife Biologist Phone: (808) 298-5097

Kaheawa Wind Power II, LLC

Habitat Conservation Plan – Downed Wildlife Incident Documentation Form

SAMPLE

Observer Name:	
Date:	
Species (common name):	
Time Observed (HST):	
Time Initially Reported (HST):	
Time Responders Arrive (HST):	
Location:	
GPS Coordinates (specify units and datum):	
Date Last Surveyed:	
Distance to Base of nearest WTG:	
Bearing from Base of nearest WTG:	
Ground Cover Type:	
Wind Direction and Speed (mph):	
Cloud Cover (%):	
Cloud Deck (magl):	
Precipitation:	
Temperature (^{o}F):	

Condition of Specimen:
Probable Cause of Injuries and Supportive Evidence:
Action Taken:

Appendix 15

BIOLOGICAL RESOURCES SURVEY

KAHEAWA WIND ENERGY PROJECT 2 (KWP2)

KAHEAWA, MAUI, HAWAII

by

ROBERT W. HOBDY
ENVIRONMENTAL CONSULTANT
Kokomo, Maui
January 2010

Prepared for: FIRST WIND ENERGY, LLC

INTRODUCTION

Kaheawa Wind Energy Project 2 (KWP2) lies on Kaheawa Ridge on the southern tip of West Maui just west of Manawainui Gulch between the elevations of 1,800 feet and 2,700 feet. This project consists of one approximately 1,500 ft. long corridor for the installation of an underground cable system and two small areas where project related structures are planned. This study has been intiated by First Wind Energy LLC to assess the botanical resources of the project area in fulfillment of environmental requirements of the planning process.

SITE DESCRIPTION

Kaheawa Ridge has moderately sloping terrain that descends to the sea at a roughly 16% grade. Vegetation is mostly grasslands and low shrubby cover with a few small scattered trees. Soils are characterized as Oli Silty Clay Loam, 10 – 30% slopes (OMB), which is a moderately deep soil formed from volcanic ash, as well as Rocklands (rRK) which are broken and uneven and with some eroded areas (Foote et al, 1972). This area is often windy, and has an annual rainfall that averages 30 inches to 40 inches with the bulk falling during the winter months (Armstrong, 1983).

BIOLOGICAL HISTORY

In pre-contact times this part of the mountain slope was entirely covered with native vegetation of low stature with dry grass and shrub lands and with a few trees in the gullies. The Hawaiians made some uses of forest resources here and had a cross-island trail cresting the ridge at 1600 ft. elevation. This trail was upgraded during the mid-1800s and used as a horse trail to Lahaina. It was resurrected to use in recent years and is the present Lahaina Pali Trail.

Cattle ranching began in the late 1800s and continued for over 100 years. During this time the grazing animals consumed much of the native vegetation which was gradually replaced by hardy weed species.

During the 1950s high voltage power lines were installed across the mountain along with access roads through this area. Increased traffic brought more disturbances and weeds. Fires became more frequent, further eliminating remnant native vegetation.

With the cessation of cattle grazing a number of grass and weed species have proliferated, creating a heightened fire hazard. Large fires have swept across the mountain consuming thousands of acres including the entire project area several times.

DESCRIPTION OF VEGETATION

The vegetation within the project area is a diverse array of grasses and low shrubs with a scattering of small trees. Five species are common throughout: molasses grass (*Melinis minutiflora*), Natal redtop (*Melinis repens*), u'ulei (*Osteomeles anthyllidifolia*), 'a'ali'i (*Dodonaea viscosa*) and lantana (*Lantana camara*). A total of 57 species were recorded during the survey.

Sixteen species of native plants were found in the project area: they include the u'ulei and 'a'ali'i as well as (*Carex wahuensis* subsp. *wahuensis*) no common name, ko'oko'olau (*Bidens micrantha* subsp. *micrantha*), naupaka kuahiwi (*Scaevola gaudichaudii*), 'akoko (*Chamaesyce celastroides* var. *amplectens*), 'öhi'a (*Metrosideros polymorpha* vars. *Glaberrima* and *incana*), 'iliahi alo'e (*Santalum ellipticum*), kilau (*Pteridium aquilinum* var. *decompositum*), koali awahia (*Ipomoea indica*), pükiawe (*Leptecophylla tameiameiae*), 'ilima (*Sida fallax*), 'uhaloa (*Waltheria indica*) and huehue (*Osteomeles anthyllidifolia*). The remaining 41 plant species were non-native grasses, shrubs and trees.

SURVEY OBJECTIVES

This report summarizes the findings of a botanical survey of the Kaheawa Pastures Wind Energy Project which was conducted in January 2010.
The objectives of the survey were to:

1. Document what plant species occur on the property or may likely occur in the existing habitat.

2. Document the status and abundance of each species.

3. Determine the presence or likely occurrence of any native plant species, particularly any that are federally listed as Threatened or Endangered. If such occur, identify what features of the habitat may be essential for these species.

4. Determine if the project area contains any special habitats which if lost or altered might result in a significant negative impact on the flora in this part of the island.

5. Note which aspects of the proposed development pose significant concerns for plants and recommend measures that would mitigate or avoid these problems.

SURVEY METHODS

The entire project area was surveyed on foot. Areas on rocky gully slopes were examined more intensively as these were the places where the most native plants survived both the grazing of cattle and the effects of wildfires. Notes were made on plant species, distribution and abundance as well as on terrain and substrate.

PLANT SPECIES LIST

Following is a checklist of all those vascular plant species inventoried during the field studies. Plant families are arranged alphabetically within three groups: Ferns, Monocots and Dicots. Taxonomy and nomenclature of the ferns are in accordance with Palmer (2003) and the flowering plants are in accordance with Wagner et al. (1999) and Staples and Herbst (2005).

For each species, the following information is provided:

1. Scientific name with author citation

2. Common English or Hawaiian name.

3. Bio-geographical status. The following symbols are used:

   endemic = native only to the Hawaiian Islands; not naturally occurring anywhere else in the world.

   indigenous = native to the Hawaiian Islands and also to one or more other geographic area(s).

   Polynesian introduction = plants introduced to Hawai'i in the course of Polynesian migrations and prior to western contact.

   non-native = all those plants brought to the islands intentionally or accidentally after western contact.

4. Abundance of each species within the project area:

   abundant = forming a major part of the vegetation within the project area.

   common = widely scattered throughout the area or locally abundant within a portion of it.

   uncommon = scattered sparsely throughout the area or occurring in a few small patches.

   rare = only a few isolated individuals within the project area.

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
FERNS			
DENNSTAEDTIACEAE (Bracken Family)			
Pteridium aquilinum (L.) Kuhn var. *decompositum* (Gaud.) R.M. Tryon	*kilau*	endemic	rare
MONOCOTS			
CYPERACEAE (Sedge Family)			
Carex wahuensis C.A. Meyen subsp. *wahuensis*	----------------	endemic	uncommon
POACEAE (Grass Family)			
Bothriochloa barbinodis (Lag.) Herter	fuzzy top	non-native	rare
Bothriochloa pertusa (L.) A. Camus	pitted beardgrass	non-native	uncommon
Cynodon dactylon (L.) Pers.	Bermuda grass	non-native	rare
Digitaria insularis (L.) Mez ex Ekman	sourgrass	non-native	rare
Hyparrhenia rufa (Nees) Stapf	thatching grass	non-native	uncommon
Melinis minutiflora P. Beauv.	molasses grass	non-native	common
Melinis repens (Willd.) Zizka	Natal red top	non-native	common
Panicum maximum Jacq.	Guinea grass	non-native	rare
Paspalum dilalatum Poir.	Dallis grass	non-native	rare
Pennisetum clandestinum Chiov.	Kikuyu grass	non-native	rare
Sprorobolus africanus (Poir.) Robyns & Tournay	smutgrass	non-native	uncommon
DICOTS			
ANACARDIACEAE (Mango Family)			
Schinus terebinthifolius Raddi	Christmas berry	non-native	uncommon
ASTERACEAE (Sunflower Family)			
Acanthospermum australe (Loefl.) Kuntze	spiny bur	non-native	rare
Bidens micrantha Gaud.	*ko'oko'olau*	endemic	uncommon
Cirsium vulgare (Savi) Ten.	bull thistle	non-native	rare
Conyza bonariensis (L.) Cronq.	hairy horseweed	non-native	uncommon
Emilia fosbergii Nicolson	red pualele	non-native	rare
Heterotheca grandiflora Nutt.	telegraph weed	non-native	rare
Hypochoeris radicata L.	gosmore	non-native	rare
Senecio madagascariensis Poir.	fireweed	non-native	uncommon
BRASSICACEAE (Mustard Family)			
Lepidium virginicum L.	pepperwort	non-native	rare
Sisymbrium altissimum L.	tumble mustard	non-native	rare
CACTACEAE (Cactus Family)			
Opuntia ficus-indica (L.) Mill.	*panini*	non-native	rare
CASUARINACEAE (She-oak Family)			
Casuarina equisetifolia L.	common ironwood	non-native	rare

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
Casuarina glauca Sieber ex Spreng	longleaf ironwood	non-native	uncommon
CONVOLVULACEAE (Morning Glory Family)			
Ipomoea indica (J. Burm.) Merr.	*koali awahia*	inidgenous	rare
ERICACEAE (Heath Family)			
Leptecophylla tameiameiae (Cham. & Schlect.) C.M. Weiller	*pükiawe*	indigenous	uncommon
EUPHORBIACEAE (Spurge Family)			
Chamaesyce celastroides (Boiss.) Croizat & Degener var. *amplectens* (Sherff) Degner & I. Degener	*'akoko*	endemic	uncommon
FABACEAE (Pea Family)			
Acacia farnesiana (L.) Willd.	klu	non-native	rare
Chamaecrista nictitans (L.) Willd.	partridge pea	non-native	uncommon
Indigofera suffruticosa Mill.	'*inikö*	non-native	rare
Leucaena leucocephala (Lam.) de Wit	*koa haole*	non-native	rare
Macroptilium lathyroides (L.) Urb.	wild bean	non-native	rare
Neonotonia wightii (Wight & Arnott) Lackey	glycine	non-native	rare
GOODENIACEAE (Goodenia Family)			
Scaevola gaudichaudii Hooker & Arnott	*naupaka kuahiwi*	endemic	rare
MALVACEAE (Mallow Family)			
Malvastrum cormandelianum (L.) Garcke	false mallow	non-native	rare
Sida fallax Walp.	'*ilima*	indigenous	uncommon
Triumfetta semitriloba Jacq.	Sacramento bur	non-native	uncommon
Waltheria indica L.	'*uhaloa*	indigenous	uncommon
MENISPERMACEAE (Moonseed Family)			
Cocculus orbiculatus (L.) DC.	*huehue*	indgenous	rare
MYRTACEAE (Myrtle Family)			
Metrosideros polymorpha Gaud. var. *glaberrima* (H.Lev.) St. John	'*öhi'a*	endemic	uncommon
Metrosideros polymorpha Gaud. var. *incana* (H. Lev.) St. John	'*öhi'a*	endemic	rare
Psidium guajava L.	common guava	non-native	rare
OXALIDACEAE (Wood Sorrel Family)			
Oxalis corniculata L.	yellow wood sorrel	Polynesian	rare
PLANTAGINACEAE (Plantain Family)			
Plantago lanceolata L.	narrow-leaved plantain	non-native	uncommon
POLYGALACEAE (Milkwort Family)			
Polygala paniculata L.	milkwort	non-native	rare

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
PROTEACEAE (Protea Family)			
Grevillea robusta A. Cunn. ex R. Br.	silk oak	non-native	rare
ROSACEAE (Rose Family)			
Osteomeles anthyllidifolia (Sm.) Lindl.	u'ulei	indigenous	common
SANTALACEAE (Sandalwood Family)			
Santalum ellipticum Gaud.	'iliahialo'e	endemic	rare
SAPINDACEAE (Soapberry Family)			
Dodonaea viscosa Jacq.	'a'ali'i	indigenous	common
SOLANACEAE (Nightshade Family)			
Solanum linnaeanum Hepper & P. Jaeger	apple of Sodom	non-native	rare
THYMELAEACEAE ('Akia Family)			
Wikstroemia oahuensis (A.Gray) Rock	'akia	endemic	uncommon
VERBENACEAE (Verbena Family)			
Lantana camara L.	lantana	non-native	common
Stachytarpheta jamaicensis (L.) Vahl	Jamaica vervain	non-native	uncommon
Verbena littoralis Kunth	ha'uöwi	non-native	rare

DISCUSSION

The excavation of a 1,500 foot long trench in which to install an underground electrical transmission cable will result in the loss of some native vegetation within a narrow corridor between turbines 12 through 20. Much less native vegetation will be impacted by the construction of additional project structures at a proposed substation near turbine 12 and an extension to the office building at the project baseyard, as these two sites are nearly entirely covered with non-native grasses. None-the-less, the area in general has experienced a dramatic loss of native plant communities over the last century and there is concern that further losses of rare species and special habitats be avoided. The proposed project was analyzed with these concerns in mind.

Of the 16 native plant species identified within the project area none were found to be federally listed as Threatened or Endangered species (USFWS, 2009), nor were any found that are candidates for such status. All but one of these native species are common throughout the state. One, *Bidens micrantha*, is found only on Maui and Lanai but is quite common in West Maui.

Most of these native plants are in low shrubland communities that are most prevalent on rocky slopes on the West side of Manawainui Gulch. This is due to the fact that these areas were less accessible to grazing cattle over the years and because these rather barren, rocky slopes are less susceptible to fires. While a few of the native shrubland communities within the project corridor have a variety of native species, none can be considered special habitats or associated with a rare or protected species.

It is likely that periodic fires will continue to be a problem into the forseeable future. The area has been nearly completely overtaken by molasses grass, a highly flammable, fire-adapted species that is quick to recover following wildfires. Meanwhile, each fire destroys more and more of even the hardiest native plants. Unless land management practices change dramatically across this dry mountain slope, little improvement in this prognosis is likely.

Previous botanical surveys on this southern tip for West Maui have identified a few Endangered species growing in gulches about a mile upslope of this project area. This area is remote from these populations and is in a habitat completely unsuitable for their growth and survival. This project is not expected to negatively impact any of these species.

Due to the general condition of the habitat and the specific lack of any environmentally sensitive native plant species or habitats on or near the project area, the proposed development work is not expected to result in any significant negative impact on the botanical resources in this part of Maui.

RECOMMENDATIONS

Sensitivity toward the remnant native plant communities on the steeper slopes should be exercised in selecting the route for the underground cable. The gentler slope near the edge of the ridgetop would be preferable.

It is recommended that some of the native plant species found in this area be used to revegetate berms and banks resulting from construction activities.

Literature Cited

Armstrong, R. W. (ed.) 1983. Atlas of Hawaii. (2nd. ed.) University of Hawaii Press.

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U.S. Fish and Wildlife Service. 1999. Endangered and threatened wildlife and Plants. 50 CFR 17.11 & 17.12

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Appendix 16

Calculation of Total Direct Take at Kaheawa Wind Power

The following are excerpts from the Kaheawa Wind Power Year 3 Annual Report:

"As presented in Section V of the HCP, the principle components that go into estimating the Adjusted Take are, a) Observed Direct Take, b) Unobserved Direct Take, c) Indirect Take, and d) Loss of Productivity. The SEEF and Carcass Removal results are used to estimate the Unobserved Direct Take (UDT). To calculate adjusted estimates of the number of Hawaiian Hoary Bat and Nene fatalities that may have occurred at KWP during the present reporting period, we used an estimator, *m*, as proposed by Shoefeld (2004) and Kerns and Kerlinger (2003) to estimate fatality rates using the formula:

$$m = \left(\frac{N * I * C}{k * t * p}\right)\left(\frac{e^{I/t} - 1 + p}{e^{I/t} - 1}\right)$$

where *I* represents the number of days between plot searches (search interval), *N* is equal to the number of turbine search plots, *k* is the number of plots searched (in the case of KWP, *N* and *k* are the same value), *t* is the mean carcass retention time, *p* is used to represent the detection probability (searcher efficiency), $e^{I/t}$ is an exponential value, and *C* is the actual number of carcasses observed (ODT) during downed wildlife monitoring."

Example from KWP Year 3 Annual Report

<u>Hawaiian Hoary Bat</u>

Observed Direct Take (C) = 1
Total Search Plots (N) = 20
Number of Plots Searched (k) = 20
Search Interval (I) = 7.6
Carcass Retention Time (t) = 10
Carcass Detection Probability (p) = 0.58
Natural Log ($e^{t/I}$) = 2.138276

$$m = \left(\frac{N * I * C}{k * t * p}\right)\left(\frac{e^{I/t} - 1 + p}{e^{I/t} - 1}\right)$$

m = 1.978

The total adjusted direct take at KWP is presented below in Table 1.

Table 1. Total Adjusted Direct Take for KWP

	Total direct take	Yearly average
Hawaiian Goose*	**5.50**	**1.37**
Hawaiian Petrel	**4.96**	**0.93**
Newell's Shearwater	**0**	**0**
Hawaiian Hoary Bat	**6**	**1.2**

***Years 1-4 only**

Appendix 17

An Assessment of Native Hawaiian Molluscan Fauna
Kaheawa Pastures, West Maui, Hawaii

Kaheawa Wind Power II: Part 2

TMK 4-8-001:001 and 3-6-001:014

Prepared for

First Wind
179 Lincoln Street, Suite 500
Boston, Massachusetts 02111

Prepared by

Mike Severns
3415 Kehala Drive
Kihei, Hawaii, 96753

January, 2010

Introduction:

The terrestrial molluscan fauna of Hawai‘i is in a state of catastrophic decline in which hundreds of species and an endemic family are in danger of extinction. Hawai‘i's molluscs evolved in isolation with an ecological naivety that has left them extremely vulnerable to environmental change, and a low fecundity that has not allowed them to recover from the pressures exerted by introduced predators. During the late 20th century perhaps as many as two-thirds of the living species described in the 19th and early 20th centuries became rare or extinct.

This survey was commissioned by Kaheawa Wind Power II (KWP II) to determine if any species of native Hawaiian snails, particularly those species federally and state listed as threatened, endangered or of substantial conservation concern occur within the proposed underground collection system routing, BESS and sub-station enclosures, expanded Operations and Maintenance facilities, and proposed water storage tank, and if so what steps could be taken to ensure their continued survival.

Survey Objectives:

This survey and report were initiated out of concern that there may be native snail populations within the proposed KWP II underground collection system routing, BESS and sub-station enclosures, expanded Operations and Maintenance, and water storage tank facilities. The objectives were to determine if any native land snail species were present in these proposed project areas, to identify them and to determine their habitat. Another objective was to look for semi-fossil shells protected beneath rocks or buried in the soil, which could indicate what species might have been present in the area in recent years, and thus may still be present.

Site Description:

The survey area was restricted to the eastern side of the lower portion of the Kaheawa Pastures within the existing Kaheawa Wind Power (KWP) leased area. The survey encompassed a 750-meter-long by 50-meter-wide corridor beginning at turbine number 20 at approximately 546 meters and extending uphill parallel to the western edge of Manawainui Gulch and bordering the existing KWP string road to turbine 12. It also included a proposed building expansion site measuring 18 by 24 meters which is beside an existing structure housing offices and equipment (Operations and Maintenance facility) and a section of pasture to the east of the present Operations and Maintenance facility where a water storage tank is proposed.

Kaheawa Pasture lies in the Lahaina District in the ahupua‘a of Ukumehame. It is defined by the upper reaches of Papalaua Gulch and its tributaries on the west and by Manawainui Gulch to the east and south. Much of the pasture was burned in 2006 in the most recent of many wind-driven fires to pass through the area.

Within the survey area there are areas of fire-stunted, native shrubs and some native and introduced grasses. A very shallow layer of leaf litter was found beneath the shrubs which rested on a layer of burnt plant material presumably from the last fire. A couple of small stands of ironwood trees found within the survey area blanket the ground with their needles preventing the growth of other plants resulting in very poor snail habitat.

When exposed, much of the stratigraphy is relatively constant in appearance with a brown layer of recent soil resting on a layer of hard-packed reddish-brown soil-like material. The upper layer was the most likely to contain evidence of snails in the form of semi-fossil shells of recent species; however none were found.

Though naturally occurring rock formations were abundant, they rested on the hard-packed ground mentioned above with pockets of ash in the cracks between the rocks. Very seldom did grass root-mats of any substantial depth form around or beneath the rocks. This grass root-mat and rock combination provides good snail habitat and can protect small snails living deep in the grass root-mat from fast-moving fires which sweep across the rocks burning exposed grass leaves, but not the root-mat.

Biological History:

[The following paragraphs are copied from my first assessment of the Kaheawa Pastures in January 2009. They are repeated here because the area of this survey is adjacent to and part of the original Kaheawa Pastures which was surveyed in January, 2009.]

Prior to European contact much of the pasture was probably blanketed by the horizontally-growing uluhe fern with scattered trees, predominantly ohia (*Metrosideros polymorpha*), as on the nearby ridges today.

Uluhe fern often acts as a fringe forest plant on mountain slopes and ridge tops. It is intermediate between the forest and the lowland vegetation and is often the dominant plant in that role. Because of the steep inclination of the ridges of West Maui’s lee side, uluhe forms an obvious broken line of bright green on the ridge backs beneath the forest. Its regularity in elevation and growth patterns permits a reasonable expectancy from one ridge to the next at the same elevation. Thus by comparing nearby ridges of similar elevation to the Kaheawa Pastures survey area it is possible to imagine what the vegetation of the pasture may have looked like in the past.

Since West Maui is heavily eroded into distinct ridges separated by deep valleys, populations of species living on the ridge tops are isolated and develop characteristics in shape and color that are unique to each population. Thus, if snails had existed in the Kaheawa Pastures they would have had distinct characteristics and would have been interesting to early collectors as subspecies. An intensive search of the collecting data showed that all of the collected variations of arboreal snail species that I would have expected to find in the survey area had data indicating their origin, but none of that data mentions Kaheawa Pastures or Ukumehame.

The nearest location for which snail collecting data exist is along the ridge overlooking Ukumehame Valley on the trail leading to the reservoir at Hanaʻula, parallel to but at a higher elevation than the Kaheawa Pastures. There, *Partulina fusoidea* was collected and still exists today. It was described in 1855 by Newcomb.

Knowing that collections were made on an adjacent and parallel ridge on the Wailuku side of the survey area in 1855, and that in 1978 semi-fossil *Partulina* were found in the soil along the Wailuku edge of that adjacent pasture at the elevation of the upper survey area, I would expect a subspecies or variation of that species to have lived in the area that the Kaheawa Pastures occupies today. Having no collecting data nor specimens whose location is unaccounted for and could be attributed to the Kaheawa Pastures suggests that the Kaheawa Pastures was unproductive for snail hunters before 1855.

One explanation for the lack of specimens is that the pastoral history of the pasture predates the study of snails in the area. The snail fauna of the pasture can be inferred from surrounding areas, but without living snails or fossil snail deposits it will not be possible to know what the pasture was like prior to what is known historically and what is there today.

Habitat Requirements for Ground dwelling Snails:

The habitats preferred by ground-dwelling snails are a moist environment beneath rocks and rock talus, often associated with the root-mats of grasses; in the leaf litter beneath trees and shrubs, and in thick mosses growing on the ground, on trees and among rocks.

Conservation Relevance:

It is highly unlikely that native snails, including those which receive protection under state or federal endangered species laws will be found in the Kaheawa Pastures. However, all of the native Hawaiian land snails should be considered rare and treated as such if discovered, with particular attention given to their habitat.

Discussion:

Since all of the habitats expected to be occupied by ground-dwelling snails are seriously degraded or non-existent within the surveyed area and since there is no habitat for arboreal snails, it is highly unlikely that living snails exist within the surveyed area.

The attention First Wind and Kaheawa Wind Power II has given to this important but devastated aspect of Hawaiian biology is commendable, but it appears that years of abuse of the land, along with tell-tale hints of pastoral use pointing back to before the 1850's, seem to have reduced the capacity of the area to support living snails.

Conclusion:

During the survey the leaves, bark and leaf litter beneath shrubs were searched. In addition, grass root-mats among and beneath rock talus and other naturally occurring rock formations were also searched for evidence of snails. The limited amount of moss was examined, and exposed ground was searched for fresh and dead shells. No snail shells, fossil or extant, native or introduced, were found.

After the meticulous search described, my assessment is that there are no living snails, native or introduced, within the area surveyed.

References:

Severns, Mike. In press. *An Illustrated Catalog of the Shelled Molluscan Fauna of the Hawaiian Islands, Marine and Land*. Conchbooks Publishers. Maizer Str. 25, D-55546, Hackenheim, Germany. Estimated 800 pages in two volumes. Estimated publication May, 2010.

Appendix 18

COPY

LINDA LINGLE
GOVERNOR OF HAWAII

PETER T. YOUNG
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

ROBERT K. MASUDA
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AQUATIC RESOURCES
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ENGINEERING
FORESTRY AND WILDLIFE
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KAHOOLAWE ISLAND RESERVE COMMISSION
LAND
STATE PARKS

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES

Division of Forestry and Wildlife
1151 Punchbowl Street, Rm. 325
Honolulu, HI 96734

June 17, 2005

Kaheawa Wind Power, LLC
Attn: Mike Gresham/Michelle McClean
1043 Makawao Avenue, Ste. 208
Makawao, HI 96768

SUBJECT: Fire Contingency Plan for CDUA MA-3103

Attached please find the approved fire contingency plan for CDUA MA-3103. Should you have any specific questions to the plan, please feel free to call Maui Branch Division of Forestry and Wildlife at 984-8100.

Very truly yours,

Wayne F. Ching
State Protection Forester
Fire Management

attachment

CDUA NO. MA-3103

Division of Forestry and Wildlife
CONSERVATION DISTRICT USE APPLICATION
Fire Contingency Plan

This plan is to be used for the construction of a project within a conservation district. In developing a plan, it is important to: 1) know what activities might start a fire, 2) analyze the fire prevention actions which can minimize the chance of starting a fire, and 3) know what action to take and whom to call in case of a fire.

I. NAME:

Kaheawa Wind Power, LLC
attn: Mike Gresham or Michele McLean

ADDRESS: 1043 Makawao Avenue
Suite 208
Makawao, Hawai`i 96768

TELEPHONE: 808-298-1055 (M. Gresham) or 808-572-3011, x. 208 (M. McLean)
808-572-8378 (facsimile)

II. LOCATION:

Island: Maui

Tax Map Key: 4-8-001: 001 (site) and 3-6-001: 014 (access roadway)

Fire Station Name/Number Closest to Project: Wailuku Station (243-7569)
Kihei Station (879-2741)

Miles from Fire Station: Approximately 10 miles from Wailuku Station
Approximately 12 miles from Kihei Station
(both measurements to project access roadway entrance at the existing highway)

III. APPROVED USE:

The approved use of the site is the construction and operation of a 30-megawatt wind energy generation facility (also known as a "wind farm"). Project components include grading and improving approximately 1.7 miles of the existing 4-wheel-drive roadway beginning at the Honoapiilani Highway entrance; clearing, grading and improving approximately 1.9 miles of a new access roadway to the site and approximately 1.75 miles of intra-site roadway; construction and operation of 20 wind turbines on concrete foundations; construction and use of an operations and maintenance (O&M) facility; construction and operation of an electrical gathering system to transmit energy from individual turbines to the project substation; and construction and use of an electrical substation and interconnection facilities (to transmit electrical energy to Maui Electric Company's transmission lines).

IV. POTENTIAL IGNITION SOURCE(S) OF ACCIDENTAL FIRES DURING THE CONSTRUCTION OF THE PROJECT:

During construction of the project, ignition sources for accidental fires would include errant sparks from a variety of vehicles, equipment and tools, and wrongly discarded matches and cigarette butts.

During operation of the project, the same potential ignition sources exist, though overall risk exposure is significantly more limited due to lower volume of concurrent work ongoing at the project site. Additional theoretical operational ignition sources would include the electrical components of the individual wind turbine generators and energized substation/interconnection facilities equipment.

V. DESCRIBE THE TYPE OF FIREFIGHTING RESOURCES AVAILABLE:

The most important preventive resource will be education of all on-site contractors and personnel and proper maintenance of all vehicles, equipment, tools and turbine hardware.

During construction, firefighting resources will include the provision of fire extinguishers in all construction vehicles and trailers, as well as the provision of shovels and water-filled backpack pumps which shall be readily accessible during construction activities. Additionally, during some periods of construction, earthmoving equipment will be present on-site that could assist in creating fire breaks. Lastly, large quantities of water will be utilized on-site for road construction, concrete batching, re-vegetation efforts and erosion control – when available, this water could also be used for firefighting purposes. Should this water be provided by a water truck, it will be fitted with a hose and cannon to be used for fire protection.

During all phases of the project, basic on-site fire-fighting resources will include fire extinguishers in the O&M facility, at the substation, and in all project vehicles, and shovels and backpack pumps in the O&M facility and maintenance vehicles.

VI. DESCRIBE THE ACCESSIBILITY OF THE PROJECT SITE FOR FIRE EMERGENCY RESPONSE VEHICLES:

The project consists of access roadways and a wind turbine site. The existing access roadway is a very difficult four-wheel-drive jeep trail, but site access will be significantly improved and extended for the access of the project's construction vehicles and equipment deliveries – including multi-axle trailers with gross weights in excess of 150,000 pounds. Construction will begin at the bottom (makai) of the road, and move upward (mauka) to the wind turbine site. As the road is improved, access for fire emergency response vehicles will be greatly improved compared to access existent today.

The applicant will meet with appropriate personnel from the County of Maui Department of Fire Control before construction begins, and again after the access roadways have been improved, to assist the Department in its fire response knowledge base.

VII. DESCRIBE, IF APPLICABLE, ANY FIRE PLAN THAT WILL APPLY TO THE COMPLETED PROJECT:

Existing vegetation in the project area consists of low brush and grass and, as such, is anticipated to be subject to relatively fast-moving fires of modest intensity and duration. During and after construction, vegetation in the immediate vicinity of project components will be appropriately maintained (cut or cleared). Cleared areas around each wind turbine, the O&M facility, and the substation/interconnection facility will be covered with gravel to assist in fire prevention and to form fuel breaks around individual project components. Specifically, a minimum 30-foot cleared (i.e., no vegetation) buffer will be provided around the O&M facility and substation/interconnection facility, while a minimum 20-foot cleared buffer will be provided around each wind turbine's concrete footprint. Should these buffers be determined by State forestry and/or County fire personnel to be inadequate, they will be increased as warranted.

Additional theoretical fire breaks/fuel breaks will be formed by project roadways running along the turbine array and from the highway to the project site. Areas that will be cleared during construction will be promptly re-vegetated with existing vegetation or otherwise appropriate plants that both (a) present limited hazards from a fire control perspective and (b) are non-attractions for wildlife.

Ongoing operation and maintenance of the completed project will involve routine checks of electrical connections, wash schedule for substation equipment (if indicated by detailed design), and periodic infrared reconnaissance of electrical components.

As referenced in Section V above, all project vehicles will carry fire extinguishers as a first response methodology. Additional on-site fire suppression equipment and supplies may be stocked in project warehouse facilities depending upon need assessment to be conducted as project design and operational plans are completed.

VIII. OTHER COMMENTS:

Wind energy generation facilities are unlikely to be the cause of a fire or wildfire. In the applicant's experience with such facilities domestically and worldwide, the turbine generators and related electrical interconnection have never been a source or cause of fire. The facility is also unlikely to be seriously impacted by a wildfire that occurs on or spreads to the site. The towers supporting the turbines are of ¾-inch plate steel, mounted on concrete foundations; the interconnecting electrical systems are below ground; and the O&M facility will be of noncombustible construction and exterior finishes (the building permit for the O&M facility will be reviewed by the County of Maui Department of Fire Control). Damage from fire could occur to the on-site substation and would potentially disrupt the facility's provision of electricity to Maui Electric, though it would not jeopardize Maui Electric's ability to provide electricity services to its customers.

On-site vegetation management will require ongoing coordination with State forestry and wildlife officials to ensure that (a) appropriate fire control efforts are implemented due to factors such as weather conditions; (b) the site does not introduce nesting, foraging or other attractions to wildlife, particularly endangered, threatened or protected species; and (c) the project infrastructure and operations are reasonably protected. Similarly, as weather conditions or other factors may dictate, Kaheawa Wind Power will work with State forestry and wildlife officials, as well as County fire personnel, during project construction and operation to implement fire prevention or control measures as the need may so arise (e.g., creating fire breaks near the Manawainui Plant Sanctuary located along the mauka portion of the subject property and turbine array).

During all phases of project construction and operation, contractors and employees will be made aware of fire prevention protocols, including failsafe methods to contact the Department of Fire Control and 911 for emergency response. The applicant will work with State and County officials to ensure that emergency response personnel have appropriate access to the site.

Lastly, Kaheawa Wind Power is aware that it may be financially liable for fire suppression efforts in the event of any fire that is caused by its project activities, and pledges its full cooperation in both fire suppression efforts and subsequent investigations. In the event of a fire in the project vicinity, project maintenance records will be made available to fire investigators.

APPROVED:

Glenn N. Shishido (signature)

for Branch Manager, DOFAW Maui

CONCUR:

Paul J Conry (signature)

Administrator, DOFAW

Appendix 19

Timetable for Implementation of HCP Requirements and Reporting Requirements

Species	Annual commitment ($)	Time of payment/execution	Length of commitment	Purpose	Relevant HCP text
Hawaiian petrel					
Alternative 1	in house	within the first year of project operation	duration to be determined based on results	social attraction project at Makamakaole	see Appendix 11, 27, 6.3.1.3 and 6.3.1.5 for Baseline Mitigation
Other Alternatives	in house	within the first year of project operation or after 5 years if social attraction at Makamakaole is deemed inadequate	duration to be determined based on results	petrel mitigation at Haleakala	see Appendix 11, 6.3.1.6 and 6.3.2.2 Other Alternatives for Baseline Mitigation
	in house	after 2016	duration to be determined based on results	petrel mitigation at ATST site	see Appendix 11, 6.3.1.6 and 6.3.2.1 Other Alternatives for Baseline Mitigation
Newell's shearwater					
Alternative 1	in house	within the first year of project operation	duration to be determined based on results	social attraction project at Makamakaole	see Appendix 11, 27, 6.3.1.3 and 6.3.1.5 for Baseline Mitigation
Additional Measures	in house	Within the first year of project operation	5 years	Reseach and development of plan for alternatives	see Appendix 11, 27, 6.3.1.3 and 6.3.1.7 for Baseline Mitigation
Other Alternatives	in house	year 6	duration to be determined based on results	Social attraction or in-situ protection at alternative site on Maui	see Appendix 11, 27, 6.3.2.6 and 6.3.2.2 for Alternatives to Baseline Mitigation
	In House	year 6	duration to be determined based on results	In-situ protection or social attraction at an alternative site on Molokai or Lanai	see 6.3.2.6 and 6.3.2.2 for Alternatives to Baseline Mitigation

Species	Annual commitment ($)	Time of payment/execution	Length of commitment	Purpose	Relevant HCP text
Bats	in-house		Year 1 to 2, 5, 10, 15	survey for bats within and in vicinity of KWPII	Surveys will be conducted during years when systematic fatality monitoring is conducted, (i.e., during the first two years and at five year intervals thereafter, or as otherwise determined under the Adaptive Management provisions), to allow observed activity levels to be correlated with any take that is observed.
	in-house		Year 1 to 2, 5, 10, 15	bat interaction research	KWPII will survey for bat activity near turbine locations for the first two years of operation using acoustic bat detectors. Surveys will be conducted during years when systematic fatality monitoring is conducted (see Appendix 2 and Section 7.2.1). …. The use of additional techniques and technologies will also be considered.
	variable	within 60 days of the commercial operation date and before June of each subsequent year	20 years	bat management	Recommendations by USFWS and DOFAW for mitigation for the Hawaiian hoary bat have consisted of habitat restoration to improve or provide additional roosting, breeding and foraging habitat.
Hawaiian short-eared owl	25,000	within 60 days of the commercial operation date	one time	research and/or rehabilitation	KWPII will contribute a total of $25,000 to appropriate programs or facilities such as the Hawaii Wildlife Center, to support owl research and rehabilitation

Species	Annual commitment ($)	Time of payment/execution	Length of commitment	Purpose	Relevant HCP text
Nene*					
Nene management at release pen	in-house		Preconstruction and construction	Nene nest surveys	Surveys will be performed in areas to be cleared for project construction to ensure that no active nēnē nests would be disturbed or destroyed by vegetation clearing activities;
	up to $158,209	before June 2015 or earlier with 6 months notification from DOFAW.	one-time	staffing at release pen	Mitigation for KWPII will consist of providing funding to DOFAW to build an additional release pen and five years of funding for conducting predator control, vegetation management and monitoring at the additional pen beginning in 2016.
	$30,000	by June 2015 and before June of each subsequent year	Year 4-8	staffing at release pen	
Additional measures independent of alternative chosen	in-house		Year 1	Weekly systematic nene observations	a wildlife biologist will make systematic visual observations of nēnē activity from representative locations within the KWP II project area during the first year of project operation

* please see HCP for other backup scenarios - Section 6.4.5 includes contingencies for additional nene pens

Appendix 20

DRAFT
IMPLEMENTING AGREEMENT
KAHEAWA WIND POWER II WIND ENERGY GENERATION FACILITY
September__, 2010

1.0 PARTIES

The parties to this Implementing Agreement (Agreement) are Kaheawa Wind Power II, LLC, a Delaware limited liability company (Permittee); the United States Fish and Wildlife Service (Service) and the State of Hawai`i (State) Department of Land and Natural Resources (DLNR) through its Division of Forestry and Wildlife (DOFAW).

2.0 RECITALS AND PURPOSES

2.1 Recitals. The parties have entered into this Agreement in consideration of the following facts:

(a) The Kaheawa Wind Power II Energy Generation Facility (Project) project site has been determined to provide, or potentially provide, habitat for the following four (4) listed species: the endangered Hawaiian Petrel (*Pterodroma sandwichensis*), the threatened Newell's (Townsend's) Shearwater (*Puffinus auricularis newelli*), the endangered Nene (*Branta sandvicensis*), and the endangered Hawaiian Hoary Bat (*Lasiurus cinereus semotus*); and

(b) The Permittee has developed a series of measures, described in the Habitat Conservation Plan (HCP), to minimize, mitigate and monitor, to the maximum extent practicable, the effects of take of Covered Species incidental to Permittee's Covered Activities.

2.2 Purposes. The purposes of this Agreement are:

(a) To ensure implementation of each of the terms of the HCP and provide benefit to the Covered Species;

(b) To describe remedies and recourse in the event that any party should fail to perform its obligations as set forth in this Agreement; and

(c) To provide assurances to Permittee that as long as the terms of the HCP, the Incidental Take Permit (Permit), the Incidental Take License (ITL) , and this Agreement are met, no additional mitigation will be required of Permittee with respect to Covered Species except as provided for in this Agreement or required by law and/or applicable regulations.

3.0 DEFINITIONS

The following terms as used in this Agreement will have the meanings set forth below. Terms used in this Agreement and specifically defined in the Endangered Species Act (ESA) or in regulations adopted by the Service or DLNR shall have the same meaning as in those implementing regulations, unless this Agreement expressly provides otherwise.

3.1 "Adaptive Management" means a flexible approach to the long-term management of the fish, wildlife and habitat resources of the project area that is directed over time by the results of ongoing monitoring activities and other information.

3.2 "Changed Circumstances" means changes in circumstances affecting a Covered Species or the geographic area covered by the HCP that can reasonably be anticipated by the parties to the HCP and that can reasonably be planned for in the HCP (e.g. the listing of a new species, or a fire or other natural catastrophic event in areas prone to such event). Changed Circumstances and the planned responses to those circumstances are described in Chapter 7("Implementation") of the HCP. Changed Circumstances are not Unforeseen Circumstances.

3.3 "Covered Activities" means certain activities carried out by Permittee on Covered Lands that may result in incidental take of Covered Species. Covered Activities means the following activities, provided that these activities are otherwise lawful: construction and operation of 14 wind turbine generators (model GE 1.5 MW, manufactured by General Electric, each capable of generating 1.5 megawatts, and each having a 213-foot tower and 231-foot diameter rotors); construction and use of new internal service roads connecting the project site to the existing Kaheawa Wind Project (KWP) access road; installation of an underground electrical network connecting all turbines; construction and use of an overhead powerline connect the turbines across the gulch; construction and use of an electrical substation and connection of the substation to the new turbines and to the existing MECO power transmission lines; construction and use of a Battery Energy Storage System (BESS) adjacent to the substation; construction and use of an operations and maintenance building; installation of an above-ground water storage tank; erection and use of one (1) permanent meteorological tower and one temporary test tower onsite to monitor and transmit wind data; construction and use of one (1) communications tower; use of an access roadway to the project site; maintenance of all of the aforementioned and related infrastructure; site visits by appointment for public education and outreach; and management of on-site vegetation in coordination with wildlife and forestry officials.

3.4 "Covered Species" means the following species, each of which the HCP addresses in a manner sufficient to meet all of the criteria for issuing an incidental take permit under ESA Section 10(a)(1)(B) and an incidental take license under Chapter 195D Hawai`i Revised Statutes (HRS): the endangered Hawaiian Petrel (*Pterodroma sandwichensis*), the threatened Newell's (Townsend's) Shearwater (*Puffinus auricularis newelli*), the endangered Nene (*Brunta sandvicensis*), and the endangered Hawaiian Hoary Bat (*Lasiurus cinereus semotus).*

3.5 "HCP" means the Habitat Conservation Plan prepared by Permittee for the Project.

3.6 "ITL" means the Incidental Take License (ITL) issued by DLNR to Permittee pursuant to Chapter 195D HRS, for take incidental to Covered Activities relating to the Project as it may be amended from time to time.

3.7 **"Listed Species"** means a species (including a subspecies, or a distinct population segment of a vertebrate species) that is listed as endangered or threatened under the ESA and/or under Chapter 195D-4 HRS.

3.8 **"Permit"** means the incidental take permit issued by the Service to Permittee pursuant to ESA Section 10(a)(1)(B) for take incidental to Covered Activities relating to the Project, as it may be amended from time to time.

3.9 **"Permittee"** means Kaheawa Wind Power II, LLC, a Delaware limited liability company.

3.10 **"Plan Area"** means the lands upon which the permit authorizes incidental take of Covered Species and the lands to which the HCP's conservation and mitigation measures apply. These lands are described in Section 1.4 of the HCP.

3.11 **"Take"** means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect any listed or unlisted Covered Species. Harm means an act that actually kills or injures a member of a Covered Species, including an act that causes significant habitat modification or degradation where it actually kills or injures a member of a Covered Species by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering.

3.12 **"Unforeseen Circumstances"** means changes in circumstances affecting a species or geographic area covered by a conservation plan that could not have been reasonably anticipated by Permittee, the nService and/or DLNR at the time of the HCP's negotiation and development, and that result in a substantial and adverse change in the status of the Covered Species.

3.13 **"Unlisted Species"** means a species (including a subspecies, or a distinct population segment of a vertebrate species) that is not listed as endangered or threatened under the ESA or State law, including proposed, candidate and other species.

4.0 OBLIGATIONS OF THE PARTIES

4.1 Obligations of Permittee.

4.1.1 General

(a) Chapter 5 of the HCP identifies impacts to Covered Species from Covered Activities. As identified in Chapter 5 of the HCP, the Permittee is to perform measures to avoid, minimize and monitor those impacts to Covered Species during the Covered Activities. In addition, as identified in Chapters 5 and 6 of the HCP, the Permittee will undertake mitigation measures and implement a monitoring program in order to assure that potential effects on Covered Species are mitigated so as to achieve a net recovery benefit. As identified in Chapter 6 of the HCP, the Permittee will engage in monitoring and adaptive management. The

Permittee's activities under the HCP will be subject to Service and DLNR review and approval as described in the HCP.

(b) The Permittee will fully and faithfully perform all obligations assigned to it under this Agreement, the ITL, the Permit and the HCP.

(c) Funding for implementation of the HCP shall be included as an annual operating expense of the Project Assurances that adequate funding will be available to support the proposed monitoring and mitigation measures will be provided by Permittee in the form of a bond, letter of credit (LC) or similar instrument (the "Surety") naming the Service and/or DLNR as the beneficiary. Permittee will provide a Surety in the amount of $500,000 to secure the obligation to fund implementation of the HCP. The Surety will have a term of one year, and will be automatically renewed prior to expiration, unless it is determined to no longer be necessary by the Service and DLNR. The Service and/or DLNR may draw upon the surety to fund or otherwise pay for any outstanding mitigation obligations of the Project only in the event that Permittee fails to fund or otherwise pay for the proposed monitoring and mitigation measures when required under the HCP or in the event that Permittee is bankrupt.

(e) Permittee will establish an additional letter of credit or other credit support in the amount of $335,000 in order to support the three (3) contingency funds specific for each of the Covered Species in Chapter 3.8 of the HCP. The separate amounts of the three (3) contingency funds are as follows: $160,000 for the Seabird Contingency Fund; $100,000 for the Nene Contingency Fund; and $75,000 for the Hawaiian Hoary Bat Contingency Fund. The amount of the letter of credit or other credit support will increase at 2.5% annually over the term of the HCP. If contingency funds are used, the amount of the bond would be reduced accordingly, and the net amount would continue to increase at a 2.5% annual rate.

4.2 Obligations of Service and DLNR. Upon execution of this Agreement by all parties, and satisfaction of all other applicable legal requirements, the Service will issue Permittee a Permit under ESA Section 10(a)(1)(B), and DLNR will issue Permittee an ITL under Chapter 195D HRS, authorizing incidental take by Permittee of each Covered Species resulting from Covered Activities on Covered Lands.

4.2.1 Permit and ITL coverage. The Permit and ITL will identify all Covered Species. The Permit and ITL will take effect for Covered Species at the time the Permit and ITL are issued, respectively.

4.2.2 "No surprises" assurances. Provided that Permittee has complied with its obligations under the HCP, this Agreement, the Permit and the ITL I (including any provisions for changed circumstances, adaptive management, or any other contingency measures provided for in the HCP), the Service and/or DLNR can require Permittee to provide mitigation beyond that provided for in the HCP only under Unforeseen Circumstances, and only in accordance with the "No Surprises" requirements set forth in Section 7.6 of the HCP.

4.3 Interim obligations upon a finding of Unforeseen Circumstances. If the Service and/or DLNR make a finding of Unforeseen Circumstances, during the period necessary to determine the nature and location of additional or modified mitigation, Permittee will avoid contributing to appreciably reducing the likelihood of the survival and recovery of the affected species.

5.0 INCORPORATION OF HCP

The HCP and each of its provisions are intended to be, and by this reference are incorporated herein. In the event of any direct contradiction between the terms of this Agreement and the HCP, the terms of this Agreement will control. In all other cases, the terms of this Agreement and the terms of the HCP will be interpreted to be supplementary to each other.

6.0 MONITORING AND REPORTING

6.1 Planned period reports. As described in the HCP, Permittee will submit periodic reports describing its activities and results of the monitoring program provided for in the HCP.

6.2 Other reports. Permittee will provide, within 30 days of being requested by the Service and/or DLNR, any additional information in its possession or control related to implementation of the HCP that is requested by the Service and/or DLNR for the purpose of assessing whether the terms and conditions of the Permit, the ITL and the HCP, including the HCP's adaptive management plan, are being fully implemented.

6.3 Certification of reports. All reports will include the following certification from a responsible company official who supervised or directed preparation of the report:

> I certify that to the best of my knowledge, after appropriate inquiries of all relevant persons involved in the preparation of this report, the information submitted is true, accurate and complete.

6.4 Monitoring by Service/DLNR. The Service and/or DLNR may conduct inspections and monitoring in connection with the Permit and ITL, respectively, in accordance with the ESA and Chapter 195D HRS and any regulations adopted under those statutes.

7.0 CHANGED CIRCUMSTANCES

7.1 General

(a) Section 7.6 of the HCP identifies Changed Circumstances. The Permittee shall carry out the responses identified in that section, including coordination with the Service and DLNR and other agencies as appropriate.

(b) The Parties acknowledge that, notwithstanding the assurances provided by Section 4.2 herein, future modifications to mitigation that are specifically contemplated under the

HCP and this Agreement may require adjustments in the mitigation program set forth in the HCP as of the effective date, including Adaptive Management changes in the Plan Area. Such changes are part of the operating conservation program, and do not violate the assurances of Section 4.2. In particular, mitigation actions related to Changed Circumstances and to changes in mitigation deriving from Adaptive Management of the Plan Area remain the responsibility of the Permittee in accordance with the responsibilities under the HCP and this Agreement and do not violate the assurances of Section 4.2. Notwithstanding the foregoing, the Parties further acknowledge that such modifications to the mitigation program described in the HCP shall not require funding in addition to that set forth in the HCP.

7.2 Notification of Changed and Unforeseen Circumstances

7.2.1 Permittee-initiated response to Changed Circumstances. Permittee will give notice to the Serviceand DLNR within seven (7) days after learning that any of the Changed Circumstances listed in Section 7.5 of the HCP has occurred. As soon as practicable thereafter, but no later than 30 days after learning of the Changed Circumstances, Permittee will modify its activities in the manner described in Section 7.5 of the HCP to the extent necessary to mitigate the effects of the Changed Circumstances on Covered Species, and will report to the Serviceand DLNR on its actions. Permittee will make such modifications without awaiting notice by the Service and/or DLNR.

7.2.2 Service/DLNR-initiated response to Changed Circumstances. If the Service and/or DLNR determine that Changed Circumstances have occurred and that Permittee has not responded in accordance with Section 7.5 of the HCP, the Service and/or DLNR will so notify Permittee and will direct Permittee to make the required changes. Within 30 days after receiving such notice, Permittee will make the required changes and report to the Serviceand/or DLNR on its actions. Such changes are provided for in the HCP, and hence do not constitute Unforeseen Circumstances or require amendment of the Permit, ITL or HCP.

7.3 Listing of species that are not Covered Species.

(a) The Parties acknowledge that the HCP covers four (4) species listed as endangered or threatened under the ESA and/or State law which have been found or are likely to be found in the Plan Area. The Parties further acknowledge that the HCP, this Agreement, the Permit and the ITL do not authorize any take, or violation of the ESA or State law, with respect to species other than Covered Species that are listed as endangered or threatened, or with respect to species that are listed subsequent to the Effective Date. When and if a species that is not a Covered Species is listed under the ESA or State law,or a Listed Species other than a Covered Species in the Plan Area is found to be affected by the Project, the Parties shall follow the procedures of this Section including, if necessary, amendments to the Permit and/or ITL.

(b) If a species that is not included as a Covered Species in the HCP is proposed for listing under the ESA or State law during the term of this Agreement, including a proposal for listing on an emergency basis, and the Service and/or DLNR determine that the species may be affected by the Covered Activities, the Service and/or DLNR shall notify the Permittee of the proposed listing as early as feasible. Similarly, the Service and/or DLNR shall notify the Permittees if other Listed Species are found to be present in the Plan Area.

(c) The Permittee shall evaluate the potential effect of the Covered Activities on the species identified in paragraphs (a) and (b) above, based on the HCP, the information developed through the ongoing management of the Plan Area and other relevant information, and the Permittee shall inform the Serviceand/or DLNR in writing of its determination with regard to such potential effect.

(d) If the Permittee notifies the Service and/or DLNR that the Covered Activities may affect the species, or if the Service and/or DLNR disagree with the Permittee's determination that the Covered Activities will not affect the species, the Parties shall meet and confer in order to develop an appropriate response.

(e) If the Service and/or DLNR determine, after consultation with the Permittee, that feasible modifications in the Adaptive Management program or minor adjustments in the Covered Activities can be used to assure that the Covered Activities remaining compliance with the ESA and Chapter 195D HRS, the Permittee will implement those changes and no amendment to the HCP, this Agreement, the Permit or the ITL will be necessary. If the Service and/or DLNR determines after consultation with Permittee that more substantial modifications are necessary in order to remain in compliance with the ESA and Chapter 195D HRS, such modification may be made by minor modifications pursuant to Section 12.1 of this Agreement or by standard amendment pursuant to Section 12.2 of this Agreement.

8.0 ADAPTIVE MANAGEMENT

8.1 Adaptive management. Parties will implement the adaptive management provisions in Section 7.3 of the HCP when changes in management practices are necessary to remain in compliance with the ESA and Chapter 195D HRS, to achieve the HCP's biological goals and objectives or to respond to monitoring results or new scientific information as provided for in the HCP.

8.2 Service/DLNR-initiated adaptive management. If the Serviceand/or DLNR determine that one or more of the adaptive management provisions in the HCP have been triggered and that Permittee has not changed its management practices in accordance with Section 7.3 of the HCP, the Service and/or DLNR will so notify Permittee and will direct Permittee to make the required changes. Within 30 days after receiving such notice, Permittee will make the required changes and report to the Service and/or DLNR on its actions. Such changes are provided for in the HCP, and hence do not constitute Unforeseen Circumstances or require amendment of the Permit, the ITL or HCP, except as provided in this section.

8.3 No reduction in conservation benefit. Permittee will not implement adaptive management changes that may result in less mitigation than provided for Covered Species under the original terms of the HCP, unless the Service and/or DLNR first provide written approval. The amount of money spent on mitigation may be less than the estimated amounts included in Appendix 6 of the HCP, provided the mitigation is sufficient to provide a net conservation benefit to the species. Permittee may propose any such adaptive management changes by notice to the Service and/or DLNR, specifying the adaptive management modifications proposed, the basis for them, including supporting data, and the anticipated effects on Covered Species, and other environmental impacts. Within 120 days of receiving such notice, the Service and/or

DLNR will either approve the proposed adaptive management changes, approve them as modified by the Service and/or DLNR, or notify Permittee that the proposed changes constitute permit amendments that must be reviewed under Section 12.2 of this Agreement.

8.4 No increase in take. This section does not authorize any modifications that would result in an increase in the amount and nature of take, or increase the impacts of take, of Covered Species beyond that analyzed under the original HCP and any amendments thereto. Any such modification must be reviewed as a permit amendment under Section 12.2 of this Agreement.

9.0 FUNDING

Permittee warrants that it has, and will expend, such funds as may be necessary to fulfill its obligations under the HCP. Permittee will promptly notify the Service and/or DLNR of any material change in Permittee's financial ability to fulfill its obligations. In addition to providing any such notice, Permittee will provide the Service and DLNR with a copy of its annual report each year of the Permit and ITL, or with such other reasonably available financial information that the Parties agree will provide adequate evidence of Permittee's ability to fulfill its obligations.

10.0 EFFECTIVE DATE AND TERM

10.1 Effective date and term of the Agreement. This Agreement and the HCP will become effective on the date that the Service and DLNR issue the respective permits. This Agreement, the HCP, the Permit and ITL will remain in effect for a period of twenty (20) years from issuance of each original permit, except as provided below.

10.2 Permit suspension or revocation. The Service and DLNR may suspend or revoke the respective permits for cause in accordance with the laws and regulations in force at the time of such suspension or revocation, except that the Service and/or DLNR may revoke their respective permits based on a determination that the continuation of the permitted activity would be likely to jeopardize the continued existence of the Covered Species only if the Service and/or DLNR have not been successful in remedying the situation in a timely fashion through other means.

10.3 Relinquishment of the permits.

10.3.1 Generally. Permittee may relinquish the Permit and the ITL in accordance with the regulations of the Service and DLNR in force on the date of such relinquishment. Notwithstanding relinquishment of the permits, Permittee will be required to provide post-relinquishment mitigation for any take of Covered Species that the Service and/or DLNR determine will not have been fully mitigated under the HCP by the time of relinquishment. Permittee's obligations under the HCP and this Agreement will continue until the Service and/or DLNR notify Permittee that no post-relinquishment mitigation is required, or that all post-relinquishment mitigation required by the Service and/or DLNR is completed. Unless the Parties agree otherwise, the Service and/or DLNR may not require more mitigation than would have been provided if Permittee had carried out the full term of the HCP.

10.3.2 Procedure for relinquishment. If Permittee elects to relinquish the Permit or the ITL before expiration of the full term of the HCP, Permittee will provide notice to the Service and/or DLNR at least 120 days prior to the planned relinquishment. Such notice will include a status report detailing the nature and amount of take of all Covered Species, the mitigation provided for those species prior to relinquishment, and the status of Permittee's compliance with all other terms of the HCP. Within 120 days after receiving a notice and status report meeting the requirements of this paragraph, the Service and/or DLNR will give notice to Permittee stating whether any post-relinquishment mitigation is required and, if so, the amount and terms of the mitigation, and the basis for the Service and/or DLNR conclusions. If the Service and/or DLNR determine that no post-relinquishment mitigation is required, all obligations assumed by the Parties under this Agreement will terminate upon the Service and/or DLNR issuance of such notice. If Permittee disagrees with the Service and/or DLNR determination, the Parties may choose to use the dispute resolution procedures described in Section 13 of this Agreement. Permittee will continue to carry out its obligations under the HCP until any such dispute is resolved. If the Parties are unable to agree, the Service and/or DLNR will have the final authority to determine whether Permittee is required to provide post-relinquishment mitigation.

10.3.3 Extension of the Permits. Upon agreement of the Parties and compliance with all applicable laws, the Permit and ITL may be extended beyond their initial terms under regulations of the Service and DLNR in force on the date of such extension. If Permittee desires to extend the Permit and ITL, it will so notify the Service and DLNR at least 180 days before the then-current terms are scheduled to expire. Extension of the Permit and ITL constitutes extension of the HCP and this Agreement for the same amount of time, subject to any modifications that the Service and DLNR may require at the time of extension.

11.0 LAND TRANSACTIONS

11.1 Acquisition of land by Permittee. Nothing in the agreement, the HCP, the Permit or the ITL limits Permittee's right to acquire additional lands. Any lands that may be acquired will not be covered by the Permit and ITL except upon amendment of the Permit and ITL as provided in Section 12.2 of this Agreement.

11.2 Disposal of land by Permittee. The Permit and ITL may be transferred in accordance with regulations in force at the time of transfer. Permittee's transfer of ownership or control of Covered Land will require prior approval by the Service and DLNR and an amendment of the Permit and ITL in accordance with Section 12.2 of the Agreement, except that transfers of Covered Lands may be processed as minor modifications in accordance with Section 12.1 of this Agreement if:

(a) The land will be transferred to an agency of the federal government and, prior to transfer, the Service and DLNR have determined that transfer will not compromise the effectiveness of the HCP based on adequate commitments by that agency regarding management of such land;

(b) The land will be transferred to a non-federal entity that has entered into an agreement acceptable to the Service and DLNR (e.g. an easement held by the County of Maui with the Service and DLNR as third-party beneficiaries) to ensure that the lands will be managed in such a manner and for such duration so as not to compromise the effectiveness of the HCP;

(c) The land will be transferred to a non-federal entity that, prior to completion of the land transaction, has agreed to be bound by the HCP as it applies to the transferred land and has obtained an incidental take permit/incidental take license following normal permit procedures covering all species then covered by the Permittee's Permit and ITL; or

(d) The Service and DLNR determine that the amount of land to be transferred will not have a material impact on the ability of the Permittee to comply with the requirements of the HCP and the terms and conditions of the Permit and ITL.

12.0 MODIFICATIONS AND AMENDMENTS

12.1 Minor modifications.

(a) Minor modifications to the HCP shall not require amendment of the Agreement, the Permit or the ITL.

(b) Minor modifications are modifications to the HCP of a minor or technical nature where the effect on Covered Species and levels of incidental take are not significantly different than those described in the HCP as originally adopted. Minor modifications to the HCP which would not require amendment of the Permit or ITL may include modifications that are minor in relation to the HCP and to which the Service and DLNR agree. They include, but are not limited to, corrections of typographic, grammatical, and similar editing errors that do not change the intended meaning; correction of any maps or exhibits to correct errors in mapping or to reflect previously approved changes in the Permit, ITL or HCP; and minor changes to survey, monitoring or reporting protocols. Any other modifications to the HCP will be processed as amendments in accordance with Section 12.2.

(c) Any Party may propose minor modification of the HCP or this Agreement by providing notice to all other Parties. Such notice shall include a statement of the reason for the proposed modification and an analysis of its environmental effect, including its effects on operations under the HCP and on Covered Species.

(d) The Parties will use best efforts to respond to proposed modifications within 60 days of receipt of such notice. Proposed modifications will become effective upon all other Parties' written approval. If, for any reason, a receiving Party objects to a proposed modification, it must be processed as an amendment of the Permit and ITL in accordance with subsection 12.2 of this section. The Service and DLNR will not propose or approve minor modifications to the HCP or this Agreement if the Service or DLNR determine that such modifications would result in (i) operations under the HCP that are significantly different from those analyzed in connection with the original HCP, (ii) adverse effects on the environment that are new or significantly different from those analyzed in connection with the original HCP, or (iii) additional take not analyzed in connection with the original HCP.

12.2 Standard Amendment

(a) Standard amendments to the HCP shall mean any amendments not treated as minor modifications. Standard amendments to the HCP shall require an amendment to this Agreement, the Permit and the ITL.

(b) The Parties anticipate that amendment of the Permit and ITL will be treated as original permit applications, pursuant to applicable legal requirements under the ESA and Chapter 195D HRS and applicable regulations. Such applications typically require submittal of a revised Habitat Conservation Plan, a complete permit application form with appropriate fees, a revised implementation agreement, and may require environmental review documents prepared in accordance with federal and State law. However, the Parties acknowledge that specific documentation requirements may vary based on the nature of the amendment.

13.0 REMEDIES, ENFORCEMENT AND DISPUTE RESOLUTION

13.1 In general. Except as set forth below, each Party shall have all remedies otherwise available to enforce the terms of this Agreement, the Permit, the ITL and the HCP.

13.2 No monetary damages. No Party shall be liable in damages to any other Party or other person for any breach of this Agreement, any performance or failure to perform a mandatory or discretionary obligation imposed by this Agreement or any other cause of action arising from this Agreement.

13.3 Injunctive and temporary relief. The Parties acknowledge that the Covered Species are unique and that therefore injunctive and temporary relief may be appropriate to ensure compliance with the terms of this Agreement.

13.4 Enforcement authority of the United States. Nothing contained in this agreement is intended to limit the authority of the United States government to seek civil or criminal penalties or otherwise fulfill its enforcement responsibilities under the ESA or other applicable law.

13.5 Dispute resolution. The Parties recognize that disputes concerning implementation of, compliance with, or termination of this Agreement, the HCP, the Permit and the ITL may arise from time to time. The Parties agree to work together in good faith to resolve such disputes, using the informal dispute resolution procedures set forth in this section, or such other procedures upon which the Parties may later agree. However, if at any time any Party determines that circumstances so warrant, it may seek any available remedy without waiting to complete the informal dispute resolution.

13.5.1 Informal dispute resolution process. Unless the Parties agree upon another dispute resolution process, or unless an aggrieved Party has initiated administrative proceedings or suit in federal or State court as provided in this section, the Parties may use the following process to attempt to resolve disputes:

(a) The aggrieved Party will notify the other Parties of the provision that may have been violated, the basis for contending that a violation has occurred, and the remedies it proposes to correct the alleged violation.

(b) The Party alleged to be in violation will have 30 days, or such other time as may be agreed, to respond. During this time it may seek clarification of the information provided in the initial notice. The aggrieved Party will use its best efforts to provide any information then available to it that may be responsive to such inquiries.

(c) Within thirty (30) days after such response was provided or was due, representatives of the Parties having authority to resolve the dispute will meet and negotiate in good faith toward a solution satisfactory to all Parties, or will establish a specific process and timetable to seek such a solution.

(d) If any issues cannot be resolved through such negotiations, the Parties will consider non-binding mediation and other alternative dispute resolution processes and, if a dispute resolution process is agreed upon, will make good faith efforts to resolve all remaining issues through that process.

14.0 MISCELLANEOUS PROVISIONS

14.1 No partnership. Neither this agreement nor the HCP shall make or be deemed to make any Party to this Agreement the agent for or the partner of any other Party.

14.2 Notices. Any notice permitted or required by this Agreement shall be in writing, delivered personally to the persons listed below, or shall be deemed given five (5) days after deposit in the United States mail, certified and postage prepaid, return receipt requested and addressed as follows, or at such other address as any Party may from time to time specify to the other Parties in writing. Notices may be delivered by facsimile or other electronic means, provided that they are also delivered personally or by certified mail. Notices shall be transmitted so that they are received within the specified deadlines.

Assistant Regional Director
U.S. Fish and Wildlife Service
911 N.E. 11th Ave.
Portland, Oregon 97232-4181
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Department of Land and Natural Resources
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14.3 Entire agreement. This Agreement, together with the HCP, the Permit and the ITL, constitutes the entire agreement among the Parties. It supersedes any and all other agreements, either oral or in writing, among the Parties with respect to the subject matter hereof and contains all of the covenants and agreements among them with respect to said matters, and each Party acknowledges that no representation, inducement, promise or agreement, oral or otherwise, has been made by any other Party or anyone acting on behalf of any other Party that is not embodied herein.

14.4 Elected officials not to benefit. No member of or delegate to Congress and no member of the Hawaii State Legislature shall be entitled to any share or part of this Agreement, or to any benefit that may arise from it.

14.5 Availability of funds. Nothing in this Agreement will be construed by the Parties to require the obligation, appropriation, or expenditure of any money from the U.S. Treasury or the State of Hawai`i. The Parties acknowledge that the Service and DLNR will not be required under this Agreement to expend any federal or State agency's appropriated funds unless and until an authorized official of that agency affirmatively acts to commit to such expenditures as evidenced in writing.

14.6 Duplicate originals. This Agreement may be executed in any number of duplicate originals. A complete original of this Agreement shall be maintained in the official records of each of the Parties hereto.

14.7 No third-party beneficiaries. Without limiting the applicability of rights granted to the public pursuant to the ESA or other federal law, or Chapter 195D HRS or any other state law, this Agreement shall not create any right or interest in the public, or any member thereof, as a third party beneficiary hereof, nor shall it authorize anyone not a Party to this Agreement to maintain a suit for personal injuries or damages pursuant to the provisions of this Agreement. The duties, obligations and responsibilities of the Parties to this Agreement with respect to third parties shall remain as imposed under existing law.

14.8 Relationship to other authorities. The terms of this Agreement shall be governed by and construed in accordance with the ESA, Chapter 195D HRS, and applicable federal and State law. In particular, nothing in this Agreement is intended to limit the authority of the Service and/or DLNR to seek penalties or otherwise fulfill their respective responsibilities under the ESA and Chapter 195D HRS. Moreover, nothing in this Agreement is intended to limit or diminish the legal obligations and responsibilities of the Service and/or DLNR as agencies of the federal and State government, respectively.

14.9 References to regulations. Any reference in this Agreement, the HCP, the Permit or the ITL to any regulation or rule of the Service and/or DLNR shall be deemed to be a reference to such regulation or rule in existence at the time an action is taken.

14.10 Applicable laws. All activities undertaken pursuant to this Agreement, the HCP, the Permit or the ITL must be in compliance with all applicable federal and State laws and regulations.

14.11 Successors and assigns; Assignment. This Agreement and each of its covenants and conditions shall be binding on and shall inure to the benefit of the Parties and their respective successors and assigns. Assignment or other transfer of the Permit and/or ITL shall be governed by the Service and/or DLNR regulations in force at the time of assignment or transfer. Permittee shall be entitled to assign this Agreement to an affiliate of Permittee and shall be entitled to collaterally assign this Agreement to any financing party or lender providing financing to the Project.

IN WITNESS WHEREOF, THE PARTIES HERETO have executed this Implementing Agreement to be in effect as of the later date that the Service or DLNR issues its Permit or ITL.

BY ____ Date____________

Deputy Regional Director
United States Fish and Wildlife Service
Portland, Oregon

BY ____ Date_____________

Chairman of the Board
Department of Land and Natural Resources
State of Hawai`i

BY ____ Date_____________

Evelyn Lim, Secretary
Kaheawa Wind Power II, LLC

Appendix 21

H. T. HARVEY & ASSOCIATES
ECOLOGICAL CONSULTANTS

ADDENDUM 6: HAWAIIAN PETREL – REVISON OF POPULATION MODELING FOR SOUTH RIM OF HALEAKALA

DRAFT

Prepared by

H. T. HARVEY & ASSOCIATES

Prepared for

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Kaheawa Wind Power, LLC
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23 September 2011 Project No. 2936-03

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BACKGROUND

This addendum is a revisit of Hawaiian Petrel Population Modeling, Addendum 3 (HTH and PRBO 2011a), which focuses on an alternative mitigation option for a potential population at a colony located at the South Rim of Haleakala Volcano. The revision is necessary owing to new figures for the baseline and high rate of take at KWPI and II. This potential mitigation would be in the form of predator control rather than predator exclusion, and therefore the "mitigation scenario" defined for this exercise assumes a low predation level, analogous to that being attained currently by the National Park Service on the West Rim, and includes reductions to survival of ages 4 years and greater and to reproductive success when compared to the no predation mitigation scenario modeled in HTH and PRBO (2011b).

This addendum was written to focus and revise results from the modeling in Addendum 3 (HTH and PRBO 2011a) in response to requests from the United States Fish and Wildlife Service (USFWS) for clarity on how the proposed mitigation would meet their defined take levels, as well as a revision in the estimated take. In this document, we focus on specific model input values and rationale for these values, both for the current conditions, "full predation scenario" (i.e., what was formerly known as "baseline scenario"), and for the conditions that will exist after mitigation, "mitigation scenario" (i.e., formerly known as "reasonable starting point" scenario). The full predation scenario considers what happens in the colony under a high level of predation, and the mitigation scenario considers what happens in the colony once the mitigation is implemented. The terminology has been changed to reduce confusion over concepts as used by USFWS. In this document, we use the term "baseline take" to refer to the lower of two take levels defined by USFWS; to avoid confusion with the term "baseline scenario", which in previous addenda referred to current conditions during modeling, we now use the term "full predation scenario" instead.

We modeled a full predation scenario to represent existing conditions, and a low predation mitigation scenario to represent the mitigation area with predator control. The full predation scenario used the same values for survival and fecundity and assumptions as used for the full predation scenario in HTH and PRBO (2011b) (Table 11). The low predation mitigation scenario assumes a survival rate for ages 4 years and greater of 0.90 based on Simons (1984), which corresponds to a mild level of predation. For reference, a survival rate of 0.80 was assumed for ages 4 years and greater for the full predation scenario and a survival rate of 0.93 was assumed for the mitigation scenario with predator exclusion at Makamaka'ole (HTH and PRBO 2011b). Breeding probability for the mitigation scenario was 0.62 for ages 6 years and older, and assumed to be half as much for ages 4 and 5 years. Although some age 4 and 5 year birds breed, we assumed that their reproductive capability is much reduced, both in terms of breeding probability and reproductive success. Reproductive success was assumed to be 0.63 for ages 6 years and older, based on Hodges (1994) and Simons (1985). We assumed a reproductive success of 0.44 for ages 4 and 5 years, based on a ratio calculated using optimal observed reproductive success of ages 4 and 5 years (0.50, for fluttering shearwater, Bell et al. 2005) and ages 6 years and older (0.72 for no predation, see HTH and PRBO 2011c).

Table 11. Parameter values used in population model, full predation scenario (current conditions) vs. low predation scenario (mitigation colony), for Hawaiian petrel at Haleakala, South Rim.

Parameter	Value		Source
	Full predation	Low predation	
Survival			
Annual age 0 survival	0.66	Same	Calculated using ratio of age 0 to 2 survival rates, based on Ainley et al. 2001
Annual age 1 survival	0.79	Same	Calculated using ratio of age 1 to 2 survival rates, based on Ainley et al. 2001
Annual age 2 survival	0.90	Same	Back-calculated to result in a fledgling to age 6 survival rate of 0.2689 (from Simons 1984)
Annual age 3 survival	0.90	Same	Assumed to be same as age 2 year survival rate (see HTH and PRBO 2011b)
Annual adult (>=4) survival	0.80	0.90	Simons 1984, high level of predation; Simons 1984, low level of predation
Fecundity			
Breeding probability (4, 5)	0.26	0.31	Assumed to be half the breeding probability of ages >=6
Breeding probability (>=6)	0.51	0.62	Hodges and Nagata 2001, no predator control (high level of predation); Hodges and Nagata 2001
Reproductive success (4, 5)	0.27	0.44	Calculated based on ratio of estimate of 0.5 for ages 4, 5 from Bell et al. 2005 to the estimate of 0.72 based on the literature and the assumed reproductive rate of 0.39 for ages >=6; Bell et al. 2005
Reproductive success (>=6)	0.39	0.63	Simons 1985, high predation; Hodges 1994, Simons 1985
Sex ratio	1:1	Same	Nur and Sydeman 1999; Simons 1985
Average age at first breeding	6	Same	Simons 1984
Maximum breeding age	36	Same	Simons 1984

POPULATION PROJECTION

Population projection results for the mitigation and full predation scenarios, where demographic variables reflected different levels of predation, showed that the initial number of active burrows required to meet baseline take levels (i.e., 42 individuals, including 28 adults) varied considerably (Figure 15, Appendix G). Results for the mitigation scenario indicated that protecting 83 active burrows would produce a net recovery benefit with respect to baseline take (i.e., at least 1 individual above the baseline take level of 42 individuals, at least 28 of which are adults) (Table 12). It would take 13 years to reach the mitigation target. To reach the mitigation target in as few as 5 years would require protection of 113 active burrows (Appendix G). To meet the baseline take level for adults, it would take considerably fewer burrows, 67, and this would be achieved by year 13 (Table 12). For fledglings, it would require 138 burrows, with take being exceeded in year 9.

The mitigation scenario requires considerably more burrows to meet high take levels of 40 adults and 20 fledglings. A net recovery benefit could be achieved by protecting 118 active burrows by year 12 (Figure 15, Appendix G). To reach the net recovery benefit in 5 years would require protection of 160 active burrows (Appendix G). For adults, it would require 95 active burrows, with take exceeded in year 14, and for fledglings, it would require 197 burrows, with take exceeded in year 9 (Table 12).

Table 12. Primary results of population modeling for the mitigation scenario of Hawaiian petrel at Haleakala, South Rim, with respect to baseline and high take levels. Baseline take level was defined by USFWS to be 28 adults and 14 fledglings; high take level was defined to be 40 adults and 20 fledglings.

Life stage	Baseline take		High take	
	# burrows	# years	# burrows	# years
Adult	67	13	95	14
Fledgling	138	9	197	9
Net recovery benefit (>1 individual above adult+fledge take, with adult take exceeded)	83	13	118	12

By observing the relationship between the initial number of active burrows and the number of years required to meet mitigation targets (Figure 15), we found that increasing the number of burrows becomes less and less effective at reducing the number of years once reaching a certain point. Increasing the number of burrows does allow for a shorter time to reach mitigation targets, however achieving a net recovery benefit prior to year 6 is difficult, because the differences between the population trajectories for mitigaton and full predation scenarios are much smaller in earlier years. Although time is really the driver here, we can use this relationship to assess the number of burrows where we are likely to gain the most benefit. A net recovery benefit can be achieved by year 7 with 99 burrows, but to get to 6 years, it would require at least 109 burrows; in contrast, a gain of 2 years (year 13 to year 11) can be achieved by going from 83 to 84 burrows. The effect of increasing the number of burrows on reducing the time to achieve mitigation targets is much reduced beginning at about 86 burrows assuming a baseline take level or at about 122 burrows assuming a high take level. Increasing the number of burrows beyond these points has increasingly diminishing returns.

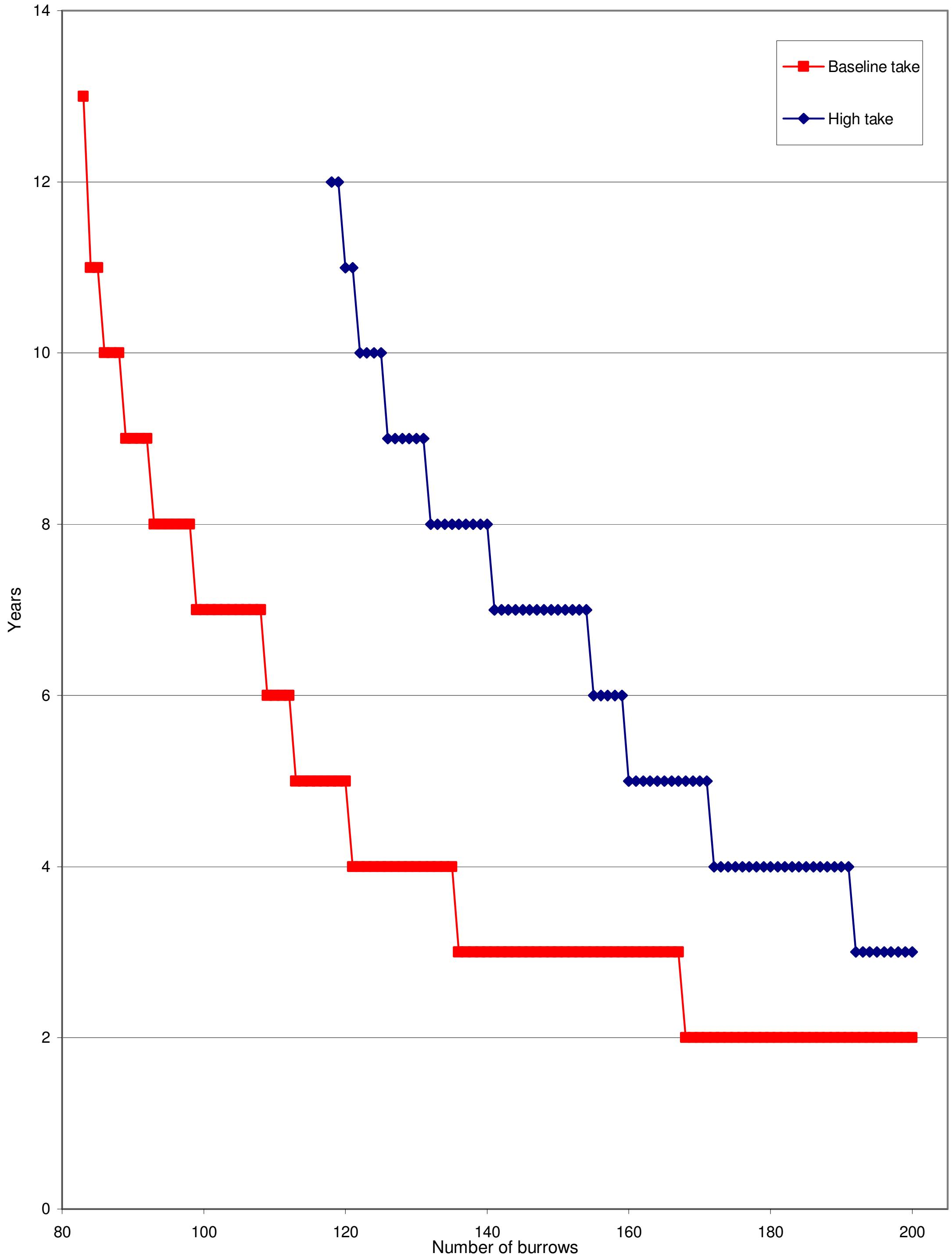

Figure 15. The number of years required to meet mitigation targets in relation to the initial number of active burrows of Hawaiian petrel for potential mitigation site, South Rim of Haleakala; baseline and high levels of take are as specified in the text.

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APPENDIX G.
POPULATION MODELING RESULTS OF HAWAIIAN PETREL AT A POTENTIAL MITIGATION SITE, SOUTH RIM OF HALEAKALA

# Burrows	Baseline take	High take
83	13	NA
84	11	NA
85	11	NA
86	10	NA
87	10	NA
88	10	NA
89	9	NA
90	9	NA
91	9	NA
92	9	NA
93	8	NA
94	8	NA
95	8	NA
96	8	NA
97	8	NA
98	8	NA
99	7	NA
100	7	NA
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102	7	NA
103	7	NA
104	7	NA
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113	5	NA
114	5	NA
115	5	NA
116	5	NA
117	5	NA
118	5	12
119	5	12
120	5	11
121	4	11
122	4	10
123	4	10
124	4	10
125	4	10
126	4	9
127	4	9
128	4	9
129	4	9

# Burrows	Baseline take	High take
130	4	9
131	4	9
132	4	8
133	4	8
134	4	8
135	4	8
136	3	8
137	3	8
138	3	8
139	3	8
140	3	8
141	3	7
142	3	7
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193	2	3
194	2	3
195	2	3
196	2	3
197	2	3
198	2	3
199	2	3
200	2	3

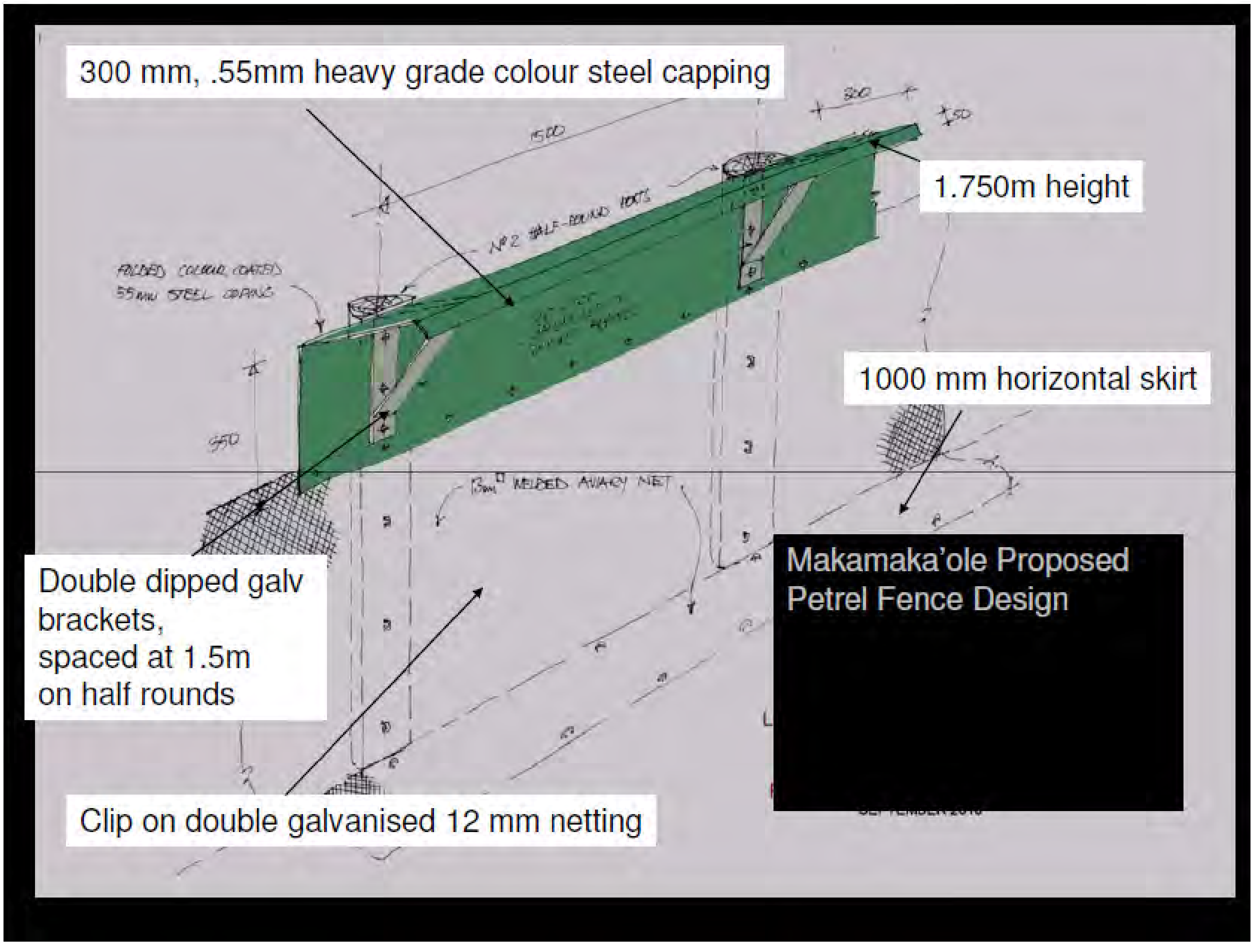
Appendix 22

Makamakaole draft mitigation design and timeline.

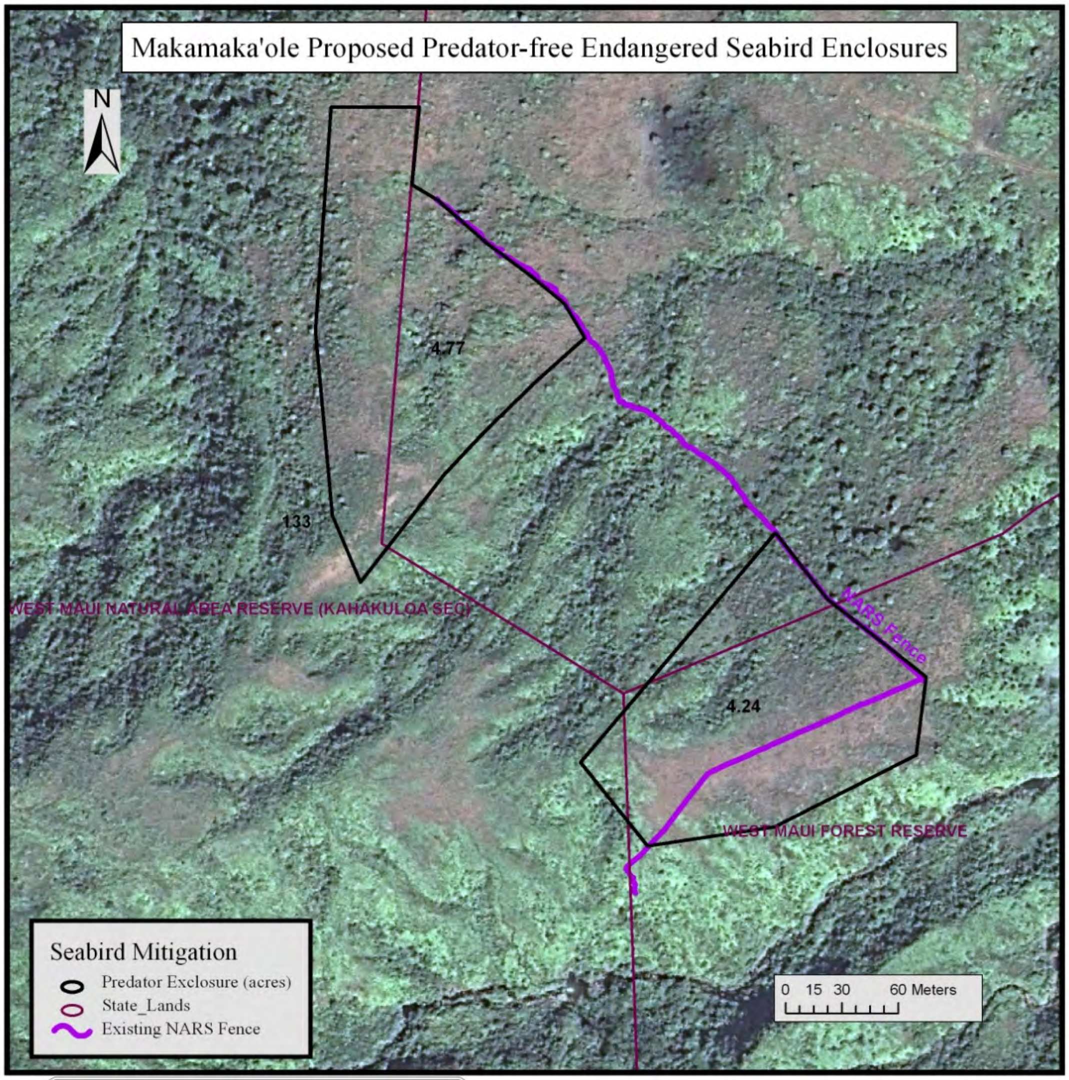
Draft Timeline

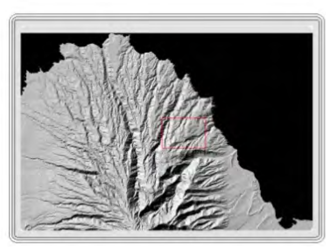
1. Delineate enclosure fence lines- Botanical and cultural surveys will be conducted to avoid sensitive resources along the fenceline and identify sensitive resources within the enclosure. The fence line will follow the terrain and be located below the tops of the ridges to maximize predator exclusion and minimize collision hazard for petrels – **November 2011**
2. Area around fenceline to be cleared with scrub bars- **December 2011**
3. Construction of fence lines with an estimated 4 weeks construction period, with a crew of 3, with a Team Leader from New Zealand. Fence equipment will be deployed by helicopter to both sites. Energiser & electric hotwires will be used to construct a pig fence 4 m from the enclosure-**mid January to mid February 2012**
4. Obtain high quality digital recording of Hawaiian petrel & Newell's shearwater vocalizations at Makamakaole. If not possible, vocalizations from Haleakala or alternate sites will be used **– by31st March 2012**
5. Ordering of digital acoustic units and speakers (already ordered) – **November 2011**.
6. Vertebrate Pest Eradication Program undertaken within both enclosures immediately after fences are completed, including Diphacinone bait boxes deployed in a 25 x 25 m grid (to control mouse populations inside enclosure), kill traps & bait for rats, conibear traps for feral cats & mongoose - **mid February 2012**
7. Control program commences outside both enclosures, using kill traps & bait for rats, conibear traps for feral cats & mongoose (conibears in plywood boxes). A Buffer zone trapping regime will be established within 1 kilometer radius of each enclosure. Trapping in the buffer zone will mainly be on the ridgelines where cat and mongoose scat have been detected (no cat or mongoose sign have been detected in the valleys and along streams) - **mid Feb-mid March 2012**
8. Acoustic system installed and activated once tracking tunnels, gnaw sticks and traps indicate no vertebrate pest species are present at all within enclosures (except for mice, see below) – **20th March 2012**
9. Tracking tunnel, gnaw stick monitoring presence/absence monitoring undertaken permanentlyfor first 12 months. Target mice only within enclosure at $<2\%$ -**15th March 2012-15th March 2013**
10. Quarterly rodent monitoring undertaken within and outside enclosure from Yr 2 on.
11. Radio collar tracking study of mongoose outside enclosure by trapping and tagging within the buffer zone to determine local home ranges – to be funded by First Wind.

Draft proposed fence design



Draft proposed location of enclosures





The actual shape of the enclosures will be determined by landscape features and in consultation with the Natural Area Reserve System. This map serves to illustrate their approximate location.

Appendix 23

AN EXAMINATION OF CURRENT INFORMATION REGARDING THE PROPORTIONS OF HAWAIIAN PETRELS VS. NEWELL'S SHEARWATERS FLYING OVER THE KWP WIND FACILITY ON MAUI

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BACKGROUND

The KWP wind facility is located on West Maui, south of the West Maui Mountains (Figure 1). All seabird-fatality modeling efforts to date at the KWP site have assumed that the shearwater/petrel targets observed during radar studies are composed of 60% Hawaiian Petrels (HAPE) and 40% Newell's Shearwaters (NESH; Day and Cooper 1999; Cooper and Day 2004a, b; Sanzenbacher and Cooper 2008, 2009; Cooper and Day 2009; Cooper et al. 2010). The basis for that 60/40 split was the timing of inland flights at the nearby Ukumehame site (located on the shoreline ~5 km west of KWP; Cooper and Day 2003) that suggested that 60% of the targets

Figure 1. Map of the KWP project area and Maui Island.

were Hawaiian Petrels and 40% of the targets were Newell's Shearwaters. Specifically, the Cooper and Day (2003) conclusion was based upon extensive visual data collected on Kauai (Day and Cooper 1995, Day et al. 2003; Day and Cooper, unpubl. data) indicating that HAPE inland movements on Kauai are essentially finished by 60 min past sunset, but that NESH inland flights begin at 30 min past sunset, overlapping with HAPE until 60 min past sunset, after which essentially all incoming birds are NESH. New information has come to light suggesting that a substantial proportion of HAPE at the KWP site also fly inland >60 min past sunset, suggesting that the composition of seabirds at the site may include more than 60% HAPE (i.e., <40% Newell's Shearwaters). The purpose of this memo is to review pertinent information to determine if the 60/40 proportion for Hawaiian Petrel/Newell's Shearwater should be modified and, if appropriate, to recommend a new proportion to be used for current and future fatality-modeling exercises.

SPECIES OBSERVED AT KWP TO DATE

Information on the species identified at the KWP site is limited but suggests that the proportion of HAPE/NESH is 100% HAPE and 0% NESH. For instance, all three of the seabirds identified to species during radar/visual studies at the site were HAPE (Table 1). Further, 1 HAPE and 0 NESH have been found during fatality surveys at KWP over the past ~5 years (G. Spencer, First Wind, pers. comm.). Lastly, one additional HAPE was found in 2006 on the inland side of transmission lines at the southern end of the KWP access road, near the Honoapi'ilani perimeter road (G. Spencer, First Wind, pers. comm.). Thus, the combined available species-specific records at or near the project area includes 5 HAPE and 0 NESH.

DISTRIBUTION AND ABUNDANCE OF HAPE AND NESH COLONIES ON MAUI

On Maui, HAPE are known to nest on Haleakala Crater (Brandt et al. 1995, Simons and Hodges 1998) and are believed to nest in West Maui (Cooper and Day 2003). For example, on 16 June 1999, a HAPE was heard calling from a bed of uluhe ferns (*Dicranopteris linearis*) at 3,300 ft (~1,000 m) elevation in the Kapunakea Preserve, which lies on the northwestern slope of the West Maui Natural Area Reserve (A. Lyons, *fide* C. Bailey) in the West Maui Mountains. In addition, recent observations of consistent calling from a single location suggests that there is at

Table 1. Records of all visual observations of Hawaiian Petrels, Newell's Shearwaters, and unidentified shearwaters/petrels at the proposed KWP II wind energy site and nearby KWP I wind energy site, Maui, Hawaii, during 1999–2009 radar studies.

Date	Time	Species[a]	Number	Altitude (m agl)	Flight direction
28 May 1999	2150[b]	HAPE	1	300[c]	NE
28 May 1999	0608	UNSP	2	500[c]	SE
12 October 2004	0608	HAPE	1	500[c]	SE
15 October 2004	0454	UNSP	1	65	SW
24 July 2009	2126[b]	HAPE	1	40	E

[a] HAPE = Hawaiian Petrel; UNSP = unidentified shearwater/petrel.
[b] Observation occurred in the evening, >60 min past sunset.
[c] Flight altitudes measured over the valley to east of the proposed turbine string ridge, not over the proposed turbine string ridge itself; measurements were done that way because that is where birds were first seen.

least one other small colony of HAPE in the West Maui Mountains ~12 km north of the KWP project area (G. Spencer, pers. comm.). The Maui population of HAPE is estimated to be at least ~1,800 birds (Simons 1984, 1985; Hodges 1994). In contrast to HAPE, NESH are rare on Maui (Ainley et al. 1997). The only suspected colonies of NESH are located on West Maui, where recent auditory observations suggest that a small colony occurs in the West Maui Mountains ~12 km north of the KWP project area in the upper reaches of the Kahakuloa drainage (G. Spencer, pers. comm.). This discovery of a colony matched a prediction of their occurrence there by Cooper and Day (2003), based on timing of movements on radar. Thus, there is an unknown, but low, number of NESH (<100 birds?) that are likely to occur on Maui and a known number of at least ~1,800 HAPE on Maui, suggesting that the proportion of HAPE to NESH island-wide is greater than 60%, and perhaps greater than 95% (i.e., ~1,800 HAPE and ~100 NESH would equate to 95% HAPE).

FALLOUT RECORDS OF HAPE AND NESH ON MAUI

Available fallout records of downed seabirds from the Hawaii Department of Fish and Wildlife (DOFAW) indicate that a total of 35 HAPE and 13 NESH have been found on Maui to date, with most of the birds being found in the valley between eastern and western Maui or on the western shore of Maui. (G. Spencer, pers. comm.). Thus, the proportion of HAPE/NESH fallout victims to date is 73% HAPE/27% NESH for the Island of Maui. An unknown proportion of these fallout victims may have been drawn in from the ocean and, hence, may not have been associated with colonies on Maui, so this proportion may not be indicative of the actual relative proportions of HAPE/NESH on Maui.

TIMING OF EVENING FLIGHTS

The basis for the 60/40 split for HAPE/NESH at KWP was the Cooper and Day (2003) data on the timing of inland flights at the nearby Ukumehame site. Their conclusions were based on the Kauai data that indicates HAPE inland movements are essentially finished by 60 min past sunset, but NESH inland flights begin at 30 min past sunset, overlapping with HAPE until 60 min past sunset, after which essentially all incoming birds on Kauai are NESH (Day and Cooper 1995, Day et al. 2003; Day and Cooper, unpubl. data). It was clear that some HAPE moved after complete darkness, but that number was swamped by the enormous numbers of NESH flying inland. Our visual observations of the two HAPE observed during evening hours at KWP suggest that a similar pattern of timing does not occur at KWP: both birds flew over KWP after 2100 h (Table 1), well into the period when essentially only NESH occur on Kauai. This later movement period for the two HAPE observed at KWP did, however, match well with what has been observed recently on Lanai, where HAPE exhibit substantial inland movements >60 min past sunset (Cooper et al. 2007 *in* TetraTech EC 2008). Hence, it is possible that the timing of movements may vary among islands for reasons that are poorly understood at this time.

We compared the percent of evening radar targets observed during each sampling session in Kauai during the summers of 1993, 1999, 2000, and 2011 combined (Day et al. 2003) with the percentages observed during spring and summer of 2007 at Lanai (where only HAPE and essentially no NESH are thought to occur; Cooper et al. 2007 *in* TetraTech EC 2008) and at the KWP wind energy site during the summers of 1999, 2008, and 2009 combined (Figure 2). Clearly, there is a marked difference in the timing pattern of evening flights between Kauai and the other two areas, with Lanai and KWP being very similar. Specifically, we observed a much greater proportion of targets after 2030 at KWP and Lanai than on Kauai. This difference alone suggests that the timing criteria used on Kauai to differentiate HAPE from NESH radar targets may not be appropriate to apply to KWP data (or Lanai data).

In summary, the available information suggests that the use of the proportion of radar targets observed beyond 60 min past sunset to calculate the proportion of NESH probably is not an accurate approach to determining that proportion at KWP. Further, because we have visual observations of HAPE after 2100 and because the pattern of movements at KWP matches up so well with that on Lanai (where only HAPE are believed to occur), those data also suggest that far more than 60% of the radar targets we observed at KWP could have been Hawaiian Petrels.

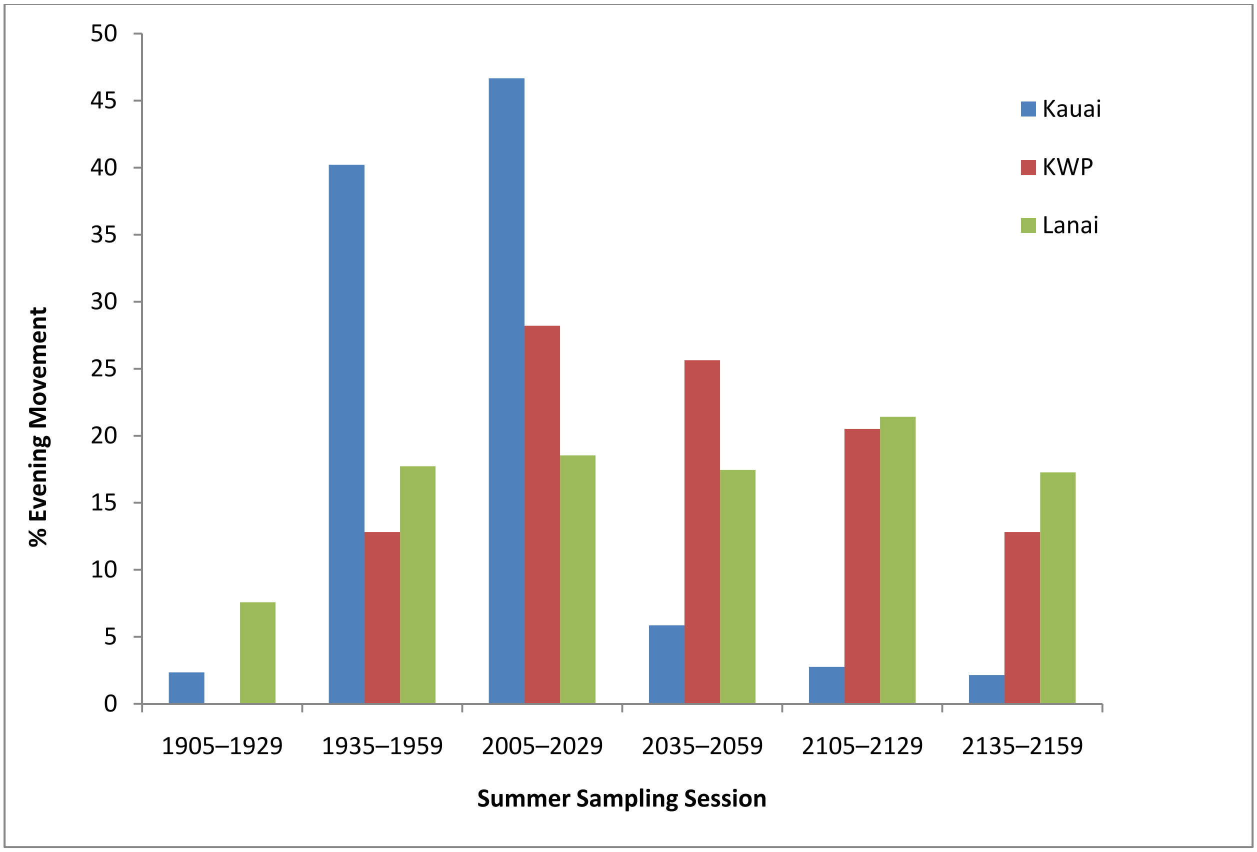

Figure 2. Percent of evening radar targets observed during each sampling session in Kauai during the summers of 1993, 1999, 2000, and 2011 combined (Day et al. 2003), at the KWP wind energy site, Maui, during the summers of 1999, 2008, and 2009 (Day and Cooper 1999; Sanzenbacher and Cooper 2008, 2009; Cooper and Day 2009), and in Lanai during spring/summer 2007 (Cooper et al. 2007 *in* TetraTech EC 2008b). The first session started near sunset, the second session included some evening twilight, and the last four sessions occurred after it became completely dark. Day et al. (2003) found that, on Kauai, only HAPE were flying during the first session, that both HAPE and NESH were flying during the second session, and that essentially only NESH were flying in the final four sessions.

IMPLICATIONS OF FLIGHT-DIRECTION DATA

There have been three visual observations of HAPE and two observations of unidentified shearwaters/petrels over the KWP study areas during 1999–2009 (Table 1; Day and Cooper 1999, Cooper and Day 2004a; Sanzenbacher and Cooper 2008, 2009). The two birds observed in the evening period were flying east or northeast, and the three birds observed in the morning were flying southeast or southwest. These flight directions fit a pattern of inbound movements toward Haleakala (i.e., movement across the southern part of the island by late-arriving birds heading to the colonies on Haleakala) in the evening and outbound movements from colonies on both Haleakala and West Maui in the morning.

In general, the radar data collected at KWP during 1999–2009 exhibited the same pattern in flight directions as the visual data from KWP. Over 80% of all radar targets at KWP were heading east, southeast, south, or southwest and only 2% were heading north (i.e., toward the direction of the suspected NESH colony in the West Maui mountains; Table 2). There are no known colonies of NESH on Maui to the northeast, east, or southeast of KWP, and it is likely that there are both NESH and HAPE colonies in the West Maui Mountains to the north of KWP. If one assumed that (1) half of the birds flying toward or away from the West Maui Mountains (i.e., flying north or south) were HAPE and half were NESH and (2) all birds headed toward or away from East Maui (i.e., flying northeast, east, southeast, southwest, west, or northwest) were HAPE, then ~89% of the radar targets observed during 1999–2009 would have been HAPE and ~11% would have been NESH.

In addition to observations at KWP, there are recent visual and radar data available from the suspected NESH colony in the upper Kahakuloa drainage on the northern side of the West Maui Mountains, north of KWP (G. Spencer, pers. comm.). Those data, along with radar data collected along the northern coast of West Maui (Cooper and Day 2003) suggest that most HAPE and NESH in northern West Maui access their colonies along valleys from the northern, rather than southern, coast of Maui. Thus, those data suggest that NESH on their way to the suspected Kahakuloa colony probably do not pass over KWP.

Table 2. Flight directions of all petrel/shearwater-like seabird radar targets observed at the proposed KWP II wind energy site and nearby KWP I wind energy site, Maui, Hawaii, during 1999–2009 radar studies during evening (Even) sampling hours, morning (Morn) sampling hours, and all sampling hours combined (Total).

Flight direction		Number and percent of targets					
Direction	Degree	Eve	Eve %	Morn	Morn %	Total	Total %
N	338–022	4	3.8	0	0.0	4	2.4
NE	023–067	10	9.5	4	6.5	14	8.4
E	068–112	20	19.0	14	22.6	34	20.4
SE	113–157	12	11.4	11	17.7	23	13.8
S	158–202	17	16.2	17	27.4	34	20.4
SW	203–247	34	32.4	11	17.7	45	26.9
W	248–292	4	3.8	5	8.1	9	5.4
NW	293–337	4	3.8	0	0.0	4	2.4
Total		105		62		167	

CONCLUSIONS

We made a thorough examination of currently available information, and the overall weight-of-evidence suggests that the method devised on Kauai that uses time of day to separate HAPE from NESH radar targets is not valid for the KWP site and, further, that the proportion of HAPE at KWP is likely to be much higher than 60%. Determining the exact proportion of HAPE at KWP is difficult without further visual observations at the site; however, while it is impossible to state with certainty that no NESH fly over KWP, we think that it is justified to raise the estimated proportion of HAPE at KWP from 60% to ~90% based upon the following information: (1) The observed proportion of HAPE/NESH at KWP to date is 100%/0% (n = 5 birds); (2) The literature suggests that at least ~1,800 HAPE occur on Maui, but there are only scattered reports of low numbers of NESH on Maui. Thus, there is an unknown, but very low, number of NESH (<100 birds?) that might occur on Maui and a known number of ~1,800 HAPE on Maui, suggesting that the proportion of HAPE to NESH island-wide may be greater than 95% (i.e., ~1,800 HAPE and ~100 NESH); (3) The ratio of HAPE/NESH in the available seabird fallout data for Maui is 73% HAPE/27% NESH; (4) The timing of movements of radar targets observed at KWP matches fairly closely with the timing of radar targets observed at Lanai (where essentially only HAPE occur), indicating that the proportion of HAPE also could be very high at KWP; and (5) If one assumed that half of the birds flying toward or away from the West Maui Mountains were HAPE and half were NESH (based upon observations of low numbers of both species in that area) and that all birds headed toward or away from East Maui were HAPE (based upon the known occurrence of HAPE but not NESH on East Maui), then ~89% of the radar targets we observed during 1999–2009 would have been HAPE and ~11% would have been NESH. Thus, taking the average of the percentages of HAPE listed in points #1, 2, 3, and 5 (i.e., 100%, 95%, 73%, and 89%), we get an average proportion of ~90% HAPE/10% NESH. Again, the exact proportion of HAPE at KWP remains unknown, but, based upon a thorough review of the available evidence, we believe that it would be more appropriate for future modeling exercises to operate under the assumption that the proportion of HAPE is much higher than 60% and suggest that using a 90% assumption (i.e., a 90%/10% HAPE/NESH ratio) would improve the accuracy of fatality-modeling calculations at KWP.

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Appendix 24

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ADDENDUM 5: HAWAIIAN PETREL POPULATION MODELING – GROWTH OF MITIGATION COLONY AT MAKAMAKA'OLE, WEST MAUI

DRAFT

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21 September 2011 Project No. 2936-03

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BACKGROUND

To date, there have been several documents detailing the population modeling for Hawaiian petrel on Maui with respect to estimating results of take at KWPI and II (HTH and PRBO 2011a, b, c, d, e). This addendum was written to focus and revise results from the modeling in Addendum 4 in response to requests from the United States Fish and Wildlife Service (USFWS) for clarity on how the proposed mitigation would meet their defined take levels, as well as a revision in the estimated take. The background on the social attraction option and rationale for why we think this would be an effective approach is presented in HTH and PRBO (2011e). In this document, we focus on specific model input values and rationale for these values, both for the currently existing conditions, "full predation scenario" (i.e., what was formerly known as "baseline scenario"), and for the conditions that will exist after mitigation, "mitigation scenario" (i.e., formerly known as "reasonable starting point" scenario) is implemented. The full predation scenario models what happens in the existing population (colony) without mitigation being instituted, and the mitigation scenario models what happens in the population, composed of both the mitigation colony and the existing colony, upon implementation of the mitigation (colony established using social attraction). The terminology has been changed to reduce confusion over concepts as used by USFWS. In this document, we use the term "baseline take" to refer to the lower of two take levels defined by USFWS; to avoid confusion with the term "baseline scenario", which in previous addenda referred to existing conditions during modeling, we now use the term "full predation scenario" instead.

In other species of procellarids observed in New Zealand, the rate of increase in colony size in both translocation and social attraction scenarios appears to be somewhat rapid, once breeding begins. With respect to translocations of fluttering shearwaters and common diving petrels, the increase in the number of breeding pairs from year 6 to year 10 was rapid (Bell et al. 2005, Miskelly and Taylor 2004); in social attraction experiments of fluttering shearwaters, similar patterns occurred, except that by borrowing pre-breeders initial breeding started sooner (Steve Sawyer, pers. comm.). After the relatively rapid initial increase in breeding pairs, it would be expected that growth rate would eventually decrease, upon becoming self sustaining without lots of new immigrants. However, the New Zealand experiments have not lasted long enough to observe such a later pattern. We assumed a rate of social attraction of immigrants based on Bell et al. (2005), who in the early years of their experiment documented 8 of 40 adults caught at the colony site as immigrants, or 20%. We believe this to be a conservative value, as other studies such as Miskelly and Taylor (2004) on common diving petrels suggest that over half of a socially attracted colony could consist of immigrants within the first several years of re-establishment. In addition, we assumed for Hawaiian petrel that the transition from social attraction to a self-sustaining colony occurs at 25 breeding pairs.

For simplicity of the modeling, we assume a fraction of the total population breeds based on the stable age structure resulting from modeling of the current conditions (i.e., the full predation scenario). We also assumed an initial population of 600 pairs of adults in the existing colony in the vicinity of Makamaka'ole. This is a crude estimate based on the fact that 50-70 Hawaiian petrels at times have been heard/seen circling and calling (including pair formation flights) in the valley next to the proposed site of the Makamaka'ole mitigation colony (predator exclosure). We assumed that the birds cavorting are equivalent to ~10% of what to expect as colony size (N. Holmes, pers. comm.).

Any ground and burrow nesting birds in west Maui would be and have been subject to intense predation by cats, mongoose and rats. During work at Makamaka'ole in July-Aug 2011, 11 mongoose were trapped in 12 days using two traps; only predated carcasses of Hawaiian petrels and deserted burrows thus far have been found in the lower Makamaka'ole area over which the petrels circle at night (First Wind, unpubl. data). According to the NARS management plan (NARS 1989), mongoose tracks have been found on the Puu Kiki Trail well above Makamaka'ole (2980 ft and higher), and rat sign to as high as 4200 ft on west Maui (more or less the summit). Cats and rats occur at the summit of Haleakala (10,029 ft) and mongoose at high altitude as well; thus, there is reason to believe that these predators are likely widespread on west Maui, which is half that altitude.

For the full predation scenario, which reflects what is happening at the existing colony, we assumed model input values based on our previous modeling exercises, but made important adjustments to a few. First, for the full predation scenario (current conditions on west Maui), we assumed an annual adult survival rate (ages 4 and older) of 0.80 (Simons 1984) (Table 9). Annual survival rates for juveniles were calculated based on an assumed fledging to age 6 survival rate of 0.2689, an agreed-upon (with USFWS) conservative rate from Addendum 1 (HTH and PRBO 2011b). Because we reduced the assumed survival rates for ages 4 and 5 years, this had the effect of slightly increasing survival rates for ages 0 – 3 years, in order for fledgling to adult survival rate to match that used in Simons (1984).

Table 9. Parameter values used in the population model, existing colony (full predation) and mitigation colony (no predation), for Hawaiian petrel at Makamaka'ole.

Parameter	Value		Source
	Existing colony	Mitigation colony	
Survival			
Annual age 0 survival	0.66	Same	Calculated using ratio of age 0 to 2 survival rates, based on Ainley et al. 2001
Annual age 1 survival	0.79	Same	Calculated using ratio of age 1 to 2 survival rates, based on Ainley et al. 2001
Annual age 2 survival	0.90	Same	Back-calculated to result in a fledgling to age 6 survival rate of 0.2689 (from Simons 1984)
Annual age 3 survival	0.90	Same	Assumed to be same as age 2 year survival rate (see HTH and PRBO 2011b)
Annual adult (>=4) survival	0.80	0.93	Simons 1984, high level of predation; no predation could be as high as 0.94, see HTH and PRBO 2011a for explanation
Fecundity			
Breeding probability	0.51	0.89	Hodges and Nagata 2001, no predator control (high level of predation); Simons 1985, no predation
Reproductive success (4, 5)	0.27	0.50	Calculated based on ratio of estimate of 0.5 for ages 4, 5 from Bell et al. 2005 to the estimate of 0.72 based on the literature and the assumed reproductive rate of 0.39 for ages >=6; Bell et al. 2005
Reproductive success (>=6)	0.39	0.72	Simons 1985, for high predation; see HTH and PRBO 2011a for explanation regarding no predation scenario
Sex ratio	1:1	Same	Nur and Sydeman 1999; Simons 1985
Age at first breeding	6	Same	Simons 1984
Maximum breeding age	36	Same	Simons 1984

For values related to fecundity in the existing colony, we assumed different values for both breeding probability and reproductive success than previously used (Table 9). We assumed a breeding probability of 0.51 based on Hodges and Nagata (2001), whose estimates were for the South Rim of Haleakala, where there was no predator control, and a reproductive success of 0.39 for ages 6 years and older based on Simons (1985), observed under a high level of predation at Haleakala. The breeding probability of 0.51 is reasonable, because this rate has been measured in the field with appreciable sample sizes and numbers of years. Likewise, reproductive success as low as 0.27 has been reported by Hodges and Nagata (2001) at the South Rim with no predator control, therefore, the value of 0.39 would be considered conservative (in terms of quantifying a net recovery benefit). In addition, we assumed a lower reproductive success for ages 4 and 5 years, based on the ratio of observed rates for fluttering shearwater (as high as 0.50, Bell et al. 2005) to the assumed rate of 0.72 for ages 6 years and older under the no predation scenario (observed by Simons (1984), among nests that did not suffer predation). This rate has been found in other petrels, as noted in some of our earlier reports (HTH and PRBO 2011a). We applied this ratio to the reproductive success of 0.39 to obtain a reproductive success of 0.27 for ages 4 and 5 years.

The mitigation scenario considers birds in both the existing colony (as potential emigrants) and the mitigation colony. Survival and reproductive values for the existing colony under the mitigation scenario are the same as those used for the existing colony in the full predation scenario, and those of the mitigation colony are those experienced by petrels under no predation pressure. In this paragraph, we only describe values for the mitigation (social attraction) colony. Survival rates for ages 4 years and older were assumed to be 0.93 (see HTH and PRBO 2011a) (Table 9). Survival rates for juveniles are assumed to be unaffected by predation, so there is no change to these rates when compared to the existing colony. With respect to fecundity, we assumed a breeding probability of 0.89, based on Simons (1985) for no predation, and a reproductive success of 0.5 for ages 4 and 5 years based on fluttering shearwater (Bell et al. 2005), and 0.72 for ages 6 years and older (see HTH and PRBO 2011a). Because the social attraction is bringing immigrants from the existing colony, we assumed that breeding would begin within two years, as was true with grey-faced petrel in a social attraction project in NZ (S. Sawyer, pers. comm.).

POPULATION PROJECTION: ACHIEVING MITIGATION TARGETS

Population projections showed that the mitigation scenario would make steady progress towards reaching mitigation targets for the baseline take level (Table 10, Figure 12, Appendix F). This was calculated by comparing the decreasing trend of the existing colony under the full predation scenario to the combined effect of the decreasing trend of the existing colony in conjunction with the increasing trend of the mitigation colony under the mitigation scenario (Figure 12). The baseline take level is the lower of two possible take levels defined by USFWS, and was previously referred to as the “low take level” in Addendum 4 (HTH and PRBO 2011e). USFWS has now defined the baseline take level to be 28 adults and 14 fledglings; the “high take level” was defined by USFWS to be 40 adults and 20 fledglings. Although net recovery would not be reached during the 20 year license period (i.e., at least 1 individual above the baseline take level of 42 individuals, at least 28 of which are adults, and assuming that the permitted take is actually realized and requiring mitigation), considerable progress would be made, especially for adults. Although the mitigation targets would not be exceeded within the license period, 67% and 65% of adult and fledgling baseline take would be met, respectively. However, mitigation accelerates with time, and net recovery benefit would be reached not long after, i.e. in year 24 (Appendix F). The baseline take would be met by year 24 for adults and year 25 for fledglings (Table 10).

The mitigation scenario would also make progress towards the high take level. The high take level was defined by USFWS as 40 adults and 20 fledglings, and reflects a worst case that is well beyond what is expected. For both adults and fledglings, the mitigation scenario would provide 47% and 45% of required adults and fledglings, respectively, by year 20 (Table 10). A net recovery benefit would be reached within a reasonable time frame beyond the license period (again, because mitigation accelerates), by year 28 (Appendix F). The mitigation targets would be reached by year 28 for adults, and year 33 for fledglings (Table 10).

Table 10. Primary results of population modeling for the mitigation scenario of Hawaiian petrel at Makamaka’ole with respect to baseline and high take levels. Baseline take level was defined by USFWS to be 28 adults and 14 fledglings; high take level was defined to be 40 adults and 20 fledglings.

Life stage	Additional burrows by year 20	Take level	Year mitigation target reached	% of mitigation target in year 20
Adult	9	Baseline (28)	Year 24	0.67
		High (40)	Year 28	0.47
Fledgling	na	Baseline (14)	Year 25	0.65
		High (20)	Year 33	0.45

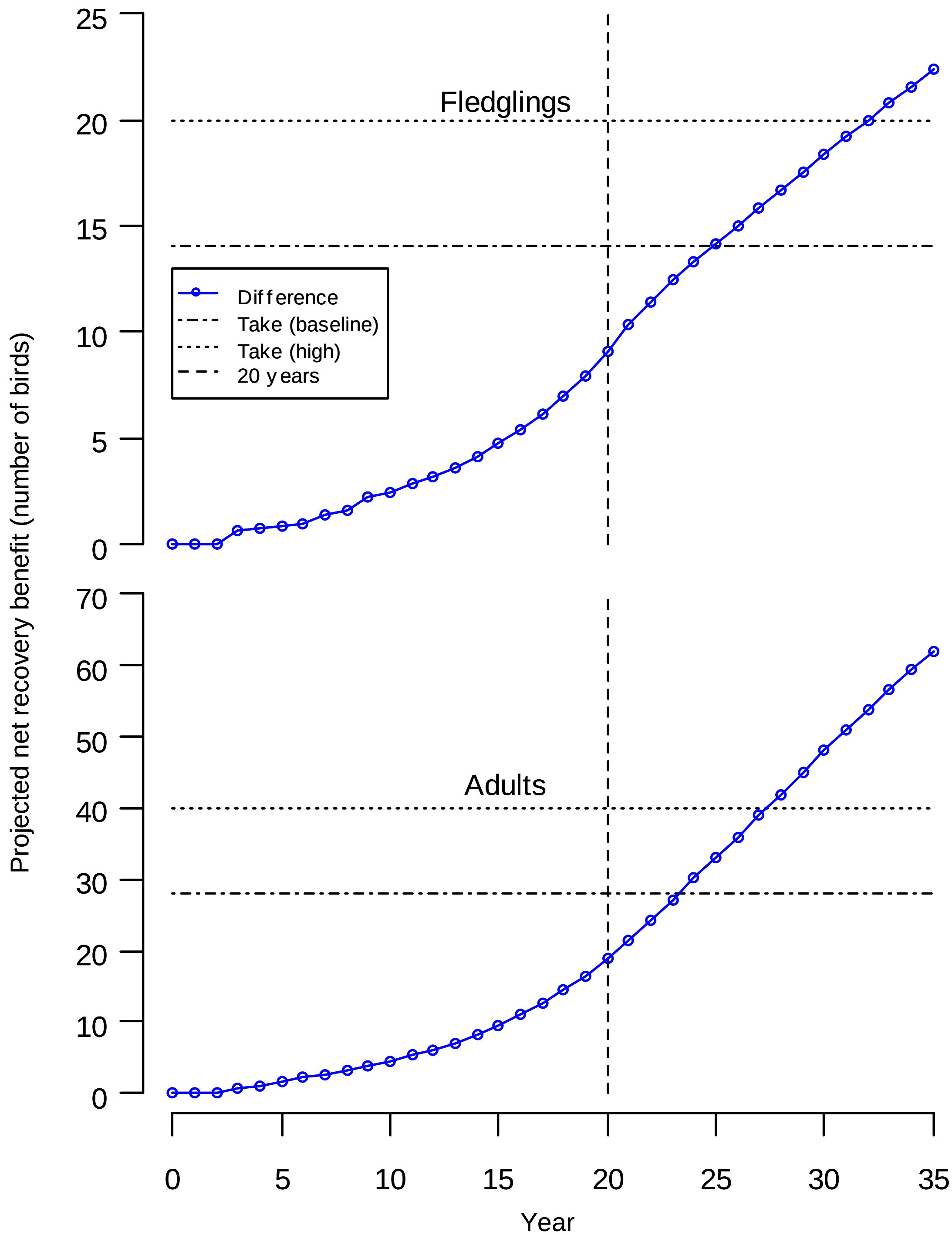

Figure 12. Difference between full predation scenario (existing colony) and mitigation scenario (mitigation and existing colony combined) for Hawaiian Petrel breeding adults and fledglings, Makamaka'ole, assuming that the social attraction mitigation project is implemented. Vertical line indicates the end of the 20-year license period.

Predator-free burrows, including 50 artificial ones, would be provided under the mitigation scenario, compared to the full predation scenario, where predation would remain rampant in the existing colony. Under the mitigation scenario, at year 20, there would be 14 active burrows at the mitigation colony and only 21 active burrows remaining at the existing colony (results not shown). By year 20, there would be a 35% increase in active burrows (35 active burrows overall in both the existing and mitigation colonies) compared to the full predation scenario, in which there would be no mitigation (26 active burrows at the existing colony).

EXTINCTION OF THE EXISTING COLONY AS THE MITIGATION COLONY GROWS

Projected number of birds for the existing colony without mitigation (i.e., full predation scenario) show a decreasing trend with time until extinction (defined as <10 breeding pairs, when stochastic processes can lead to complete loss of all individuals in the population; Figure 13). Modeling results show that adding mitigation (i.e., mitigation scenario, social attraction to a predator free colony), despite an initially decreasing trend, will eventually reverse the decreasing trend for the population as a whole by year 27 (Figure 13). For the existing colony without mitigation, the trend leads to extinction () by year 27. In contrast, the population with mitigation never reaches extinction levels.

Within the mitigation colony itself, the trend is clearly an increasing one, with a larger rate of increase occurring after year 10 (Figure 14). By year 20, we would expect 16 nesting pairs of adults in the mitigation colony, and by year 50, 58 nesting pairs of adults.

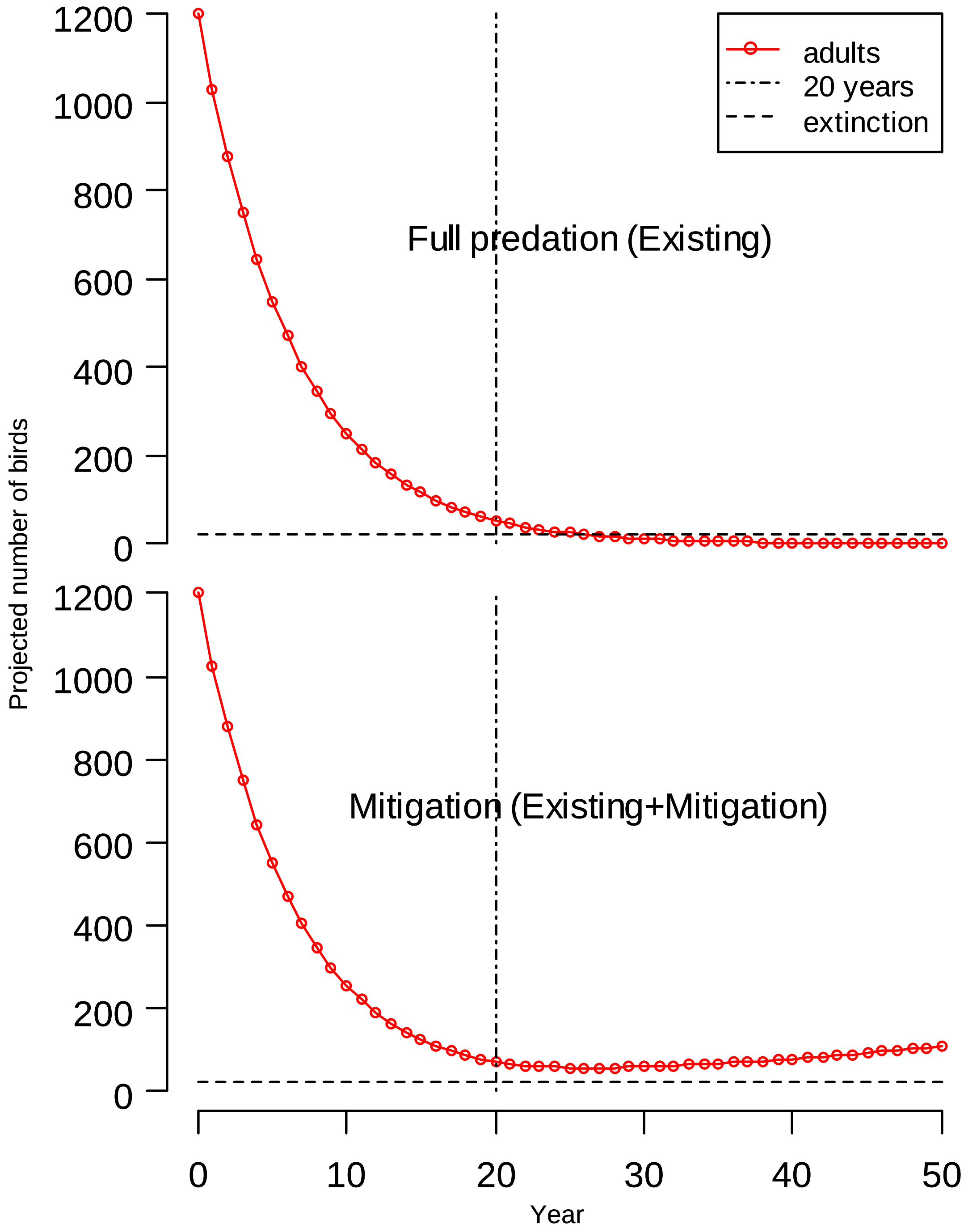

Figure 13. Projected number of Hawaiian Petrels, by life stage, for the overall population under full predation (no mitigation) and mitigation (no predation) scenarios, Makamaka'ole, West Maui. Vertical line indicates the end of the 20-year license period, and the horizontal line indicates the threshold for extinction (10 breeding pairs), which is only reached in the existing colony (full predation).

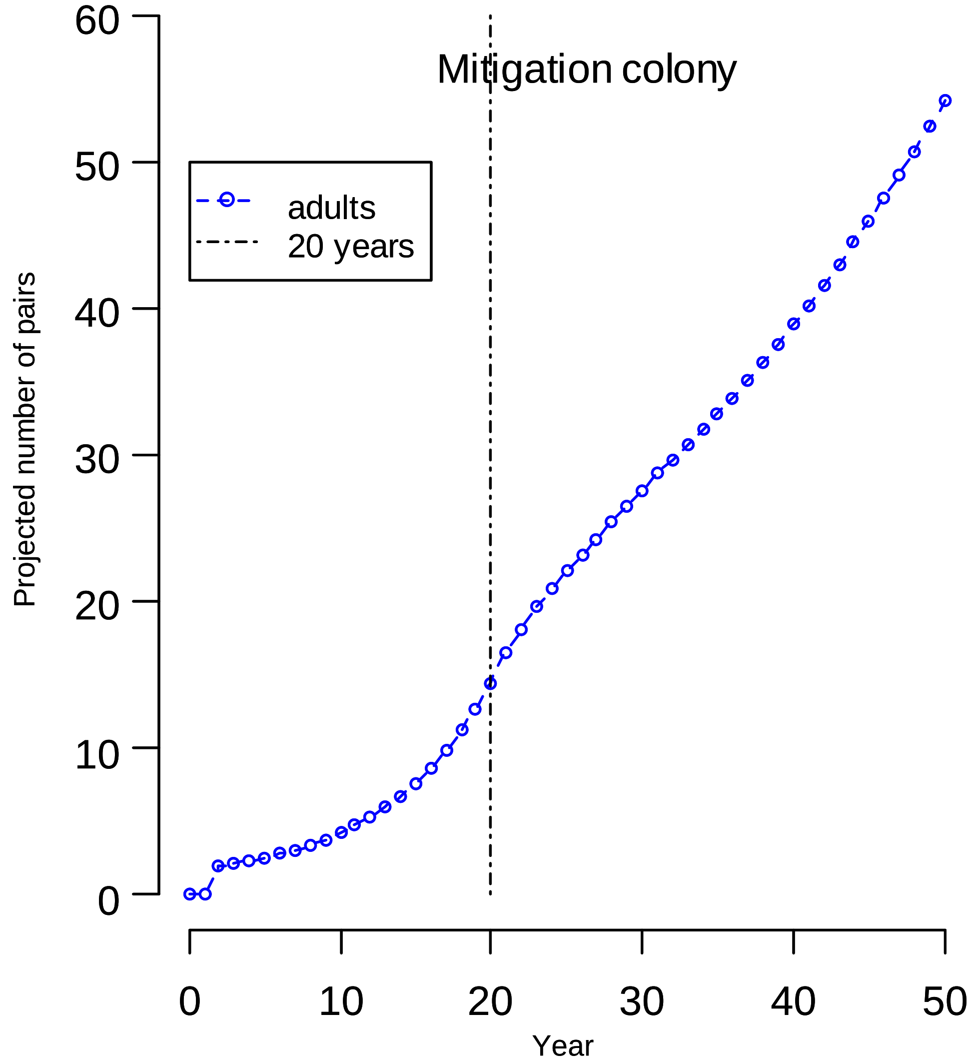

Figure 14. Projected number of Hawaiian petrel adults for mitigation colony (social attraction), Makamaka'ole, West Maui. Vertical line indicates the end of the 20-year license period.

CONCLUSION

This addendum presents a more concise version of the modeling results for the purpose of evaluation by USFWS than what was contained in previous modeling efforts for Hawaiian petrel. We still agree with the conclusions from the previous addendum (HTH and PRBO 2011e). As was stated in Addendum 4 (HTH and PRBO 2011e), we believe that the social attraction mitigation, even with conservative values, provides a viable way by which to meet mitigation targets within a reasonable timeframe. Model results suggest that substantial progress can be made toward take levels, with the baseline level of take for fledglings and adults being met a few years after the 20-year license period under the proposed mitigation.

Most importantly, our modeling efforts suggest that under the current conditions, the population will likely be nearing extinction within the timeframe of the license period. Modeling results from the social attraction option, and the experience with similar projects in New Zealand, show that it may be possible to reverse the trend, if this option is implemented soon.

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APPENDIX F.
POPULATION MODELING RESULTS OF HAWAIIAN PETREL AT A POTENTIAL MITIGATION SITE, MAKAMAKA'OLE (WEST MAUI) – SOCIAL ATTRACTION

Table F1. Number of Hawaiian petrel individuals projected per year and differences between no predation and predation scenarios, based on 600 pairs of breeding adults in the existing colony at year 0, and high predation level in the existing colony.

					# Greater than Baseline Scenario			
Scenario	Year	Adults	Juveniles	Fledglings	Adults	Juveniles	Fledglings	Total
Baseline	0	1200.0	613.2	129.1				
	1	1026.3	524.5	110.4				
	2	877.7	448.5	94.4				
	3	750.7	383.6	80.8				
	4	642.0	328.1	69.1				
	5	549.1	280.6	59.1				
	6	469.6	240.0	50.5				
	7	401.6	205.2	43.2				
	8	343.5	175.5	36.9				
	9	293.7	150.1	31.6				
	10	251.2	128.4	27.0				
	11	214.8	109.8	23.1				
	12	183.7	93.9	19.8				
	13	157.1	80.3	16.9				
	14	134.4	68.7	14.5				
	15	114.9	58.7	12.4				
	16	98.3	50.2	10.6				
	17	84.1	43.0	9.0				
	18	71.9	36.7	7.7				
	19	61.5	31.4	6.6				
	20	52.6	26.9	5.7				
	21	45.0	23.0	4.8				
	22	38.5	19.7	4.1				
	23	32.9	16.8	3.5				
	24	28.1	14.4	3.0				
	25	24.1	12.3	2.6				
	26	20.6	10.5	2.2				
	27	17.6	9.0	1.9				
	28	15.1	7.7	1.6				
	29	12.9	6.6	1.4				
	30	11.0	5.6	1.2				
	31	9.4	4.8	1.0				
	32	8.1	4.1	0.9				
	33	6.9	3.5	0.7				
	34	5.9	3.0	0.6				
	35	5.0	2.6	0.5				
	36	4.3	2.2	0.5				
	37	3.7	1.9	0.4				
	38	3.2	1.6	0.3				
	39	2.7	1.4	0.3				
	40	2.3	1.2	0.2				
	41	2.0	1.0	0.2				
	42	1.7	0.9	0.2				
	43	1.4	0.7	0.2				
	44	1.2	0.6	0.1				

Table F1. Number of Hawaiian petrel individuals projected per year and differences between no predation and predation scenarios, based on 600 pairs of breeding adults in the existing colony at year 0, and high predation level in the existing colony.

					# Greater than Baseline Scenario			
Scenario	Year	Adults	Juveniles	Fledglings	Adults	Juveniles	Fledglings	Total
Baseline	45	1.1	0.5	0.1				
	46	0.9	0.5	0.1				
	47	0.8	0.4	0.1				
	48	0.7	0.3	0.1				
	49	0.6	0.3	0.1				
	50	0.5	0.2	0.1				
Reasonable	0	1200.0	613.2	129.1	0.0	0.0	0.0	0.0
	1	1026.3	524.5	110.4	0.0	0.0	0.0	0.0
	2	877.7	448.5	94.4	0.0	0.0	0.0	0.0
	3	751.2	384.3	81.4	0.6	0.7	0.6	1.3
	4	643.1	329.3	69.8	1.1	1.2	0.7	2.3
	5	550.7	282.3	59.9	1.7	1.7	0.8	3.4
	6	471.8	242.2	51.5	2.2	2.2	0.9	4.4
	7	404.3	208.4	44.6	2.7	3.1	1.4	5.8
	8	346.6	179.5	38.5	3.1	4.0	1.6	7.2
	9	297.6	155.3	33.8	3.8	5.2	2.2	9.0
	10	255.7	134.7	29.5	4.5	6.3	2.5	10.8
	11	220.1	117.3	25.9	5.3	7.5	2.8	12.7
	12	189.8	102.7	23.0	6.1	8.8	3.2	14.8
	13	164.2	90.4	20.6	7.1	10.1	3.6	17.2
	14	142.5	80.3	18.6	8.1	11.7	4.2	19.8
	15	124.4	72.0	17.1	9.5	13.3	4.7	22.8
	16	109.3	65.4	16.0	11.0	15.1	5.4	26.1
	17	96.7	60.2	15.2	12.6	17.2	6.2	29.8
	18	86.3	56.4	14.7	14.4	19.6	7.0	34.0
	19	78.0	53.8	14.6	16.5	22.3	8.0	38.8
	20	71.4	52.3	14.7	18.8	25.4	9.1	44.2
	21	66.4	51.9	15.2	21.4	28.9	10.3	50.4
	22	62.7	52.2	15.6	24.3	32.5	11.4	56.8
	23	60.1	52.9	16.0	27.2	36.1	12.4	63.3
	24	58.2	53.9	16.3	30.1	39.6	13.3	69.7
	25	57.1	55.3	16.8	33.0	43.0	14.2	76.0
	26	56.5	56.7	17.2	35.9	46.2	15.0	82.1
	27	56.5	58.3	17.8	38.9	49.3	15.9	88.3
	28	57.0	60.0	18.4	42.0	52.3	16.7	94.3
	29	57.9	61.8	19.0	45.0	55.2	17.6	100.2
	30	59.0	63.7	19.6	48.0	58.1	18.4	106.1
	31	60.3	65.7	20.2	50.9	60.9	19.2	111.8
	32	61.8	67.8	20.8	53.7	63.7	20.0	117.5
	33	63.4	70.0	21.5	56.5	66.5	20.8	123.0
	34	65.2	72.3	22.2	59.3	69.3	21.6	128.6
	35	67.1	74.6	22.9	62.1	72.1	22.4	134.1
	36	69.2	77.1	23.7	64.9	74.9	23.2	139.7
	37	71.3	79.6	24.5	67.7	77.7	24.1	145.4

Table F1. Number of Hawaiian petrel individuals projected per year and differences between no predation and predation scenarios, based on 600 pairs of breeding adults in the existing colony at year 0, and high predation level in the existing colony.

					# Greater than Baseline Scenario			
Scenario	Year	Adults	Juveniles	Fledglings	Adults	Juveniles	Fledglings	Total
Reasonable	38	73.6	82.3	25.3	70.5	80.7	25.0	151.1
	39	76.0	85.1	26.2	73.3	83.7	25.9	157.0
	40	78.5	87.9	27.1	76.1	86.8	26.8	162.9
	41	81.0	90.9	28.0	79.0	89.9	27.8	168.9
	42	83.7	94.0	29.0	82.0	93.1	28.8	175.1
	43	86.5	97.2	29.9	85.0	96.4	29.8	181.5
	44	89.3	100.5	30.9	88.1	99.8	30.8	187.9
	45	92.3	103.9	32.0	91.2	103.3	31.9	194.5
	46	95.3	107.4	33.0	94.4	106.9	33.0	201.3
	47	98.4	111.0	34.1	97.7	110.6	34.1	208.2
	48	101.6	114.7	35.3	101.0	114.3	35.2	215.3
	49	104.9	118.5	36.4	104.4	118.2	36.4	222.5
	50	108.3	122.4	37.6	107.8	122.1	37.6	229.9

Appendix 25

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ADDENDUM 4: NEWELL'S SHEARWATER POPULATION MODELING – GROWTH OF MITIGATION COLONY AT MAKAMAKA'OLE, WEST MAUI AND GROWTH IN A POSSIBLE PROJECT IN EAST MAUI

FINAL

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04 October 2011 Project No. 2936-03

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BACKGROUND

Recently, we developed several documents detailing the population modeling for Newell's shearwater on Maui with respect to estimating mitigation for take at KWP I and II (HTH and PRBO 2011a, b, c, d). This addendum was written to focus and revise results from the modeling in Addendums 2 and 3 in response to requests from the United States Fish and Wildlife Service (USFWS) for clarity on how the proposed mitigation would meet their defined take levels. The background on the social attraction option and rationale for why we think this would be an effective approach is presented in HTH and PRBO (2011c, d). In this document, we focus on specific model input values and rationale for these values, both for the existing conditions, "full predation scenario" (i.e., what was formerly known as "baseline scenario"), and for conditions that will exist upon initiation of mitigation, "mitigation scenario" (i.e., formerly known as "reasonable starting point" scenario). The full predation scenario considers what happens in the existing colony, and the mitigation scenario considers what happens in both the mitigation colony and the existing colony once the mitigation is implemented. The terminology has been changed to reduce confusion over concepts as used by USFWS. In this document, we use the term "baseline take" to refer to the lower of two take levels defined by USFWS; to avoid confusion with the term "baseline scenario", which in previous addenda referred to current conditions during modeling, we now use the term "full predation scenario" instead.

In other species of procellarids observed in New Zealand, the rate of increase in colony size in both translocation and social attraction scenarios appears to be somewhat rapid, once breeding begins. "Somewhat rapid" is a relative term, acknowledging that the life-history strategies of procellarids, being K-selected, do not allow for the sort of increase one could expect from, for example, game birds, which can breed at one year of age and tend to lay relatively large numbers of eggs. The proposed project is one of social attraction only, but with respect to translocations of fluttering shearwater and common diving petrel, Bell et al. (2005) and Miskelly and Taylor (2004) observed that the increase in the number of breeding pairs from year 6 to year 10 was rapid; in social attraction experiments of fluttering shearwaters, similar patterns occurred, except that by borrowing pre-breeders from the existing population, initial breeding started sooner in the new colony (Steve Sawyer, pers. comm.). After the relatively rapid initial increase in breeding pairs as a result of immigration, it would be expected that growth rate would eventually decrease, with the population becoming self-sustaining without lots of new immigrants. However, the New Zealand experiments have not yet lasted long enough to observe a self-sustaining population. We assumed a rate of social attraction of immigrants based on Bell et al. (2005), who in the early years of their experiment documented 8 of 40 adults caught at the translocation colony site as immigrants, or 20%. We believe this to be a conservative value, as other studies such as Miskelly and Taylor (2004) suggest that over half of a socially attracted colony could consist of immigrants within the first several years of re-establishment. Initially, a social attraction colony, without translocation, would be composed entirely of immigrants. Finally, we assumed that the transition from social attraction to a self-sustaining colony occurs at 25 breeding pairs.

For simplicity of the modeling, we assume a fraction of the total population breeds based on the stable age structure resulting from the full predation scenario. We also assumed an initial population of 40 pairs of adults in the existing colony in the vicinity of Makamaka'ole; this was a minimum estimate based on several bits of information. 1) The Cooper and Day (2003) radar survey from 6 locations around west Maui in 2001 detected just 51 seabird targets/hr (for first 3 hrs of the night = 153 detections); almost all the detections were in the portion of west Maui that contains Makamaka'ole. Based on time of night (well after sundown), these authors thought that an average 30% were Newell's shearwaters, or ~45 Newell's shearwaters per night. Subsequently it has been found that Hawaiian petrels come ashore throughout the night and, thus, this Newell's shearwater estimate is overly generous; thus, we decreased the Newell's estimate a further 20% to ~35 Newell's per night visiting west Maui. 2) The usual traffic of calling Newell's shearwater up slope through the Makamaka'ole Valley is 1-3 per night (high count 13) during the last few years. 3) A survey of Kahakuloa by G. Spencer in 2007 detected calls of 20-30 birds, but a survey in 2011 of the same area detected none. Finally, 4) based on studies on Kauai (B. Zaun, pers.comm.), it is known that one member of each Newell's pair visits its chick each night. Therefore, the number of burrows is equivalent to the number of birds flying inland in the early evening, less than 100, but at least 40 for west Maui.

The full predation scenario is justified for current conditions in the existing colony. Any ground and burrow nesting birds in west Maui would be and have been subject to intense predation by cats, mongoose and rats. During work at Makamaka'ole in July-Aug 2011, 11 mongoose were trapped in 12 days using two traps; only predated carcasses of Hawaiian petrels and deserted burrows thus far have been found in the lower Makamaka'ole area (First Wind, unpubl. data). According to the NARS management plan (NARS 1989), mongoose tracks have been found on the Puu Kiki Trail well above Makamaka'ole (2980 ft and higher), and rat sign to as high as 4200 ft on west Maui (more or less the summit). Cats and rats occur at the summit of Haleakala (10,029 ft) and mongoose at high altitude as well; thus, there is reason to believe that these predators are likely widespread on west Maui, whose altitude is half that of Haleakala.

In order to determine the net benefit of the mitigation, in comparison to estimated take at KWP I and II, we evaluated trends in the overall population. We compared the mitigation scenario, which includes both the migitation colony and the existing colony acting synergistically, to a full predation scenario that only includes the existing colony.

For the mitigation colony (mitigation scenario only), adult and juvenile survival for the mitigation colony were the same as those defined in previous addenda for scenarios with no predation (HTH and PRBO 2011a,b), with the exception of age 0 survival, which was increased due to changes in our perception of potential fallout mortality. Previously, we had modeled low fallout mortality for all scenarios, however, based on recently available data from the Maui SOS program, it appears that the effect of fallout on Newell's shearwater is negligible given so few Newell's shearwaters are found by the program (see HTH and PRBO 2011c). Therefore, we assumed no fallout mortality for the scenarios modeled in this addendum, increasing age 0 survival to 0.654 (stable population value, as described in Griesemer and Holmes 2010). We also used the maximum adult survival rate that has been determined for the closely related Manx shearwater, 0.93 (Schreiber and Burger 2001).

Fecundity rates in the mitigation colony were primarily based on Griesemer and Holmes (2010), with some important adjustments to account for social attraction. Breeding probability for the mitigation colony was 0.5 for ages 6 years and older, and assumed to be half as much for ages 3, 4, and 5 years. Although we assumed an average age at first breeding to be 6 years (Ainley et al. 2001), it is possible for shearwaters to begin breeding as early as age 3 (e.g., for Manx Shearwater, see Brooke 1990). Although ages 3, 4 and 5 year birds can sometimes breed, we assumed that their reproductive capability is much reduced, both in terms of breeding probability and reproductive success. For ages 6 years and older, we assumed a reproductive success of 0.4 for years 2 – 5 (i.e., the first four years of breeding) based on a slight reduction from the full predation scenario (which was 0.45), a medium level of reproductive success (0.55) for years 6 and 7, and a maximum of 0.70 (Griesemer and Holmes 2010) for years 8 and above. Rates were based on previously defined scenarios assuming varying levels of predation (HTH and PRBO 2011a,b), as well as information from the very well studied Manx shearwater (Brooke 1990). Such a gradual increase in success is consistent with increased proficiency as seabirds gain experience, and as seen for fluttering shearwater (Bell et al. 2005) and Manx shearwater (Brooke 1990). For ages 3, 4, and 5 years, we scaled the reproductive rates downwards, based on a ratio calculated using optimal observed reproductive success of ages 4 and 5 years (0.50, for fluttering shearwater, Bell et al. 2005) and ages 6 years and older (0.70, based on Griesemer and Holmes 2010).

We assumed 2 breeding pairs to start, as an initial value for the number of breeders at the first breeding occasion. This was consistent with what was found for fluttering shearwaters and common diving petrels in their first year of breeding at a new colony, following social attraction.

Table 7. Parameter values used in the population model, existing colony (full predation and mitigation scenarios) and mitigation colony (mitigation scenario only), for Newell's shearwater at Makamaka'ole.

Parameter	Value		Source
	Existing colony	Mitigation colony	
Survival			
Annual age 0 survival	0.654	Same	Greisemer and Holmes (2010)
Annual age 1 survival	0.780	Same	Greisemer and Holmes (2010)
Annual age 2 survival	0.815	0.890	Greisemer and Holmes (2010), high predation; Greisemer and Holmes (2010), no predation
Annual age 3 survival	0.830	0.905	Greisemer and Holmes (2010), high predation; Greisemer and Holmes (2010), no predation
Annual age 4 and 5 survival	0.770	0.920	Ainley et al. (2001), Griesemer and Holmes (2010); assumed same survival as for ages 6 and older under no predation
Annual adult (>=6) survival	0.877	0.930	Ainley et al. (1995), Griesemer and Holmes (2010), high predation; Schreiber and Burger (2001), Manx shearwater
Fecundity			
Breeding probability (3, 4, 5)	0.25	0.4	Assumed to be half of breeding probability for ages 6 years and older
Breeding probability (>=6)	0.5	0.8	Griesemer and Holmes (2010), high predation; Griesemer and Holmes (2010), no predation
Reproductive success (3, 4, 5)	0.21	0.29, 0.39, 0.50	Calculated based on ratio of estimate of 0.5 for ages 4, 5 from Bell et al. 2005 to the estimate of 0.7 based on Griesemer and Holmes (2010); Bell et al. (2005), gradual increase from year 2 to 8 (see HTH and PRBO 2011c)
Reproductive success (>=6)	0.30	0.4, 0.55, 0.70	Griesemer and Holmes (2010), high predation; Griesemer and Holmes (2010), low predation, gradual increase from year 2 to 8 (see HTH and PRBO 2011c)
Sex ratio	1:1	Same	Nur and Sydeman 1999
Average age at first breeding	6	Same	Ainley et al. 2001
Maximum breeding age	36	Same	Ainley et al. 2001

The existing colony was modeled for both the full predation and mitigation scenarios. For each scenario, we modeled the existing colony, assuming no fallout mortality and no powerline strike mortality but full predation (see HTH and PRBO 2011c for explanation). Model input values for survival and fecundity were based primarily on values from Griesemer and Holmes (2010) for a high predation level, but included some important adjustments (described below).

Breeding probability for the full predation scenario was the same as that from Griesemer and Holmes (2010) for a high predation level, and were averages given the absence of actual age-specific data; assuming a high predation level, the reduction from a stable population with breeding probability of 0.80 (used by Ainley et al. 2001 for their stable population model) was assumed to be -0.30, resulting in a breeding probability of 0.50. We assumed that the breeding probability of ages 3, 4, and 5 years would be half the value (0.25) of age 6 years and older. Griesemer and Holmes (2010) noted that their assumed reductions in breeding probability due to medium (-0.20) and high (-0.30) predation levels resulted in a breeding probability that was similar to the observed breeding probability in a population experiencing moderate predation (0.55 breeding probability, from Ainley et al. (2001)). Reproductive success was adjusted by the same reduction used in Griesemer and Holmes (2010) for their high predation model, -0.4, but the stable population value of 0.7 based on Ainley et al. (2001) was used instead (see HTH and PRBO 2011a for detail), resulting in reproductive success of 0.3. For ages 3, 4, and 5 years, we scaled the reproductive rates down from 0.30 to 0.21, based on a ratio calculated using optimal observed reproductive success of ages 4 and 5 years (0.50, for fluttering shearwater, Bell et al. 2005) and ages 6 years and older (0.70, based on Griesemer and Holmes 2010).

Parameterization of survival rates for the full predation scenario was based on information for fledgling to adult survival from Ainley et al. (2001) and annual adult survival rates from Griesemer and Holmes (2010). We used the same survival rates for ages 0, 1, and 2 years as Griesemer and Holmes (2010) for their high predation, no fallout mortality model; however, the survival rates for ages 3, 4, 5 and 6+ differed.

Survival rates for the full predation scenario for ages 0 through 2 years were based on values identified by Griesemer and Holmes (2010) for a population experiencing high predation, without powerline or fallout mortality (see HTH and PRBO 2011b for further detail). Griesemer and Holmes (2010) assumed that the survival rates for ages 0 and 1 were the same as those from a stable population, 0.654 and 0.780, respectively, and would remain unchanged under various predation levels. The survival rate for age 2 years was based on reductions from a stable population (survival rate of 0.89) based on Griesemer and Holmes (2010). The stable population survival rate was adjusted by -0.075 for a high predation level, resulting in a survival rate of 0.815 for age 2 years.

The calculation of survival rates for ages 3, 4, and 5 years at the high predation level followed the approach used by Ainley et al. (2001), as described in HTH and PRBO (2011a). We used the reduction for high predation based on Griesemer and Holmes (2010), -0.15, but assumed a stable population value of 0.92 based on Griesemer and

Holmes (2010), resulting in a survival rate of 0.77. These age classes would dominate those birds that are prospecting for new nest sites and for mates. They would be even more vulnerable to ground predators than nest-holding adults, which don't spend much time at all on the surface; adults typically arrive on a given night and immediately disappear into their cavities rather than scampering around, rustling the vegetation, and attempting to dig beneath roots and rocks.

The calculation of survival rate for ages 6 years and older for the high predation level followed the approach as described by HTH and PRBO (2011a), adjusting survival rate based on the observed predation rate from Ainley et al. (1995). Their data indicate that predation rates could be as high as 0.05 (based on observed mortality of age 2+ years) and even higher in some years. We made an adjustment to the stable population value based on a reduction in survival commensurate with an assumed 0.05 predation mortality; we reduced the stable population value of survival from Griesemer and Holmes (2010) (0.92) by 0.043 to obtain a survival rate of 0.877 for ages 6 years and older.

POPULATION PROJECTION: ACHIEVING MITIGATION TARGETS

Population projections showed that the mitigation scenario would make steady progress towards reaching mitigation targets for the baseline take level (Table 8, Figure 19, Appendix F). This was calculated by comparing the decreasing trend of the existing colony under the full predation scenario to the combined effect of the decreasing fate of the existing colony in conjunction with the increasing trend of the mitigation colony under the mitigation scenario, as shown in Figure 19. USFWS defined the baseline take level to be 4 adults and 4 fledglings; the "high take level" was defined to be 10 adults and 6 fledglings. Net recovery would be reached during the 20 year license period (i.e., at least 1 individual above the baseline take level of 8 individuals, at least 4 of which are adults, and assuming that the permitted take is actually realized and requiring mitigation), by year 16 (Table 8). The mitigation target for adults would be reached in year 13. For fledglings, the mitigation target would not be reached (4 fledglings), however 90% of baseline take would be met by the end of the license period. However, mitigation accelerates with time, and the baseline take would be met by year 23 for fledglings (Table 8).

The mitigation scenario would also make progress towards the high take level. The high take level was defined by USFWS as 10 adults and 6 fledglings, and reflects a worst case that is beyond what is expected. For both adults and fledglings, the mitigation scenario would provide 93% and 60% of required adults and fledglings, respectively, by year 20 (Table 8). A net recovery benefit would be reached shortly after the license period ends (again, because mitigation accelerates), by year 26 (Table 8). The mitigation targets would be reached by year 22 for adults, and year 35 for fledglings (Table 8).

Table 8. Primary results of population modeling for the mitigation scenario of Newell's shearwater at Makamaka'ole with respect to baseline and high take levels. Baseline take level was defined by USFWS to be 4 adults and 4 fledglings; high take level was defined to be 10 adults and 6 fledglings.

Life stage	Additional burrows by year 20	Take level	Year mitigation target reached	% of mitigation target in year 20
Adult	5	Baseline (4)	Year 13	>100%
		High (10)	Year 22	93%
Fledgling	na	Baseline (4)	Year 23	90%
		High (6)	Year 35	60%
Adult + Fledgling	na	Baseline (≥9, ≥4 adults)	Year 16	>100%
		High (≥17, ≥10 adults)	Year 26	76%

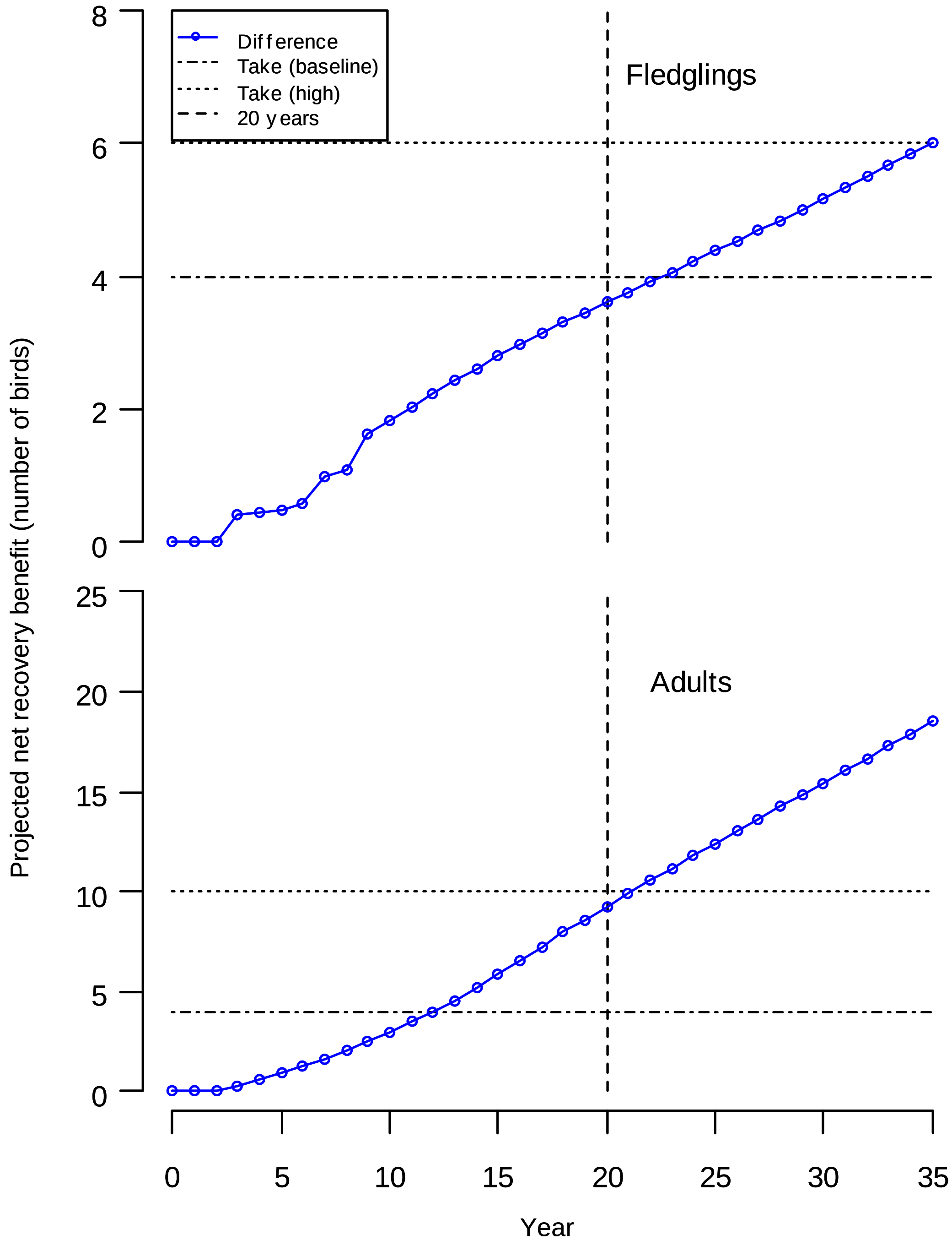

Figure 19. Difference between full predation scenario (existing colony) and mitigation scenario (mitigation and existing colony combined) for Newell's shearwater breeding adults and fledglings, Makamaka'ole, assuming that the social attraction mitigation project is implemented. Vertical line indicates the end of the 20-year license period.

We also evaluated a potential alternative project in East Maui that would be very similar to the proposed project in west Maui, with complete predator exclusion. The potential site could be located, within flyways, along Koolau Gap on state and The Nature Conservancy land, or another area east of the Park, also on state land. This project would only be triggered if the social attraction at Makamaka'ole, west Maui, is not successful owing to too few birds to attract to the area and the project falls short for the mitigation requirements. From Cooper and Day (2003), our calculations indicate that combined Newell's shearwater and Hawaiian Petrel movement rate over Kaenae (below Koolau Gap) would be less than Kahakuloa (near Makamaka'ole): ~6.7 birds/h. This is determined as follows: Cooper and Day (2003) report Newell's shearwaters to be 5% of targets at Kaenae, so 0.05*134=6.7 birds/h. From this, only 20% of these are likely to be Newell's shearwater, so 1.3 birds/h * 3h (the length of the Cooper and Day (2003) survey period each night, i.e., when most birds would have flown inland) = 4 birds per night flying inland; an estimate of breeding pairs would then be <100 but perhaps 40, assuming a two week period. Therefore, it appears that the situation there would be somewhat similar to that at Makamaka'ole, although likely worse, as the Koolau Gap Newell's shearwater location (vocalizations heard a few years ago) had no evidence of Newell's shearwater this past year. Results for the modeling were the same as for west Maui, given an assumed initial population of 40 breeding pairs (Figure 20).

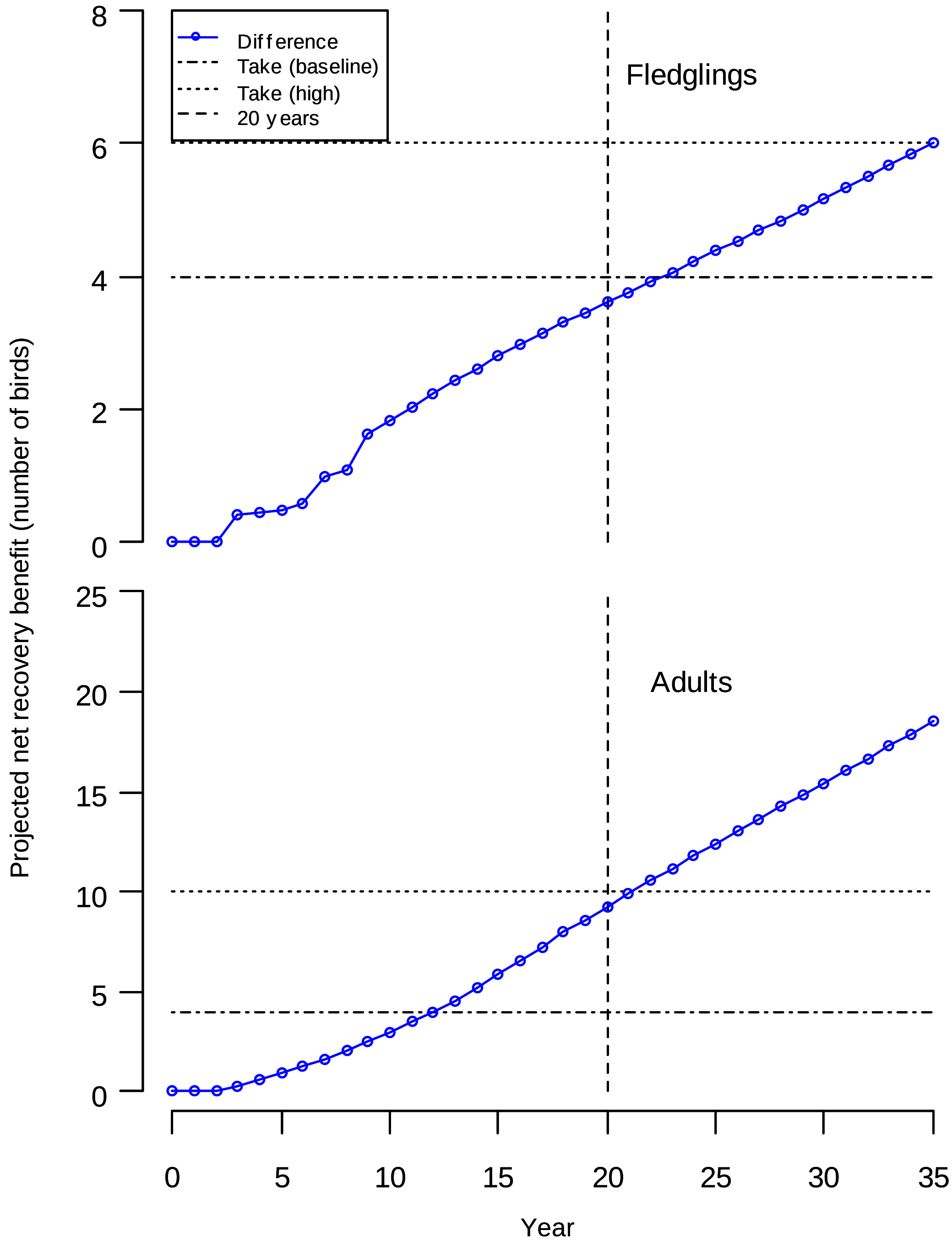

Figure 20. Difference between full predation scenario (existing colony) and mitigation scenario (mitigation and existing colony combined) for Newell's shearwater breeding adults and fledglings, east Maui, assuming that the social attraction mitigation project is implemented. Vertical line indicates the end of the 20-year license period.

Predator-free burrows, including 50 artificial ones, would be provided under the mitigation scenario, compared to the full predation scenario, where predation would remain rampant in the existing colony. Under the mitigation scenario, at year 20, there would be 6 active burrows at the mitigation colony and only 2 active burrows remaining at the existing colony (results not shown). By year 20, there would be over twice as many active burrows (8 active burrows overall in both the existing and mitigation colonies) compared to the full predation scenario, in which there would be no mitigation (3 active burrows at the existing colony).

EXTINCTION OF THE EXISTING COLONY AS THE MITIGATION COLONY GROWS

The projected number of birds for the existing colony without mitigation (i.e., full predation scenario) shows a rapidly decreasing trend with time (Figure 21). Both scenarios lead to extinction (defined as <10 breeding pairs), although the modeling results show that adding mitigation (i.e., mitigation scenario, social attraction to a predator free colony), despite an initially decreasing trend, could eventually reverse the decreasing trend for the population as a whole by year 22, if the population does not lose all its members before that (Figure 21). The designation of 10 breeding pairs as on the verge of extinction is somewhat arbitrary, though we believe that a population this small would certainly be vulnerable to any stochastic processes that lead to decreased survival or reproductive success, and could result in a loss of all the individuals from the population. For the existing colony without mitigation, the trend leads to extinction by year 11 (Figure 21), with fewer than 2 adults by year 29. In contrast, under the mitigation scenario, the population decreases to 15 adults before the decreasing trend reverses, and the population, assuming stochastic factors don’t completely eliminate it, exceeds 20 adults by year 37.

Within the mitigation colony itself, the trend is clearly an increasing one, with a stronger rate of increase beginning in about year 5 (Figure 22). By year 20, we would expect 6 nesting pairs of adults in the mitigation colony, and by year 50, 14 nesting pairs of adults.

A major caveat to the modeling is that uncertainty in model parameter values may also add to the uncertainty regarding risk of extinction. For instance, under the given values for the full predation scenario for Newell’s shearwater, the population has been modeled to decrease at a rate that is slightly slower than that for Hawaiian petrel. However observations seem to indicate that Newell’s shearwater is actually declining more quickly than Hawaiian petrel on west Maui. Less is known about the population parameters for Newell’s shearwater, and therefore the population projections based on these values are also less certain.

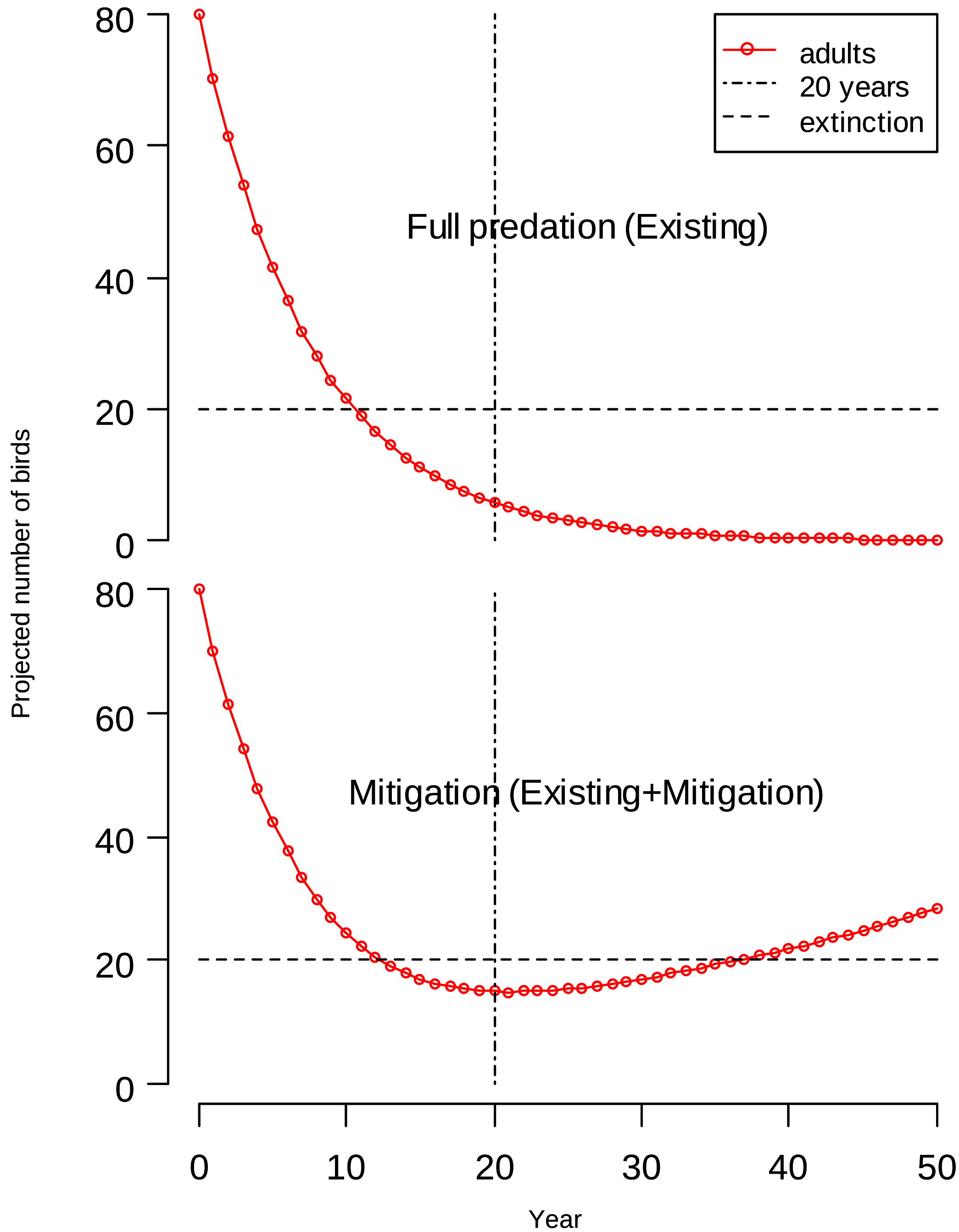

Figure 21. Projected number of Newell's shearwaters, by life stage, for the overall population under full predation (no mitigation) and mitigation (no predation) scenarios, Makamaka'ole, West Maui. Vertical line indicates the end of the 20-year license period, and the horizontal line indicates the threshold for extinction (10 breeding pairs), which is only reached under full predation.

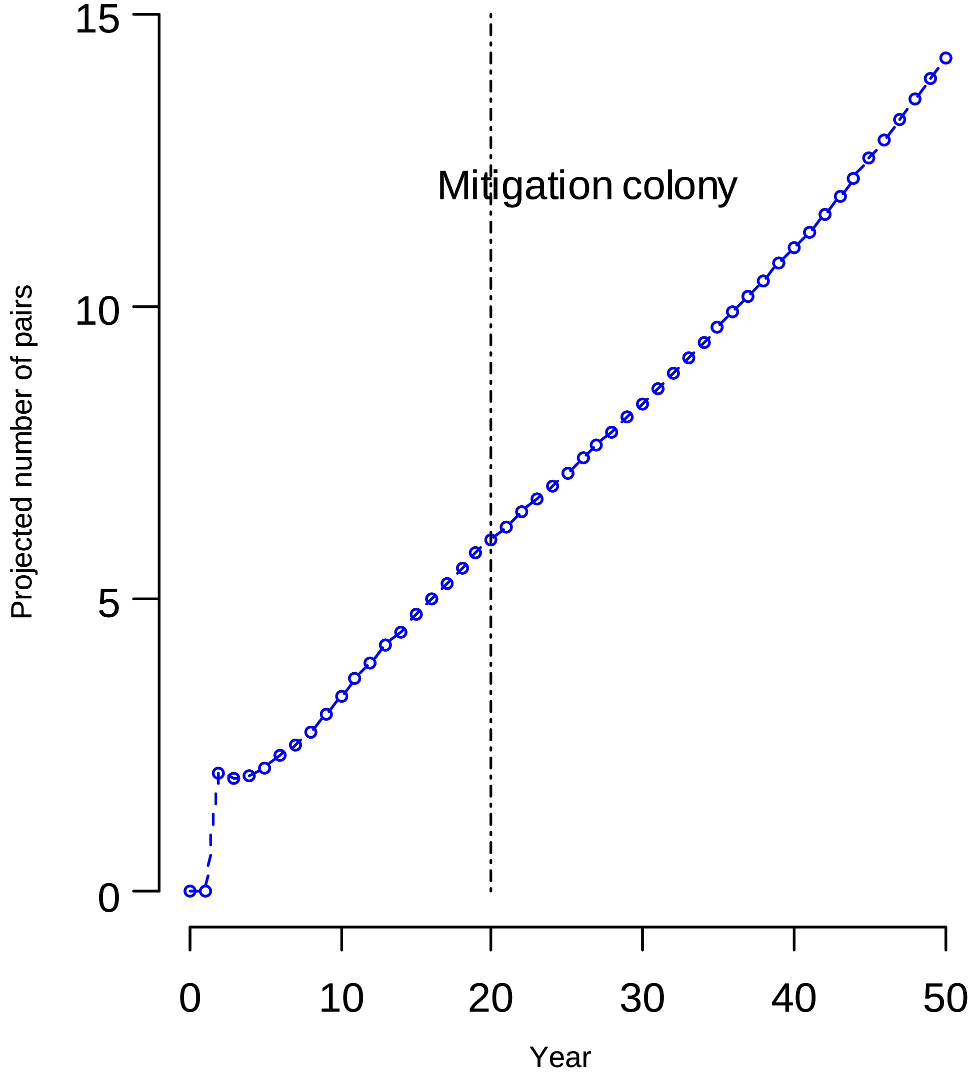

Figure 22. Projected number of Newell's shearwater adults for mitigation colony (social attraction), Makamaka'ole, West Maui. Vertical line indicates the end of the 20-year license period.

CONCLUSION

This addendum presents a more concise version of the modeling results for the purpose of evaluation by USFWS than what was contained in previous modeling efforts for Newell's shearwater. We still agree with the conclusions from the previous addenda (HTH and PRBO 2011c, d). As was stated in Addenda 2 and 3 (HTH and PRBO 2011c, d), we believe that the social attraction mitigation provides a viable way by which to meet mitigation targets within a reasonable timeframe. Model results suggest that substantial progress can be made toward take levels, with the baseline level of take for adults being met within the 20-year license period, and within a few years of the 20-year license period for fledglings under the proposed mitigation.

Most importantly, our modeling efforts suggest that under the current conditions, the west Maui population may become extinct within the timeframe of the license period, especially if this project is not undertaken in the very immediate future. Modeling results from the social attraction option, and the experience with similar projects in New Zealand, show that it may be possible to reverse the trend, if this option is implemented soon. Some additional recovery efforts should also be made to decrease the risk of complete loss of all individuals due to stochastic events.

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APPENDIX F.
POPULATION MODELING RESULTS OF NEWELL'S SHEARWATER PETREL AT A POTENTIAL MITIGATION SITE, MAKAMAKA'OLE (WEST MAUI) – SOCIAL ATTRACTION

Table F1. Number of Newell's shearwater individuals projected per year and differences between mitigation and full predation scenarios, based on 40 nesting pairs in the existing colony and high predation level in existing colony.

					# Greater than Baseline Scenario			
Scenario	Year	Adults	Juveniles	Fledglings	Adults	Juveniles	Fledglings	Total
Baseline	0	80.0	24.9	6.2				
	1	70.2	21.9	5.4				
	2	61.5	19.2	4.7				
	3	53.9	16.8	4.2				
	4	47.3	14.7	3.6				
	5	41.5	12.9	3.2				
	6	36.4	11.3	2.8				
	7	31.9	9.9	2.5				
	8	28.0	8.7	2.2				
	9	24.5	7.6	1.9				
	10	21.5	6.7	1.7				
	11	18.9	5.9	1.5				
	12	16.5	5.2	1.3				
	13	14.5	4.5	1.1				
	14	12.7	4.0	1.0				
	15	11.1	3.5	0.9				
	16	9.8	3.0	0.8				
	17	8.6	2.7	0.7				
	18	7.5	2.3	0.6				
	19	6.6	2.1	0.5				
	20	5.8	1.8	0.4				
	21	5.1	1.6	0.4				
	22	4.4	1.4	0.3				
	23	3.9	1.2	0.3				
	24	3.4	1.1	0.3				
	25	3.0	0.9	0.2				
	26	2.6	0.8	0.2				
	27	2.3	0.7	0.2				
	28	2.0	0.6	0.2				
	29	1.8	0.6	0.1				
	30	1.6	0.5	0.1				
	31	1.4	0.4	0.1				
	32	1.2	0.4	0.1				
	33	1.0	0.3	0.1				
	34	0.9	0.3	0.1				
	35	0.8	0.3	0.1				
	36	0.7	0.2	0.1				
	37	0.6	0.2	0.0				
	38	0.5	0.2	0.0				
	39	0.5	0.1	0.0				
	40	0.4	0.1	0.0				
	41	0.4	0.1	0.0				
	42	0.3	0.1	0.0				
	43	0.3	0.1	0.0				
	44	0.2	0.1	0.0				

Table F1. Number of Newell's shearwater individuals projected per year and differences between mitigation and full predation scenarios, based on 40 nesting pairs in the existing colony and high predation level in existing colony.

					# Greater than Baseline Scenario			
Scenario	Year	Adults	Juveniles	Fledglings	Adults	Juveniles	Fledglings	Total
Baseline	45	0.2	0.1	0.0				
	46	0.2	0.1	0.0				
	47	0.2	0.1	0.0				
	48	0.1	0.0	0.0				
	49	0.1	0.0	0.0				
	50	0.1	0.0	0.0				
Reasonable	0	80.0	24.9	6.2	0.0	0.0	0.0	0.0
	1	70.2	21.9	5.4	0.0	0.0	0.0	0.0
	2	61.5	19.2	4.7	0.0	0.0	0.0	0.0
	3	54.2	17.4	4.6	0.3	0.6	0.4	0.8
	4	47.8	15.7	4.1	0.5	1.0	0.4	1.5
	5	42.4	14.3	3.7	0.9	1.3	0.5	2.2
	6	37.6	13.0	3.4	1.3	1.6	0.6	2.9
	7	33.5	12.3	3.4	1.6	2.3	1.0	4.0
	8	30.0	11.7	3.2	2.0	3.0	1.1	4.9
	9	27.0	11.5	3.5	2.5	3.9	1.6	6.4
	10	24.5	11.5	3.5	3.0	4.8	1.8	7.7
	11	22.3	11.5	3.5	3.5	5.7	2.0	9.1
	12	20.5	11.7	3.5	4.0	6.6	2.2	10.5
	13	19.1	11.9	3.5	4.6	7.4	2.4	11.9
	14	17.9	12.1	3.6	5.1	8.1	2.6	13.3
	15	17.0	12.2	3.7	5.9	8.8	2.8	14.6
	16	16.3	12.4	3.7	6.6	9.4	3.0	15.9
	17	15.8	12.6	3.8	7.3	9.9	3.1	17.2
	18	15.5	12.8	3.9	7.9	10.5	3.3	18.4
	19	15.2	13.1	4.0	8.6	11.0	3.5	19.6
	20	15.0	13.4	4.1	9.3	11.6	3.6	20.8
	21	15.0	13.7	4.2	9.9	12.1	3.8	22.0
	22	15.0	14.0	4.3	10.5	12.6	3.9	23.1
	23	15.1	14.3	4.4	11.2	13.1	4.1	24.3
	24	15.2	14.7	4.5	11.8	13.6	4.2	25.4
	25	15.4	15.1	4.6	12.4	14.1	4.4	26.5
	26	15.6	15.5	4.7	13.0	14.6	4.5	27.7
	27	15.9	15.9	4.9	13.6	15.2	4.7	28.8
	28	16.3	16.3	5.0	14.2	15.7	4.8	29.9
	29	16.6	16.8	5.1	14.8	16.2	5.0	31.0
	30	17.0	17.2	5.3	15.4	16.7	5.2	32.2
	31	17.4	17.7	5.4	16.1	17.3	5.3	33.3
	32	17.9	18.2	5.6	16.7	17.8	5.5	34.5
	33	18.3	18.7	5.8	17.3	18.4	5.7	35.7
	34	18.8	19.3	5.9	17.9	19.0	5.8	36.9
	35	19.3	19.8	6.1	18.5	19.6	6.0	38.0
	36	19.8	20.4	6.2	19.1	20.1	6.2	39.2
	37	20.3	20.9	6.4	19.7	20.7	6.4	40.4

Table F1. Number of Newell's shearwater individuals projected per year and differences between mitigation and full predation scenarios, based on 40 nesting pairs in the existing colony and high predation level in existing colony.

					# Greater than Baseline Scenario			
Scenario	Year	Adults	Juveniles	Fledglings	Adults	Juveniles	Fledglings	Total
Reasonable	38	20.8	21.5	6.6	20.3	21.3	6.5	41.6
	39	21.4	22.1	6.8	20.9	21.9	6.7	42.8
	40	21.9	22.6	6.9	21.5	22.5	6.9	44.0
	41	22.5	23.2	7.1	22.1	23.1	7.1	45.2
	42	23.1	23.8	7.3	22.8	23.7	7.3	46.5
	43	23.7	24.5	7.5	23.4	24.4	7.5	47.8
	44	24.3	25.1	7.7	24.1	25.0	7.7	49.1
	45	25.0	25.8	7.9	24.7	25.7	7.9	50.4
	46	25.6	26.5	8.1	25.4	26.4	8.1	51.8
	47	26.3	27.1	8.3	26.1	27.1	8.3	53.2
	48	27.0	27.9	8.5	26.8	27.8	8.5	54.6
	49	27.7	28.6	8.8	27.6	28.6	8.7	56.1
	50	28.4	29.3	9.0	28.3	29.3	9.0	57.6

Appendix 26

Triggers and Timelines for Tier 2 Mitigation and Mitigation Contingencies.

Newell’s Shearwater

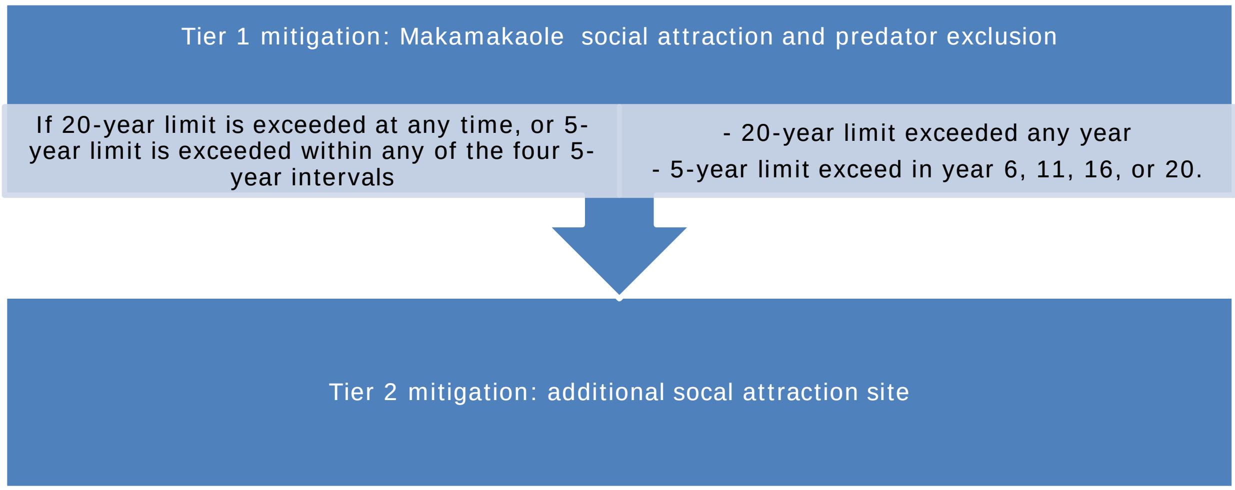

Figure 1: Triggers and timeline for Tier 2 mitigation for Newell's shearwater

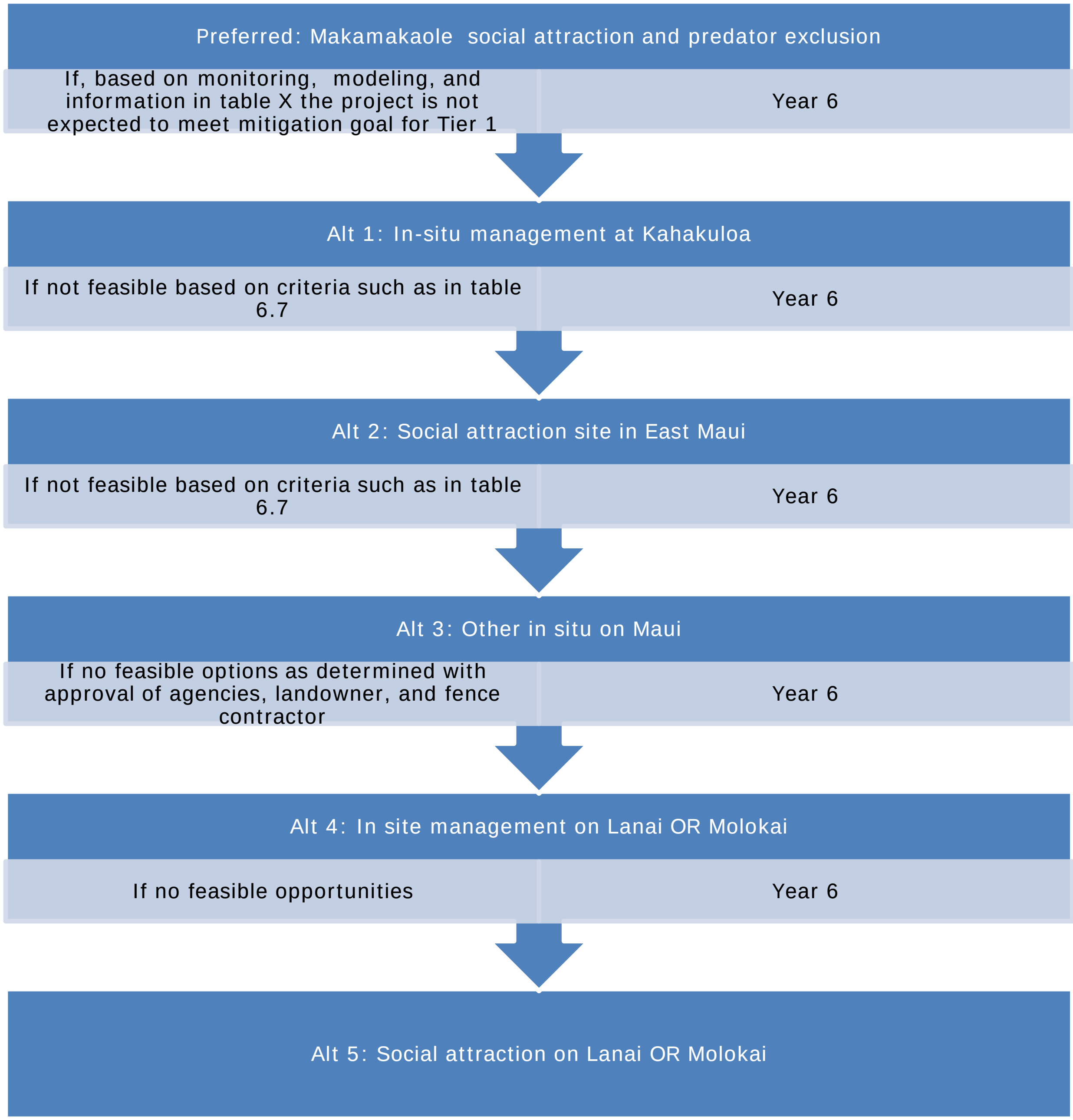

Figure 2: Triggers and timeline for mitigation contingencies for Newell's shearwater

Hawaiian Petrel

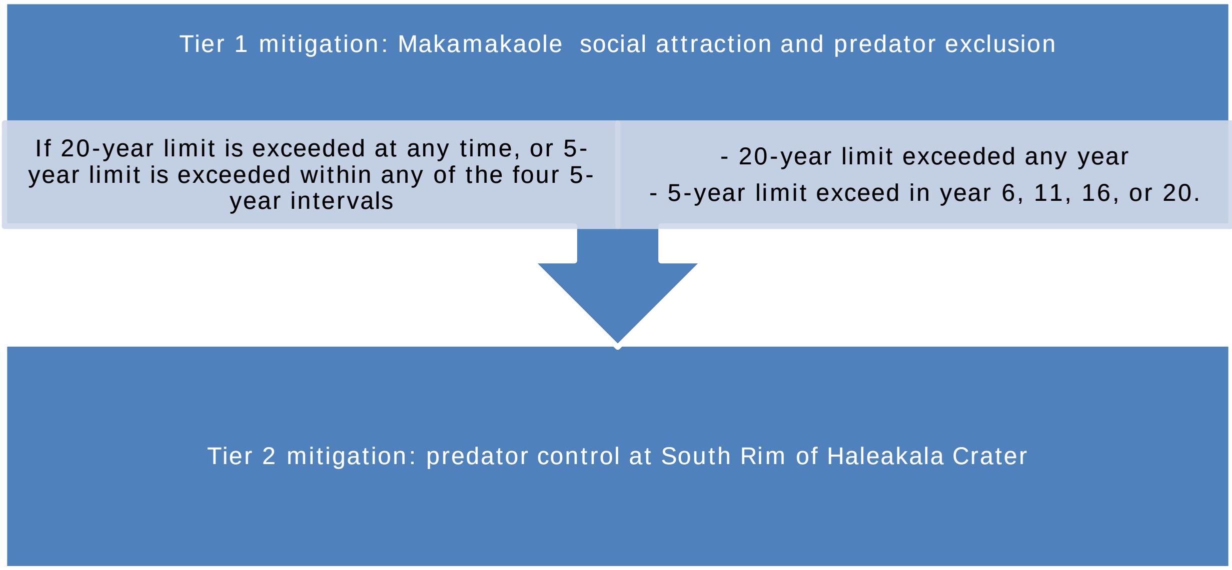

Figure 3: Triggers and timeline for Tier 2 mitigation for Hawaiian petrel

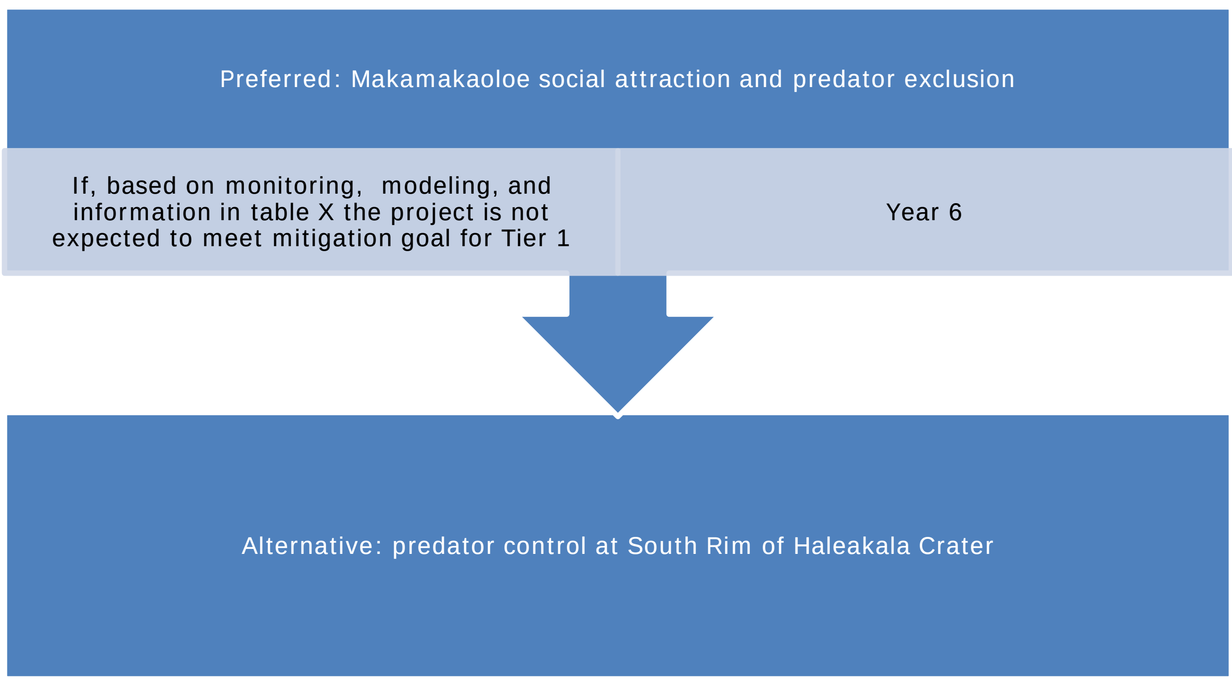

Figure 4: Triggers and timeline for mitigation contingencies for Hawaiian petrel

Nene

Tier 1 mitigation: Funding to DOFAW for release pen and predator management on Molokai for five years, starting 2016

If 20-year limit is exceeded at any time, or 5-year limit is exceeded within any of the four 5-year intervals	- 20-year limit exceeded any year - 5-year limit exceed in year 6, 11, 16, or 20.

Tier 2 mitigation: three year funding to DOFAW for management and predator control at additional release pen

Figure 5: Triggers and timeline for Tier 2 mitigation for nene

Preferred: Funding to DOFAW for release pen and predator management on Molokai for five years, starting 2016

- If DOFAW chooses alternative location for release pen - If management for 5 years does not result in meeting Tier 1 mitigation obligation	2016, or 2021

Alternative: Same as preferred mitigation, but at alternate location.

Or

Additional mitigation at original site, if necessary

Figure 6: Triggers and timeline for mitigation contingencies for nene

Hawaiian Hoary Bat

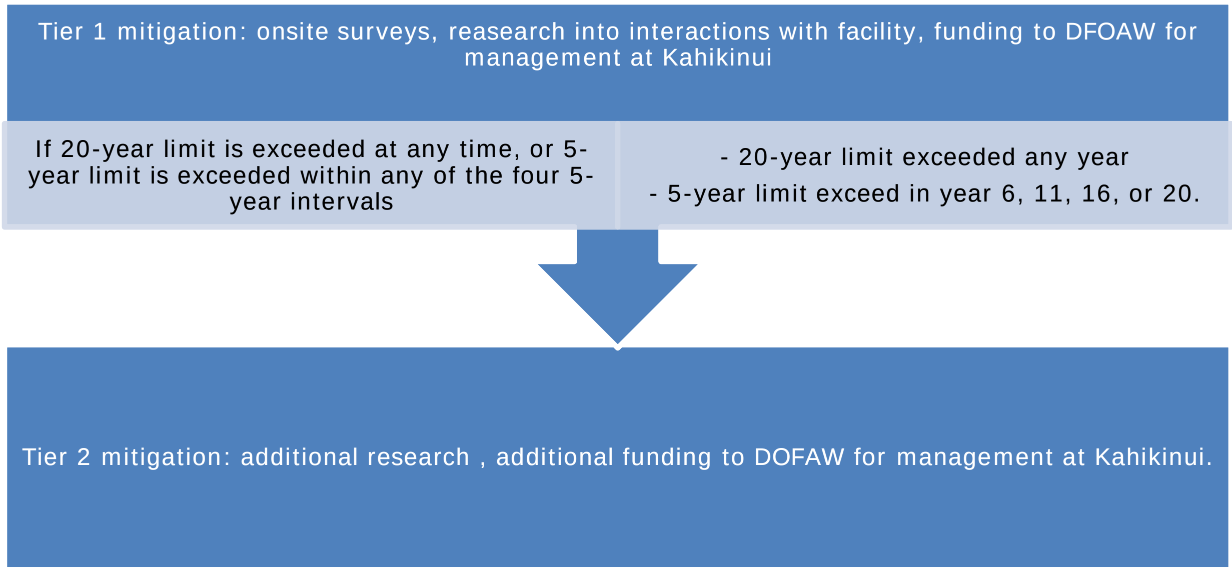

Figure 7: Triggers and timeline for Tier 2 mitigation for Hawaiian hoary bat

Appendix 27

Estimating Fatalities for Nēnē and the Hawaiian Hoary Bat at Kaheawa Wind Power II

<u>Nēnē</u>

Kaheawa Wind Power II (KWP II) estimated total nēnē fatalities from take observed during downed wildlife monitoring and projected an estimate for the 20-year permit period (Table 1) using the Evidenceof Absence (EoA v2.06) software (Huso *et al*. 2015, Dalthorp *et al.* 2017). The actual period during which the turbines have been and will be operating is 19.5 years. Operations began in July 2012 and the permit term ends January 2032. All estimates for the "20-year permit period" are for 19.5 years.

The number of fatalities assumed to be observed for the remaining years of the permit is extrapolated by the EoA software from the actual take observed during six years of monitoring and adjusted for the reduced search area (began July 2015) defined in the long-term reduced monitoring protocol (see Appendix 28).

Biologists' intensive monitoring at KWP II (prior to July 2015) searched the areas around all turbines within circles centered on the WTG having a radius extending to 75m. Based on ballistics modeling Hull and Muir (2010) calculated that approximately 20% of the total fall distribution of large birds (nēnē) found around "small" turbines may fall *beyond* 75m. They considered turbines with a hub height of 65m to be a "small" turbine in their model; 75m and 97m were considered the distances within which 80% and 99%, respectively, of all large birds might fall around a "small" turbine.

Long-term monitoring (Appendix 28) will continue to the end of the permit period at the same reduced search area effort as began in July 2015. The reduced effort at KWP II consists of searching only the roads and graded pads that occur within a 70m radius circle centered on each turbine (Figure 1a and 1b). The portion of all nēnē fatalities from turbine strikes that could fall within the 70m circle is calculated based on the known fall distribution of all observed nēnē take at KWP I and KWP II (Figure 2). The KWP I and KWP II nacelle heights are 68 and 72m, respectively, and the maximum height of the rotor swept zone are 90 and 100m, respectively. Since these heights are similar all the observed nēnē take from both sites has been used in creating the fall distribution. We assume approximately 20% of nēnē may have fallen beyond 70m and therefore were not observed. To create a total fall distribution, we add six more nēnē beyond those observed within 70m: three at 71-80m, two at 81-90m, and one at 91-100m or approximately 20% more than the 30 observed nēnē used in creating the fall distribution. The fall distribution is assumed to be uniform around the turbine.

The area around the turbines within a 70m circle centered on each turbine that is graded road or turbine pads is calculated to include 80.6% of all nēnē carcasses expected to fall from turbine strikes (Figure 2). More birds are expected to and do fall closer to the WTG; the distribution of fatalities is not uniform, becoming less dense per acre as distance increases from the WTG. To determine the density-weighted proportion (DWP) of the total fall distribution, the 70m circle is divided into six circular adjacent bands around the WTG. The first, closest band encompasses the area from the WTG out to 20m radius and each band farther from the WTG has a 10m radius (Table 2). The total area in acres is calculated for each band and summed for all 14 turbines. The proportion of the total area in each band for each turbine that will be searched (roads and pads) is determined using ARCGIS (Table 2) and summed for all 14 turbines. The product of the portion of total area searched per band for all turbines and the expected portion of the total fatality distribution per band are determined for each band and the results summed for all six bands to derive the portion of the entire fall distribution searched across all turbines (Table 2). The reduced search area of roads and pads is estimated to encompass 34.0% of all nēnē fatalities that could occur from turbine strikes (Table 1).

For nēnē at KWP II SEEF is 100% with canine-assisted downed wildlife monitoring and average CARE is usually as long as the 28-day trials. In other words, the search conditions for nēnē at KWP II are nearly perfect, all nēnē falling in the searched area should be found. Therefore, if one nēnē is found in the formal search area we can assume that approximately two nēnē landed beyond the search area and were assumed to have not been found. There may or may not have been two additional nēnē killed but not found but we are assured (with 80% credibility) that no more than two nēnē were killed for everyone found. The actual observed nēnē fatalities found during the three-year intensive monitoring period was three and the actual observed nēnē fatalities found during the three-year reduced monitoring period was two. Since the proportion of the total fall distribution searched during intensive monitoring was 70% and the proportion during reduced searching was 34% we might expect an average of 1.5 nēnē observed during the three years of reduced searching (34%/70% * 3 observed nēnē = 1.46 observed nēnē).

Our estimation projecting take 14 years into the future assumes that the most recent SEEF and CARE values from 2018 continue to be similar for the remainder of the permit term. The SEEF values for nēnē on pads and roads may be higher than the overall SEEF observed during intensive monitoring when grass and shrubs of varying height were more likely to obscure areas searched.

With 80% credibility and five observed nēnē fatalities, no more than 43.0 nēnē would have been directly taken after 19.5 years (the operations period of the permit term of KWPII, Table 1); an average estimated annual direct take rate of 2.205 nēnē/year. If only 50% credibility level is chosen the total estimated direct take for the permit period is 35.8 adult nēnē.

Table 1. Input Parameters and Observed/Projected results for nēnē at KWPII.

Fiscal Year	% Year (*rho*)	Search Interval (*I*)	Carcass Count (*X*)	SEEF (*p*)			Persistence Distribution (CARE)				Spatial Coverage (*a*)	Probability of Detection (*g*)			Probability of Detection Beta Distribution (*B*)		M*
				found	placed	*k*	distribution	scale	95% CI for scale			*g*	min	max	*B*a	*B*b	
2013	1	7	**1**	6	9	1	Exponential	1000	45.9	237000	0.7	0.654	0.503	0.791	26.32	13.91	**3**
2014	1	7	**0**	5	5	1	Exponential	593	27.3	152000	0.7	0.653	0.474	0.812	18.94	10.05	**3**
2015	1	7	**2**	23	28	1	Exponential	1900	86.7	362000	0.7	0.681	0.583	0.771	62.81	29.46	**6**
2016	1	7	**1**	11	11	1	Exponential	844	38.7	207000	0.340	0.327	0.255	0.403	49.59	102.08	**9**
2017	1	7	**0**	12	12	1	Exponential	1280	58.7	434000	0.340	0.33	0.271	0.391	76.79	156.17	**10**
2018Q3	0.75	7	**1**	9	9	1	Exponential	796	36.5	195000	0.340	0.324	0.241	0.413	36.11	75.30	**13**
2018Q4	0.25											0.324	0.241	0.413	36.11	75.30	**13.4**
2019	1											0.324	0.241	0.413	36.11	75.30	**15.8**
2020	1											0.324	0.241	0.413	36.11	75.30	**18.2**
2021	1											0.324	0.241	0.413	36.11	75.30	**20.3**
2022	1											0.324	0.241	0.413	36.11	75.30	**22.6**
2023	1											0.324	0.241	0.413	36.11	75.30	**24.8**
2024	1											0.324	0.241	0.413	36.11	75.30	**26.9**
2025	1											0.324	0.241	0.413	36.11	75.30	**29.2**
2026	1											0.324	0.241	0.413	36.11	75.30	**31.2**
2027	1											0.324	0.241	0.413	36.11	75.30	**33.4**
2028	1											0.324	0.241	0.413	36.11	75.30	**35.5**
2029	1											0.324	0.241	0.413	36.11	75.30	**37.6**
2030	1											0.324	0.241	0.413	36.11	75.30	**39.7**
2031	1											0.324	0.241	0.413	36.11	75.30	**41.9**
Jan 2032	0.5											0.324	0.241	0.413	36.11	75.30	**43.0**

Table 2. Proportion of nēnē Expected to Fall within the Reduced Search Area

Distance Band (m)	Search Area Within Distance Band (m^2)*	Total Area of Distance Band (m^2)*	Proportion of Distance Band Searched (A)	Portion Birds Found Within Distance Band (B)	DWP of Distance Band (A x B)
20	17584	15745.8	0.895	0.139	0.124
30	21980	12284.1	0.559	0.194	0.109
40	30772	9141.1	0.297	0.278	0.083
50	39564	7621.3	0.193	0.056	0.011
60	48356	5914.9	0.122	0.056	0.007
70	57148	4491.8	0.079	0.083	0.007
			Totals	**0.806**	**0.340**

*ARCGIS derived

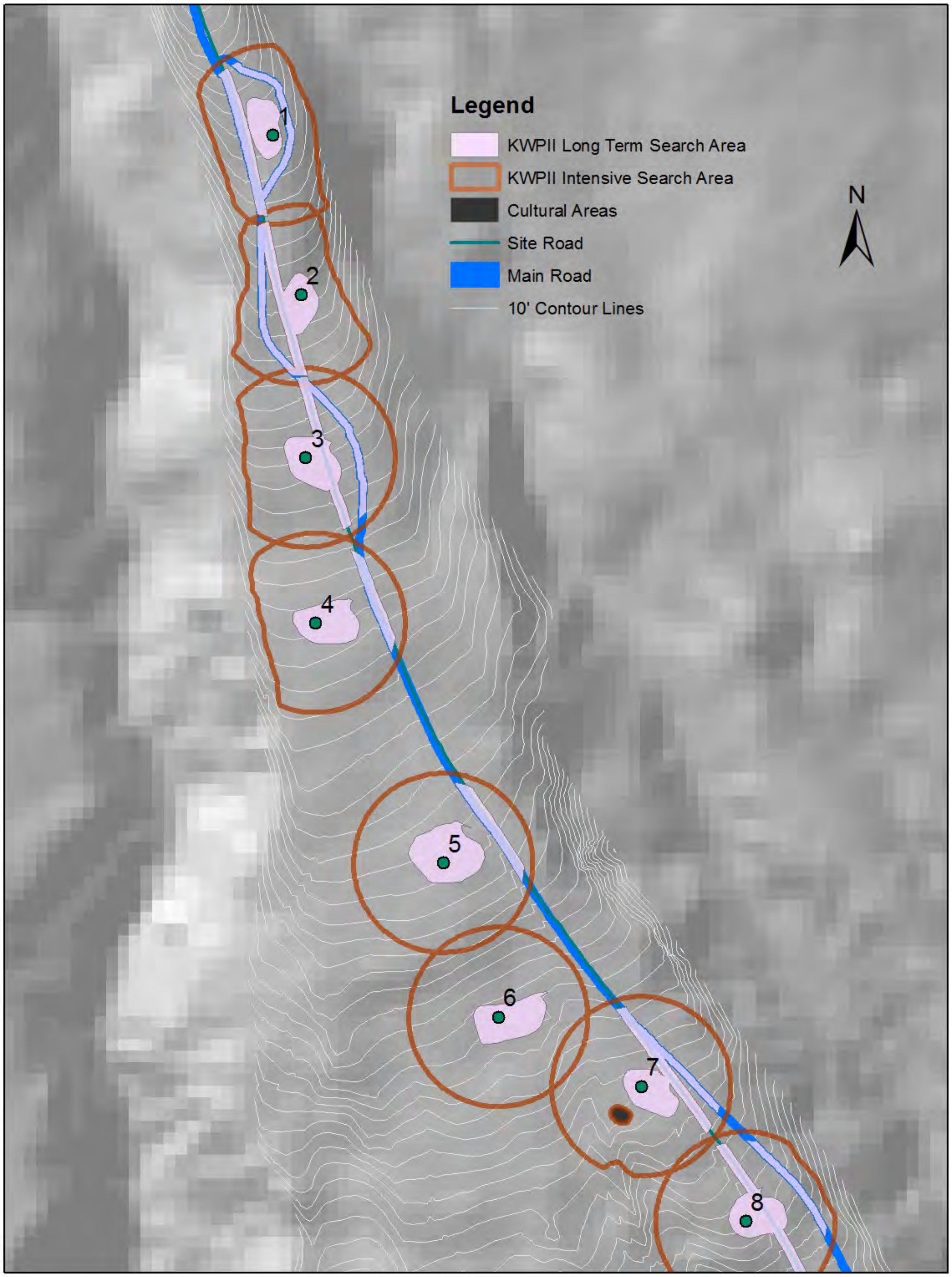

Figure 1a. Long Term Monitoring Search Area for KWPII (Turbines 1-7) with Roads and Pads Out to 70 m. Complete circles are 70 m radius.

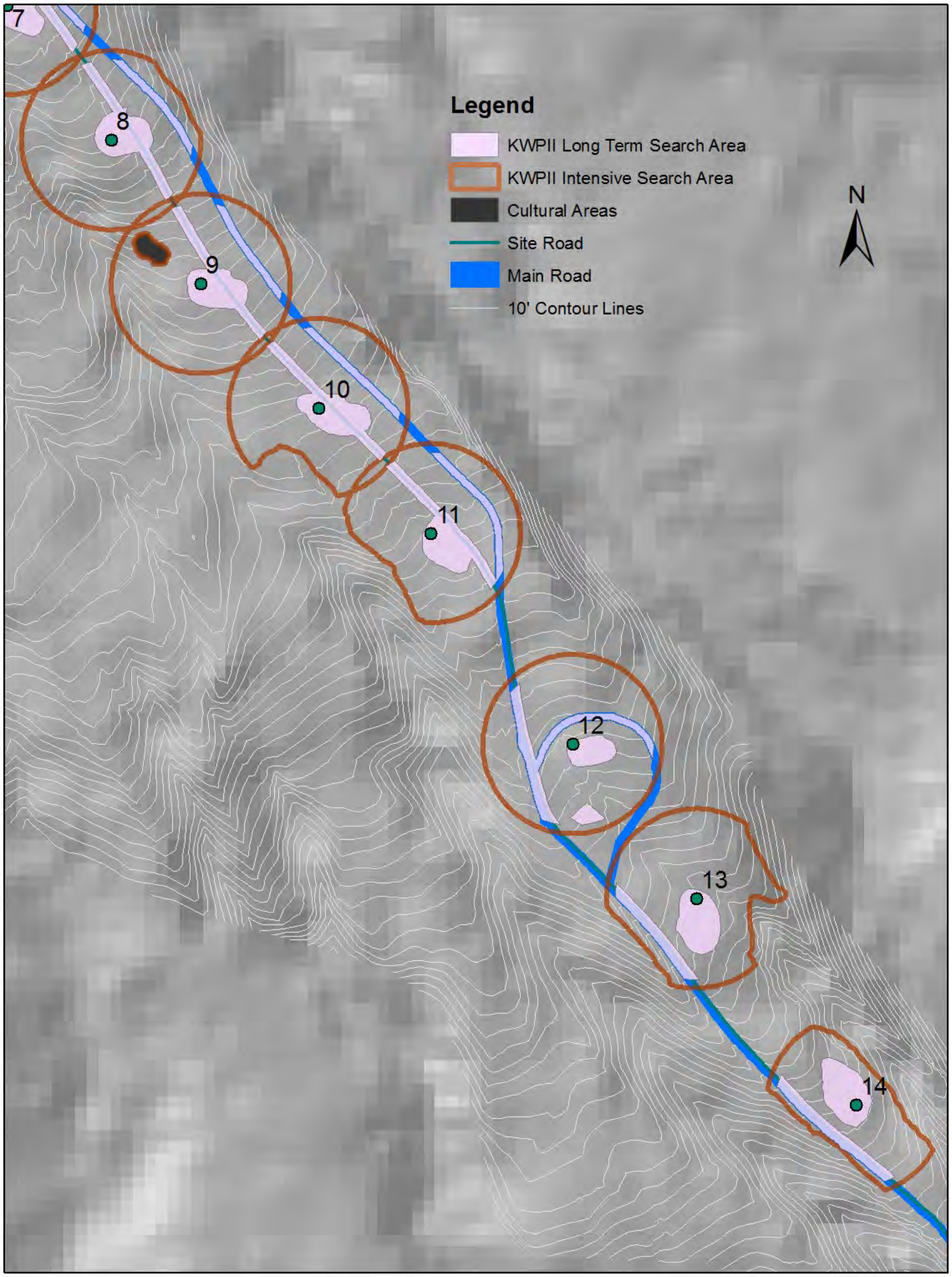

Figure 1b. Long Term Monitoring Search Area for KWPII (Turbines 8-14) with Roads and Pads Out to 70 m.

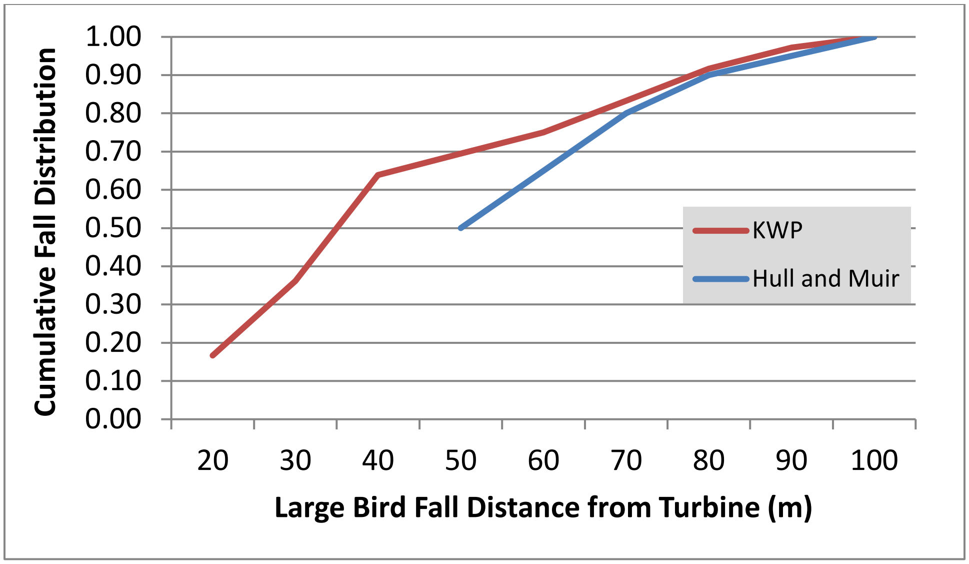

Figure 2. Cumulative Distribution of Large Birds' Distances from the Turbines at KWPI and KWPII (n = 30 observed nēnē between 0-70m radius and n = 6 hypothesized between 71-100m radius) and Hull and Muir (2010) large bird/small turbine ballistics model results.

Hawaiian Hoary Bat Fatality Rates

KWP II estimates total bat fatalities from take observed during monitoring and also projects an estimate for the 20-year permit period (Table 1) using the Evidence of Absence software (v2.06; Huso *et al*. 2015, Dalthorp *et al.* 2017). The actual period during which the turbines have been and will be operating is 19.5 years. Operations began in July 2012 and the permit term ends January 2032. All estimates for the "20-year permit period" are for 19.5 years.

The number of fatalities likely to be observed for the remaining years of the permit is extrapolated from the actual take observed at KWP I and KWP II during monitoring (12 years and 6 years, respectively) and adjusted for the reduced search area defined in the long-term reduced monitoring protocol that began July 2015 (see Appendix 28).

Biologists' intensive monitoring at KWP II searched the areas around all turbines within a circle centered on the WTG having a radius of 75m. Based on ballistics modeling Hull and Muir (2010) calculated that less than 1% of the total fall distribution of bats found around "small" turbines would fall beyond 75m. They considered turbines with a hub height of 65m to be a "small" turbine in their model; 32m and 45m were considered the distances within which 80% and 99%, respectively, of all bats might fall around a "small" turbine.

Long-term monitoring (Appendix 28) will continue to the end of the permit period at the same reduced search area effort as began in July 2015. The reduced effort at KWP II consists of searching only the roads and graded pads that occur within the 70m radius circle centered on each turbine (Figure 1a and 1b). The portion of all bat carcasses from turbine strikes that could fall within this 70m circle is calculated based on the known fall distribution of all observed bat take at KWP I and KWP II (Figure 3). Based on Hull and Muir (2010) ballistics modelling and observed carcasses we assume less than 1% of bats may have fallen beyond 70m. The KWP I and KWP II nacelle heights are 68 and 72m, respectively, and the maximum height of the rotor swept zone are 90 and 100m, respectively. Since these heights are similar all of the observed bat take from both sites has been used in creating the fall distribution. The fall distribution is assumed to be uniform around the turbine.

A 70m circle centered on each WTG is modeled to include 100% of all bat carcasses expected to fall from turbine strikes (Figure 3). More bats are expected to and do fall closer to the WTG and the distribution of fatalities is not uniform but is becoming less dense per acre as distance increases. To determine this density-weighted proportion (DWP) of the total fall distribution, the 70m circle is divided into six circular adjacent bands around the WTG. The first, closest band encompasses the area from the WTG out to 20m radius and each band farther from the WTG is 10m radius (Table 4). The total area in acres is calculated for each band and summed for all 14 turbines. The proportion of the total area in each band that is searched (roads and pads) is determined using ARCGIS (Table 4) and summed for all 14 turbines. The product of the portion of the total area actually searched per band area for all turbines and the expected portion of the total fatality distribution per band is determined for each band and the results summed for all six bands to derive the final portion of the entire fall distribution searched across all turbines (Table 4). The reduced search area of roads and pads is estimated to encompass 55.9% of all bat fatalities that could occur (Table 4). If the searching conditions were perfect (they are not) we would assume to find in the searched area half of all bats killed.

Our estimation projecting take 14 years into the future assumes that the most recent SEEF and CARE values from FY 2018 continue to be similar for the remainder of the permit term. The SEEF values for bats on pads and roads should be higher than the overall SEEF observed during intensive monitoring when grass and shrubs of varying height were more likely to obscure areas searched.

With 80% credibility, no more than 36.5 bats would have been directly taken after 19.5 years (the operations period of the 20-year permit term of KWPII, Table 1); an average estimated annual direct take rate of 1.87 bats/year. If only 50% credibility level is chosen the total estimated direct take for the permit period is 29.9 adult bats.

Table 3. Input Parameters and Observed/Projected Results for the Hawaiian Hoary Bat at KWPII.

Fiscal Year	% Year (rho)	Search Interval (*I*)	Carcass Count (*X*)	SEEF (*p*)			Persistence Distribution (CARE)					Spatial coverage (*a*)	Probability of Detection (*g*)			Probability of Detection Beta Distribution (*B*)		M*
				found	placed	*k*	distribution	shape	scale	95% CI for scale			*g*	min	max	*B*a	*B*b	
2013	1	7	**1**	8	19	0.7	LogNormal	0.613	2.138	1.629	2.647	1	0.443	0.241	0.656	9.080	11.412	**5**
2014	1	7	**2**	26	50	0.7	LogNormal	1.077	1.426	0.915	1.936	1	0.359	0.235	0.493	18.503	33.022	**12**
2015	1	7	**0**	21	56	0.7	Exponential	-	9.416	3.850	23.030	1	0.336	0.187	0.504	10.953	21.675	**12**
2016	1	7	**0**	34	42	1	LogNormal	9.214	2.589	1.056	4.122	0.559	0.362	0.27	0.46	35.087	61.842	**12**
2017	1	7	**0**	40	43	1	LogNormal	3.209	2.629	1.815	3.444	0.559	0.442	0.374	0.511	87.960	111.122	**12**
2018Q3	0.75	7	**0**	29	29	1	LogNormal	5.164	1.844	0.497	3.191	0.559	0.349	0.244	0.462	25.149	46.942	**12**
2018Q4	0.25												0.349	0.244	0.462	25.149	46.942	**12.4**
2019	1												0.349	0.244	0.462	25.149	46.942	**14.1**
2020	1												0.349	0.244	0.462	25.149	46.942	**15.7**
2021	1												0.349	0.244	0.462	25.149	46.942	**17.6**
2022	1												0.349	0.244	0.462	25.149	46.942	**19.5**
2023	1												0.349	0.244	0.462	25.149	46.942	**21.5**
2024	1												0.349	0.244	0.462	25.149	46.942	**23.2**
2025	1												0.349	0.244	0.462	25.149	46.942	**25**
2026	1												0.349	0.244	0.462	25.149	46.942	**26.7**
2027	1												0.349	0.244	0.462	25.149	46.942	**28.6**
2028	1												0.349	0.244	0.462	25.149	46.942	**30.4**
2029	1												0.349	0.244	0.462	25.149	46.942	**32.1**
2030	1												0.349	0.244	0.462	25.149	46.942	**34**
2031	1												0.349	0.244	0.462	25.149	46.942	**35.8**
Jan 2032	0.5												0.349	0.244	0.462	25.149	46.942	**36.5**

Table 4. Proportion of Hawaiian Hoary Bats Expected to Fall Within the Search Area

Distance Band	Area of Distance Band (m^2)*	Search Area Within Distance Band (m^2)*	Proportion of Distance Band Searched (A)	Portion Bats Found Within Distance Band (B)	DWP of Distance Band (A x B)
20	17584	15745.8	0.895	0.357	0.320
30	21980	12284.1	0.559	0.214	0.120
40	30772	9141.1	0.297	0.357	0.106
50	39564	7621.3	0.193	0.071	0.014
60	48356	5914.9	0.122	0.000	0.000
70	57148	4491.8	0.079	0.000	0.000
			Totals	**1.0**	**0.559**

* ARCGIS derived

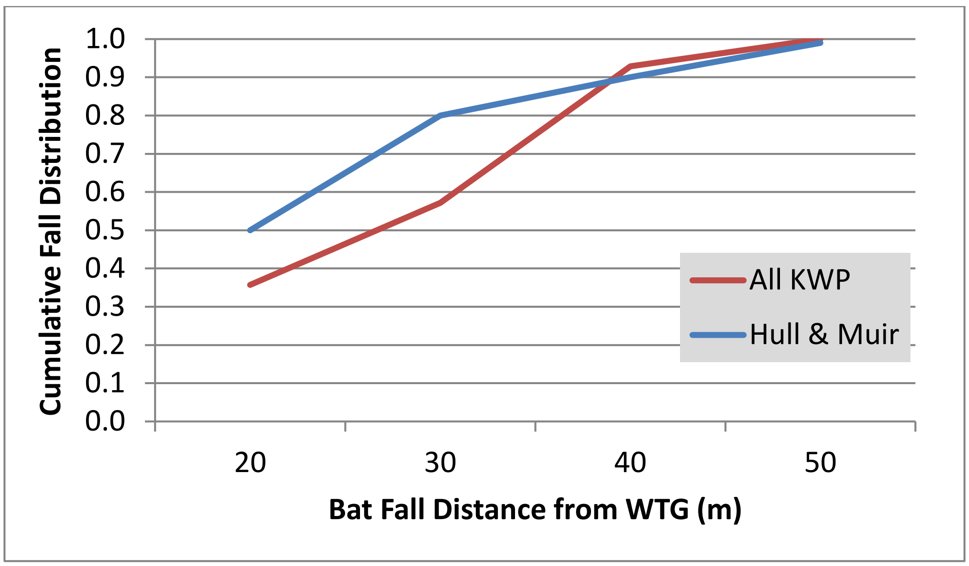

Figure 3. Cumulative Distribution of Bats' Distances from the Turbines at KWPI and KWPII (n=14) and Hull and Muir (2010) bat/small turbine ballistics model results.

References:

Hull, C.L. and S. Muir. 2010. Search areas for monitoring bird and bat carcasses at wind farms using a Monte-Carlo model. *Australasian Journal of Environmental Management*, vol. 17, pp. 77-87.

Huso, M. M. P., D. H. Dalthorp, D. A. Dail, and L. J. Madsen. 2015. Estimating wind-turbine caused bird and bat fatality when zero carcasses are observed. Ecological Applications. http://dx.doi.org/10.1890/14-0764.1

Dalthorp, D., M.M.P. Huso, and D. Dail. 2017. Evidence of absence (v 2.0) software user guide: U.S. Geological Survey Data Series 1055, 109p. https://doi.org/10.3133/ds1055 .

Appendix 28

KWPII - Long Term Monitoring Protocol

Summary of Intensive Monitoring Results to Date

KWPII has challenging search conditions due to rugged terrain and vegetation cover, and the use of canine assistance has until recently been restricted due to nēnē concerns. Canine assisted Downed Wildlife Monitoring began as trials in FY 2015 and had been integrated into weekly searches in FY 2016. Canine assisted monitoring will continue to the end of the 20-year permit term.

For KWPII the average observed annual take of nēnē and the Hawaiian hoary bat at KWPII was approximately one bird/year and one bat/year during intensive monitoring (Table 1 and Appendix 27). No take of Hawaiian petrels (HAPE) or Newell's shearwaters (NESH) have been documented at KWPII.

Carcass Retention (CARE) is measured in 28 day long trials. SEEF and CARE values reported include all data collected through June 30, 2015 (Table 1). Search interval has been approximately seven days at KWPII.

Table 1. Observed take, SEEF, and CARE for Nene, HAPE/NESH, and the Hawaiian hoary bat at KWPII.

	Nēnē			HAPE/NESH			Hawaiian Hoary Bat		
Fiscal Year	Observed Take	Mean SEEF	Mean CARE (days)	Observed Take	Mean SEEF	Mean CARE (days)	Observed Take	Mean SEEF	Mean CARE (days)
2013	1	0.67	27	0	1.0	24	1	0.42	10
2014	0	1.0	28	0	0.64	28	2	0.52	6
2015	2	0.82		0	0.67	18	0	0.38	8

KWPII assumes that the observed take rate, fatality estimation and the variability in the environmental, ecological, and searching conditions that had been recorded during the three-year intensive monitoring period appropriately represents expected variation in the future.

Proposed Long Term Search Protocol

<u>Search Area</u>

KWPII proposes a long term monitoring protocol for the remaining years of the permit term. The searched area will consist of roads and graded pads that occur within a 70m radius circle centered on each WTG (Appendix 27). The area searched represents 34% and 56% of the expected total fall distribution of nēnē and bats (Appendix 27). Searches will continue to be conducted once a week. Visual searches are along approximately 6m wide parallel transects and canine assisted search patterns vary depending on wind direction and speed. Canine search tracks are recorded via GPS on a collar worn by the canine. Vegetation on pads and along roads will be managed to maximize searcher efficiency (i.e., eliminated or closely mowed). Exact GIS maps of the searched areas and the proportion of each 10 m wide band out to 70 m that the searched areas represent has been determined and is provided in Appendix 27.

CARE Trials

CARE trials will be conducted once every quarter and will include one medium and one large bird and at least five rats for each quarter trial with a minimum of four large and four medium birds and 20 rats per year. Predator trapping for scavengers may be implemented or intensified if carcass persistence averages less than seven days during a quarter trial.

SEEF Trials

SEEF trials will be conducted year round and will include a minimum of 40 rats (an average 10/quarter) and 10 medium and 10 large birds each year (between 2-3 birds of each bird size class each quarter).

References:

Manuela M. P. Huso, Daniel H. Dalthorp, David A. Dail, and Lisa J. Madsen. 2015. Estimating wind-turbine caused bird and bat fatality when zero carcasses are observed. Ecological Applications. http://dx.doi.org/10.1890/14-0764.1

Appendix 29

KAHEAWA WIND POWER II
HAWAIIAN HOARY BAT MITIGATION PLAN

(for Tier 1 and Tier 2 KWP II Mitigation Fulfillment)

Applicant

Kaheawa Wind Power II, LLC
First Wind
56 Honuhula Street
Kihei, HI 96753

Prepared by

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September 2014

Table of Contents

List of Tables

1.0 INTRODUCTION

The Hawaiian hoary bat is an endangered species found on all the Main Hawaiian Islands except Niʻihau. Current population estimates range from a few hundred to a few thousand, but the actual number remains essentially unknown. According to the state Comprehensive Wildlife Conservation Strategy (2005), primary threats include habitat loss (especially tree cover), pesticides, predation, and roost disturbance.

As per the mitigation requirements described in the Kaheawa Wind Power II (KWP II) Habitat Conservation Plan (HCP) (SWCA, 2011), Kaheawa Wind Power II, LLC (Kaheawa Wind) must provide funding for Tier 1 mitigation for the authorized take of 6 adult bats and 3 juveniles (see Section 5.2.5.3 of the HCP), which equates to a total of 7 adults (with an estimated 30% survival rate of juveniles to adulthood; see Appendix 5 of the HCP for life history information). According to the HCP, baseline mitigation must consist of, "implementation of bat habitat improvement measures to benefit bats as approved by DNLR, USFWS, and ESRC in consultation with KWP II."

The HCP specifies that, "one core area of 84.3 ac supports one male bat at a given time, and assuming that the lifespan of a Hawaiian hoary bat is approximately 10 years…then it could be assumed that one core area could be used by, or benefit, up to 2 male bats over the 20-year permit term… Based on this assumption, the mitigation area required for 4 adult male bats is two male core areas totaling 168.6 acres." Since the management is being conducted on State conservation lands, the required acreage is doubled, meaning 338 acres must be restored to mitigate for the requested Tier 1 take of bats at the KWP II facility at a cost of $250,000 ($126,260 Years 1-5, $123,740 Years 6-20). Mitigation measures must contribute to preserving or enhancing foraging and/or roosting habitat capable of supporting a commensurate number of bats to achieve the mitigation requirement.

As of February 26, 2014, adjusted take has reached the authorized Tier 2 level – 9 adult bats and 5 juveniles, equating to a total of 11 adults – requiring additional restoration of 84.3 ac of forest at Kahikinui or at another location on Maui at a cost of $125,000. Page 114 of the HCP states, "recommended [Tier 2] mitigation would consist of the additional restoration of 84.3 ac of forest at Kahikinui or at another location on Maui. If the acreage is required to be doubled because management is being conducted on State conservation land, KWPII will fund the management of 169 ac (84.3 x 2 = 169 ac) of land." However, per page 115 of the HCP, "if, at the time the Tier 2 level of take is triggered, new scientific information may indicate mitigation measures other than habitat restoration are more important or pressing for recovery of the Hawaiian hoary bat, KWPII may revise the Tier 2 mitigation plans with the approval of USFWS and DLNR."

Given that the cost for restoration and monitoring of the 340 acre unit exceeds the amount required to mitigate Tier 1 take levels, DOFAW and USFWS recommended that Kaheawa Wind direct Tier 2 mitigation funds toward the same 340 acre parcel to cover additional planting, as well as monitoring efforts which will occur in five year increments over the life of the project (Section 6.0). This plan therefore describes allocation of both Tier 1 and Tier 2 mitigations funds.

Currently, there are multiple ongoing restoration efforts being conducted at Kahikinui through various sources of funding, including funding from another First Wind development project – Kahuku Wind Power. In conjunction with these ongoing efforts, this document provides a description of the proposed allocation of the $375,000 in mitigation funds to fencing and restoring a 340 acre section of the Kahikinui Forest Reserve (FR) in order to achieve the mitigation goals described in the HCP.

2.0 OBJECTIVE

The objective of the mitigation effort is to implement measures that will not only mitigate for the permitted take, but provide a net benefit to the species by increasing population numbers of the Hawaiian hoary bat via the creation/restoration of available foraging and roosting habitat.

3.0 STUDY AREA

The proposed 340 acre project area is located between the 4,800 to 6,200 foot elevation contours in the Kahikinui FR (Mauka Unit). The upper reaches of this area are located just below the temperature inversion layer, which settles at about 6,500 feet in elevation. This is a koa-ohia montane mesic forest with an understory comprised of aʽaliʽi and other native plant species. Mesic forests are found in the transition zones between dry forest and rainforest in Hawaiʽi, receiving about 120-150 cm of annual precipitation. Mesic forests are home to a large number of endemic plant species and provide important ecosystem services in the form of habitat for native animal species and watershed protection. There is great potential for koa-ohia reforestation efforts in this wetter zone of the FR. Due to ungulate grazing and the lack of ungulate control in the area, the natural forest understory has been largely eliminated and replaced by non-native pasture grasses. However, gulches, intermittent stream beds, and other topographically protected areas still contain a diversity of native overstory tree species, understory plants, and native ferns.

Over time, restoration efforts are intended to increase native vegetation cover and provide a forest structure suitable for bat foraging, roosting and breeding. Additionally, the restoration of native forest within the parcel is expected to improve the functional connectivity of habitat within the Kahikinui area across the FR, Nakula Natural Area Reserve (NAR), and the adjacent Department of Hawaiian Home Lands (DHHL) lands.

4.0 PROPOSED MANAGEMENT ACTIONS

As mentioned above, multiple management efforts are occurring across the larger Kahikinui area, including efforts to control ungulates, restore and create native habitat, and increase native forest bird populations. The efforts funded by KWP II mitigation funds will contribute to a broader restoration and conservation management effort in the region, and will not only benefit the Hawaiian hoary bat, but other native plant and animal species as well. This collaborative, concentrated management approach increases the likelihood of success as compared to a similar project that might be isolated and surrounded by conflicting land uses.

The following measures will be implemented using funds provided by First Wind and other sources in a collective effort to improve native habitat.

4.1 Fencing

Approximately 2.8 miles of fence apron is currently being installed by DOFAW field crews, and is planned to be completed by July 2014.

Source: Partially funded by Capital Improvement Project funds and DOFAW Forestry operating funds

4.2 Ungulate Control

Following the completion of the fence apron (slated to be completed by July 2014), DOFAW Forestry staff will conduct ACETA (aerial capture, eradication, and tagging of animals) missions to dispatch all feral ungulates within the Nakula NAR and Kahikinui FR. These missions will be completed by December 2014. Subsequent missions will be conducted to ensure that these units remain at 'zero tolerance'. Monitoring of ungulate populations will occur at least quarterly to ensure that all ungulates were removed and no fence breaches occur.

Source & Cost: Ungulate control work will be funded by KWP II funds. ($16,000 – approx. 8 trips). Monitoring costs will be provided by the Forest Stewardship Special Fund.

4.3 Site Preparation – Soil Testing/Conditioning

Soil sampling to detect any nutrient deficiencies in the bare soil areas will be conducted from May to September 2014. Possible soil conditioning of nutrients to bare soil areas may be conducted to possibly increase outplanting survival rates within these nutrient depleted areas.

Source & Cost: Helicopter time for site prep work to be funded by KWPII funds.*

4.4 Plant Quality & Procurement

Based on bat recovery recommendations from Hawaiian hoary bat experts, koa and ohia were chosen as the forest canopy species of choice along with other native overstory species (pers. comm. Frank Bonaccorso & Chris Todd, March 2014). Other native tree species will be interspersed among the koa and ohia, along with a diverse understory of native species. Natural gullies and contours will serve as flight passage corridors, and 30 foot wide open spaces will be incorporated into the planting plan to connect the natural corridors and form an interconnected system to facilitate movement and foraging within the forest (pers. comm. Frank Bonaccorso, July 2014).

Source & Cost: Helicopter time, crew subsistence payments and plant purchase to be funded by KWP II funds and grant funds as detailed below.*

Initial actions for implementation starting January 2015 when precipitation increases:

a. 15’ x 15’ spacing; approximately 200 trees per acre (TPA)
b. 200 TPA x 300 acres = 60,000 seedlings at $3.00 per seedling
    1. 56,000 koa and ohia seedlings
    2. 4,000 seedlings of other native overstory species (kolea lau nui, sandalwood, olapa, ohe, etc.)
    3. 3 to 1 species ratio (koa to ohia)
c. Planting contractor at $500 per acre = $170,000 (*grant application in process)*
   Cost: $180,000 KWP II funds, $170,000 outside funding (price subject to change)

Subsequent actions beginning in January 2016:

a. Approximately 15,000 seedlings of understory plant species to be outplanted (pilo, aʻaliʻi, mamane, ferns, etc.)
   Cost: $45,000 (price subject to change)
b. Weed surveys and suppression to commence Year 2
   Cost: $50,000

**Total Helicopter time cost to be determined.*

Total funded by KWP II: $291,000 as listed here. However, these are preliminary estimates, and the total does not include all helicopter time or any monitoring costs.

5.0 SCHEDULE AND DURATION

Table 1 provides a tentative schedule for mitigation activities.

Table 1. Preliminary Schedule of Mitigation Activities.

Implementation Activities	FY 2014	Fiscal Year 2015				Fiscal Year 2016				Fiscal Year 2017				Entity Responsible
	4th Qtr	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	
Fence Construction	XX	XX												DOFAW Maui Nui Branch
ACETA Activities	XX	XX	XX											DOFAW Maui Nui Branch
Soil Sampling and Conditioning	XX	XX												DOFAW to collect samples, NRCS or CTAHR to conduct analysis
Plant Procurement	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	Obtained from Native Nursery, LLC* by DOFAW
Initial Planting of Overstory Species			XX	XX			XX	XX				XX	XX	DOFAW Maui Nui Branch
Subsequent Planting of Understory Species							XX	XX	XX			XX	XX	DOFAW Maui Nui Branch

* DOFAW's current contract is with Native Nursery, LLC. However, this contract expires December 2014 and is currently out for bid.

6.0 MONITORING & MEASURES OF SUCCESS

According to the HCP (page 116) management measures will be considered successful if:

Prior to the start of management measures:

a. Ground and canopy cover at the mitigation site is measured.

After 6 years:

b. The fencing is completed.
c. The ungulates have been removed within the fenced area and the area is kept free of ungulates for the 20-year permit term.

After 20 years:

d. The cover of non-native species (excluding kikuyu grass) in the managed areas is less than 50%.
e. The mitigation area should have a canopy cover composed of dominant native tree species (particularly koa and ohia) that are representative of that habitat after 15 years of growth. According to Wagner *et al.* (1999), mature koa/ohia montane mesic forests "consist of open-to-closed uneven canopy of 35 m tall koa emergent above 25 m tall ohia." Therefore, there should be at least a 25% increase in canopy cover over original conditions throughout the mitigation area, and closed canopy areas should attain at least 60% canopy cover.
f. Restoration trials are implemented.
g. Radio-transmitter monitoring (or other measures as appropriate) is conducted every three to five years to detect changes in bat density and home range core area size as the site is restored.

Adaptive Management

The Annual Reports received in the Years 3 through 5 after the initial planting shall contain an evaluation of whether or not efforts are on track to reach the mitigation targets described above. If they are not on track, then DOFAW, USFWS, and Kaheawa Wind will discuss adaptive management measures to address the problem. Such measures could include additional planting, intensive management measures (*e.g.,* use of water absorbent gels) increased monitoring frequency, or other measures as deemed appropriate by all parties.

6.1 Forest Health Monitoring

Monitoring of ungulate populations, forest cover, and canopy structure will be conducted once per quarter by DOFAW Forestry staff and/or Leeward Haleakala Watershed

Restoration Partnership (LHWRP) staff. An Annual Report will be produced by DOFAW at the end of each fiscal year describing the activities that took place during the year (*e.g.*, fence construction/ incursions, weed control, bat detections, etc.), documenting the flora species present, status of ungulate populations, and a visual assessment of canopy cover and forest structure, with a quantitative scientific analysis of canopy cover completed if deemed necessary by field staff, DOFAW, and USFWS.

6.2 Bat Activity Level Monitoring

It was determined by USFWS and DOFAW, and agreed upon by Kaheawa Wind, that radio-transmitter monitoring to determine bat density would not be the most effective way to measure the success of the restoration activities at Kahikinui. Instead, it was determined that acoustic monitoring for bat activity levels would be a more appropriate approach. As of the writing of this plan, a study entitled Baseline Surveys for Two Wind Power Habitat Conservation Plans in the State of Hawaii is being conducted by USGS under Principal Investigator Frank Bonaccorso. This effort is funded by a Section 6 Cooperative Endangered Species Conservation Fund Habitat Conservation Planning Assistance Grant. The results of the study are expected in 2015, and will be used as the baseline bat activity level for Kahikinui.

Considering input from Mr. Bonaccorso (pers. comm., April 2014), it was determined by the agencies that subsequent monitoring efforts should occur at years 5, 10, 15, and 20 (measured after the start of habitat restoration activities), and should consist of 3-month continual sampling efforts in the same three months of each sampling year. Selection of the appropriate 3-month time period will be determined in collaboration with Mr. Bonaccorso based on the results of the USGS Baseline Surveys. A 5-year cycle of feedback will be very important in planning new restoration parcels for other mitigation activities in Kahikinui as well as for adaptive management of the current project.

Mr. Bonaccorso's suggested monitoring approach for 340 acres would employ at least four detection stations, but could potentially employ up to eight depending on the heterogeneity of the habitat (more heterogeneity would require more detectors). Based on the cost of this type of effort in 2014, it is estimated that each sampling effort will cost approximately $70,000. This is a rough figure that includes helicopter time, salaries for two field biologists for field data collection, data analysis and report preparation, inter-island travel costs of the two biologists, supplies, and contractor overhead and/or profit margin for a third-party contractor. This costing also assumes the permanent equipment (bat detectors) is already available for the project, otherwise this equipment will need to be purchased ($1,500 per bat detector station at 2014 prices).

Given that four monitoring efforts at a cost of $70,000 each cannot be supported by the budget for this project, the agencies will work to lower or supplement costs by:

a. Incorporating agency staff into monitoring efforts (*e.g.,* assisting with detector set up, downloading data from detectors, etc.);
b. Putting out a Request for Proposals to see if another qualified entity can provide similar services at a lower bid;
c. Seeking additional grant funding;
d. Pooling funding from current and future HCP mitigation efforts at Kahikinui; or
e. Other actions as deemed appropriate by the agencies and ITL Applicants.

It is understood that given the timeframe of this effort, it is not confirmed what entity or entities (agency or third party) will implement the monitoring efforts, and therefore a prescriptive scope of work is not laid out in this plan. The scope of work will be developed for the Year 5 monitoring effort, and will set the precedent for all subsequent monitoring. Protocols and equipment should remain identical in the Year 10, 15, and 20 sampling efforts to the extent practicable. Any amendments to the protocol/equipment must be justified by the entity carrying out the monitoring effort (*e.g.*, a particular brand of detector is no longer available), and must be taken into consideration during data analysis. A report will be produced at the conclusion of each monitoring season and will be reviewed by the agencies, Kaheawa Wind, and other bat experts as deemed appropriate to determine success of this project.

7.0 REFERENCES

DLNR. 2005. Hawaii's Comprehensive Wildlife Conservation Strategy. As submitted to the National Advisory Acceptance Team, October 1, 2005.

SWCA. 2011. Kaheawa Wind Power II Wind Energy Generation Facility Habitat Conservation Plan. Prepared for Kaheawa Wind Power II, LLC. December 2011.

Appendix 30

HAWAIIAN HOARY BAT CONSERVATION BIOLOGY: MOVEMENTS, ROOSTING BEHAVIOR, AND DIET

KWP II- Tier 3 Mitigation Plan

A Proposal Prepared for State of Hawaii Endangered Species Committee

Submitted: July, 2016

From: U. S. Geological Survey, Pacific Island Ecosystems Research Center

SUMMARY

This proposal is designed to advance understanding of key aspects of Hawaiian hoary bat (*Lasiurus cinereus semotus*) ecology and population biology listed as priority research goals both in the ESRC "Request for Proposals" and the USFWS 1998 Recovery Plan for the Hawaiian Hoary Bat. Central topics include: 1) seasonal and annual home range and movement patterns, 2) diet composition and food availability, 3) identifying habitats used for foraging roosting, and breeding, and 4) mother-pup demographics and predation at maternity roosts.

A key feature of our project will be deployment of a network of antennae masts wired to automated radio-telemetry systems supplemented by ground crew hand-held radio-telemetry that will provide coverage of a 1,500 km^2 area of eastern Hawaii Island to include native forests, agro-ecosystems, lava tubes, and urban/suburban landscapes from sea level to 3,500 m elevation, all in a region with previously demonstrated high presence levels for hoary bats. We plan to radio-tag 48 bats per year with a goal of 8 radio-tagged bats pulsed every two months over a three year period for a total of 144 tagged bats. The capture and release effort will provide opportunity to collect and bank skin, fecal, and hair samples for dietary analysis (this study), population genetics, and examination of pesticides and heavy metal accumulation in hoary bats (the latter two topics are proposed elsewhere by collaborative USGS teams). When possible, bats that are recaptured multiple times and identifiable from permanent wrist bands will become focal animals for tracking long term movements and monitoring site fidelity. We will also track bats to day roost trees and monitor bats with video, acoustic, and microclimate recording devices to study mother-pup behaviors and demographics through fledging. We will select among important bat foraging locations determined from radio-telemetry sites locations to sample insect diversity, abundance and biomass. Fecal pellets collected in this study from bat capture/release will be used in a meta-barcoding dietary study to identify and quantify insect prey items from matched barcodes in a reference library of insects we will compile to understand prey choice and seasonal movement patterns of the bat.

Major objectives in our study of Hawaiian hoary bats will document all the following points identified as Priority Objectives by the ESRC:

- foraging and home range size including winter and summer seasonal ranges over three annual cycles
- habitat use devoted to foraging, roosting, and breeding
- roost fidelity and roost tree geometry and characteristics
- mother-pup behavior and demographics through fledging at breeding roost trees
- quantitative diet analysis of insect prey selection and availability using molecular bar-coding techniques
- examination of the relationships between movement patterns and food availability
- insect prey-host plant associations providing guidance to wildlife managers for bat habitat restoration
- a tissue and fecal collection bank for genetic, dietary studies, and pesticide studies

Our research plan represents the largest sampling effort ever attempted to characterize Hawaiian hoary bat movement ecology and behavior through radio-telemetry. Only a single published radio-telemetry study of Hawaiian hoary bats spanning multiple years (Bonaccorso et al. 2015) exists and although informative about individual movements this study was limited to hand-held tracking in lowland areas and did not sample high elevation winter range of the bat. Our understanding of hoary bat spatial ecology will be vastly improved by successful completion of our

proposed objectives and will provide wildlife managers much more thorough home range estimates than those now existing.

The USGS and HCSU biologists available for this research project have unparalleled experience (over 125 years cumulative in Hawaii) in practicing field ecology throughout the ecosystems of Hawaii and specifically on the conservation biology of Hawaiian hoary bats. Furthermore, the USGS as an organization has an exceptional staff of field biologists at the Pacific Island Ecosystems Research Center (PIERC) at Kilauea Field Station and can call upon a national network of multi-disciplinary scientists for numerous specialized fields. USGS/PIERC ecologists and entomologists will lead the insect prey aspects of our study as well as providing expertise in the use of automated radio-telemetry arrays.

Information forthcoming from this study will provide wildlife managers key information, data, and maps for planning recovery of the Hawaiian hoary bat, as well as information that will better guide planning and implementation of current and future mitigation and management areas. Examples of new critical information expected as outcomes include first estimates of the size of the winter foraging range, survivorship of pups from birth to fledging, identification of predators of infant bats and other causes of mortality, and assessment of bat diet-insect prey base-host plant inter-relationships.

GOALS

The strategic goal is to provide strong multi-disciplinary sets of data showing the inter-relationships between daily and annual movement patterns, breeding biology, roosting biology, predation, and relationships of insect prey abundance, biomass, diversity, and distribution as drivers of hoary bat ecology. The information we gather will directly help managers make informed decisions assisting the recovery of Hawaiian hoary bats and for improved selection and design of bat mitigation reserves that will offer a balance of winter and summer habitat, foraging and roosting habitat, guidance on key plant species for propagation to benefit bats in restoration-mitigation areas, and potential precautions such as predator control that may be warranted.

Furthermore, tissue samples from bats captured for radio-telemetry will be banked for future use in population demographic studies and for study of heavy metal/pesticides accumulation both in hoary bats and lower levels of their food web as funds and partners become available.

OBJECTIVES

Major objectives in our study of Hawaiian hoary bats will document the following topics identified as Priority Objectives by the ESRC:

- foraging/home range size including winter and summer seasonal ranges over three annual cycles (ESRC Goal 1a, 1c)
- habitat use devoted to foraging, roosting, and breeding (ESRC 2a)
- roost fidelity and roost tree geometry and characteristics (2a)
- mother-pup demographics including predation/mortality at maternity roosts (1b, 2d)
- diet composition and insect prey availability (ESRC 2b)
- relationships of home range to food availability (ESRC 2b)

- prey-host plant associations (ESRC 2a, 2b, 4)
- tissue and fecal collections for presently proposed and future diet, population demographic, and pesticide/heavy metal studies (banking materials for ESRC 1d, 2b, 2c)

Each of the objectives when fulfilled will contribute to a more informed guidance toward mitigation strategies for the future selection, restoration and protection of natural reserve lands for the management to recovery of Hawaii hoary bats.

TASKS AND ACTIVITIES

- Capture and release – Hawaiian hoary bats will be captured with mist nets by an experienced and fully permitted group of bat ecologists having extensive experience in Hawaiian ecosystems. The use of social and foraging call playback will be used to enhance mist-net capture rates. Eastern Hawaii as proposed for our study is the best proven region in the state to capture large numbers of bats in order to produce robust data sets. Bats will be taken through a data collection protocol in less than 45 minutes and released at the capture site with radio-tags and individual wrist bands. Fecal pellets for dietary study will be collected from bats as expelled in soft cloth holding bags within the 45 minute handling protocol. Biological sampling of bat skin biopsies and hair clippings will be banked and available for complementary studies of bat genetics and pesticides.
- Radio-tagging – application of BD-2XC Holohil radio transmitters will be applied by a proven collar method for attachment of radios to small bats described in detail by Winkelmann *et al* (2003). Collars are designed to drop off bats soon after the 6 week battery life is expended via a cotton thread weak point in the collar. The BD-2XC offers a greatly extended battery life (John Edwards, Holohil Inc., personal communication) for tracking bats than previously employed by any study of Hawaiian hoary bats (6 week potential versus 13 days achieved previously).
- Banding—USFWS and DLNR permit approved plastic split rings color coded for individual visual identity will be used to identify bats both in hand and at roosts. Banding will permit long term identification of individuals upon recapture or at roost observations on a permanent basis long after radio-tags have ceased to function. Banding will be particularly important in our study of roost fidelity as well as providing some information on lifespan (banded hoary bats have been captured previously by us up to 4 years after banding).
- Radio-tracking—automated tracking using an array of elevated (mast) antennae/receiver systems will be deployed around eastern Hawaii to track movements in a 1500 km^2 area and supplemented with hand-held ground based tracking teams. Hand held tracking by humans in real time will permit homing to exact roost tree locations and visual observation of roosting bats essential for videography and acoustic monitoring of roosting bats. The automated tracking will provide minute by minute tracking of individuals and offers long distance tracking tens of miles beyond range of a ground based, hand held antennae. The antennae masts will be placed in the extensive study area to provide maximum line of sight coverage for effective triangulation of bat positions. The automated system will

rotate between up to 8 individual bats with a position triangulation recorded every minute during entire nights and hourly by daylight hours. This will make it possible to track individuals for up to 6 weeks on daily movements with a high probability of tracking some transition movements between summer and winter foraging ranges and for the first time make it possible to calculate true annual home ranges for the Hawaiian hoary bats. Our goal is to radio-tag and track eight individuals in each of six bimonthly periods throughout the year over a three year time-span. The telemetry combination of automated systems tracking from elevated antennae and ground based tracking will provide a very thorough monitoring of bat presence at day roosts and permit complimentary monitoring using video and acoustic apparatus in close proximity to day roosts thus providing details of roost fidelity, frequency of roost switching (multiple roost use), weather attributes confining bats to roosts or acceptable for foraging, predator presence, and mother-pup behaviors and demographics.

- Video monitoring—both thermal imaging and near infra-red cameras will be used to record bats at roosting trees to provided visual documentation of timing of roost departures and returns, observations of predators such as rats, owls or ants, and responses by bats, recordings of mother-pup interactions including times mothers are with pups during day roosting and intermittently between foraging bouts by the mother through the night.
- Acoustic Monitoring—will primarily be used in this study to record social calls of mother-pup communication and adult social communication in the vicinity of maternity roosts. We will use the latest available range of automated bat detector and ultrasonic microphones available from Wildlife Acoustics and Pedersen Electronik.
- Roost Tree Characterization—measurements will be taken of tree species, height, DBH, percent foliage cover, canopy geometry, bat perch height and position, slope aspect, and elevation among other attributes that may be deemed valuable.
- Prey Base—insects will be evaluated for biomass, abundance, and taxon diversity through light trap, malaise trap, sweep netting, and branch clipping collection techniques. Collections will be pulsed at two month intervals over two-years to provide insect phenology data as these prey items will have seasonal and spatial variation as aerial bat prey. Associations of insect communities on native Hawaiian plants potentially suitable for habitat restoration at bat mitigation sites will be evaluated. Insects will be identified by our staff entomologists using the extensive museum collections of USGS, USDA, and the Bishop Museum. Samples from the insect collections will be retained to provide tissue for expanding a bar code library for identification of insects in our dietary study as well as implementing a tissue bank for companion studies of heavy metal (eg. lead and mercury) and pesticide levels in Hawaiian hoary bats and insect prey tissues as such studies are funded and partners identified.
- Diet Analysis—fecal pellet samples will be collected during mist netting events, under bat roosts, and taken from our existing banked collections. Insect prey DNA inside the feces will be amplified using meta-barcoding techniques. A library of insect DNA barcode sequences will be generated from the most common prey base

insects including know agricultural pests collected from our study sites. Diet composition will be explored using bioinformatics techniques, through comparison of prey items barcoded in fecal matter to our reference library of local insects as well as publically available sequence data. Bat diet will be analyzed with respect to age, sex, season, and habitat. Important prey species will be linked to host plant associations as possible with emphasis on native plant community restoration.

OUTPUTS

Data outputs will include measurement of summer and winter foraging ranges (95% kernel) and core area (50% kernel), total home range and core area, habitat preferences for foraging and roosting, site fidelity for roosting and foraging core areas, weather correlates of flight activity, pup survivorship, description of mother-pup behavior, skin and ambient foliage temperatures of roosting bats, roost tree geometry, insect prey-base abundance, diversity, and biomass, insect-plant host associations for restoration of bat habitat, dietary contents of bat fecal pellets using molecular genetics. Biological samples from captured bats (tissue, fecal, hair) will directly contribute to our proposed and future studies which will analyze population genetics and demographics, diet composition, and prey selection. Biological samples from both hoary bat and insect tissue samples will be banked for possible pesticide and heavy metal analysis of the hoary bat food. Insect CO1 barcode sequences generated from the bat diet study will be an important contribution to entomological science in Hawaii, adding to the genetic data available for studies in Hawaiian biodiversity and ecological food webs.

OUTCOMES

While the USGS is a research agency, its project staff will be available to advise state, federal and private organizations about the applicability of data outputs in relation to bat ecology and behavior. We will do this through providing technical assistance by phone, in person conferences, presentations at scientific meetings, management workshops, technical reports, and publication of peer reviewed scientific publications. USGS and HCSU biologists will frequently present data at appropriate conferences such as the Hawaii Conservation Conference and the North American Symposium for Bat Research or at such relevant conferences as periodically are hosted in the State of Hawaii.

MATERIALS AND METHODS

Radio Tracking and Roost Monitoring

We propose a three year radio-telemetry study on the island of Hawaii with a study area spanning the Wailoa-Wailuku-Waikaumalo watersheds from near sea-level to montane sites at 3,500 m and including the northern slope of Mauna Loa that harbors important winter foraging habitat for Hawaiian hoary bats (Bonaccorso et al. 2016). USGS currently is using an automated telemetry system for tracking forest birds across difficult terrain in the Hakalau

Forest National Wildlife Refuge. We propose to supplement the existing network with seven additional masts that will expand coverage for the purpose of tracking of hoary bats across 1,500 km^2 of the island's windward region (Figure 1). Final locations for placement of telemetry masts will be based on local topography designed to maximize line-of-sight coverage as well as security from vandalism.

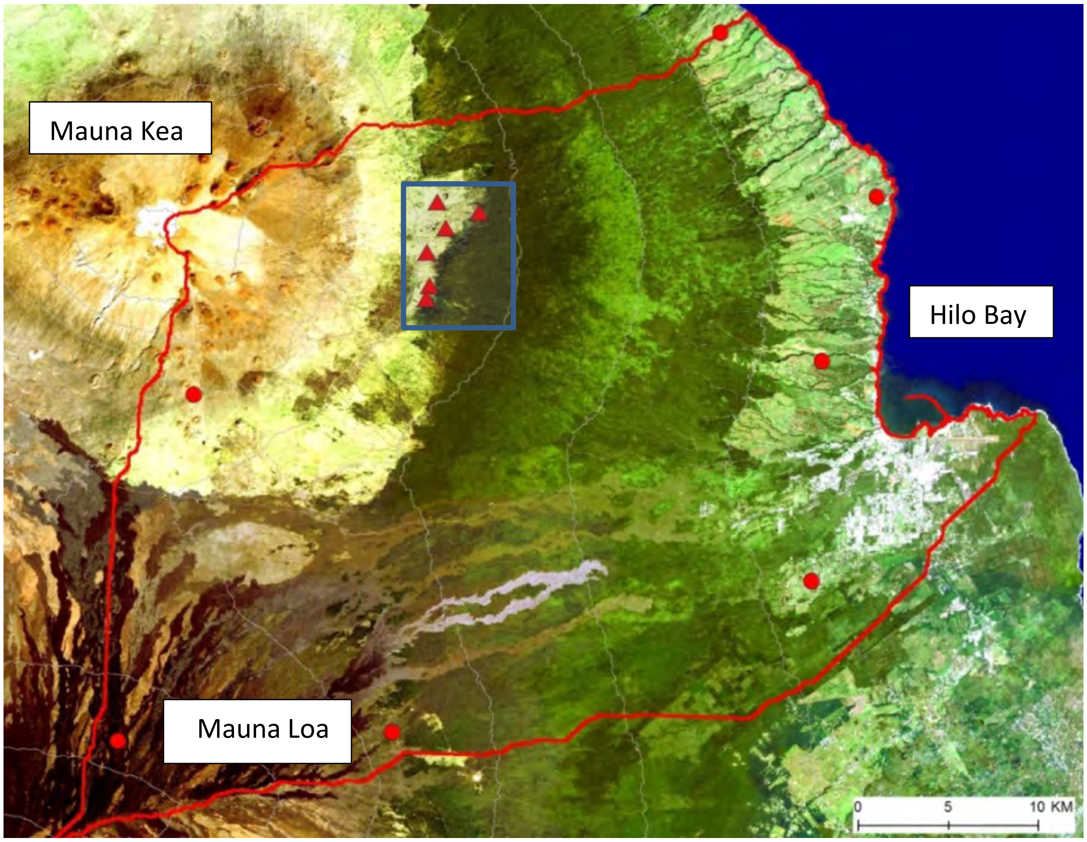


Figure 1. Map of proposed study on eastern Hawaii Island showing the existing Hakalau antennae array (rectangular blue outline enclosing red triangles) and approximate point locations for additional antennae (red dots).

Figure 2 Forty foot telemetry mast at Hakalau Forest NWR.

Bats will be captured by mist-netting following guidelines of the American Society of Mammalogists (Sikes et al. 2011). Our staff scientists hold current permits from USFWS, Hawaii DLNR, and University of Hawaii at Hilo IACUC that include all research protocols described in this proposal. Upon capture we will record sex, age class, morphology, and reproductive status. We will collect skin and hair tissue to bank for genetics and pesticide analysis. We will collect fecal pellets to bank for dietary analysis. Conducting this study in Eastern Hawaii offers the most dependable region known for hoary bat live capture. Nevertheless, the proposed study duration of three years will greatly enhance the opportunity to obtain statistically robust telemetry data on large numbers of bats.

Bats will be tagged with transmitters ≤5% body weight (Sikes et al. 2011) that operate continuously up to 40 days (BD-2XC model, Holohil Systems). Automatic Receiving Units (ARU; Orion model; Sigma Eight) will scan transmitter frequencies with 6 to 8 directional antennae while recording signal strength, date, and time used in combination with a network of 20 or 40 ft high antennae masts. Post-processing converts signal strengths into bearings and bat location is triangulated from multiple masts. Field testing has confirmed a reception potential of 30 km. Masts may be repositioned as needed to track long range bat movements.

Ground-crews will supplement the ARU system using hand-held receivers and directional yagi antennae to track bats to day roost locations and record fine-scale foraging movements from close range. Warbling (rapidly variable) versus steady signal strengths from radio transmitters will allow us to reconstruct flight and roost time budgets within each night.

Near-infrared and thermal videography will image roosting individuals, particularly recording mother-pup behavior and documenting pup survivorship. A Fluke Thermal Imaging Camera (FLUKE FLK-TIS75 30HZ Thermal Imager with IR-Fusion Technology, -20 °C to

550 °C, 320 x 240 Resolution, 30 Hz) will remotely measure bat skin temperature while roosting and temperature of surrounding foliage at the roost to track thermoregulatory patterns and the possible use of shallow torpor. Data loggers (iButton DS1921) also will record ambient temperature in roost trees.

Seasonal patterns in habitat use and movement patterns will be derived from the movement of successive individuals across a year to quantify composites of annual home range and population movements. Data will be analyzed with customized R software to determine spatial coordinates that will be mapped with ArcGIS to determine range size, elevation, and land-cover associations. Vegetation attributes of trees and stands used by bats as day roosts will be compared to randomly selected stands. Tree attributes will include species, diameter, height, roost aspect, elevation, and proximity to nearest road. Stand attributes will include land-cover class, composition of neighboring dominant tree species, canopy closure, and understory density. Roosts will be monitored with surveillance cameras to obtain information on predators, mother-pup behavior, frequency and duration of foraging bouts, time budgets and pup survivorship (Winchell and Kunz 1993). Acoustic sampling at roost sites will collect information on vocalization including mother-pup communication.

Home range – Bat locations from telemetry will be analyzed with kernel density estimators in the R package *adehabitat*. Brownian bridge movement modeling will predict trajectories of movement between successive locations (Horne et al. 2007).

Foraging habitat - Euclidean distance analysis will quantify habitat use (Conner and Plowman 2001) by comparing the mean distance of an individual's locations to each habitat type and the mean distance of a set of random locations to each habitat type. This analysis: 1) does not require explicit error modeling or equal sampling of individuals; 2) avoids habitat misclassification resulting from telemetry error; and 3) allows evaluation of surrounding habitat regardless if included within home range (Conner et al. 2003).

Roost selection and behavior – Logistic regression models will compare tree and stand characteristics at day roosts to randomly selected locations. An information theoretic model will rank variable importance. Descriptive statistics on behavior and body temperatures will be produced from video, thermal imaging, and acoustic recordings of mother-pup interactions at roosts. Generalized linear models will examine the proportion of the night which bats spend roosting and foraging, and its relationship to reproductive condition, regional weather conditions (temperature, precipitation, wind speed and barometric pressure), moon illumination and time of year (Anthony et al. 1981).

Insect Prey Base and Host Plant-Insect Associations

The abundance of nocturnal, flying insects that may act as prey for bats will be quantitatively assessed in the second and third years of radio-tracking after important foraging locations have been identified. Site selection for insect sampling will include low elevation rain forest, mid elevation rain forest, high elevation shrubland with lava tubes present, macadamia nut orchard, and a mixed agro-ecosystem with cattle because Todd (2012) identified insects associated with cattle in the bat's diet. We will use several standard entomological methods to assess insect diversity and abundance, including light traps, malaise traps, sweep nets, and lightly beating vegetation. Light traps utilize ultraviolet light to attract night-flying insects and are particularly effective at attracting moths and some beetles. Light traps utilize ultraviolet light to attract night-flying insects and are particularly effective at drawing moths and some beetles. Malaise traps are mesh, tent-like structures that intercept insects that fly close to the ground and trap a wide variety of insects but most effectively collect moths and flies. An insect net will be used to sweep grass and a beating stick and sheet will be used to dislodge and collect insects from shrubs and trees. The latter two methods will focus on collecting beetles and moth larvae (caterpillars) that can be projected as future prey in the adult moth. Collectively, these methods will sample the vast majority of the potential prey base. However, if diet analyses suggest that we are missing particular prey then we will adapt our sampling strategy to target those taxa (e.g. bark emergence traps aimed to collect bark beetles).

The bat prey base assessment will be conducted over five day periods at two month intervals at 5-6 sites within the study area (Figure 1). At each site, two light traps and two malaise traps will be operated; light traps will be operated 3-4 nights per month and malaise traps, which run continuously, will be serviced twice per month. For each of the most common species of grass, shrub and tree, 20 sweep-net or vegetation beating samples will be obtained during the sampling period. Regardless of abundance, we will sample mature specimens of the plant species that are currently being out-planted as part of the effort to restore native plants throughout the state (Table 1). All arthropods collected will be counted, weighed, and identified to species or to the greatest taxonomic precision practical.

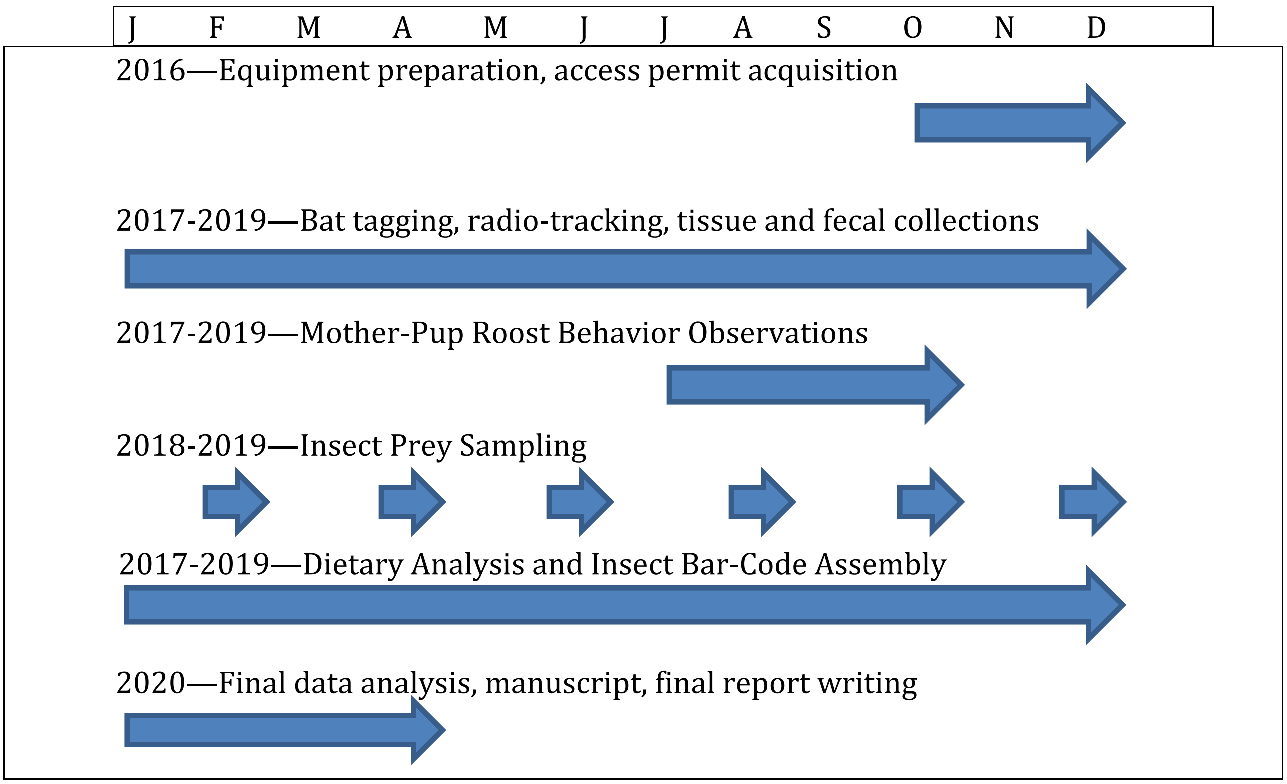
Insect Reference Library Barcoding and Hoary Bat Dietary Analysis

Detailed information on the insect prey taxa and relative compositions of prey within Hawaiian hoary bat diets are generally understated in previous studies concerning food habits and dietary needs for this endangered species. Past studies exploring the composition of hoary bat diet have relied on microscopy and dried collection comparison methods to determine the taxonomic identity and general abundance of insect prey items (Belwood & Fuller 1984, Jacobs 1999, Todd 2012, Valdez & Cryan 2013). These methods can limit or even bias the information gained since hard-bodied insects, such as beetles, are easier to recognize from fragments in the fecal matter than those with soft bodies, such as moths. New molecular genetics techniques are available that overcome many of the observational limitations in insect identification by using DNA barcoding (Clare 2014, Pompanon et al. 2012, Zeale et al. 2011) and have been successfully used on many bat species around the world including tree-roosting lasurine bats (Clare et al. 2009) and endangered bat species including the Ozark big-eared bat (Van Den Bussche et al. 2016). Specifically, the use of high throughput sequencing and meta-barcoding analyses of the mitochondrial cytochrome I gene (COI) of insects have aided in detecting the diversity and quantifying the relative contributions of insect taxa in bat diets across differing habitats, seasons, between the sexes, and prey selection (Bohmann et al. 2011, Burger et al 2013, Clare et al. 2014, Mata et al. 2016, and Vesterinen et al. 2013, 2016)

We will utilize meta-barcoding services and bioinformatics analysis at the University of Hawaii, to prepare and sequence thousands of insect CO1 barcodes from each individual fecal sample using high-throughput sequencing techniques. Barcodes generated from bat fecal pellets will be compared to a library of insect DNA barcodes sequences established from our insect sampling from the sites within our 1,500 km^2 field study area and publically available barcode databases (such as BOLD, www.barcodinglife.org). This reference library database will be based on the CO1 gene barcodes which has been cross-checked with local insect distribution and publically available data. Thus, we will identify insects consumed by bats to the most specific level of taxonomy possible, in many cases to species level. Our analysis will look for differences in diet for bats of differing sex, age class, season, foraging habitat and available prey.

TIMETABLE AND MILESTONES

Hoary Bat Research Timeline



PERMITS AND AUTHORIZATIONS

U. S. Geological Survey holds current research/take permits from U. S. Fish and Wildlife Service (Permit TE 003483-29) and Hawaii Department of Lands and Natural Resources (Permit WL-16-04), and additionally has an approved IACUC protocol approved by the University of Hawaii for vertebrate animal research. USGS has an excellent network of contacts with both private and public land stewards throughout the island of Hawaii that have frequently provided access to lands for bat research.

MONITORING AND EVALUATION

The project manager will closely supervise all aspects of research. Staff will have periodic meetings (usually quarterly) with the project manager and with supervisory directors of USGS and HCSU. Data downloads (e.g. telemetry data will be downloaded and reviewed frequently to better position tracking stations for focal animals) will be reviewed on weekly, monthly, bimonthly schedules as appropriate for specific analyses and cumulative data sets updated frequently. Project managers will employ adaptive management to improve and refine data collection with major reviews of success or weakness each year as the project proceeds. Annual reports will be provided to key wildlife management contacts (ESRC, DOFAW, USFWS) as well as oral reports or posters at the annual Hawaii Conservation Conference. Research staff will be available for phone consultations with wildlife managers when management issues arise in which new data inputs from the project may be helpful as updates.

ORGANIZATIONS

U. S. Geological Survey (USGS) is based at Kilauea Field Station inside Hawaii Volcanoes National Park and offers computer and research labs and a large multi-disciplinary staff of senior biologist researchers and technicians.

Hawaii Cooperative Studies Unit (HCSU) is based at the University of Hawaii at Hilo and offers research lab facilities and opportunities to collaborate with senior staff, technicians and students in the biological sciences.

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Appendix 31

MEMORANDUM OF UNDERSTANDING

BETWEEN

KAHEAWA WIND POWER II, LLC

AND

THE STATE OF HAWAIʻI
Department of Land and Natural Resources
Division of Forestry and Wildlife

(Monitoring of Nene and Predator Control Management on the Island of Maui – Tier 1 Nene Mitigation Obligations under the Kaheawa Wind Power II Habitat Conservation Plan)

1. Preface.

This Memorandum of Understanding ("MOU") is made on July ___, 2018 between Kaheawa Wind Power II, LLC (hereinafter referred to as "KWP II") and The State of Hawaiʻi, Department of Land and Natural Resources, Division of Forestry and Wildlife ("DOFAW").

WHEREAS, on January 5, 2012 the Board of Land and Natural Resources ("BLNR") approved KWP II's Final Habitat Conservation Plan (HCP) and issued to KWP II a State Incidental Take License ("ITL") pursuant to Hawaiʻi Revised Statute Chapter 195D, authorizing the incidental take of the following Covered Species: Nēnē (*Branta sandvicensis*), Newell's Shearwater (*Puffinus newelli*), Hawaiian petrel (*Pterodroma sandwichensis*), and Hawaiian Hoary Bat (*Lasiurus cinereus semotus*) on property owned or otherwise controlled by KWP II on the island of Maui;

WHEREAS, the HCP and State ITL provide that certain mitigation and monitoring tasks be implemented, and provide that DOFAW or another qualified entity may implement certain of those mitigation and monitoring tasks using funds to be provided by KWP II in partial fulfillment of the requirements of the HCP;

WHEREAS, DOFAW and KWP II have identified Nene nesting and release sites on the island of Maui that will benefit from predator control, monitoring, and vegetation management actions;

WHEREAS, KWP II and DOFAW, by mutual agreement, desire to establish a MOU pursuant to which KWPII and DOFAW will collaborate from April 1, 2016 to June 30, 2019 on efforts to protect and mitigate take for endangered Nene on Maui, and DOFAW will provide staff directly and all necessary equipment deemed appropriate to conduct Nene predator control, monitoring, and vegetation management;

NOW, **THEREFORE,** KWP II and DOFAW mutually agree to the following:

2. Purpose.

The purpose of this Agreement is to establish a MOU whereby:

- KWP II accepts the proposal by DOFAW titled *Scope of Work for Maui Nui Nene Monitoring and Predator Control Management* UPDATED April 15, 2018 (hereinafter referred to as the "Scope of Work");
- DOFAW will implement the Scope of Work for the purpose of providing Tier 1 mitigation for the incidental take of Nene during construction and operation of the KWP II project; and
- KWP II will have provided funds to DOFAW necessary to implement the Scope of Work indicated, the "Amount Requested" in the Scope of Work.

This MOU does not negate or affect any other agreements in effect between KWP II and DOFAW. The attached Scope of Work may be updated by agreement from both parties in order to maintain the purpose and intent of this MOU, in concurrence with the U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office (USFWS PIFWO).

3. Responsibilities.

DOFAW**:**

- Will implement the Scope of Work (Attachment 1). This Scope of Work covers activities from April 1, 2016 to June 30, 2019. This Scope of Work has been reviewed by DOFAW, KWP II, and the USFWS PIFWO.
- Will report to KWP II and USFWS PIFWO as specified in the Scope of Work attached to this Agreement.
- Will have deposited checks from KWP II, described below, in the State of Hawaiʻi Endangered Species Trust Fund, and ensure that such deposits have been specifically designated for use by DOFAW to implement the attached Scope of Work.
- Will provide a budget plan for the Amount Requested and maintain an ongoing accounting of the funds spent implementing the attached Scope of Work including any expenditure reports and will provide these to KWP II upon request.

KWP II:

- Will have, within 60 days of the execution of this MOU, delivered a check to DOFAW in the Amount Requested for the attached Scope of Work.

4. Implementation

The parties agree that this MOU constitutes a commitment by KWP II and DOFAW to collaborate on the projects described in the Scope of Work (Attachment 1), a commitment by KWP II to have provided DOFAW with funds to be used to benefit and provide mitigation for the incidental take of Nene as described in the HCP, and a commitment by DOFAW to utilize such funds to implement the attached Scope of Work. The parties further agree that completion of the projects described in the attached Scope of Work will begin to satisfy Tier 1 mitigation requirements for Nene as set forth in the HCP and will provide information to be able to determine what additional actions and cost will be necessary to completely satisfy Tier 1 mitigation requirements. Performance by DOFAW of the mitigation actions depends upon the timely receipt of funds from KWP II.

5. Termination

For any reason whatsoever, either party may terminate involvement in this MOU by providing 90 days prior written notice to the other party. Any unused funds will be returned to KWP II.

6. Counterparts

This MOU may be executed in several counterparts, each of which shall be an original and all of which shall constitute one and the same document. By signing below, each indicates that they have the requisite authority to enter into this Memorandum of Understanding.

IN WITNESS WHEREOF the **PARTIES** hereto have executed this, **MEMORANDUM OF UNDERSTANDING** by way of signature and date below.

Kaheawa Wind Power II, LLC:

_________________________ Date:______________

Marc Fioravanti
(*VP Wind Operations*)

Department of Land and Natural Resources
Division of Forestry and Wildlife:

_________________________ Date:______________

Suzanne D. Case, Chairperson
Board of Land and Natural Resources

APPROVED AS TO FORM:

____

Deputy Attorney General
State of Hawaii

Attachment 1. Scope of Work for Maui Nui Nene Monitoring and Predator Control Management

PROPOSAL

to

KAHEAWA WIND POWER II

PROJECT TITLE:	Maui Nui Nene Monitoring and Predator Control Management
DEPARTMENT:	Land and Natural Resources
DIVISION:	Forestry & Wildlife
DISTRICT:	Maui
PROJECT PERIOD:	April 1, 2016 to June 30, 2019
AMOUNT REQUESTED:	$162,750.00

Maui Nui Nēnē Monitoring and Predator Control Management

Project Description

On January 5, 2012 the Board of Land and Natural Resources approved the Kaheawa Wind Power II Habitat Conservation Plan (HCP) and Incidental Take License (ITL). The ITL authorizes the incidental take of the Nēnē (*Branta sandvicensis*).

The project objective for Maui Nui Nēnē Monitoring and Predator Control Management is to assist in the recovery of the Nēnē (*Branta sandvicensis*). The primary objectives are to establish predator control and remove invasive vegetation in and around the open-top release pen at Pi'iholo Ranch.

Project Objectives and Tasks

- Establish and maintain trap lines at Pi'iholo Ranch. Traps or other methods will control rats, mongoose, cattle egrets, feral cats and dogs that may pose a threat to Nēnē and their nesting sites. No rodenticides will be used. Trapping protocols and control methods will follow state guidelines for humane treatment of animals. Trapping will be year-round.

- Control alien plants at Piʻiholo Ranch using chemical and mechanical means, mow grass areas, and assist native vegetation restoration at this open-top release pen site. Herbicide application will follow state and federal use guidelines.

- General maintenance of the open-top release pen including maintenance of storage buildings, fence lines and water units.

- Monitor movements, nest success, distribution and survival of Nēnē at the Pi'iholo open-top release site. Keep records of individual birds sighted, GPS nest locations, and nesting activities and hatching and fledging success. Assist examinations, measurement and banding of unidentified birds. All birds will be banded if possible.

- At Pi'iholo, the baseline number of fledglings is considered zero since all fledglings produced in the period covered by this proposal will be from actions funded under this proposal. In state fiscal year 2017, the number of nests recorded in the pen were 10 nests. The total fledglings produced was zero. There has not been sufficient state funding in the past years to successfully control predators and consistently produce fledglings.

Reporting

Detailed records kept of adults present and band resightings; nesting attempts, eggs hatched and fledglings successfully produced; trap location maps, trap types, trap days, and predator types and number removed; and number of nēnē banded will be submitted in an annual report by July 15 each year.

Coordination

Coordinates with Maui Branch Nongame Biologist.

Figure 1. Pi'iholo Ranch Pen: A one acre open-top release pen in Makawao, Maui.

Figure 2. The seventy trap locations of Tomahawk, Sherman, and A24 traps around and in Piiholo Ranch open-top release pen.

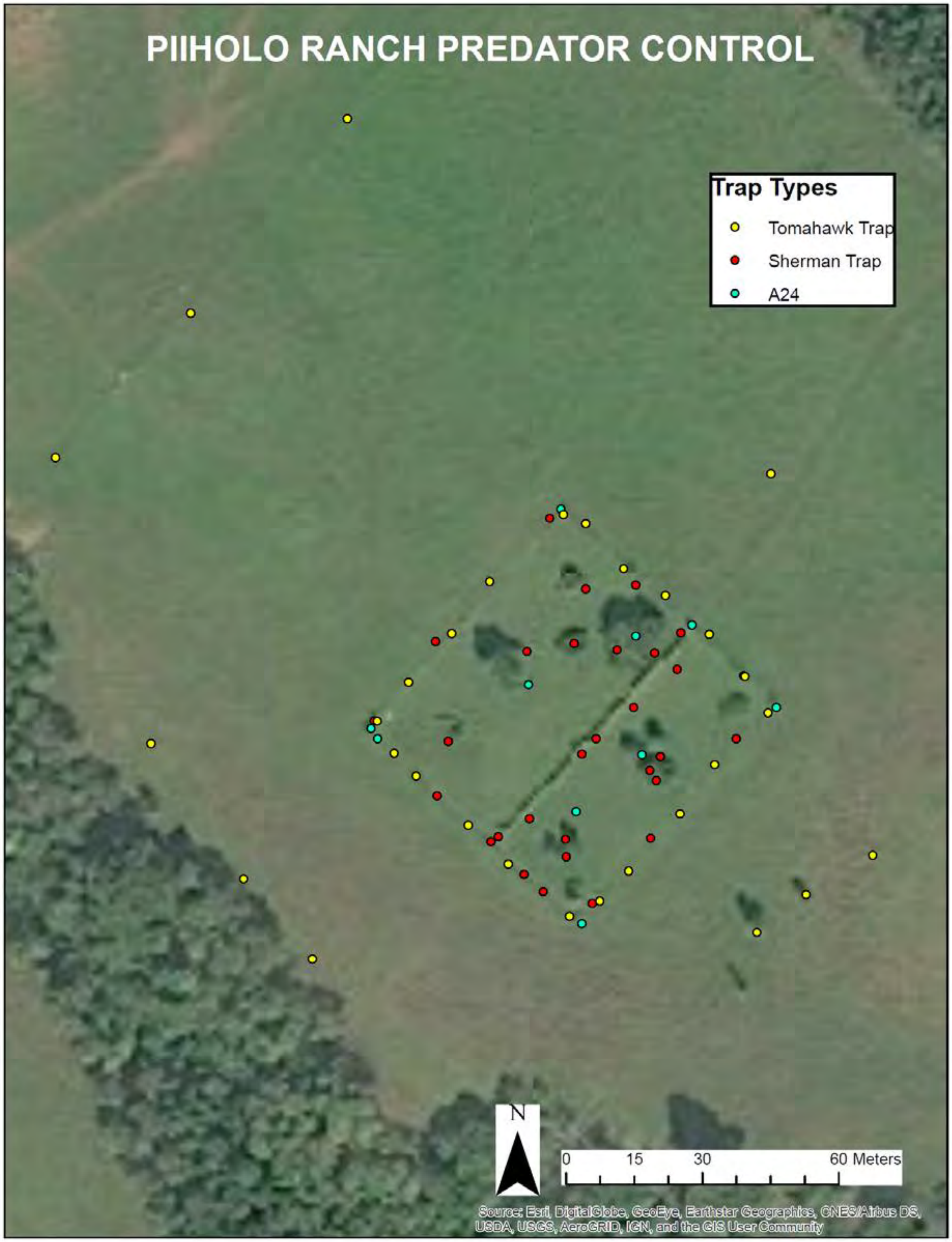


Table 2. Pi'iholo Ranch Pen Trap Types.

Trap Type	Trap Number	Target Predator	Trap Visit Frequency
Tomahawk Traps	**30**	**Cats, Mongoose, & Rats**	**Year-round**
Sherman Traps	**30**	**Rats, Mice, and Mongoose**	**Year-round**
A24s	**10**	**Rats & Mice (Mongoose)**	**Year-round**

Table 4. Overall Budget for Service Period Proposed (April 1, 2016 to June 30, 2019).

Category	Detail	Cost
Funding Source	KWP II	**$162,750**
Positions funded	Wildlife Field Assistants (2)	**$151,250**
Administrative fee	X% of Positions/Equipment/Supplies	**$11,500**

Site Specific Plan and Budget

Table 5. Pi'iholo Ranch Pen Annual Budget.

Position	Task	Hours/week	Cost/week	Annual Cost
Wildlife Field Assistants (2)	Trapping	20 hours/week	$777/week	$40,385
	Vegetation Management	20 hours/week	$777/week	$40,385
	Travel	4 hours/week	$146/week	$7,592
	Data management	10 hours/week	$314/week	$16,312
	Sightings	10 hours/week	$314/week	$16,312
	Maintenance	16 hours/week	$582/week	$30,264

Success Metrics/Adaptive Management

1) Results of each year's efforts will be reviewed by the USFWS, DLNR-DOFAW (Oahu) and by the ESRC at the annual HCP review.
2) Based on results and review, the agencies will provide suggested changes to the scope of work (if warranted). These could include increasing trap effort, changing trap types,

increasing area to be managed or finding a new area to attempt to manage and protect (with a new scope of work approved).

3) The survival rate for fledgling to adult (over two years) is assumed to be 64%. Therefore 1.56 fledglings must be produced for every adult nēnē take estimated. For Tier 1 at least 31 fledglings ((18*1.56) + 3 = 31) would be required to be produced. For Tier 2 alone, an additional 14 fledglings (9*1.56 = 14) would be required and for Tier 3 alone an additional 22 fledglings (14*1.56 = 22) would be required.

Appendix 32

FY 2017 –KAHIKINUI FOREST RESERVE MANAGEMENT INITIATED FOR HAWAIIAN HOARY BAT MITIGATION for Kaheawa Wind Power II, ISLAND OF MAUI

Prepared by: Lance De Silva, Forest Management Supervisor
Division of Forestry and Wildlife, Maui Branch

INTRODUCTION

Since June 4, 2014, the Division of Forestry and Wildlife (DOFAW) is actively managing 340 acres within the Kahikinui State Forest Reserve (SFR), and including ungulate eradication in the larger surrounding units of the Nakula Natural Area Reserve (NAR) and Kahikinui SFR. Kaheawa Wind Power II, per their Habitat Conservation Plan (HCP) and the requirement to mitigation for incidental take of the Hawaiian Hoary Bat, has provided some of the funding for this work. Maintaining "zero" tolerance for ungulate presence, restoring and creating native habitat, and increasing native bird and bat populations are some of the multiple management efforts that continue to be geared for this area. These management efforts continue to be conducted and managed primarily by Maui DOFAW staff.

OVERVIEW

All helicopter services have continued to be procured with Windward Aviation, a Maui based company. The pilots' familiarities with the area, weather and flying conditions, and type of contract operations required for this type of work continue to be beneficial to the efficiency of the project and overall continued success. The construction and maintenance of temporary landing zones and campsites near the project area has also provided work crews with better accessibility. During the past year, the area has seen average seasonal weather patterns as compared to last year's above normal precipitation accumulations.

Since the initial efforts to remove the feral ungulates in October 2014, staff members have continued to notice significant changes within the project area, as well as the surrounding Nakula NAR and Kahikinui SFR. There continues to be an increase in grass and native shrub growth and, more noticeably, a steady increase of bracken fern *(Pteridium aquilinum)* recruitment in the hardpan and gulch areas. Large sections of rock surface areas are being populated with these bracken ferns. As mentioned in last year's report and still holds true through this year, the most impressive change has been the increase in natural generation of native flora, specifically koa *(Acacia koa)* and pukiawe *(Styphelia tameiameiae)*; largely in part due to a viable seed bank and ungulate free environment. We continue to see an increase in game bird species presence and activity, as well as an increase in sightings of nene, all of which are positive improvements. There are currently 29 Hawaiian petrel *(Pterodroma sandwichensis)* burrows located and documented within the Nakula NAR/Kahikinui FR's ungulate proof fenced unit, as well as visual and acoustic confirmation of presence of Hawaiian hoary bats *(Lasiurus cinereus semotus)*. With the absence of feral ungulates, there are new issues that have risen and continue to threaten the restoration and reforestation efforts; most significantly, the threats of increased fuel loading and weed infestation. Plans to install firebreaks along the ungulate proof fenceline are scheduled for spring 2018. These issues are being addressed through various control and mitigation efforts, and continuous collaborations and discussions between agencies are on-going. In May 2016, DOFAW was awarded a USDA Forest Service State & Private Forestry (S&PF) grant that will help address some of the challenges identified in last fiscal year's end of year report.

ACTIVITIES & RESULTS

Fencing

Approximately 2.8 miles of fence apron was installed in July 2014 by DOFAW Forestry Program field crews. This fence section is part of the 7.3 miles of ungulate proof fence that has been installed to protect the entire Nakula NAR and sections of the Kahikinui SFR from encroaching ungulates. This protected larger unit encompasses approximately 2,700 acres. Four inspections, including one inspection immediately following the onset of a storm front (July 2016) have been conducted by DOFAW staff while conducting aerial control missions for feral ungulates within the reserves.

DOFAW personnel continue to maintain approximately 2.8 miles of white poly tape along the fenceline to prevent bird strikes.

Ungulate Control

During the reporting period for fiscal year 2017, a total of three aerial control missions (approximately 4.5 hours total flight time) were conducted by DOFAW staff resulting in 8 feral goats and 1 feral pig dispatched within the entire Nakula NAR and Kahikinui SFR unit. Since the initial mission completed in October 2014, DOFAW has dispatched 696 feral goats and 18 feral pigs within the fenced unit resulting in near "zero" presence and therefore has entered the "maintenance" phase of the animal removal project and will continue to conduct aerial surveys on a quarterly basis. To ensure 'zero' tolerance, a collared goat also referred to as a 'Judas' goat was placed within the unit in July 2016 to 'round up' any remaining goats, taking advantage of its natural instinct to socialize and congregate. As long as ungulates remain outside of the fenced unit, it is crucial to continue these survey missions.

Quarterly scheduled aerial control missions to monitor ungulate presence within the unit will continue in fiscal year 2018. Ungulates detected during subsequent monitoring flights will be dispatched accordingly in a timely manner through scheduled aerial control missions. New detections or ungulate ingress into this protected unit may, at any time, occur because of a fence break that may be caused by inclement weather, vandalism, normal wear and tear, etc. Per our DOFAW Forestry Program's fence maintenance protocol, personnel will continue to conduct regular scheduled fence checks throughout the year, as well as immediately following the onset of any strong weather disturbances that may pose a threat to the integrity of the fence.

Plant Quality and Procurement

The out-planting work for this reporting period covered approximately 27 acres of the 340 total acres of the project area. During this period, 12,988 native plant seedlings were out-planted, making the total number of native plant seedlings out-planted within the unit at approximately 55,000 since the initial reforestation efforts began. Another 20,000 seedlings were procured in fiscal year 2017 and will be planted in fiscal years 2018-19 to supplement and account for anticipated plant mortality due to various causes.

A new experimental product utilizing a self-condensing 'planter's' box will be installed on an experimental basis in several hard pan areas where success and survivorship of recently out-planted seedlings have been mildly low.

Site Preparation – Soil Testing/Conditioning

Several soil collections from various areas within the unit were conducted in July 2015 and samples were sent for analysis in August 2015. In general, the majority of the sites contain sufficient to high levels of pH and calcium, while showing deficiencies in potassium, phosphate, and magnesium. Recommendations on how to improve soil conditions have been noted for future field application use. Results are used to monitor the survivorship of out-planted seedlings and natural regenerated populations to determine if supplementing the soil conditions is necessary. Collecting and analyzing soil samples to evaluate deficiencies remain a priority and will aid in future reforestation and restoration efforts. Soil sampling is anticipated for fiscal year 2019 to evaluate how the area or soil conditions are changed or influenced by the increase of seedlings growing in the area.

Grass control treatments for site prep work within the 340 unit that were scheduled for fiscal year 2017 were completed on September 9, 2016. Approximately 50 acres were treated and portions of the treated area were out-planted in spring and summer of 2017 (Figure 1).

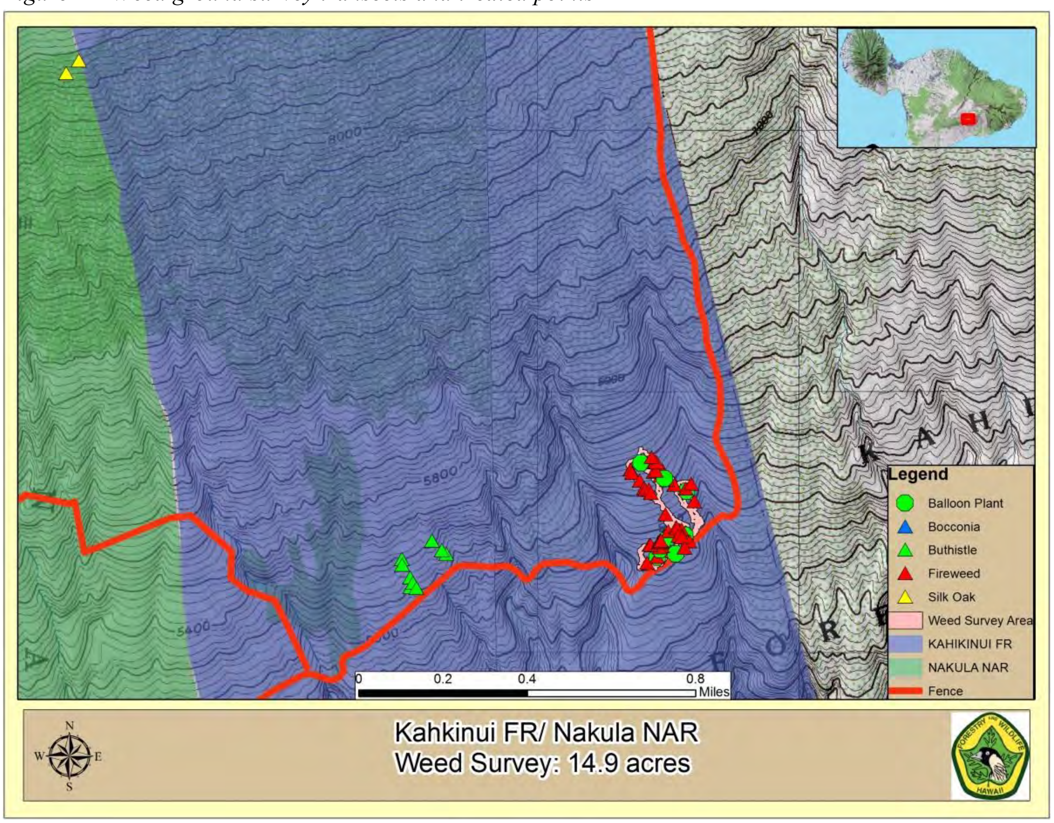
Figure 1 – Aerial view of the grass treatments in the Kahikinui FR project area (areas depicted in grey contrast above fenceline)

Weed Monitoring and Suppression

One aerial weed survey covering the entire Nakula NAR and Kahikinui SFR unit, as well as one ground survey targeting the 340 acre project area were conducted in fiscal year 2017. As in the previous year, the aerial survey focused primarily on Rapid Ohia Death (R.O.D). Fortunately, there were no visual signs or symptoms of the disease. Forestry personnel who are conducting aerial control missions within the unit continue to survey for weed species during their missions. Fireweed (*Senecio madagascariensis*), bull thistle (*Cirsium vulgare*) and balloon plant (Asclepias physocarpa) were sighted and documented across the lower elevations of the Nakula NAR and Kahikinui SFR.

The ground survey covered approximately 15 acres and targeted the southeastern portion of the project unit where the first phase of seedlings were out-planted (Figure 2). As a result, forestry program personnel detected and removed 2 mature silk oak trees *(Grevillea robusta)*, 10 mature balloon plants *(Asclepias physocarpa),* 20 bull thistle plants *(Cirsium vulgare),* and 520 fireweed plants *(Senecio madagascariensis)*.

Figure 2 – Weed ground survey transects and treated points



Partnering agencies will continue to work to monitor and control populations of bocconia *(Bocconia frutescens)* that are sited outside of the project area to prevent further spread into this unit. Subsequent weed surveys are scheduled for this area to ensure early detection and rapid response.

Table 1. Schedule of Mitigation Activities

Implementation Activities	Fiscal Year 2017				Entity Responsible	Total Cost
	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr		
Fence Inspection	XX	XX	XX	XX	DOFAW Maui Nui Branch	*included into aerial control missions
Aerial Control Eradication and Tagging of Animals (ACETA) Activities			XX	XX	DOFAW Maui Nui Branch	**$7,500.00** *$7,500 paid by DOFAW
Soil Sampling and Conditioning	XX				*DOFAW Maui Nui Branch submitted to CTAHR for analysis in July 2016	**$15.00** *sampling fee by CTAHR paid with DOFAW funds
Plant Procurement			XX	XX	Obtained from Native Nursery, LLC by DOFAW	**$59,999.68** *procured approximately 20k seedlings paid by DOFAW fed grant
Planting of Overstory/Understory Species	XX	XX	XX	XX	DOFAW Maui Nui Branch	**$19,065.00** *costs included overstory/understory cost paid by DOFAW
Weed Surveys/Site Prep	XX	XX	XX	XX	DOFAW Maui Nui Branch	*weed surveys included into aerial control missions paid by DOFAW ***$2,665.00** for site prep paid by DOFAW
Survivorship Monitoring	XX		XX	XX	DOFAW Maui Nui Branch	**$8,608.00** *costs paid by DOFAW
Total						**$97,852.68**

MEASURES OF SUCCESS

According to the HCP, prior to the start of management measures, the following must be achieved:

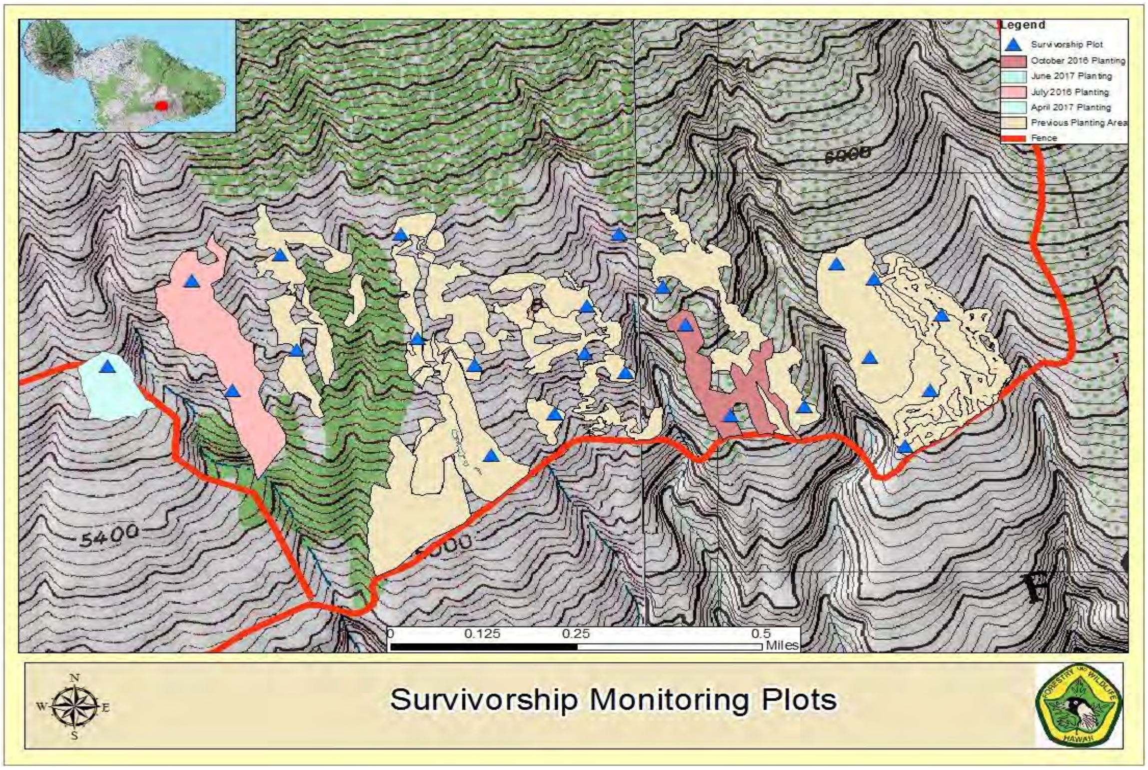
a. **Survivorship monitoring of out-planted seedlings.** Survivorship plots are randomly established throughout the planting area. Plot size is 1/10 acre with a radius of 37.2 feet from plot center. The vigor of the plot is noted on a scale from 1-3, where 1 is poor health and 3 is excellent health. A general survey of the top 3 dominant flora besides the planted trees within the plot is also recorded. Plots are scheduled to be revisited every six months. Forestry personnel have installed another 4 plots in addition to the existing 20 plots (11 grass, 3 rock/grass, 2 rock, 4 hardpan, and 4 herbicide treated) to date, covering all substrate and ground cover types (Figure 3). The results of these monitoring plots represent the average % of plants surviving per plot per ground type since initial out-planting. The monitoring and installation trips were completed on August 4, 2016, February 13, 2017, March 15, 2017 and June 15, 2017. The results are as follows:

Grass average = 74.9%
Grass/Rock average = 75.6%
Rock average = 45.3%
Dirt/Hardpan average = 40.7%
Herbicide pretreated average = 87.3%

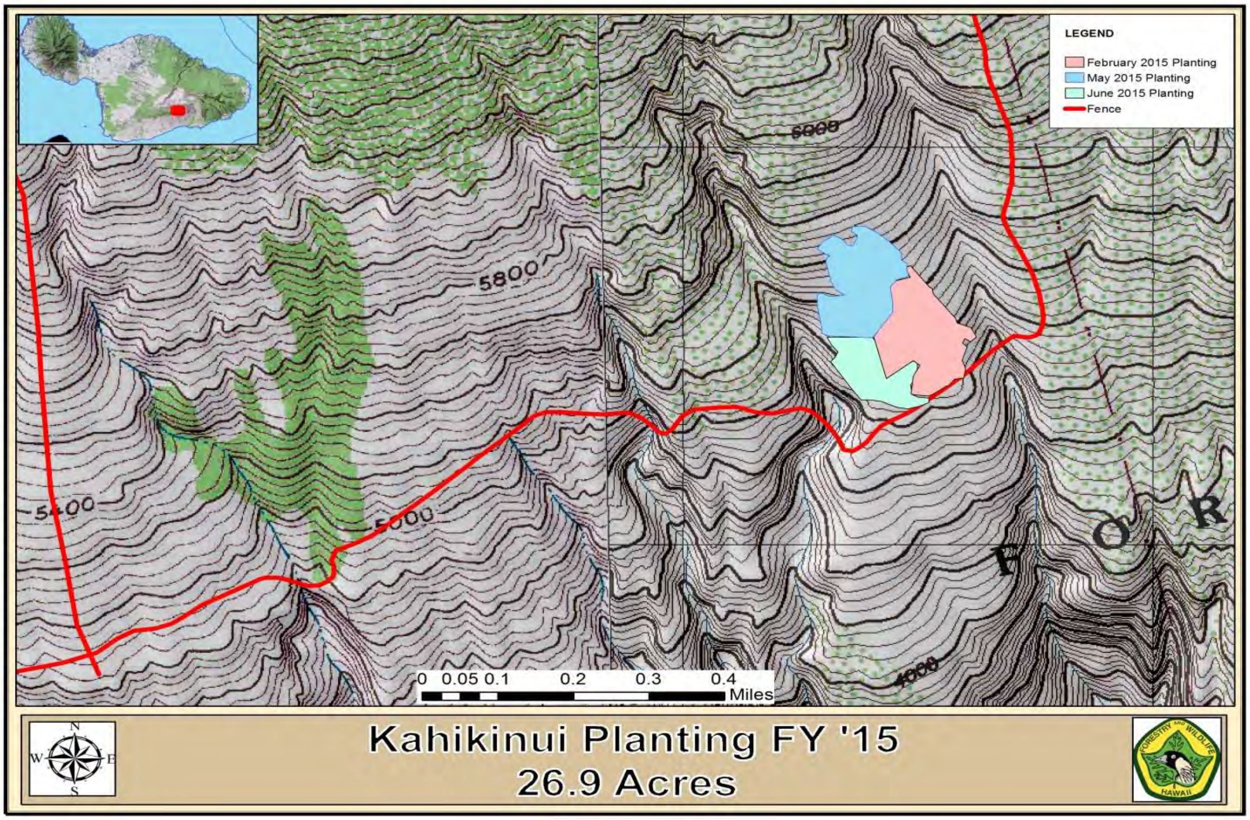
By Species:
Koa *(Acacia koa)* – 541/656 *overall yielding a 82.47% survival rate
Aalii *(Dodonaea viscosa)* – 315/400 *overall yielding a 78.75% survival rate
Pilo *(Cosprosma spp.)* **-** 41/42 *overall yielding a 97.62% survival rate
Ohia *(Metrosideros polymorpha)* – 71/78 *overall yielding a 91.03% survival rate
Mamane *(Sophora chrysophylla)* – 50/65 *overall yielding a 76.9*2% survival rate

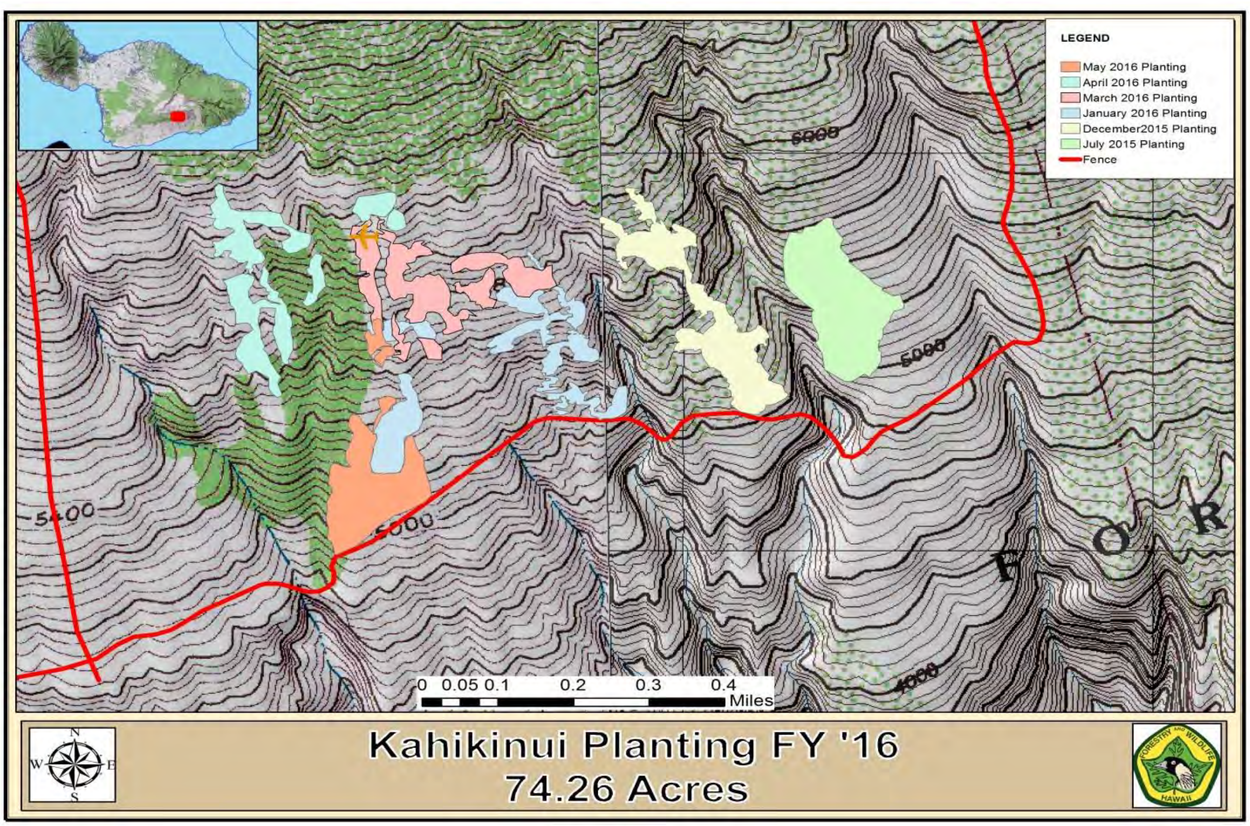
**other plant species such as Osteomeles anthyllidifolia, Santalum freycinetianum, and Cheirodendron trigynum were not present in the random sample plots taken so far.*

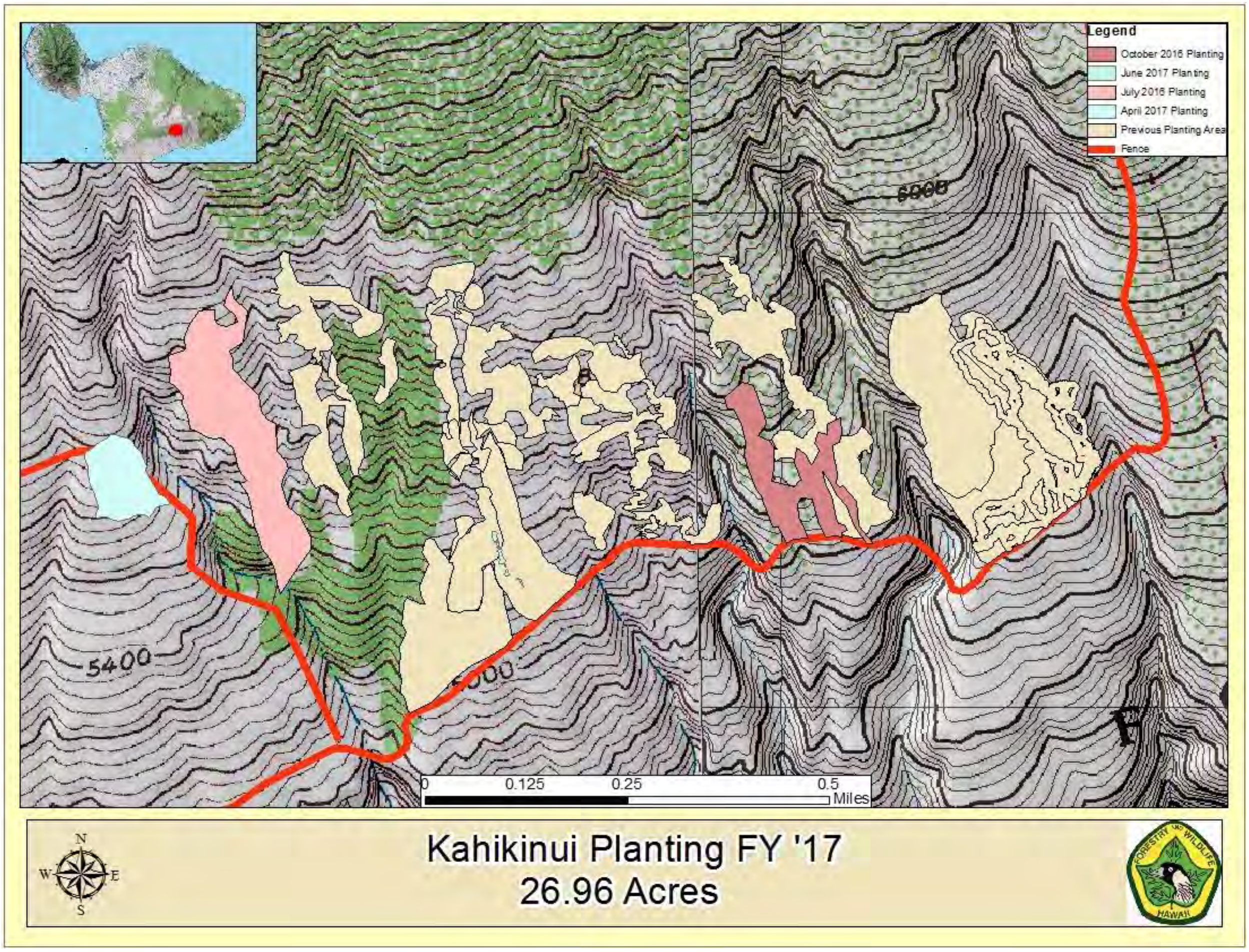
Figure 3 – Survivorship Monitoring Plot Locations



APPENDIX 1 – MAPS, LISTS & PHOTOS







Outplanting Taxon By Subunit

Subunits = <All>
From 1/1/2015 to 6/30/2017

Kahikinui-Nakula Units-Ka

Action = Plant

Taxon:	***Quantity:***
Acacia koa	32197
Argyroxiphium sandwicense	59
Cheirodendron trigynum sub	236
Coprosma ochracea	32
Coprosma waimeae	270
Deschampsia nubigena	1578
Dodonaea viscosa	10901
Metrosideros polymorpha	4133
Myrsine knudsenii	50
Osteomeles anthyllidifolia	161
Pisonia umbellifera	12
Santalum freycinetianum	15
Sophora chrysophylla	4776
Action Total Plants	54420
Polygon Total Plants	54420
Total all subunits	54420

Subunits = <All>

From 7/1/2016 to 6/19/2017

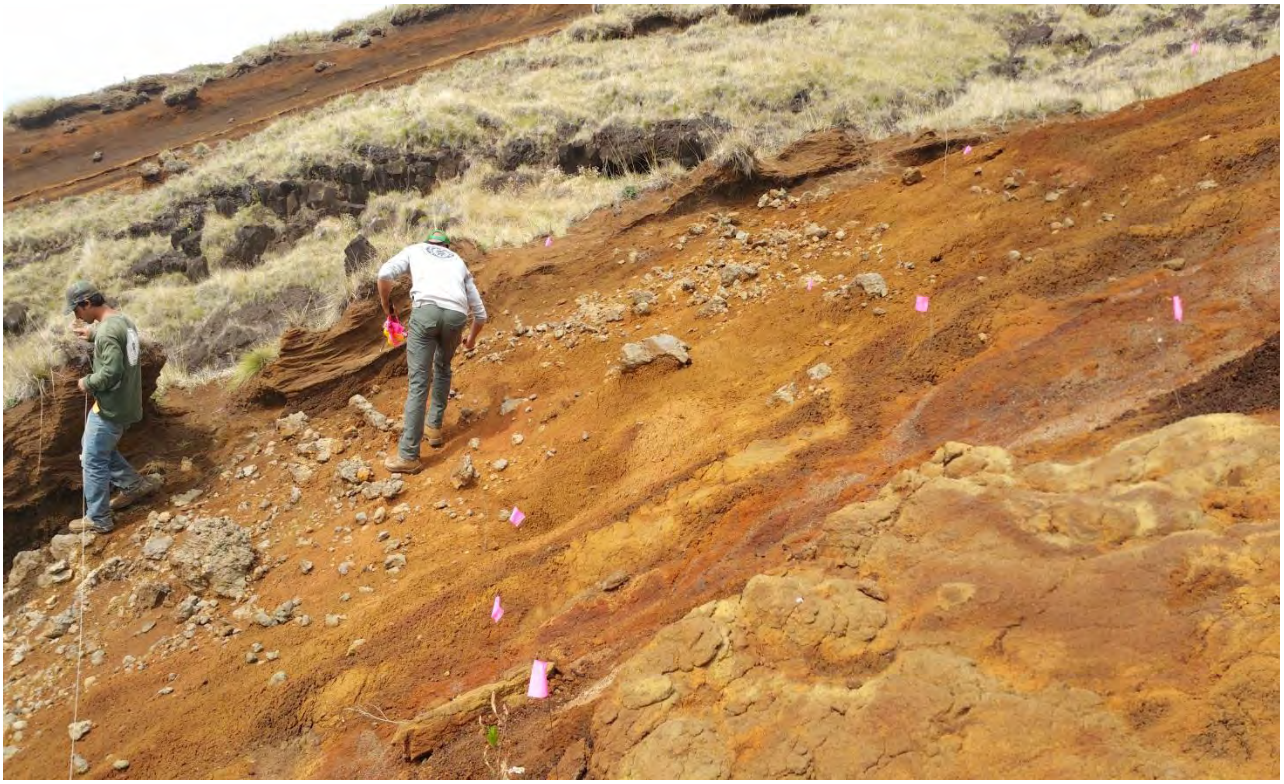
Kahikinui-Nakula Units-Ka

Action = Plant

Taxon:	*Quantity:*
Acacia koa	6785
Argyroxiphium sandwicense	59
Cheirodendron trigynum sub	145
Deschampsia nubigena	1578
Dodonaea viscosa	3809
Metrosideros polymorpha	350
Myrsine knudsenii	50
Pisonia umbellifera	12
Sophora chrysophylla	200
Action Total Plants	12988
Polygon Total Plants	12988
Total all subunits	12988

Temporary campsite located in the Kahikinui State Forest Reserve. View from project area looking makai with Pahihi Gulch in the background.

Acacia koa (koa) seedlings out-planted in the "hard pan" areas emerging above the non-native grass and bracken fern.



Forestry staff installing and monitoring survivorship plots in the "hard pan" areas.

Forestry staff using 5" blade auger machine to out-plant native seedlings in the project area

Natural regeneration of Acacia koa (koa) seedlings flourishing 8-12 months after removal of feral ungulates

Appendix 33

Low Wind Speed Curtailment Bat Mortality Rate Study Results

Region	Cut-in (m/s)	Full Feather	Treatment (LWSC m/s)	Average Reduction (%)	p Significant	Citation	Notes
Summerview Wind, Alberta	4.0	Yes	4.0	57	Yes	Baerwald *et al.* 2009	significance between control and each treatment, no difference between treatments
	4.0	No	5.5	60	Yes		no difference between feathering only and LWSC to 5.5 m/s w/out feathering
Wolfe Island Wind, Ontario	4.0	No	4.5	48	N/A	Stantec Consulting Ltd 2012	no statistical test, just averages, small sample size
	4.0	No	5.5	60	N/A		
Casselman Wind, PA	3.5	No	5.0	87	Yes	Arnett *et al.* 2009	no difference between treatments, 82% average for both treatments combined, small sample size
	3.5	No	6.5	74	Yes		
Casselman Wind, PA	3.5	No	5.0	68	Yes	Arnett *et al.* 2010	no difference between treatments, 72% average for both treatments combined, small sample size
	3.5	No	6.5	76	Yes		
Fowler Ridge Wind, IN	3.5	No	5.0	50	Yes	Good *et al.* 2011	significant 57.3% reduction between treatments
	3.5	No	6.5	78	Yes		
Fowler Ridge Wind, IN	3.5	Yes	3.5	36	Yes	Good *et al.* 2012	between treatments also significant
	3.5	Yes	4.5	57	Yes		
	3.5	Yes	5.5	73	Yes		
Fowler Ridge Wind, IN	3.5	Yes	5.0	84	Yes	Good *et al.* 2013	compared to Fowler Ridge 2010 without LWSC
Fowler Ridge Wind, IN	3.5	Yes	5.0	78	Yes	Good *et al.* 2015	
Fowler Ridge Wind, IN	3.5	Yes	5.0	71.8	Yes	Good *et al.* 2016	
Fowler Ridge Wind, IN	3.5	Yes	5.0	72.3	Yes	Good *et al.* 2017	
Fowler Ridge Wind, IN	3.5	Yes	5.0	66.3	Yes	Good *et al.* 2018	
Sheffield Wind, VT	4.0	Yes	6.0	62	Yes	Martin *et al.* 2017	combined 2012-2013, majority tree-roosting bats
Midwest US	3.5	No	4.5	47	Yes	Arnett *et al.* 2013	did not test 4.5 to 5.5 m/s between treatments
	3.5	No	5.5	72	Yes		
Pacific SW US	3.0	No	4.0	20	No	Arnett *et al.* 2013	4 hrs. from sunset only, low numbers of fatalities, 73.5 % Brazilian Freetail
	3.0	No	5.0	35	No		
	3.0	No	6.0	38	No		
	3.0	No	5.0	33	No		sunset to sunrise
Mt. Storm Wind, WV	4.0	Yes	4.0	72	Yes	Young *et al.* 2010	5 hrs. after sunset only
	4.0	Yes	4.0	50	Yes		5 hrs. before sunrise only
Mt. Storm Wind, WV	4.0	Yes	4.0	ND	No	Young *et al.* 2011	small sample size, winds high >6m/s
Beech Ridge Wind, WV	3.5	Yes	6.9	73	No	Tidhar *et al.* 2013	no control, compared to average of nearby windfarms, 89% less than WV average (with no LWSC)
Criterion Wind, MD	4.0	Yes	5.0	62	No	Young *et al.* 2013	compared to 2011 when blades not feathered, assumes conditions the same between years or turbines

Appendix 34

Wildlife agency standardized protocols for wildlife fatalities found outside the designated search area or discovered incidentally outside of a routine search

Evidence of Absence software (Dalthorp et al 2017; https://pubs.er.usgs.gov/publication/ds1055) utilizes the number of observed carcasses and the detection probability to produce a probability distribution of the number of fatalities that may have occurred based on imperfect detection. The number of carcasses entered as "Observed" assumes that the carcasses were found in the designated search area and during a routine search. In January 2018, the wildlife agencies discussed the need for establishing a standardized protocol for fatalities of protected wildlife species that are modeled with Evidence of Absence Ver. 2.0.6. but fail to meet the input criteria required by the model. Such exceptions may include carcasses found outside of the designated search area during a routine search, or carcasses incidentally discovered outside of a routine search day. "Rules" for treating these exceptions in the Evidence of Absence model should recognize and encumber the best science in order to maintain the validity of the software's output and not purposefully violate the basic mathematical assumptions that drive the model.

To best accommodate these types of Observed carcasses, the wildlife agencies provide the following standardized guidance. For the purposes of this guidance, assume the carcass found is of the species you are modeling.

<u>Fatality found outside of the designated reduced search area</u>
This situation would only apply to projects that have a carcass search area that has been reduced below where a carcass could potentially fall.
The Downed Wildlife Protocol and accompanying reporting procedures should be followed for carcasses found outside of the reduced routine search area. The carcass will be considered accounted for in the Unobserved take by the Evidence of Absence model. The report should clearly note the measured location of the carcass and relationship to the area searched in addition to the standard data required on the downed wildlife report. Measurements reported in meters will be based on distance from the turbine base or nearest structure. Such measurement should be conducted with a tape measure and with GPS. Project reports should also clearly identify the carcasses that fall in this category.

<u>Fatality found outside of the designated "full" search area.</u>
This situation would imply that the initial monitoring and search area based on turbine height and carcass size may have been undersized and will require expanding the area.
A designated "full" search area is expected to account for all carcasses. The lack of project specific data for small carcass sizes as resulted in the general adoption of the standards presented in Hull and Muir (2010). The wildlife agencies recommend an additional buffer zone of 20% be added to account for the wind effect on carcass fallout and uncertainty until adequate data is gathered for a site. The additional 20% buffer zone would need to be included in the routine searches. The buffer should be located on the down-wind side of the project if the wind is predominantly from one direction. The calculated area based on Hull and Muir plus the buffer area is designated as the "full" search area. Fatalities found during a routine search of the "full" search area (Hull & Muir predicted + 20% buffer zone) would be treated as an Observed fatality in the model.

If the carcass is found beyond this "full" monitoring area, the Downed Wildlife Protocol and accompanying reporting procedures should still be followed. In addition, the permittee should contact the appropriate wildlife agency personnel listed in the Downed Wildlife Protocol to discuss adjusting the size of the fall out area and if expanding the area searched is needed to account for all potential fallout.

<u>Fatality found incidentally (not during a routine scheduled search) in the designated search area</u>
The model takes into account the frequency of searches. If a carcass is found incidentally, then it must be determined if the carcass would have been found on the next routine search day and therefore counted as Observed, or if the carcass would have been missed or be gone on the next routine search and accounted for in the Unobserved portion of fatalities." The Hawaiian hoary bat carcasses are important to ongoing genetic research, so leaving the listed carcass in place is not in the best interest for the species. If a carcass is found incidentally, in the designated search area the Downed Wildlife Protocol and reporting should be followed. The report should clearly indicate who found the carcass, and under what circumstances (turbine maintenance, weeding, mowing, etc). The report should also indicate the method of determining how to categorize the carcass. The three methods are:

1) Permittee chooses to include the carcass as Observed in the model, regardless of searcher efficiency.

2) Wildlife agencies will include the carcass as Observed in the model when the documented detection probability is sufficiently high so as to reasonably assume the carcass would have been found on a subsequent scheduled search. Specifically, this method makes the assumption that the search efficiency and *k* value are such that there is a high probability that the carcass would have been found on a subsequent search. This method will be used for all large and medium carcasses found. This method will also be used for smaller carcasses when it is reasonable to assume the carcass or carcass trace would have been found on a subsequent search. The wildlife agencies will assume a carcass would have been found when the documented searcher efficiency $\geq$75% and k value ≥ 0.7.

   In the case of small carcasses where the searcher efficiency is less than 75% (based on permittee's documented efficacy), a double-blind search with a replacement surrogate should be conducted to determine how the recovered carcass shall be categorized: Observed or Unobserved. That trial shall include the following criteria:

   a. The surrogate (typically a rat) should be identical to that used for search efficacy trials and similar in size to the carcass found.
   b. The surrogate carcass should be labeled as a surrogate for the specific carcass it is representing, and placed by a third party in the proximity of where the carcass that was recovered was found with label hidden.
   c. The placement of this carcass should be conducted by the same party responsible for placing carcasses for efficiency trials, whenever possible.

d. Under no circumstances should the searcher conducting the routine search, be the one placing the surrogate or have knowledge of the surrogate's location or the timing of the placement.
e. Routine fatality searches should be carried out following standard search procedures.
f. The outcome of the trial should be reported in the compliance report and include the date the surrogate was placed and the date the carcass was found. If the carcass was never found, the third party should check on the status of the carcass. If the carcass is still present, leave it in place for subsequent searches. Include this information in the compliance report.
g. If the surrogate was found, the original carcass should be reported as Observed. If the surrogate was not found, the original carcass should be reported as Unobserved.

Note: The wildlife agencies expect the permittee's to conduct thorough, fair, and impartial searches and not to purposefully conduct searches for carcasses outside of the scheduled routine fatality searches in an attempt to manipulate fatality documentation or calculation of take. The agencies also acknowledge the amount of effort it takes to conduct the thorough routine fatality searches and trials necessary to measure carcass retention and searcher efficiency. If a carcass is found outside of a routine search and a searcher efficiency trial is scheduled to be conducted within the next 30 days, it may be possible to include option 3 within that searcher efficiency trial. However, you must contact the wildlife agencies for approval.

Literature Cited

Dalthorp, Daniel, Huso, Manuela, and Dail, David, 2017, Evidence of absence (v2.0) software user guide: U.S. Geological Survey Data Series 1055, 109 p., https://doi.org/10.3133/ds1055.

Hull, C. L. and S. Muir (2010). Search areas for monitoring bird and bat carcasses at wind farms using a Monte-Carlo model. Austalasian Journal of Environmental Management 17: 77-87.