Auwahi **Wind**

September 16, 2022

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Via Email

SUBJECT: Auwahi Wind Farm Project Habitat Conservation Plan FY 2022 (Year 10) Annual Report

Dear Ms. Ouellete and Dr. Radley:

Please find the attached annual report for the Auwahi Wind Farm Project Habitat Conservation Plan (HCP), prepared in compliance with the U.S. Fish and Wildlife Service Incidental Take Permit (ITP) TE64153A-1 and Department of Land and Natural Resources Incidental Take License (ITL) ITL-17. This annual report covers monitoring and mitigation activities conducted from July 1, 2021, through June 30, 2022. The report identifies each HCP requirement and ITP and ITL condition completed, ongoing requirements and conditions, compliance status, and basis for determining compliance. Also, in compliance with HCP monitoring requirements, a post-construction mortality monitoring update is included.

Should you have any questions on this annual report, please feel free to contact me at (808) 876-4100 or via email at gjakau@aepes.com.

Sincerely,

George Akau

Project Biologist/Auwahi Wind Farm

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Auwahi Wind Farm Habitat Conservation Plan FY 2022 Annual Report

Incidental Take Permit TE64153A-1/ Incidental Take License ITL-17

Submitted To:

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An AEP Company
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August 2022

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1.0 Introduction

Auwahi Wind Energy, LLC (Auwahi Wind) finalized a Habitat Conservation Plan (HCP) for the construction and operation of the Auwahi Wind Farm Project (Project) on east Maui, Hawaiʻi in 2012 (Tetra Tech 2012a). The HCP and the associated incidental take permit (ITP; (number TE64153A-0) from the U.S. Fish and Wildlife Service (USFWS) and incidental take license (ITL; number ITL-17) from the Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife (DOFAW) authorize incidental take (hereafter take) for the Hawaiian petrel (*Pterodroma sandwichensis*), Hawaiian goose (*Branta sandvicensis*), Hawaiian hoary bat (*Lasiurus cinereus semotus*), and Blackburn's sphinx moth (*Manduca blackburni*), collectively referred to as the Covered Species. This report provides a summary of monitoring and mitigation activities that have occurred during Fiscal Year (FY) 2022 (from July 1, 2021, to June 30, 2022). This report includes an overview of post-construction mortality monitoring (PCMM) and mitigation activities, addresses other required annual reporting items as identified in the HCP, reviews an annual work plan for the upcoming year, and details annual cost expenditures as required under the ITP and ITL.

2.0 Post-Construction Mortality Monitoring

The HCP includes a detailed description of the monitoring protocol. In FY 2022, standardized carcass searches were performed around all eight turbines and the meteorological tower every 7 days using a canine search team consisting of a dog and handler. Bias trials consisting of carcass persistence trials (CPT), and searcher efficiency (SEEF) trials were conducted throughout FY 2022.

Other permits also required for compliance include a Migratory Bird Special Purpose Utility permit (Permit No. MB92518A-1) for handling migratory bird carcasses, which was reissued by USFWS on April 1, 2021, and a State Protected Wildlife Permit (Permit No. WL22-03) for handling native bird and bat carcasses, which was reissued by DOFAW on January 27, 2022.

2.1 Fatality Monitoring

2.1.1 Systematic Carcass Searches

The canine search team searched for downed wildlife along all pads and roads that occur within a 100-meter radius of the turbines and within 10 meters of the meteorological tower. Based on carcass fall distributions compiled by Tetra Tech, Inc. (Tetra Tech) from 25 publicly available studies at other wind facilities, the areas searched at the Project represented a total of 54 percent of the large bird fall distribution and 77 percent of the bat fall distribution (Sempra Energy 2015). These values are consistent with results based on a theoretical carcass distribution model (Hull and Muir 2010).

2.1.2 Detections Outside of Designated Searches and Searched Areas

Project staff, contractors, and ranch personnel with access to the Project area may detect downed wildlife in the course of their regular activities. The USFWS protocol for incidental detections (USFWS 2018) is applied to determine if the detections should be included in Project fatality estimates depending on the location of the recovered animal or carcass relative to the search area, the timing of the detection relative to the next search, and the likelihood of detection based on estimates of carcass persistence from Project-specific bias correction trials.

2.2 Downed Wildlife Observations

Twenty-five fatalities were documented and reported in FY 2022; eighteen of these fatalities were documented during standardized carcass searches (within the search area and during a scheduled search) and seven were detected incidentally (outside of the search area or outside of a scheduled search; Table 2-1). Five of the recorded fatalities were species protected under the Migratory Bird Treaty Act (MBTA). Ten of the recorded fatalities were Covered Species—all Hawaiian hoary bats (Table 2-1). For each of the fatalities, USFWS and DOFAW were notified within 24 hours, with follow-up fatality report and take estimates, as required by the ITP and ITL.

Table 2-1. Documented Fatalities at the Project in FY 2022

Species	Legal Status[1]	Found Date	Location (Turbine)	Type of Detection[2]	Outside Search Area	Outside Scheduled Search
African Silverbill (*Euodice cantans*)	None	7/12/2021	4	Carcass Survey		
Bulwer's Petrel (*Bulweria bulwerii*)	MBTA	8/2/2021	7	Incidental Finding	X	
African Silverbill (*Euodice cantans*)	None	8/23/2021	1	Carcass Survey		
Hawaiian Hoary Bat (*Lasiurus cinereus semotus*)	T&E	8/23/2021	1	Carcass Survey		
African Silverbill (*Euodice cantans*)	None	8/30/2021	1	Carcass Survey		
Hawaiian Hoary Bat (*Lasiurus cinereus semotus*)	T&E	8/30/2021	5	Incidental Finding	X	
Hawaiian Hoary Bat (*Lasiurus cinereus semotus*)	T&E	8/30/2021	2	Carcass Survey		
African Silverbill (*Euodice cantans*)	None	9/20/2021	4	Carcass Survey		
Hawaiian Hoary Bat (*Lasiurus cinereus semotus*)	T&E	10/4/2021	1	Carcass Survey		

Species	Legal Status[1]	Found Date	Location (Turbine)	Type of Detection[2]	Outside Search Area	Outside Scheduled Search
Hawaiian Hoary Bat (*Lasiurus cinereus semotus*)	T&E	10/11/2021	1	Carcass Survey		
Great Frigatebird (*Fregata minor*)	MBTA	11/8/2021	6	Carcass Survey		
Hawaiian Hoary Bat (*Lasiurus cinereus semotus*)	T&E	11/8/2021	8	Carcass Survey		
Unidentified Bird[3]	_	11/15/2021	5	Incidental Finding	X	
Zebra Dove (*Geopelia striata)*	None	12/20/2021	1	Carcass Survey		
Hawaiian Hoary Bat (*Lasiurus cinereus semotus*)	T&E	1/31/2022	6	Carcass Survey		
Hawaiian Hoary Bat (*Lasiurus cinereus semotus*)	T&E	2/14/2022	7	Incidental Finding	X	
African Silverbill (*Euodice cantans*)	None	3/14/2022	2	Carcass Survey		
Zebra Dove (*Geopelia striata)*	None	3/21/2022	1	Carcass Survey		
Black-crowned Night-heron (*Nycticorax nycticorax*)	MBTA	4/4/2022	3	Carcass Survey		
Warbling White-eye (*Zosterops japonicus*)	None	4/11/2022	1	Carcass Survey		
Hawaiian Hoary Bat (*Lasiurus cinereus semotus*)	T&E	4/25/2022	1	Carcass Survey		
Zebra Dove (*Geopelia striata)*	None	5/16/2022	1	Carcass Survey		
White-tailed Tropicbird (*Phaethon lepturus*)	MBTA	5/16/2022	7	Incidental Finding	X	
Hawaiian Hoary Bat (*Lasiurus cinereus semotus*)	T&E	5/16/2022	7	Incidental Finding	X	
White-tailed Tropicbird (*Phaethon lepturus*)	MBTA	5/24/2022	1	Incidental Finding		X

1. T&E = Federally endangered and State endangered, MBTA=Protected under the Migratory Bird Treaty Act.
2. *Incidental Finding* indicates the observation was detected outside the scheduled search or outside the search area. *Carcass Survey* indicates the species was observed within the search area and during a scheduled search .
3. Feathers found. No other body part recovered. Likely wedge-tailed shearwater feathers associated with carcass persistence trial, which disappeared from the search pad and road search area on 5/20/2021.

2.3 Carcass Persistence Trials

Fifty-two CPTs were conducted during FY 2022 and are summarized by carcass size class in Table 2-2. The objective of these trials is to estimate the likelihood that carcasses persist to the next search at the Project. Species used for CPTs include great frigatebird (*Fregata minor*), barn owl (*Tyto alba*), gray francolin (*Ortygornis pondicerianus*), black francolin (*Francolinus francolinus), and* zebra dove (*Geopelia striata*) as surrogates for HCP-covered bird species; small sized black rats (*Rattus rattus*) were used as surrogates for Hawaiian hoary bats.

Surrogate carcasses were placed at randomly generated points on turbine pads and roads within search plots. Carcasses were typically checked twice weekly in FY 2022 (every Monday during canine team searches and one additional check weekly), until carcasses were no longer detectable, or the trial period was complete. Trial periods were up to 44 days in length. Changes in carcass condition were tracked and documented with photos. Probability of carcass persistence and 95 percent confidence intervals for each carcass category were estimated using the single class module of Evidence of Absence software (EoA; Dalthorp et al. 2017). The probability that a bat carcass would persist until the next search was 0.87 in FY 2022 (Table 2-2). The probability that a large bird carcass would persist until the next search was 0.95 in FY 2022 (Table 2-2).

Table 2-2. Carcass Persistence Estimates for Systematic Searches at the Project in FY 2022

Carcass Size Class	N	Probability of Carcass Persistence until Next Search	95 Percent Confidence Interval	Search Interval (days)
Bats	42	0.870	[0.820, 0.907]	7
Large Birds	10	0.948	[0.850, 0.983]	7

2.4 Searcher Efficiency

Fifty-five SEEF trials were conducted during FY 2022 (Table 2-3). The objective of these trials was to assess the effectiveness of the canine search team at finding downed wildlife. Each trial was conducted by the Project biologist or environmental technician (tester) on site. The canine search team had no prior knowledge of the trials; every fatality search day was treated as if it had the potential to be a SEEF trial day. During FY 2022, 44 SEEF trials were performed for bats and 11 for large birds. Species used for SEEF trials included the same as used for carcass persistence trials. SEEF carcasses were placed at randomly generated points on turbine pads and roads within search plots. Carcasses found during SEEF trials were left in place and were then monitored for carcass persistence (Section 2.3). Estimates of searcher efficiency and 95 percent confidence intervals for each carcass category were calculated using the single class module of EoA (Table 2-3; Dalthorp et al. 2017). Searcher efficiency was 98 percent for bats and 100 percent for large birds (Table 2-3).

Table 2-3. Searcher Efficiency Estimates for Wildlife Fatality Searches at the Project in FY 2022

Carcass Size Class	Search Method	Carcasses Available	Carcasses Found	Average Searcher Efficiency	95 Percent Confidence Interval
Bats	Canine	44	43	0.977	[0.899, 0.998]
Large birds	Canine	11	11	1.000	[0.800, 1.000]

2.5 Take

2.5.1 Direct Take

Auwahi Wind evaluated Project compliance under the ITL and ITP by estimating unobserved take using EoA software. The EoA analysis incorporated observed fatalities, results of bias correction trials (SEEF and CPT), search intervals, and proportions of the carcass distributions searched. EoA provides an estimate of total mortality for a given level of credibility to help evaluate if the number of fatalities has exceeded a given threshold of take. An 80-percent credibility level has been required by USFWS and DOFAW to assess compliance with an ITP and ITL so that there is only a 20 percent probability that actual take exceeds estimated take.

Auwahi Wind used EoA to model past Project take with PCMM data collected over the past 9.5 years for the Hawaiian hoary bat and Hawaiian petrel (Table 2-4; Attachment 1). Because the fiscal year does not coincide with the Project's operational year, the observed fatalities, carcass persistence, searcher efficiency, and detection bias values in Table 2-4 represent values for calendar years, with the period from January 1, 2022, through June 30, 2022, representing 2022 (Year 10). Therefore, values differ from those reported for the full FY 2022 in the sections above.

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Table 2-4. Summary of PCMM Data at the Project, From the Start of the Project through June 2022 (2013 - 2022)

Calendar Year	Low-wind Speed Curtailment (5 m/s)	Low-wind Speed Curtailment (6.9 m/s)[1]	Number of Fatalities Detected	Proportion of Carcass Distribution Searched	Average Search Interval (days)	Probability of Carcass Persistence	Average Searcher Efficiency	Detection Bias[2]	Cumulative Direct Take Estimate[3]	Cumulative Indirect Take Estimate in Adult Equivalents[4]
Hawaiian Hoary Bat										
2013	No	No	1	0.97	9	0.44	0.57	0.28	8	1 (0.47)
2014	No	No	4	0.94	5	0.75	0.52	0.55	16	1 (0.74)
2015	Yes	No	1	0.76	3	0.73	0.68	0.45	18	1 (0.74)
2016	Yes	No	7	0.76	3	0.76	0.76	0.55	34	4 (3.03)
2017[5]	Yes	No	3	0.76	3-4	0.88	0.67	0.60	39	5 (4.25)
2018	Yes	No	1	0.76	4-7	0.77	1	0.52	41	5 (4.25)
2019	Yes	Yes	7	0.77	7	0.93	1	0.72	52	6 (5.05)
2020	Yes	Yes	4	0.77	7	0.93	1	0.71	59	7 (6.03)
2021	Yes	Yes	6	0.77	7	0.87	0.97	0.66	67	7 (6.34)
2022[6]	Yes	Yes	4	0.77	7	0.79	1.00	0.60	70	8 (7.49)
Hawaiian Petrel										
2013	No	No	0	0.91	9	0.79	0.74	0.67	0	0
2014	No	No	1	0.91	5	0.98	0.75	0.84	2	1 (0.19)
2015	Yes	No	0	0.56	3	0.99	0.89	0.55	2	1 (0.19)
2016	Yes	No	0	0.56	3	0.96	0.96	0.48	3	1 (0.19)
2017	Yes	No	0	0.56	3-4	0.99	0.96	0.55	3	1 (0.19)
2018	Yes	No	0	0.56	4-7	0.99	1.00	0.55	3	1 (0.38)
2019	Yes	Yes	0	0.54	7	0.99	1.00	0.53	3	1 (0.38)
2020	Yes	Yes	0	0.54	7	1.00	1.00	0.53	3	1 (0.38)
2021	Yes	Yes	0	0.54	7	0.99	1.00	0.52	3	1 (0.38)
2022[6]	Yes	Yes	0	0.54	7	0.91	1.00	0.47	3	1 (0.38)

1. 6.9 m/s curtailment from August 1 – November 1; Section 2.8.1.
2. Detection bias calculated using EoA software (Dalthorp et al. 2017).
3. Estimate of direct take based on EoA single class module; values represent the upper 80 percent confidence interval (see Attachment 1).
4. Estimate of indirect take based on USFWS 2016 guidance. Take estimates subject to change pending genetic analysis of observed fatalities. The actual value is presented in parentheses and the value rounded up to the nearest whole number is presented first.
5. Detection bias calculated using pooled data with custom search interval in single class module from EoA software.
6. Calendar year 2022 includes the dates from January 1 through June 30.
7. Estimate of indirect take based on calculations in the HCP. The actual value is presented in parentheses and the value rounded up to the nearest whole number is presented first.

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2.5.1.1 Hawaiian Hoary Bat

Based on the 36 bat fatalities detected during fatality searches and ten fatalities detected incidentally during 9.5 years of PCMM, this analysis can be interpreted as: there is an 80 percent probability that actual direct take at the Project was less than or equal to 70 Hawaiian hoary bats. Based on results from the EoA, up to 34 undetected bat fatalities may also have occurred.

2.5.1.2 Hawaiian Petrel

Based on the one Hawaiian petrel fatality detected during fatality surveys and one fatality detected incidentally during 9.5 years of PCMM, this analysis can be interpreted as: there is an 80 percent probability that actual direct take at the Project was less than or equal to three Hawaiian petrels.

2.5.2 Indirect Take

It is assumed that take of an adult bird or bat during the breeding season may result in the indirect loss of a dependent young. Thus, for every petrel or bat carcass detected during the breeding season, modifiers are applied to estimate indirect take based on average reproductive success to account for 1)the likelihood that a given adult is reproductively active and, 2) the likelihood that the loss of a reproductively active adult results in the loss of its young (Tetra Tech 2012a: Section 5.2).

2.5.2.1 Hawaiian Hoary Bat

Indirect take is estimated to account for the potential loss of individuals that may occur indirectly as the result of the loss of an adult female through direct take during the breeding period when females may be pregnant or supporting dependent young. The seasonal timing and sex of all observed fatalities (those observed in fatality monitoring as well as incidental to fatality monitoring) is used in the calculation of indirect take. USFWS (2016) guidance was used for fatalities that lacked verified sex information. All detected bat fatalities had genetically verified sex information provided in Pinzari and Bonaccorso (2018); however, the take estimate at the 80 percent upper credible limit suggests that there may be up to 24 unobserved direct take of unknown sex bats. Indirect take was estimated as 7.49 adult Hawaiian Hoary bats (Attachment 2).

2.5.2.2 Hawaiian Petrel

Two Hawaiian petrel fatalities have been observed within the breeding season (May 1 through September 30) at the Project. The one Hawaiian petrel observed on site during systematic fatality monitoring was found in 2014. One Hawaiian petrel was observed incidentally (outside of the search plot) in 2018. Based on estimates from EoA, up to one additional petrel fatality may have occurred and been undetected. The detection of an adult Hawaiian petrel recorded during the breeding season is assumed to result in the loss of one chick (Tetra Tech 2012a). The average reproductive success for Hawaiian petrels on Maui was previously estimated at 63 percent (Simons and Bailey 2020). The final assessment of indirect take at the end of the permit term will round up to the nearest whole number.

Indirect take is estimated to account for the potential loss of individuals (i.e., offspring) that may occur as the result of the loss of their parents. Both parents of the Hawaiian petrel care for their young until fledging (Simons and Bailey 2020). The point during the breeding season when an adult is taken determines to what extent offspring may be affected. Indirect take was calculated as 1.26 juveniles (observed take of 2 adults during the breeding season * 0.63 average reproductive success) or 0.38 adults (1.26 juveniles * 0.3 surviving to adulthood).

2.6 Take Projection and Estimated Fatality Rates for Hawaiian Hoary Bat

Auwahi Wind used EoA to estimate the Hawaiian hoary bat direct take projected for the remainder of the permit term based on the past monitoring data. The direct take estimate does not account for indirect take, which is based on agency guidance, and the seasonal timing and gender of observed fatalities. Auwahi Wind reports the direct take projection at the 80-percent credibility level as required by USFWS and DOFAW to assess compliance with an ITP and ITL. The take authorization is based on a direct take estimate of 129 bats. The median take projection (as calculated using EoA) is estimated as 140 bats (interquartile range: 128 to 152 bats) in the last year of expected operations, 2032.

The estimated Baseline Fatality Rate calculated by EoA is 6.83 (95 percent confidence interval, 4.79 to 9.25), which currently exceeds the Threshold Value of 6.45 (Table 2-5), as specified in the HCP. The Project began implementing its Adaptive Management Plan in FY2020, has updated the Adaptive Management Plan to incorporate additional minimization measures, and is working with USFWS and DOFAW to approve a Tier 5 mitigation plan (Section 3.2.3).

Table 2-5. EoA Estimated Hawaiian Hoary Bat Baseline Annual Fatality Rate

Source	Metric	Take Value
Value calculated from EoA analysis of PCMM data	Baseline Annual Fatality Rate[1]	6.83
Comparison values from the HCP	Annual Threshold Value	6.45
	Average annual take rate to remain within Tier 4	4.05
	Average annual take rate to remain within Tier 5	5.75

1. Any estimated Baseline Fatality Rate partially through the sampling year may skew results by estimating bias correction trial results with smaller data sets than would be available after a full year of study.

2.7 Wildlife Education and Incidental Reporting

Auwahi Wind continues to implement a wildlife education and incidental reporting program for contractors, Project staff members, and ʻUlupalakua Ranch staff who are on site regularly. Annual training enables staff to identify the Covered Species that may occur in the Project area, record observations of these species, and take appropriate steps for documenting and reporting any species encountered during the operation of the Project. Auwahi Wind trained 80 contractors and new staff in FY 2022.

2.8 Avoidance and Minimization

Avoidance and minimization measures outlined in the HCP continue to be implemented in FY 2022. Actions taken for avoidance and minimization measures for Hawaiian hoary bat and Blackburn's sphinx moth are described below.

2.8.1 Hawaiian hoary bat

Auwahi Wind continues to implement low-wind speed curtailment (LWSC) at cut-in speeds of 5 meters per second (m/s) from November through July. August through October, LWSC cut-in speeds are increased to 6.9 m/s. For all periods, LWSC is implemented from 30 minutes before sunset to 30 minutes after sunrise. In addition to LWSC, Auwahi Wind installed NRG ultrasonic acoustic deterrents at all Project turbines in June of 2020. Ultrasonic acoustic deterrents operate at a minimum from 1 hour before sunset until 1 hour after sunrise, year-round.

Due to the ineffectiveness of reducing bat fatalities with the installation of deterrents, Auwahi Wind submitted additional minimization measures in February 2022 as part of the Adaptive Management Plan, see Attachment 3. Auwahi Wind also supplied acoustic detectors for a test of acoustic bat deterrent function at another wind farm after results of monitoring showed no difference between deterrent and non-deterrent turbines (Attachment 4). Specifically, this study found "Deterrent turbines had lower levels of fatality of silver-haired bats and to a certain extent big brown bats. Fatality rates were estimated to be higher at deterrent turbines for hoary bats and eastern red bats. Overall fatality rates for all bat species were nearly identical between control and deterrent turbines" (Stucker et al. 2021). Auwahi Wind continues to implement acoustic bat deterrents as a minimization measure as specified in the HCP Amendment.

2.8.2 Blackburn's Sphinx Moth

Areas within 10 meters of roadsides and edges of turbine pads are targeted for tree tobacco (*Nicotiana glauca*) removal because these areas may present a proximity hazard for the moth due to exposure to dust, possible trampling, and increased chance of vehicle collisions (USFWS and DOFAW email instructions Feb 7, 2014). Through continued implementation of this removal approach, there has been a decrease in tree tobacco plants occurring within hazard areas. During FY 2022, forty-three tree tobacco plants were removed from the Project with most plants observed to be in the immature vegetative state. The removal of the plants followed USFWS guidance for take avoidance and minimization (USFWS 2022). Auwahi continued monthly field surveys for Blackburn's Sphinx Moth (BSM) in FY 2022 following the survey protocol described in Auwahi Wind's state Native Invertebrate Research Permit (Endorsement #I1303; NPS 2019). The presence of BSM was not detected during any monthly surveys, and no BSM were translocated from the Project in FY 2022.

3.0 Mitigation

Auwahi Wind has fulfilled mitigation obligations for Blackburn's sphinx moth, Hawaiian goose and red ʻilima (*Abutilon menziesii*) and are detailed in previous annual reports (Tetra Tech 2012b, Sempra Energy 2016, Tetra Tech 2019a). Ongoing mitigation efforts by Auwahi Wind for the Hawaiian petrel and Hawaiian bat are described below.

3.1 Hawaiian Petrel Mitigation

Auwahi Wind continues to implement Hawaiian Petrel Mitigation as outlined in the HCP, and in the 2021 management season, 78 burrows were protected, and 10 Hawaiian petrel chicks successfully fledged from the Kahikinui Petrel Management Area (PMA). Beginning in August 2013, Auwahi Wind implemented its Hawaiian Petrel Management Strategy (Tetra Tech 2012c) within Kahikinui PMA with the main objective to increase the survival of Hawaiian petrels and reproductive success of the breeding colony. As in previous years, the objectives of the 2021 Kahikinui PMA management season were to monitor Hawaiian petrel burrows and determine the number of active burrows, evaluate reproductive success, and continue to implement the current predator control strategy.

3.1.1 Petrel Burrow Monitoring

Auwahi Wind monitors petrel burrows using two methods 1) burrow checks, and 2) game cameras. The cameras also document activity by predators and goats. Burrows were classified into categories of seasonal status (see Auwahi Wind FY2017 Attachment 2, Table 1 for definitions) based on the activity patterns observed during the burrow checks and from footage captured at 34 burrows using game cameras. Auwahi Wind included burrows in the reproductive success calculations based on each burrow's seasonal status. For all calculations of reproductive success, it was assumed there was a maximum of one egg or fledgling per burrow, and burrows categorized as prospecting or seasonally inactive were excluded. Metrics of reproductive success are described in previous reports (e.g., Tetra Tech 2020b).

Monthly visits to monitor burrow activity began on February 24, 2021. Monitoring of active burrows ended on November 8, 2021; at which time all the burrows had ceased to be active. One new burrow was located in 2021. Of the 78 petrel burrows monitored, 35 showed signs of activity during the breeding season, and 27 burrows were consistently active throughout the breeding season. By the end of the breeding season, 10 burrows had successfully fledged a chick. All of the fledging events were documented via game camera. The remaining 17 burrows that were consistently active either failed or showed signs of occupation by a non-breeder. There were images that possibly show cat predation at one of the burrows documented in 2021 and one chick was found dead in a burrow of unknown causes. Game cameras detected cats and a dog at burrows. Cat detections were most likely a single cat visiting multiple burrows over multiple nights, the dog visit was limited to one burrow on one night. The number of consistently active burrows has remained relatively constant throughout all years of monitoring with an average of 29.3 active burrows across all years with total numbers ranging between 25 to 37 across all years monitored.

3.1.1.1 Predator Monitoring and Control

Auwahi Wind continues to implement predator control year-round through the use of a trapping grid, with the placement of traps informed by game camera data. A combination of four trap types were used regularly, which included 49 DOC250 kill traps, 44 Goodnature A24 traps, three Victor foothold traps (equipped with Reconyx cellular cameras), and 39 KaMate traps. Foothold traps are opened and set when cats and dogs are observed. Other traps are open year-round and checked monthly February – November. Traps were checked throughout the 2021 monitoring season and 10 rats and 30 mice were removed.

3.1.1.2 Benefits

Auwahi Wind Hawaiian Petrel mitigation is on track to fully offset impacts to the Hawaiian petrel based on the agreed upon model described in the HCP and updated in concurrence with USFWS and DOFAW. Auwahi Wind continues to protect 78 petrel burrows through predator control. Additionally, petrel take projections for the life of the project are significantly less than the Tier 1 take authorization. Petrel management activities will be considered successful if (1) predator control is successfully implemented and (2) mitigation efforts result in an increase in reproduction that offsets authorized take, as outlined in the Hawaiian Petrel Management Plan (Tetra Tech 2012c), approved by USFWS and the DOFAW. Auwahi Wind has measured reproductive success of Hawaiian petrels and predator activity within Kahikinui PMA. Auwahi Wind, USFWS, and DOFAW, have discussed the benefit of Auwahi Wind's mitigation actions. The measures of success and the implementation status are on track to be completed and mitigation efforts will result in one more fledgling or adult than that required to compensate for the requested take of the required tier.

3.2 Hawaiian Hoary Bat Mitigation and Monitoring

Tier 1 bat mitigation is on-going at the Puʻu Makua parcel of the Waihou Mitigation Area, located on ʻUlupalakua Ranch. Tier 1 mitigation consists of the restoration of native forest on ranch land (including installation of an ungulate proof fence, ungulate removal, and native reforestation). This parcel was placed into a conservation easement and will be protected for bat habitat in perpetuity. Tier 2/3 mitigation consisted of funding Hawaiian hoary bat research to contribute to the overall knowledge of the Hawaiian hoary bat on Maui and was completed and reported upon in FY 2020 (Tetra Tech 2020a). Implementation of Tier 4 mitigation is ongoing and focuses on protecting, managing, and enhancing habitat that is suitable for bat foraging and roosting on a 709-hectare parcel within ranch land. Tier 1-4 of mitigation have been funded and either are completed or are still being implemented in accordance with mitigation plans approved by USFWS and DOFAW. A summary of all ongoing or completed measures of success relating to habitat-based Hawaiian hoary bat mitigation is provided in the sections below.

3.2.1 Tier 1 Mitigation

Auwahi Wind is in its seventh year of habitat restoration efforts at the Puʻu Makua mitigation site. The habitat restoration includes ungulate fence installation, ungulate removal, invasive plant species removal, and plantings of native trees and shrubs. The ungulate fence, which was installed in 2013, is in good condition. The 2.4-meter tall ungulate exclusion fence surrounding the parcel was repaired in FY 2022 after storm damage was identified; the parcel remains ungulate-free. Other management activities continued in FY 2022 and include targeted invasive plant species removal and outplanting. The addition of expanding habitat restoration efforts to the surrounding Tier 4 mitigation lands has added additional ungulate barriers to this parcel. Cattle grazing continues by the landowner, Ulupalakua Ranch, on the surrounding ranch lands including the Tier 4 mitigation lands.

3.2.1.1 Management

Quarterly fence checks in FY 2022 identified storm damage to the fence. A fallen tree was removed from the fence and repairs were made. No ungulates were able to access through the damaged area of the fence due to the quick response and repairs made.

Vegetation management of the restoration site performed in FY 2022 included targeted weed surveys and treatments of tropical ash (*Fraxinus uhdei*), bocconia (*Bocconia frutescens*), black wattle (*Acacia mearnsii*), and Monterey pine (*Pinus radiata*). as identified in the HCP (Tetra Tech 2012a). Additional native species were outplanted in the existing koa (*Acacia koa*) plots including ʻōhiʻa (*Metrosideros polymorpha*) and aʻaliʻi (*Dodonaea viscosa*). Benefits of adding koa to ranch lands in a silvopastoral context was published and detailed findings of the research can be found in Akau et al. (2022).

3.2.1.2 Benefits

The measures of success as defined in the HCP and current status of each measure of success are presented in Table 3-1.

Table 3-1. Hawaiian Hoary Bat Tier 1 Measures of Success and Implementation Status

Measures of Success	Implementation Status
After 6 years, mitigation fencing is completed, and ungulates have been removed from within the fenced area.	Completed
Over the 25-year permit term, the fence is maintained, and the area is kept free of ungulates.	Ongoing
After 25 years, the cover of invasive species (excluding kikuyu grass) in the managed areas is less than 50 percent.	Ongoing
After 25 years, reforested areas within the Waihou mitigation area have greater than 50 percent cover dominated by native woody species.	Ongoing

3.2.2 Tier 4 Mitigation

Tier 4 Mitigation is located on 709 hectares (1,752 acres) of ʻUlupalakua Ranch land. The objective of the Tier 4 Mitigation is to protect, manage, and enhance habitat that is suitable for bat foraging and roosting through the addition of features necessary for those stages of the Hawaiian hoary bat life cycle. The final conservation easement was fully executed on December 7, 2020. Detailed progress regarding milestones for Tier 4 mitigation management and monitoring activities per FY quarter are provided in Attachment 5.

3.2.2.1 Management

Auwahi Wind began fence construction of the next 100 acre parcel in FY 2022. A total of 35 acres was planted with approximately 7,000 koa seedlings within the fenced area. Quarterly fence inspections began in 2021 and the area remains cattle free. The constructed 50,000-gallon capacity ponds were monitored for bat activity in FY 2022 (Attachment 6). Bat activity was documented at one of the pond locations and both fenced areas have been outplanted with additional native plantings. No barbwire was used in the construction of new fences within the Tier 4 mitigation area.

3.2.2.2 Monitoring

Auwahi Wind continued insect monitoring in the Tier 4 mitigation site in FY 2022. Three malaise traps were checked semi-annually in FY 2022. A complete report of the monitoring can be found in Attachment 7.

The second year of acoustic monitoring was completed for the Tier 4 mitigation site in FY 2022. The average number of Hawaiian hoary bat detections throughout the study area remained stable to increasing in the second year of monitoring (Attachment 8).

3.2.2.3 Benefits

The measures of success as defined in the HCP and current status of each measure of success are presented in Table 3-2, with additional detailed provided in Attachment 5.

Table 3-2. Hawaiian Hoary Bat Tier 4 Mitigation Measures of Success and Implementation Status

Measures of Success	Implementation Status
Protect the mitigation parcel in perpetuity through a conservation easement with oversight of the parcel by Hawaiian Islands Land Trust (or other appropriate conservation entity).	Completed
Install two additional ponds in the Mitigation Area according to the HCP, or other number as specified through adaptive management.	Completed
Increase forest cover to 20 percent within the pasture parcels through hedgerow reforestation at approximately 500 trees per hectare, or other cover and parcels as specified through adaptive management.	Ongoing
Record an increase in bat activity through acoustic monitoring over the baseline monitoring year(s). The statistical power with which the increase is recorded will also be reported.	Ongoing
Summarize and report the results of monitoring in annual reports.	Ongoing

3.2.3 Tier 5 Mitigation

Auwahi Wind submitted multiple drafts of the Tier 5 Site Specific Management Plan for the Hawaiian hoary bat in FY 2022. Auwahi Wind will continue to coordinate closely with DOFAW and USFWS in the development of Auwahi Wind's site-specific mitigation implementation plan. Once a plan has been prepared and a Memorandum of Understanding is in place with DOFAW, Auwahi Wind will implement the plan upon triggering Tier 5 bat take levels.

3.2.3.1 Baseline Monitoring

Auwahi Wind deployed two acoustic detectors on May 12 and May 13, 2021, to gather baseline information on bat acoustic activity of the proposed Tier 5 mitigation area at Kamehamenui Forest Reserve. Detectors were checked on regularly in FY 2022 to ensure they were functioning properly. A report of the first year of monitoring can be found in Attachment 9.

4.0 Adaptive Management

4.1 Post-Construction Mortality Monitoring

Auwahi Wind investigated bat fatality events at Project turbines in FY 2022. Hawaiian hoary bats continue to be detected as fatalities at the Project despite implementation of acoustic bat deterrents on all Project turbines year-round from one hour before sunset to one hour after sunrise. Although not significant, the fatality rate has increased from 6.28 bats per year in the FY 2019 annual report to 6.83 bats per year in the FY 2022 report. Auwahi Wind staff continued to collect thermal camera data from the turbines after the completion of the U.S. Geological Survey study (Gorresen et al. 2020) and after ultrasonic acoustic deterrents had been installed at all Project turbines. Wildlife Imaging Systems subsequently analyzed data collected in FY 2022. After analyzing the data, no fatality events were detected via thermal camera. Based on the observed increased fatality rate and results from Stucker et al. (2021), the deterrent system may be contributing to an increased risk to bats.

4.2 Minimization

Auwahi Wind, in coordination with USFWS and DOFAW, updated the Adaptive Management Plan for minimization measures implemented at the Project. An additional minimization measure of removing the meteorological tower was approved by USFWS and DOFAW, see Attachment 3 for more details.

Auwahi Wind has not seen a reduction in the fatality rate of Hawaiian hoary bats as a result of installing acoustic deterrents. Contrary to expectation, Hawaiian hoary bat fatalities have been observed in months where no fatalities have been recorded previously. Auwahi Wind has used thermal monitoring to attempt to elucidate patterns of behavior that would indicate that deterrents are working, however thermal monitoring shows bats continuing to utilize the rotor swept zone despite deterrents being active. On the mainland, new tests of acoustic deterrent effectiveness have shown little or no effectiveness (Attachment 4).

5.0 Changed or Unforeseen Circumstances

No changed or unforeseen circumstances occurred in FY 2022.

6.0 Auwahi Wind Community Involvement

Highlights of Auwahi Winds community involvement in FY 2022 are:

- Provide support to the Maui Nui Seabird Recovery Project with banding of Ua'u kani breeding colonies on Maui and acoustic analysis of surveys conducted in Nakula/Kahikinui
- Share results and lessons learned of Leeward Haleakala Hawaiian Hoary bat occupancy and distribution study with landowners
- Continue to loan DOFAW bat acoustic detectors and partner in collecting bat acoustic data
- Provide resources to DHHL Kahikinui families to add a security surveillance system to the main gate and fund feral cattle removal/harvest
- Fund Auwahi Forest Restoration Project to conduct volunteer outplanting trips
- Support research of graduate student studying impacts of Koa plantings in ranch setting
- Support student research in capstone thesis of predator control management of waterbirds in Hawaii
- Auwahi Wind participated in island wide forest bird surveys within the Puʻu Makua mitigation area. Transects were installed in 2017, and native forest birds continue to use the area.

7.0 Annual Workplan and Schedule

A work plan for FY 2022 will be provided in Attachment 10. This work plan identifies major monitoring and mitigation activities and their associated timelines.

8.0 Cost Expenditures and Budget

A summary of HCP-related expenditures for FY 2022 will be provided in Attachment 11. This summary lists costs (including staff labor) that Auwahi Wind has expended toward fulfilling the terms of the HCP in FY 2022, as well as cumulatively, and compares them against the budgeted amounts specified in the HCP.

9.0 References

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Attachment 1

Evidence of Absence Software Inputs and Outputs – Fatality Estimation

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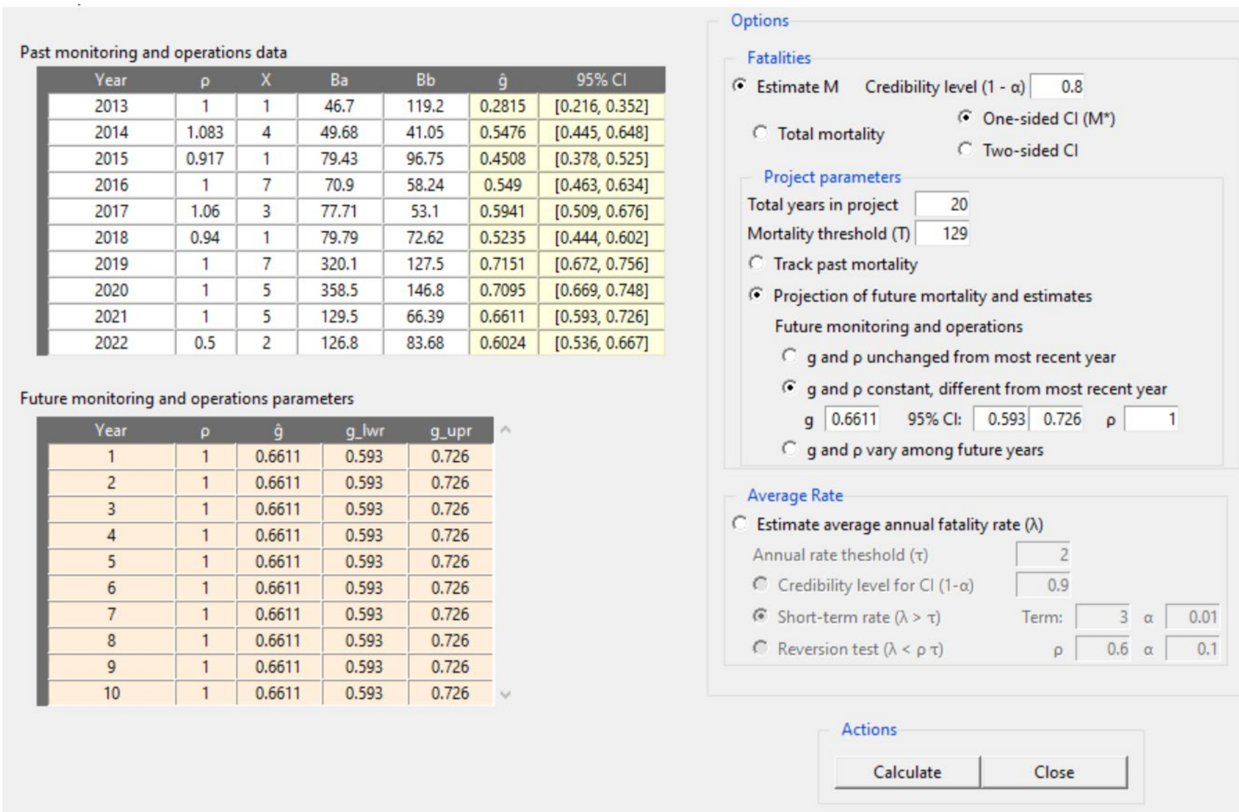
Figure 1. Evidence of Absence Inputs for Hawaiian Hoary Bat Multi-Year Analysis in FY 2022 (Dalthorp et al. 2017).



Past monitoring and operations data

Year	ρ	X	Ba	Bb	ĝ	95% CI
2013	1	1	46.7	119.2	0.2815	[0.216, 0.352]
2014	1.083	4	49.68	41.05	0.5476	[0.445, 0.648]
2015	0.917	1	79.43	96.75	0.4508	[0.378, 0.525]
2016	1	7	70.9	58.24	0.549	[0.463, 0.634]
2017	1.06	3	77.71	53.1	0.5941	[0.509, 0.676]
2018	0.94	1	79.79	72.62	0.5235	[0.444, 0.602]
2019	1	7	320.1	127.5	0.7151	[0.672, 0.756]
2020	1	5	358.5	146.8	0.7095	[0.669, 0.748]
2021	1	5	129.5	66.39	0.6611	[0.593, 0.726]
2022	0.5	2	126.8	83.68	0.6024	[0.536, 0.667]

Future monitoring and operations parameters

Year	ρ	ĝ	g_lwr	g_upr
1	1	0.6611	0.593	0.726
2	1	0.6611	0.593	0.726
3	1	0.6611	0.593	0.726
4	1	0.6611	0.593	0.726
5	1	0.6611	0.593	0.726
6	1	0.6611	0.593	0.726
7	1	0.6611	0.593	0.726
8	1	0.6611	0.593	0.726
9	1	0.6611	0.593	0.726
10	1	0.6611	0.593	0.726

Figure 2. Evidence of Absence Total Mortality Output for Hawaiian Hoary Bat Multi-Year Analysis in FY 2022 (Dalthorp et al. 2017).

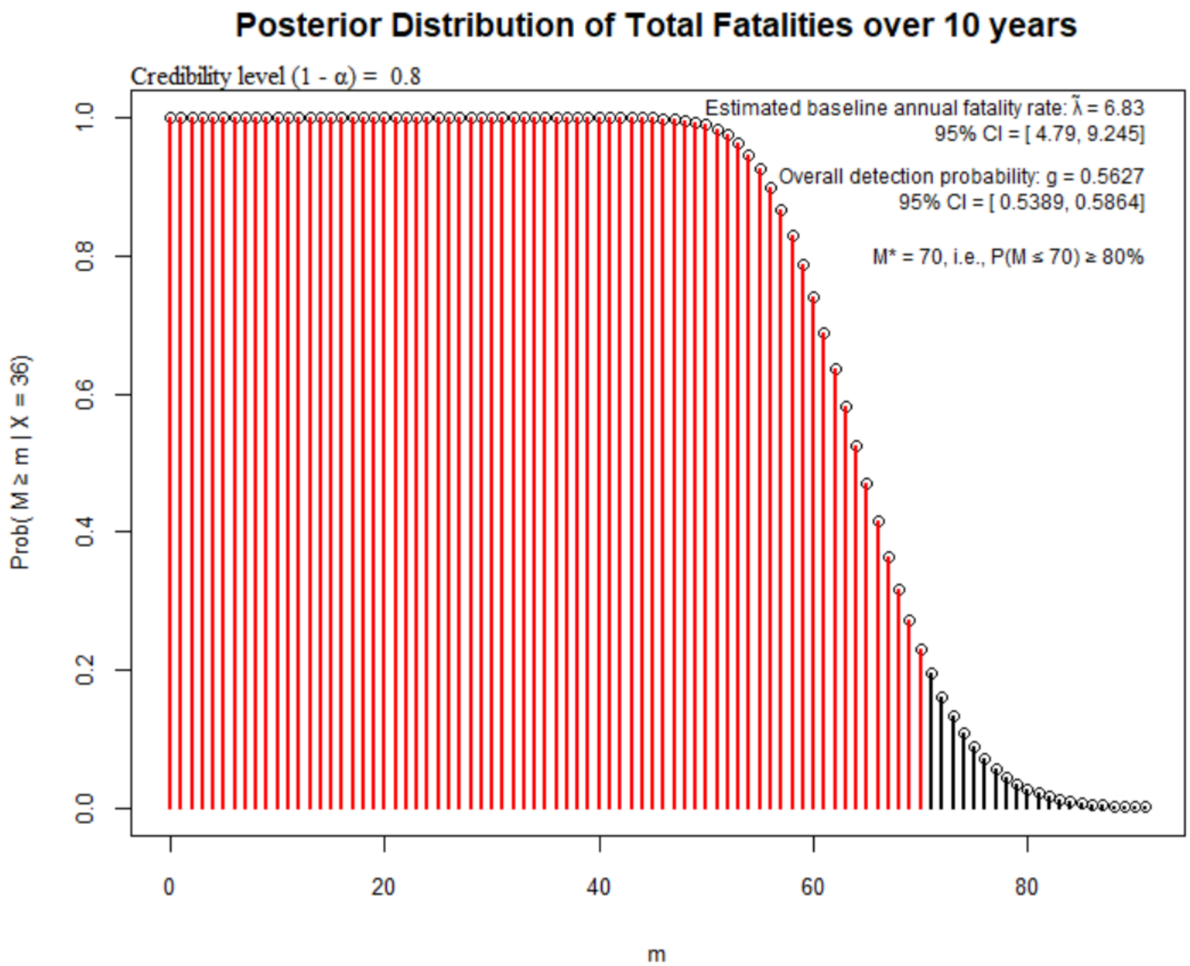


Figure 3. Evidence of Absence Cumulative Mortality (Estimated and Projected) Output for Hawaiian Hoary Bat Multi-Year Analysis in FY 2022 (Dalthorp et al. 2017)

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================================================================================
Summary statistics from posterior predictive distributions for 10000 simulated projects
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Estimated annual baseline fatality rate (lambda for rho = 1): mean = 6.83, 95% CI = [4.79, 9.25]

Projected fatalities and fatality estimates...
p(M > Tau within 20 years) = 0.5659  [exceedance]
p(M* > Tau within 20 years) = 0.7323  [triggering]
M* based on credibility level 1 - alpha = 0.8

Among projects with triggering (73.23%), mean(M) = 124.69 at time of triggering, with median = 124 and IQR = [118, 131]
Among projects with no triggering (26.77%), mean(M) = 117.32 at end of 20 years, with median = 117 and IQR = [110, 124]

Years of operations without triggering:
 Mean = 18.70, with median =  19 and IQR = [18, 20]

----------------------------------------
Summary statistics for projection years
------------------------------------------------------------------------------------------------
Yr   Mean            quantiles of M                        | quantiles of M*
        M       M*  0.05  0.10  0.25  0.50  0.75  0.90  0.95 |  0.05  0.10  0.25  0.50  0.75  0.90  0.95
------------------------------------------------------------------------------------------------
1      71.2   77.4    59    62    66    71    76    81    85 |    71    73    75    76    80    84    86
2      78.0   84.5    65    67    72    78    84    89    93 |    75    77    81    84    88    93    95
3      84.8   91.5    70    73    78    84    91    97   101 |    80    82    85    90    96   101   105
4      91.7   98.5    76    79    85    91    98   105   109 |    84    88    91    98   104   111   116
5      98.5  105.4    81    85    91    98   106   112   117 |    89    92    97   104   113   120   125
6     105.3  112.4    87    90    97   105   113   121   125 |    93    97   104   112   119   128   133
7     112.2  119.5    92    96   103   112   121   129   134 |   100   103   110   118   129   137   142
8     119.0  126.5    97   102   109   118   128   137   143 |   104   107   116   126   136   145   152
9     125.8  133.5   103   107   116   125   135   145   152 |   109   114   122   132   144   154   161
10    132.6  140.4   108   113   122   132   143   153   160 |   115   120   128   140   152   162   170

================================================================================

Governing parameters: Tau = 129, alpha = 0.2

Data for 10 years of monitoring:
            yr    x    g     glwr   gupr  rho  M*
           2013   1 0.2815 0.2119 0.3511  1    8
           2014   4 0.5476 0.4436 0.6515  1.08  16
           2015   1 0.4508 0.3761 0.5256  0.917  18
           2016   7 0.5490 0.4618 0.6363  1  34
           2017   3 0.5941 0.5085 0.6796  1.06  38
           2018   1 0.5235 0.4429 0.6042  0.94  40
           2019   7 0.7151 0.6725 0.7578  1  52
           2020   5 0.7095 0.6691 0.7498  1  59
           2021   5 0.6611 0.5936 0.7286  1  67
           2022   2 0.6024 0.5351 0.6697  0.5  70

Parameters for future monitoring and operations:
  Number of years:  10
  g = 0.6611, 95% CI  [0.593, 0.726]
  Relative weight (rho): 1
*****************************************************************************************
```

Figure 3 (Continued). Evidence of Absence Cumulative Mortality (Estimated and Projected) Output for Hawaiian Hoary Bat Multi-Year Analysis in FY 2022 (Dalthorp et al. 2017)

```
Summary statistics for mortality estimates through 10 years
------------------------------------
Results
Totals through 10 years

M* = 70 for 1 - alpha = 0.8, i.e., P(M <= 70) >= 80%
Estimated overall detection probability: g = 0.563, 95% CI = [0.539, 0.586]
    Ba = 943.86, Bb = 733.5
Estimated baseline fatality rate (for rho = 1): lambda = 6.832, 95% CI = [4.79, 9.25]

Cumulative Mortality Estimates
Year         M*    median   95% CI   mean(lambda) 95% CI
2013         8      4      [1, 13]  5.4550   [0.3851,  17.29]
2014         16     12     [6, 22]  13.2100   [ 4.524,  26.68]
2015         18     14     [8, 25]  15.2200   [ 5.814,  29.19]
2016         34     28     [19, 42]  29.4900   [ 15.79,  47.55]
2017         38     33     [23, 46]  33.9300   [ 19.46,  52.47]
2018         40     35     [25, 49]  35.5500   [ 20.79,  54.31]
2019         52     46     [35, 60]  46.7400   [ 29.98,  67.25]
2020         59     53     [41, 67]  53.8900   [ 36.11,  75.24]
2021         67     61     [49, 76]  61.6000   [ 42.66,  84.02]
2022         70     64     [52, 80]  64.9100   [ 45.46,  87.83]

Annual Mortality Estimates
Year         M*    median   95% CI   mean(lambda) 95% CI
2013         8      4      [1, 13]  5.4550   [0.3851,  17.29]
2014         10     7      [4, 13]  8.3330   [ 2.453,  17.95]
2015         4      2      [1, 7]  3.3620   [0.2398,  10.56]
2016         16     13     [8, 21]  13.7900   [ 5.661,  25.71]
2017         7      5      [3, 9]  5.9380   [  1.42,  13.71]
2018         3      2      [1, 6]  2.8910   [0.2065,  9.069]
2019         12     10     [7, 14]  10.5000   [ 4.374,  19.29]
2020         9      7      [5, 11]  7.7610   [ 2.687,  15.49]
2021         9      7      [5, 12]  8.3520   [  2.88,  16.74]
2022         5      3      [2, 7]  4.1690   [0.6898,  10.75]


Test of assumed relative weights (rho) and potential bias              Fitted rho
Assumed rho     95% CI
      1     [0.043, 2.137]
   1.08     [0.343, 2.318]
  0.917     [0.027, 1.396]
      1     [0.755, 3.287]
   1.06     [0.211, 1.801]
   0.94     [0.024, 1.228]
      1     [0.640, 2.578]
      1     [0.392, 1.986]
      1     [0.384, 2.237]
    0.5     [0.087, 1.405]

p = 0.55468 for likelihood ratio test of H0: assumed rho = true rho
Quick test of relative bias: 1.03

================================================================================
Input
Year (or period) rel_wt  X    Ba     Bb   ghat     95% CI
2013             1.000   1   46.7  119.2 0.281 [0.216, 0.352]
2014             1.083   4  49.68  41.05 0.548 [0.445, 0.648]
2015             0.917   1  79.43  96.75 0.451 [0.378, 0.525]
2016             1.000   7   70.9  58.24 0.549 [0.463, 0.634]
2017             1.060   3  77.71   53.1 0.594 [0.509, 0.676]
2018             0.940   1  79.79  72.62 0.524 [0.444, 0.602]
2019             1.000   7  320.1  127.5 0.715 [0.672, 0.756]
2020             1.000   5  358.5  146.8 0.709 [0.669, 0.748]
2021             1.000   5  129.5  66.39 0.661 [0.593, 0.726]
2022             0.500   2  126.8  83.68 0.602 [0.536, 0.667]
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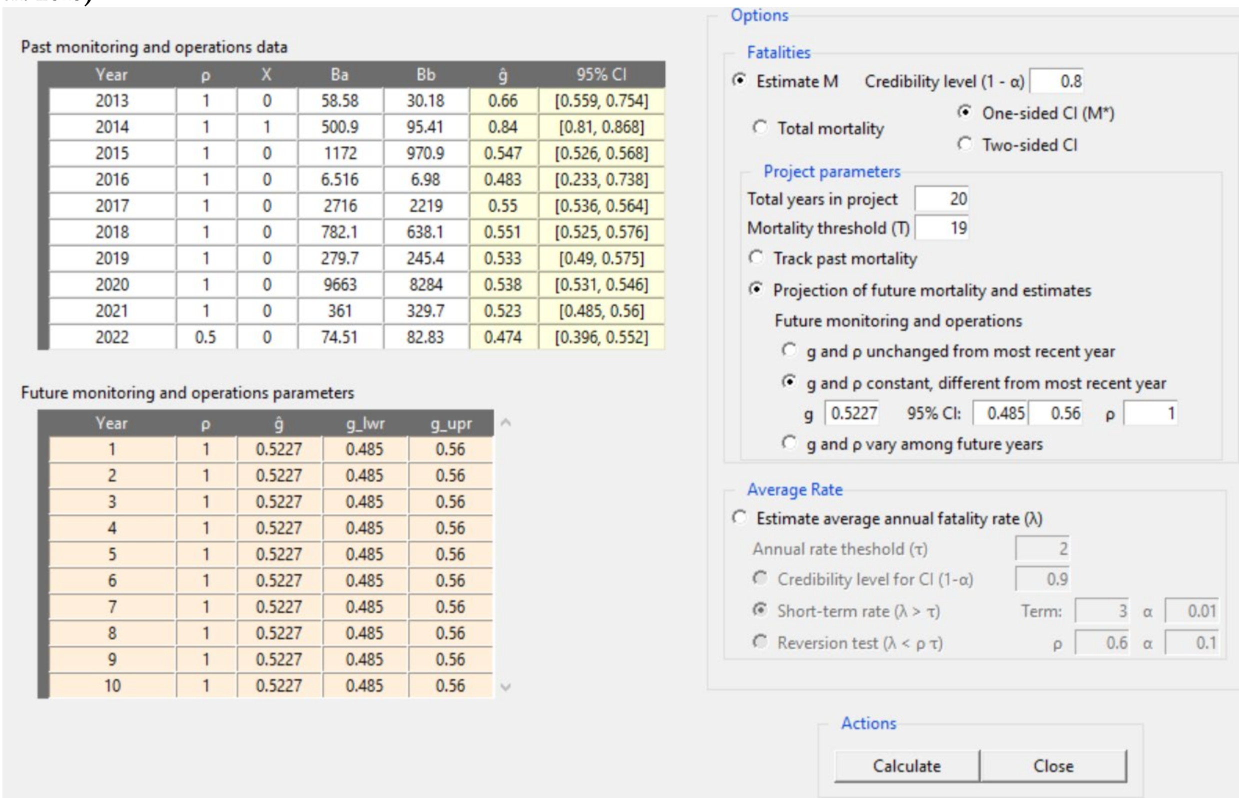
Figure 4. Evidence of Absence Inputs for Hawaiian Petrel Multi-Year Analysis in FY 2022 (Dalthorp et al. 2017)



Past monitoring and operations data

Year	ρ	X	Ba	Bb	ĝ	95% CI
2013	1	0	58.58	30.18	0.66	[0.559, 0.754]
2014	1	1	500.9	95.41	0.84	[0.81, 0.868]
2015	1	0	1172	970.9	0.547	[0.526, 0.568]
2016	1	0	6.516	6.98	0.483	[0.233, 0.738]
2017	1	0	2716	2219	0.55	[0.536, 0.564]
2018	1	0	782.1	638.1	0.551	[0.525, 0.576]
2019	1	0	279.7	245.4	0.533	[0.49, 0.575]
2020	1	0	9663	8284	0.538	[0.531, 0.546]
2021	1	0	361	329.7	0.523	[0.485, 0.56]
2022	0.5	0	74.51	82.83	0.474	[0.396, 0.552]

Future monitoring and operations parameters

Year	ρ	ĝ	g_lwr	g_upr
1	1	0.5227	0.485	0.56
2	1	0.5227	0.485	0.56
3	1	0.5227	0.485	0.56
4	1	0.5227	0.485	0.56
5	1	0.5227	0.485	0.56
6	1	0.5227	0.485	0.56
7	1	0.5227	0.485	0.56
8	1	0.5227	0.485	0.56
9	1	0.5227	0.485	0.56
10	1	0.5227	0.485	0.56

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Figure 5. Evidence of Absence Total Mortality Output for Hawaiian Petrel Multi-Year Analysis in FY 2022 (Dalthorp et al. 2017)

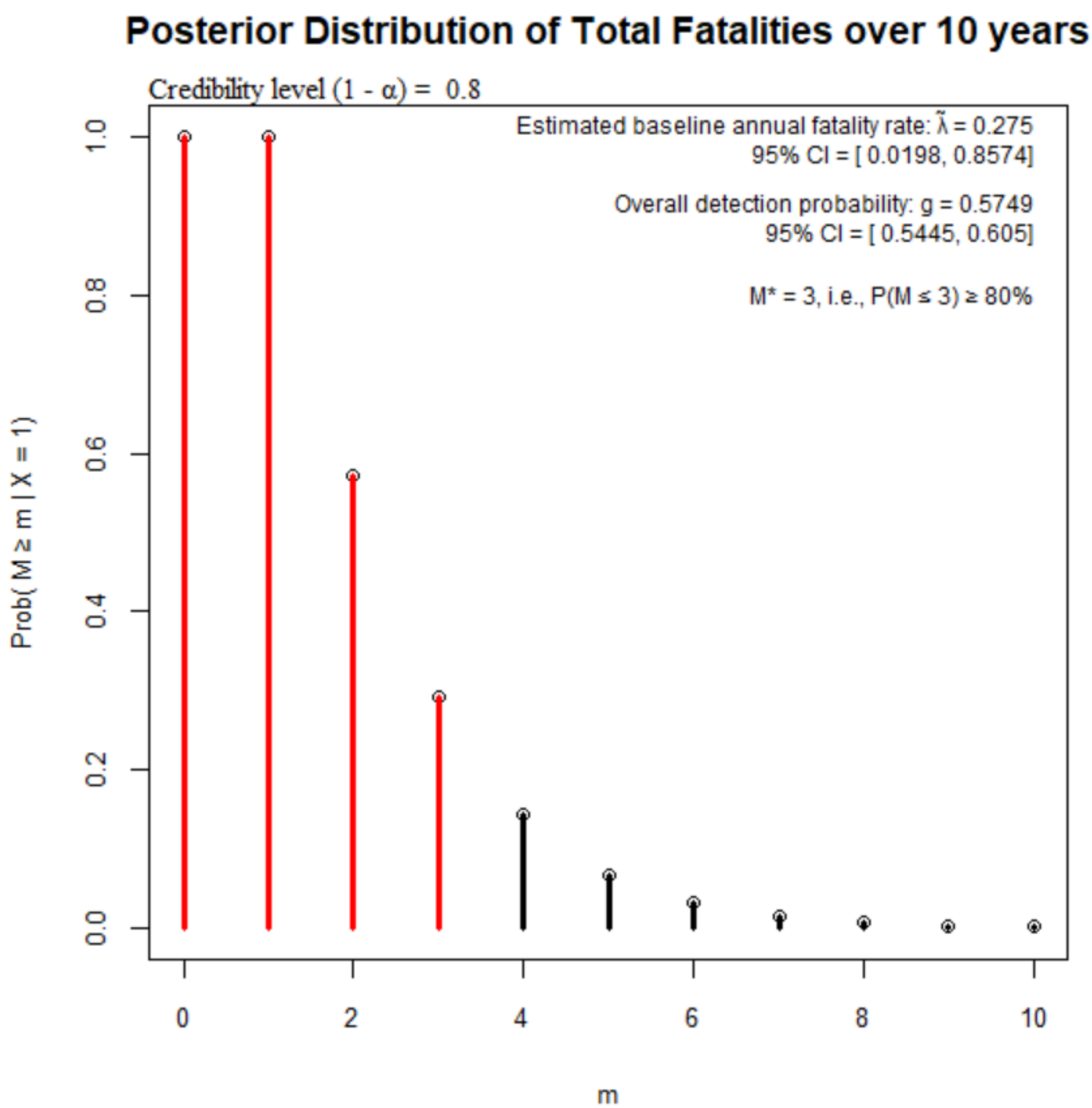

Figure 6. Evidence of Absence Cumulative Mortality (Estimated and Projected) Output for Hawaiian Petrel Multi-Year Analysis in FY 2022 (Dalthorp et al. 2017)

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Summary statistics from posterior predictive distributions for 10000 simulated projects

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Estimated annual baseline fatality rate (lambda for rho = 1): mean = 0.275, 95% CI = [0.0198, 0.857]

Projected fatalities and fatality estimates...
p(M > Tau within 20 years) = 0.0017 [exceedance]
p(M* > Tau within 20 years) = 0.0087 [triggering]
M* based on credibility level 1 - alpha = 0.8

Among projects with triggering (0.87%), mean(M) = 14.52 at time of triggering, with median = 14 and IQR = [12, 16]
Among projects with no triggering (99.13%), mean(M) = 4.79 at end of 20 years, with median = 4 and IQR = [3, 6]

Years of operations without triggering:
Mean = 19.99, with median = 20 and IQR = [20, 20]

Summary statistics for projection years

Yr	Mean M	M*	quantiles of M 0.05	0.10	0.25	0.50	0.75	0.90	0.95	quantiles of M* 0.05	0.10	0.25	0.50	0.75	0.90	0.95
1	2.4	3.3	1	1	1	2	3	4	5	3	3	3	3	3	5	5
2	2.7	3.6	1	1	1	2	3	5	6	3	3	3	3	3	5	5
3	3.0	3.9	1	1	2	3	4	5	6	3	3	3	3	5	5	7
4	3.2	4.1	1	1	2	3	4	6	7	3	3	3	3	5	7	7
5	3.5	4.5	1	1	2	3	5	6	8	3	3	3	3	5	7	10
6	3.8	4.8	1	1	2	3	5	7	8	3	3	3	3	5	7	10
7	4.1	5.3	1	1	2	4	5	7	9	3	3	3	5	8	10	12
8	4.3	5.6	1	1	2	4	6	8	9	3	3	3	5	8	10	12
9	4.6	5.9	1	2	2	4	6	9	10	3	3	3	5	8	10	12
10	4.9	6.2	1	2	3	4	6	9	11	3	3	3	5	8	12	14

==

Governing parameters: Tau = 19, alpha = 0.2

Data for 10 years of monitoring:

yr	x	g	glwr	gupr	rho	M*
2013	0	0.6600	0.5600	0.7600	1	0
2014	1	0.8400	0.8100	0.8700	1	2
2015	0	0.5469	0.5254	0.5684	1	2
2016	0	0.4828	0.2203	0.7453	1	3
2017	0	0.5504	0.5362	0.5645	1	3
2018	0	0.5507	0.5243	0.5771	1	3
2019	0	0.5327	0.4892	0.5762	1	3
2020	0	0.5384	0.5310	0.5459	1	3
2021	0	0.5227	0.4847	0.5606	1	3
2022	0	0.4736	0.3942	0.5529	0.5	3

Parameters for future monitoring and operations:
Number of years: 10
g = 0.5227, 95% CI [0.485, 0.56]
Relative weight (rho): 1

****

Summary statistics for mortality estimates through 10 years

Results
Totals through 10 years

M* = 3 for 1 - alpha = 0.8, i.e., P(M <= 3) >= 80%
Estimated overall detection probability: g = 0.575, 95% CI = [0.544, 0.605]
Ba = 588.3, Bb = 435.06
Estimated baseline fatality rate (for rho = 1): lambda = 0.2749, 95% CI = [0.0198, 0.857]

Figure 6 (Continued). Evidence of Absence Cumulative Mortality (Estimated and Projected) Output for Hawaiian Petrel Multi-Year Analysis in FY 2022 (Dalthorp et al. 2017)

```
Cumulative Mortality Estimates
Year         M*    median    95% CI    mean(lambda) 95% CI
2013         0     0        [0, 1]  0.7642    [0.0007638,   3.851]
2014         2     1        [1, 3]  2.0040    [0.1439,   6.252]
2015         2     1        [1, 4]  2.2000    [0.1582,   6.862]
2016         3     2        [1, 4]  2.3830    [0.1708,   7.451]
2017         3     2        [1, 4]  2.4430    [0.1753,    7.63]
2018         3     2        [1, 5]  2.4840    [0.1784,   7.755]
2019         3     2        [1, 5]  2.5260    [0.1815,   7.882]
2020         3     2        [1, 5]  2.5550    [0.1836,   7.971]
2021         3     2        [1, 5]  2.5870    [0.1859,   8.068]
2022         3     2        [1, 5]  2.6120    [0.1877,   8.145]

Annual Mortality Estimates
Year         M*    median    95% CI    mean(lambda) 95% CI
2013         0     0        [0, 1]  0.7642    [0.0007638,   3.851]
2014         2     1        [1, 2]  1.7860    [0.1285,   5.569]
2015         1     0        [0, 2]  0.9145    [0.0009128,   4.596]
2016         1     0        [0, 3]  1.1940    [0.001072,   6.304]
2017         1     0        [0, 2]  0.9085    [0.0009072,   4.565]
2018         1     0        [0, 2]  0.9085    [0.0009069,   4.566]
2019         1     0        [0, 2]  0.9409    [0.0009376,   4.731]
2020         1     0        [0, 2]  0.9285    [0.0009264,   4.665]
2021         1     0        [0, 2]  0.9583    [0.0009559,   4.818]
2022         1     0        [0, 3]  1.0670    [0.001059,   5.381]


Test of assumed relative weights (rho) and potential bias            Fitted rho
Assumed rho     95% CI
      1     [0.002, 3.338]
      1     [0.117, 4.915]
      1     [0.005, 3.516]
      1     [0.007, 4.644]
      1     [0.004, 3.641]
      1     [0.005, 3.787]
      1     [0.004, 3.560]
      1     [0.004, 3.920]
      1     [0.005, 3.585]
    0.5     [0.006, 4.229]

p = 0.92749 for likelihood ratio test of H0: assumed rho = true rho
Quick test of relative bias: 1.018

================================================================================
Input
Year (or period) rel_wt  X    Ba      Bb   ghat     95% CI
2013              1.000  0  58.58  30.18 0.660 [0.559, 0.754]
2014              1.000  1  500.9  95.41 0.840 [0.810, 0.868]
2015              1.000  0   1172  970.9 0.547 [0.526, 0.568]
2016              1.000  0  6.516   6.98 0.483 [0.233, 0.738]
2017              1.000  0   2716   2219 0.550 [0.536, 0.564]
2018              1.000  0  782.1  638.1 0.551 [0.525, 0.576]
2019              1.000  0  279.7  245.4 0.533 [0.490, 0.575]
2020              1.000  0   9663   8284 0.538 [0.531, 0.546]
2021              1.000  0    361  329.7 0.523 [0.485, 0.560]
2022              0.500  0  74.51  82.83 0.474 [0.396, 0.552]
```

Attachment 2

Indirect Take Calculations for Hawaiian Hoary Bat at the Project in FY 2022

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Label	Description	Calendar Year										Total
		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	
A	Observed Breeding Female Take	0	0	0	2	2	1	2	1	1	2	**11**
B	Indirect Take from Observed Breeding Female Take (A x 1.8)	0	0	0	3.6	3.6	1.8	3.6	1.8	1.8	3.6	**19.80**
C	Observed Breeding Unknown Sex Take	0	0	0	0	0	0	0	0	0	0	**0**
D	Indirect Take from Observed Breeding Unknown Sex Take (C * 0.48 * 1.8)	0	0	0	0	0	0	0	0	0	0	**0**
E	All Observed Take (Search and Incidental)	1	3	2	7	5	3	10	5	6	4	**46**
F	Estimated Take Multiplier (70 / 46)	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	**1.52**
G	Estimated Direct Take (E x F)	1.52	4.57	3.04	10.65	7.61	4.57	15.22	7.61	9.13	6.09	**70.00**
H	Unobserved Direct Take (G - E)	0.52	1.57	1.04	3.65	2.61	1.57	5.22	2.61	3.13	2.09	**24.00**
I	Indirect Take Calculated from Unobserved Take (H * 0.48 * 0.25 * 1.8)	0.11	0.34	0.22	0.79	0.56	0.34	1.12	0.56	0.67	0.45	**5.17**
Total Indirect Take (B + D + I; juveniles)												**24.97**
Total Indirect Take (B + D + I)*0.3 (adults)												**7.49**

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Attachment 3

Auwahi Wind Adaptive Management Plan 2022

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Auwahi **Wind**	**Adaptive Management Plan 2022**	
	REVISION NUMBER:	4
	EFFECTIVE DATE:	2/28/2022
	REVISION DATE:	2/28/2022
	REVIEWED DATE:	2/28/2022
	REVIEW CYCLE:	12 MONTHS

1. Introduction

This Adaptive Management Plan (AMP) was initially approved in the Auwahi Wind Farm (Project) Habitat Conservation Plan (HCP) Final Amendment (HCP Amendment); Incidental Take Permit (ITP) Number: TE64153A-1 issued September 4, 2019 and Incidental Take License (ITL) Number: ITL-17 issued August 23, 2019. The HCP Amendment identifies specific measures that Auwahi Wind Energy LLC (Auwahi Wind) will implement if the estimated fatality rate exceeds the Threshold Value (TV) needed to ensure compliance with the permitted take value over the permit term. As discussed in Section 4.1.7 of the HCP Amendment, Auwahi Wind implemented baseline minimization measures in 2018 and will continue to apply these measures for the duration of the permit, unless specific adaptive management triggers are reached that would initiate an adaptive management action. The original AMP will be in effect upon permit issuance and until it is superseded by subsequent revisions to the AMP or other adaptive management triggers. The AMP is periodically revised using the results of the ongoing risk analysis (Section 7.4.1.3 of the HCP Amendment) and updates will be provided to the U.S. Fish and Wildlife Service (USFWS) and State of Hawaiʻi Department of Land and Natural Resources: Division of Forestry and Wildlife (DOFAW) for review. The deadline for the first revision was April 30, 2020, and the revision history for this living document is provided on the signature page. All terms and acronyms are defined in the Auwahi Wind HCP Amendment.

2. Evaluation Schedule

The effectiveness of the minimization measures in place at the Project will be evaluated on a routine basis to ensure compliance with the permitted take value (Table 1). These evaluations will take place as part of routine reporting tasks and scheduled agency reviews, as well as in response to observed take.

Table 1. Schedule for Regular Evaluation of Minimization Measures

Period	Action	Timeframe
Immediate Evaluations	Summary of Take Report	Due within 3 weeks of observed take
Semi-Annual Evaluation	HCP Semi-Annual Compliance Report	Due January 31
Annual Evaluations	HCP Annual Compliance Report	Due September 1
	AMP Review	Scheduled with USFWS and DOFAW after Annual Report
Scheduled Evaluations	Adaptive Management Action Review	Due February 28
	If adaptive management actions are required, implement adaptive management actions[1]	Due March 31

1. See Follow-up Evaluation in Section 2.4.

To track compliance, Auwahi Wind will use Evidence of Absence (EoA) to evaluate the Post-Construction Mortality Monitoring (PCMM) data and calculate the Baseline Fatality Rate (BFR). The BFR will then be compared to the TV. The TV for the Project is 6.45 based on analysis presented in Section 7.4.1.1 of the HCP Amendment.

Additionally, Auwahi Wind will track the BFR relative to each of the tiers of take (Table 2) to support agency discussions during routine reviews.

Table 2. Average Take Rates for Each Tier Over 20 Years

Tier	Maximum Take	Average BFR
4	81	4.05
5	115	5.75

The details from the schedule are described in the following subsections.

2.1 Immediate Evaluations

Summary of Take Report (on Observed Fatalities): Auwahi Wind notifies USFWS and DOFAW of any bat fatality observed during PCMM or incidentally and submits a Summary of Take report within 3 weeks. The Summary of Take report is described in Appendix E of the HCP Amendment and will include the following items related to adaptive management (in addition to other reporting requirements):

- Direct take estimate;
- Direct take projection;
- Calculation of the BFR and comparison of BFR to TV; and
- Comparison of BFR to tier based rates.

2.2 Semi-Annual Evaluations

HCP Compliance Report: Auwahi Wind reports on activities and analyses associated with HCP compliance in a semi-annual report provided to USFWS and DOFAW in January each year. The semi-annual report includes the following items related to adaptive management (in addition to other reporting requirements):

- Direct take estimate;
- Direct take projection;
- Calculation of the BFR and comparison of BFR to TV; and
- Comparison of BFR to tier based rates.

2.3 Annual Evaluations

HCP Compliance Report: Auwahi Wind reports on activities and analyses associated with HCP compliance in an annual report provided to USFWS and DOFAW in August each year. In an annual meeting, Auwahi Wind reviews the HCP compliance status summary and take estimate projections with USFWS and DOFAW. The annual reports will include the following items related to adaptive management (in addition to other reporting requirements):

- Direct take estimate;
- Direct take projection;
- Calculation of the BFR and comparison of BFR to TV;
- Comparison of BFR to tier based rates; and,
- Adaptive management actions triggered or taken during the reporting year.

AMP Review: The AMP is intended to be a living document and will be updated as new information becomes available. Auwahi Wind will review the current AMP during the annual meeting with USFWS and DOFAW. Prior to the annual meeting, Auwahi Wind will review and summarize new literature relating to the development and effectiveness of minimization measures for the Hawaiian hoary bat and similar bat species. Literature to be reviewed includes: site-specific data, peer-reviewed literature, annual reports, industry publications, literature recommended by USFWS and DOFAW, or other sources. If Auwahi Wind determines, in consultation with USFWS and DOFAW, that new minimization measures are applicable and likely to be an improvement over those currently implemented or proposed in the AMP, the AMP will be updated to include the new measures and provided to the agencies for approval.

2.4 Scheduled Evaluations

Adaptive Management Action Review: Auwahi Wind will evaluate the PCMM data from the start of monitoring through December 31 of the preceding year (the most recent complete calendar year) to calculate the BFR using EoA in years 2020, 2025, and 2030. Auwahi Wind will then compare the BFR to the TV.

- If the BFR exceeds the TV, adaptive management actions, as described in Section 3 of the AMP, will be implemented no later than March 31 (see Follow-up Evaluation below).
- If the BFR does not exceed the TV, no action will be required.

Should a projection predict that the Project will exceed the permitted take authorization between scheduled evaluations, Auwahi Wind, in coordination with USFWS and DOFAW, will determine if adaptive management actions are warranted.

Follow-up Evaluation: When adaptive management actions are implemented, the effectiveness of the actions will be assessed after two years using PCMM data. At that time, the BFR will be compared to the TV to determine if additional adaptive management actions are warranted. Should the BFR exceed the TV at that time, adaptive management actions will be implemented as described in Section 3 of the AMP, and the BFR will be re-evaluated again at 2-year intervals until the BFR is equal to or less than the TV. Should adaptive management actions be implemented less than 2 years from a scheduled evaluation year (2025 or 2030), the next evaluation will occur 2 years after the adaptive management actions instead of at the scheduled evaluation.

3. Adaptive Management Actions

Since the initiation of Project development, Auwahi Wind has been collecting Project-specific information that can help inform minimization measures and adaptive management of minimization measures decisions. Table 3 summarizes Auwahi Wind's actions. In addition, since early in Project operations, Auwahi Wind has been implementing measures such as low-wind speed curtailment

(LWSC) and thermal and acoustic monitoring to reduce take of the Hawaiian hoary bat. Table 4 provides a timeline of actions taken.

Table 3. Adaptive Management Research Summary

Date	Action	Follow-up
2010	Preconstruction bat acoustic monitoring and radar studies performed to 2011	Low bat activity observed. Restrictions on tree cutting. Habitat loss in the upper elevation identified as main threat.
2012	Post construction mortality monitoring initiated	Bat fatality found in 2013. Increase carcass persistence, reduce search area, increase searcher efficiency
2013	Tetra Tech perform post construction acoustic monitoring study to 2015	Ground based monitors. Season and elevation trends. Bats found throughout the project site
2015	USGS perform bat acoustic activity, diet, and prey availability study to 2018	Detectors placed throughout project. Bat diet analysis performed. Multiple bats tagged at pond
2017	Two Bat carcasses sent to USGS for necropsy to determine cause of fatality	Cause of death not determined. List of island-wide fatalities from USGS provided for past fatalities i.e. pools, cats
2018	Bat carcasses provided to USGS for sexing	Site specific sex ratio calculated
	USGS and Natural Power perform thermal monitoring and acoustic monitoring at nacelle	No fatalities observed on camera. Bats heard and seen at different ratio than Kawailoa Wind Project study.
	LWSC at 6.9 m/s August – October at all turbines	BFR continue to increase
2019	Smart Curtailment study	Natural Power report show poor results of equipment and low evidence that would be beneficial at the site
	Partner with NRG to have Western EcoSystems Technology, Inc. (WEST) analyze thermal data from turbine mounted camera for multiple fatality events found with dog searcher	No bat fatality found in thermal data. Gleaning observed.
2020	Daytime observations recorded in DWM	Bat observation in mitigation area during daytime hours
2021	WIS confirm bat using 2 separate constructed water features	USGS confirm anecdotal observations of bats visiting water features (i.e., golf course ponds) in daytime hours.
	WEST perform Leeward Haleakalā and Tier 4 study with acoustic detectors within the project boundaries but not at turbines	Year round activity

Date	Action	Follow-up
2022	WIS performing study at turbine with 2 cameras, met tower, and turbine with water feature	Inform additional minimization measures

Table 4. Adaptive Management of Minimization Measures Implementation Timeline.

Date	Trigger/Action	Follow-up
December 2012	HCP initiated	Restrictions on tree cutting
September 2014	PCMM results indicate higher bat take than expected	Investigate LWSC as option for minimization
January 2015	Increase LWSC to 5.0 m/s year round at all turbines	Increase in fatality rate. Investigate additional minimization measures.
August 2019	LWSC at 6.9 m/s August – October at all turbines	Increase in fatality rate. Investigate additional minimization measures.
February 2020	BFR exceeded TV	Deterrent installation
July 2020	Deterrents installed	Re-evaluate BFR in July 2022
February 2021	Updated AMP submitted to USFWS and DOFAW (rev 3)	Investigate additional minimization measures
January 2022	BFR 6.93 exceeds the TV of 6.45	Update AMP and prepare for implementation of adaptive management of minimization measures
February 2022	Updated AMP provided to USFWS and DOFAW	Submit final in March 2022
July 2022	Evaluate BFR to determine if adaptive management of minimization is required	Inform potential additional minimization measures

3.1 Project Research and Observations to Inform Minimization

Auwahi Wind has continued to analyze Project-specific data and perform studies to better understand how to minimize bat fatalities.

These findings fall into three broad categories:

3.1.1 Bat activity

- Bat detections at the Project exhibit a unimodal distribution. The majority of bat activity occurs in the first 6 hours of the night with a peak in activity occurring 3.4 hours after sunset (Gorresen et al. 2020).

- Temperature has not been found to predict bat activity at the Project (Gorresen et al. 2020, Natural Power 2019).
- Bats may be active outside of nighttime hours. Natural Power reported bat acoustic detections during daytime hours, as late as 10 am at the Project (Natural Power 2019; see Section 3.1.3 for more detail on this data). Auwahi Wind personnel have recorded bat observations in daytime hours on 'Ulupalakua Ranch property in the Waihou Mitigation Area (10 am). Wildlife Imaging Systems (WIS) noted the occurrence of bat activity up to 1 hour after sunrise in September 2020 thermal monitoring data (USGS 2020). USGS provided examples of bat activity during daytime hours, as late as 9:15 am, observed anecdotally (pers. comm.. Corinna Pinzari, USGS, emailed October 7, 2020).
- Bat activity at the Project is logarithmically negatively correlated with wind speed (Gorresen et al. 2020). In other words, as wind speed increases fewer bats are observed for equivalent increases in wind speed. "The KS test statistic D, defined as the maximum value of the absolute difference between the two cumulative distribution functions, was located at a wind speed value of 6.6 m/s, corresponding to approximately 81 percent of cumulative bat detection events."
- **Thermal monitoring:** Auwahi Wind began monitoring bat activity using thermal cameras in 2018. Monitoring of bat activity with the use of thermal cameras is ongoing and used to investigate correlations between patterns of bat activity and fatalities.
    - Thermal data collected at the Project in 2019 – 2021 found that periods with increased insect activity were positively correlated with an increase in detections of bats (USGS 2019, WEST 2021, WIS 2021).
    - Bat activity at the Project is characterized as having "long and unpredictable time periods between consecutive detection events, both within and among nights" (Gorresen et al. 2020). This unpredictability leads to difficulty in predictive algorithms used for "smart" curtailment.
    - Auwahi has documented bats drinking and foraging at constructed ponds (WIS 2021). The presence of two water troughs at turbines 1 and 6 warrants further investigation as mainland bats have been observed to utilize water troughs for foraging (Taylor and Tuttle 2007). These water troughs at the Project are only filled when cattle are present (see Section 3.1.2 for discussion of grazing at the Project).

  - Between 2018 and 2022, dog searches at the Project, as part of the PCMM, found 26 bat fatalities. However, during this same period no bat fatalities due to collision with a turbine structure were observed with thermal imaging at turbines 2, 4, 5, and 7.
  - Analysis of thermal data from the Project by Gorresen et al. 2020, WEST 2021, and WIS 2021; all noted bats at the Project approaching the turbine tower and nacelle or "touch-and-go" behaviors. Other studies have associated these behaviors with foraging (Foo et al. 2017) or olfactory marking (Guest et al. 2022). The purpose of this behavior at the Project is not known.
- **Acoustic Monitoring:**
  - Auwahi Wind contracted Western EcoSystems Technology, Inc. (WEST) to perform acoustic Monitoring across leeward Haleakalā. High rates of occupancy (as measured by acoustic activity) across the study area were positively correlated with reproductive season and increasing elevation. (Thompson and Starcevich 2021)
  - Acoustic data from nacelle mounted detectors at the Project demonstrated August was month with highest activity, data collected August 2018 – October 2019 (Natural Power 2019). Bat activity is "primarily in the first few hours after sunset (around 6 pm), with relatively low activity after midnight." Microphones facing the rear of nacelle consistently detected more bat calls than microphones facing rotor.

3.1.2 Bat Fatalities

- The months of May through October represent the highest continuous months of observed downed bat observations. Of these months August, September and October have 70 percent (31 of 44) of observed fatalities. Bat fatalities have been observed in 10 out of 12 months at the Project, no fatalities have been observed in the months of April or December.
- Of the 36 bat fatalities with confirmed genetic identification 16 are female and 20 are male or 44 percent female and 56 percent male (Pinzari and Bonaccorso 2018).
- Disproportionate number of bat fatalities observed at turbines 1, 2, and 6, accounting for 73 percent (32 of 44) observed bat fatalities. At least one bat fatality has been detected at each of the other turbines: 3, 4, 5, 7, and 8.
- Bat fatalities at Turbine 6 account for 10 of 44 observed fatalities over 9 years and an average of 1.1 fatalities per year while low risk turbines (3, 4, 5, 7, and 8) average 0.27 bats per year (12 bats over 45 turbine years). The Project has a meteorological (met) tower

upwind of Turbine 6. Guest et al. (2022) describes observations of increased feeding buzzes at met towers. This suggests bats transiting through the rotor swept zone if flying from Turbine 6 to the met tower could be at increased risk of collision.

- When comparing observed bat fatalities to grazing records; 7 of 44 observed bat fatalities have occurred while cattle are actively grazing at the wind farm. An additional 6 fatalities have occurred during the 30 days post grazing. When combined, these 13 fatalities account for 29 percent of observed fatalities, suggesting no strong correlation between grazing and increased risk of fatalities. In addition to cattle, feral deer and goats are common in large numbers at the Project and they are free to roam unmanaged throughout the Project area. Ungulate excretions including cattle dung are present year round at the Project. In Europe, Pipistrellus spp. are found to forage over livestock (Ancillotto et al. 2017). USGS looked at bat activity in relation to goat and sheep herds but found no correlation with bat activity (Montoya-Aiona et al. 2020). It is unknown if grazing ungulates change the risk to bats associated with wind turbines.

- Pinzari et al. (2019) found "The female bat found in August under a turbine at the Auwahi Wind Energy facility, had the most diverse diet of the eight bats examined, including all six orders identified by PCR. About a third of [operational taxonomic units] (OTUs) in this sample were from the dung beetle *Digitonthophagus gazella*." Additionally, guano from bats found at the Project contained more diverse diets; lower proportions of moths, and included Coleoptera, Diptera, Hemiptera, and Blattodea.

3.1.3 Minimization measures

- Increasing LWSC thresholds and installation of deterrents has not been associated with a decrease in fatalities at the Project. Conversely, the average of observed, and estimated fatalities have increased in years of implementation. This observation is preliminary given the small sample sizes and variability in the data, however it warrants careful consideration of LWSC and deterrents as a minimization measure applied at the Project.

- Despite the implementation of deterrents, bats are still recorded near turbines and nacelles through thermal monitoring (WEST 2021, WIS 2021)

- Gorresen et al. (2020) found that bats were likely to be present at the Project when the turbine blades were moving slowly or stopped. However, Gorresen et al. (2020) also demonstrated that variability in wind speed and turbine blade rotation intermittency were positively related to bat detection probability. An increase of detections was associated with starting and stopping the wind turbines blade rotation.

- Auwahi Wind contracted Natural Power to perform a smart curtailment study in 2019 (Natural Power 2019). Overall, the study found no actionable minimization measures. Monitoring equipment failed for most of the study period. Natural Power's smart curtailment technology is not ready to implement.

A number of key assumptions have been built into the previously implemented minimization measures and are continuing to be evaluated:

1. Bat activity (acoustic, or thermal) is correlated with bat fatality rates;
2. Bat fatalities are equally likely throughout the night and no bat fatalities occur during daytime hours;
3. The bat population is not changing;
4. Previously implemented minimization measures have been effective at reducing bat fatalities.

Despite increasing minimization measures, Auwahi Wind has observed a general increasing fatality rate from 2013 to 2021 at the Project. The USFWS, DOFAW, and Endangered Species Recovery Committee have assumed that the bat population is stable (ESRC 2020). If true, the increased fatality rates at the Project may be related to an increased attraction to the site, possibly through the installation of deterrents or implementation of additional LWSC measures. Alternatively, if the bat population is increasing the increase in observed fatality rates may be a result of increasing numbers of bats in the population.

3.2 Adaptive Management Options

Adaptive management actions will be required if, at a Scheduled Evaluation or Follow-up Evaluation, the BFR exceeds the TV. If adaptive management actions are required, Auwahi Wind will implement adaptive management actions in the order listed below.

Currently available options:

1. Removal of the met tower to discourage bats from flying between tall structures and spending additional time in the rotor swept zone. If the met tower is responsible for the increased risk of fatalities at Turbine 6, the removal of the met tower could provide a reduction in the Project fatality rate by approximately 10 – 20 percent. Such a reduction could reduce the Project fatality rate from 7 bats per year to between 5.6 to 6.3 bats per year

(below the TV). This reduction may take more than 2 years to impact the BFR due to the previous 9 years of monitoring data.

2. Spatial redistribution of Curtailment Nights (see definition in Section 7.4.1.1 of the HCP Amendment): A higher proportion of fatalities have been observed at turbines 1, 2, and 6 than at the other turbines. Redistribution of Curtailment Nights from low risk turbines to turbines with higher risk would be the second adaptive management action. The redistribution will allocate Curtailment Nights from low risk turbines to high risk turbines either nightly or seasonally. Selection of nightly or seasonal application would be based on post-construction monitoring results.

3. Temporal redistribution of Curtailment Nights: Curtailment at 6.9 m/s would be continued for the first 6 hours of the night for the months of August through October. Cut-in speeds for the remaining hours of the night would be 5.0 m/s. This would provide an additional 704 Curtailment Nights, with cut- in speeds of 6.9 m/s for the first 6 hours of the night, to be redistributed. These additional Curtailment Nights would be applied May 5 through July 31 to address the intermediate risk months.

3.2.1 Future adaptive management options worth further investigation

1. Minimize the amount of start and stop of blade rotations at turbines, this type of turbine operation is correlated with increased bats detection events (Gorresen et al. 2020).

2. Modification of ranching operations subject to approval of ʻUlupalakua Ranch:

    - Risks to bats from wind turbines may have complex interactions with the timing of grazing warranting further investigation. Should implementable management actions be determined to have scientifically justified reductions in risk to bats, Auwahi Wind will discuss the practicability of implementation with ʻUlupalakua Ranch.

    - The presence of water troughs at Turbines 1 and 6, which have water available when cattle are present, may modify bat activity at the Project. Further investigation is necessary to determine if bats utilize these water troughs. If bats are utilizing these water troughs, modification or movement of the water troughs may reduce risk to bats. Auwahi Wind will continue to look for evidence of actions that could reduce risk to bats associated with these water troughs. Should implementable management actions be determined to have scientifically justified reductions in risk to bats, Auwahi Wind will discuss the practicability of implementation with 'Ulupalakua Ranch.

3. Apply any practicable and scientifically-supported new deterrent technology that becomes commercially available (e.g. smart curtailment system, deterrent units affixed to turbine blades, application of olfactory bat deterrents to reduce bat activity around the wind turbine structures).

3.3 Previously implemented Adaptive Management:

An adaptive management action was triggered at the February 2020 Scheduled Evaluation (Table 4). Auwahi Wind implemented an acoustic deterrent system. DOFAW and USFWS were notified the adaptive management action had been triggered and were in support of Auwahi Wind installing NRG bat deterrents (March 9, 2020). Adaptive management was implemented in July of 2020 with the finalization of the NRG installation of bat deterrent systems at all turbines.

The continued utilization of near-turbine airspace, and the detection of bat fatalities despite the implementation of deterrents, and the inability to detect a reduction in fatality rates resulting from deterrents raise concerning questions regarding the suitability of NRG deterrents as a minimization measure for bats at the Project. The increase of bat fatalities at the Project suggests the need to test LWSC and deterrent effectiveness to determine if these strategies have no effect, or possibly increase the risk bat collision with wind turbines at the Project.

4. Adaptive Management of Baseline Minimization

The suite of minimization measures available to reduce the risk to bats may change over time because of ongoing industry research and development of new technology. Auwahi Wind may propose a change to baseline minimization measures identified in the HCP Amendment (Section 4.2.7) or adaptive management actions in the AMP, such as replacement of low wind speed curtailment with bat deterrent technology. Such a change would be subject to review and approval by USFWS and DOFAW prior to being implemented at the Project.

Auwahi **Wind**	Adaptive Management Plan 2022	
	REVISION NUMBER:	4
	EFFECTIVE DATE:	2/28/2022
	REVISION DATE:	2/28/2022
	REVIEWED DATE:	2/28/2022
	REVIEW CYCLE:	12 MONTHS

REVISION HISTORY LOG			
Rev.	**Date**	**Description**	**By Initials**
0	7/29/2019	Auwahi Wind Habitat Conservation Plan Amendment	MVZ
1	3/20/2020	Edits, Additions, Formatting	GA
2	4/2/20	Remove the term “Interim” for clarification and update HCP annual report due date to reflect ITP due dates	GA
3	6/10/20	Adding ITL permit number	GA
4	2/28/2022	Revised to incorporate additional observations and new minimization measures	GA, MWS

X ______________________

George Akau
Auwahi Wind Biologist

X ______________________

DOFAW Protected Species Habitat Conserva...

X ______________________

USFWS Alternative Energy Program/HCP Co...

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Attachment 4

Black Oak Wind Bat Deterrent Effectiveness Study

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2021 Post-Construction Monitoring Study

Bat Deterrent Effectiveness Study – Year 1

Black Oak Wind Project

Stearns County, Minnesota

July 1 – October 1, 2021

Prepared for:

Black Oak Wind, LLC

Prepared by:

Jennifer Stucker, Kevin Heist, Molly Tuma, Julie Bushey, and Joyce Pickle

Western EcoSystems Technology, Inc.
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December 15, 2021

EXECUTIVE SUMMARY

Black Oak Wind, LLC is currently operating the 78-megawatt (MW) Black Oak Wind Project (Project) in Stearns County, Minnesota (Figure 1). The Project became operational on December 23, 2016 and consists of 39 Vestas 2.0 MW V110 conical tubular steel tower wind turbine generators. Each turbine is a three-bladed, upwind, horizontal axis wind turbine with a rotor diameter of 361 feet and blades measuring 177 feet. A study to test the efficacy of an acoustic deterrent system was implemented in 2021 in an effort to reduce bat fatalities. The turbines not involved in the deterrent study followed a modified informed curtailment strategy in 2021.

Acoustic deterrents were installed on four turbines and were operational during the study period of July 1 – October 1. An additional four turbines were used as a control group for the purpose of examining the effect of the deterrents on fatality rates. Both deterrent and control turbines were subject to an intensive search schedule of twice-weekly searches of a large (150 m [492 ft] square) plot by a dog-assisted search team. The other 31 turbines were curtailed by feathering blades when wind speeds were below 4.5 m (14.8 ft) per second during a 7-hour period of the night identified as having the highest bat activity during a 2019 operational acoustic study. The curtailed turbines were surveyed for fatalities via once-weekly searches of the turbine pad and access road, to a distance of 100 m (328 ft), by a human observer.

The primary objective of this 2021 study was to estimate the reduction in bat fatality rates resulting from use of the deterrents on Project turbines, relative to the control group of turbines without deterrents; a secondary objective of the first year of study was to evaluate the bat fatality rates associated with the informed curtailment strategy of 4.5 m/s cut-in speeds using the revised 7-hour target periods from July 1 – September 30 that was implemented at the 31 other turbines at the Project. Additionally, the fatalities and fatality rates were compared to PCMM results from previous years at the Project.

PCMM at Black Oak began on July 1 and concluded October 1, 2021, resulting in 215 dog-assisted full plot searches and 431 road and pad searches. During scheduled searches, 191 bat carcasses were found at search plots. These included five species: 68 silver-haired bats, 53 hoary bats, 48 eastern red bats, 19 big brown bats, two little brown bats, and one unidentified bat. Full plot searches accounted for 121 fatalities (62 at control plots and 59 at deterrent plots) and road and pad searches accounted for 70 fatalities.

The overall estimated fatality rate for the study was 20.99 bats per MW. The estimated fatality rate was 9.33 at deterrent turbines, 9.36 at control turbines, and 23.92 at curtailed turbines. Raw fatality numbers and fatality rate estimates provided no evidence of a reduction in bat fatality rates caused by deterrents. Further, modeling of deterrent effect on fatality rates in a Before-After Control-Impact structured analysis to control for inter-annual and inter-turbine effects indicated there was no evidence of a significant reduction in bat fatality rates caused by the deterrents. However, fatalities of silver-haired bats were found to be lower at deterrent turbines.

STUDY PARTICIPANTS

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Andrea Palochak	Technical Editor
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Ellen Mattson	Field Technician
Riley Knoedler	QA/QC Technician

REPORT REFERENCE

Stucker, J., K. Heist, M. Tuma, J. Bushey, and J. Pickle. 2021. Post-Construction Monitoring Study, Black Oak Wind Project, Stearns County, Minnesota. July 1 – October 1, 2021. Prepared for Black Oak Wind, LLC. Prepared by Western EcoSystems Technology, Inc. (WEST), Golden Valley, Minnesota. December 15, 2021. Revised February 1, 2022.

ACRONYM LIST

Acronym	Definition
AEP	AEP Renewables
AICc	corrected Akaike Information Criterion
BACI	Before-After Control-Impact
BDS	bat deterrent system
CI	confidence interval
DU	deterrent units
DWM	Downed Wildlife Monitoring system
ft	foot
ft/s	feet per second
GenEst	generalized estimator
GLMM	Generalized linear mixed-effects model
hr	hour
k	detection reduction factor
MW	megawatt
m	meter
m/s	meters per second
MNDNR	Minnesota Department of Natural Resources
NRG	NRG Systems
O&M	Operations and Maintenance
PCMM	Post-construction mortality monitoring
Project	Black Oak Wind Project
SGCN	Species of Greatest Conservation Need
SPC	Species of Special Concern
study	post-construction adaptive management study
USFWS	US Fish and Wildlife Service
WEST	Western EcoSystems Technology, Inc.

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INTRODUCTION

AEP Renewables (AEP) is operating Black Oak Wind Project (Project) in Stearns County, Minnesota (Figure 1). The Project is a 78-megawatt (MW) wind energy facility that became operational on December 23, 2016, and consists of 39 Vestas 2.0 MW V110 conical tubular steel tower wind turbine generators. Each turbine is a 3-bladed, upwind, horizontal axis wind turbine with a rotor diameter of 110 meters (m; 361 feet [ft]) and blades measuring 54 m (177 ft).

AEP is continuing to pursue strategies to reduce bat fatality levels at Black Oak by means of operational adjustments and acoustic deterrents. Western EcoSystems Technology, Inc. (WEST) has assisted in development and implementation of three years of post-construction mortality monitoring (PCMM) at the Project in 2017, 2018, and 2019. For example, in 2018 (second year of operation), AEP implemented a curtailment regime to increase the cut-in speed to 3.5 m per second (m/s; 11.5 ft/s) nightly from July 1 through September 30, compared to feathering below 3.0 m/s (9.8 ft/s) from April 1 to October 31 per the Project's site permit requirements. In 2019, AEP further increased the cut-in speed to 4.5 m/s (14.8 ft/s) for a targeted 7-hour (hr) nightly period from July 1 through September 30; AEP also conducted an operational acoustic study in 2019 to provide more information on bat activity patterns at the Project. Findings from the 2018 study did indicate that the raised cut-in speed of 3.5 m/s reduced bat fatality rates compared to 3.0 m/s. However, the overall bat fatality rates per MW remained relatively high in both 2018 and 2019 compared to other Minnesota PCMM studies. In 2020, AEP engaged in discussions with the Minnesota Department of Commerce and the Minnesota Department of Natural Resources (MNDNR) about installing acoustic deterrent devices (Weaver et al. 2020) in order to further reduce bat fatalities at the Project. Additionally, as coordinated with the MNDOC and MNDNR, AEP proposed that the 31 turbines not involved in the deterrent study would follow an a modified informed curtailment strategy of feathering below a cut-in speed of 4.5 m/s during a consecutive 7-hr period every night from July 1 – September 30, 2021 based on the 7-hour periods identified as having the highest bat activity during the 2019 operational acoustic study.

AEP contracted WEST to conduct a two-year post construction adaptive management study (study) to assess the efficacy of NRG acoustic deterrents beginning in 2021. This study constitutes a Tier 5 study under the U.S. Fish and Wildlife Service Land-Based Wind Energy Guidelines (USFWS 2012). The primary objective of the first year of this study was to evaluate the effect of the deterrent system on bat fatality rates at a select group of turbines with and without deterrents installed (deterrent study), with a secondary objective to estimate bat fatality rates associated with an informed curtailment strategy of 4.5 m/s cut-in speeds during a 7-hour target period implemented on turbines not used in the deterrent study.

STUDY AREA

The Project is located in Stearns County in west-central Minnesota, in the North Central Hardwood Forests ecoregion (US Environmental Protection Agency 2013). The Project boundaries encompass 14,719 acres (approximately 23 square miles), with all facilities on private lands. The area is mostly agricultural, with cropland constituting more than 80% of the land cover within the Project (Pickle et al. 2019).

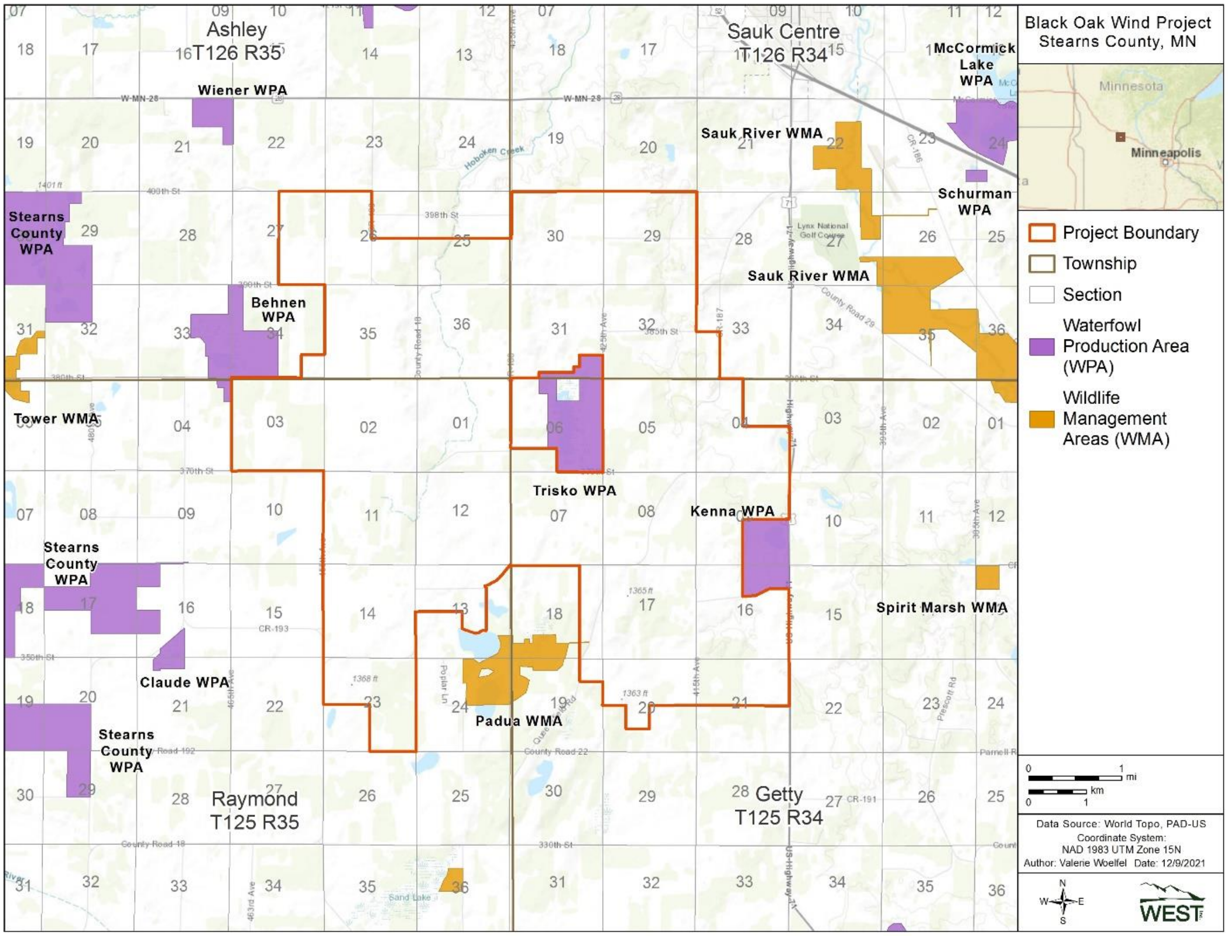

Figure 1. Location of the Black Oak Wind Project, Stearns County, Minnesota.

METHODS

The study conducted at the Project included:

- Standardized carcass searches of 150 m (492 ft) square plots by detection dog teams at eight (8) turbines in the deterrent study: four in the deterrent group and four in the control group;
- Road and pad searches by human searchers at the remaining 31 turbines operating with an informed curtailment regime (curtailed turbines);
- Bias estimation for bats, including searcher efficiency and carcass persistence trials;

- Estimation of bat fatality rates using the generalized estimator (GenEst; Dalthorp et al. 2018a) for treatment, control, and curtailed turbines; as well as overall facility estimates; and
- Analysis to evaluate the potential reduction in bat fatalities from the acoustic deterrents.

Standardized Carcass Searches

Turbines Sampled and Search Frequency

All turbines within the Project were searched from July 1 – October 1, 2021. Eight turbines were searched intensively as part of the deterrent study. Of these, four turbines were outfitted with NRG acoustic deterrents (deterrent group), and another four constituting a control group operated without deterrents (Table 1, Figure 2). Deterrent and control group turbines were selected by the Project based on landowner willingness to participate in a two-year intensive fatality study and restrict their crop growing within the square plot to something low, such as alfalfa (*Medicago sativa*) or soybeans (*Glycine max*).

Searches in square plots were conducted twice a week at these eight turbines using detection dog teams (methods outlined below). These plots were searched within a 150-m square plot centered on the turbine and were planted with low crops. The boundaries of all square plots were delineated in the field using a hand-held global positioning system unit. All eight turbines in the deterrent study were feathered below the manufacturer's cut-in speed of 3.0 m/s during the study period, in order to determine the effectiveness of acoustic deterrents across the deterrent and control groups without the potentially confounding effects of more restrictive curtailment.

Table 1. 2021 deterrent and control turbine designations at the Black Oak Wind Project.

Turbine	Treatment	Search Type
A07	Control	Square plot (150-m square)
A11	Control	Square plot (150-m square)
B12	Deterrent	Square plot (150-m square)
B18	Deterrent	Square plot (150-m square)
C27	Deterrent	Square plot (150-m square)
D35	Control	Square plot (150-m square)
D38	Deterrent	Square plot (150-m square)
D39	Control	Square plot (150-m square)

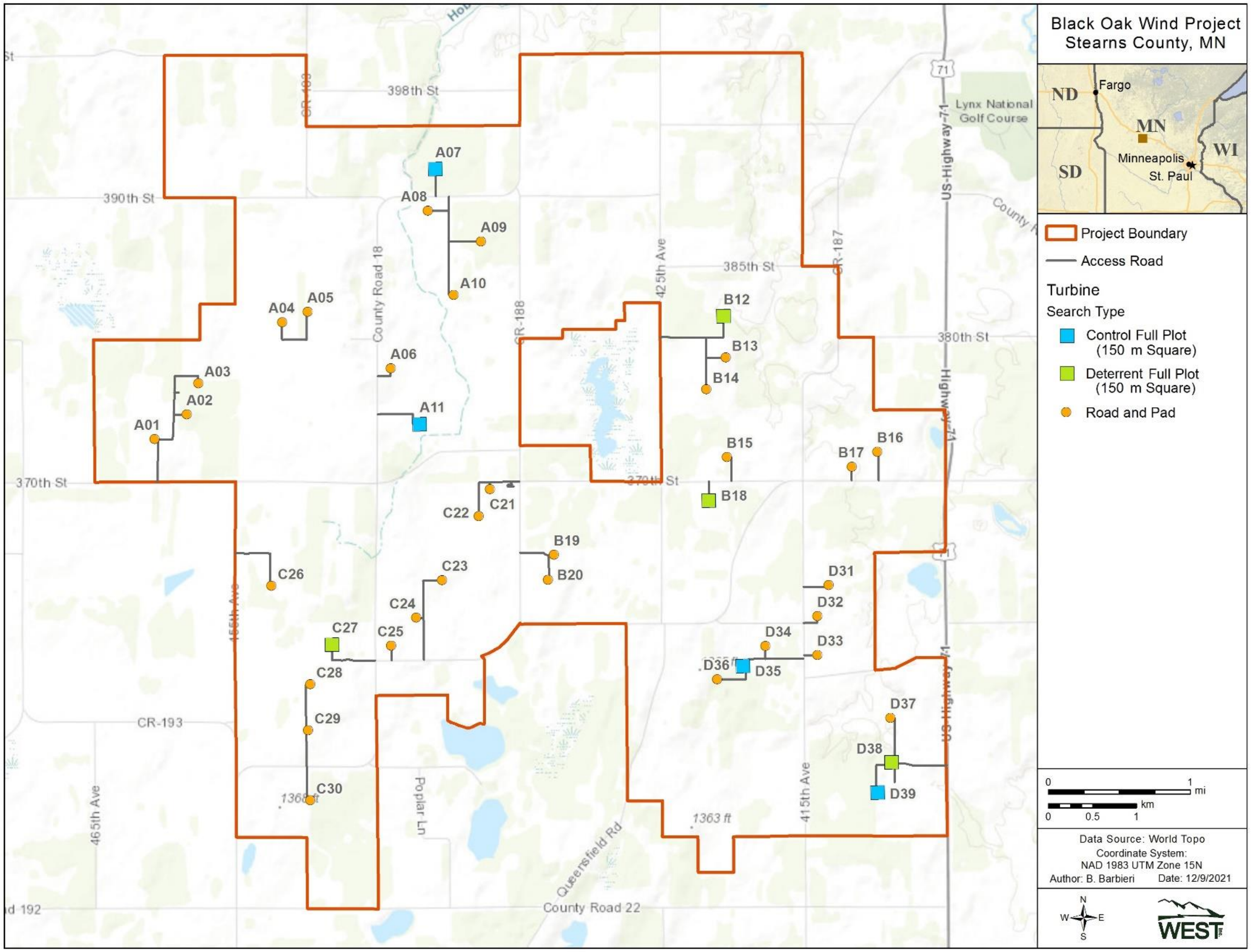

Figure 2. Layout for the Black Oak Wind Project, Stearns County, Minnesota, and turbines with Deterrents or that served as a Control with 150-meter square plots, and turbines with road and pad searches.

The remaining 31 turbines that were not a part of the deterrent study operated under informed curtailment (curtailed turbines), in which turbines had a cut-in speed of 4.5 m/s during a 7-hr target period of potentially elevated bat activity, the timing of which varied by month. Road and pad searches were conducted once per week by human searchers without the assistance of dogs. The gravel road and pad areas were searched within 100 m (328 ft) of the turbine. Road and pad boundaries were established from delineations conducted in previous years.

Carcass Searches

WEST technicians and detection dog teams trained in proper search techniques completed carcass searches. A detection dog team (one dog and one handler) conducted square plot searches at the eight deterrent study turbines (Figure 2). The detection dog team systematically walked parallel transects at a casual rate of 45–60 m (148–197 ft) per minute, allowing the dog to traverse the transect and locate carcasses. Both the detection dog and handler scanned the area on both sides of each search transect; the dog searched based on scent, while the handler searched visually for carcasses. Variables such as wind speed, vegetation density, ambient temperature, and topography affected scent dispersal across a search area, and depending on these variables, search transects were spaced approximately 15–30 m (49–98 ft) apart. Handlers oriented detection dogs to walk transects perpendicular to the wind to maximize the detection of scent cones emitted by bird and bat carcasses. Wind direction was also used to determine the starting point for each survey to keep the dog downwind of potential carcasses. Transect lines were modified in the field when necessary to avoid unsearchable areas or hazards (e.g., tall vegetation, deep mud puddles), or to compensate for challenging search conditions (e.g., tighter transect lines in order to maximize searcher efficiency when search plot vegetation is overgrown).

Detection dogs were trained to recognize the scent of bat carcasses using methods derived from search and rescue and drug detection programs (Kay 2012, Helfers 2017). Dogs were initially trained with dehydrated bat carcasses and worked through a training protocol that included scent discrimination, distraction odors, and simulated field environments. Prior to study commencement, each detection dog team was evaluated over two days in multiple simulated and actual search areas by the detection dog coordinator. Detection dog teams achieving a searcher efficiency of 75% or greater were approved to conduct standardized carcass searches. Methods to determine searcher efficiency for detection dogs using bats are described in Searcher Efficiency Trials, below.

For road and pad searches at the remaining 31 turbines, human searchers systematically scanned for carcasses while walking transects spaced up to six m (20 ft) apart at a pace of approximately 45–60 m per minute within the road and pad plots, which consisted of the access road out to 100 m and the pad surrounding the turbine.

When a bat or bird carcass was found during a search, the searcher placed a metal pin flag at the carcass and finished searching the plot. All bird and bat carcasses found were recorded; all carcasses found were assumed to be from collision with turbines. However, only bats were included for analysis at this Project. Data recorded for all carcasses included:

- turbine number

- search type (road and pad or square plot)
- Indication of inside/outside plot
- an identification code
- species, sex, and age (when identifiable)
- date and time
- Universal Transverse Mercator and latitude/longitude locations
- measured distance and bearing from turbine
- estimated time of death and notes on decomposition and potential infestation
- photograph(s) of carcass as found
- condition (i.e., intact, scavenged, dismembered, feather spot, injured)
    - Intact—a completely intact carcass, not badly decomposed, and showing no sign of being fed upon by a predator or scavenger.
    - Scavenged—an entire carcass showing signs of scavenging or that is heavily infested by insects, or portion(s) of a carcass in one location (e.g., wings)
    - Dismembered—a carcass that has missing limbs
    - Feather Spot—10 or more feathers (or two or more flight feathers) at one location indicating predation or scavenging
    - Injured—a live bird or bat that is harmed, damaged, or impaired in some way

Data Collection

WEST technicians collected data following AEP's preferred fatality documentation application Downed Wildlife Monitoring system (DWM; Neural Direct, LLC) using an iPad tablet in the field. DWM was used to manage search schedules, workload, and results from both searches and bias trials. Data from DWM were transferred to WEST's database weekly. Formal results and analyses were produced from data in WEST's database (see Statistical Analysis below).

Carcass Collection

WEST worked under the USFWS Migratory Bird Special Purpose Utility Permit held by Black Oak Wind LLC (Permit Number MB13133C-0) and the MNDNR Scientific Research—Salvage Special Permit (Number 19024, as amended) held by WEST. Searchers collected all carcasses and placed them in a re-sealable plastic bag labeled with a unique carcass identification number that included the turbine number and date, and stored the bag in a freezer onsite at the Operations and Maintenance (O&M) building. Searchers wore both leather and nitrile gloves to handle all bird and bat carcasses to eliminate possible contraction of rabies or other diseases. Injured birds or bats were not handled (in accordance with permit conditions), but were recorded according to protocols described above, and were considered fatalities for purposes of analysis. Carcasses will remain at the O&M facility until next year's study unless requested by the MNDNR or USFWS.

Federally permitted bat biologists (Larisa Bishop-Boros [permit number: TE21829B-2], Kristina Hammond [TE03495B-2], Brenna Hyzy [TE26854C-1], Ashley Matteson [TE19208C-0], or Pallavi Sirajuddin [TE62046D]) verified all bat species identifications for any potential species of concern. Biologists experienced in avian identification verified all bird species identifications. Species of concern for the Project are those designated as federally or state-listed threatened or endangered species (MNDNR 2013, USFWS 2020), as well as state-designated species of Special Concern (SPC; MNDNR 2013). In the event any federally protected, state-listed threatened, endangered, or SPC species, or migratory bird or bat casualties were found, the USFWS, Minnesota Public Utilities Commission, and MNDNR were notified within 24 hours as per the site permit (State of Minnesota 2013).

Bat Deterrent

An acoustic bat deterrent system developed by NRG was purchased and installed at four wind turbines prior to the deterrent study and activated by the night of July 1, 2021. Each deterrent system was operational from 30 minutes before sunset to 30 minutes after sunrise nightly thereafter. The system on each deterrent turbine consisted of five deterrent units (DU), a controller, cables, and power supply, and was connected to the SCADA system which allowed Vestas to monitor the system status. The bat deterrent system produced an ultrasonic sound field around the rotor-swept zone that overlapped bat call frequencies and only operated at night. The DUs were mounted on the outer surface of the turbine's nacelle and oriented toward the rotor-swept zone. The controller and power supply were mounted inside the wind turbine.

Bias Trials

Searcher Efficiency Trials

The objective of the searcher efficiency trials was to estimate the probability a bat casualty was found by human searchers and detection dog teams. Searcher efficiency trials during this study were limited to bats, but were otherwise conducted following the same methodology as the 2017, 2018, and 2019 PCMM studies at the Project (Pickle et al. 2018, 2019; Stucker et al. 2020). Separate searcher efficiency trials were conducted for road and pad searches and for square plot searches in order to estimate searcher efficiency for human searchers and detection dog teams, respectively. Searcher efficiency trials were conducted in the same areas where carcass searches occurred. Estimates of searcher efficiency were used to adjust the total number of bat carcasses found for those missed by technicians or detection dog teams, accounting for detection bias in the fatality estimates.

WEST personnel placed trial carcasses to ensure searchers did not know when trials were conducted or the location of the detection carcasses. Bat carcasses found during searches were incorporated into the searcher efficiency trials. Overall, 63 bat carcasses were used in the searcher efficiency trials across all turbines.

The carcasses used were found during PCMM studies at the Project in previous years. Only hoary bat (*Lasiurus cinereus*), eastern red bat (*L. borealis*), and silver-haired bat (*Lasionycteris noctivagans*) carcasses were used. Because detection dog teams rely on carcass scent, intact bat carcasses which had been collected and frozen during prior PCMM studies were used for searcher efficiency carcasses on square plots. Each trial carcass was discreetly marked with a yellow zip-tie around the upper arm prior to placement so that it could be identified as a study carcass after it was found. All carcasses were placed at random locations within search plots by someone not conducting the search, and were placed within 24 hours of the search. Carcasses were dropped from waist height or higher and allowed to land in a random posture. The number and location of carcasses found during the subsequent search was recorded, and the number of carcasses available for detection during each trial was determined immediately after the search by the searcher returning to the placement location using the DWM system.

Carcass Persistence Trials

The objective of carcass persistence trials was to estimate the average length of time (in days) a bat carcass persisted in the field (i.e., before a carcass was no longer available for detection). Carcass persistence trials during this study were conducted following the same methodology as the 2017, 2018, and 2019 PCMM studies at the Project (Pickle et al. 2018, 2019; Stucker et al. 2020). Carcasses may be removed by scavenging, or rendered undetectable by farming activities such as harvesting or tilling. Estimates of bat carcass persistence were used to adjust the total number of carcasses found for those removed from the study area prior to searches, accounting for persistence bias in the fatality estimates.

Four trials were conducted at different times throughout the study to incorporate the effects of varying weather, climatic conditions, and scavenger densities. Over the course of the study, 32 bat carcasses were monitored in the carcass persistence trials. Searchers monitored persistence trial carcasses over a 30-day period according to the following schedule as closely as possible: carcasses were checked every day for the first four days, and then on days 7, 10, 14, 20, and 30, or until the carcass disappeared prior to 30 days, in which case no more checks occurred. Human technicians or detection dog teams checked carcasses. A carcass was determined to be removed if it could not be found on two consecutive checks. Otherwise, carcasses were left at the location until the end of the carcass removal trial. At the end of the 30-day period, any evidence of the remaining carcasses was removed from the search plot.

Statistical Analysis

Quality Assurance and Quality Control

Quality assurance and quality control measures were implemented at all stages of the study, including in the field, during data entry and analysis, and report writing. Following field surveys, searchers were responsible for making sure that all information entered into the tablet was successfully uploaded onto the DWM system. WEST database managers were responsible for transferring the data from DWM into WEST's Project-specific Microsoft® SQL database. The Microsoft database was used to store, organize, and retrieve survey data. All electronic data files were retained for reference. Potentially erroneous data were identified using a series of database queries. Irregular codes or data suspected as questionable were discussed with the searcher and/or Project manager. Errors, omissions, or problems identified in later stages of analysis were traced back to the original entries from the tablet, and appropriate changes were made in all affected steps.

Fatality Rate Estimation

Carcasses included in the fatality rate estimation were bats found during scheduled searches within the search plots that had an estimated time of death within the study period. Any carcasses with estimated time of death prior to the start of the study were excluded from the analyses. A clearing search was conducted at all square plots on June 25 – 30 to eliminate any fatalities existing prior to the beginning of the deterrent study on July 1. Fatality estimates were calculated for bats for each turbine operation regime (control, deterrent, and curtailed) using GenEst (Dalthorp et al. 2018a, Simonis et al. 2018). To obtain an overall estimate of fatality, each carcass included in the analysis was adjusted for searcher efficiency, carcass persistence, a detection reduction factor (also referred to as "*k*"; see below), and a search area adjustment. Estimates and 90% confidence intervals (CI) were calculated using a parametric bootstrap (Dalthorp et al. 2018a). An overall facility estimate was developed by taking the weighted average fatality rate across plot types, weighted by number of turbines searched.

Searcher Efficiency Estimation

Data collected during searcher efficiency trials were used to estimate the probability that searchers detected bat carcasses, given the carcass was available to be found. Estimates of searcher efficiency were used to adjust carcass counts for detection bias. Estimates were obtained using a logit regression model (Dalthorp et al. 2018a). A covariate for the type of search conducted (detection dog team or human searcher) was considered and a model with no covariates was fit. Model selection was done using an information theoretic approach known as AICc, or corrected Akaike Information Criterion (Burnham and Anderson 2002). The selected model was determined as the most parsimonious model within two AICc units of the model with the lowest AICc value.

Carcass Persistence Estimation

Data collected during carcass persistence trials were used to estimate the amount of time, in days, carcasses remained available to be detected by the searcher. Estimates of carcass persistence were used to adjust carcass counts for removal bias. The carcass persistence adjustment estimated the average probability a carcass persisted through the search interval (i.e., the time between scheduled searches). The persistence of a carcass was modeled using an interval-censored survival regression using exponential, log-logistic, lognormal, and Weibull distributions (Kalbfleisch and Prentice 2002, Dalthorp et al. 2018b) as potential persistence distributions. Plot type (square plot or road and pad) was considered as a potential covariate when fitting each of the parameters of the persistence distributions to account for differences between the two plot types and models with no covariates were fit. The selected model was determined as the most parsimonious model within two AICc units of the model with the lowest AICc value.

Detection Reduction Factor

The change in searcher efficiency between successive searches was defined by a parameter called the *detection reduction factor* (*k*) that ranged from zero to one. When *k* is zero, it implies a carcass missed on the first search would never be found. A *k* of one implies searcher efficiency remains constant no matter how many times a carcass is missed. The detection reduction factor was a required parameter for GenEst; however, data were not collected to estimate *k*. A value for *k* of 0.67 has been estimated for bats (Huso et al. 2017) and was assumed in this study.

Search Area Adjustment Estimate

The search area adjustment accounted for areas beneath turbines that went unsearched, but could potentially contain fatalities. The adjustment was calculated as a probability that ranged from zero to one. For example, an area adjustment of 0.75 meant that an estimated 75% of carcasses fell within the search plot. Smaller searched areas with a lower area adjustment can result in greater uncertainty and wider confidence intervals around fatality estimates. Unsearched areas were due primarily to study design parameters (e.g., road and pad searches), but could also result from survey obstacles such as ground cover (e.g., tall crops) or terrain, or carcasses falling far from the turbine and landing outside of search plots. The area adjustment was estimated as the product of the unsearched area around each turbine and a carcass-density distribution. The carcass-density distribution predicts the likelihood a carcass fell a given distance from the turbine base.

A number of analysis methods exist to calculate the search area adjustment. The number of carcasses found during surveys determined the method used. For this PCMM study, enough bat fatalities occurred to use a truncated weighted maximum likelihood modeling approach (Khokan et al. 2013) to estimate the carcass-density distribution of bats for each turbine operation regime (control, deterrent, and curtailed). Truncation accounts for carcasses beyond the search radius and weights account for unequal search effort. Distributions considered were normal, gamma, Gompertz, Rayleigh and Weibull (parameterized according to R Development Core Team [2016] and Yee and Moler [2020]). The proportion of area searched was calculated in a Geographic Information System as the amount of area searched divided by the total area searched at each 1-m (3-ft) annulus around the turbine. The area adjustment was estimated by combining the carcass-density distribution with the proportion of area searched for each 1-m annulus across the plot and summarizing across the distances.

Deterrent Analysis

A Before-After Control-Impact (BACI) analysis design was used to evaluate if there was a difference in fatality rates observed between turbine operations (control and deterrent) for the deterrent study (McDonald et al. 2000). A PCMM study conducted at the Project in 2017 was used as the “before” component of the analysis design; the eight turbines in the 2021 deterrent study were also monitored in 2017 and were operating under normal conditions specified by the site permit. For the analysis, the turbines were assigned into group “A” (turbines with no deterrents in 2021 operating normally in 2017 and 2021) and group “B” (turbines operating normally in 2017 but had the deterrents applied in 2021). This grouping variable was used as the “control-impact” component of the BACI analysis. The BACI analysis design accounts for differences in fatality rates between years and among turbines.

The effect of the deterrent at the Project was evaluated using a generalized linear mixed-effects model (GLMM; Laird and Ware 1982, Pinheiro and Bates 2000, Bolker et al. 2009, Millar 2011). The fatality estimate at each turbine by year was used as the response. Plot type, group, year, and a group by year interaction were used as covariates in the GLMM. In addition, a random effect for each turbine was included to quantify variability in fatality rates among turbines.

Besides the turbine operation differences in 2021 (control and deterrent), there were differences in the 2017 and 2021 PCMM study at the eight turbines included in the deterrent study. First, the Huso estimator (Huso 2011) was used to estimate fatality rates in 2017 whereas GenEst (Dalthorp et al. 2018) was used in 2021. Therefore, the year covariate in the model accounts for differences in years as well as differences in estimator. In addition, in 2017 120 m square plots and road and pad plots were used, and in 2021, only vegetated 150 m square plots were used. The plot type covariate in the model accounts for the difference in fatality estimates due to the search method.

RESULTS

Bat and Bird Carcass Surveys

All 39 turbines were searched over the 13-week survey period from July 1 – October 1, including 224 square plot searches and 434 road and pad searches. A total of 201 bat carcasses were found, 197 of which were found during the study period (Table 2, Appendix A1). Twenty-six bird carcasses were also found during the study period (Appendix A2). The number, species, location, characteristics of the bat and bird carcasses, and the fatality estimates adjusted for searcher efficiency and carcass persistence biases are discussed below, and a full listing of carcasses is presented in Appendix A. Surveys were missed at both plot types periodically due to turbine maintenance, weather, and farming activity. A section of the square plot B18 (a deterrent turbine), comprising approximately 30% of the plot, was planted with a tall crop that could not be searched completely by the detection dog teams during two different, 2-week periods in July and August. The entire area was searched for the rest of the study period.

Species Composition

Among the 201 bat carcasses found, 121 were found during detection dog team square plot searches, 70 were found during road and pad searches, 6 were found incidentally during the survey period, and 4 were found during the clearing search and had an estimated time of death outside of the survey period (Table 2). Fatalities found incidentally outside of search plots, or outside of the study period were excluded from formal analyses and fatality rate estimation.

Five bat species were found: silver-haired bat (*Lasionycteris noctivagans*; 73 found, 36.3% of overall bat carcasses), hoary bat (*Lasiurus cinereus*; 56 found, 27.9%), eastern red bat (*Lasiurus borealis*; 49 found, 24.4%), big brown bat (*Eptesicus fuscus*; 19 found, 9.5%), and little brown bat (*Myotis lucifugus*; 3 found, 1.5%). Additionally, one unidentified bat carcass was found (Appendix A1). Species composition by plot type can be seen in Table 2. Two special status bat species were documented: big brown bat and little brown bat are state SPC in Minnesota (MNDNR 2013). All bat species found as fatalities at the Project are listed as Species of Greatest Conservation Need (SGCN) in Minnesota's 2015 – 2025 Wildlife Action Plan (MNDNR 2015).

Twenty-one birds were found during square plot searches and three birds were found during road and pad searches. An additional bird was found incidentally outside of searches. Seventeen bird species were documented during 2021, most of which were passerines (Appendix A2). One American white pelican (*Pelecanus erythrorhynchos*) was found; American white pelican is a Minnesota SPC. No Minnesota endangered, threatened, or SGCN were found. No federally or state-listed threatened or endangered bird species were found. No raptors were found during searches.

Table 2. Number and percent (%) of carcasses by species included and excluded from analysis at the Black Oak Wind Project, Stearns County, Minnesota, in 2021.

	Included in Fatality Analysis											
	Deterrent Square Plots		Control Square Plots		Road and Pad Plots		Outside Search Area*		Outside Study Period*		Total	
Species	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%
silver-haired bat	15	25.4	27	43.5	26	37.1	4	66.7	1	25	73	36.3
hoary bat	17	28.8	11	17.7	25	35.7	2	33.3	1	25	56	27.9
eastern red bat	20	33.9	15	24.2	13	18.6	0	0	1	25	49	24.4
big brown bat	6	10.2	8	12.9	5	7.1	0	0	0	0	19	9.5
little brown bat	0	0	1	1.6	1	1.4	0	0	1	25	3	1.5
unidentified bat	1	1.7	0	0	0	0	0	0	0	0	1	0.5
Overall Bats	**59**	**100**	**62**	**100**	**70**	**100**	**6**	**100**	**4**	**100**	**201**	**100**

* Carcasses not included in analysis

Timing of Bat Carcasses

Appendix A provides a complete list of fatalities found at the Project between July 1 and October 1, 2021, along with date and turbine/location information. Bat fatalities were relatively low during the first three weeks of July, and then increased at the end of July. Among square plots there was a bimodal pattern of elevated fatalities during late July, and then again in late August (Figure 3a), which is not evident on road and pad plots (Figure 3b). The overall timing of fatalities was similar between square plots and road and pad plots, with fatalities largely trailing off near the end of the study period in late September at both plot types. The highest overall fatality finds occurred during the August 30 – September 1 visit to square plots. Similarly, the highest number of carcasses found during road and pad searches occurred August 31 – September 2.

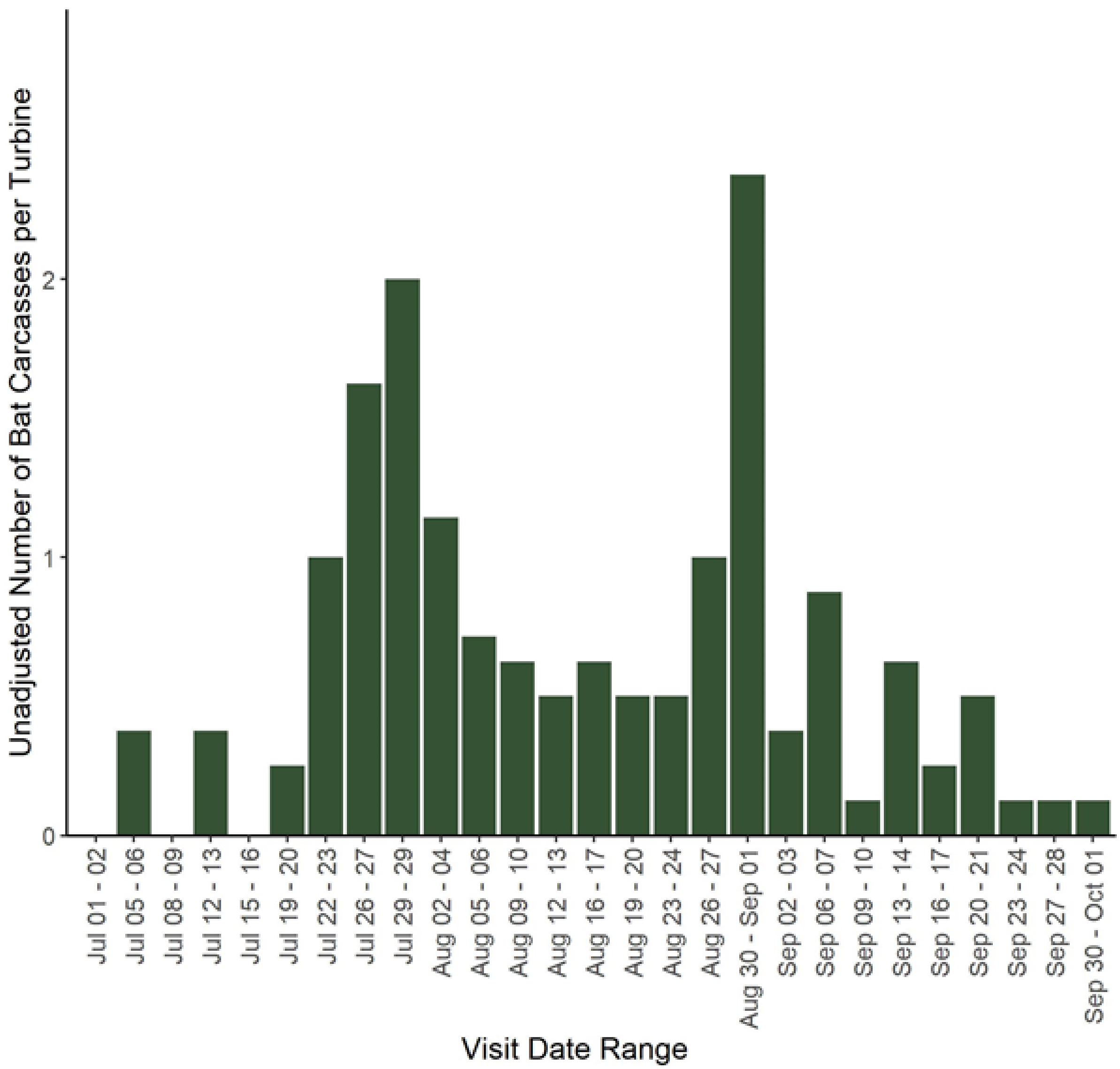

Figure 3a. Timing of bat carcass discoveries found during square plot searches at the Black Oak Wind Project. Plots were 150-meter square and searched by detection dog teams. Turbines were searched twice per week from July 1 to October 1, 2021.

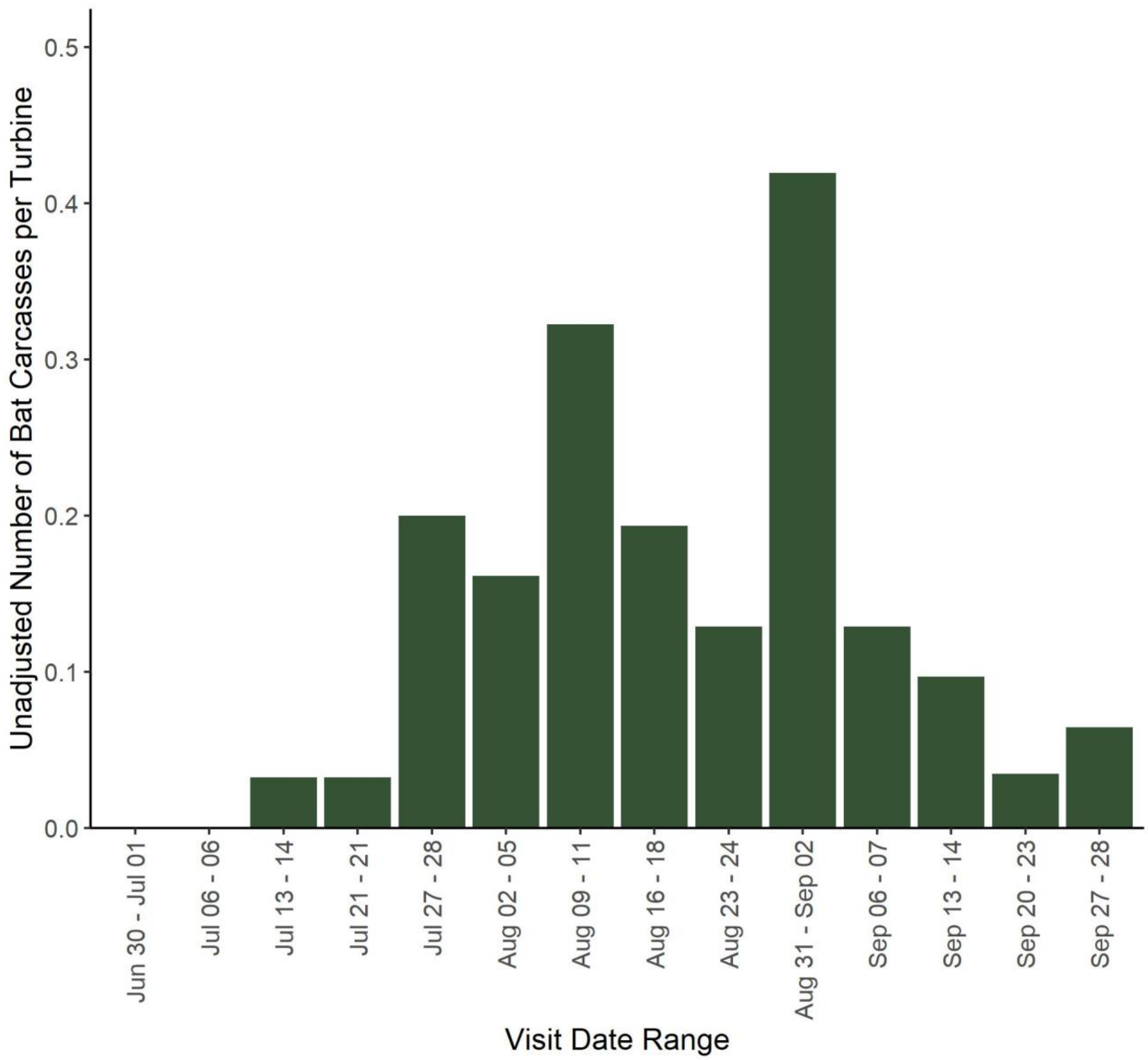

Figure 3b. Timing of bat carcass discoveries found during road and pad searches at the Black Oak Wind Project. Turbine pads and access roads were searched once per week out to 100 meters from the turbine from July 1 to October 1, 2021.

Distribution of Bat Carcasses within the Project

Fatalities were concentrated in the southern portion of the Project. The highest number of carcasses found were found at square plots C27 (n = 28), D39 (n = 26), and D35 (n = 18), all of which are all located in the southern portion of the Project (Figure 4). However, substantial numbers of carcasses were found within each square plot (minimum of eight at Turbine A11). Carcass counts were lower and relatively uniform across the northern A and B turbine strings. Although there does appear to be some difference between number of fatalities found at northern and southern turbines, there is no definitive pattern or land cover/habitat relationship apparent. For example, Turbine D38 (n = 10) is adjacent to, and within 400 m (1,312 ft) of D39 (n = 26), with no notable differences in land cover or habitat proximity and yet had only a fraction of the fatalities (Figure 4, Appendix A), although D38 was a deterrent turbine and D39 was a control turbine.

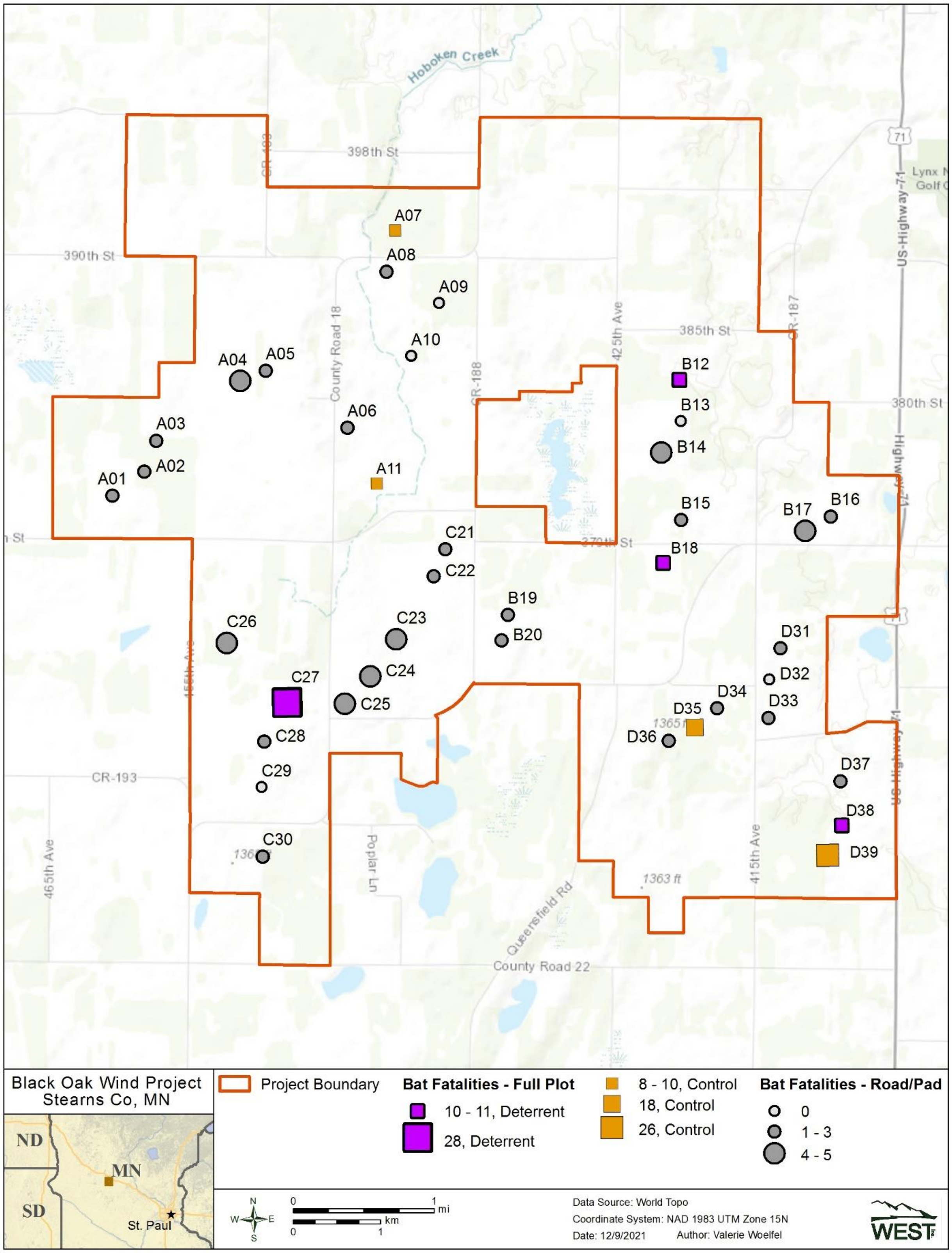

Figure 4. Bat fatalities by turbine documented during the post-construction mortality study at the Black Oak Wind Project from July 1 – October 1, 2021.

Searcher Efficiency Trials

Searcher efficiency trials for bats were conducted throughout the PCMM study period at the Project. Three trials were conducted in July, one in August, and three in September. In total, 63 bats were placed as searcher efficiency carcasses, and 56 were available to be found (Table 3). Trials were carried out for both dog-assisted search teams at square plots with low crops (n = 32), and human searchers at road and pad plots (n = 31). Both detection dog teams and human searchers had relatively high efficiency (Table 3) although human searchers at road and pad plots had slightly higher rates. Modeling of variation in searcher efficiency rates considered search type as a potential covariate, but a model with no covariates was determined to be adequate (Table 4). The searcher efficiency was estimated as 0.77 (90% CI of 0.66 - 0.85).

Table 3. Searcher efficiency results for dog-assisted square plot searches and unassisted road and pad searches at the Black Oak Wind Project, Stearns County, Minnesota, in 2021.

Size Class	Season	Search Area Type	# Placed	# Available	# Found	% Found	Dog Detection Search
Bat	Summer	150-m square	32	30	21	70.00	yes
Bat	Summer	Road and pad	31	26	22	84.62	no

m = meter

Table 4. Searcher efficiency models for bats from the Black Oak Wind Project, Stearns County, Minnesota, in 2021 (n = 56 searcher efficiency bat carcasses).

Covariates	*k* Value	AICc	Delta AICc
No Covariates	*k* fixed at 0.67	62.76	0*
Aided Search Type	*k* fixed at 0.67	63.20	0.44

* Selected model

AICc = corrected Akaike Information Criterion

Carcass Persistence Trials

Thirty-two bat carcasses were placed throughout the Project to test carcass persistence across the study period (Table 5). Four trials were conducted between July 12 and August 30. Carcass persistence was high at both plot types, but it was particularly high at square plots (Figure 5). The top model included plots type as a covariate with a Weibull distribution (Table 6). Long persistence times were estimated indicating low rates of scavenging or carcass removal between searches, and high availability of carcasses to be found over successive search intervals. Five out of 14 carcasses at road and pads, and 13 out of 18 carcasses at square plots remained on the plot at the end of the 30-day trial. This resulted in long estimated persistence times of 143 days for square plots, 14 days for roads and pads, and 47 days for the facility overall. The average probability a carcass persistence though a 3.5-day search interval at square plots was 0.93 (90% CI of 0.83 - 0.97) and the average probability a carcass persistence through a 7.0-day search interval at a road and pad plot was 0.72 (90% CI of 0.57 - 0.86).

Table 5. Bat carcasses placed for persistence trials during post-construction mortality monitoring at the Black Oak Wind Project from July 1 – October 1, 2021.

Size Class	Season	Size	Plot Type	# Placed
Bat	Summer	Bat	Square plot	18
Bat	Summer	Bat	Road and pad	14
Bat	Summer	Bat	Combined	32

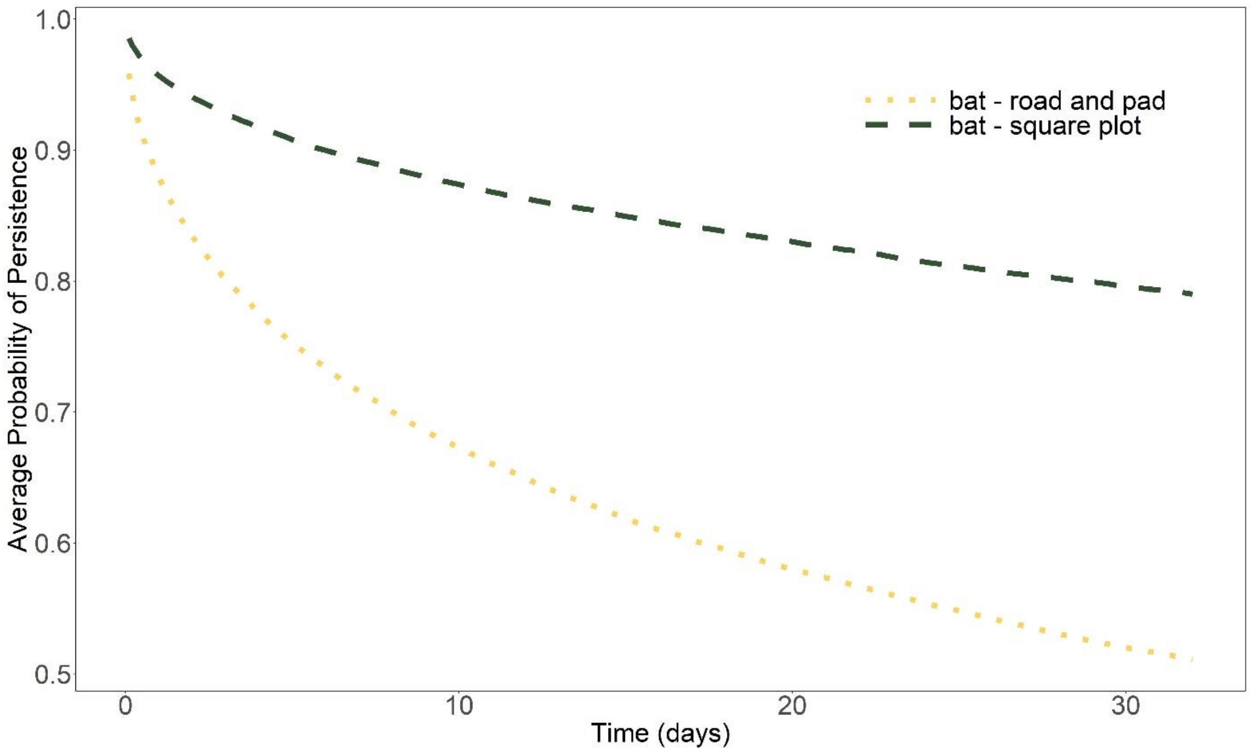

Figure 5. Persistence of bat carcasses at square plots (green dashed line) and road and pad plots (yellow dotted line) through 30-day carcass persistence trials during the post-construction mortality monitoring at the Black Oak Wind Project from July 1 – October 1, 2021.

Table 6. Carcass persistence top model distributions and model parameters for the Black Oak Getty Wind Project, Stearns County, Minnesota, in 2021.

Size Class	Plot Search Type	Distribution	Predicted Median Persistence Times (days)	Parameter 1	Parameter 2
Bat	Square	Weibull*	142.86	shape = 0.4857	scale = 303.6877
Bat	Road and pad	Weibull*	13.79	shape = 0.4857	scale = 29.3121

* Parameterization follows the base R parameterization for this distribution.

Search Area Adjustment

Area adjustments for control, deterrent, and curtailed turbines were analyzed separately due to divergent modelled carcass distributions among these groups (see Distribution of Bat Carcasses within the Project, above). Model selection details for estimates of area adjustment are available in Appendix B. The best fitting distribution for control and curtailed turbines was a gamma distribution, whereas deterrent turbines had a best fitting distribution of a Gompertz distribution (Table 7, Appendix B). The area adjustment value for square plots (deterrent and control) was very high, at 0.92 (90% CI of 0.88 - 0.95) and 0.96 (90% CI of 0.92 - 0.99), respectively, indicating the search area covered almost all of the area into which carcasses fell (Table 7). An area adjustment of 0.08 (90% CI of 0.05 - 0.12) represents a large adjustment for fatalities found on the road and pad for the purpose of estimating fatality rates.

Table 7. Truncated weighted maximum likelihood search area adjustment estimates for the Black Oak Wind Project, Stearns County, Minnesota, in 2021 (n = 68 bats).

Size Class	Turbine Operation	Distribution	Parameter 1	Parameter 2	Area Adjustment
Bat	Control	gamma	2.1134	0.0658	0.96
Bat	Deterrent	Gompertz	0.0257	0.0121	0.92
Bat	Curtailed	gamma	2.2525	0.0500	0.08

Carcasses were found most frequently within 50 m (164 ft) of the turbine, however, the modeled distribution of carcasses differed between control, deterrent, and curtailed turbines (Figures 6a, 6b, and 6c). The mean of the distribution for the four control square plot turbines was closer to the turbine relative to the other carcass-density distributions (Figure 6a), and almost all carcasses were expected to have fallen within 100 m based on the location of carcasses found. As a result, it is estimated that a higher portion of carcasses were available to be found at those the control turbines (A07, A11, D35, and D39; Figure 4). Carcasses at deterrent (square plot) and curtailed (road and pad) turbines were found farther from the turbine, relative to the control turbines, resulting in modeled distributions with carcasses expected to be spread more widely across turbines. At deterrent turbines, almost all of the carcasses were still estimated to fall within 100 m of the turbine, and, therefore, mostly available to be found. However, carcasses at curtailed turbines with road and pad searches were estimated to have a substantial portion of carcasses falling outside of 100 m. This, coupled with the relatively small proportion of area searched for road and pad searches (yellow line), resulted in relatively low proportion of bat carcasses falling on road and pads at the 31 curtailed turbines.

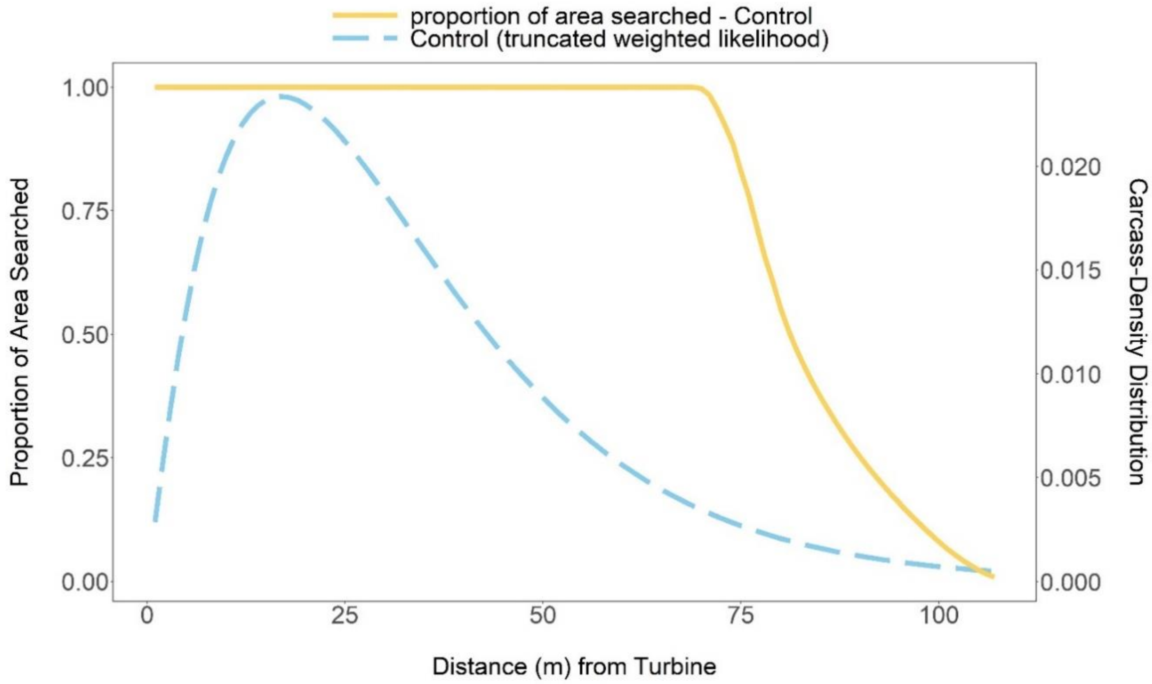

Figure 6a. Proportion of area searched (solid yellow line) using 150-meter (m) square plots compared to bat carcass-density distribution (blue dotted line) for normally operating turbines without deterrents (control) from July 1 – October 1, 2021, at the Black Oak Wind Project. Normal operations included feathering to cut-in speed of 3.0 m/second from 30 minutes (min) before sunset to 30 min after sunrise.

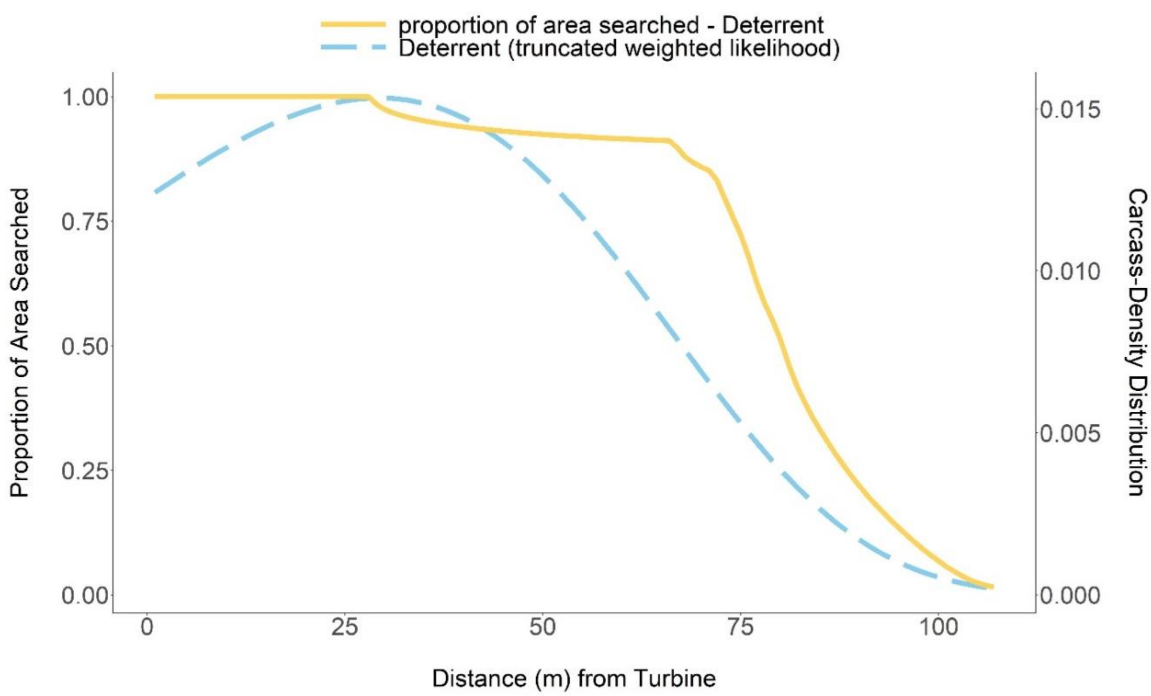

Figure 6b. Proportion of area searched (solid yellow line) with 150-meter (m) square plots compared to bat carcass-density distribution (blue dotted line) for turbines with acoustic deterrents from July 1 – October 1, 2021, at the Black Oak Wind Project. Turbine operations included feathering to cut-in speed of 3.0 m/second from 30 minutes (min) before sunset to 30 min after sunrise.

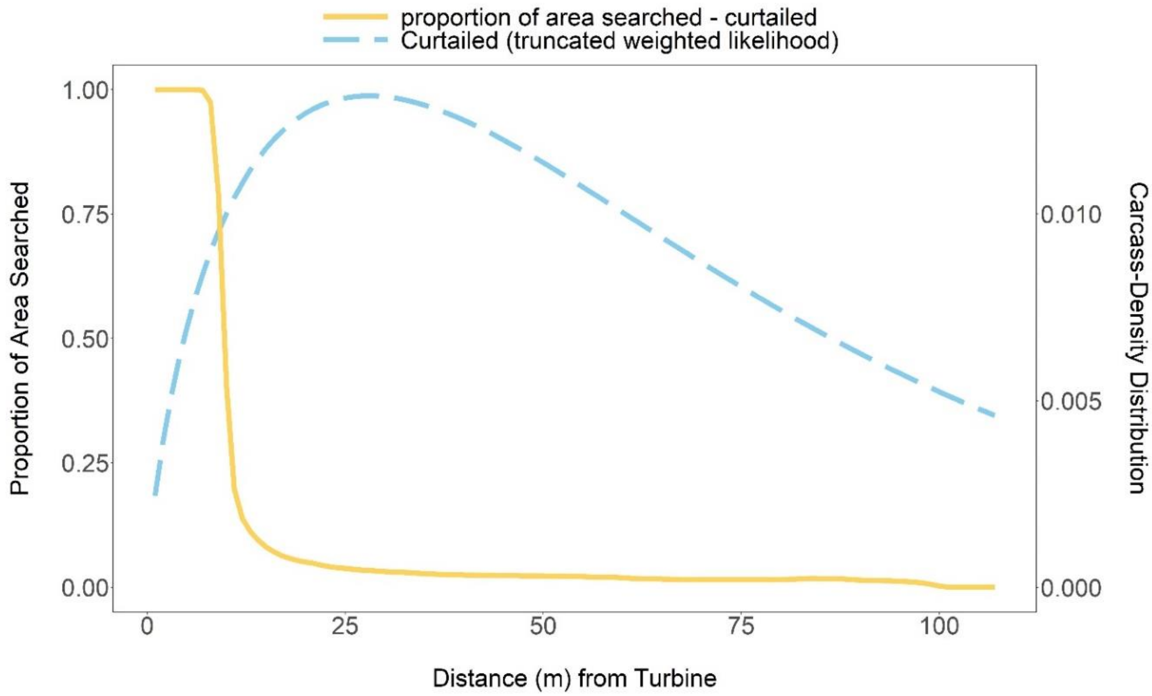

Figure 6c. Proportion of area searched (solid yellow line) with road and pad plots searched to 100 meters (m) from the turbine, compared to bat carcass-density distribution (blue dotted line) for turbines operating under 4.5 m/second (s) curtailment from July 1 – October 1, 2021, at the Black Oak Wind Project. Turbine operations included feathering to cut-in speed of 4.5 m/s beginning one hour after sunset for seven consecutive hours.

Adjusted Fatality Estimates

Estimates of fatality rates and CIs were estimated for bats using GenEst (Dalthorp et al. 2018a). Fatality estimates included adjustments for carcass persistence, searcher efficiency, and the search area adjustment. Table 8 provides the Project's overall adjusted bat fatality rate and 90% CI for all plot types using GenEst for the 2021 study period (July 1 – October 1, 2021). Table 9 provides estimates and CI for each adjustment, as well as fatality rates separately for control, deterrent, and curtailed turbines.

Table 8. Overall bat fatality rates per megawatt (MW) and per turbine for all searches conducted at the Black Oak Wind Project, Stearns County, Minnesota, in 2021.

	Per MW Estimates		Per Turbine Estimates	
	Estimate	**90% CI**	**Estimate**	**90% CI**
Bat	20.99	13.02–35.79	41.99	26.05–71.59

CI = confidence interval

The overall Project fatality rate was 20.99 bats per MW in 2021 during the study period, and fatality rates differed between search types. Road and pad (curtailed) turbines had an estimated fatality rate of 23.92. Square plots had estimated fatality rates of 9.36 (control) and 9.33 (deterrent; Table 9).

Table 9. Estimated fatality rates and adjustment factors with 90% confidence intervals (CI) for all plot types (control, deterrent, and curtailed) at the Black Oak Wind Project, Stearns County, Minnesota, in 2021.

	Control 4 Turbines Searched		Deterrent 4 Turbines Searched		Curtailed 31 Turbines Searched	
	Estimate	90% CI	Estimate	90% CI	Estimate	90% CI
Search Area Adjustment						
Bat	0.96	0.91–0.99	0.92	0.88–0.95	0.08	0.05–0.12
Searcher Efficiency						
Bat	0.77	0.66–0.85	0.77	0.66–0.85	0.77	0.66–0.85
Average Probability of a Carcass Persisting Through the Search Interval*						
Bat	0.93	0.83–0.97	0.93	0.83–0.97	0.72	0.57–0.86
Probability of Available and Detected						
Bat	0.85	0.75–0.92	0.85	0.75–0.92	0.63	0.48–0.77
Estimated Fatality Rates (Fatalities/Turbine/Season)						
Bat	18.72	16.66–22.08	18.66	16.39–21.89	47.85	27.85–85.33
Estimated Fatality Rates (Fatalities/MW/Season)						
Bat	9.36	8.33–11.04	9.33	8.19–10.94	23.92	13.92–42.67

* The search interval was twice per week for full plots (Control and Deterrent) and weekly for road and pads (Curtailed).
MW = megawatt

Deterrent Analysis

A GLMM was fit to evaluate the effect of the deterrent on bat fatality rates. The estimated reduction in bat fatalities from the deterrent was -45.1% (90% CI of -72.5% to 9.5%) and the p-value for the treatment by year effect was 0.152 (Table 10). This indicates there was uncertainty in the effectiveness of the deterrent given the wide CI and a p-value greater than 0.05. The plot type covariate was significant (p-value 0.003) indicating there was a difference in fatality estimates developed by plot type (square plot [2017, 2020] and road and pad [2017]). In addition, the covariate for group was significant (p-value = 0.081) indicating the fatality rate at the turbines in group B was higher than the fatality rate at the turbines in group A. Although estimated per-turbine fatality levels were lower in 2021 compared to 2017 for both deterrent and control groups (Figure 7), the BACI analysis indicated these differences are attributable primarily to plot type (road and pad versus full plot), which corresponded to the biggest differences in turbine-specific fatality rates between the two studies.

Table 10. Generalized linear mixed-effect model used to evaluate the effect of deterrents on bat fatality rates at the Black Oak Wind Project, Stearns County, Minnesota, in 2021.

Covariate	Estimate	Standard Error	p-value
(Intercept)	2.744	0.362	0
Group B	0.562	0.322	0.081
Year: 2021	0.189	0.415	0.649
Plot Type: Road/Pad	1.192	0.397	**0.003**
Deterrent Effect (Group: B * Year: 2021)	-0.601	0.420	0.152

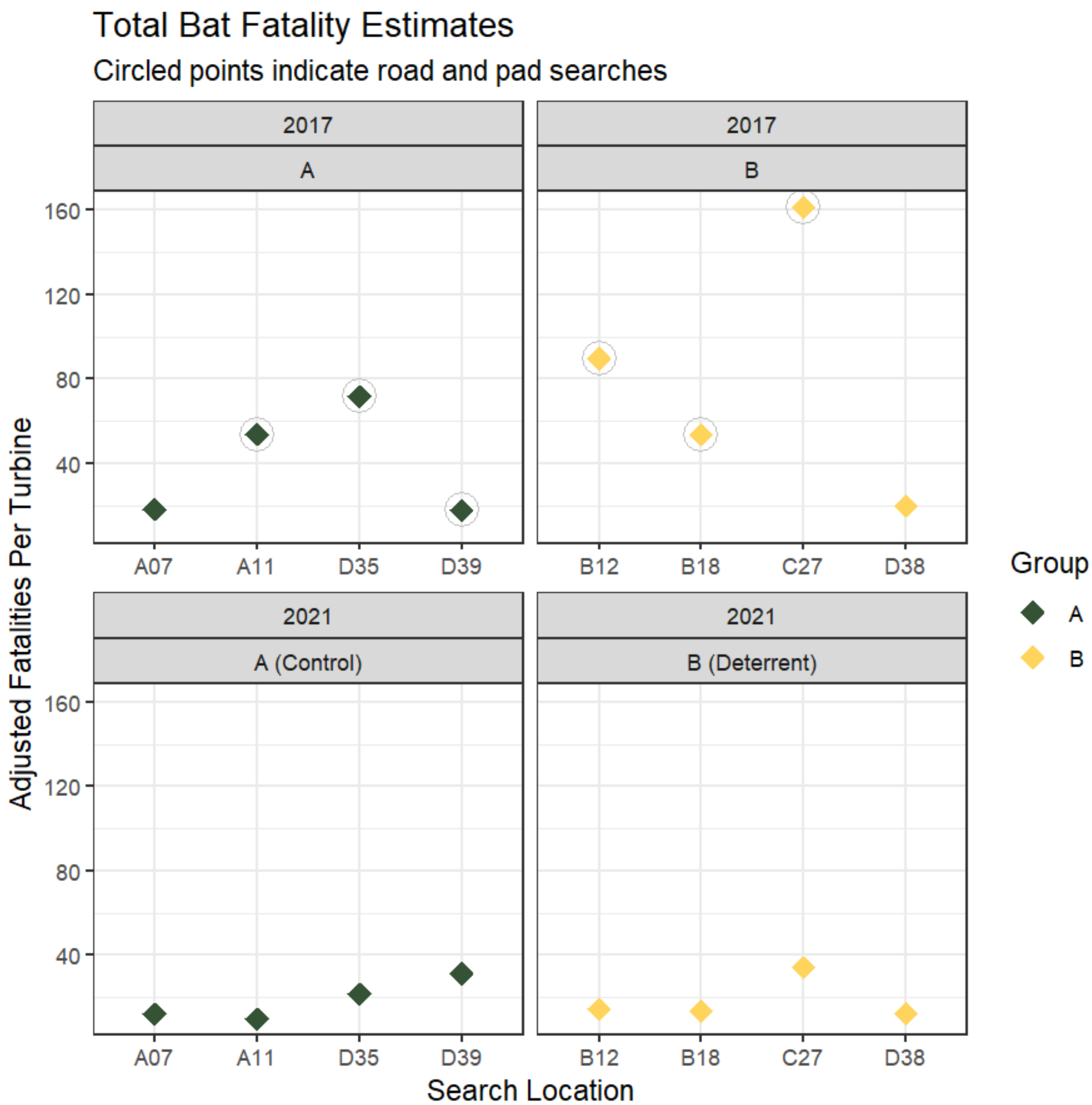

Figure 7. Estimated adjusted fatalities per turbine in 2017 and 2021 for the current control and deterrent search locations at the Black Oak Wind Project. Note that all turbines operated under normal conditions in 2017 and the treatments (control and deterrent) were implemented in 2021. Turbines assessed in 2017 using road and pad plots are indicated with circles (above).

Species-Specific Results

Fatality rates did vary significantly by species between control and deterrent square plot turbines (Table 9). Deterrent turbines had lower levels of fatality of silver-haired bats and to a certain extent big brown bats. Fatality rates were estimated to be higher at deterrent turbines for hoary bats and eastern red bats. Overall fatality rates for all bat species were nearly identical between control and deterrent turbines.

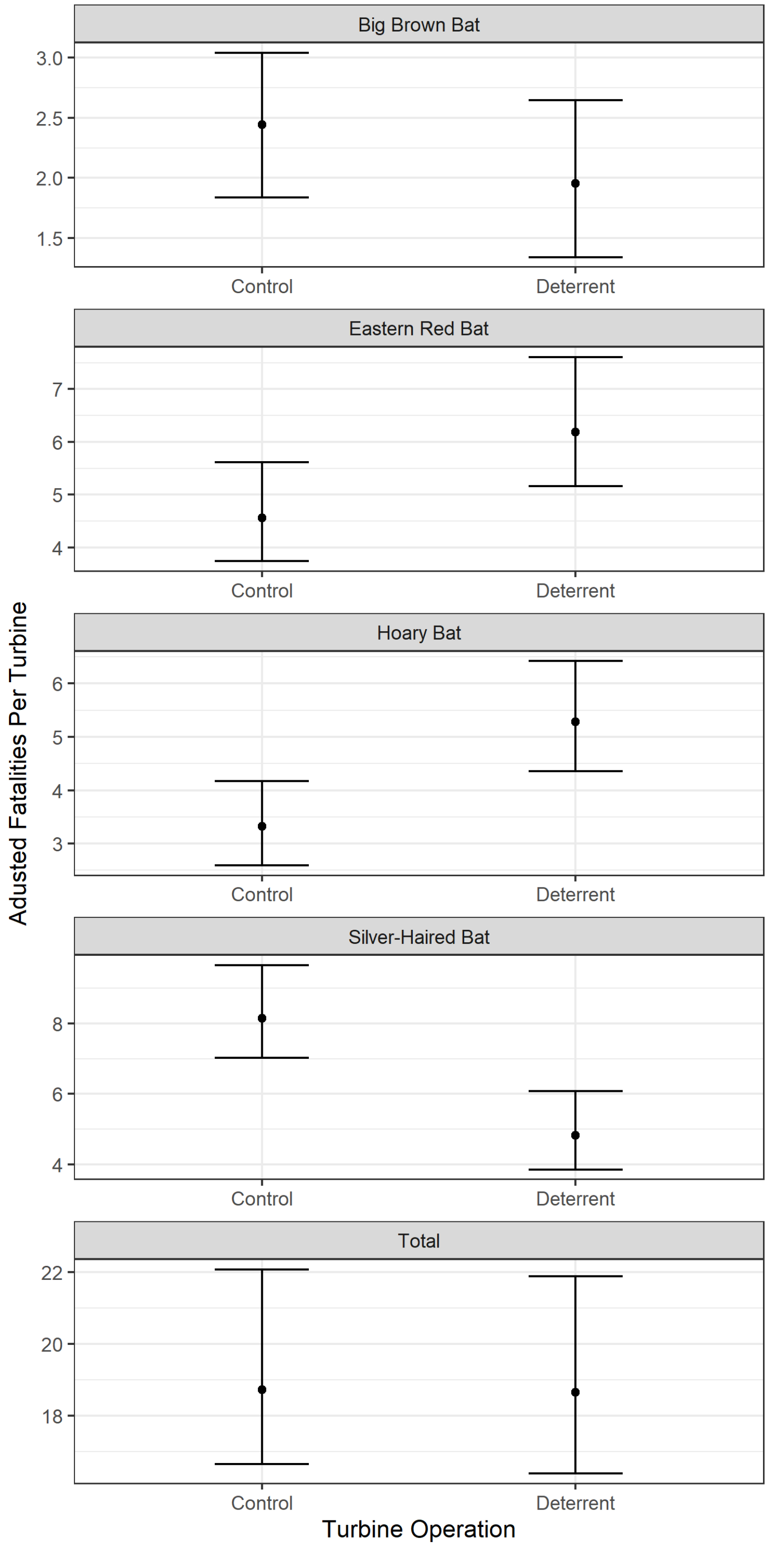

Figure 8. Estimate per-turbine bat fatality rates (mean represented by dot, confidence interval represented by upper and lower bars) by species, and overall for deterrent (n=4) and control (n=4) turbines.

DISCUSSION

The primary objective of this study was to evaluate the efficacy of acoustic deterrents at the Black Oak Wind Project by estimating bat fatality rates at turbines with deterrents installed and a control group without deterrents. The secondary objective was to estimate fatality rates at turbines being curtailed up to 4.5 m/s. Bat fatality during the study period was lower in 2021 than in previous years studied by WEST (Pickle et al. 2018, 2019, Stucker et al. 2020; Figure 9); however, it is important to note that the study periods differed between all four years and this year's study does not contain bat fatality information from spring, early summer or late fall. While the July 1 – September 30 timeframe studied in this year represents the months with the highest proportion of bat fatalities documented in the previous three years of studies, direct comparisons should not be made.

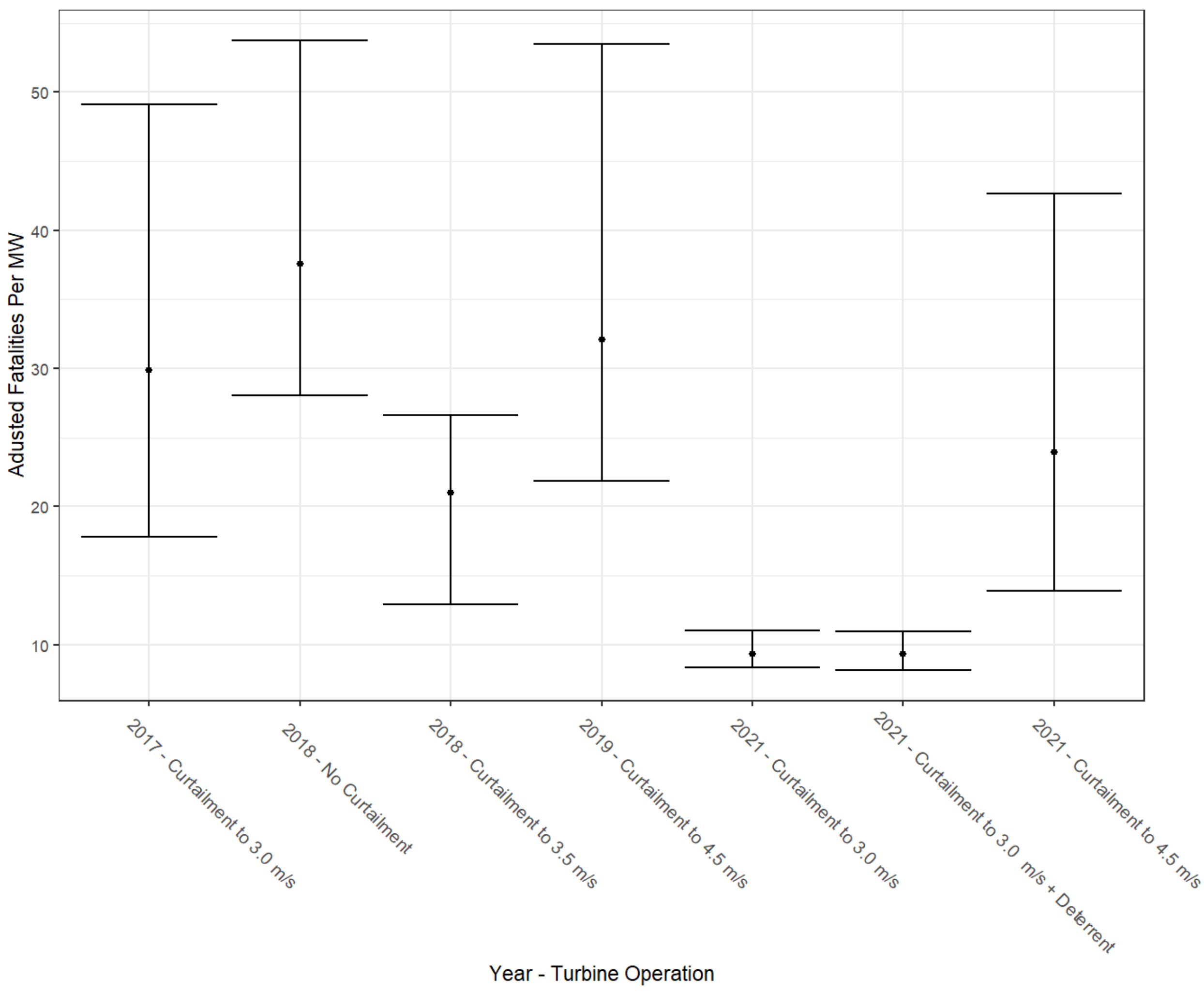

Figure 9. Bat fatality rate estimates for post-construction mortality monitoring at Black Oak Wind Project in 2017 (March – November), 2018 (April – October), 2019 (April – September) and 2021 (July – September) (Pickle et al. 2018, 2019, Stucker et al. 2020).

Overall bat fatality was estimated at 20.99 bats per MW, which is within the range of documented fatality rates in the Midwest (Appendix C). Although bat fatality levels at the Project remained relatively high, no federally protected species were found, and relatively low numbers of both *Myotis* species and Minnesota special concern species were found (three little brown bats [1.5%] and 19 big brown bats [9.5%]), similar to previous years.

Carcasses found at the Project were more evenly distributed among the three migratory tree bat species than in previous years, with similar numbers of silver-haired, hoary, and eastern red bats found (Table 2; Pickle et al. 2018, 2019, Stucker et al. 2020). The overall trend observed in 2019 of fewer silver-haired bats and more eastern red bats documented as fatalities continued, but the proportion of hoary bats also increased this year. These differences in species composition may be part of a long-term trend at the site, or may be related to the varying effect of deterrents by species, as discussed below. Among road and pad plots, the number of silver-haired (26) and hoary bats (25) found was nearly equivalent, which is a shift from earlier years of PCMM when silver-haired bats were more prevalent. The representation of silver-haired bats has decreased each year since 2017 when they composed over half (54%) of all fatalities.

Deterrents used at the Project did not result in significantly lower overall fatality rates at the turbines on which they were deployed. Deterrent turbines had a nearly identical fatality rate to those in the control group, which were surveyed using the same search methodology and level of effort. The BACI-structured analysis incorporated 2017 bat fatality data to control for inter-annual variability and the potential for deterrents being placed on higher-fatality turbines. Even when accounting for these potential sources of bias in the analysis, there was no indication the deterrents caused a significant reduction in fatalities.

Despite these findings, there is some evidence to suggest the deterrents may have been effective for certain species. In particular, silver-haired bats, the species most frequently found as a fatality at the Project, did have a significant reduction in fatalities at turbines with deterrents installed. Big brown bats similarly had fewer fatalities at deterrent turbines, although the low number of fatalities for this species made it difficult to attribute any effect of the deterrents specifically. Reductions in fatalities for these two species may be related to how the deterrent systems worked within a particular acoustic frequency range. Silver-haired and big brown bats have similar echolocation calls, both having a primary search phase signal in the 25–30 kilohertz range. By comparison, hoary bats use lower frequencies and eastern red bats use higher frequencies. It is possible the acoustic deterrents were particularly effective in the frequency range used by silver-haired and big brown bats, but less effective outside that range, in this installation.

A pattern of higher fatalities at turbines in the southern portion of the Project was qualitatively observed again in 2021. Among full plots, all high-fatality turbines (those with more than 11 carcasses found: C27, D35, D39) were all in the southern half of the facility. Perhaps the strongest evidence for the potential effect of the deterrents is the difference in fatalities between D38 (deterrent, 10 fatalities found) and D39 (control, 26 fatalities found), which are adjacent turbines in the southeast corner of the Project.

The difference in fatality rates between plot types (lower rates at full plots compared to road and pads) may be explained, at least in part, by the search methods used during 2021, and conditions on the ground at the search plots. The large (150-m square) plots were searched by detection dog teams twice per week. Most plots were planted with low crops (i.e., not corn [*Zea mays*]) that grew in prior to, and throughout the study's survey period. The resulting dense vegetative structure near the ground has three effects that may influence estimated fatality rates. First, they are more challenging to search than cleared plots, even with assistance from a trained search dog. The vegetation can reduce air movement and limit the spread of the "scent cone" emanating from a carcass, which dogs rely on to find carcasses, thereby reducing detection rates.

Second, dense crops may reduce scavengers' ability to find carcasses, for the reason above, or due to reduced visibility (e.g., from the air) or difficulty in accessing and/or removing carcasses on the ground, especially for larger mammals. The results of this are apparent in the exceedingly long carcass persistence rates observed during this study, which were estimated at over 140 days for full plots. Although GenEst accounts for reduced detectability over time, these estimates may reflect that true availability was lower than expected due to decomposition or desiccation, and may, therefore, result in lower fatality estimates.

Third, searcher efficiency may be affected by vegetation in a way that is inconsistent with the effects on searches. Searcher efficiency trial carcasses are placed by humans who walk to a pre-specified point on the plot and drop the carcass before returning to the access road. Although searcher efficiency carcass placement typically occurs the night prior to the search to develop an adequate scent plume, there is potential for the placer also to leave a scent trail on vegetation that can be detected and learned by dogs (who are rewarded for any carcass found) over the course of a season. This effect could bias searcher efficiency upwards, resulting in lower estimated fatality rates. While imperfect, it is notable that the detect dog teams here did have searcher efficiency that was equal to detection dog teams elsewhere in Minnesota where vegetation was not always mowed (Stucker et al. 2021a) as compared to detection dog searcher efficiency on mowed plots (Stucker et al. 2021b).

These factors, in combination, may partly explain elevated fatality rates at road and pad plots compared to full plots, despite a 4.5 m/s curtailment regime at the road and pad turbines. Although the location of carcasses found at roads and pads reflected a broad fatality distribution (Figure 6c), which has the effect of increasing fatality rate estimates by accounting for carcasses falling beyond the search plot (100 m from turbine), this is unlikely to explain the more than 2-fold difference in fatality rates. Results from road and pad searches also include a much higher degree of uncertainly due to the small proportion of area under turbine that is searched. As a result, it is difficult to make direct comparisons between fatality rates at curtailed turbines and full plots from 2021, or between curtailed turbines in 2021 and prior years.

These findings indicate that overall bat fatality likely declined in 2021 as compared to prior PCMM assessments under varying turbine operation at the Project. Importantly there were indications that the bat deterrents may be working for silver-haired bats. A definitive result from additional curtailment or deterrents at this Project has not been observed. The planned second year of deterrent effectiveness monitoring may clarify their value as a fatality reduction strategy at the Project.

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Appendix A. Complete Fatality Listing for the Black Oak Wind Project for Studies Conducted July 1 – October 1, 2021

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Appendix A1. Complete listing of bat carcasses found July 1 – October 1, 2021, at the Black Oak Wind Project, Stearns County, Minnesota.

Date Found	Species	Distance from Turbine	Turbine	Search Type	Search Area Type	Physical Condition	Detection Dog Search
06/29/2021	eastern red bat	28	A07	carcass search	twice per week square	scavenged	yes*
06/30/2021	hoary bat	71	B18	carcass search	twice per week square	scavenged	yes*
07/05/2021	big brown bat	10	B12	carcass search	twice per week square	intact	yes*
07/05/2021	hoary bat	64	B18	carcass search	twice per week square	intact	yes*
07/06/2021	eastern red bat	84	C27	carcass search	twice per week square	scavenged	yes*
07/12/2021	silver-haired bat	16	B12	carcass search	twice per week square	scavenged	yes*
07/13/2021	hoary bat	5	B20	carcass search	weekly road and pad	scavenged	no
07/13/2021	silver-haired bat	38	C27	carcass search	twice per week square	scavenged	yes*
07/13/2021	silver-haired bat	34	C27	carcass search	twice per week square	scavenged	yes*
07/20/2021	eastern red bat	51	D35	carcass search	twice per week square	scavenged	yes*
07/20/2021	hoary bat	19	C27	carcass search	twice per week square	dismembered	yes*
07/21/2021	silver-haired bat	1	C24	carcass search	weekly road and pad	intact	no
07/21/2021	silver-haired bat	20	C26	carcass search**	weekly road and pad	scavenged	no
07/22/2021	big brown bat	42	A07	carcass search	twice per week square	scavenged	yes*
07/22/2021	silver-haired bat	24	A07	carcass search	twice per week square	scavenged	yes*
07/22/2021	silver-haired bat	42	A07	carcass search	twice per week square	intact	yes*
07/23/2021	eastern red bat	15	C27	carcass search	twice per week square	scavenged	yes*
07/23/2021	eastern red bat	44	C27	carcass search	twice per week square	scavenged	yes*
07/23/2021	eastern red bat	38	D39	carcass search	twice per week square	scavenged	yes*
07/23/2021	silver-haired bat	6	A08	incidental	weekly road and pad	dismembered	no
07/23/2021	silver-haired bat	10	D35	carcass search	twice per week square	scavenged	yes*
07/23/2021	silver-haired bat	6	D38	carcass search	twice per week square	intact	yes*
07/26/2021	big brown bat	47	B18	carcass search	twice per week square	scavenged	yes*
07/26/2021	eastern red bat	7	C27	incidental	twice per week square	intact	no
07/27/2021	big brown bat	57	C27	carcass search	twice per week square	scavenged	yes*
07/27/2021	big brown bat	20	D35	carcass search	twice per week square	scavenged	yes*
07/27/2021	eastern red bat	19	B15	carcass search	weekly road and pad	intact	no
07/27/2021	eastern red bat	18	C27	carcass search	twice per week square	scavenged	yes*
07/27/2021	eastern red bat	33	D35	carcass search	twice per week square	scavenged	yes*
07/27/2021	eastern red bat	16	D38	carcass search	twice per week square	scavenged	yes*
07/27/2021	eastern red bat	23	D39	carcass search	twice per week square	scavenged	yes*
07/27/2021	hoary bat	15	A09	carcass search**	weekly road and pad	intact	no
07/27/2021	hoary bat	3	B17	carcass search	weekly road and pad	scavenged	no
07/27/2021	hoary bat	15	C24	carcass search	weekly road and pad	scavenged	no
07/27/2021	hoary bat	81	C27	carcass search	twice per week square	dismembered	yes*

Appendix A1. Complete listing of bat carcasses found July 1 – October 1, 2021, at the Black Oak Wind Project, Stearns County, Minnesota.

Date Found	Species	Distance from Turbine	Turbine	Search Type	Search Area Type	Physical Condition	Detection Dog Search
07/27/2021	hoary bat	8	C27	carcass search	twice per week square	intact	yes*
07/27/2021	hoary bat	22	C27	carcass search	twice per week square	scavenged	yes*
07/27/2021	hoary bat	5	C30	incidental	weekly road and pad	intact	no
07/27/2021	hoary bat	9	D38	carcass search	twice per week square	scavenged	yes*
07/27/2021	hoary bat	32	D39	carcass search	twice per week square	injured	yes*
07/27/2021	silver-haired bat	9	A06	carcass search	weekly road and pad	intact	no
07/27/2021	silver-haired bat	20	B17	carcass search	weekly road and pad	scavenged	no
07/27/2021	silver-haired bat	66	C27	carcass search	twice per week square	scavenged	yes*
07/27/2021	silver-haired bat	5	D34	carcass search	weekly road and pad	intact	no
07/28/2021	hoary bat	6	B14	incidental	weekly road and pad	intact	no
07/29/2021	hoary bat	80	B12	carcass search**	twice per week square	scavenged	yes*
07/29/2021	hoary bat	0	B12	carcass search	twice per week square	scavenged	yes*
07/29/2021	unidentified bat	46	B12	carcass search	twice per week square	intact	yes*
08/02/2021	eastern red bat	22	B18	carcass search	twice per week square	scavenged	yes*
08/02/2021	eastern red bat	35	B18	carcass search	twice per week square	scavenged	yes*
08/02/2021	eastern red bat	46	B18	carcass search	twice per week square	scavenged	yes*
08/02/2021	eastern red bat	8	C24	carcass search	weekly road and pad	scavenged	no
08/02/2021	silver-haired bat	36	A03	incidental	weekly road and pad	scavenged	no
08/03/2021	big brown bat	57	B16	carcass search	weekly road and pad	intact	no
08/03/2021	eastern red bat	58	C27	carcass search	twice per week square	scavenged	yes*
08/03/2021	eastern red bat	4	D36	carcass search	weekly road and pad	intact	no
08/03/2021	hoary bat	17	B17	carcass search	weekly road and pad	scavenged	no
08/03/2021	hoary bat	15	C27	carcass search	twice per week square	scavenged	yes*
08/03/2021	silver-haired bat	10	B14	carcass search	weekly road and pad	scavenged	no
08/04/2021	eastern red bat	50	D38	incidental	twice per week square	intact	no
08/04/2021	eastern red bat	10	D39	carcass search	twice per week square	dismembered	yes*
08/04/2021	hoary bat	22	D39	carcass search	twice per week square	scavenged	yes*
08/04/2021	silver-haired bat	24	D39	carcass search	twice per week square	scavenged	yes*
08/05/2021	hoary bat	29	B12	carcass search	twice per week square	scavenged	yes*
08/06/2021	big brown bat	16	A05	incidental	weekly road and pad	intact	no
08/06/2021	eastern red bat	59	C27	carcass search	twice per week square	scavenged	yes*
08/06/2021	eastern red bat	15	D35	carcass search	twice per week square	scavenged	yes*
08/06/2021	eastern red bat	87	D39	carcass search	twice per week square	scavenged	yes*
08/06/2021	hoary bat	35	D39	carcass search	twice per week square	scavenged	yes*
08/09/2021	hoary bat	31	B18	carcass search	twice per week square	intact	yes*

Appendix A1. Complete listing of bat carcasses found July 1 – October 1, 2021, at the Black Oak Wind Project, Stearns County, Minnesota.

Date Found	Species	Distance from Turbine	Turbine	Search Type	Search Area Type	Physical Condition	Detection Dog Search
08/09/2021	silver-haired bat	8	A08	carcass search	weekly road and pad	intact	no
08/09/2021	silver-haired bat	10	D38	carcass search	twice per week square	scavenged	yes*
08/10/2021	big brown bat	4	D39	carcass search	twice per week square	intact	yes*
08/10/2021	eastern red bat	30	A02	incidental	weekly road and pad	dismembered	no
08/10/2021	eastern red bat	4	C25	carcass search	weekly road and pad	intact	no
08/10/2021	silver-haired bat	5	C23	carcass search	weekly road and pad	intact	no
08/10/2021	silver-haired bat	19	D35	carcass search	twice per week square	intact	yes*
08/10/2021	silver-haired bat	7	D39	carcass search	twice per week square	intact	yes*
08/11/2021	eastern red bat	7	D31	carcass search	weekly road and pad	intact	no
08/11/2021	hoary bat	9	A01	carcass search	weekly road and pad	intact	no
08/11/2021	hoary bat	4	D37	carcass search	weekly road and pad	scavenged	no
08/11/2021	silver-haired bat	12	A02	carcass search	weekly road and pad	scavenged	no
08/11/2021	silver-haired bat	5	B20	carcass search	weekly road and pad	intact	no
08/11/2021	silver-haired bat	13	C26	carcass search	weekly road and pad	scavenged	no
08/11/2021	silver-haired bat	50	D36	carcass search	weekly road and pad	intact	no
08/12/2021	big brown bat	68	D38	carcass search	twice per week square	scavenged	yes*
08/12/2021	eastern red bat	2	C21	incidental	weekly road and pad	intact	no
08/12/2021	hoary bat	38	D38	carcass search	twice per week square	scavenged	yes*
08/12/2021	silver-haired bat	46	A11	carcass search	twice per week square	intact	yes*
08/12/2021	silver-haired bat	2	D35	incidental	twice per week square	intact	no
08/13/2021	big brown bat	22	D39	carcass search	twice per week square	dismembered	yes*
08/16/2021	eastern red bat	11	B15	carcass search	weekly road and pad	scavenged	no
08/16/2021	hoary bat	3	A01	carcass search	weekly road and pad	intact	no
08/16/2021	hoary bat	33	A07	carcass search	twice per week square	scavenged	yes*
08/16/2021	hoary bat	97	B19	incidental	weekly road and pad	scavenged	no
08/16/2021	hoary bat	97	D37	carcass search	weekly road and pad	scavenged	no
08/16/2021	silver-haired bat	25	B20	carcass search**	weekly road and pad	scavenged	no
08/17/2021	big brown bat	28	D35	carcass search	twice per week square	scavenged	yes*
08/17/2021	eastern red bat	6	C21	carcass search	weekly road and pad	intact	no
08/17/2021	eastern red bat	32	C27	carcass search	twice per week square	scavenged	yes*
08/17/2021	eastern red bat	31	D35	carcass search	twice per week square	scavenged	yes*
08/17/2021	hoary bat	94	C24	carcass search	weekly road and pad	scavenged	no
08/17/2021	silver-haired bat	46	C27	carcass search	twice per week square	scavenged	yes*
08/18/2021	hoary bat	6	B16	carcass search	weekly road and pad	scavenged	no
08/19/2021	eastern red bat	31	A07	carcass search	twice per week square	scavenged	yes*

Appendix A1. Complete listing of bat carcasses found July 1 – October 1, 2021, at the Black Oak Wind Project, Stearns County, Minnesota.

Date Found	Species	Distance from Turbine	Turbine	Search Type	Search Area Type	Physical Condition	Detection Dog Search
08/20/2021	big brown bat	18	D35	carcass search	twice per week square	intact	yes*
08/20/2021	hoary bat	42	C27	carcass search	twice per week square	scavenged	yes*
08/20/2021	hoary bat	30	D35	carcass search	twice per week square	scavenged	yes*
08/23/2021	big brown bat	9	D34	carcass search	weekly road and pad	intact	no
08/23/2021	eastern red bat	34	A11	carcass search	twice per week square	scavenged	yes*
08/23/2021	eastern red bat	9	B16	carcass search	weekly road and pad	intact	no
08/23/2021	hoary bat	62	B14	carcass search	weekly road and pad	intact	no
08/23/2021	hoary bat	32	B18	carcass search	twice per week square	scavenged	yes*
08/24/2021	big brown bat	34	D39	carcass search	twice per week square	scavenged	yes*
08/24/2021	hoary bat	11	C22	incidental	weekly road and pad	scavenged	no
08/24/2021	hoary bat	63	D39	carcass search	twice per week square	scavenged	yes*
08/24/2021	silver-haired bat	7	A04	carcass search	weekly road and pad	intact	no
08/25/2021	hoary bat	20	B17	incidental	weekly road and pad	intact	no
08/26/2021	eastern red bat	9	B18	carcass search	twice per week square	scavenged	yes*
08/26/2021	silver-haired bat	19	A11	carcass search	twice per week square	scavenged	yes*
08/26/2021	silver-haired bat	48	B12	carcass search	twice per week square	scavenged	yes*
08/27/2021	eastern red bat	5	D35	carcass search	twice per week square	intact	yes*
08/27/2021	hoary bat	47	C27	carcass search	twice per week square	scavenged	yes*
08/27/2021	hoary bat	47	D38	carcass search	twice per week square	scavenged	yes*
08/27/2021	hoary bat	72	D39	carcass search	twice per week square	scavenged	yes*
08/27/2021	silver-haired bat	13	D38	carcass search	twice per week square	scavenged	yes*
08/30/2021	big brown bat	31	B18	carcass search	twice per week square	dismembered	yes*
08/30/2021	eastern red bat	10	B18	carcass search	twice per week square	scavenged	yes*
08/30/2021	eastern red bat	17	D31	incidental	weekly road and pad	scavenged	no
08/30/2021	hoary bat	18	A07	carcass search	twice per week square	scavenged	yes*
08/30/2021	hoary bat	25	A11	carcass search	twice per week square	scavenged	yes*
08/30/2021	hoary bat	31	B18	carcass search	twice per week square	scavenged	yes*
08/30/2021	hoary bat	4	C26	incidental	weekly road and pad	intact	no
08/30/2021	little brown bat	4	A07	carcass search	twice per week square	intact	yes*
08/30/2021	silver-haired bat	48	A07	carcass search	twice per week square	scavenged	yes*
08/30/2021	silver-haired bat	13	B17	incidental	weekly road and pad	intact	no
08/30/2021	silver-haired bat	19	D34	incidental**	weekly road and pad	scavenged	no
08/30/2021	silver-haired bat	17	D36	incidental**	weekly road and pad	intact	no
08/31/2021	big brown bat	23	D39	carcass search	twice per week square	scavenged	yes*
08/31/2021	eastern red bat	24	C27	carcass search	twice per week square	scavenged	yes*

Appendix A1. Complete listing of bat carcasses found July 1 – October 1, 2021, at the Black Oak Wind Project, Stearns County, Minnesota.

Date Found	Species	Distance from Turbine	Turbine	Search Type	Search Area Type	Physical Condition	Detection Dog Search
08/31/2021	eastern red bat	35	D39	carcass search	twice per week square	scavenged	yes*
08/31/2021	hoary bat	11	C25	carcass search	weekly road and pad	scavenged	no
08/31/2021	hoary bat	19	C27	carcass search	twice per week square	scavenged	yes*
08/31/2021	silver-haired bat	10	C25	carcass search	weekly road and pad	scavenged	no
08/31/2021	silver-haired bat	9	C25	carcass search	weekly road and pad	scavenged	no
08/31/2021	silver-haired bat	0	C28	carcass search	weekly road and pad	injured	no
08/31/2021	silver-haired bat	6	D38	carcass search	twice per week square	scavenged	yes*
08/31/2021	silver-haired bat	12	D39	carcass search	twice per week square	scavenged	yes*
08/31/2021	silver-haired bat	25	D39	carcass search	twice per week square	scavenged	yes*
08/31/2021	silver-haired bat	27	D39	carcass search	twice per week square	scavenged	yes*
09/01/2021	hoary bat	8	A04	carcass search	weekly road and pad	scavenged	no
09/01/2021	hoary bat	9	A04	carcass search	weekly road and pad	scavenged	no
09/01/2021	hoary bat	45	B14	carcass search	weekly road and pad	intact	no
09/01/2021	hoary bat	7	B14	carcass search	weekly road and pad	intact	no
09/01/2021	hoary bat	8	D33	carcass search	weekly road and pad	scavenged	no
09/01/2021	hoary bat	42	D35	carcass search	twice per week square	scavenged	yes*
09/01/2021	silver-haired bat	7	A04	carcass search	weekly road and pad	scavenged	no
09/01/2021	silver-haired bat	24	A05	carcass search	weekly road and pad	dismembered	no
09/01/2021	silver-haired bat	7	C23	carcass search	weekly road and pad	scavenged	no
09/01/2021	silver-haired bat	26	C23	carcass search	weekly road and pad	scavenged	no
09/01/2021	silver-haired bat	17	D35	carcass search	twice per week square	scavenged	yes*
09/01/2021	silver-haired bat	15	D35	carcass search	twice per week square	scavenged	yes*
09/01/2021	silver-haired bat	31	D35	carcass search	twice per week square	scavenged	yes*
09/02/2021	big brown bat	54	B12	carcass search	twice per week square	scavenged	yes*
09/03/2021	silver-haired bat	44	C27	carcass search	twice per week square	scavenged	yes*
09/03/2021	silver-haired bat	24	D39	carcass search	twice per week square	intact	yes*
09/06/2021	big brown bat	17	B20	carcass search	weekly road and pad	scavenged	no
09/06/2021	silver-haired bat	9	A07	carcass search	twice per week square	scavenged	yes*
09/06/2021	silver-haired bat	4	B12	carcass search	twice per week square	intact	yes*
09/07/2021	big brown bat	2	C25	carcass search	weekly road and pad	injured	no
09/07/2021	eastern red bat	18	D39	carcass search	twice per week square	intact	yes*
09/07/2021	silver-haired bat	9	C23	carcass search	weekly road and pad	scavenged	no
09/07/2021	silver-haired bat	9	C26	carcass search	weekly road and pad	intact	no
09/07/2021	silver-haired bat	50	C27	carcass search	twice per week square	scavenged	yes*
09/07/2021	silver-haired bat	30	C27	carcass search	twice per week square	scavenged	yes*

Appendix A1. Complete listing of bat carcasses found July 1 – October 1, 2021, at the Black Oak Wind Project, Stearns County, Minnesota.

Date Found	Species	Distance from Turbine	Turbine	Search Type	Search Area Type	Physical Condition	Detection Dog Search
09/07/2021	silver-haired bat	5	D35	carcass search	twice per week square	intact	yes*
09/07/2021	silver-haired bat	22	D39	carcass search	twice per week square	intact	yes*
09/09/2021	eastern red bat	44	B12	carcass search	twice per week square	scavenged	yes*
09/13/2021	silver-haired bat	54	A08	carcass search	weekly road and pad	scavenged	no
09/13/2021	silver-haired bat	69	A11	carcass search	twice per week square	dismembered	yes*
09/13/2021	silver-haired bat	28	A11	carcass search	twice per week square	scavenged	yes*
09/13/2021	silver-haired bat	19	B12	carcass search	twice per week square	scavenged	yes*
09/13/2021	silver-haired bat	10	B15	incidental	weekly road and pad	scavenged	no
09/14/2021	hoary bat	3	D33	carcass search	weekly road and pad	scavenged	no
09/14/2021	hoary bat	48	D39	carcass search	twice per week square	scavenged	yes*
09/14/2021	little brown bat	2	C26	carcass search	weekly road and pad	intact	no
09/14/2021	silver-haired bat	53	D39	carcass search	twice per week square	scavenged	yes*
09/17/2021	silver-haired bat	31	D39	carcass search	twice per week square	scavenged	yes*
09/17/2021	silver-haired bat	36	D39	carcass search	twice per week square	scavenged	yes*
09/20/2021	eastern red bat	46	A04	carcass search	weekly road and pad	scavenged	no
09/20/2021	eastern red bat	13	A07	carcass search	twice per week square	scavenged	yes*
09/21/2021	eastern red bat	82	C27	carcass search	twice per week square	intact	yes*
09/21/2021	eastern red bat	60	C27	carcass search	twice per week square	scavenged	yes*
09/21/2021	silver-haired bat	22	D35	carcass search	twice per week square	scavenged	yes*
09/23/2021	silver-haired bat	69	A11	carcass search	twice per week square	scavenged	yes*
09/27/2021	eastern red bat	58	A11	carcass search	twice per week square	scavenged	yes*
09/28/2021	eastern red bat	29	C28	carcass search	weekly road and pad	intact	no
09/28/2021	hoary bat	97	D33	carcass search	weekly road and pad	scavenged	no
10/01/2021	eastern red bat	38	C27	carcass search	twice per week square	scavenged	yes*

* detection dog search.

** Carcass was found outside the search area

Appendix A2. Complete listing of bird carcasses found July 1 – October 1, 2021, at the Black Oak Wind Project, Stearns County, Minnesota.

Date Found	Species	Distance from Turbine	Turbine	Search Type	Search Area Type	Physical Condition	Detection Dog Search
7/1/2021	mallard	20	B18	carcass search	twice per week square	dismembered	yes*
7/1/2021	unidentified small bird	60	B18	carcass search	twice per week square	dismembered	yes*
7/2/2021	marsh wren	88	C27	carcass search	twice per week square	scavenged	yes*
7/6/2021	northern flicker	26	C27	carcass search	twice per week square	dismembered	yes*
7/8/2021	mallard	19	B18	carcass search	twice per week square	dismembered	yes*
7/13/2021	northern flicker	59	C27	carcass search	twice per week square	dismembered	yes*
7/16/2021	American robin	32	C27	carcass search	twice per week square	scavenged	yes*
7/16/2021	red-bellied woodpecker	38	C27	carcass search	twice per week square	dismembered	yes*
7/20/2021	ring-necked pheasant	51	D38	carcass search	twice per week square	feather spot	yes*
7/20/2021	tree swallow	45	C27	carcass search	twice per week square	scavenged	yes*
7/21/2021	American white pelican	47	C23	carcass search	weekly road and pad	scavenged	no
7/22/2021	cliff swallow	27	B12	carcass search	twice per week square	dismembered	yes*
7/27/2021	tree swallow	38	D39	carcass search	twice per week square	scavenged	yes*
7/27/2021	tree swallow	19	D38	carcass search	twice per week square	scavenged	yes*
8/2/2021	ring-necked pheasant	78	B18	carcass search	twice per week square	dismembered	yes*
8/4/2021	red-winged blackbird	6	D38	incidental	weekly road and pad	scavenged	no
8/9/2021	horned lark	48	D38	carcass search	twice per week square	scavenged	yes*
8/10/2021	tree swallow	44	D39	carcass search	twice per week square	scavenged	yes*
8/12/2021	ring-necked pheasant	101	B18	carcass search	twice per week square	feather spot	yes*
8/13/2021	least flycatcher	25	D39	carcass search	weekly road and pad	scavenged	no
8/16/2021	vesper’s sparrow	3	C26	carcass search	weekly road and pad	scavenged	no
8/31/2021	common yellowthroat	167	C27	incidental**	twice per week square	intact	no
9/14/2021	Nashville warbler	70	D39	carcass search	twice per week square	scavenged	yes*
9/21/2021	Nashville warbler	38	D36	carcass search	weekly road and pad	scavenged	no
9/24/2021	American robin	30	C27	carcass search	twice per week square	scavenged	yes*
10/1/2021	golden-crowned kinglet	73	D39	carcass search	twice per week square	scavenged	yes*

* detection dog search.

** Carcass was found outside the search area

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Appendix B. Fatality Adjustment Modeling Results for Search Area Correction

Appendix B1. Search area adjustment models for bats at curtailed turbines from the Black Oak Wind Project, Stearns County, Minnesota, in 2021.

Distribution	AICc	Delta AICc
gamma	12,152.89	0*
Weibull	12,160.04	7.15
Rayleigh	12,208.78	55.89
normal	12,222.90	70.00
Gompertz	12,277.76	124.87

* Selected model

AICc = corrected Akaike Information Criterion

Appendix B2. Search area adjustment models for bats at control turbines from the Black Oak Wind Project, Stearns County, Minnesota, in 2021.

Distribution	AICc	Delta AICc
gamma	640.01	0*
Weibull	640.44	0.43
normal	644.63	4.62
Rayleigh	645.72	5.71
Gompertz	647.21	7.20

* Selected model

AICc = corrected Akaike Information Criterion

Appendix B3. Search area adjustment models for bats at deterrent turbines from the Black Oak Wind Project, Stearns County, Minnesota, in 2021.

Distribution	AICc	Delta AICc
Gompertz	665.65	0*
normal	666.08	0.43
Weibull	666.94	1.29
gamma	668.33	2.68
Rayleigh	672.18	6.53

* Selected model

AICc = corrected Akaike Information Criterion

Appendix C. Midwestern Region of North American Fatality Summary Tables

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Appendix C1. Regional bat estimated fatality rates for wind-energy facilities in the Midwestern region of North America.

Project	Bat Fatality/ MW/Year	Plot Size	Estimator	Projects Land Cover	Citation
Black Oak Getty, MN (2018)	**37.59**	**60-m radius road/pad**	**Huso**	**Cropland, grassland, wetlands**	**Pickle et al. 2019**
Ida Grove, IA (2017)	33.8	100-m radius road/pad, 100-m x 100-m plot, 60-m x 60-m plot	Huso	Cropland, corn, soybean	Baumgartner et al. 2018
Black Oak Getty, MN (2017)	**29.88**	**60-m radius road/pad**	**Huso**	**Cropland, grassland, wetlands**	**Pickle et al. 2018**
Black Oak, MN (2021)	**20.993**	**100 –m radius road/pad, 150 m x 150 m plot**	**GenEst**	**Cropland, grassland, wetlands**	**This study.**
O'Brien, IA (2017)	19.72	100-m radius road/pad	Huso	Cropland, corn, soybean	Baumgartner et al. 2018
Intrepid, IA (2015-2016)	19.13	100-m radius road/pad, 60-m x 60-m plot, 100-m x 100-m plot	Huso	Cropland, pasture, corn, soybean	MidAmerican Energy Company 2019
Blazing Star, MN (2020)	19.06	120-m x 120-m cleared, 100-m radius road/pad	GenEst	Cropland, pasture, corn, soybean	Stucker et al. 2021b
Red Pine, MN (2018)	18.74	60-m radius road/pad	Huso	Cropland, developed, deciduous tree, open water, pasture, woody wetlands, wetlands	Trana et al. 2019
Lake Benton II, MN (2020)	18.44	120-m x 120-m cleared, 100-m radius road/pad	GenEst	Cropland, corn, soybean, herbaceous	Stucker et al. 2021a
Laurel, IA (2015-2016)	14.22	100-m radius road/pad, 60-m x 60-m plot, 100-m x 100-m plot	Huso	Cropland, pasture, corn, soybean	MidAmerican Energy Company 2019
Wellsburg, IA (2016)	12.55	100-m radius road/pad, 60-m x 60-m plot, 100-m x 100-m plot	Huso	Cropland, pasture, corn, soybean	MidAmerican Energy Company 2019
Adair, IA (2014-2015)	12.19	100-m radius road/pad	Huso	Cropland, pasture, corn, soybean	MidAmerican Energy Company 2019
Headwaters, IN (2019)	11.74	100-m radius road/pad, 70-m radius cleared, 70-m radius plot	GenEst	Cropland, soybean	Rodriguez et al. 2020
Macksburg, IA (2015-2016)	11	100-m radius road/pad, 200-m x 200-m plot	Huso	Cropland, pasture, corn, soybean	MidAmerican Energy Company 2019

Appendix C1. Regional bat estimated fatality rates for wind-energy facilities in the Midwestern region of North America.

Project	Bat Fatality/ MW/Year	Plot Size	Estimator	Projects Land Cover	Citation
Vienna II, IA (2016)	10.48	100-m radius road/pad, 60-m x 60-m plot, 100-m x 100-m plot	Huso	Cropland, pasture, corn, soybean	MidAmerican Energy Company 2019
Century, IA (2015-2016)	9.86	100-m radius road/pad, 60-m x 60-m plot, 100-m x 100-m plot	Huso	Cropland, pasture, corn, soybean	MidAmerican Energy Company 2019
Adams, IA (2016-2017)	9.4	100-m radius road/pad, 60-m x 60-m plot, 100-m x 100-m plot	Huso	Cropland, pasture, corn, soybean	Bay et al. 2017
Vienna I, IA (2016)	9.27	100-m radius road/pad, 60-m x 60-m plot, 100-m x 100-m plot	Huso	Cropland, pasture, corn, soybean	MidAmerican Energy Company 2019
Lundgren, IA (2015-2016)	8.97	100-m radius road/pad, 60-m x 60-m plot, 200-m x 200-m plot	Huso	Cropland, pasture, corn, soybean	MidAmerican Energy Company 2019
Highland, IA (2015-2016)	8.8	100-m radius road/pad, 60-m x 60-m plot, 100-m x 100-m plot	Huso	Cropland, pasture, corn, soybean	MidAmerican Energy Company 2019
Eclipse, IA (2014-2015)	8.66	100-m radius road/pad	Huso	Cropland, pasture, corn, soybean	MidAmerican Energy Company 2019
Waverly Wind, KS (2016-2017)	8.2	160-m x 160-m plot, 80-m radius road/pad	Huso	Agriculture, grassland	Tetra Tech 2017a
Odell, MN (2016-2017)	6.74	120-m x 120-m cleared	Huso	Agriculture	Chodachek and Gustafson 2018
Rolling Hills, IA (2016)	6.3	100-m radius road/pad, 60-m x 60-m plot, 100-m x 100-m plot	Huso	Cropland, pasture, corn, soybean	MidAmerican Energy Company 2019
Pomeroy, IA (2016)	6.01	100-m radius road/pad, 60-m x 60-m plot, 100-m x 100-m plot	Huso	Cropland, pasture, corn, soybean	MidAmerican Energy Company 2019
Lake Winds, MI (2014-2015)	4.6	160-m x 160-m plot, 150-m radius plot	unmodified Huso	Cropland, forest/woodlot, corn, soybean	Kerlinger et al. 2016
Cimarron II, KS (2015-2016)	2.3	126-m x 126-m plot	Huso	Agriculture, cropland, developed, forest/woodlot, grassland, open water	ARCADIS U.S. 2016

Appendix C1. Regional bat estimated fatality rates for wind-energy facilities in the Midwestern region of North America.

Project	Bat Fatality/ MW/Year	Plot Size	Estimator	Projects Land Cover	Citation
Pleasant Valley, MN (2016-2017)	1.8	160-m x 160-m cleared, 80-m radius road/pad	Huso	Agriculture, grassland, wetlands	Tetra Tech 2017b
Ironwood, KS (2014-2015)	1.5	126-m x 126-m plot	Huso	Cropland, developed, grassland, open water, playa	ARCADIS U.S. 2015a
Cimarron II, KS (2014-2015)	1.49	126-m x 126-m plot	Huso	Agriculture, cropland, developed, forest/woodlot, grassland, open water, playa	ARCADIS U.S. 2015b

m = meters, MW = megawatt, NA = not applicable/no data

Appendix C2. Wind energy facilities in the Midwest with comparable activity and fatality data for bats.

Project	Total Number of Turbines	Total MW	Number Turbines Searched[a]	Search Area Type	Survey Frequency	Length of Study	Tower Size (m)	Citation
Adair, IA (2014-2015)	76	174.8	76	Road/pad	Weekly, twice per month	12	80	MidAmerican Energy Company 2019
Adams, IA (2016-2017)	64	154.3	5, 47, 6, 7, 48, 59	Road/pad, full plot	Twice per week, weekly, twice per month	12.1	80	Bay et al. 2017
Black Oak Getty, MN (2017)	**39**	**78**	**34**	**Road/pad**	**Weekly**	**8**	**80**	**Pickle et al. 2018**
Black Oak Getty, MN (2018)	**39**	**78**	**18, 17**	**Road/pad**	**Weekly, twice per week**	**7**	**80**	**Pickle et al. 2019**
Blazing Star, MN (2020)	100	200	5, 10, 33, 60	Cleared, road/pad	Twice per week, weekly	8		Stucker et al. 2021b
Century, IA (2015-2016)	145	200	28, 3, 4, 6, 1, 83, 8, 10, 29, 85, 35, 100	Road/pad, full plot	Twice per week, twice per month	12	64.7	MidAmerican Energy Company 2019
Cimarron II, KS (2014-2015)	57	131	19	Full plot	Weekly, twice per month	11	101	ARCADIS U.S. 2015b
Cimarron II, KS (2015-2016)	57	131	19	Full plot	Weekly, twice per month	11	101	ARCADIS U.S. 2016
Eclipse, IA (2014-2015)	87	200.1	87	Road/pad	Weekly, twice per month	12	80	MidAmerican Energy Company 2019
Headwaters, IN (2019)	100	200	10, 60, 35, 5	Road/pad, cleared, full plot	Weekly	3.5		Rodriguez et al. 2020
Highland, IA (2015-2016)	214	502	171, 21, 22, 172, 23, 214, 2, 1	Road/pad, full plot	Twice per week, twice per month	12	80	MidAmerican Energy Company 2019
Ida Grove, IA (2017)	134	301	12, 2, 95, 13	Road/pad, full plot	Twice per week	12	80	Baumgartner et al. 2018
Intrepid, IA (2015-2016)	122	175.5	10, 2, 3, 88, 15, 107	Road/pad, full plot	Twice per week, twice per month	12	64.7	MidAmerican Energy Company 2019
Ironwood, KS (2014-2015)	73	168	24	Full plot	Weekly, twice per month	12	100	ARCADIS U.S. 2015a
Lake Benton II, MN (2020)	44	100	5, 39	Cleared, road/pad	Weekly	8	80	Stucker et al. 2021a
Lake Winds, MI (2014-2015)	56	100	17, 1	Full plot	Weekly	12	80	Kerlinger et al. 2016

Appendix C2. Wind energy facilities in the Midwest with comparable activity and fatality data for bats.

Project	Total Number of Turbines	Total MW	Number Turbines Searched[a]	Search Area Type	Survey Frequency	Length of Study	Tower Size (m)	Citation
Laurel, IA (2015-2016)	52	119.6	41, 5, 6, 52	Road/pad, full plot	Twice per week, twice per month	12	80	MidAmerican Energy Company 2019
Lundgren, IA (2015-2016)	107	251	86, 11, 10, 107	Road/pad, full plot	Twice per week, twice per month	12	80	MidAmerican Energy Company 2019
Macksburg, IA (2015-2016)	51	119.6	41, 10, 51	Road/pad, full plot	Twice per week, twice per month	12	80	MidAmerican Energy Company 2019
O'Brien, IA (2017)	104	250.3	13, 91	Road/pad	Weekly	12	80	Baumgartner et al. 2018
Odell, MN (2016-2017)	100	200	15	Cleared	Monthly, weekly	12	80	Chodachek and Gustafson 2018
Pleasant Valley, MN (2016-2017)	100	200	5, 92, 95	Cleared, road/pad	Weekly	12	80	Tetra Tech 2017b
Pomeroy, IA (2016)	184	286.4	13, 136, 18, 21, 134, 19	Road/pad, full plot	Twice per week	12	80	MidAmerican Energy Company 2019
Red Pine, MN (2018)	100	200	40	Road/pad	Weekly	8	80	Trana et al. 2019
Rolling Hills, IA (2016)	193	443.9	154, 19, 20	Road/pad, full plot	Twice per week	12	80	MidAmerican Energy Company 2019
Vienna I, IA (2016)	45	105.6	36, 5, 4	Road/pad, full plot	Twice per week	12	80	MidAmerican Energy Company 2019
Vienna II, IA (2016)	19	44.6	15, 2	Road/pad, full plot	Twice per week	12	80	MidAmerican Energy Company 2019
Waverly Wind, KS (2016-2017)	95	199	29, 26, 3	Full plot, road/pad	Twice per month, weekly	12	93	Tetra Tech 2017a
Wellsburg, IA (2016)	60	140.8	48, 7, 6	Road/pad, full plot	Twice per week	12	80	MidAmerican Energy Company 2019

m = meter, MW = megawatt

[a] Number of turbines searched may vary by season and plot type.

APPENDIX C REFERENCES

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Attachment 5

Tier 4 Mitigation Checklist

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Auwahi Wind HCP Tier 4 Bat Mitigation Actions	Current Status	2022 Q4	FY20-FY22 Q4 Total	HCP Total Required	Notes
Provide a copy of the conservation easement to USFWS and DOFAW	Complete	N/A	N/A	N/A	Provided copy to USFWS/DOFAW on 12/12/2020
Letter of credit in the amount of $4,013,047 payable to DOFAW	Complete	N/A	N/A	N/A	Reduced LOC based on implemented mitigation per concurrence from USFWS/DOFAW in 2021.
Record the conservation easement for the Leeward Haleakala Mitigation Project land to preserve it in perpetuity.	Complete	N/A	N/A	N/A	HILT recorded with State of Hawaii Bureau of Conveyances 12/7/2020
Install Ponds	Complete	N/A	2 pond installed	2 ponds installed	1 pond completed in 2020. Second pond completed 3/5/2021.
Install acoustic detectors	Complete	N/A	38 acoustic detectors installed	38 acoustic detectors installed	Tier 4 mitigation area detectors installed.
Install wildlife egress structures in all troughs within the mitigation area	Complete	N/A	Structures installed in 10 troughs	All troughs (10)	Photos taken for documentation
Consider and install understory with hedgerow canopy	Complete	N/A	5 acres planted	None required	A'ali'i added
Quarterly insect monitoring for the baseline monitoring period	Complete	N/A	3 malaise traps checked quarterly	3 malaise traps checked quarterly	Data analysis and report due next
Fence ponds	Complete	N/A	2 ponds fenced	2 ponds fenced	Koa added to perimeter area
Use thermal cameras to document the behavior of bats at ponds and/or water troughs.	Complete	data collected from 1 thermal camera	Thermal camera installed at pond	Document the behavior of bats at ponds or troughs	Data collected documenting bat behavior of pond. Data shared with USFWS/DOFAW

Remove barbed wire from the mitigation area	Complete	N/A	67 acres of barbed fencing removed	Removal of wire as found	Ranch utilizing volunteers to remove. Barb wire near elk fence removed by contractors.
Install hedgerow fencing	In Progress	8 acres	108 acres	311 acres	Contractor accident delayed next fence. Bid awarded for next fenced area to be built.
Install hedgerow plantings	In Progress	8 acres	108 acres	311 acres	Focused plantings around natural occurring springs including Waihou and Waikahi
Quarterly detector checks	In Progress, Ongoing	38 acoustic detectors checked	38 acoustic detectors checked	38 acoustic detectors checked quarterly in yrs. 0, 1, 2, 3, 5, 7, 9, 11	Year 1 complete. Quarterly check data sent to West for analysis. West performing analysis investigating new metric
Annually analyze acoustic monitoring data to ensure units working properly	In Progress, Ongoing	Repairs made to detector	data from 38 acoustic detectors analyzed	38 acoustic detector data analyzed annually in monitoring years	All units working properly, units repaired. WEST performing analysis. Possible sd card or mic failure to occur soon. Preventative maintenance investigated
Quarterly pond monitoring	In Progress, Ongoing	2 ponds checked	2 ponds checked	Quarterly checks of ponds in years 1, 2, 3, 5, 7, 9, and 11	Ponds intact
Quarterly fence inspections	In Progress, Ongoing	Fence-lines checked	Fence-lines checked	None required	Fence-lines intact.
Twice annual insect monitoring in years 1, 2, 3, 5, 7, 9, and 11	In Progress, Ongoing	3 malaise traps checked	3 malaise traps checked twice annually	3 malaise traps checked twice annually	Second insect monitoring twice-annually initiated. Data collected and next monitoring planned for Q2

Attachment 6

Auwahi Pond Study Interim Report Tier 4 Bat Baseline Study Final Report

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AUWAHI POND STUDY INTERIM REPORT

Brogan Morton

10/22/21

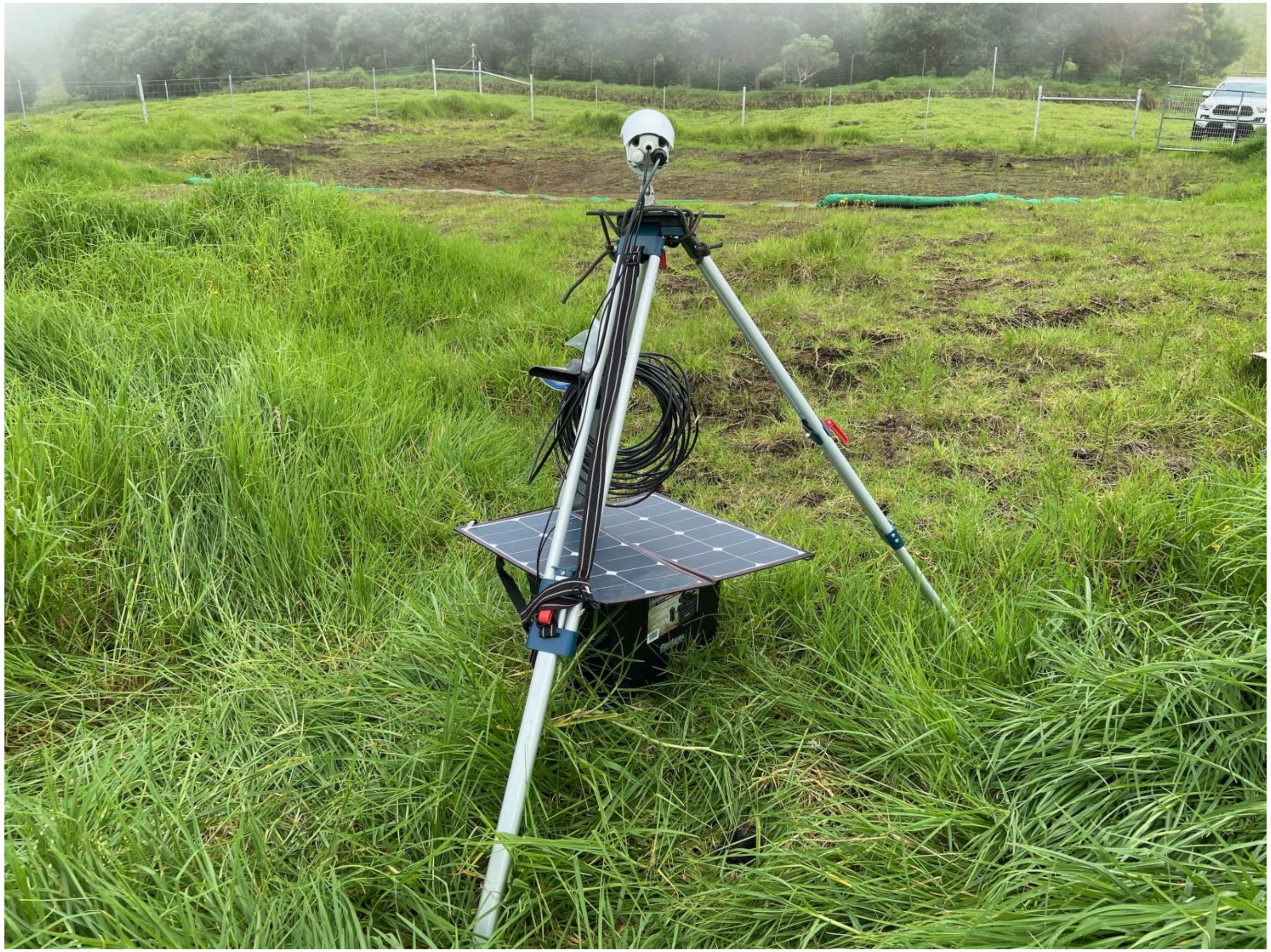
CONTAINS CONFIDENTIAL INFORMATION

Wildlife Imaging Systems

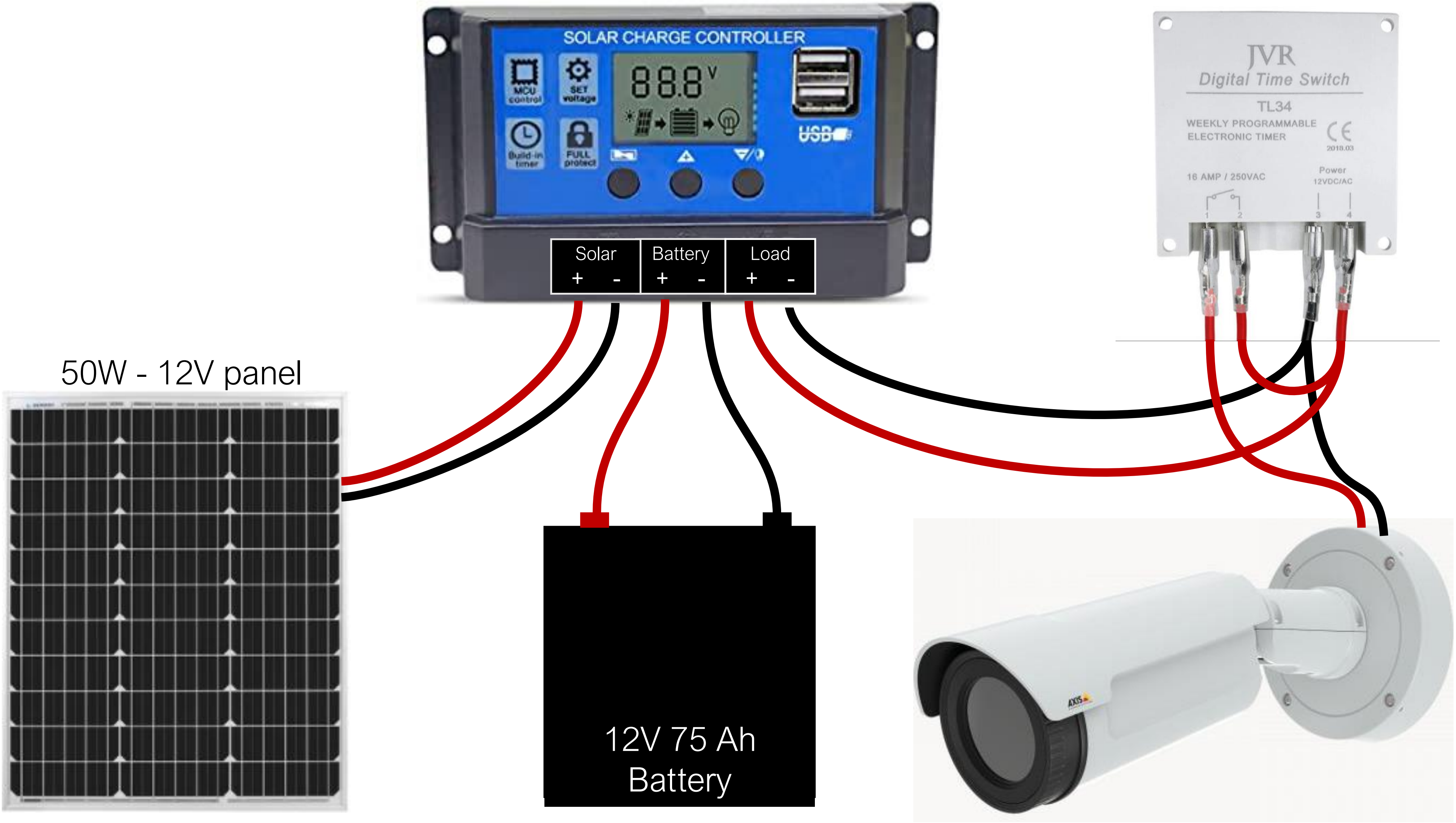
PROJECT OVERVIEW

- GOAL: Document the bats' use of the water sources and characterize behaviors around them.
  - Are bats drinking?
  - Are bats foraging?
  - Are bats roosting around the pond?
  - How much time (e.g. minutes, visits) per night are bats using the pond?
  - Are multiple bats using the pond?

EQUIPMENT



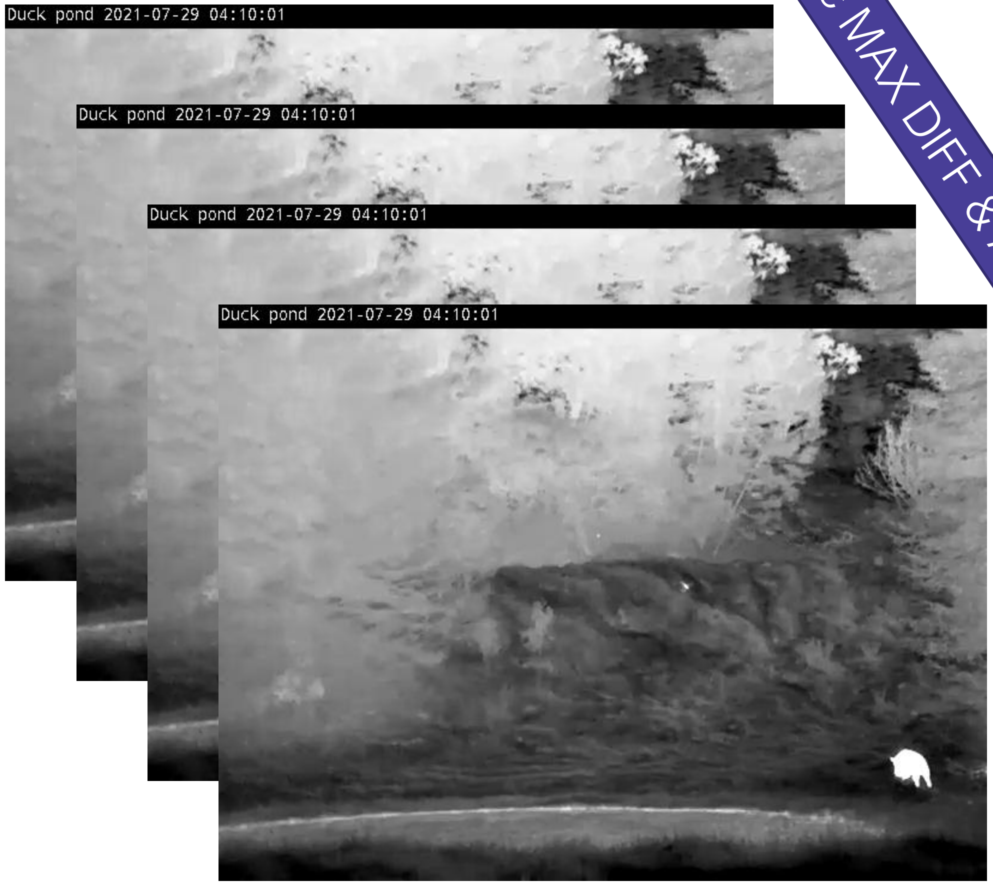
EQUIPMENT


SOLAR CHARGE CONTROLLER
MCU control
SET voltage
Build-in timer
FULL protect
888 V
USB
Solar + -
Battery + -
Load + -
JVR
Digital Time Switch
TL34
WEEKLY PROGRAMMABLE ELECTRONIC TIMER
16 AMP / 250VAC
Power 12VDC/AC
50W - 12V panel
12V 75 Ah Battery

VIDEO

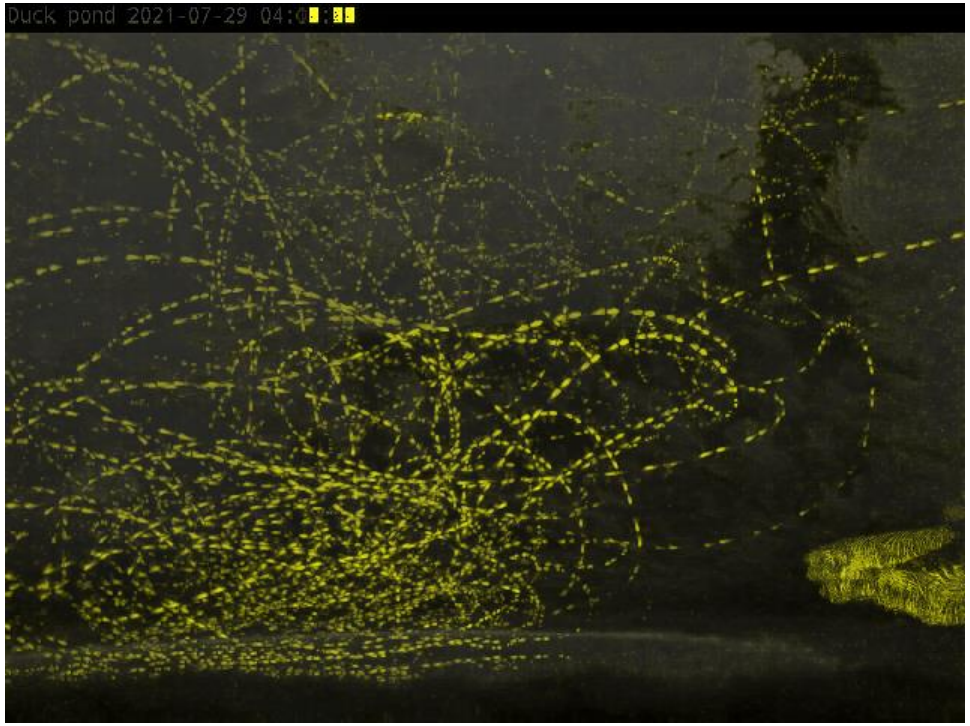
- 640 x 480 thermal video @ 20 fps
- 12 hours a night
  - 18:30 to 06:30
- Video clips 5/15 minutes long

QUALITATIVE PROCESSING – SUMMARY IMAGES



Calc MAX DIFF & AVG frame

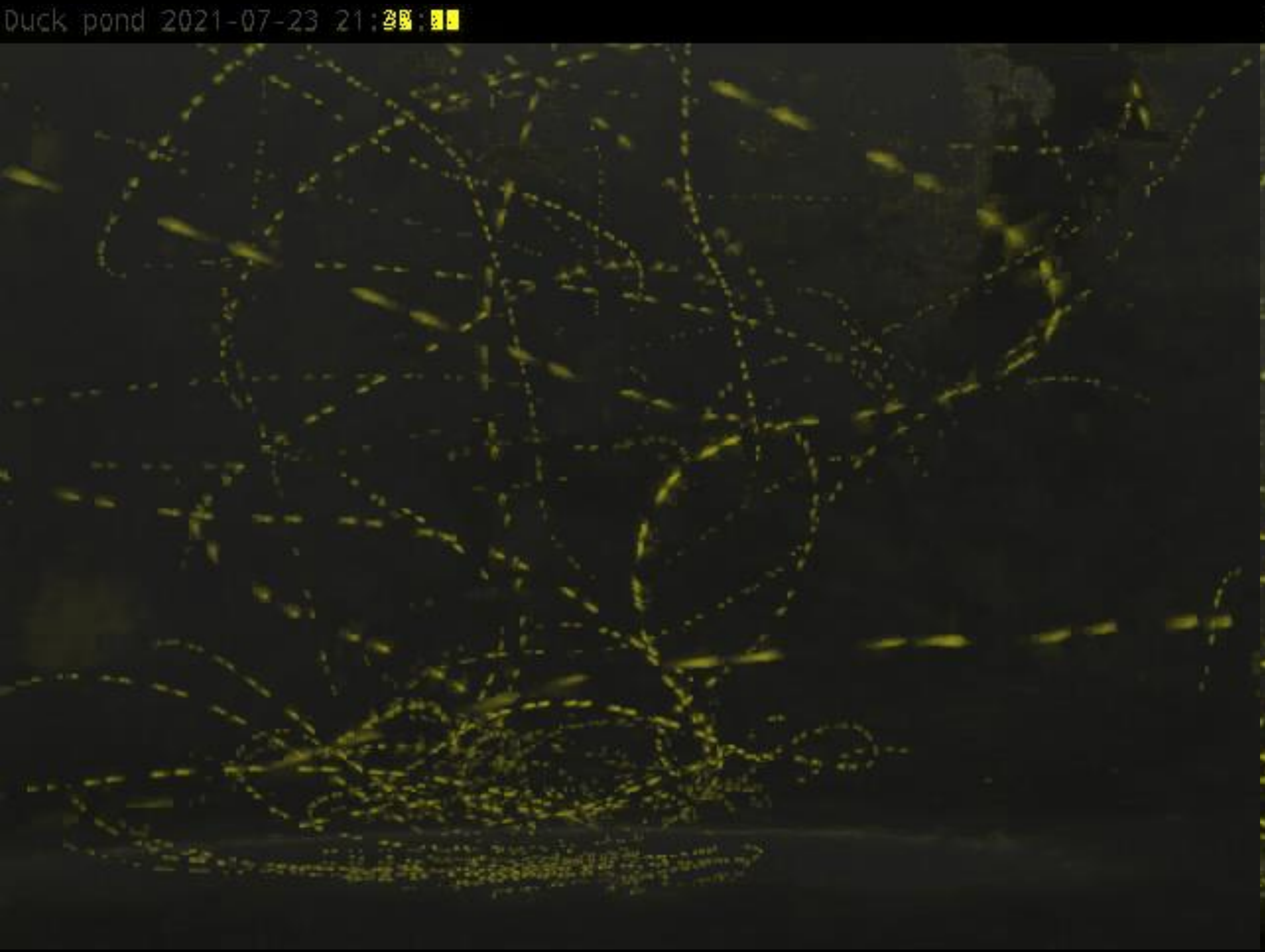
Combine MAX DIFF & AVG frames

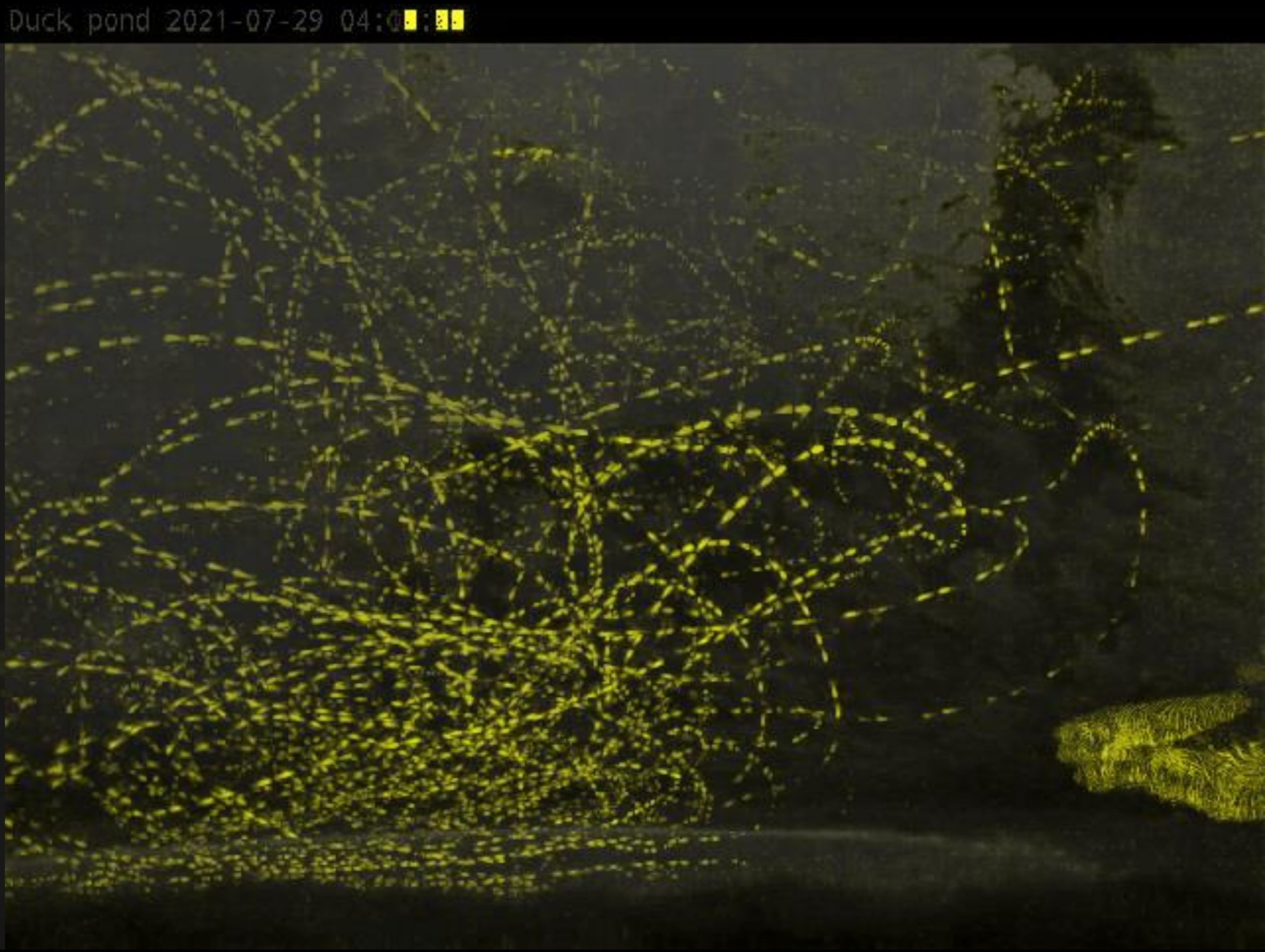


SITE 1 – DUCK POND

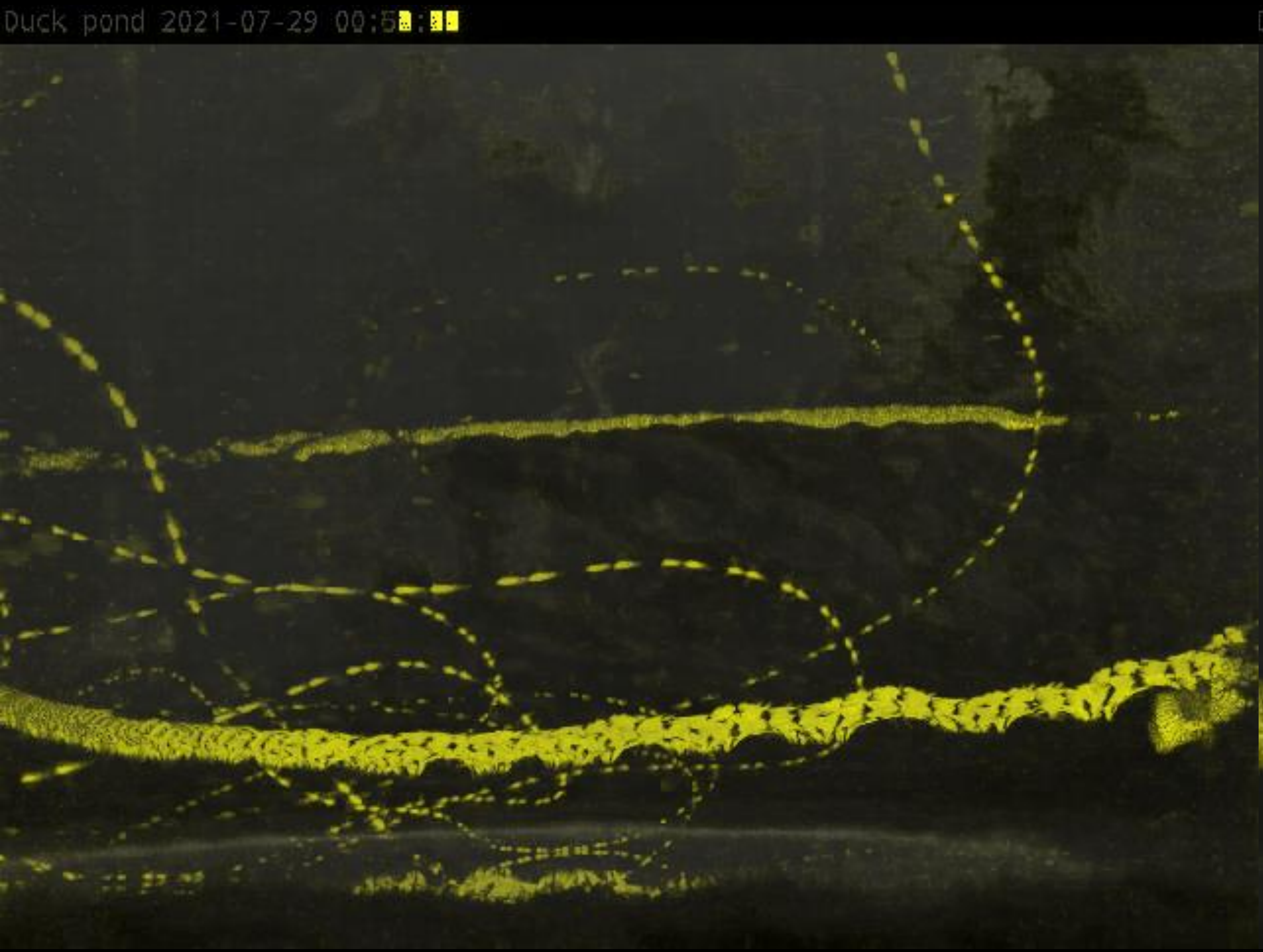
EXAMPLES OF DRINKING

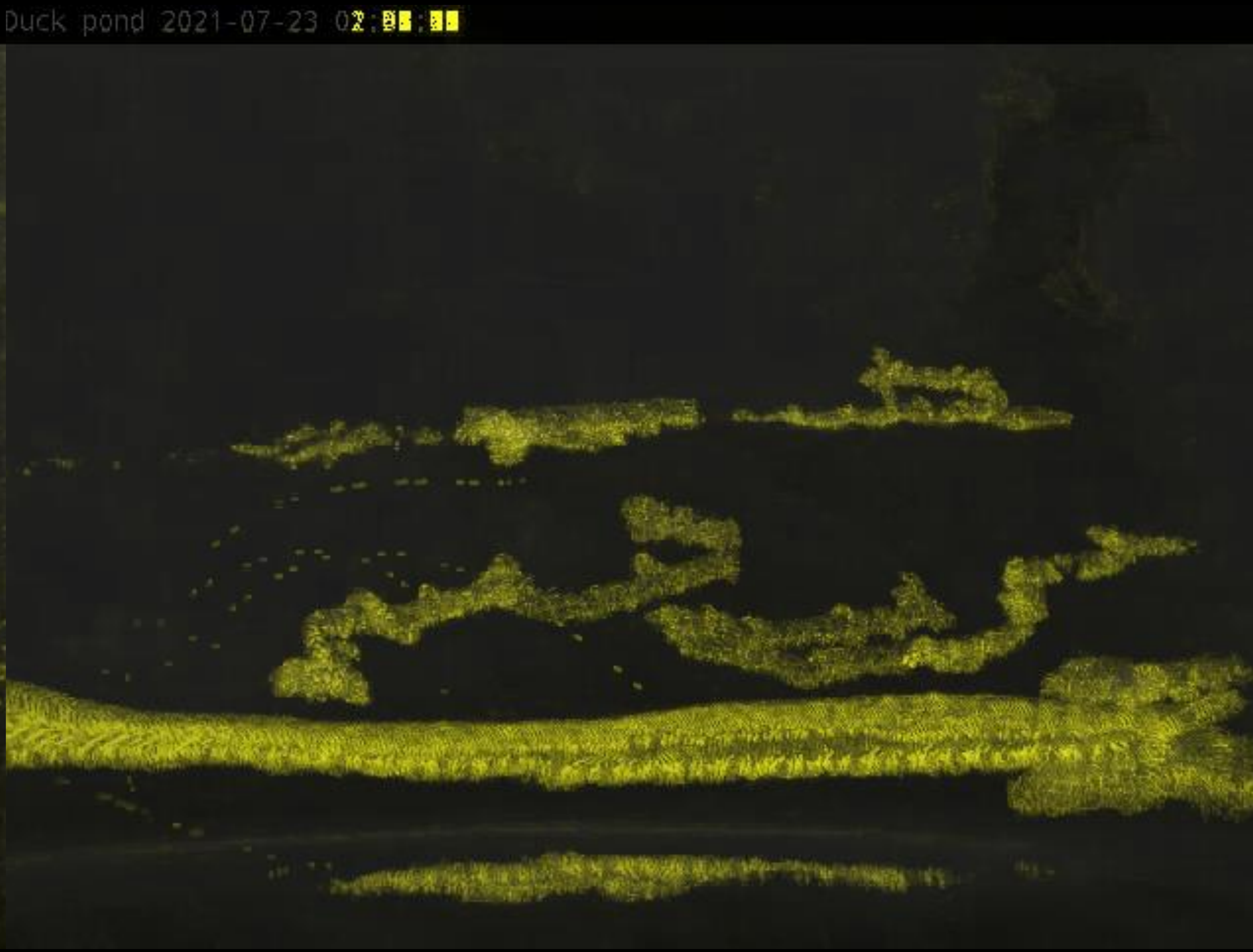
EXAMPLES OF FORAGING



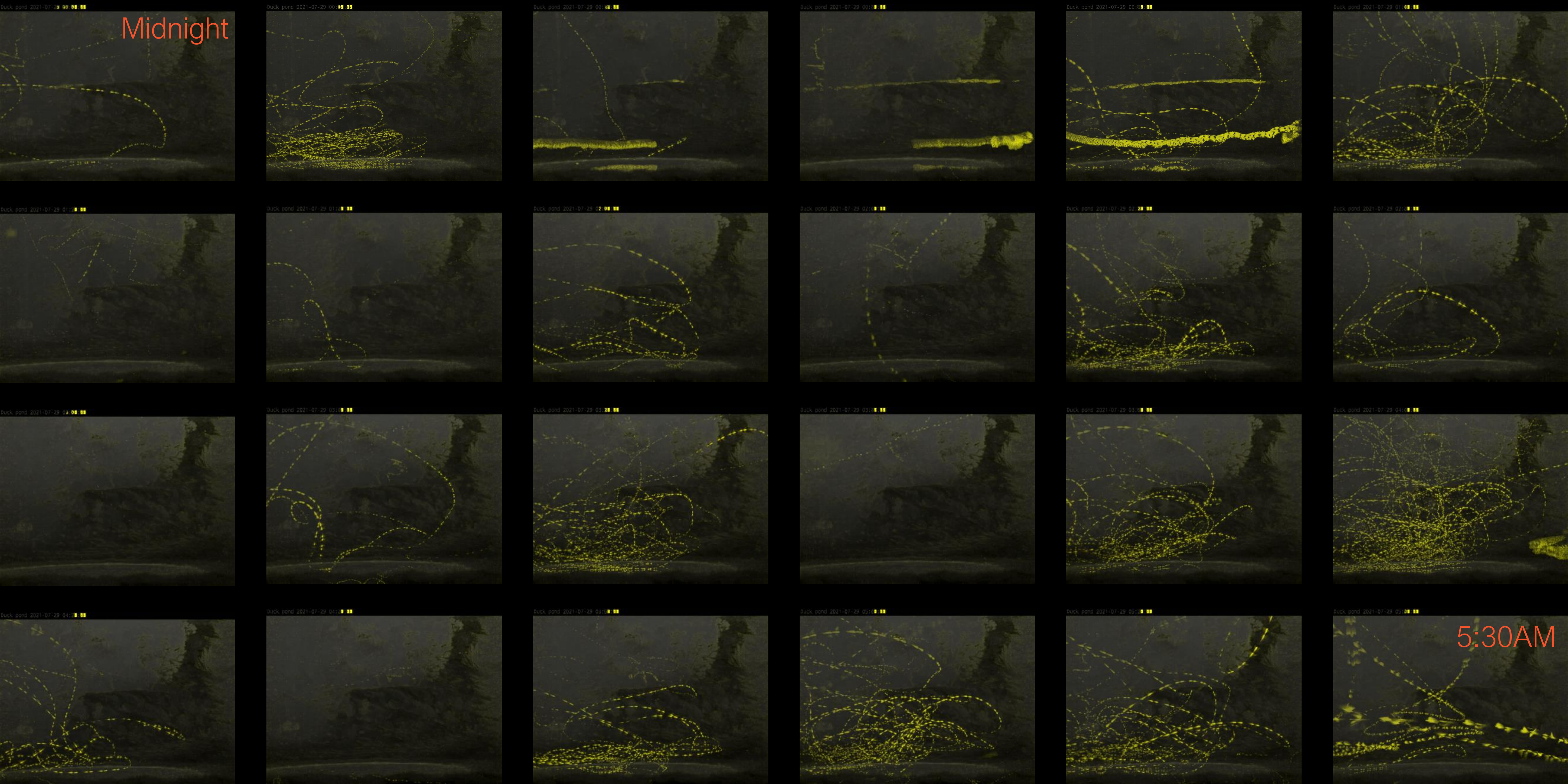


EXAMPLES OF DEER/PIG

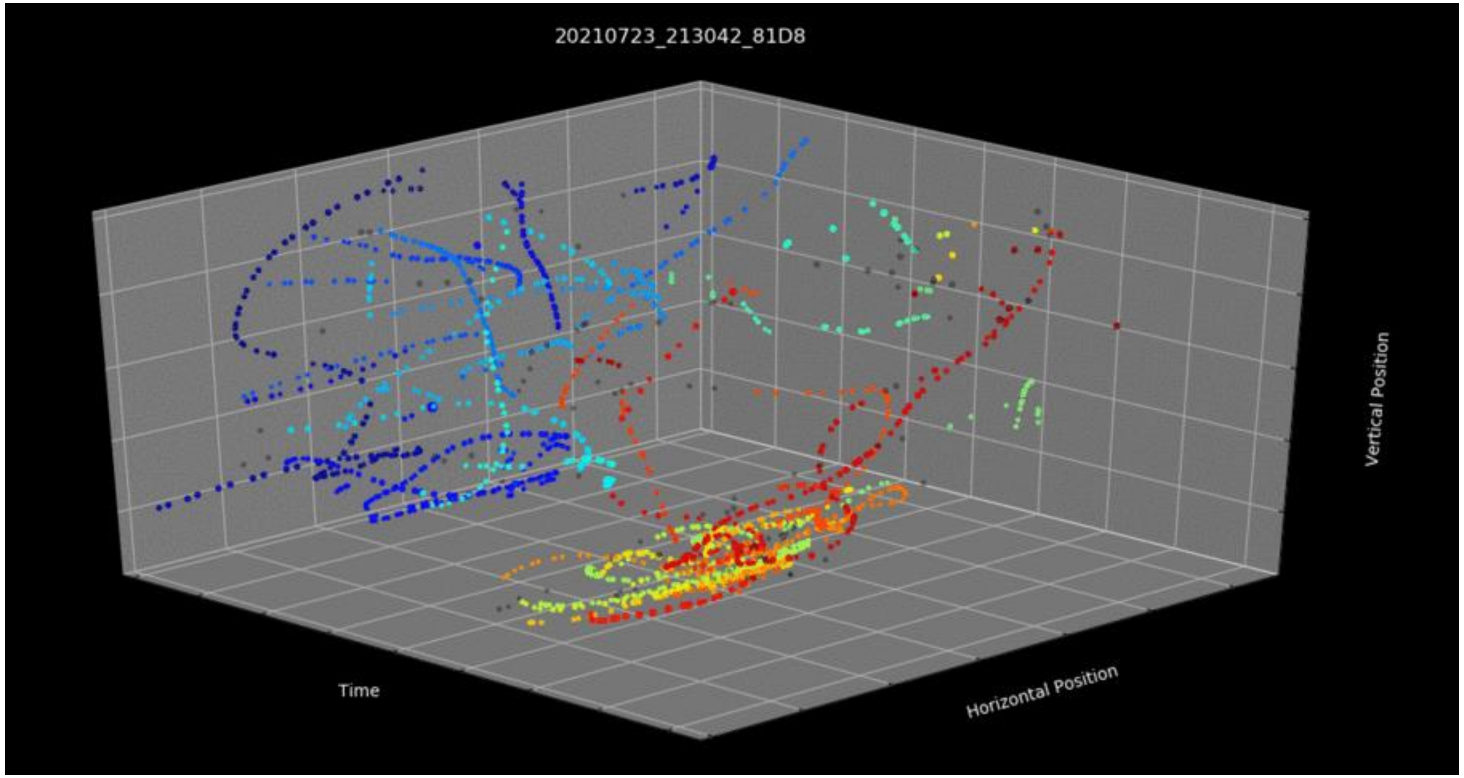




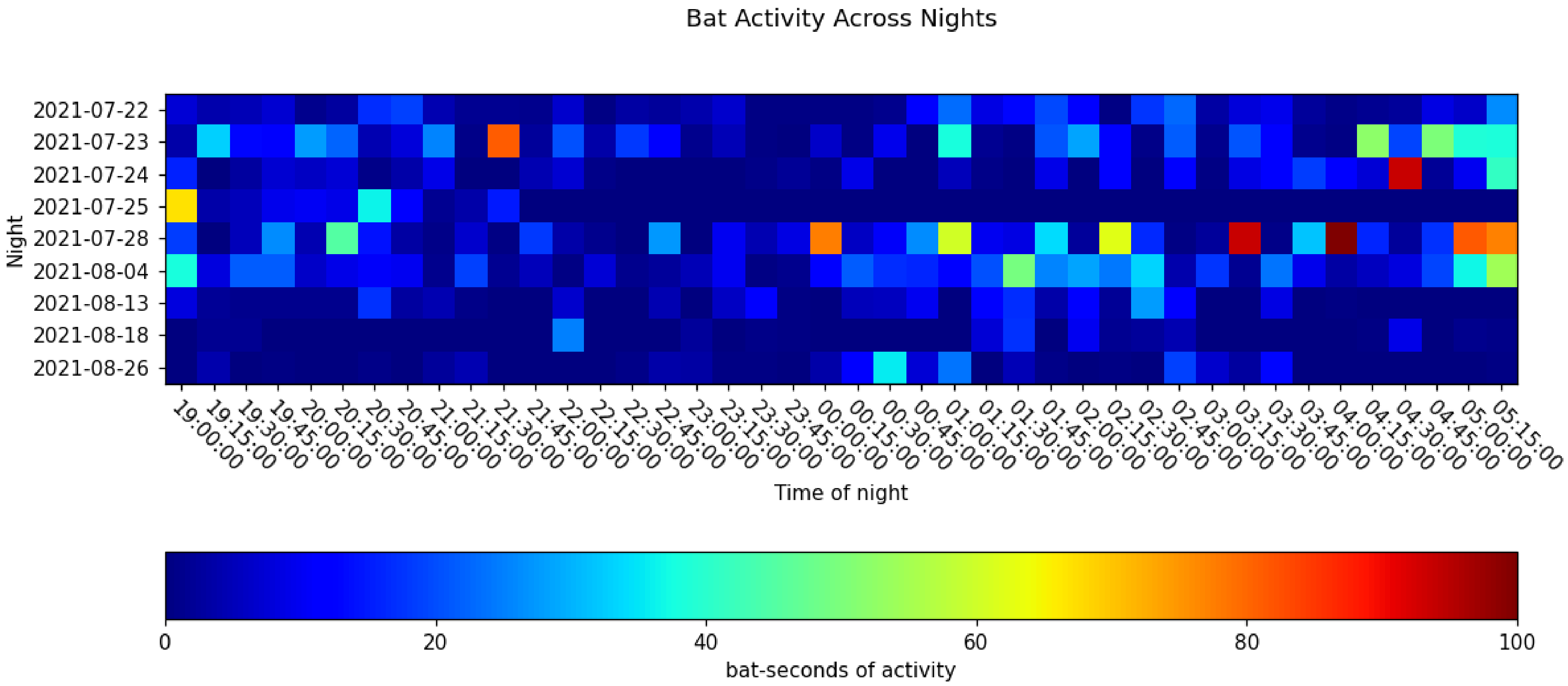
EXAMPLE NIGHT – JULY 28TH – MIDNIGHT TILL 5:30



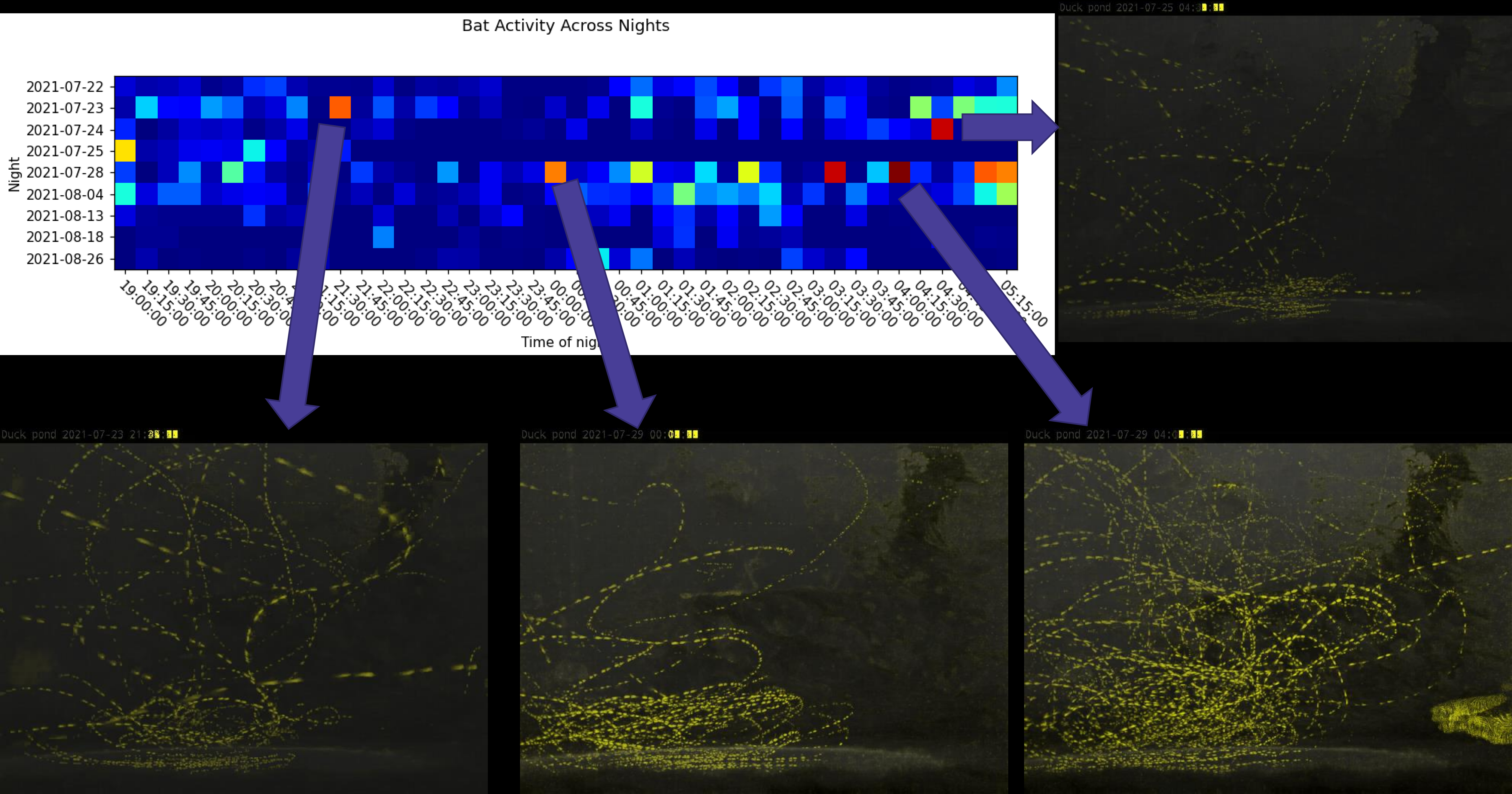
QUANTITATIVE PROCESSING - DETECTIONS



QUANTITATIVE PROCESSING - DATA AGGREGATION



- *Filtered detections summed in 15-minute bins*
- *Each detection is 1/20 of a second, so convert from detections to bat-seconds of activity*


Bat Activity Across Nights
2021-07-22
2021-07-23
2021-07-24
2021-07-25
2021-07-28
2021-08-04
2021-08-13
2021-08-18
2021-08-26
Night
19:00:00
19:15:00
19:30:00
19:45:00
20:00:00
20:15:00
20:30:00
21:30:00
21:45:00
22:00:00
22:15:00
22:30:00
22:45:00
23:00:00
23:15:00
23:30:00
23:45:00
01:00:00
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02:45:00
03:00:00
03:15:00
03:30:00
03:45:00
04:00:00
04:15:00
04:30:00
05:15:00
Duck pond 2021-07-25
Duck pond 2021-07-23
Duck pond 2021-07-29
Duck pond 2021-07-29

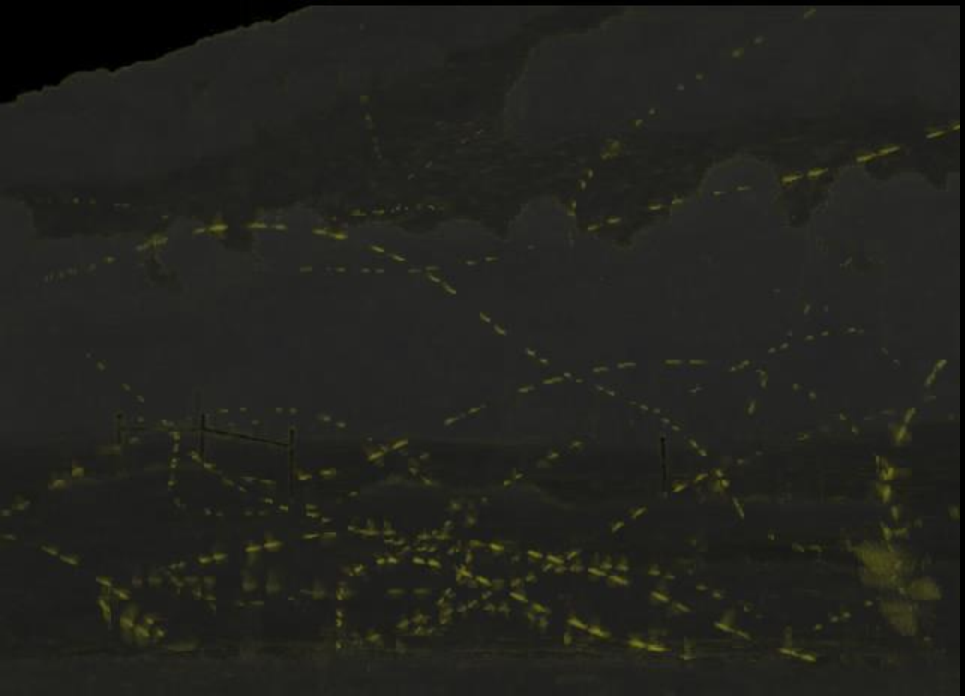
SITE 2 – NEW POND

The water level is well below the edge of the pond so we could not video the surface.

ACTIVITY AT NEW POND

Bat activity 10 out of 12 nights

DRINKING AT NEW POND



Bats dipping below ground level. I assume they are taking a drink from the pond. Given the water level of the pond, we couldn't capture the surface.

PRELIMINARY CONCLUSIONS

- Bats are drinking from the duck pond and most likely new pond
- Bats are foraging around the duck pond, not at new pond
- Cannot find evidence of nearby roosting
- Bats are spending significant time around the duck pond and making multiple visits per night
- Bats are visiting new pond consistently but not to the same level as duck pond
- Unsure about multiple bats
    - We cannot determine if different visits are different bats

Brogan Morton

Wildlife Imaging Systems

brogan@wildlifeimagingsystems.com

QUESTIONS?

Attachment 7

Tier 4 Bat Mitigation Insect Monitoring Results

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TETRA TECH

MEMO

To:	George Akau, AEP Energy
Cc:	Matt Stelmach, AEP Energy
From:	Tetra Tech, Inc.
Date:	April 20, 2022
Correspondence #	TTCES-PTLD-2022-024
Subject:	Tier 4 Bat Mitigation: Insect Monitoring Results

1.0 Introduction

Auwahi Wind is currently conducting Tier 4 Bat Mitigation to increase and enhance bat foraging and night-roosting habitat by adding resource features and augmenting the landscape to connect areas that provide bat habitat. To achieve this objective, AEP Energy will create suitable and consistent water resources and forested linear landscape features consisting of hedgerows and active cattle grazing pasture. These will provide foraging areas, night-roosting substrate, and travel corridors for bats. The mitigation efforts are anticipated to increase foraging and night-roost habitat by providing a patchwork of open, edge, and closed canopy habitat, thus increasing the availability of insect prey, primarily moths and beetles. As part of the Tier 4 Bat Mitigation monitoring efforts, AEP Energy incorporated insect sampling as a tool to better understand the effects of the management actions on the foraging resources of bats and guide adaptive management actions if required.

2.0 Methods

Baseline monitoring of insects was conducted using malaise traps from July 2020 to June 2021 (state fiscal year 2021) at three separate habitats: pond, future hedgerow (currently pasture), and pasture. Insect sampling was conducted quarterly, and sampling quarters were selected to align with the bats' reproductive periods (lactation, post-lactation, pre-pregnancy, and pregnancy) as defined by Gorresen et al (2016; see Table 1).

Following sampling, insects > 10 millimeters in the orders Lepidoptera and Coleoptera were identified and counted. Insect Capture Rate (number of insects/number of trap nights) was used as a metric to standardize efforts among sampling events within each sampling quarter. No insects in the order

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Coleoptera were observed during the sampling periods, therefore we only report results as they pertain to Lepidoptera > 10 millimeters.

All statistical tests were two-tailed, employed an α value of 0.05, and were conducted in R version 4.05 (R Core Team 2017). Insect Capture Rate for each sampling quarter is characterized by median ($\tilde{x}$) and interquartile range (IQR). General linear models (GLMs) were constructed to test for differences in median Insect Capture Rate among habitats, sampling periods and the interaction between habitat and sampling period. The response variables were normalized using an Ordered Quantile (ORQ) normalization transformation using the "bestNormalize" package (Peterson and Peterson 2020).

3.0 Results

During the first quarter sampling period (July – August), the median Insect Capture Rate among all habitats was 0.69 (IQR: 0.26 – 1.05; Table 1) and was significantly larger (GLM: F = 2.33, P < 0.020) than the median Insect Capture Rate among all habitats sampled in Quarter 2 ($\tilde{x}$ = 0.12; IQR: 0.09 – 0.15]), Quarter 3 ($\tilde{x}$ = 0.09; IQR: 0.07 – 0.11), and Quarter 4($\tilde{x}$ = 0.13; IQR: 0.12 – 0.16)(Table 1; Figure 1). Median Insect Capture Rate was significantly greater at the pasture habitat when pooled for entire year (GLM: F = 2.01, P < 0.045). Within each quarter, median Insect Capture Rate at the pasture habitat was not significantly different from the median insect activity collected at the pond and hedgerow habitats (GLM; Quarter 1: t = 1.49, P = 0.234; Quarter 2: t = 2.07, P > 0.083; Quarter 3: t = 2.97, P > 0.068; Quarter 4: t = 1.309, P = 0.321; Figure 2).

Table 1. Median Insect Capture Rate and IQR During Each Sampling Quarter

Sampling Period	Sampling Location	Median Insect Capture Rate for Lepidoptera > 10 Millimeters	IQR
Quarter 1 (1 July – 31 August)	Pond	0.64	0.38 – 089
	Pasture	1.38	1.08 – 1.69
	Hedgerow	0.37	0.26 – 0.49
	All sites	0.69	0.26 – 1.05
Quarter 2 (1 September – 12 December)	Pond	0.10	0.07 – 0.12
	Pasture	0.41	0.27 – 0.42
	Hedgerow	0.09	0.07 – 0.12
	All sites	0.12	0.09 – 0.15
Quarter 3 (13 December – 11 March)	Pond	0.13	0.12 – 0.13
	Pasture	0.09	0.09 – 0.09
	Hedgerow	0.04	0.03 – 0.04
	All sites	0.09	0.07 – 0.11

Sampling Period	Sampling Location	Median Insect Capture Rate for Lepidoptera > 10 Millimeters	IQR
Quarter 4 (12 March – 30 June)	Pond	0.13	0.12 – 0.13
	Pasture	0.20	0.20 – 0.20
	Hedgerow	0.10	0.06 – 0.13
	All sites	0.13	0.12 – 0.16

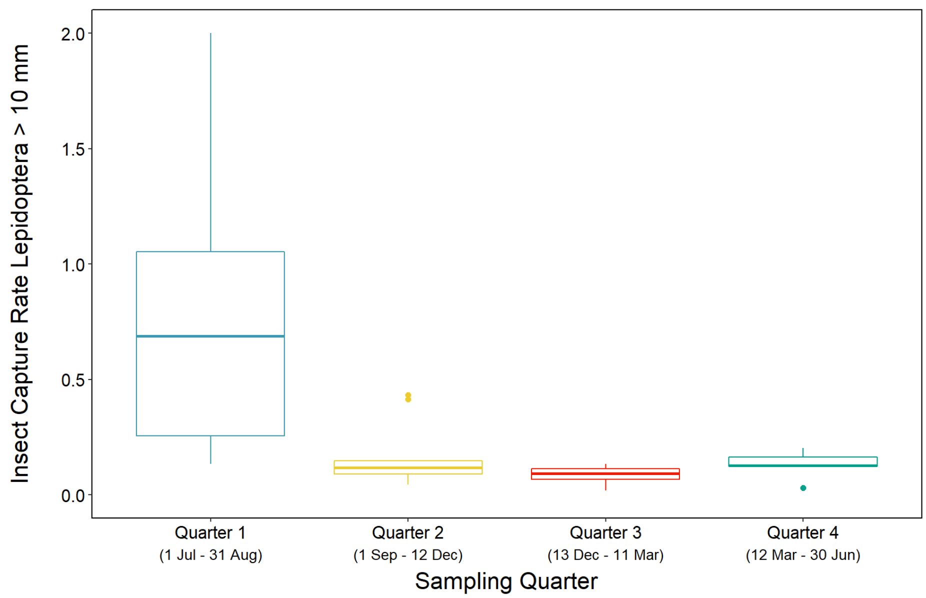

Figure 1. Box-Plot with Median, Lower (Q1) and Upper (Q3) Quartiles, and Whiskers (IQR*1.5) for Insect Capture Rate During Each Quarter Among All Pooled Sites

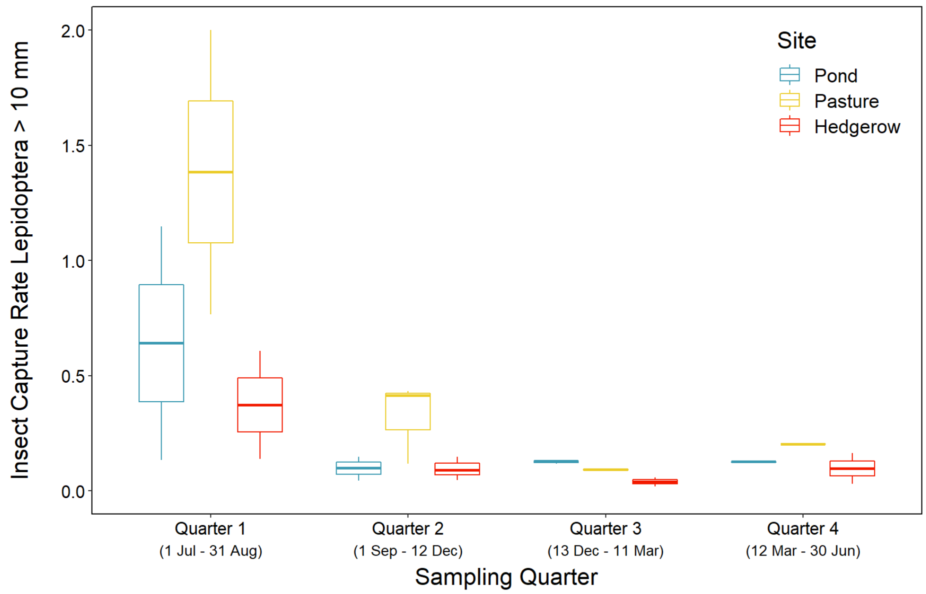

Figure 2. Box-Plot with Median, Lower (Q1) and Upper (Q3) Quartiles, and Whiskers (IQR*1.5) for Insect Capture Rate at the Three Habitats During Each Sampling Quarter

4.0 Future Work

Beginning in 2022, insect sampling is scheduled to continue twice per year. Results from future sampling years will be compared to the baseline values established during the FY 2021 sampling year to inform adaptive mitigation measures, if required.

5.0 References

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Attachment 8

Tier 4 Bat Mitigation Monitoring: 2-Year Baseline Monitoring Summary for February 2020–March 2022

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WEST Inc.
ENVIRONMENTAL & STATISTICAL CONSULTANTS
2725 NW Woodland Blvd, Corvallis, OR 97330
Phone: 307-214-2799 ◆ www.west-inc.com ◆ Fax: 307-637-6981

TECHNICAL MEMORANDUM

Date: September 16, 2022

To: George Akau – Auwahi Wind

From: Joel Thompson and Kristina Hammond-Rendon–WEST, Inc.

Subject: Tier 4 Bat Mitigation Monitoring: 2-Year Baseline Monitoring Summary for February 2020–March 2022

INTRODUCTION

Auwahi Wind Energy LLC (Auwahi Wind) established a Tier 4 Mitigation Site (Mitigation Site) to mitigate the take of Hawaiian hoary bat (HAHOBA) at their Auwahi Wind Energy Facility. Within the Mitigation Site, Auwahi Wind is implementing management actions to improve habitat conditions for HAHOBA and will monitor bat activity within the Mitigation Site over a period of 12 years to assess the success of the management activities. Consistent with the monitoring timeline presented in Auwahi Wind's Habitat Conservation Plan (HCP; Tetra Tech 2019), baseline monitoring was considered Year 0, with successive years of monitoring spanning Years 1–11. The primary goal of the monitoring is to document changes in HAHOBA activity over time in order to assess the impact of management actions on bat activity within the Mitigation Site.

In spring 2020, Auwahi Wind deployed acoustic bat detectors to begin baseline (Year 0) monitoring of HAHOBA activity in and adjacent the Mitigation Site (Figure 1). Auwahi Wind provided all acoustic monitoring equipment and associated accessories (e.g., microphones, solar panels, and batteries). Auwahi Wind staff are responsible for managing all aspects of the field study, including the ongoing maintenance of the detectors and swapping of data cards.

Once collected in the field, Auwahi Wind staff provided the raw data for QAQC and analysis by Western EcoSystems Technology, Inc. (WEST). This Technical Memorandum (Memo) provides a summary of the cumulative acoustic monitoring dataset spanning the first two years (Year 0 and Year 1) of acoustic monitoring at the Mitigation Site, from February 2020–March 2022.

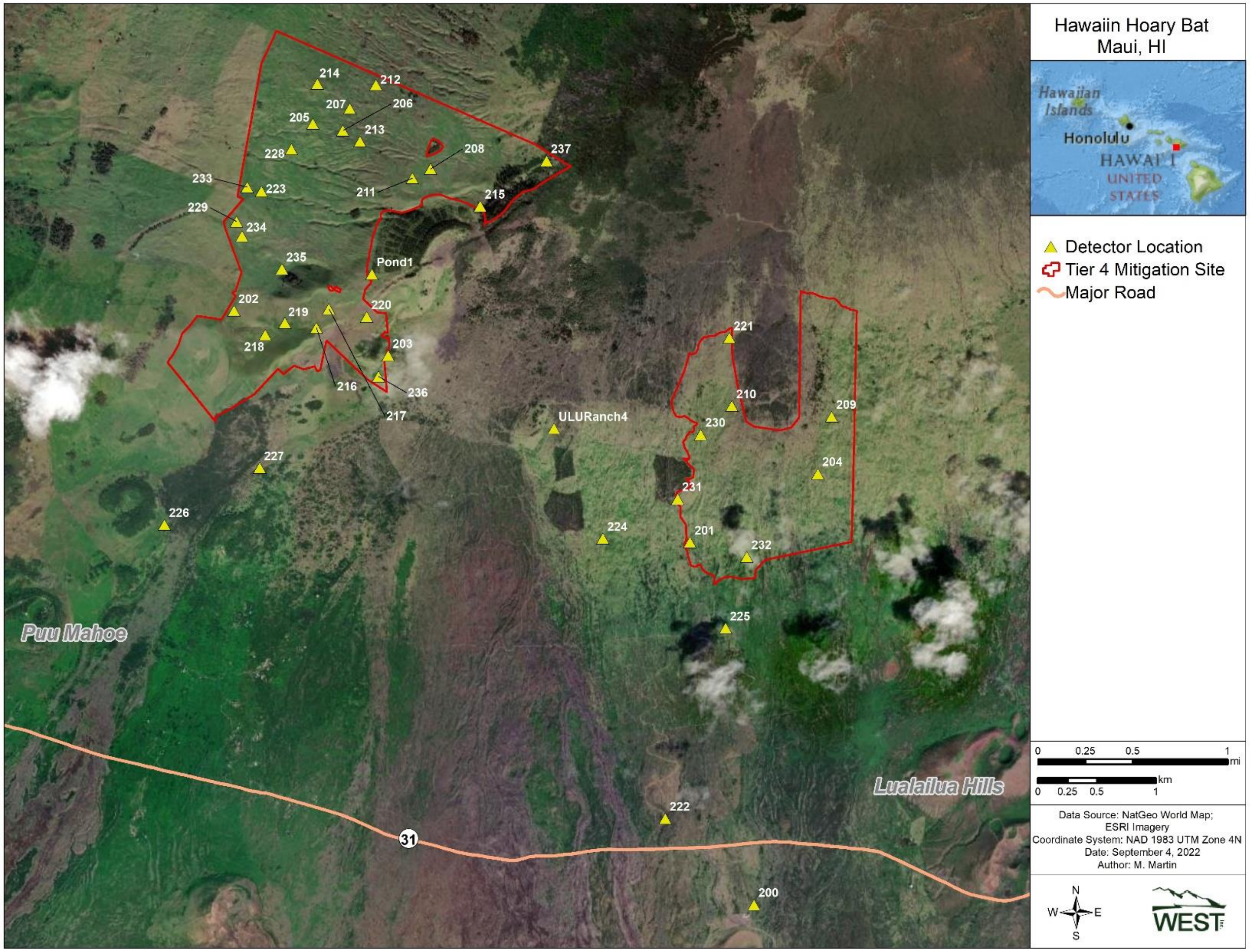

Figure 1. Overview of the Auwahi Wind Tier 4 Hawaiian hoary bat mitigation site and acoustic bat detector locations, Maui, Hawaii.

METHODS

Thirty-eight Wildlife Acoustics SM4Bat full spectrum bat detectors (Wildlife Acoustics, Maynard, Massachusetts) were deployed across the Mitigation Site in spring 2020. In fall 2021, two additional acoustic detectors (Pond1 and ULURanch4) were added to the monitoring effort (Figure 1); however, data collected at ULURanch4 was compromised due to apparent equipment issues and therefore not included in the analysis of Year 1 metrics reported on herein. Sampling locations throughout the Mitigation Site were selected using a spatially balanced (Generalized Random Tessellation Sampling; Stevens and Olsen [2004]) design based on a grid of 100 x 100 meter grid cells. Within selected grid cells, there was leeway to place detectors according to the habitat subtype requirements of Auwahi Wind's HCP (Tetra Tech 2019). Thirty detectors were subset into three habitat subtypes for future management activities within the Mitigation Site: pasture, hedgerow, and water trough/pond. Eight additional detectors were placed outside of the Mitigation Site and spread among similar habitat features (i.e., pasture, trough, and hedgerow). These eight locations are meant to serve as controls when conducting analyses to assess increasing trends in bat activity within the Mitigation Site following mitigation activities, although it is not known how distant from the Mitigation Site the impacts on bat acoustic activity may be observed. The two detectors added in fall 2021 were located near a trough (ULURanch4) located outside the Mitigation Site, and at a newly created pond (Pond1) located within the Mitigation Site;

A baseline habitat condition was identified for each detector station. The baseline (i.e., Year 0) conditions for the 30 initial sampling stations within the Mitigation site included 20 pasture and 10 trough/pond locations (nine trough and one pond; Table 1). As mitigation activities are completed and hedgerows and ponds are installed, it is anticipated that pasture stations located within 100 meters of installed features will transition to hedgerow or pond stations during future analyses. The nine detectors located outside the Mitigation Site include two trough, two hedgerow, and five pasture locations (Table 1). The Pond1 detector was added in fall 2021 at a newly created pond site that was not sampled prior to pond development. Additional details on the sampling design and mitigation requirements can be found in Auwahi Wind's amended HCP (Tetra Tech 2019).

Acoustic data from the acoustic bat detectors was collected by Auwahi Wind staff and transferred to WEST. Once downloaded and verified for completeness, WEST completed a quality check of the summary and acoustic files to ensure detectors and microphones were functioning properly. Full spectrum data were then processed and converted to zero-cross data using the software package Kaleidoscope Pro (version 5.1.0; Wildlife Acoustics), reducing the overall file sizes for storage and further analysis. During the conversion process, Kaleidoscope filtered zero-cross files suspected to be noise into a folder separate from the other zero-cross files. Once converted and filtered, all zero-cross files, including suspect noise files, were reviewed as digital sonograms and labeled by a bat biologist using program Analook (Titley Scientific). This process was used to confirm the presence of sufficient echolocation pulses (a minimum of two) to qualify as a bat call, consistency with the call parameters of HAHOBA (both call frequency and pattern), and to classify the call type (i.e., searching/location calls or feeding buzzes). Data handling procedures were consistent with those used by WEST for other acoustic studies conducted in Hawaii (e.g., Oahu and Leeward Haleakala occupancy studies; Thompson and Starcevich 2021a, 2021b) to ensure consistent organization and comparability of data across studies.

Once all call files were reviewed and bat presence verified, the call data were used to calculate the bat use metrics requested by Auwahi Wind:

1. **Call abundance** = total bat calls / total active detector-nights; and
2. **Call nightly detection** = total nights with bat calls / total active detector-nights.

A second set of metrics was generated based on feeding buzzes only:

1. **Feeding buzz abundance** = total feeding buzzes / total active detector-nights; and
2. **Feeding buzz nightly detection** = total nights with feeding buzzes / total active detector-nights.

A detector-night was defined as one detector operating for one full night.

RESULTS

Cumulative Data (Years 0 and 1 Combined)

All calls

Bat calls were recorded at all 39 detectors used in analyses. For the period February 26–March 30, 2022, the number of detector nights totaled 27,390, and ranged from 168 to 757 among the 39 detectors monitored (Table 1). Among the 39 detectors, the number of bat calls recorded ranged from a low of 572 calls at station AW222 to a high of 117,019 calls at station AW237 (Table 1). Bat call abundance at these same 39 detectors averaged 12.36 calls/detector night across all stations during the survey period, and varied from a low of 0.74 at station AW222 to a high of 156.44 at station AW237 (Table 1; Figure 2). Call nightly detection averaged 0.74 at the 39 stations during the survey period, and varied from a low of 0.34 at detector AW222 to a high of 0.98 at detector AW215 (Table 1). Bat calls were recorded on more than 50% of all detector nights at 38 of the 39 detectors with bat calls and more than 75% of detector nights at 21 of the 39 detectors with bat calls.

Feeding Buzz Calls

Feeding buzzes were recorded at all 39 (100%) detectors; however, 50% of all feeding buzzes were recorded at only two detectors, AW215 and AW237 (Table 2). Feeding buzz abundance averaged 0.04 buzzes/detector night and varied from a low of <0.01 buzzes/detector night detectors to a high of 0.42 at stations AW237 (Table 2). The feeding buzz nightly detection rate was consistently low, averaging 0.03 across all stations (Table 2). With the exception of detectors AW215, AW237, and Pond1, which recorded feeding buzzes on 21%, 16%, and 15% of detector nights, respectively, feeding buzzes were recorded on 5% or fewer detector nights (Table 2).

Table 1. Results of acoustic surveys conducted at monitoring stations associated with Auwahi Wind Energy's tier 4 mitigation monitoring, Maui, Hawaii from February 26, 2020–March 30, 2022. Calls are separated by total number of bat calls, the number of detector-nights bats were detected, total number of detector-nights, call abundance, and nightly detection rate.

Station	Associated Habitat Feature	# of Bat Calls	Detector-Nights with Bat Calls	Total Detector-Nights	Call Abundance[a] (Bat Calls/ Detector-Night)	Nightly Detection (Nights Bats Detected/Total Detector-Nights)
AW200[c]	trough	767	308	717	1.07±0.10	0.43
AW201	pasture	1,701	402	757	2.25±0.11	0.53
AW202	pasture	3,717	471	697	5.33±0.28	0.68
AW203	pasture	3,400	424	618	5.50±0.30	0.69
AW204	pasture	1,915	499	738	2.59±0.13	0.68
AW205	trough	3,868	612	734	5.27±0.24	0.83
AW206	trough	4,427	640	734	6.03±0.25	0.87
AW207	trough	4,298	647	734	5.86±0.24	0.88
AW208	trough	3,792	476	586	6.47±0.36	0.81
AW209	pasture	2,401	598	755	3.18±0.12	0.79
AW210	pasture	2,473	558	736	3.36±0.16	0.76
AW211	pasture	4,137	571	731	5.66±0.25	0.78
AW212	pasture	3,515	605	731	4.81±0.22	0.83
AW213	pasture	4,720	644	731	6.46±0.24	0.88
AW214	pasture	4,138	618	732	5.65±0.24	0.84
AW215	pasture	104,076	698	713	145.97±8.83	0.98
AW216	pasture	6,842	648	715	9.57±0.34	0.91
AW217	pasture	5,435	610	715	7.60±0.35	0.85
AW218	pasture	1,983	345	631	3.14±0.24	0.55
AW219	pasture	1,820	437	713	2.55±0.14	0.61
AW220[c]	pasture	6,769	647	707	9.57±0.37	0.92
AW221[c]	pasture	3,462	625	710	4.88±0.18	0.88
AW222[c]	pasture	527	246	716	0.74±0.05	0.34
AW223	pasture	2,683	523	700	3.83±0.19	0.75
AW224[c]	pasture	1,741	447	703	2.48±0.14	0.64
AW225[c]	pasture	1,300	380	716	1.82±0.12	0.53
AW226[c]	hedgerow	10,481	651	708	14.80±0.55	0.92
AW227[c]	hedgerow	8,669	634	708	12.24±0.55	0.90
AW228	pasture	3,408	519	731	4.66±0.28	0.71
AW229	pasture	2,327	481	731	3.18±0.18	0.66
AW230	pasture	2,175	570	743	2.93±0.12	0.77
AW231	trough	1,584	386	744	2.13±0.13	0.52
AW232	pasture	2,227	505	756	2.95±0.17	0.67
AW233	trough	2,797	416	621	4.50±0.28	0.67
AW234	trough	3,613	543	746	4.84±0.24	0.73
AW235	trough	4,407	552	746	5.91±0.35	0.74
AW236	trough	4,793	607	751	6.38±0.28	0.81
AW237	pond	117,019	712	748	156.44±8.23	0.95
Pond1	pond	1,967	142	168	11.71±1.17	0.85
Total		**351,374**	**20,397**	**27,371**	**12.36±0.49**[b]	**0.75**

[a] estimate ± bootstrapped standard error

[b] average of individual detectors to account for unbalanced design (i.e., differing number of detector nights)

[C] indicates detector location is outside the Tier 4 Mitigation Site

Table 2. Results for feeding buzz detections during acoustic surveys conducted at 40 stations associated with Auwahi Wind Energy's tier 4 mitigation monitoring, Maui, Hawaii from February 26, 2020–March 30, 2022. Calls are separated by number of feeding buzz calls, detector-nights buzz calls were detected, total detector-nights, feeding buzz abundance, and feeding buzz nightly detection rate.

Station	Baseline Habitat Type	# of Feeding Buzzes	Detector-Nights with Feeding Buzz Calls	Total Detector - Nights	Feeding Buzz Abundance[a] (Feeding Buzzes Calls/ Detector-Night)	Feeding Buzz Nightly Detection (Nights Feeding Buzz detected/Total Detector-Nights)
AW200[c]	trough	7	6	717	0.01±0.00	0.01
AW201	pasture	3	3	757	0.00±0.00	0.00
AW202	pasture	4	3	697	0.01±0.00	0.00
AW203	pasture	9	9	618	0.01±0.00	0.01
AW204	pasture	9	8	738	0.01±0.00	0.01
AW205	trough	16	16	734	0.02±0.01	0.02
AW206	trough	18	18	734	0.02±0.01	0.02
AW207	trough	19	15	734	0.03±0.01	0.02
AW208	trough	19	16	586	0.03±0.01	0.03
AW209	pasture	17	17	755	0.02±0.01	0.02
AW210	pasture	19	17	736	0.03±0.01	0.02
AW211	pasture	9	8	731	0.01±0.00	0.01
AW212	pasture	7	7	731	0.01±0.00	0.01
AW213	pasture	12	11	731	0.02±0.01	0.02
AW214	pasture	13	12	732	0.02±0.01	0.02
AW215	pasture	193	116	713	0.27±0.03	0.16
AW216	pasture	31	27	715	0.04±0.01	0.04
AW217	pasture	21	20	715	0.03±0.01	0.03
AW218	pasture	7	7	631	0.01±0.00	0.01
AW219	pasture	3	3	713	0.00±0.00	0.00
AW220[c]	pasture	42	36	707	0.06±0.01	0.05
AW221[c]	pasture	13	12	710	0.02±0.01	0.02
AW222[c]	pasture	1	1	716	0.00±0.00	0.00
AW223	pasture	4	3	700	0.01±0.00	0.00
AW224[c]	pasture	6	6	703	0.01±0.00	0.01
AW225[c]	pasture	6	6	716	0.01±0.00	0.01
AW226[c]	hedgerow	40	35	708	0.06±0.01	0.05
AW227[c]	hedgerow	30	26	708	0.04±0.01	0.04
AW228	pasture	10	9	731	0.01±0.00	0.01
AW229	pasture	1	1	731	0.00±0.00	0.00
AW230	pasture	9	8	743	0.01±0.00	0.01
AW231	trough	5	5	744	0.01±0.00	0.01
AW232	pasture	6	6	756	0.01±0.00	0.01
AW233	trough	5	4	621	0.01±0.00	0.01
AW234	trough	9	9	746	0.01±0.00	0.01
AW235	trough	15	15	746	0.02±0.00	0.02
AW236	trough	17	17	751	0.02±0.01	0.02
AW237	pond	316	160	748	0.42±0.04	0.21
Pond1		52	26	168	0.31±0.11	0.15
Total		**1,023**	**724**	**27,371**	**0.04±0.00**[b]	**0.03**

[a] estimate ± bootstrapped standard error
[b] average of abundance estimates for individual detectors to account for unbalanced design (i.e., differing number of detector nights)
[C] indicates detector location is outside the Tier 4 Mitigation Site

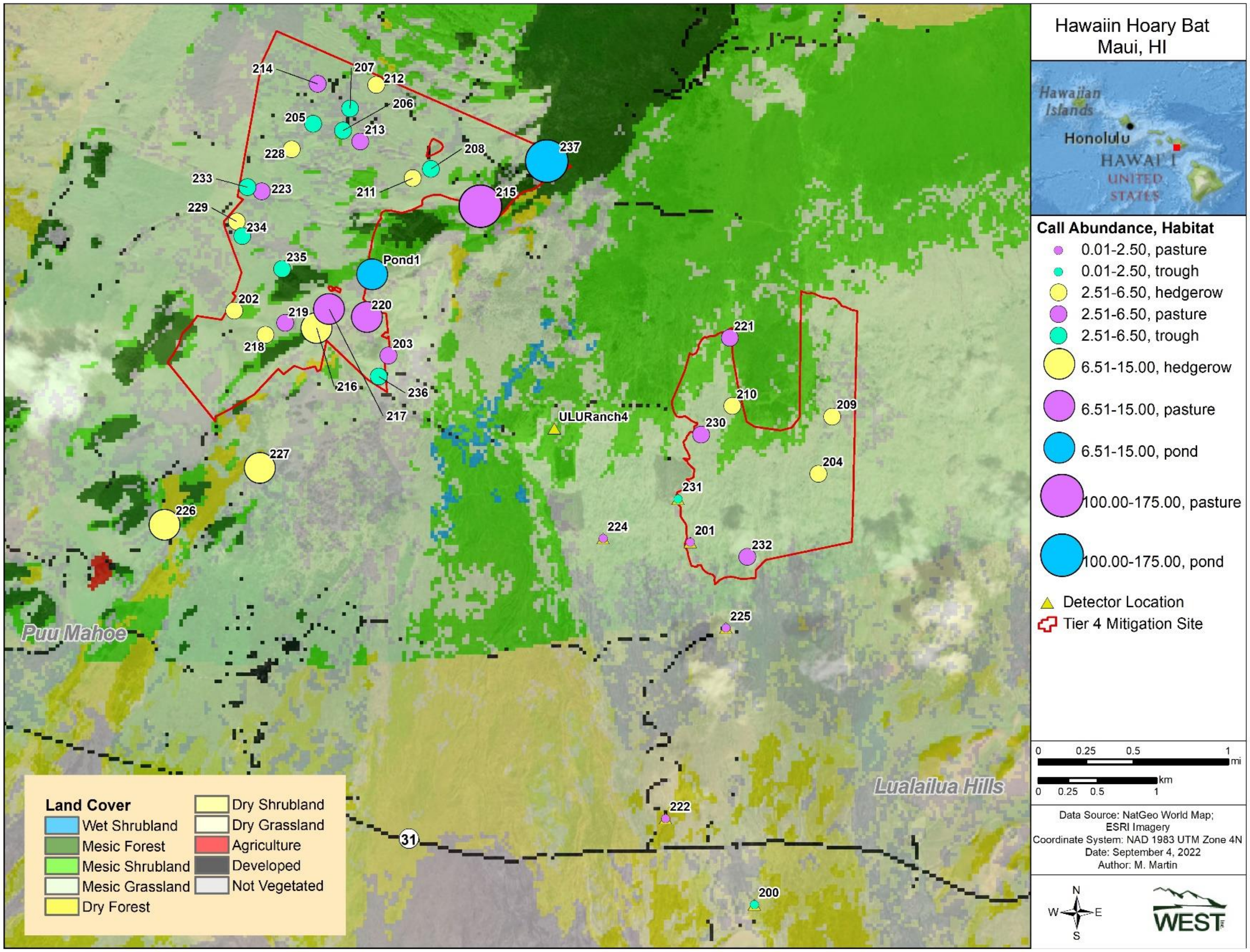

Figure 2. Call abundance by habitat feature type at Auwahi Wind's Tier 4 Hawaiian hoary bat mitigation site for the period February 26, 2020–March 30, 2022.

Annual Data

All Bat Calls

Bat calls were recorded at all detectors in both years (Appendix A1 and A2) of the study. For Year 0 (February 26, 2020–March 31, 2021), the number of detector nights sampled totaled 14,327 and the number of bat calls recorded totaled 158,054, for an overall average call abundance of 10.90 bat calls/detector night (Appendix A1). Bat call abundance varied from a low of 0.81 at station AW222 to a high of 152.86 at station AW237 (Appendix A1). Call nightly detection averaged 0.76 at the 38 stations during the survey period, and varied from a low of 0.39 at detector AW222 to a high of 0.97 at detector AW215 (Appendix A1). Bat calls were recorded on more than 50% of all detector nights at 35 of the 38 detectors and more than 75% of detector nights at 20 of the 38 detectors.

For Year 1 (April 1, 2021–March 30, 2022), the number of detector nights sampled totaled 9,536 and the number of bat calls recorded totaled 193,320, for an overall average call abundance of 14.57 bat calls/detector night (Appendix A2). Bat call abundance varied from a low of 0.66 at station AW222 to a high of 192.13 at station AW215 (Appendix A2). Call nightly detection averaged 0.73 at the 39 stations evaluated during the survey period, and varied from a low of 0.30 at detector AW222 to a high of 0.99 at detector AW215 (Appendix A2). Bat calls were recorded on more than 50% of all detector nights at 32 of the 39 detectors and more than 75% of detector nights at 20 of the 38 detectors (Appendix A2).

Feeding Buzz Calls

In Year 0, feeding buzzes were recorded at 25 of 38 (66%) detectors; however, 65% of all feeding buzzes were recorded at only two stations, AW215 and AW237 (Appendix B1). Feeding buzz abundance averaged 0.02 buzzes/detector night and varied from a low of zero at several detectors to a high of 0.22 at AW237 (Appendix B1). The feeding buzz nightly detection rate was consistently low, averaging 0.01 across all stations (Appendix B1). With the exception of detectors AW215 and AW237, which recorded feeding buzzes on 12% and 14% of detector nights, respectively, feeding buzzes were only recorded on 3% or fewer detector nights (Appendix B1).

In Year 1, feeding buzzes were recorded at all 39 (100%) detectors monitored; however, 45% of all feeding buzzes were again recorded at only two stations, AW215 and AW237 (Appendix B2). Newly added detector Pond1 accounted for another almost 7% of feeding buzzes Feeding buzzes at Pond1 totaled 52 buzzes over a much shorter sampling period of only 168 detector nights compared to 348 nights each at AW215 and AW237. Feeding buzz abundance averaged 0.06 buzzes/detector night and varied from a low of <0.01 buzzes/detector night at several detectors to a high of 0.65 at station AW237 (Appendix B2). The feeding buzz nightly detection rate in Year 1 was again consistently low, averaging 0.04 across all stations (Appendix B2). With the exception of detectors Pond1, AW215, AW237, which recorded feeding buzzes on 15%, 21%, and 30% of detector nights, respectively, feeding buzzes were recorded on only 8% or fewer detector nights (Appendix B1).

DISCUSSION

Based on the data collected during the monitoring period, HAHOBA were regularly active throughout the Mitigation Site, with bat activity recorded at all 39 functional stations monitored during the 2-year study period. In addition, bat activity was recorded and on most nights (74% of nights on average across all detectors). Only one (AW222) out of 39 detectors averaged less than one call per detector night during the cumulative study period, while 90% averaged more than two calls per detector night.

Relative to the baseline (Year 0) survey results, call abundance estimates appeared generally consistent with or slightly elevated at most stations in Year 1 (Figure 3), with an overall mean call abundance up from 10.9 in Year 0 to 14.6 in Year 1 (Figure 4). Detectors AW237 and Pond1 are the only detectors located in close proximity to ponds. Detector AW237 had the highest feeding buzz abundance rate in both Year 0 and Year 1 (0.22 and 0.65 buzzes/detector night, respectively), while Pond1 had the third highest feeding buzz abundance rate in Year 1 (0.31), its first year of monitoring (Appendix B). Detector AW237 also had the highest overall call abundance rate (152.86 calls/detector night) in Year 0 and the second highest overall abundance rate in Year 1 (160.55), while Pond1 ranked 5th in overall call abundance (11.71), substantially lower than that at AW237 (Figure 4; Appendix A).

While AW237 was located in close proximity to a pond, it was also among the highest elevation sites and was located in a small opening within the largest area of mesic forest land cover within or adjacent the Mitigation Site (Figure 2). The higher elevation and proximity to the larger mesic forest patch are two characteristics also shared with detector AW215, which exhibited the second highest activity rate (145.97 calls/detector night) over the full monitoring period, and the highest rate (192.13) in Year 1. This pattern of activity was consistent with that recorded in the Leeward Haleakala occupancy study conducted in 2019–2020 immediately east of the Mitigation Site (Thompson and Starcevich 2021b), which also found higher activity rates at upper elevation sites associated with mesic land cover types. The USGS study conducted in the Waihou Mitigation Area from 2015–2018 (Pinzari et al. 2019) also documented substantially higher activity rates (based on mean monthly detection rate) at their two upper most sample sites, which were located in roughly the same areas as AW215 and AW237. The Pond1 detector is also located at upper elevations within the Mitigation Site, although still at least 1,000 ft lower than detectors AW215 and AW237. While feeding buzz rates at the two pond sites (AW237 and Pond1) were among the highest of all detectors in this dataset, ongoing monitoring will provide additional data to better evaluate activity rates at ponds located at different elevational gradients and in differing land cover types. Additional monitoring will also allow for assessing changes in activity rates at ponds over time, as they mature and show increased aquatic vegetation growth and a likely commensurate increase in insect activity.

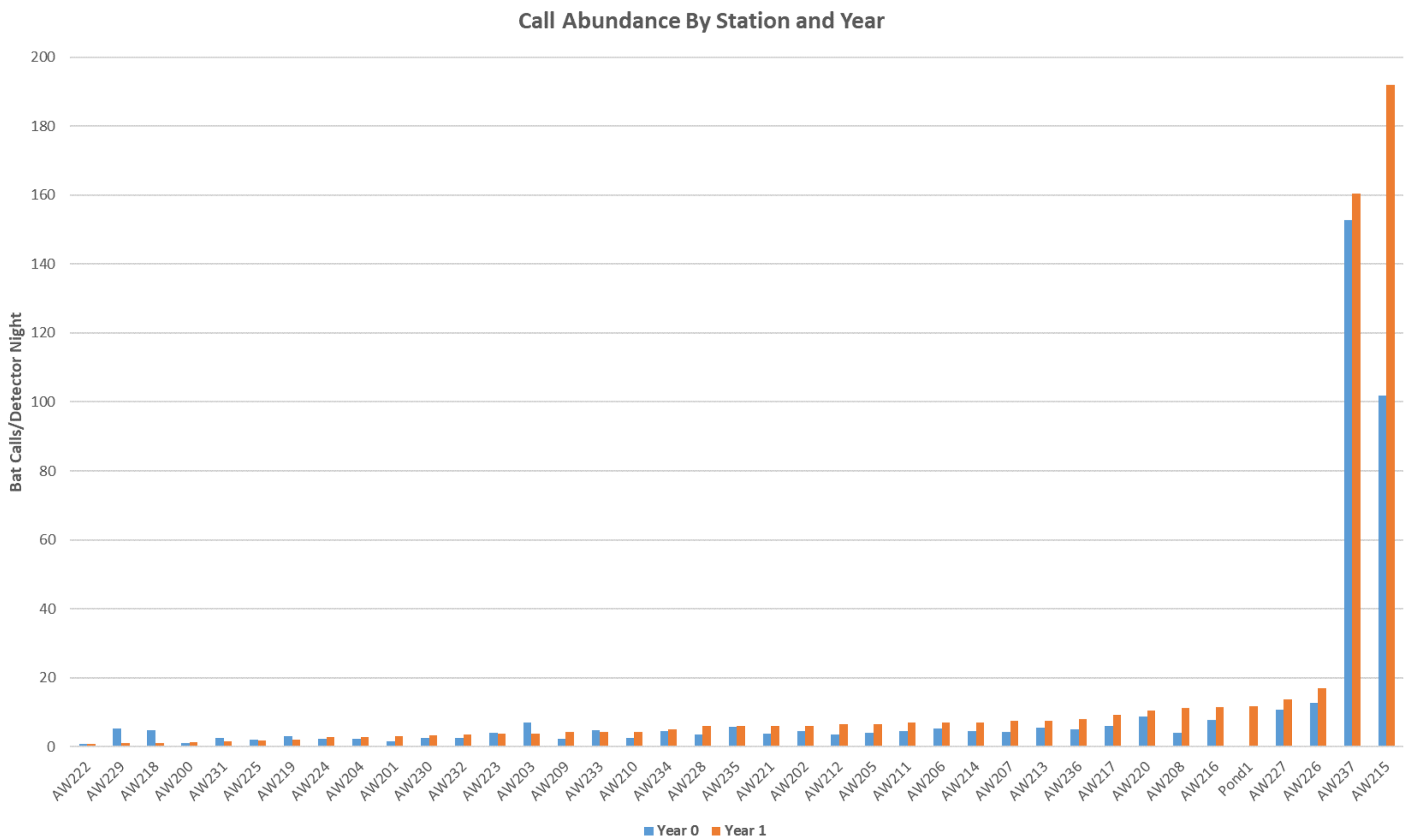

Figure 3. Call abundance (bat calls/detector night) by station and year based on acoustic surveys conducted at 39 sampling stations associated with Auwahi Wind Energy's tier 4 mitigation monitoring, Maui, Hawaii from February 26, 2020–March 30, 2022. Year 0 spans February 26, 2020–March 31, 2021, and Year 1 spanned April 30, 2021–March 30, 2022.

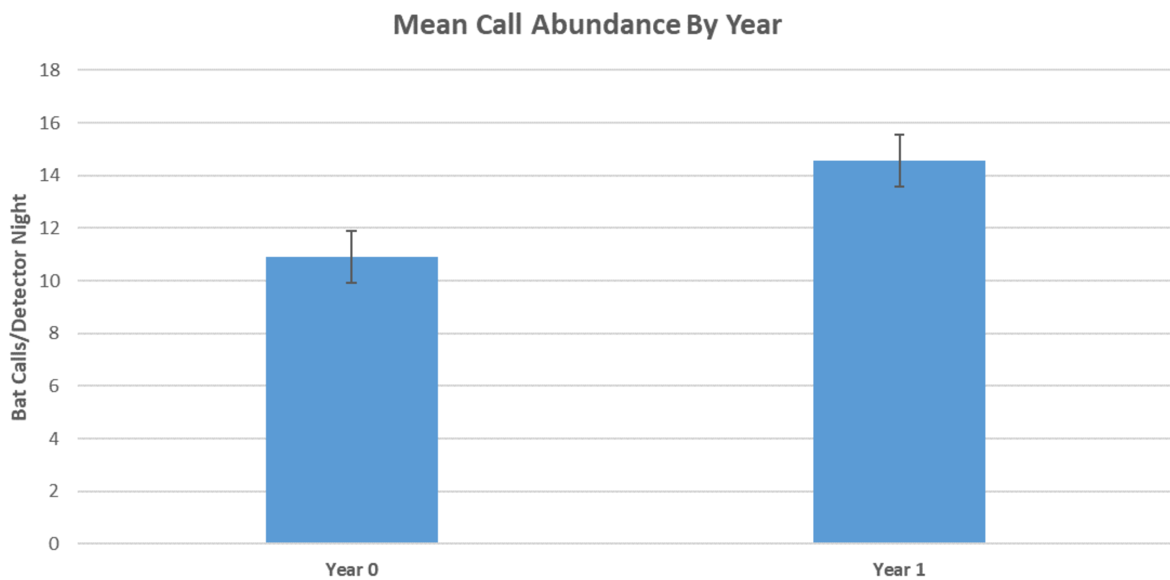

Figure 4. Mean call abundance (bat calls/detector night) for all stations combined by year based on acoustic surveys conducted at 39 sampling stations associated with Auwahi Wind Energy's tier 4 mitigation monitoring, Maui, Hawaii from February 26, 2020–March 30, 2022. Year 0 spans February 26, 2020–March 31, 2021, and Year 1 spanned April 30, 2021–March 30, 2022.

Overall call abundance and feeding buzz activity rates during the second-year of monitoring (Year 1) were generally consistent with or slightly elevated, on average, relative to the baseline year (Year 0) monitoring. Additionally, with the exception of detectors AW215 and AW237, activity rates in and around the Mitigation Site were also generally consistent with the activity rates measured in the Leeward Haleakala study at similar elevations (approximately 2–18 bat calls/detector night; Thompson and Starcevich 2021b).

Monitoring of bat activity in and surrounding the Mitigation Site is planned for the another 10 years Years 2-11) as mitigation activities (e.g., hedgerow plantings, water source installations) continue to be implemented. The goal of the ongoing monitoring is to quantify bat activity rates both spatially and temporally relative to the mitigation activities, and ideally provide a robust means of determining mitigation success (i.e., did the mitigation actions increase bat abundance/use, as measured by bat activity rates within the Mitigation Site relative to areas outside the Mitigation Site). While data are limited at this point, given only one of year of post-baseline data collection, the initial indication is that bat activity rates associated with the Mitigation Site increased slightly from Year 0 to Year 1 (see Figures 3 and 4). However, additional collected in future years will provide a more robust dataset for evaluating trends in activity over time.

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Appendix A: Hawaiian Hoary Bat Call Abundance and Call Nightly Detection by Year for 39 Acoustic Monitoring Stations Associated with Auwahi Wind Energy's Tier-4 Mitigation Monitoring, Maui, Hawaii from February 26, 2020–March 30, 2022.

Appendix A1. Results for all bat detections during acoustic surveys conducted at 39 stations associated with Auwahi Wind Energy's tier 4 mitigation monitoring, Maui, Hawaii from February 26, 2020–March 31, 2021 (Year 0).

Station	Associated Habitat Feature	# of Bat Calls	Detector-Nights with Bat Calls	Total Detector-Nights	Call Abundance[a] (Bat Calls/ Detector-Night)	Nightly Detection (Nights Bats Detected/Total Detector-Nights)
AW200[c]	trough	329	152	353	0.93± 0.08	0.43
AW201	pasture	617	189	393	1.57± 0.12	0.48
AW202	pasture	1,613	252	350	4.61± 0.35	0.72
AW203	pasture	2,315	281	336	6.89± 0.40	0.84
AW204	pasture	918	279	391	2.35± 0.14	0.71
AW205	trough	1,585	320	387	4.10± 0.23	0.83
AW206	trough	2,010	335	387	5.19± 0.32	0.87
AW207	trough	1,689	337	387	4.36± 0.24	0.87
AW208	trough	1,527	287	386	3.96± 0.27	0.74
AW209	pasture	886	287	391	2.27± 0.13	0.73
AW210	pasture	967	277	385	2.51± 0.16	0.72
AW211	pasture	1,750	334	384	4.56± 0.23	0.87
AW212	pasture	1,302	306	384	3.39± 0.23	0.80
AW213	pasture	2,107	337	384	5.49± 0.30	0.88
AW214	pasture	1,697	314	385	4.41± 0.23	0.82
AW215	pasture	37,215	354	365	101.96± 8.14	0.97
AW216	pasture	2,823	329	367	7.69± 0.45	0.90
AW217	pasture	2,222	301	367	6.05± 0.39	0.82
AW218	pasture	1,713	240	366	4.68± 0.35	0.66
AW219	pasture	1,108	227	365	3.04± 0.24	0.62
AW220[c]	pasture	3,155	325	359	8.79± 0.43	0.91
AW221[c]	pasture	1,344	305	359	3.74± 0.21	0.85
AW222[c]	pasture	285	138	352	0.81± 0.08	0.39
AW223	pasture	1,513	294	384	3.94± 0.25	0.77
AW224[c]	pasture	810	227	352	2.30± 0.17	0.64
AW225[c]	pasture	674	199	352	1.91± 0.20	0.57
AW226[c]	hedgerow	4,538	339	357	12.71± 0.72	0.95
AW227[c]	hedgerow	3,859	330	357	10.81± 0.57	0.92
AW228	pasture	1,349	268	384	3.51± 0.22	0.70
AW229	pasture	1,976	313	384	5.15± 0.28	0.82
AW230	pasture	994	281	392	2.54± 0.16	0.72
AW231	trough	1,011	255	393	2.57± 0.19	0.65
AW232	pasture	943	251	392	2.41± 0.18	0.64
AW233	trough	1,873	319	399	4.69± 0.29	0.80
AW234	trough	1,843	289	399	4.62± 0.31	0.72
AW235	trough	2,329	292	399	5.84± 0.51	0.73
AW236	trough	2,019	321	400	5.05± 0.31	0.80
AW237	pond	61,146	377	400	152.86±10.95	0.94
Pond1	pond	NA	NA	NA	NA	NA
Total		**158,054**	**10,861**	**14,327**	**10.90± 0.58**	**0.76**

[a] estimate ± bootstrapped standard error
[b] average of individual detectors to account for unbalanced design (i.e., differing number of detector nights)
[c] indicates detector location is outside the Tier 4 Mitigation Site

Appendix A2. Results for all bat detections during acoustic surveys conducted at 39 stations associated with Auwahi Wind Energy's tier 4 mitigation monitoring, Maui, Hawaii from April 1, 2021–March 31, 2022 (Year 1).

Station	Associated Habitat Feature	# of Bat Calls	Detector-Nights with Bat Calls	Total Detector-Nights	Call Abundance[a] (Bat Calls/ Detector-Night)	Nightly Detection (Nights Bats Detected/Total Detector-Nights)
AW200[c]	trough	438	156	364	1.20± 0.18	0.43
AW201	pasture	1,084	213	364	2.98± 0.21	0.59
AW202	pasture	2,104	219	347	6.06± 0.47	0.63
AW203	pasture	1,085	143	282	3.85± 0.40	0.51
AW204	pasture	997	220	347	2.87± 0.21	0.63
AW205	trough	2,283	292	347	6.58± 0.47	0.84
AW206	trough	2,417	305	347	6.97± 0.39	0.88
AW207	trough	2,609	310	347	7.52± 0.41	0.89
AW208	trough	2,265	189	200	11.32± 0.88	0.95
AW209	pasture	1,515	311	364	4.16± 0.20	0.85
AW210	pasture	1,506	281	351	4.29± 0.27	0.80
AW211	pasture	2,387	237	347	6.88± 0.43	0.68
AW212	pasture	2,213	299	347	6.38± 0.37	0.86
AW213	pasture	2,613	307	347	7.53± 0.37	0.88
AW214	pasture	2,441	304	347	7.03± 0.41	0.88
AW215	pasture	66,861	344	348	192.13±15.00	0.99
AW216	pasture	4,019	319	348	11.55± 0.58	0.92
AW217	pasture	3,213	309	348	9.23± 0.49	0.89
AW218	pasture	270	105	265	1.02± 0.10	0.40
AW219	pasture	712	210	348	2.05± 0.15	0.60
AW220[c]	pasture	3,614	322	348	10.39± 0.56	0.93
AW221[c]	pasture	2,118	320	351	6.03± 0.28	0.91
AW222[c]	pasture	242	108	364	0.66± 0.07	0.30
AW223	pasture	1,170	229	316	3.70± 0.30	0.72
AW224[c]	pasture	931	220	351	2.65± 0.20	0.63
AW225[c]	pasture	626	181	364	1.72± 0.16	0.50
AW226[c]	hedgerow	5,943	312	351	16.93± 0.99	0.89
AW227[c]	hedgerow	4,810	304	351	13.70± 0.85	0.87
AW228	pasture	2,059	251	347	5.93± 0.50	0.72
AW229	pasture	351	168	347	1.01± 0.08	0.48
AW230	pasture	1,181	289	351	3.36± 0.18	0.82
AW231	trough	573	131	351	1.63± 0.15	0.37
AW232	pasture	1,284	254	364	3.53± 0.34	0.70
AW233	trough	924	97	222	4.16± 0.58	0.44
AW234	trough	1,770	254	347	5.10± 0.38	0.73
AW235	trough	2,078	260	347	5.99± 0.44	0.75
AW236	trough	2,774	286	351	7.90± 0.41	0.81
AW237	pond	55,873	335	348	160.55±11.86	0.96
Pond1	pond	1,967	142	168	11.71± 1.20	0.85
Total		**193,320**	**9,536**	**13,044**	**14.57± 0.85**	**0.73**

[a] estimate ± bootstrapped standard error
[b] average of individual detectors to account for unbalanced design (i.e., differing number of detector nights)
[c] indicates detector location is outside the Tier 4 Mitigation Site

Appendix B: Hawaiian Hoary Bat Feeding Buzz Abundance and Feeding Buzz Nightly Detection by Year for 39 Acoustic Monitoring Stations Associated with Auwahi Wind Energy's Tier-4 Mitigation Monitoring, Maui, Hawaii from February 26, 2020–March 30, 2022.

Appendix B1. Results for feeding buzz detections during acoustic surveys conducted at 39 stations associated with Auwahi Wind Energy's tier 4 mitigation monitoring, Maui, Hawaii from February 26, 2020–March 31, 2021 (Year 0).

Station	Associated Habitat Feature	# of Bat Calls	Detector-Nights with Bat Calls	Total Detector-Nights	Call Abundance[a] (Bat Calls/ Detector-Night)	Nightly Detection (Nights Bats Detected/Total Detector-Nights)
AW200[c]	trough	0	0	353	0.00±0.00	0.00
AW201	pasture	0	0	393	0.00±0.00	0.00
AW202	pasture	0	0	350	0.00±0.00	0.00
AW203	pasture	4	4	336	0.01±0.01	0.01
AW204	pasture	1	1	391	0.00±0.00	0.00
AW205	trough	2	2	387	0.01±0.00	0.01
AW206	trough	3	3	387	0.01±0.00	0.01
AW207	trough	2	2	387	0.01±0.00	0.01
AW208	trough	7	7	386	0.02±0.01	0.02
AW209	pasture	6	6	391	0.02±0.01	0.02
AW210	pasture	1	1	385	0.00±0.00	0.00
AW211	pasture	1	1	384	0.00±0.00	0.00
AW212	pasture	0	0	384	0.00±0.00	0.00
AW213	pasture	1	1	384	0.00±0.00	0.00
AW214	pasture	0	0	385	0.00±0.00	0.00
AW215	pasture	65	43	365	0.18±0.03	0.12
AW216	pasture	2	2	367	0.01±0.00	0.01
AW217	pasture	6	6	367	0.02±0.01	0.02
AW218	pasture	6	6	366	0.02±0.01	0.02
AW219	pasture	1	1	365	0.00±0.00	0.00
AW220[c]	pasture	10	10	359	0.03±0.01	0.03
AW221[c]	pasture	1	1	359	0.00±0.00	0.00
AW222[c]	pasture	0	0	352	0.00±0.00	0.00
AW223	pasture	1	1	384	0.00±0.00	0.00
AW224[c]	pasture	0	0	352	0.00±0.00	0.00
AW225[c]	pasture	0	0	352	0.00±0.00	0.00
AW226[c]	hedgerow	6	6	357	0.02±0.01	0.02
AW227[c]	hedgerow	3	3	357	0.01±0.01	0.01
AW228	pasture	0	0	384	0.00±0.00	0.00
AW229	pasture	0	0	384	0.00±0.00	0.00
AW230	pasture	1	1	392	0.00±0.00	0.00
AW231	trough	0	0	393	0.00±0.00	0.00
AW232	pasture	0	0	392	0.00±0.00	0.00
AW233	trough	0	0	399	0.00±0.00	0.00
AW234	trough	3	3	399	0.01±0.00	0.01
AW235	trough	8	8	399	0.02±0.01	0.02
AW236	trough	7	7	400	0.02±0.01	0.02
AW237	pond	89	54	400	0.22±0.04	0.14
Pond1	pond	NA	NA	NA	NaN± NA	NA
Total		**237**	**180**	**14,327**	**0.02±0.00[b]**	**0.01**

[a] estimate ± bootstrapped standard error
[b] average of individual detectors to account for unbalanced design (i.e., differing number of detector nights)
[c] indicates detector location is outside the Tier 4 Mitigation Site

Appendix B2. Results for feeding buzz detections during acoustic surveys conducted at 39 stations associated with Auwahi Wind Energy's tier 4 mitigation monitoring, Maui, Hawaii from April 1, 2021–March 31, 2022 (Year 1).

Station	Associated Habitat Feature	# of Bat Calls	Detector-Nights with Bat Calls	Total Detector-Nights	Call Abundance[a] (Bat Calls/ Detector-Night)	Nightly Detection (Nights Bats Detected/Total Detector-Nights)
AW200[c]	trough	7	6	364	0.02±0.01	0.02
AW201	pasture	3	3	364	0.01±0.00	0.01
AW202	pasture	4	3	347	0.01±0.01	0.01
AW203	pasture	5	5	282	0.02±0.01	0.02
AW204	pasture	8	7	347	0.02±0.01	0.02
AW205	trough	14	14	347	0.04±0.01	0.04
AW206	trough	15	15	347	0.04±0.01	0.04
AW207	trough	17	13	347	0.05±0.02	0.04
AW208	trough	12	9	200	0.06±0.02	0.05
AW209	pasture	11	11	364	0.03±0.01	0.03
AW210	pasture	18	16	351	0.05±0.01	0.05
AW211	pasture	8	7	347	0.02±0.01	0.02
AW212	pasture	7	7	347	0.02±0.01	0.02
AW213	pasture	11	10	347	0.03±0.01	0.03
AW214	pasture	13	12	347	0.04±0.01	0.03
AW215	pasture	128	73	348	0.37±0.05	0.21
AW216	pasture	29	25	348	0.08±0.02	0.07
AW217	pasture	15	14	348	0.04±0.01	0.04
AW218	pasture	1	1	265	0.00±0.00	0.00
AW219	pasture	2	2	348	0.01±0.00	0.01
AW220[c]	pasture	32	26	348	0.09±0.02	0.07
AW221[c]	pasture	12	11	351	0.03±0.01	0.03
AW222[c]	pasture	1	1	364	0.00±0.00	0.00
AW223	pasture	3	2	316	0.01±0.01	0.01
AW224[c]	pasture	6	6	351	0.02±0.01	0.02
AW225[c]	pasture	6	6	364	0.02±0.01	0.02
AW226[c]	hedgerow	34	29	351	0.10±0.02	0.08
AW227[c]	hedgerow	27	23	351	0.08±0.02	0.07
AW228	pasture	10	9	347	0.03±0.01	0.03
AW229	pasture	1	1	347	0.00±0.00	0.00
AW230	pasture	8	7	351	0.02±0.01	0.02
AW231	trough	5	5	351	0.01±0.01	0.01
AW232	pasture	6	6	364	0.02±0.01	0.02
AW233	trough	5	4	222	0.02±0.01	0.02
AW234	trough	6	6	347	0.02±0.01	0.02
AW235	trough	7	7	347	0.02±0.01	0.02
AW236	trough	10	10	351	0.03±0.01	0.03
AW237	pond	227	106	348	0.65±0.08	0.30
Pond1	pond	52	26	168	0.31±0.12	0.15
Total		**786**	**544**	**13,044**	**0.06±0.00[b]**	**0.04**

[a] estimate ± bootstrapped standard error
[b] average of individual detectors to account for unbalanced design (i.e., differing number of detector nights)
[c] indicates detector location is outside the Tier 4 Mitigation Site

Attachment 9

Tier 5 Baseline Bat Activity Monitoring

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Table 1. Results for all bat detections during acoustic surveys conducted at two stations within the Auwahi Wind Energy Project's tier 5 mitigation area, Maui, Hawaii from May 11 – September 17, 2021

Station	# Of Bat Calls	Detector-Nights with Bat Calls	Total Detector-Nights	Call Abundance (Bat Calls/ Detector-Night[1])	Nightly Detection (Nights Bats Detected/Total Detector-Nights[2])
Kam1	6,423	127	129	49.79 ± 5.71	0.98
Kam2	3,620	126	128	28.28 ± 2.75	0.98
Total	**10,043**	**253**	**257**	**39.04 ± 3.81**	**0.98[3]**

Calls are separated by number of all bat calls, detector-nights bats detected, total detector-nights, abundance, and nightly detection.

1. ± bootstrapped standard error.
2. Average of abundance estimates for individual detectors to account for unbalanced design (i.e., differing number of detector-nights).
3. Unweighted estimate (i.e., total calls for all detectors/total detector-nights).

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Attachment 10

FY 2022 Annual Work Plan and Timeline

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<table>
<tr><th colspan="3" rowspan="2"></th><th colspan="6">2022</th><th colspan="6">2023</th></tr>
<tr><th>July</th><th>Aug</th><th>Sept</th><th>October</th><th>November</th><th>December</th><th>January</th><th>February</th><th>March</th><th>April</th><th>May</th><th>June</th></tr>
<tr><td colspan="2" rowspan="4">PCMM</td><td>Fatality Searches</td><td colspan="12">Weekly Canine-Assisted Searches</td></tr>
<tr><td>Searcher Efficiency Trials</td><td colspan="12">Quarterly Trials</td></tr>
<tr><td>Carcass Persistence Trials</td><td colspan="12">Quarterly Trials</td></tr>
<tr><td>Predator Control</td><td colspan="12">Weekly Checks</td></tr>
<tr><td colspan="2" rowspan="4">HAPE</td><td>HAPE Monitoring</td><td colspan="12">Monthly Monitoring</td></tr>
<tr><td>Predator Control
(Trap Checks and Maintenance)</td><td colspan="12">Monthly Checks</td></tr>
<tr><td>Predator Assessment
(Game Cameras Only)</td><td colspan="12">Monthly Reviews</td></tr>
<tr><td>Reconyx Game Cameras Remote Monitoring</td><td colspan="12">Monthly Reviews</td></tr>
<tr><td rowspan="13">Bat</td><td>Tier 1</td><td>Vegetation Monitoring and Invasive Species Control</td><td colspan="12">Targeted Weed Control</td></tr>
<tr><td rowspan="3">Tier 1 & 4</td><td>Ungulate Control</td><td colspan="12">Quarterly Fence Inspection</td></tr>
<tr><td>Conservation Easement</td><td colspan="6"></td><td>Submit Annual Report to HILT</td><td colspan="5"></td></tr>
<tr><td>Barbed Wire Removal</td><td colspan="12">Coordinated by Ranch on As Needed Basis</td></tr>
<tr><td rowspan="7">Tier 4</td><td>Fence Construction</td><td colspan="12">Monthly Status Checks</td></tr>
<tr><td>Reforestation</td><td colspan="12">Weekly Koa Outplanting</td></tr>
<tr><td>Ponds</td><td colspan="12">Quarterly Checks</td></tr>
<tr><td>Water Troughs</td><td colspan="12">Quarterly Checks</td></tr>
<tr><td>Accoustic Monitoring</td><td colspan="12">Quarterly Checks</td></tr>
<tr><td>Thermal Camera Study (Pond)</td><td colspan="3">Monthly Checks</td><td colspan="8"></td><td>Report submitted in FY22 HCP annual report</td></tr>
<tr><td>Insect Monitoring</td><td colspan="12">Twice Yearly Checks</td></tr>
<tr><td rowspan="2">Tier 5</td><td>Baseline Acoustic Monitoring of Kamehamenui Forest Reserve</td><td colspan="12">Quarterly Checks</td></tr>
<tr><td>Pond Construction</td><td colspan="10"></td><td colspan="2">Pond Constructed</td></tr>
<tr><td colspan="2">Reporting</td><td>ITP & ITL Conditions</td><td colspan="2"></td><td>Annual HCP Report Submitted</td><td colspan="2"></td><td>HCP FYQ1 Update Submitted</td><td>Incidental Take Summary Tables Submitted</td><td></td><td>Semiannual Progress Report Submitted</td><td></td><td></td><td>HCP FYQ3 Update Submitted</td></tr>
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Attachment 11

FY 2022 Expenditures for HCP Implementation

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	Tier, Ongoing, or One-time	Event	Proposed Costs	Total Costs Incurred to Date (up to June 2021)	Costs Incurred FY 13 (July 1, 2012 - June 30, 2013)	Costs Incurred FY 14 (July 1, 2013 -June 30, 2014)	Costs Incurred FY 15 (July 1, 2014 -June 30, 2015)	Costs Incurred FY 16 (July 1, 2015 -June 30, 2016)	Costs Incurred FY 17 (July 1, 2016 -June 30, 2017)	Costs Incurred FY 18 (July 1, 2017 - June 30, 2018)	Costs Incurred FY 19 (July 1, 2018 - June 30, 2019)	Costs Incurred FY 20 (July 1, 2019 - June 30, 2020)	Costs Incurred FY 21 (July 1, 2020 - June 30, 2021)	Costs Incurred FY 22 (July 1, 2021 - June 30, 2022)
General Measures	Ongoing	Wildlife Education and Incidental Reporting Program	$5,000	$4,667	$3,000	$1,500	$167	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Ongoing	Downed Wildlife Post-Construction Monitoring and Reporting and Mitigation Monitoring	$1,810,000	$1,333,130	$100,000	$185,145	$152,901	$108,727	$96,700	$140,167	$154,185	$176,497	$90,225	$128,583
	Ongoing	*DOFAW Compliance Monitoring (only if needed)	$200,000	$44,758	N/A	N/A	$2,423	N/A	4600	$8,100	$15,600	$7,800	$2,775	$3,460
		Subtotal General Measures	*$2,015,000*	*$1,377,888*	*$100,000*	*$185,145*	*$155,324*	*$108,727*	*$101,300*	*$148,267*	*$169,785*	*$184,297*	*$93,000*	*$132,043*
Hawaiian Hoary Bat	Tier 1	Retrofit fencing and restoration measures at the Waihou Mitigation Project	$522,000	$1,111,589	$314,900	$63,173	$128,410	$149,833	$126,463	$124,852	$137,337	$36,937	$26,238	$3,446
	Tier 1	Acoustic Monitoring onsite	$40,000	$39,827	$5,000	$8,691	$14,663	$11,473	N/A	N/A	N/A	N/A	N/A	N/A
	Tier 2	Telemetry Research	$250,000	$249,999	N/A	$32,726	$8,308	$142,819	$66,146	N/A	N/A	N/A	N/A	N/A
	Tier 3	USGS Expanded Research	$250,000	$503,853	N/A	$32,726	$8,308	$142,819	$234,360	$81,518	$4,122	N/A	N/A	N/A
	Tier 4	Ulupalakua Ranch Conservation Easement and Related Work	$4,013,047	$1,656,188	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$188,161	$881,452	$586,575
	Ongoing	Minimization Adaptive Management	N/A	$223,615	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$223,615	N/A	N/A
		Subtotal Bats	*$5,075,047*	*$3,785,071*	*$319,900*	*$137,316*	*$159,689*	*$446,944*	*$426,969*	*$206,370*	*$141,459*	*$448,713*	*$907,690*	*$590,021*
Hawaiian Petrel	Tier 1	Burrow Monitoring and Predator Control	$550,000	$1,102,004	$214,000	$74,572	$107,743	$56,410	$62,731	$116,885	$187,437	$76,083	$118,037	$88,106
		Subtotal Petrels	*$550,000*	$1,102,004	*$214,000*	*$74,572*	*$107,743*	*$56,410*	*$62,731*	*$116,885*	*$187,437*	*$76,083*	*$118,037*	*$88,106*
Nene	One-Time	Research and Management Funding	$25,000	$25,000	$25,000	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Subtotal Nene	*$25,000*	*$25,000*	*$25,000*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
Backburn's Sphinx Moth	One-Time	Restoration of 6 acres of Dryland Forest	$144,000	$144,000	$144,000	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Subtotal Moth	*$144,000*	*$144,000*	*$144,000*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
		Total HCP-related Expenditures	**$7,809,047**	**$6,433,964**	**$802,900**	**$397,033**	**$422,756**	**$612,081**	**$591,000**	**$471,522**	**$498,681**	**$709,093**	**$1,118,727**	**$810,171**

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