2018 Post-Construction Monitoring Study

Red Pine Wind Energy Facility
Lincoln County, Minnesota

March 18 – November 15, 2018

Prepared for:

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EXECUTIVE SUMMARY

Red Pine Wind Farm, LLC is currently operating the 200-megawatt (MW) Red Pine Wind Project (Project) in Lincoln County, Minnesota. The Project became operational on January 31, 2018 and consists of 100 utility scale Vestas, 2.0 MW V110 (50 turbines) and V100 (50 turbines) wind turbine generators. Each turbine is a 3-bladed, upwind, horizontal axis wind turbine with rotor diameters of 100 meters (m; 328 feet [ft]; V100) and 110 m (361 ft; V110), tubular steel tower, and 80 meters (262 feet) hub height. Red Pine Wind Farm, LLC contracted Western EcoSystems Technology, Inc. (WEST) to complete a post-construction wildlife fatality monitoring study consistent with the goals and objectives of Tier 4 of the US Fish and Wildlife Service *Land-Based Wind Energy Guidelines* and the Minnesota Department Natural Resources' *Avian and Bat Survey Protocols*. This report presents the results of a post-construction fatality monitoring study conducted for the Project from March 2018 to November 2018.

The post-construction bird and bat mortality monitoring studies began on March 18, 2018, and continued through November 15, 2018. The objectives of the monitoring studies were to provide a summary of documented bird and bat fatalities, present estimates of searcher efficiency and carcass persistence, and calculate annual fatality rates at per turbine and per MW levels.

Carcass searches were completed by WEST technicians, trained in proper search techniques, between March 18, 2018 and November 15, 2018. A total of 10 turbines had a search area of 120 m x 120 m (394 ft x 394 ft) cleared of vegetation and centered on the turbine; these cleared plots were searched at a frequency of four times per week. The gravel roads and pads at the remaining 40 turbines were searched within 60 m (197 ft) of the turbine; these road and pad searches occurred once a week during the study period. Searcher efficiency and carcass persistence trials were conducted throughout the study period using bat, small bird, large bird, and raptor carcasses.

During the study, 79 birds comprising 39 identifiable species were found during scheduled searches. Seven casualties were unidentified small birds or passerines. Three raptors were found during the study: one red-tailed hawk, one sharp-shinned hawk, and one Swainson's hawk. The ruby-crowned kinglet and marsh wren were found most frequently, with nine and eight records, respectively, representing approximately 11.4% and 10.1%, respectively, of the overall composition. The red-eyed vireo and sedge wren each had four records (each approximately 5.1% of the overall composition), and the golden-crowned kinglet was found three times (3.8% of the overall composition). The remaining species were all documented once or twice. No federally listed or state-threatened, endangered, or species of special concern birds were documented during surveys. Eight avian species (19 individuals) listed as Species of Greatest Conservation Need in Minnesota's Wildlife Action Plan 2015 – 2025 were documented: Le Conte's sparrow (two found), marsh wren (eight found), ovenbird (one found), Philadelphia vireo (one found), sedge wren; (four found), Swainson's hawk (one found), swamp sparrow (one found), and Virginia rail (one found).

A total of 168 bat carcasses were found at the Project between May 5 and October 18, 2018; 115 were found on cleared plots, 50 bats were found on road and pads, six of these were found incidentally on search plots but not during a search. Four species of bats were found: hoary bat (63 found, 37.5%), eastern red bat (44 found; 26.2%), silver-haired bat (37 found, 22.0%), and big brown bat (24 found, 14.3%). One special status bat species was documented: the big brown bat is a state species of special concern in Minnesota; no federally or state-listed threatened or endangered bat species were documented during the surveys. Hoary bats and eastern red bats are listed as Species of Greatest Conservation Need in Minnesota's Wildlife Action Plan 2015 – 2025.

STUDY PARTICIPANTS

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REPORT REFERENCE

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INTRODUCTION

Red Pine Wind Farm, LLC is currently operating the 200-megawatt (MW) Red Pine Wind Energy Facility (Project) in Lincoln County, Minnesota (Figure 1). The Project became operational on January 31, 2018 and consists of 100 utility scale Vestas, 2.0 (MW) V110 (50 turbines) and V100 (50 turbines) wind turbine generators with tubular steel towers, and 80 m (262 feet) hub height. Each turbine is a 3-bladed, upwind, horizontal axis wind turbine with rotor diameters of 100 and 110 meters (m; 328 and 361 feet [ft], respectively) and blades measuring 49 m (161 ft; V100) and 54 m (177 ft; V110).

Red Pine Wind Farm, LLC developed an Avian and Bat Protection Plan (ABPP) for the Project, which included a Tier 4 post-construction mortality (PCM) study designed to estimate potential impacts to bird and bat species. As committed to in the ABPP, direct impacts of the Project on bird and bat populations were quantified through PCM monitoring during the first year of operation, and a second year of PCM studies will occur in 2019. The protocol for the second year of surveys will be developed through coordination between Red Pine Wind Farm, LLC, the US Fish and Wildlife Service (USFWS), and the Minnesota Department of Natural Resources (DNR), using the results of this study to inform any changes in methodology.

Bird and bat mortality monitoring studies began on March 18, 2018, and continued through November 15, 2018. The objectives of the monitoring studies were to provide a summary of documented bird and bat fatalities, present estimates of searcher efficiency and carcass persistence, and calculate annual fatality rates per turbine and per MW. This report summarizes the methods and results of the post-construction monitoring conducted by Western EcoSystems Technology, Inc. (WEST) at the Project. This report also provides information on how the estimated fatality rates compare to other wind projects in the state and region.

STUDY AREA

The Project is located approximately 21 kilometers (13 miles) west of Marshall and the project boundary follows the city limits along the east side of Ivanhoe in Lincoln County, Minnesota (Figure 1). The Project is located in the Northern Glaciated Plains Level III Ecoregion, with portions in the Prairie Coteau and Prarie Coteau Escarpment Level IV Ecoregions which is described as higher elevation plateau to slopes from plateau to river basins with perennial streams and riparian vegetation, many lakes, and mix of row crops and some pasture (US Environmental Protection Agency 2007). The Project boundaries encompass approximately 18,078 hectares (ha; 44,672 acres [ac]), with all facilities on private lands. According to the National Land Cover Database (NLCD; US Geological Survey NLCD 2011, Homer et al. 2015), the Project area is dominated by cultivated crops (71.9%), primarily corn (*Zea mays*) and soybean (*Glycine max*) covering 12,989 ha (32,096 ac), followed by grassland/herbaceous cover (10.8%; 1,945 ha [4,807 ac]) and hay/pasture (9.4%; 1,701 ha [4,204 ac]). All other habitats collectively compose less than 8.0 percent of Project (Figure 2, Table 1).

Table 1. Land cover types present within the Red Pine Wind Energy Project.

Land Use/Cover Types	Acres	Hectares	% Composition
Cultivated Crops	32,111	12,995	71.9
Herbaceous	4,809	1,946	10.8
Hay/Pasture	4,206	1,702	9.4
Developed	2,008	812	4.5
Open Water	944	382	2.1
Emergent Wetlands	360	146	0.8
Deciduous Forest	176	71	0.4
Barren Land (Rock/Sand/Clay)	42	17	0.1
Woody Wetlands	16	6	<0.1
Shrub/Scrub	1	<0	<0.1
Total[a]	**44,672**	**18,078**	**100**

Data from the National Land Cover Database (NLCD; US Geological Survey NLCD 2011, Homer et al. 2015).

[a] Sums of values may not add to total value shown due to rounding.

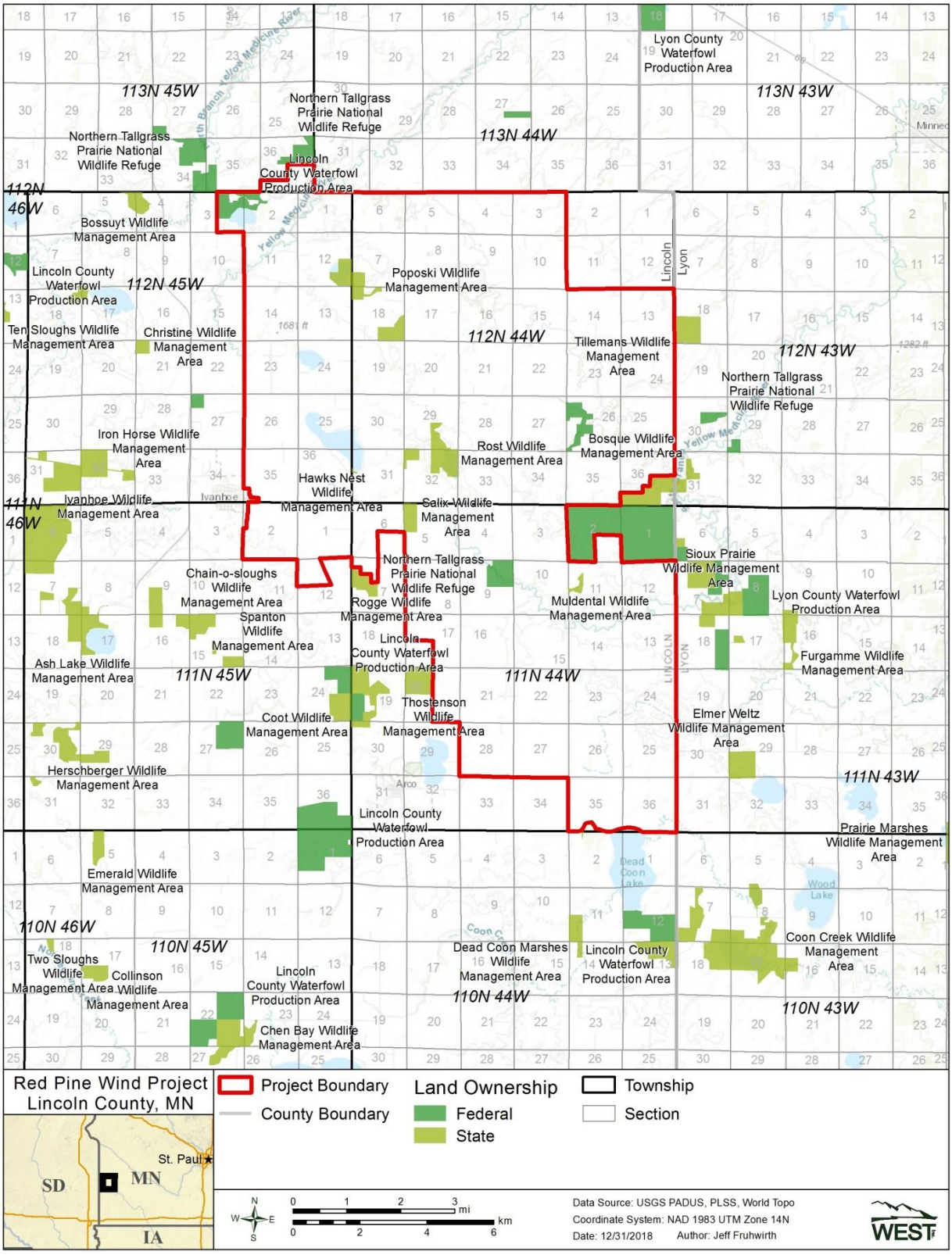

Figure 1. Location of the Red Pine Wind Energy Project.

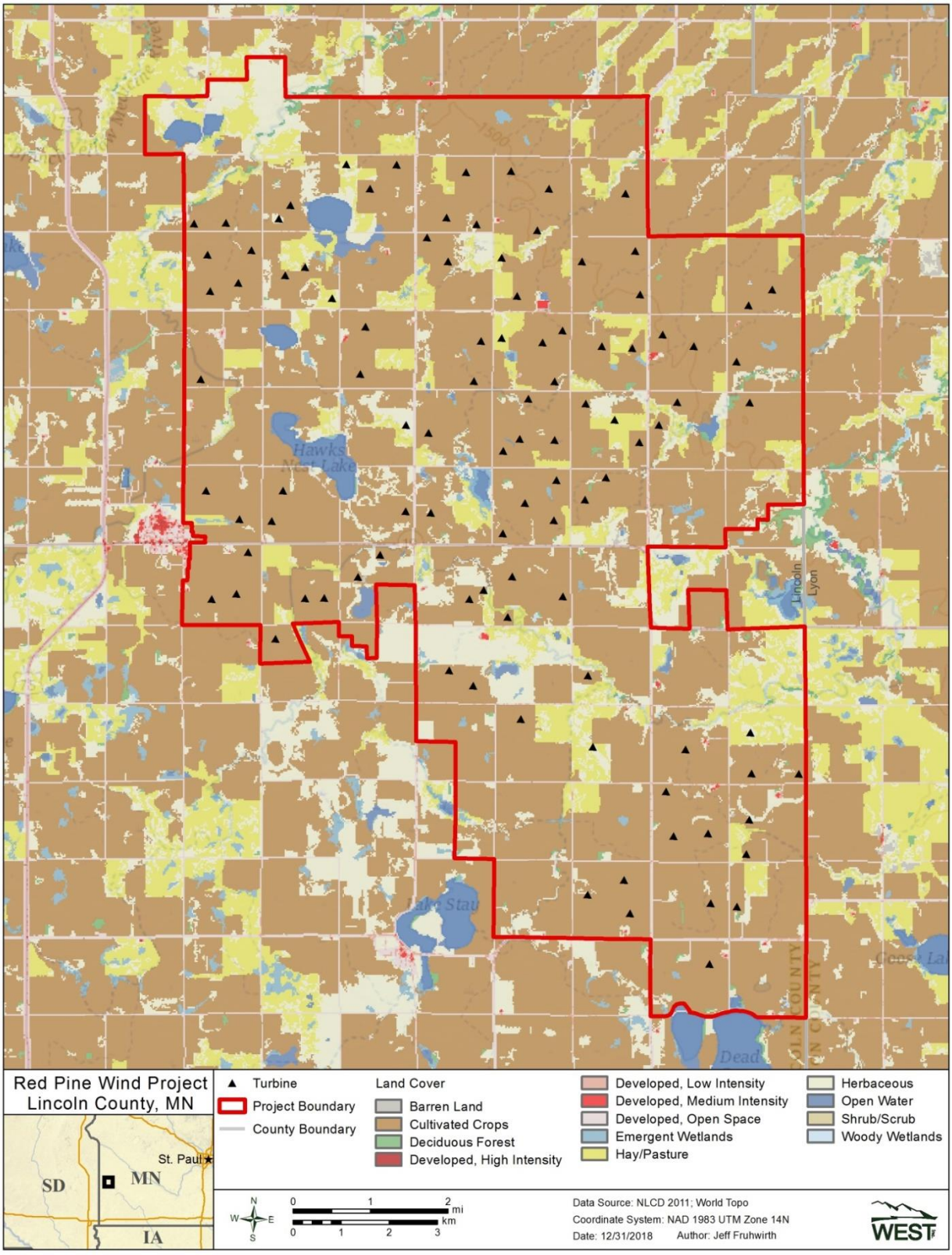

Figure 2. Land cover map for the Red Pine Wind Energy Project.

METHODS

Standardized Carcass Searches

Carcass searches were completed by WEST technicians trained in proper search techniques between March 18, 2018 and November 15, 2018. Data recorded during each carcass search included date, start and end time, observer, and weather data. When a dead bird or bat was found, the observer recorded the species, sex and age (when identifiable), observer name, measured distance from turbine, azimuth from turbine (including Universal Transverse Mercator coordinates), habitat surrounding carcass, condition of carcass (intact, scavenged, dismembered, injured, feather spot [for birds only]), and estimated time of death (e.g., less than one day or two days). Digital photographs were taken of the carcass, any visible injuries, and the surrounding habitat. All carcasses were collected, placed in a re-sealable plastic bag, labeled with a unique carcass identification number, and stored in an on-site freezer. WEST worked under the USFWS Migratory Bird Special Purpose Utility Permit held by Red Pine Wind Project, LLC (Permit Number MB72256C-1), and the DNR Scientific Research – Salvage Special Permit (Number 19024, as amended) held by WEST.

The identification of all bird and bat carcasses was verified by biologists with experience identifying birds and bats to species. Due to the difficulty of identifying *Myotis* species, the identification of all bat carcasses was verified by WEST biologists permitted to identify and handle threatened and endangered bat species.

Casualties found in non-search areas (e.g., near a turbine not included in the search area) were recorded as incidental discoveries and documented in a similar fashion as those found during standard searches. These casualties were not included in the estimation of fatality rates.

Number of Turbines Sampled, Search Frequency, and Search Area/Plot Size

Fifty of the Project's turbines were searched in the 2018 PCM monitoring period. Vegetation was cleared within 120 x 120 m (394 x 394 ft) of 10 turbines (Table 2a, Figure 3). The gravel road and pad areas were searched within 60 m (197 ft) of the remaining 40 turbines (the searchable area around each turbine pad varied between 10–20 m [33-66 ft], with the roads searched out to a distance of 60 m; Table 2b, Figure 3).

The cleared plot turbines were searched at a frequency of four times per week, and the road and pad turbines were searched once a week. Searchers walked at a casual walking rate of approximately 45-60 m (148-197 ft) per minute through the search area while scanning for carcasses. The searcher scanned the area on both sides of each search transect, spaced six m (20 ft) apart. For road and pad searches, searchers scanned the cleared area as delineated by the road and pad; this was accomplished by parking on the access road, walking toward the turbine, walking around the pad surrounding the turbine and back to the vehicle, scanning for carcasses.

Table 2a. Turbines searched as 120 x 120 meter (394 x 394 feet) cleared plots at the Red Pine Wind Facility.

Cleared Plot Search Turbines
5
16
26
45
48
54
71
85
92
97

Table 2b. Turbines searched on turbine pads and roads within 60 meters (197 feet) at the Red Pine Wind Facility.

Road and Pad Search Turbines			
8	27	64	88
10	36	66	89
11	37	69	90
14	40	72	93
17	41	74	94
18	46	75	98
19	47	80	99
20	50	81	100
22	51	83	105
25	52	86	106

Plotting of Search Plot Boundaries; Maintenance of Cleared Plots

The boundaries of all cleared plots and roads and pads were recorded using Global Positioning System technology on handheld units in the field. All of the cleared plots were located within corn or soybean fields and were regularly mowed to maintain a height of 15 centimeters (six inches) or less, providing relatively uniform searching conditions across all cleared plots. Areas of roads and pads within cleared plots were also delineated.

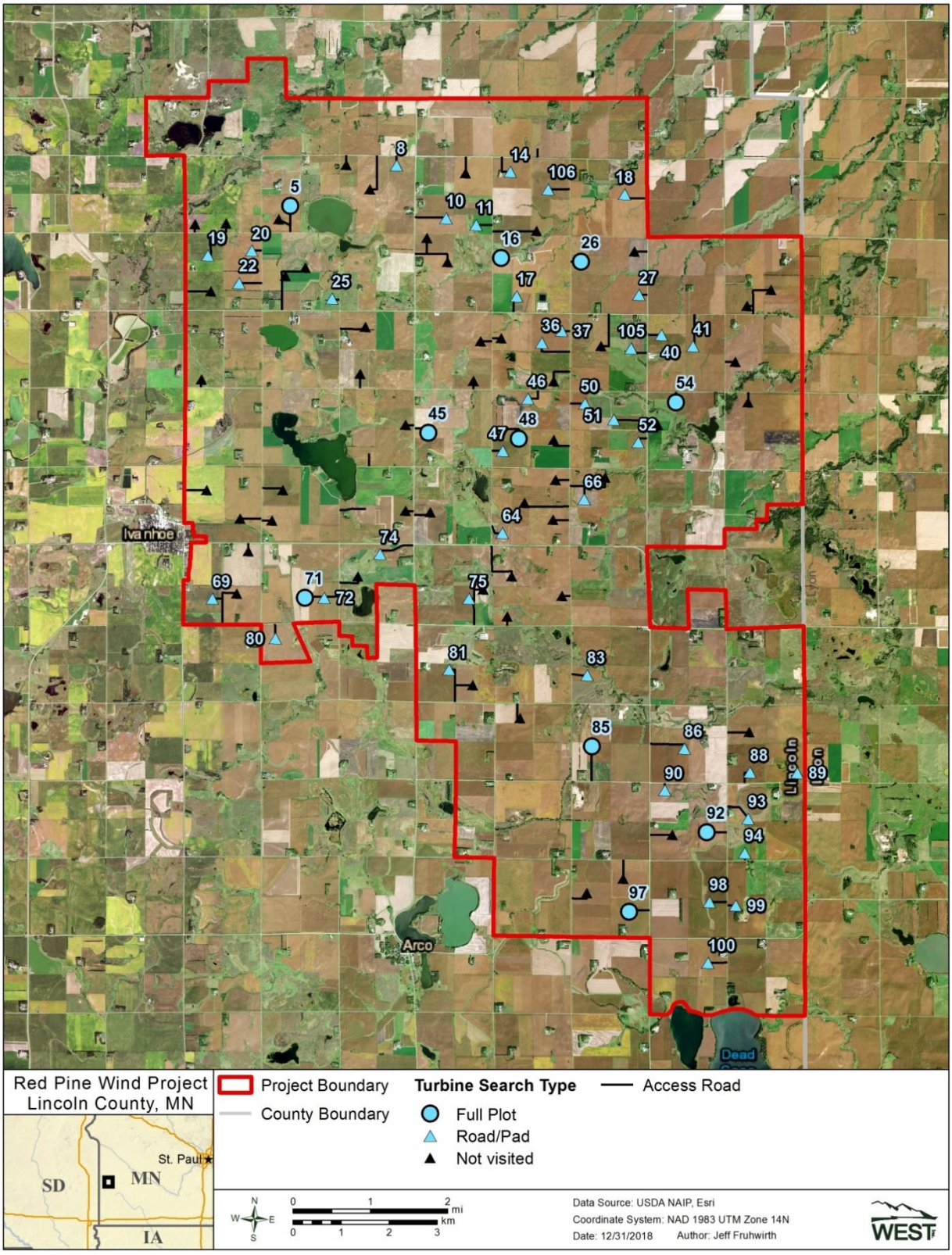

Figure 3. Layout and Search Type for the Red Pine Wind Energy Project.

Bias Trials

Searcher Efficiency Trials

The objective of the searcher efficiency trials was to estimate the percentage of casualties found by searchers. Searcher efficiency trials were conducted in the same areas where carcass searches occurred, and separate trials were held for cleared plot turbines and road and pad turbines. Searcher efficiency was estimated by size of carcass (small bird, large bird, bat, and raptor). Multiple trials were conducted in each season of the study period in order to estimate searcher efficiency rates by season. Seasons were defined as spring (March 15 – May 14), summer (May 15 – August 4) and fall (August 5 – November 15). Estimates of searcher efficiency were used to adjust the total number of bird and bat carcasses found for those missed by technicians, accounting for detection bias in the fatality estimates.

Trial carcasses were placed by WEST personnel to ensure carcass searchers did not know when trials were conducted or the location of the detection carcasses. Rock pigeons (*Columba livia*) carcasses were used to represent large birds, juvenile coturnix quail (*Coturnix* spp.) carcasses were used for small birds, and brown/black mice carcasses represented bat carcasses. Raptor carcasses were also used in searcher efficiency trials separate from the large bird trials; raptors obtained from the University of Minnesota's Raptor Center were used. Raptor carcasses included sharp-shinned hawk (*Accipiter striatus*), Cooper's hawk (*A. cooperii*), red-tailed hawk (*Buteo jamaicensis*), red-shouldered hawk (*B. lineatus*), broad-winged hawk (*B. platypterus*), peregrine falcon (*Falco peregrines*), barred owl (*Strix varia*), great horned owl (*Bubo virginianus*), and long-eared owl (*Asio otus*). Bat and bird carcasses found during carcass searches (or birds obtained from properly permitted facilities) were also incorporated into the searcher efficiency trials.

Overall, a total of 71 mice/bat carcasses, 71 small bird carcasses, 73 large bird carcasses, and 22 raptor carcasses were used in the searcher efficiency trials (Table 3). Because the supply of raptor carcasses was relatively limited, searcher efficiency trials for those carcass types were only conducted on cleared plots; trials for the other size classes were conducted on both road and pad and cleared plot turbines.

Each trial carcass was discreetly marked with a black zip-tie around the leg for birds or upper arm for bats or mice prior to dropping 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 on the same day 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 carcass search was recorded, and the number of carcasses available for detection during each trial was determined immediately after the search by the person responsible for distributing the carcasses.

Table 3. Distribution of carcasses used in searcher efficiency trials by size class and plot type at the Red Pine Wind Facility.

Size Class	Cleared Plots	Road and Pad Plots	Total
Bats	37	34	71
Small Birds	37	34	71
Large Birds	39	34	73
Raptors	22	0	22
Total	**135**	**102**	**237**

Carcass Persistence Trials

The objective of carcass persistence trials was to estimate the average length of time (in days) a carcass persisted in the field (i.e., before a carcass was no longer available for detection). Carcasses could be removed by scavenging, or rendered undetectable by typical farming activities and mowing the search plots (for cleared plots only). Differences in carcass persistence between cleared plots and road and pad searches were also examined. Estimates of small bird, large bird, bat, and raptor carcass persistence were used to adjust the total number of carcasses found for those removed from the study area, accounting for persistence bias in the fatality estimates.

Trials were conducted during all seasons to incorporate the effects of varying weather, climatic conditions, and scavenger densities. Throughout the study period, 289 carcasses were monitored (Table 4). A subset of the same carcasses used for searcher efficiency trials were used for carcass persistence trials. Similar to the searcher efficiency trials, carcass persistence trials for raptors were only conducted on cleared plots; trials for the other size classes were conducted on both road and pad and cleared plot turbines.

Technicians conducting carcass searches monitored the carcass persistence trial carcasses for bats, small birds, and large birds 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. For raptors, a 90-day monitoring period was used, with the same initial checked days through day 30 described above, then every 10 days after that. Carcasses were left at the location until the end of the carcass removal trial. At the end of the applicable monitoring period, any evidence of the remaining carcasses was removed from the search plot.

Table 4. Distribution of carcasses used in carcass persistence trials by size class and plot type at the Red Pine Wind Project.

Search Protocol	Cleared Plots	Road and Pad Plots	Total
Bats	45	45	90
Small Birds	45	45	90
Large Birds	45	45	90
Raptors	19	0	19
Total	**154**	**135**	**289**

Statistical Analysis

Quality Assurance and Quality Control

Quality assurance and quality control measures were implemented at all stages of the study, including field studies, data entry, data analysis, and report writing. All field data sheets were inspected for completeness, accuracy, and legibility. Any anomalous records from the database were compared to the raw data forms and any errors detected were corrected. Irregular codes or data suspected as questionable were discussed with the observer and/or project manager. Errors, omissions, or problems were traced back to the raw data forms and rectified. All data sheets and electronic data files were retained for reference.

Fatality estimates were calculated for all birds, all bats, small birds, large birds, and raptors, including diurnal raptors and owls, by season, plot type, and for the study period. Estimates and confidence intervals (CI) were calculated for each individual category listed above, assuming a sufficient number of fatalities (i.e., more than five) were detected to compute a CI. The Huso estimator (Huso 2011, Huso et al. 2012), which is a Horvitz-Thompson (1952) estimator, is used to obtain fatality estimates. The counts for number of carcasses found on standardized search plots were adjusted for carcass persistence, searcher efficiency, and area correction bias. The 90% CI were calculated using bootstrapping (Manly 1997). Bootstrapping is a computer simulation technique that is useful for calculating variances and CI for complicated test statistics. A total of 1,000 bootstrap samples were used. The lower 5^{th} and upper 95^{th} percentiles of the 1,000 bootstrap estimates were estimates of the lower limit and upper limit of 90% CI.

Carcasses Excluded from Fatality Estimation

One of the underlying assumptions of the Huso estimator is that searchers have a single opportunity to discover a carcass (Huso 2011). In practice, particularly when carcass persistence times are long, carcasses may be discovered that have been available for more than one search. In order to meet the assumptions of the Huso estimator, the estimated time since death was estimated for each carcass in the field. A carcass was included in fatality estimates if the estimated time since death was less than the search interval associated with that carcass.

The Shoenfeld estimator does not censor carcasses due to an estimated time of death longer than the search interval (Shoenfeld 2004).

Searcher Efficiency

Searcher efficiency estimates were obtained for each size class separately using a logistic regression model (Agresti 2007). Covariates for these logistic regression models included plot type, season, and the interactions between these variables. Logistic regression models the natural logarithm of the estimated odds of finding an available carcass as a function of the above covariates. The model assumes searchers have a single opportunity to discover a carcass. The best model was selected using Akaike Information Criteria (AICc).

Carcass Persistence

Estimates of carcass persistence rates were used to adjust carcass counts for removal bias. Carcass persistence was modeled for each size class as a function of variables including season. The average probability of persistence of a carcass through the effective search interval is estimated from an interval-censored survival regression (Huso 2011, Kalbfleisch and Prentice 2002). The effective search interval is defined as the shorter of the actual search interval and that period of time after which the average probability of persistence would be 0.01. Huso (2011) advocated the use of the effective search interval to reduce bias in fatality estimates when carcass persistence probabilities are very low. The carcass persistence adjustment has two components: the probability of persistence through the search interval and the adjustment for the effective search interval, if appropriate. Exponential, loglogistic, lognormal, and Weibull distributions were fitted to the bias trial persistence data separately by size class (e.g., bat, small bird, or large bird). The best model was selected using an information theoretic approach known as AICc. (Burnham and Anderson 2002).

For the Shoenfeld estimator, the exponential distribution was fit to the bias trial persistence data. Otherwise the modeling procedure was identical to Huso.

Search Area Adjustment

It is not always possible or feasible to search the entire area beneath turbines due to ground cover (e.g., tall crops) or terrain. The proportion of carcasses falling within searched areas was estimated to account for unsearched areas and the carcass-density distribution; one estimate was calculated for small birds. A likelihood modeling approach was used to estimate the carcass-distance density distribution from the results of the monitoring study for bats and small birds. For large birds, the carcass counts were too low to obtain a fitted distribution. A physics-based model which predicts the maximum fall distance for a given turbine height and rotor diameter was used (Hull & Muir 2013) and the relative carcass density was assumed to follow a linear decrease from the turbine base out to the maximum predicted fall distance (Huso and Dalthorp 2014). The carcass-distance density distribution (either estimated from monitoring data or physics-based) was combined with the proportion of area searched to calculate an area correction value.

RESULTS

Avian and Bat Carcass Surveys

The 50 searched turbines were searched in the spring, summer and fall for 2,555 turbine searches (each of the 10 cleared plot turbines were searched approximately 140 times and each of the 40 road and pad turbines were searched approximately 35 times). One hundred and sixty-eight bat and 79 bird carcasses were found at the Project during surveys conducted between March 18 and November 15, 2018 (Table 5). Of those found six bats and 3 birds were found incidentally. The number, species, location, characteristics of the bird and bat 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.

Species Composition

During the study, 79 birds comprising 39 identifiable species were found during scheduled searches; 67 were found on cleared plots, 11 were found on road and pads and one was found incidentally outside of a search location (Table 5, Appendix A). Seven carcasses were unidentified small birds or passerines. Three raptors were found during the study: one red-tailed hawk, one sharp-shinned hawk, and one Swainson's hawk (*Buteo swainsoni;* Table 5). The ruby-crowned kinglet (*Regulus calendula*) and marsh wren (*Cistothorus palustris*) were found most frequently, with nine and eight records, respectively, representing approximately 11.4% and 10.1%, respectively, of the overall composition. The red-eyed vireo (*Vireo olivaceus*) and sedge wren (*Cistothorus platensis*) each had four records (each approximately 5.1% of the overall composition), and the golden-crowned kinglet (*Regulus satrapa*) was found three times (3.8% of the overall composition). The remaining species were all documented once or twice. No federally listed or state-threatened, endangered, or species of special concern birds were documented during surveys. Eight avian species (19 individuals) listed as Species of Greatest Conservation Need in Minnesota's Wildlife Action Plan 2015 – 2015 (DNR 2015) were documented: Le Conte's sparrow (*Ammodramus leconteii*; two found), marsh wren (eight found), ovenbird (*Seiurus aurocapilla*; one found), Philadelphia vireo (*Vireo philadelphicus*; one found), sedge wren (four found), Swainson's hawk (one found), swamp sparrow (*Melospiza georgiana*; one found), and Virginia rail (*Rallus limicola*; one found).

A total of 168 bat carcasses were found at the Project between May 5 and October 18, 2018; 118 were found on cleared plots, 50 bats were found on road and pads (Table 5, Appendix A). Four species of bats were found: hoary bat (*Lasiurus cinereus*; 63 found, 37.5%), eastern red bat (*L. borealis*; 44 found; 26.2%), silver-haired bat (*Lasionycteris noctivagans*; 37 found, 22.0%), and big brown bat (*Eptesicus fuscus*; 24 found, 14.3%). One special status bat species was documented: the big brown bat is a state species of special concern in Minnesota. Hoary bats and eastern red bats are listed as Species of Greatest Conservation Need in the 2015 – 2025 Wildlife Action Plan (DNR 2015).

Table 5. Total number of casualties and the composition of casualties discovered at the Red Pine Wind Energy Facility, Lincoln County, Minnesota, from March 18, 2018 to November 15, 2018.

	Casualties Included		Casualties Off Plot		Clearing Search Casualties		Casualties Censored		Other Casualties Excluded		Total	
Species	**Total**	**% Comp**	**Total**	**% Comp**	**Total**	**% Comp**	**Total**	**% Comp**	**Total**	**% Comp**	**Total**	**% Comp**
Bat												
hoary bat	46	36.8	6	37.5	0	0	11	40.7	0	0	63	37.5
eastern red bat	31	24.8	5	31.2	0	0	8	29.6	0	0	44	26.2
silver-haired bat	31	24.8	2	12.5	0	0	4	14.8	0	0	37	22.0
big brown bat	17	13.6	3	18.8	0	0	4	14.8	0	0	24	14.3
Overall Bats*	**125**	**100**	**16**	**100**	**0**	**0**	**27**	**100**	**0**	**0**	**168**	**100**
Bird												
ruby-crowned kinglet	8	12.7	0	0	0	0	1	11.1	0	0	9	11.4
marsh wren	7	11.1	1	14.3	0	0	0	0	0	0	8	10.1
red-eyed vireo	4	6.3	0	0	0	0	0	0	0	0	4	5.1
golden-crowned kinglet	3	4.8	0	0	0	0	0	0	0	0	3	3.8
sedge wren	3	4.8	0	0	0	0	1	11.1	0	0	4	5.1
American coot	2	3.2	0	0	0	0	0	0	0	0	2	2.5
brown creeper	2	3.2	0	0	0	0	0	0	0	0	2	2.5
clay-colored sparrow	2	3.2	0	0	0	0	0	0	0	0	2	2.5
chipping sparrow	2	3.2	0	0	0	0	0	0	0	0	2	2.5
Le Conte's sparrow	2	3.2	0	0	0	0	0	0	0	0	2	2.5
Lincoln's sparrow	2	3.2	0	0	0	0	0	0	0	0	2	2.5
Nashville warbler	2	3.2	0	0	0	0	0	0	0	0	2	2.5
Savannah sparrow	2	3.2	0	0	0	0	0	0	0	0	2	2.5
American redstart	1	1.6	0	0	0	0	0	0	0	0	1	1.3
American robin	1	1.6	0	0	0	0	0	0	0	0	1	1.3
blackpoll warbler	1	1.6	0	0	0	0	0	0	0	0	1	1.3
cliff swallow	1	1.6	0	0	0	0	0	0	0	0	1	1.3
common yellowthroat	1	1.6	0	0	0	0	0	0	0	0	1	1.3
gray catbird	1	1.6	0	0	0	0	0	0	0	0	1	1.3
house wren	1	1.6	0	0	0	0	0	0	0	0	1	1.3
mallard	1	1.6	0	0	0	0	0	0	0	0	1	1.3
mourning dove	1	1.6	0	0	0	0	0	0	0	0	1	1.3
northern waterthrush	1	1.6	0	0	0	0	0	0	0	0	1	1.3
ovenbird	1	1.6	0	0	0	0	0	0	0	0	1	1.3
Philadelphia vireo	1	1.6	0	0	0	0	0	0	0	0	1	1.3
red-breasted nuthatch	1	1.6	0	0	0	0	0	0	0	0	1	1.3
red-tailed hawk	1	1.6	0	0	0	0	0	0	0	0	1	1.3

Table 5. Total number of casualties and the composition of casualties discovered at the Red Pine Wind Energy Facility, Lincoln County, Minnesota, from March 18, 2018 to November 15, 2018.

	Casualties Included		Casualties Off Plot		Clearing Search Casualties		Casualties Censored		Other Casualties Excluded		Total	
Species	**Total**	**% Comp**	**Total**	**% Comp**	**Total**	**% Comp**	**Total**	**% Comp**	**Total**	**% Comp**	**Total**	**% Comp**
sharp-shinned hawk	1	1.6	0	0	0	0	0	0	0	0	1	1.3
swamp sparrow	1	1.6	0	0	0	0	0	0	0	0	1	1.3
Tennessee warbler	1	1.6	0	0	0	0	0	0	0	0	1	1.3
unidentified flycatcher	1	1.6	0	0	0	0	0	0	0	0	1	1.3
unidentified passerine	1	1.6	0	0	0	0	0	0	0	0	1	1.3
unidentified sparrow	1	1.6	0	0	0	0	0	0	0	0	1	1.3
unidentified warbler	1	1.6	0	0	0	0	1	11.1	0	0	2	2.5
yellow-throated vireo	1	1.6	0	0	0	0	0	0	0	0	1	1.3
bank swallow	0	0	1	14.3	0	0	0	0	0	0	1	1.3
blue-headed vireo	0	0	0	0	0	0	1	11.1	0	0	1	1.3
hermit thrush	0	0	0	0	0	0	1	11.1	0	0	1	1.3
northern flicker	0	0	1	14.3	0	0	0	0	0	0	1	1.3
ring-necked pheasant	0	0	0	0	0	0	1	11.1	0	0	1	1.3
sora	0	0	1	14.3	0	0	0	0	0	0	1	1.3
song sparrow	0	0	0	0	0	0	1	11.1	0	0	1	1.3
Swainson's hawk	0	0	1	14.3	0	0	0	0	0	0	1	1.3
turkey vulture	0	0	1	14.3	0	0	0	0	0	0	1	1.3
unidentified kingbird	0	0	0	0	0	0	1	11.1	0	0	1	1.3
unidentified wren	0	0	0	0	0	0	1	11.1	0	0	1	1.3
Virginia rail	0	0	1	14.3	0	0	0	0	0	0	1	1.3
Overall Birds*	**63**	**100**	**7**	**100**	**0**	**0**	**9**	**100**	**0**	**0**	**79**	**100**

*Sums of values may not add to total value shown due to rounding.

Timing of Bird and Bat Carcasses

Appendix A provides a complete list of fatalities found at the Project between March 18 and November 15, 2018, along with date and turbine/location information. The first bird fatality was found in late April, after which the unadjusted rates of bird fatalities per turbine remained fairly steady through mid-May. The week of May 18, 2018 had the highest unadjusted rates of bird fatalities found during the study period (Figure 4a). Fatalities dropped to zero during the summer months, with the exception of a few fatalities being found the week of July 12, 2018. Fatalities increased again in late August to rates similar to or lower than seen in mid-April to mid-May, and persisted through the fall season before finally dropping off again in early November.

For bats, no carcasses were found until late April, and the number of unadjusted fatalities per turbine remained relatively low between late April and early July. The week of July 21, 2018 had the highest unadjusted rates of bat fatalities found during the study period (Figure 4b). Bat fatalities remained relatively higher throughout the late summer and early fall, likely attributable to fall migration (Figure 4b). No bat fatalities were found after the week of October 12, 2018.

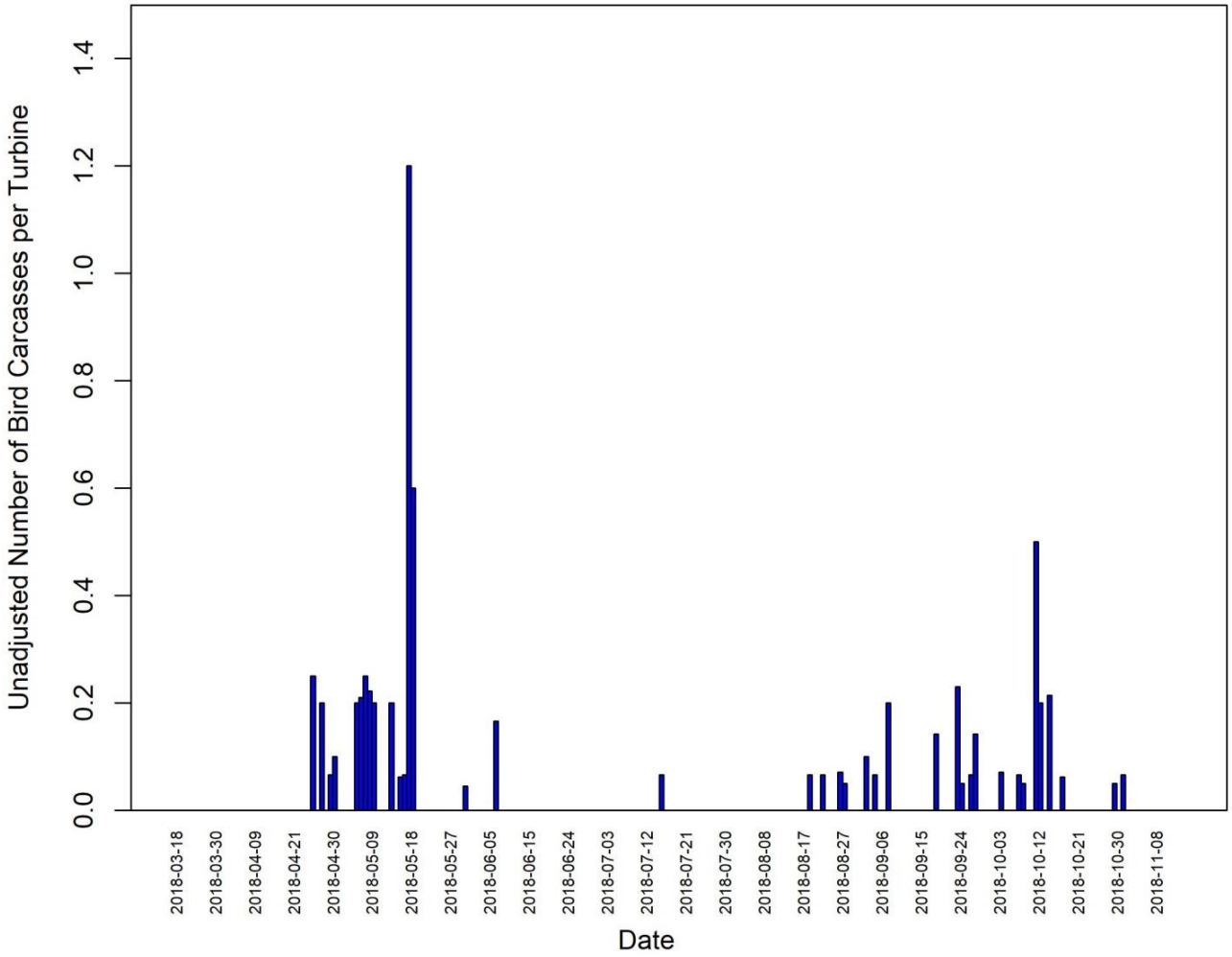

Figure 4a. Timing of bird carcass discoveries found during scheduled searches, or incidentally, at the Red Pine Wind Project on turbine search plots from March 18 to November 15, 2018.

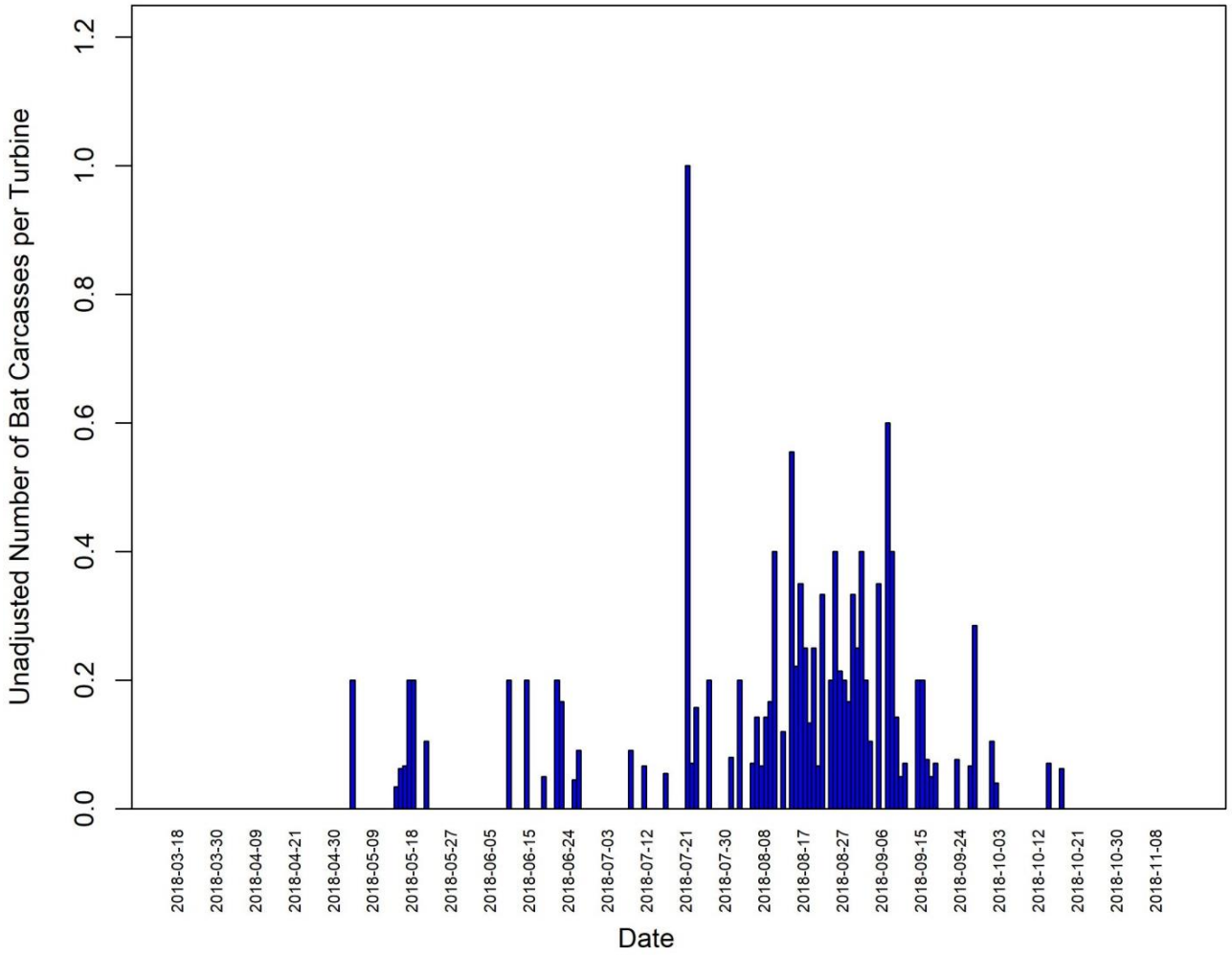

Figure 4b. Timing of bat carcass discoveries found during scheduled searches, or incidentally, at the Red Pine Wind Project on turbine search plots from March 18 to November 15, 2018.

Distribution of Bird and Bat Carcasses within the Project

There was not a clear spatial pattern of turbines with higher numbers of documented bird fatalities (Figure 5a). Among the turbines that received cleared plot searches, the most bird fatalities found at any one search plot was 13 carcasses at Turbine 5. Eight bird carcasses were found at Turbine 16, seven were found at Turbine 71, and six bird carcasses each were found at turbines 85 and 97; the remaining five cleared plot turbines each had four or fewer bird carcasses (Figure 5a). Among the 40 road and pad searched turbines, four (turbines 10, 25, 27 and 41) had one or two bird carcasses found, while no birds were found at the remaining 30 turbines .

There, also, was no clear spatial pattern of turbines with higher numbers of documented bat fatalities (Figure 5b). Among the turbines that received cleared plot searches, the most bat fatalities found at any one search plot was 19 at Turbine 5. Turbine 16 had 12 bat carcasses, Turbine 97 had 11 bat carcasses, and turbines 26 and 85 each had 10 bat carcasses (Figure 5b). Among the 40 road and pad searched turbines, 24 had between one and four bat carcasses, while no bats were found at the remaining 16 turbines.

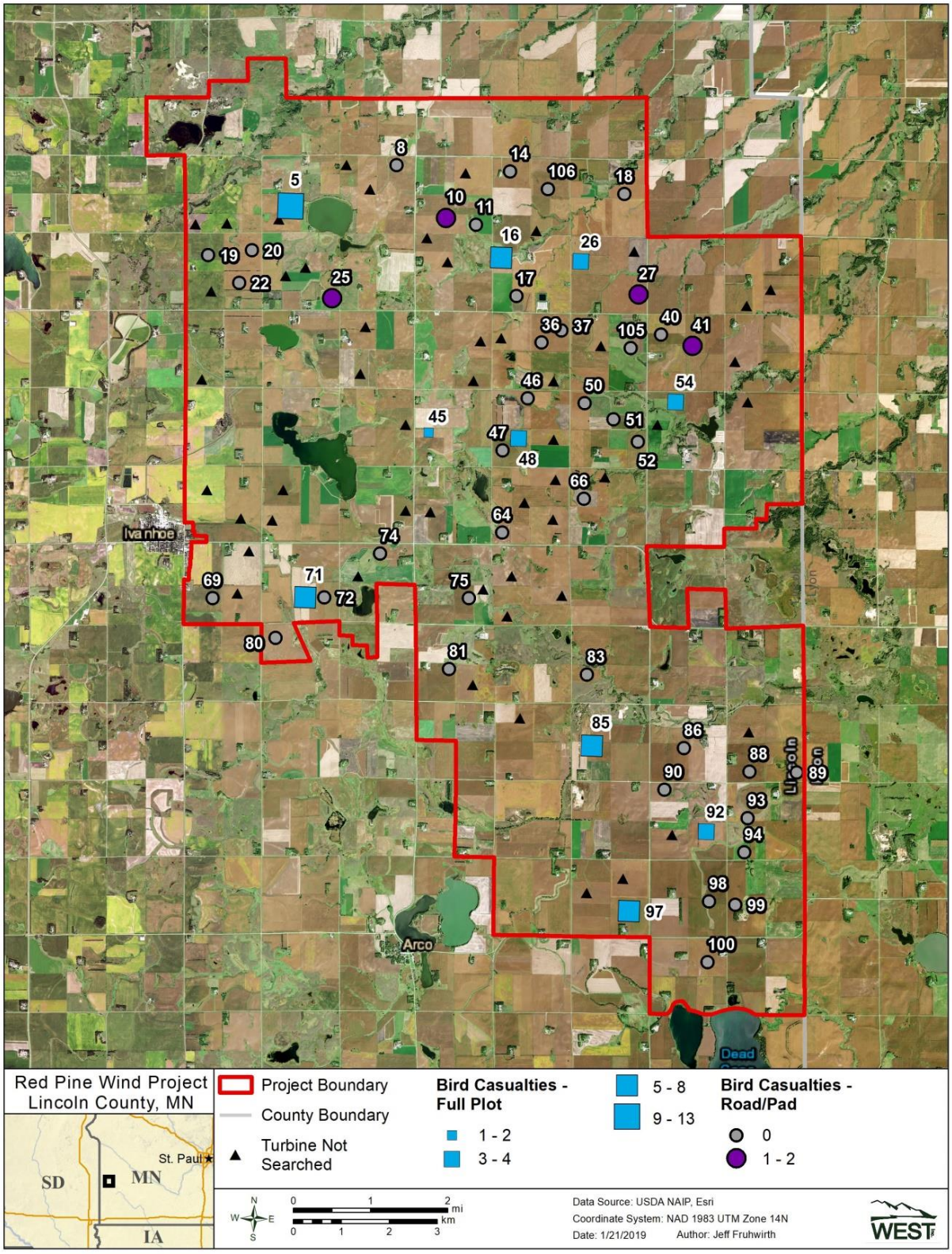

Figure 5a. Bird detections by turbine and search type at the Red Pine Wind Project, March 18 to November 15, 2018 (data includes only carcasses used in analysis).

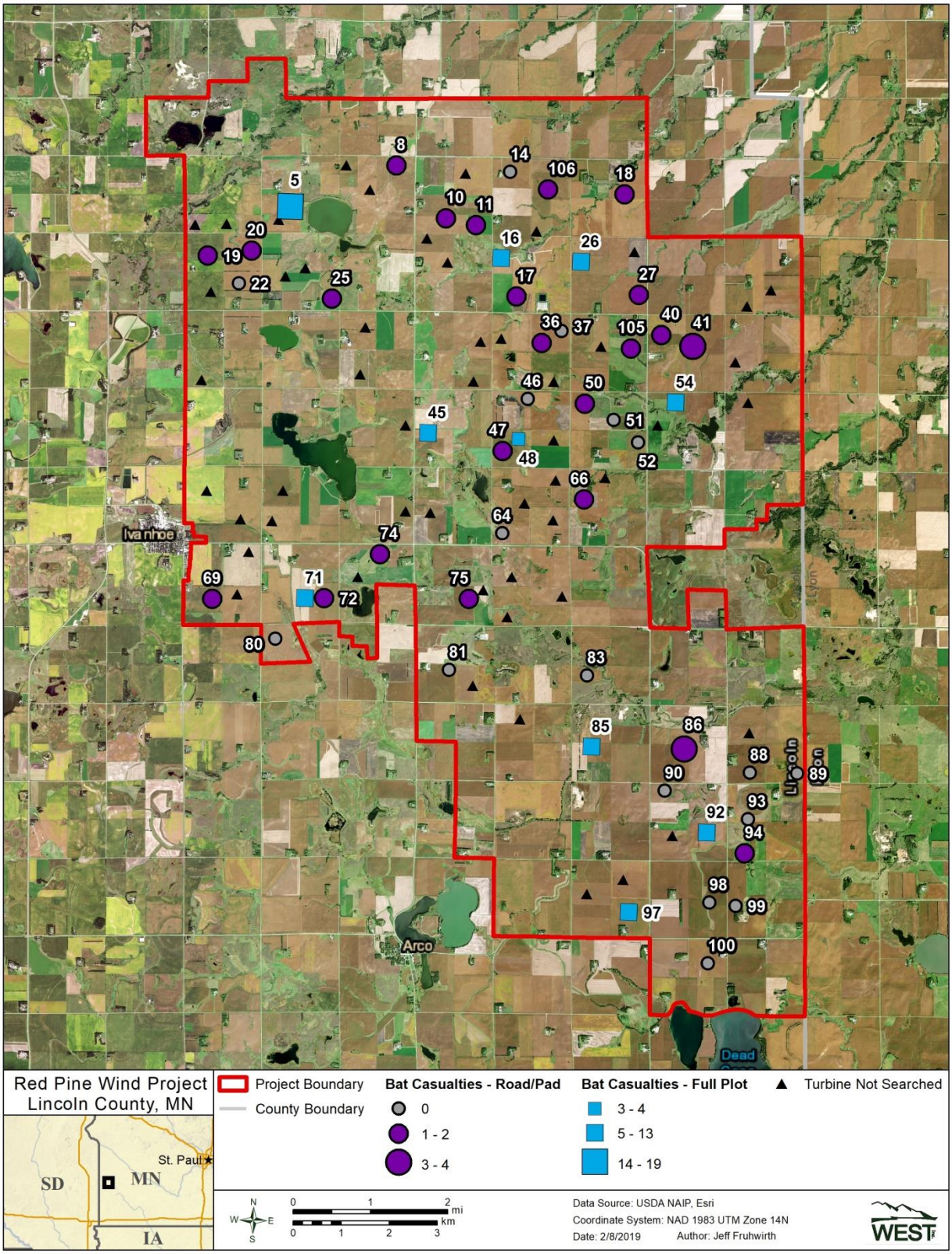

Figure 5b. Bat detections by turbine and search type at the Red Pine Wind Project, March 18 to November 15, 2018 (data includes only carcasses used in analysis).

Distribution of Bird and Bat Carcasses—Distances from Turbines

Bird carcasses were found out to 80 m (263 ft) from the turbine on cleared plot searches and out to 60 m on road and pad searches (Tables 6a and 6b). Distribution of bird carcasses gradually increased from zero m to 60 m intervals on cleared plots, decreasing after 60 m (Table 6a, Figure 6a). On road and pad plots, distribution showed no clear pattern but only a small number of birds were found on road and pad searches (Table 6b, Figure 6b). Approximately 93% of bat carcasses were found within 50 m (164 ft) of turbines at cleared plots, with only 1% of carcasses found farther than 60 m (Table 6a, Figure 6c). The highest percentages of bat carcasses on cleared plots were found 10 to 40 m (131 ft) from the turbines (80% of all bat carcasses found; Table 6a, Figure 6c). No bats were found farther than 60 m away from turbines at road and pad searches and 67% of the bats found on these searches were found within 10 m of the turbine (Table 6b; Figure 6d).

Table 6a. Distribution of distances from turbines of all bird and bat carcasses found at cleared plots during scheduled searches on cleared plot turbines searched at the Red Pine Wind Project.

Distance to Turbine (meters)	% Bird Casualties	% Bat Casualties
0 to 10	0	15.22
10 to 20	6.90	18.48
20 to 30	8.62	25.00
30 to 40	13.79	21.74
40 to 50	22.41	14.13
50 to 60	27.59	4.35
60 to 70	15.52	1.09
70 to 80	5.17	0
80 to 90	0	0

Table 6b. Distribution of distances from turbines of all bird and bat carcasses found at road and pads during scheduled searches on road and pad plot turbines searched at the Red Pine Wind Project.

Distance to Turbine (meters)	% Bird Casualties	% Bat Casualties
0 to 10	40.00	66.67
10 to 20	0	3.03
20 to 30	20.00	6.06
30 to 40	20.00	3.03
40 to 50	0	15.15
50 to 60	20.00	6.06
60 to 70	0	0
70 to 80	0	0
80 to 90	0	0

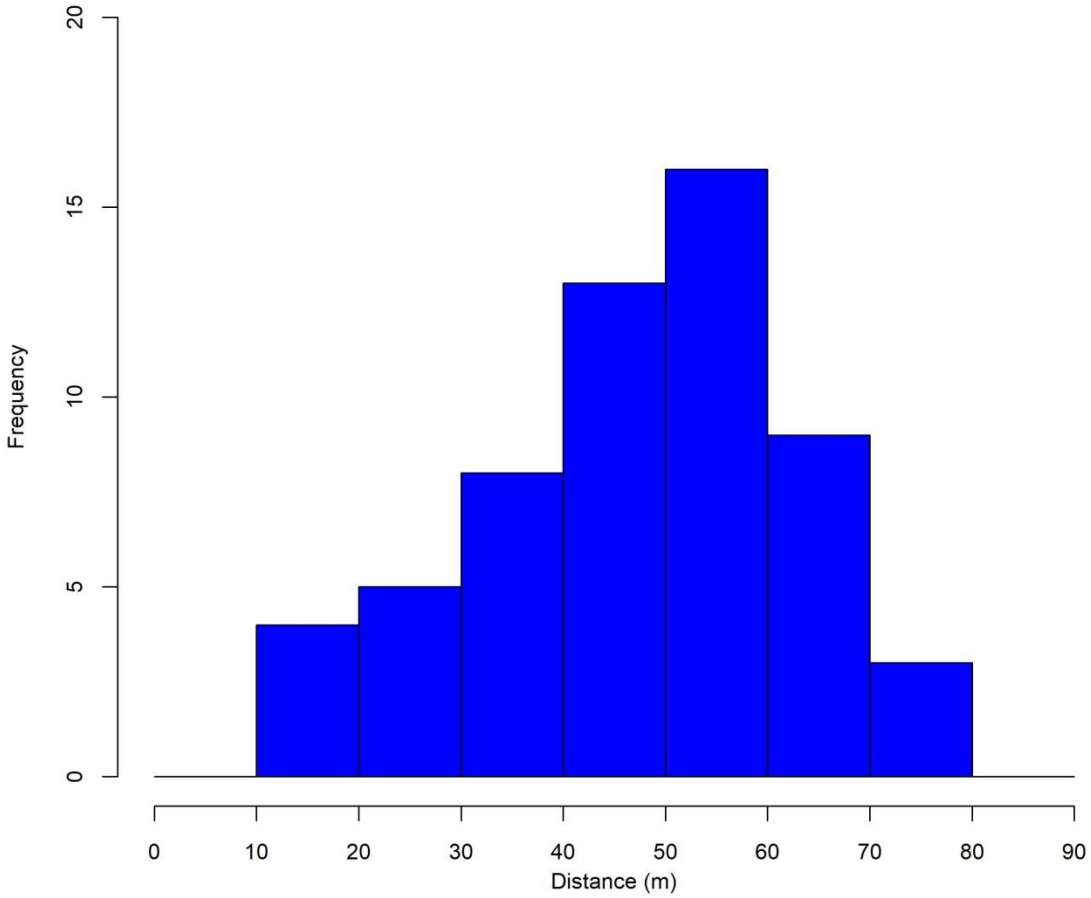

Figure 6a. Distance of bird fatalities from the turbine found during scheduled cleared plot turbine search plots at the Red Pine Wind Project.

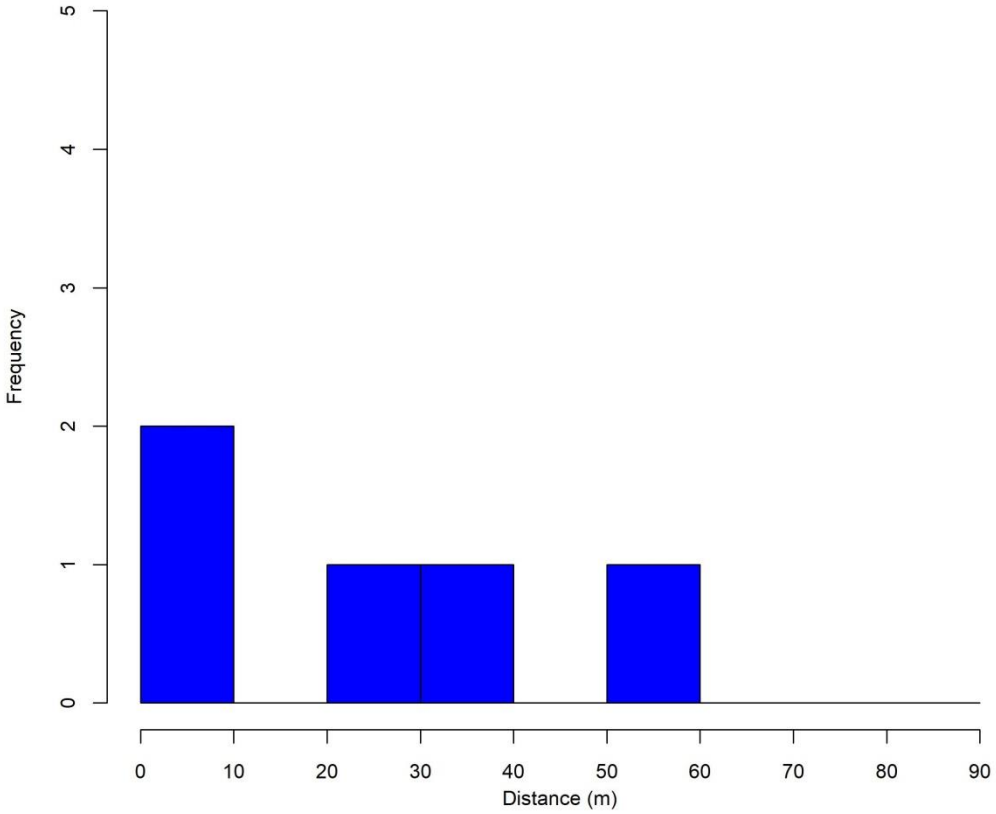

Figure 6b. Distance of bird fatalities from the turbine found during scheduled road and pad turbine search plots at the Red Pine Wind Project.

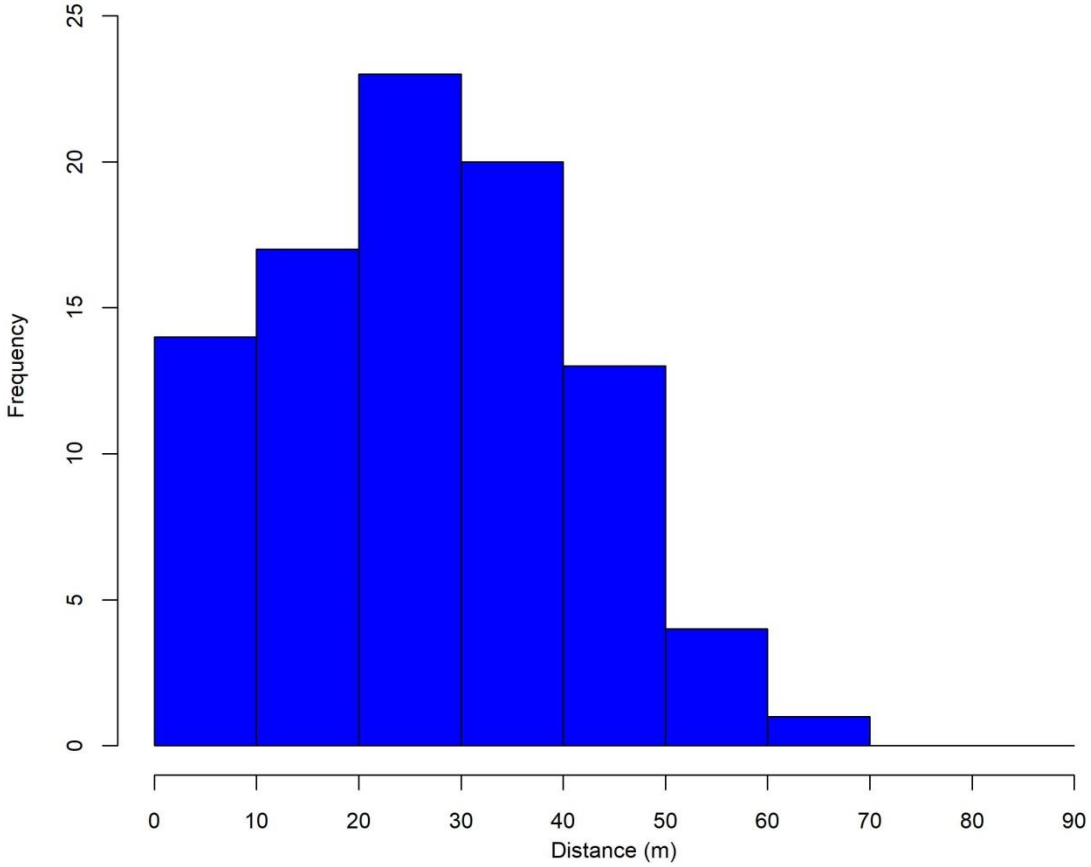

Figure 6c. Distance of bat fatalities from the turbine found during scheduled cleared plot turbine search plots at the Red Pine Wind Project.

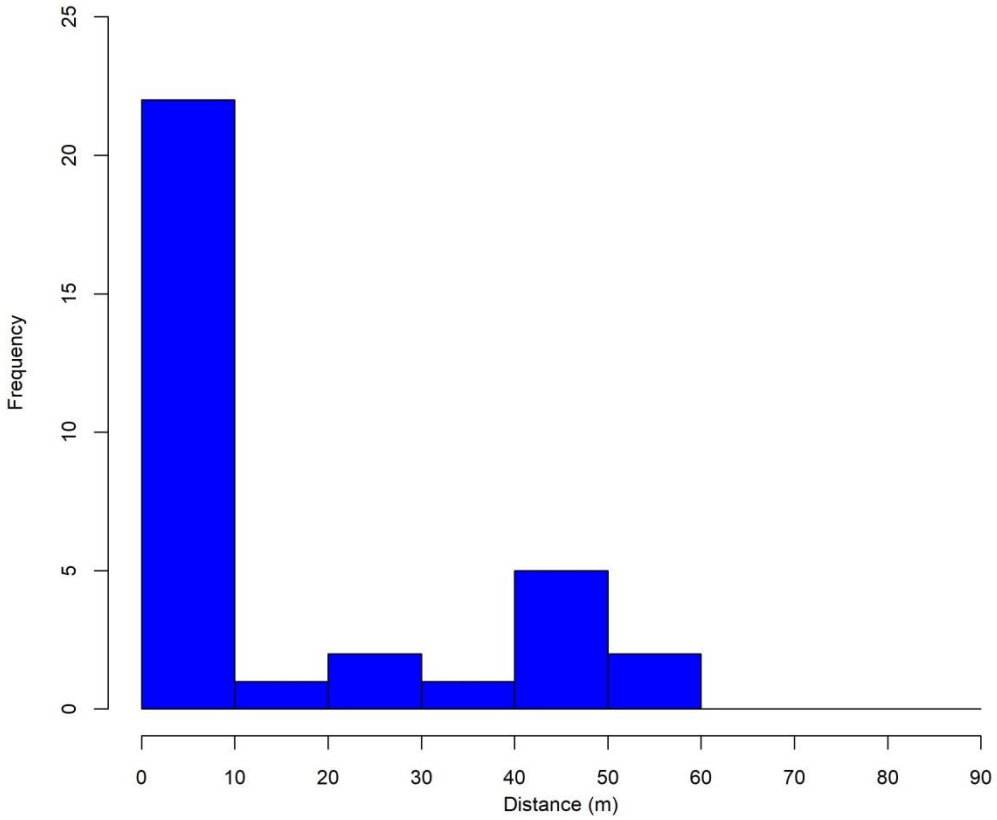

Figure 6d. Distance of bat fatalities from the turbine found during scheduled road and pad turbine search plots at the Red Pine Wind Project.

Searcher Efficiency Trials

Searcher efficiency trials were conducted for each size class, during each season throughout the study period (Tables 7a – 7e). Separate searcher efficiency models were fit for each size class, and to determine if any other explanatory variables (i.e., season or plot search type) provided the best model for estimating searcher efficiency, based on AICc values. Explanatory variables from the selected best models for bats, small birds, large birds, and raptors were season + plot search type, plot search type only, and intercept only, respectively. Searchers found 75% of bats, 80% of small birds, 99% of large birds, and 100% of raptors that were available during trials (Tables 7b – 7e).

Although there was some variation in searcher efficiency among seasons within a given size class (Table 7a), this difference was not statistically significant for small birds, large birds, or raptors ($p > 0.10$). Seasonal variation was significant for bats, along with the plot type (Table 7b). Plot type was also statistically significant for small birds. Searcher efficiency logistic regression models for the bat, small bird, and large bird, and raptor trials are shown in Tables 7b – 7e.

Table 7a. Searcher efficiency results at the Red Pine Wind Project as a function of season and carcass size.

Size Class	Season	# Placed	# Available	# Found	% Found
Bat	Spring	23	21	17	80.95
	Summer	24	23	20	86.96
	Fall	24	23	13	56.52
	Overall	**71**	**67**	**50**	**74.63**
Small Bird	Spring	23	23	20	86.96
	Summer	24	23	20	86.96
	Fall	24	23	15	65.22
	Overall	**71**	**69**	**55**	**79.71**
Large Bird	Spring	27	27	26	96.30
	Summer	23	23	23	100
	Fall	23	23	23	100
	Overall	**73**	**73**	**72**	**98.63**
Raptor	Spring	7	7	7	100
	Summer	8	8	8	100
	Fall	7	7	7	100
	Overall	**22**	**22**	**22**	**100**

Table 7b. Searcher efficiency logistic regression models for bats from the Red Pine Wind Project search efficiency trials. Selected models are denoted by an asterisk in the 'delta (Δ) AICc' column.

Explanatory Variables	AICc	Δ AICc
Season + Plot Type	73.35	0*****
Season + Plot Type + Season * Plot Type	75.25	1.90
Plot Type	75.84	2.49
Season	76.14	2.78
Intercept-only	77.96	4.61

AIC = Akaike Information Criteria

Table 7c. Searcher efficiency logistic regression models for small birds from the Red Pine Wind Project search efficiency trials. Selected models are denoted by an asterisk in the 'delta (Δ) AICc' column.

Explanatory Variables	AICc	Δ AICc
Season + Plot Type	67.30	0
Plot Type	68.05	0.75*****
Season + Plot Type + Season * Plot Type	69.00	1.70
Intercept-only	71.67	4.37
Season	71.71	4.41

AIC = Akaike Information Criteria

Table 7d. Searcher efficiency logistic regression models for large birds from the Red Pine Wind Project search efficiency trials. Selected models are denoted by an asterisk in the 'delta (Δ) AICc' column.

Explanatory Variables	AICc	Δ AICc
Intercept-only	12.62	0*****
Plot Type	13.47	0.85
Season	14.90	2.28
Season + Plot Type	15.94	3.31
Season + Plot Type + Season * Plot Type	20.62	8.00

AIC = Akaike Information Criteria

Table 7e. Searcher efficiency logistic regression models for raptors from the Red Pine Wind Project search efficiency trials. Selected models are denoted by an asterisk in the 'delta (Δ) AICc' column.

Covariate	AICc	Δ AICc
Intercept-only	2.20	0*****
Season	7.33	5.13

AIC = Akaike Information Criteria

Carcass Persistence Trials

Carcass removal trials were conducted for each size class, during each season throughout the study period. A total of 289 carcasses were placed in the project area throughout the duration of the monitoring period for carcass removal trials (90 bats, 90 small birds, 90 large birds, and 19 raptors; Table 8). By day 30, roughly 3% of bats, 8% of small birds, and 19% of large birds remained where they were placed (Figure 7a). By day 30, roughly 74% of raptors remained where they were placed; by day 90, roughly 37% of raptors remained where they were placed (Figure 7b).

Separate survival regression models were fit for each size class. For each size class, combinations of distribution (i.e., Weibull, exponential, loglogistic, and lognormal) and other explanatory variables (i.e., season and plot search type) were fit and AICc values were used to determine the best model. There were no statistically significant differences between seasons or between plot search type as indicated by the modeling results (Tables 9a – 9e).

Mean removal time, $(\bar{t})$, for the Shoenfeld estimator was calculated using a survival regression model with an exponential distribution (the Shoenfeld model assumes exponentially distributed persistence times; Shoenfeld 2004). Since an exponential model was the top model for small birds, bats, large birds, and raptors, the model selection was the same for Shoenfeld as it was for Huso.

Mean removal time was 17.49 days for large birds, 10.94 days for small birds, 7.81 days for bats, and 91.18 days for raptors (Table 9e). As Appendix B shows, there was no significant seasonal difference in persistence time for the Huso estimator (Appendix B1 and B2). The probability of persisting through the search interval, $\hat{r}_i$, varied between plot types due to the longer search interval on roads and pads.

Table 8. Carcasses placed for persistence trials by size class and season at the Red Pine Wind Project.

Size Class	Season	# Placed
Bat	Spring	30
	Summer	30
	Fall	30
	Overall	**90**
Small Bird	Spring	30
	Summer	30
	Fall	30
	Overall	**90**
Large Bird	Spring	30
	Summer	30
	Fall	30
	Overall	**90**
Raptor	Spring	4
	Summer	8
	Fall	7
	Overall	**19**

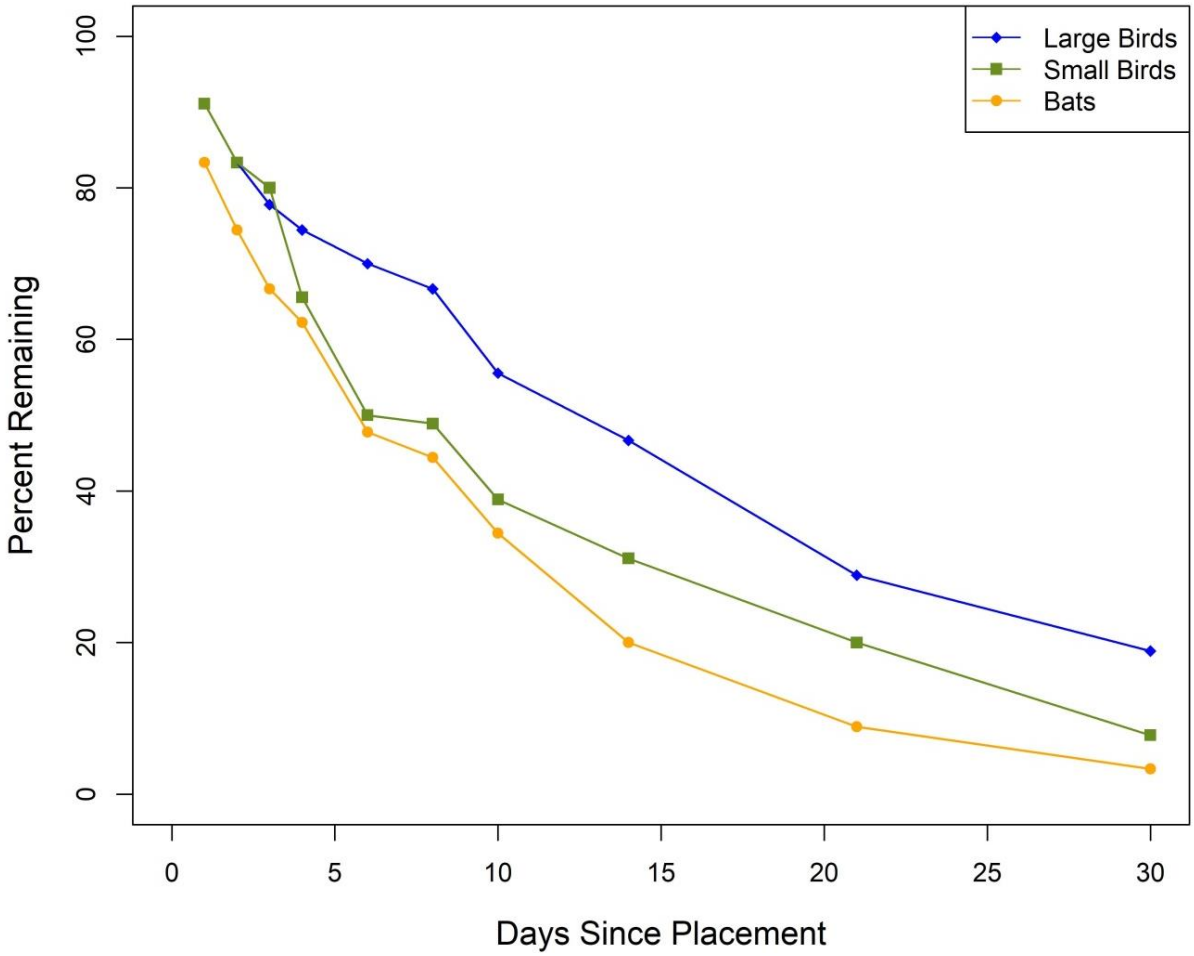

Figure 7a. Persistence of bird and bat carcasses through 30-day carcass persistence trials at the Red Pine Wind Project from March 18 to November 15, 2018.

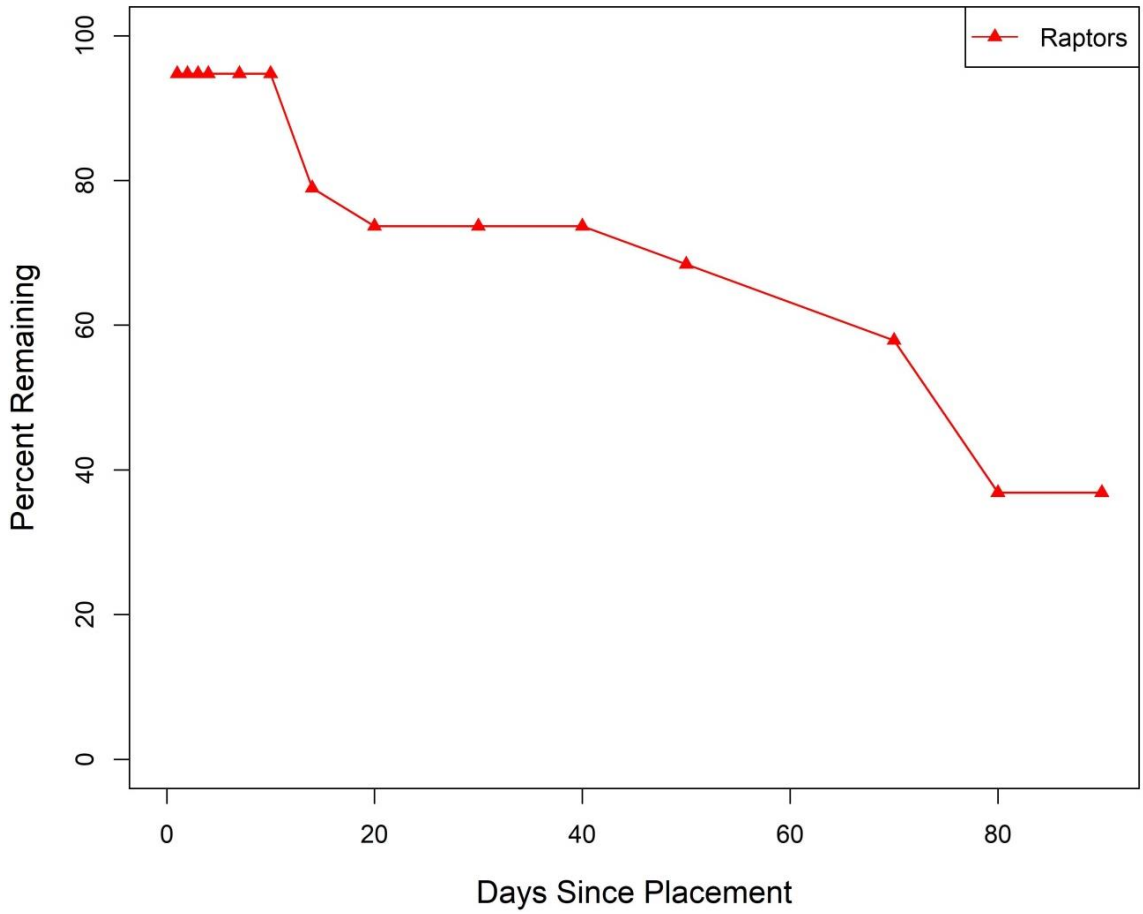

Figure 7b. Persistence of raptor carcasses through 90-day carcass persistence trials at the Red Pine Wind Project from March 18 to November 15, 2018.

Table 9a. Carcass persistence models and parameters for bats at the Red Pine Wind Energy Facility. Selected models are denoted by an asterisk in the 'Delta (Δ) AICc' column.

Covariate	Distribution	AICc	Δ AICc
Intercept-only	Weibull	329.24	0
Intercept-only	Exponential	329.89	0.64*
PlotSearchType	Weibull	331.00	1.76
PlotSearchType	Exponential	331.48	2.24
Season	Weibull	331.70	2.46
Season	Exponential	331.75	2.50
Season + PlotSearchType	Exponential	333.67	4.43
Season + PlotSearchType	Weibull	333.73	4.49
Intercept-only	Lognormal	334.96	5.71
Intercept-only	Loglogistic	335.76	6.52
Season + PlotSearchType + Season*PlotSearchType	Exponential	335.91	6.67
Season + PlotSearchType + Season*PlotSearchType	Weibull	336.51	7.26
PlotSearchType	Lognormal	336.93	7.69
PlotSearchType	Loglogistic	337.71	8.47
Season	Lognormal	337.75	8.50
Season	Loglogistic	338.69	9.44
Season + PlotSearchType	Lognormal	339.83	10.59
Season + PlotSearchType	Loglogistic	340.78	11.53
Season + PlotSearchType + Season*PlotSearchType	Lognormal	341.17	11.93
Season + PlotSearchType + Season*PlotSearchType	Loglogistic	341.95	12.70

AIC = Akaike Information Criteria

Table 9b. Carcass persistence models and parameters for small birds at the Red Pine Wind Energy Facility. Selected models are denoted by an asterisk in the 'Delta (Δ) AICc' column.

Covariate	Distribution	AICc	Δ AICc
Season	Exponential	365.53	0
Intercept-only	Exponential	366.00	0.47*
Season + PlotSearchType	Exponential	366.65	1.12
Intercept-only	Weibull	366.80	1.27
Season	Weibull	367.10	1.57
PlotSearchType	Lognormal	367.23	1.70
PlotSearchType	Exponential	367.24	1.72
Intercept-only	Loglogistic	367.60	2.08
Intercept-only	Lognormal	367.66	2.13
PlotSearchType	Loglogistic	367.89	2.36
PlotSearchType	Weibull	368.12	2.60
Season + PlotSearchType	Weibull	368.33	2.80
Season + PlotSearchType + Season*PlotSearchType	Exponential	370.03	4.51
Season + PlotSearchType	Lognormal	370.97	5.45
Season	Lognormal	371.27	5.74
Season	Loglogistic	371.75	6.22
Season + PlotSearchType + Season*PlotSearchType	Weibull	371.95	6.42

Table 9b. Carcass persistence models and parameters for small birds at the Red Pine Wind Energy Facility. Selected models are denoted by an asterisk in the 'Delta (Δ) AICc' column.

Covariate	Distribution	AICc	Δ AICc
Season + PlotSearchType	Loglogistic	372.20	6.67
Season + PlotSearchType + Season*PlotSearchType	Lognormal	374.63	9.10
Season + PlotSearchType + Season*PlotSearchType	Loglogistic	375.22	9.69

AIC = Akaike Information Criteria

Table 9c. Carcass persistence models and parameters for large birds at the Red Pine Wind Energy Facility. Selected models are denoted by an asterisk in the 'Delta (Δ) AICc' column.

Covariate	Distribution	AICc	Δ AICc
Intercept-only	Weibull	384.35	0
Intercept-only	Exponential	384.61	0.26*
Season	Exponential	384.74	0.39
Season	Weibull	385.00	0.64
PlotSearchType	Weibull	385.51	1.16
PlotSearchType	Exponential	385.55	1.20
Season + PlotSearchType	Exponential	385.57	1.22
Season + PlotSearchType	Weibull	386.07	1.72
Season	Loglogistic	387.67	3.32
Intercept-only	Loglogistic	389.39	5.03
Season + PlotSearchType + Season*PlotSearchType	Exponential	389.58	5.23
Season	Lognormal	389.60	5.24
Season + PlotSearchType	Loglogistic	389.62	5.26
Season + PlotSearchType + Season*PlotSearchType	Weibull	390.24	5.89
Intercept-only	Lognormal	390.40	6.05
PlotSearchType	Loglogistic	391.28	6.93
Season + PlotSearchType	Lognormal	391.75	7.40
PlotSearchType	Lognormal	392.43	8.08
Season + PlotSearchType + Season*PlotSearchType	Loglogistic	393.96	9.61
Season + PlotSearchType + Season*PlotSearchType	Lognormal	395.94	11.59

AIC = Akaike Information Criteria

Table 9d. Carcass persistence models and parameters for raptors at the Red Pine Wind Energy Facility. Selected models are denoted by an asterisk in the 'Delta (Δ) AICc' column.

Covariate	Distribution	AICc	Δ AICc
Intercept-only	Exponential	88.33	0*
Season	Exponential	89.95	1.61
Intercept-only	Weibull	90.83	2.50
Intercept-only	Loglogistic	92.41	4.08
Season	Weibull	93.20	4.87
Intercept-only	Lognormal	94.05	5.72
Season	Loglogistic	94.60	6.26
Season	Lognormal	95.64	7.31

AIC = Akaike Information Criteria

Table 9e. Carcass removal top model with covariates, distributions, and model parameters for the Red Pine Wind Project.

Size	Distribution	Predicted Persistence Time (Days)	Scale Parameter
Bat	Exponential	7.81	1.0
Small Bird	Exponential	10.94	1.0
Large Bird	Exponential	17.49	1.0
Raptor	Exponential	91.18	1.0

Adjustment for Searched Area Results

The Gompertz distribution was the best-fit distribution to estimate the density of both bat and small bird carcasses as a function of distance to turbine (Appendix C). There was not a sufficient number of carcasses to model the density distribution for large birds and therefore, the Hull and Muir 2013 model was used to estimate the maximum distance a carcass would fall from the turbine; a linear decrease in density of carcasses from the turbine base out to the maximum predicted fall distance was assumed (Table 10a and 10b). The large bird Hull and Muir estimate was used as a surrogate for raptor carcasses found. While the Project includes both 100 and 110 meter blade diameters the difference in area correction between the two diameters was negligible.

Table 10a. Hull and Muir area correction estimates for the Red Pine Wind Energy Facility.

Size Class	Hub Height (meters)	Blade Diameter (meters)	Cleared Plot Area Correction	Road & Pad Area Correction
Large Bird/Raptor	80	100	1	0.13

Table 10b. TWL area correction estimates for the Red Pine Wind Energy Facility.

Size Class	Hub Height (meters)	Blade Diameter (meters)	Cleared Plot Area Correction	Road & Pad Area Correction

Table 10b. TWL area correction estimates for the Red Pine Wind Energy Facility.

Size Class	Hub Height (meters)	Blade Diameter (meters)	Cleared Plot Area Correction	Road & Pad Area Correction
Bat	80	100	1	0.04
Small Bird	80	100	1	0.03

Adjusted Fatality Estimates

Estimates of mortality and CI were calculated for bats, small birds, large birds, raptors, and all birds using the Huso estimator (Huso 2011, Huso et al. 2012; See Appendix E). Fatality estimates were calculated using adjustments for carcass persistence, searcher efficiency, and the density-weighted proportion (Appendix B). Adjusted fatality estimates were calculated for each of the plot types (cleared plot, road and pad) as well as for the entire facility. The adjusted fatality rate for the entire facility was calculated using a weighted average of the adjusted fatality rates for the search types. Weights were assigned as the proportion of all turbines covered by each search type. No bats and no birds were excluded from the fatality estimates because they were estimated to have occurred before the start of the study period. The adjusted fatality rate for cleared plots was 22.71, 8.28, 0.65, and 0.20 fatalities/turbine/study period for bats, small birds, large birds, and raptors respectively (Table 11a). The adjusted fatality rate for road and pad surveys was 37.47 and 5.35 fatalities/turbine/study period for bats and small birds, respectively (Table 11b).

Table 11a. Overall adjusted mortality estimates using the Huso estimator for cleared plot surveys at the Red Pine Wind Project, March 18 to November 15, 2018.

	Estimate #/turbine (90% CI)	Estimate #/MW (90% CI)
All Bats	**22.71 (10.42 – 48.51)**	**11.35 (5.21 – 24.25)**
Small Birds	8.28 (4.21 – 13.10)	4.14 (2.10 – 6.55)
Large Birds	0.65 (0.11 – 1.19)	0.33 (0.06 – 0.59)
Raptors	0.20 (0 – 0.41)	0.10 (0 – 0.20)
All Birds	**8.94 (4.50 – 14.02)**	**4.47 (2.25 – 7.01)**

Note: CI = Confidence Interval, MW = megawatt

Table 11b. Overall adjusted mortality estimates using the Huso estimator for road and pad surveys at the Red Pine Wind Project, March 18 to November 15, 2018.

	Estimate #/turbine (90% CI)	Estimate #/MW (90% CI)
All Bats	**37.47 (25.33 – 55.09)**	**18.74 (12.67 – 27.54)**
Small Birds	5.35 (1.13 – 10.22)	2.68 (0.56 – 5.11)
Large Birds	–	–
Raptors	–	–
All Birds	**5.35 (1.13 – 10.22)**	**2.68 (0.56 – 5.11)**

Note: CI = Confidence Interval, MW = megawatt

Table 11c. Overall adjusted mortality estimates using the Shoenfeld estimator for cleared plot surveys at the Red Pine Wind Project, March 18 to November 15, 2018.

	Estimate #/turbine (90% CI)	Estimate #/MW (90% CI)
All Bats	**16.83 (8.90 – 26.52)**	**8.42 (4.45 – 13.26)**
Small Birds	7.06 (3.65 – 11.06)	3.53 (1.82 – 5.53)
Large Birds	0.73 (0.21 – 1.37)	0.36 (0.10 – 0.69)
Raptors	0.20	0.10
All Birds	**7.79 (4.00 – 12.08)**	**3.90 (2.00 – 6.04)**

Note: CI = Confidence Interval, MW = megawatt

Table 11d. Overall adjusted mortality estimates using the Shoenfeld estimator for road and pad surveys at the Red Pine Wind Project, March 18 to November 15, 2018.

	Estimate #/turbine (90% CI)	Estimate #/MW (90% CI)
All Bats	**34.71 (24.69 – 44.66)**	**17.36 (12.34 – 22.33)**
Small Birds	5.13 (1.03 – 10.26)	2.57 (0.51 – 5.13)
Large Birds	–	–
Raptors	–	–
All Birds	**5.13 (1.03 – 10.26)**	**2.57 (0.51 – 5.13)**

Note: CI = Confidence Interval, MW = megawatt

DISCUSSION

The primary objective of the 2018 PCM survey was to estimate the overall bird and bat mortality rates at the Project. The adjusted all bird fatality rate estimates of 4.47 birds/MW/study period (90% CI of 2.25 – 7.01, using the Huso estimator) at the cleared plot turbines and 2.68 birds/MW/study period (90% CI of 0.56 – 5.11, using the Huso estimator) the road and pad turbines are both within the range of other facilities in the Midwest and Minnesota (Appendix D). It should be noted, the all bird fatality estimate was driven by the small-bird estimate (4.14 birds/MW/study period with 90% CI of 2.10 – 6.55 using the Huso estimator) for the cleared plot searches, which were in turn driven by the number of small-bird casualties found on the cleared survey plots compared to large birds and raptors. For road and pad searches, no large birds or raptors were found so the all bird estimate (2.68 birds/MW/Study period with 90% CI of 0.56 – 5.11, using the Huso estimator) is based only on small birds. We do not have regional comparisons from other facilities for large birds only, but the large-bird estimate is low compared to the all bird estimates for other facilities in the region (0.33 birds/MW/study period with 90% CI of 0.06 – 0.59 using the Huso estimator). Raptor fatality estimates (0.10 birds/MW/study period with 90% CI of 0.00 – 0.20, using the Huso estimator) for cleared plots are moderate when compared to other facilities within the region and Minnesota specifically. All birds documented as fatalities were spread among multiple species that are common in the region. Therefore, we do not believe impacts to particular avian species populations from the Project were significant.

The cleared plot estimate of 11.35 bats/MW/study period (90% CI of 5.21 – 24.25, using the Huso estimator) and the bat fatality rate estimate at the road and pad searches of 18.74 bats/MW/study period (90% CI of 12.67 – 27.54, using the Huso estimator) are within the range of other facilities in the region, but relatively high (Appendix D). Bats found during searches included only four species that are common in the region (hoary, eastern red, silver-haired, and big brown bat [state-listed]). The relative proportion of species fatalities was similar to that found at many other wind facilities in the region.

As noted above, comparisons between fatality rates documented at other projects should be done qualitatively as different survey designs were likely used. All bird and raptor fatality rates documented at the Project in 2018 are within the range of others documented in both Minnesota and the Midwest Region (Appendix D1 and D2). Bat fatality estimates for both search types in 2018 are relatively high compared to other publicly available wind facilities in Minnesota (Appendix D3). When looking at publicly available data from projects in the Midwest, the Project's bat fatality estimates are still relatively high, although the bat fatality levels documented in 2018 at the Project are more within the range of what has been found at other wind projects, particularly more recent studies (those conducted in the past 5 years). As Appendix D3 shows, the majority of the projects with fatality estimates of less than 5.0 bats/MW/study period occurred prior to 2005, while the majority of the publicly available studies that occurred after 2012 had estimated bat fatalities of greater than 10.0 bats/MW/study period; there are eight projects (four in Iowa, two in Wisconsin, one in Minnesota and one in Indiana)

with bat fatality estimates of more than 20 bats/MW/study period. The reasons for this apparent trend of increasing bat fatality/MW associated with more recent studies are not known, but are likely related to one or more of the following: changing turbine technology potentially affecting bat fatality, updates to the statistical methodology used to estimate fatality rates, and changes to survey methodology (length of survey period, approach to bias trials, search interval, cleared plot size and/or use of road and pad searches, etc.; see Appendix D5) affecting how many bats are found. When compared to the studies that occurred after 2012, the Red Pine estimated bat fatality rates are within the midrange of what has been found at other projects in the Midwest.

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Appendix A. Complete Fatality Listing for the Red Pine Wind Project for Studies Conducted March 18 – November 18, 2018

Appendix A. Complete listing of carcasses found at the Red Pine Wind Project.

Date Found	Common Name	Search Location	Distance from Turbine (m)	Type of Find	Search Type	Condition
2018-04-24	Northern flicker	39	-	Incidental	n/a	Intact
2018-04-26	American coot	5	61	Carcass search	Cleared plot	Intact
2018-04-26	Brown creeper	5	64	Carcass search	Cleared plot	Scavenged
2018-04-28	Chipping sparrow	5	52	Carcass search	Cleared plot	Intact
2018-04-30	Chipping sparrow	5	59	Carcass search	Cleared plot	Intact
2018-05-01	Clay-colored sparrow	45	75	Carcass search	Cleared plot	Intact
2018-05-01	Le Conte's sparrow	16	37	Carcass search	Cleared plot	Dismembered
2018-05-02	Ruby-crowned kinglet	92	43	Carcass search	Cleared plot	Scavenged
2018-05-05	Big brown bat	5	25	Carcass search	Cleared plot	Intact
2018-05-06	Ruby-crowned kinglet	71	61	Carcass search	Cleared plot	Intact
2018-05-07	Brown creeper	25	9	Carcass search	Road/pad	Dismembered
2018-05-07	Clay-colored sparrow	16	61	Carcass search	Cleared plot	Intact
2018-05-07	Unidentified flycatcher	16	69	Carcass search	Cleared plot	Intact
2018-05-08	Marsh wren	8	125	Incidental	Road/pad	Intact
2018-05-08	Sedge wren	85	59	Carcass search	Cleared plot	Intact
2018-05-08	Marsh wren	97	41	Carcass search	Cleared plot	Intact
2018-05-08	Gray catbird	92	45	Carcass search	Cleared plot	Intact
2018-05-10	Sedge wren	5	60	Carcass search	Cleared plot	Intact
2018-05-10	American redstart	16	47	Carcass search	Cleared plot	Intact
2018-05-14	Unidentified wren	5	52	Carcass search	Cleared plot	Scavenged
2018-05-14	Unidentified kingbird	5	39	Carcass search	Cleared plot	Scavenged
2018-05-14	Silver-haired bat	26	40	Carcass search	Cleared plot	Scavenged
2018-05-14	Silver-haired bat	48	41	Carcass search	Cleared plot	Scavenged
2018-05-14	Blackpoll warbler	5	53	Carcass search	Cleared plot	Intact
2018-05-09	House wren	71	62	Carcass search	Cleared plot	Intact
2018-05-09	Marsh wren	71	55	Carcass search	Cleared plot	Intact
2018-05-09	Swamp sparrow	97	56	Carcass search	Cleared plot	Intact
2018-05-09	Sedge wren	92	38	Carcass search	Cleared plot	Scavenged
2018-05-09	Unidentified sparrow	92	56	Carcass search	Cleared plot	Intact
2018-05-15	Silver-haired bat	5	4	Carcass search	Cleared plot	Intact
2018-05-15	Big brown bat	5	42	Carcass search	Cleared plot	Intact
2018-05-16	Lincoln's sparrow	27	4	Carcass search	Road/pad	Scavenged
2018-05-16	Silver-haired bat	97	38	Carcass search	Cleared plot	Intact
2018-05-17	Tennessee warbler	48	49	Carcass search	Cleared plot	Dismembered
2018-05-17	Hoary bat	48	21	Carcass search	Cleared plot	Intact
2018-05-19	Silver-haired bat	54	40	Carcass search	Cleared plot	Intact
2018-05-19	American coot	26	42	Carcass search	Cleared plot	Intact
2018-05-19	Song sparrow	16	59	Carcass search	Cleared plot	Intact

Appendix A. Complete listing of carcasses found at the Red Pine Wind Project.

Date Found	Common Name	Search Location	Distance from Turbine (m)	Type of Find	Search Type	Condition
2018-05-19	Ruby-crowned kinglet	16	48	Carcass search	Cleared plot	Intact
2018-05-19	Common yellowthroat	16	37	Carcass search	Cleared plot	Scavenged
2018-05-22	Silver-haired bat	74	52	Carcass search	Road/pad	Intact
2018-05-07	Red-tailed hawk	16	12	Carcass search	Cleared plot	Dismembered
2018-07-10	Big brown bat	5	39	Carcass search	Cleared plot	Scavenged
2018-07-11	Eastern red bat	99	15	Carcass search	Road/pad	Intact
2018-07-11	Eastern red bat	99	8	Carcass search	Road/pad	Intact
2018-05-31	Marsh wren	54	73	Carcass search	Cleared plot	Intact
2018-06-07	Mallard	26	20	Carcass search	Cleared plot	Dismembered
2018-06-13	Swainson's hawk	105	28	Carcass search	Road/pad	Dismembered
2018-06-15	Big brown bat	97	11	Carcass search	Cleared plot	Scavenged
2018-06-19	Hoary bat	16	20	Carcass search	Cleared plot	Intact
2018-06-22	Big brown bat	45	1	Carcass search	Cleared plot	Scavenged
2018-06-23	Hoary bat	16	25	Carcass search	Cleared plot	Intact
2018-07-09	Eastern red bat	5	16	Carcass search	Cleared plot	Intact
2018-07-12	Eastern red bat	16	37	Carcass search	Cleared plot	Scavenged
2018-07-16	American robin	16	71	Carcass search	Cleared plot	Intact
2018-07-17	Hoary bat	92	36	Carcass search	Cleared plot	Intact
2018-07-21	Hoary bat	26	46	Carcass search	Cleared plot	Scavenged
2018-07-22	Hoary bat	97	23	Carcass search	Cleared plot	Dismembered
2018-07-22	Hoary bat	85	25	Carcass search	Cleared plot	Intact
2018-07-22	Hoary bat	85	15	Carcass search	Cleared plot	Scavenged
2018-07-22	Hoary bat	85	44	Carcass search	Cleared plot	Scavenged
2018-07-22	Eastern red bat	45	36	Carcass search	Cleared plot	Intact
2018-05-18	Ruby-crowned kinglet	85	51	Carcass search	Cleared plot	Intact
2018-05-18	Marsh wren	85	50	Carcass search	Cleared plot	Intact
2018-05-18	Marsh wren	97	51	Carcass search	Cleared plot	Intact
2018-05-18	Silver-haired bat	97	47	Carcass search	Cleared plot	Intact
2018-05-18	Savannah sparrow	97	69	Carcass search	Cleared plot	Intact
2018-05-18	Sedge wren	97	49	Carcass search	Cleared plot	Intact
2018-05-18	Silver-haired bat	72	41	Incidental	Road/pad	Intact
2018-05-18	Marsh wren	71	69	Carcass search	Cleared plot	Intact
2018-06-26	Hoary bat	5	25	Carcass search	Cleared plot	Intact
2018-06-27	Hoary bat	17	1	Carcass search	Road/pad	Intact
2018-07-17	Eastern red bat	26	50	Carcass search	Cleared plot	Intact
2018-06-08	Big brown bat	97	3	Incidental	Cleared plot	Intact
2018-07-23	Hoary bat	47	9	Carcass search	Road/pad	Intact
2018-07-24	Silver-haired bat	5	32	Carcass search	Cleared plot	Scavenged

Appendix A. Complete listing of carcasses found at the Red Pine Wind Project.

Date Found	Common Name	Search Location	Distance from Turbine (m)	Type of Find	Search Type	Condition
2018-07-24	Eastern red bat	5	35	Carcass search	Cleared plot	Scavenged
2018-07-24	Hoary bat	97	20	Carcass search	Cleared plot	Intact
2018-07-24	Big brown bat	92	27	Carcass search	Cleared plot	Intact
2018-07-26	Eastern red bat	26	35	Carcass search	Cleared plot	Scavenged
2018-07-26	Hoary bat	54	19	Carcass search	Cleared plot	Scavenged
2018-07-27	Eastern red bat	85	19	Carcass search	Cleared plot	Intact
2018-07-31	Eastern red bat	16	45	Carcass search	Cleared plot	Dismembered
2018-08-01	Big brown bat	86	4	Carcass search	Road/pad	Scavenged
2018-08-01	Hoary bat	86	14	Carcass search	Road/pad	Scavenged
2018-08-01	Eastern red bat	97	49	Carcass search	Cleared plot	Intact
2018-08-03	Silver-haired bat	92	12	Carcass search	Cleared plot	Intact
2018-08-06	Hoary bat	52	13	Carcass search	Road/pad	Scavenged
2018-08-06	Silver-haired bat	26	9	Carcass search	Cleared plot	Scavenged
2018-08-06	Big brown bat	75	9	Carcass search	Road/pad	Scavenged
2018-08-07	Hoary bat	71	34	Carcass search	Cleared plot	Scavenged
2018-08-07	Hoary bat	48	50	Carcass search	Cleared plot	Intact
2018-08-07	Hoary bat	36	2	Carcass search	Road/pad	Scavenged
2018-08-08	Eastern red bat	97	23	Carcass search	Cleared plot	Intact
2018-08-09	Big brown bat	5	12	Carcass search	Cleared plot	Scavenged
2018-08-09	Hoary bat	18	0	Carcass search	Road/pad	Intact
2018-08-09	Hoary bat	5	15	Carcass search	Cleared plot	Scavenged
2018-08-09	Hoary bat	11	0	Carcass search	Road/pad	Scavenged
2018-08-10	Hoary bat	45	42	Carcass search	Cleared plot	Intact
2018-08-11	Hoary bat	48	42	Carcass search	Cleared plot	Scavenged
2018-08-11	Eastern red bat	5	21	Carcass search	Cleared plot	Intact
2018-08-11	Eastern red bat	5	23	Carcass search	Cleared plot	Scavenged
2018-08-13	Eastern red bat	75	0	Carcass search	Road/pad	Intact
2018-08-13	Silver-haired bat	86	49	Carcass search	Road/pad	Scavenged
2018-08-13	Big brown bat	54	3	Carcass search	Cleared plot	Scavenged
2018-08-14	Hoary bat	5	51	Carcass search	Cleared plot	Scavenged
2018-08-15	Hoary bat	71	14	Carcass search	Cleared plot	Intact
2018-08-15	Hoary bat	45	28	Carcass search	Cleared plot	Intact
2018-08-15	Big brown bat	26	39	Carcass search	Cleared plot	Scavenged
2018-08-15	Hoary bat	16	24	Carcass search	Cleared plot	Intact
2018-08-15	Hoary bat	16	20	Carcass search	Cleared plot	Intact
2018-08-16	Big brown bat	26	30	Carcass search	Cleared plot	Scavenged
2018-08-16	Hoary bat	5	37	Carcass search	Cleared plot	Intact
2018-08-17	Hoary bat	40	2	Carcass search	Road/pad	Intact

Appendix A. Complete listing of carcasses found at the Red Pine Wind Project.

Date Found	Common Name	Search Location	Distance from Turbine (m)	Type of Find	Search Type	Condition
2018-08-17	Hoary bat	40	0	Carcass search	Road/pad	Dismembered
2018-08-17	Hoary bat	41	8	Carcass search	Road/pad	Intact
2018-08-17	Big brown bat	27	42	Carcass search	Road/pad	Intact
2018-08-17	Hoary bat	106	18	Carcass search	Road/pad	Intact
2018-08-17	Hoary bat	11	55	Carcass search	Road/pad	Intact
2018-08-17	Hoary bat	10	0	Carcass search	Road/pad	Intact
2018-08-17	Hoary bat	8	3	Carcass search	Road/pad	Intact
2018-08-17	Hoary bat	25	4	Carcass search	Road/pad	Intact
2018-08-19	Hoary bat	85	0	Carcass search	Cleared plot	Scavenged
2018-08-20	Cliff swallow	48	26	Carcass search	Cleared plot	Intact
2018-08-20	Hoary bat	16	27	Carcass search	Cleared plot	Scavenged
2018-08-20	Hoary bat	16	5	Carcass search	Cleared plot	Scavenged
2018-08-20	Hoary bat	75	10	Carcass search	Road/pad	Scavenged
2018-08-20	Hoary bat	54	42	Carcass search	Cleared plot	Scavenged
2018-08-21	Hoary bat	85	35	Carcass search	Cleared plot	Intact
2018-08-21	Silver-haired bat	48	35	Carcass search	Cleared plot	Intact
2018-08-21	Hoary bat	41	3	Carcass search	Road/pad	Scavenged
2018-08-21	Silver-haired bat	27	51	Carcass search	Road/pad	Dismembered
2018-08-21	Silver-haired bat	17	36	Carcass search	Road/pad	Dismembered
2018-08-21	Hoary bat	16	37	Carcass search	Cleared plot	Intact
2018-08-22	Silver-haired bat	92	27	Carcass search	Cleared plot	Intact
2018-08-22	Bank swallow	94	8	Carcass search	Road/pad	Scavenged
2018-08-23	Silver-haired bat	5	18	Carcass search	Cleared plot	Scavenged
2018-08-23	Ovenbird	5	35	Carcass search	Cleared plot	Intact
2018-08-23	Silver-haired bat	11	22	Carcass search	Road/pad	Scavenged
2018-08-23	Sora	8	188	Incidental	Road/pad	Intact
2018-08-23	Hoary bat	26	48	Carcass search	Cleared plot	Scavenged
2018-08-23	Big brown bat	26	21	Carcass search	Cleared plot	Intact
2018-08-23	Hoary bat	54	35	Carcass search	Cleared plot	Scavenged
2018-08-25	Eastern red bat	16	33	Carcass search	Cleared plot	Intact
2018-08-26	Hoary bat	45	15	Carcass search	Cleared plot	Intact
2018-08-26	Big brown bat	97	15	Carcass search	Cleared plot	Intact
2018-08-27	Silver-haired bat	5	28	Carcass search	Cleared plot	Scavenged
2018-08-27	Marsh wren	5	58	Carcass search	Cleared plot	Feather spot
2018-08-27	Hoary bat	16	49	Carcass search	Cleared plot	Scavenged
2018-08-27	Silver-haired bat	74	2	Carcass search	Road/pad	Intact
2018-08-27	Silver-haired bat	54	22	Carcass search	Cleared plot	Scavenged
2018-08-27	Hoary bat	54	48	Carcass search	Cleared plot	Scavenged

Appendix A. Complete listing of carcasses found at the Red Pine Wind Project.

Date Found	Common Name	Search Location	Distance from Turbine (m)	Type of Find	Search Type	Condition
2018-08-28	Eastern red bat	75	35	Carcass search	Road/pad	Intact
2018-08-28	Hoary bat	5	44	Carcass search	Cleared plot	Intact
2018-08-28	Silver-haired bat	5	47	Carcass search	Cleared plot	Intact
2018-08-28	Unidentified warbler	27	21	Carcass search	Road/pad	Scavenged
2018-08-28	Eastern red bat	85	8	Carcass search	Cleared plot	Injured
2018-08-28	Eastern red bat	85	41	Carcass search	Cleared plot	Injured
2018-08-29	Eastern red bat	14	21	Carcass search	Road/pad	Intact
2018-08-29	Eastern red bat	10	33	Carcass search	Road/pad	Scavenged
2018-08-29	Eastern red bat	94	48	Carcass search	Road/pad	Intact
2018-08-29	Hoary bat	20	19	Carcass search	Road/pad	Intact
2018-08-29	Eastern red bat	71	7	Carcass search	Cleared plot	Scavenged
2018-08-29	Hoary bat	71	33	Carcass search	Cleared plot	Intact
2018-08-30	Hoary bat	16	14	Carcass search	Cleared plot	Scavenged
2018-08-30	Eastern red bat	26	53	Carcass search	Cleared plot	Intact
2018-08-31	Eastern red bat	97	47	Carcass search	Cleared plot	Intact
2018-09-01	Big brown bat	5	25	Carcass search	Cleared plot	Intact
2018-09-01	Big brown bat	5	27	Carcass search	Cleared plot	Intact
2018-09-03	Eastern red bat	5	14	Carcass search	Cleared plot	Intact
2018-09-03	Mourning dove	45	48	Carcass search	Cleared plot	Scavenged
2018-09-03	Big brown bat	71	8	Incidental	Cleared plot	Intact
2018-09-04	Silver-haired bat	45	37	Carcass search	Cleared plot	Intact
2018-09-04	Hoary bat	71	34	Carcass search	Cleared plot	Intact
2018-09-04	Big brown bat	86	52	Carcass search	Road/pad	Scavenged
2018-09-04	Hoary bat	26	37	Carcass search	Cleared plot	Scavenged
2018-09-05	Red-eyed vireo	10	57	Carcass search	Road/pad	Dismembered
2018-09-05	Silver-haired bat	54	11	Incidental	Cleared plot	Intact
2018-09-06	Silver-haired bat	5	22	Carcass search	Cleared plot	Intact
2018-09-06	Eastern red bat	26	5	Carcass search	Cleared plot	Intact
2018-09-06	Big brown bat	54	1	Carcass search	Cleared plot	Intact
2018-09-06	Silver-haired bat	54	20	Carcass search	Cleared plot	Scavenged
2018-09-08	Silver-haired bat	54	35	Carcass search	Cleared plot	Intact
2018-09-08	Red-breasted nuthatch	48	24	Carcass search	Cleared plot	Scavenged
2018-09-08	Eastern red bat	26	43	Carcass search	Cleared plot	Intact
2018-09-08	Big brown bat	5	3	Carcass search	Cleared plot	Scavenged
2018-09-09	Hoary bat	85	24	Carcass search	Cleared plot	Intact
2018-09-09	Eastern red bat	85	34	Carcass search	Cleared plot	Intact
2018-09-10	Silver-haired bat	41	44	Carcass search	Road/pad	Scavenged
2018-09-10	Silver-haired bat	41	10	Carcass search	Road/pad	Intact

Appendix A. Complete listing of carcasses found at the Red Pine Wind Project.

Date Found	Common Name	Search Location	Distance from Turbine (m)	Type of Find	Search Type	Condition
2018-09-10	Eastern red bat	5	29	Carcass search	Cleared plot	Intact
2018-09-10	Silver-haired bat	20	2	Incidental	Road/pad	Scavenged
2018-09-11	Big brown bat	93	57	Carcass search	Road/pad	Dismembered
2018-09-11	Ring-necked pheasant	26	75	Carcass search	Cleared plot	Dismembered
2018-09-13	Turkey vulture	47	15	Carcass search	Road/pad	Intact
2018-09-15	Eastern red bat	16	18	Carcass search	Cleared plot	Intact
2018-09-16	Eastern red bat	45	34	Carcass search	Cleared plot	Intact
2018-09-17	Eastern red bat	50	0	Carcass search	Road/pad	Intact
2018-09-17	Hoary bat	105	41	Carcass search	Road/pad	Scavenged
2018-09-17	Virginia rail	51	31	Carcass search	Road/pad	Scavenged
2018-09-18	Hoary bat	5	34	Carcass search	Cleared plot	Scavenged
2018-09-18	Silver-haired bat	5	10	Carcass search	Cleared plot	Intact
2018-09-19	Red-eyed vireo	97	41	Carcass search	Cleared plot	Intact
2018-09-19	Silver-haired bat	18	3	Carcass search	Road/pad	Intact
2018-09-19	Northern waterthrush	85	28	Carcass search	Cleared plot	Intact
2018-09-19	Eastern red bat	71	30	Carcass search	Cleared plot	Scavenged
2018-09-24	Ruby-crowned kinglet	5	57	Carcass search	Cleared plot	Intact
2018-09-24	Eastern red bat	16	51	Carcass search	Cleared plot	Dismembered
2018-09-24	Nashville warbler	54	47	Carcass search	Cleared plot	Intact
2018-09-24	Unidentified passerine	54	37	Carcass search	Cleared plot	Scavenged
2018-09-25	Unidentified warbler	85	52	Carcass search	Cleared plot	Scavenged
2018-09-25	Yellow-throated vireo	85	24	Carcass search	Cleared plot	Scavenged
2018-09-27	Silver-haired bat	66	6	Carcass search	Road/pad	Intact
2018-09-25	Eastern red bat	16	29	Carcass search	Cleared plot	Scavenged
2018-09-27	Philadelphia vireo	26	34	Carcass search	Cleared plot	Intact
2018-09-27	Hermit thrush	54	26	Carcass search	Cleared plot	Scavenged
2018-09-28	Blue-headed vireo	85	37	Carcass search	Cleared plot	Scavenged
2018-09-28	Eastern red bat	92	47	Carcass search	Cleared plot	Intact
2018-09-28	Ruby-crowned kinglet	92	44	Carcass search	Cleared plot	Scavenged
2018-09-28	Eastern red bat	97	59	Carcass search	Cleared plot	Intact
2018-09-29	Eastern red bat	48	40	Carcass search	Cleared plot	Scavenged
2018-10-02	Eastern red bat	26	63	Carcass search	Cleared plot	Intact
2018-10-02	Silver-haired bat	48	42	Carcass search	Cleared plot	Dismembered
2018-10-03	Eastern red bat	19	42	Carcass search	Road/pad	Intact
2018-10-04	Le Conte’s sparrow	48	20	Carcass search	Cleared plot	Intact
2018-10-06	Hoary bat	48	35	Carcass search	Cleared plot	Scavenged
2018-10-07	Silver-haired bat	45	48	Carcass search	Cleared plot	Scavenged
2018-10-08	Ruby-crowned kinglet	54	15	Carcass search	Cleared plot	Intact

Appendix A. Complete listing of carcasses found at the Red Pine Wind Project.

Date Found	Common Name	Search Location	Distance from Turbine (m)	Type of Find	Search Type	Condition
2018-10-09	Eastern red bat	48	43	Carcass search	Cleared plot	Scavenged
2018-10-09	Red-eyed vireo	85	51	Carcass search	Cleared plot	Intact
2018-10-12	Savannah sparrow	71	57	Carcass search	Cleared plot	Intact
2018-10-12	Ruby-crowned kinglet	71	35	Carcass search	Cleared plot	Scavenged
2018-10-12	Nashville warbler	92	48	Carcass search	Cleared plot	Intact
2018-10-13	Sharp-shinned hawk	5	54	Carcass search	Cleared plot	Intact
2018-10-15	Eastern red bat	26	37	Carcass search	Cleared plot	Intact
2018-10-15	Red-eyed vireo	5	29	Carcass search	Cleared plot	Intact
2018-10-15	Lincoln's sparrow	5	34	Carcass search	Cleared plot	Intact
2018-10-15	Golden-crowned kinglet	5	40	Carcass search	Cleared plot	Dismembered
2018-10-18	Ruby-crowned kinglet	26	62	Carcass search	Cleared plot	Scavenged
2018-10-18	Big brown bat	5	51	Carcass search	Cleared plot	Intact
2018-08-29	Eastern red bat	106	42	Carcass search	Road/pad	Scavenged
2018-07-24	Hoary bat	105	2	Carcass search	Road/pad	Injured
2018-09-06	Silver-haired bat	75	2	Carcass search	Road/pad	Scavenged
2018-09-06	Silver-haired bat	69	23	Carcass search	Road/pad	Scavenged
2018-09-06	Hoary bat	86	2	Incidental	Road/pad	Intact
2018-10-30	Golden-crowned kinglet	71	58	Carcass search	Cleared plot	Scavenged
2018-11-01	Golden-crowned kinglet	41	38	Carcass search	Road/pad	Intact

M = meters

Appendix B. Huso Estimates for the 2018 Post-Construction Surveys at the Red Pine Wind Project

Appendix B1. Estimated fatality rates and correction factors, with 90% confidence intervals (CI), for cleared plot studies conducted at the Red Pine Wind Energy Facility, Lincoln County, Minnesota, from March 18, 2018 to November 15, 2018.

	Spring – cleared plot		Summer – cleared plot		Fall – cleared plot	
Parameter	**Estimate**	**90% CI**	**Estimate**	**90% CI**	**Estimate**	**90% CI**
Search Area Adjustment						
A (Bat)	1.00	NA – NA	1.00	NA – NA	1.00	NA – NA
A (LB)	1.00	NA – NA	1.00	NA – NA	1.00	NA – NA
A (RAPT)	1.00	NA – NA	1.00	NA – NA	1.00	NA – NA
A (SB)	1.00	NA – NA	1.00	NA – NA	1.00	NA – NA
Observer Detection Rate						
P (Bat)	0.70	0.50 – 0.91	0.80	0.63 – 0.94	0.39	0.18 – 0.59
P (LB)	0.99	0.96 – 1.00	0.99	0.96 – 1.00	0.99	0.96 – 1.00
P (RAPT)	1.00	1.00 – 1.00	1.0	1.0 – 1.0	1.00	1.00 – 1.00
P (SB)	0.69	0.56 – 0.81	0.69	0.56 – 0.81	0.69	0.56 – 0.81
Probability of a Carcass Persisting Through the Search Interval						
Bat	0.88	0.86 – 0.90	0.88	0.86 – 0.90	0.88	0.86 – 0.90
LB	0.95	0.93 – 0.96	0.95	0.94 – 0.98	0.95	0.94 – 0.98
RAPT	0.99	0.97 – 0.99	0.99	0.97 – 0.99	0.99	0.97 – 0.99
SB	0.91	0.90 – 0.93	0.91	0.90 – 0.93	0.91	0.90 – 0.93
Probability of Available and Detected						
Bat	0.62	0.44 – 0.80	0.71	0.53 – 0.84	0.35	0.16 – 0.53
LB	0.93	0.91 – 0.95	0.93	0.92 – 0.97	0.93	0.92 – 0.97
RAPT	0.99	0.97 – 0.99	0.99	0.97 – 0.99	0.99	0.97 – 0.99
SB	0.63	0.51 – 0.74	0.63	0.51 – 0.74	0.63	0.51 – 0.74
Unadjusted Number of Fatalities						
Bat	1.00	0 – 3.00	24.00	10.00 – 40.00	67.00	34.00 – 105.00
LB	2.00	0 – 4.00	2.00	0 – 6.00	2.00	0 – 4.00
RAPT	1.00	0 – 3.00	0.00	0.00	1.00	0 – 3.00
SB	18.00	7.00 – 30.00	11.00	4.00 – 20	23.00	11.00 – 36.00
Observed Fatality Rates (Fatalities/Turbine/Season(s))						
Bat	0.10	0 – 0.30	2.40	1.00 – 4.00	6.70	3.40 – 10.40
LB	0.20	0 – 0.40	0.20	0 – 0.60	0.20	0 – 0.40
RAPT	0.10	0 – 0.30	0.00	0.00	0.10	0 – 0.30
SB	1.80	0.60 – 2.90	1.10	0.40 – 2.00	2.30	1.10 – 3.60
Adjusted Fatality Rates (Fatalities/Turbine/Seasons(s))						
Bat	0.16	0 – 0.46	3.38	1.37 – 6.25	19.17	8.12 – 45.00
LB	0.21	0 – 0.44	0.22	0 – 0.63	0.22	0 – 0.44
Bird	3.05	1.04 – 5.21	1.98	0.74 – 3.42	3.90	1.79 – 6.42
RAPT	0.10	0 – 0.30	0.00	0.00	0.10	0 – 0.30
SB	2.84	1.01 – 4.87	1.76	0.61 – 3.21	3.68	1.66 – 6.12
Adjusted Fatality Rates (Fatalities/Megawatt/Seasons(s))						
Bat	0.08	0 – 0.23	1.69	0.69 – 3.12	9.58	4.06 – 22.5
LB	0.11	0 – 0.22	0.11	0 – 0.32	0.11	0 – 0.22
Bird	1.53	0.52 – 2.60	0.99	0.37 – 1.71	1.95	0.89 – 3.21
RAPT	0.05	0 – 0.15	0.00	0.00	0.05	0 – 0.15
SB	1.42	0.51 – 2.44	0.88	0.31 – 1.61	1.84	0.83 – 3.06

LB = large bird; RAPT = raptor; SB = small bird; A = search area adjustment; P = observer detection rate

Table B2. Estimated fatality rates and correction factors, with 90% confidence intervals (CI), for road and pad studies conducted at the Red Pine Wind Energy Facility, Lincoln County, Minnesota, from March 18, 2018 to November 15, 2018.

Parameter	Spring – road and pad Estimate	Spring – road and pad 90% CI	Summer – road and pad Estimate	Summer – road and pad 90% CI	Fall – road and pad Estimate	Fall – road and pad 90% CI
Search Area Adjustment						
A (Bat)	0.04	0.03 – 0.08	0.04	0.03 – 0.08	0.04	0.03 – 0.08
A (LB)	0.13	NA – NA	0.13	NA – NA	0.13	NA – NA
A (RAPT)	0.13	NA – NA	0.13	NA – NA	0.13	NA – NA
A (SB)	0.03	0.02 – 0.09	0.03	0.02 – 0.09	0.03	0.02 – 0.09
Observer Detection Rate						
P (Bat)	0.91	0.78 – 0.99	0.94	0.87 – 0.99	0.72	0.54 – 0.90
P (LB)	0.99	0.96 – 1.00	0.99	0.96 – 1.00	0.99	0.96 – 1.00
P (RAPT)	1.00	1.00 – 1.00	1.00	1.00 – 1.00	1.00	1.00 – 1.00
P (SB)	0.91	0.85 – 0.97	0.91	0.85 – 0.97	0.91	0.85 – 0.97
Probability of a Carcass Persisting Through the Search Interval						
Bat	0.66	0.60 – 0.71	0.66	0.60 – 0.71	0.66	0.60 – 0.71
LB	0.82	0.78 – 0.86	0.82	0.82 – 0.92	0.82	0.79 – 0.92
RAPT	0.96	0.91 – 0.96	0.96	0.91 – 0.96	0.96	0.91 – 0.96
SB	0.73	0.69 – 0.78	0.73	0.69 – 0.78	0.73	0.69 – 0.78
Probability of Available and Detected						
Bat	0.59	0.49 – 0.67	0.62	0.55 – 0.68	0.47	0.35 – 0.60
LB	0.81	0.77 – 0.85	0.81	0.80 – 0.91	0.81	0.78 – 0.91
RAPT	0.96	0.91 – 0.96	0.96	0.91 – 0.96	0.96	0.91 – 0.96
SB	0.67	0.60 – 0.74	0.67	0.60 – 0.74	0.67	0.60 – 0.74
Unadjusted Number of Fatalities						
Bat	-	-	6.00	2.00 – 10.00	27.00	19.00 – 36
SB	1.00	0 – 3.00	1.00	0 – 3.00	3.00	1.00 – 6.00
Observed Fatality Rates (Fatalities/Turbine/Season(s))						
Bat	-	-	0.15	0.05 – 0.25	0.68	0.48 – 0.90
SB	0.02	0 – 0.08	0.02	0 – 0.08	0.08	0.02 – 0.15
Adjusted Fatality Rates (Fatalities/Turbine/Seasons(s))						
Bat	-	-	5.40	1.85 – 9.19	32.07	20.59 – 48.78
SB	1.07	0 – 3.20	1.07	0 – 3.15	3.21	0.89 – 6.48
Adjusted Fatality Rates (Fatalities/MW/Seasons(s))						
Bat	-	-	2.70	0.93 – 4.59	16.04	10.30 – 24.39
SB	0.54	0 – 1.60	0.54	0 – 1.58	1.61	0.45 – 3.24

LB = large bird; RAPT = raptor; SB = small bird; A = search area adjustment; P = observer detection rate

Appendix C. Shoenfeld Estimates for the 2018 Post-Construction Surveys at the Red Pine Wind Project

Appendix C1. Estimated fatality rates and correction factors, with 90% confidence intervals (CI), for cleared plot studies conducted at the Red Pine Wind Energy Facility, Lincoln County, Minnesota, from March 18, 2018 to November 15, 2018.

	Spring – cleared plot		Summer – cleared plot		Fall – cleared plot	
Parameter	**Estimate**	**90% CI**	**Estimate**	**90% CI**	**Estimate**	**90% CI**
Search Area Adjustment						
A (Bat)	1.00	NA – NA	1.00	NA – NA	1.00	NA – NA
A (LB)	1.00	NA – NA	1.00	NA – NA	1.00	NA – NA
A (RAPT)	1.00	NA – NA	1.00	NA – NA	1.00	NA – NA
A (SB)	1.00	NA – NA	1.00	NA – NA	1.00	NA – NA
Observer Detection Rate						
P (Bat)	0.70	0.47 - 0.91	0.80	0.61 - 0.95	0.39	0.19 - 0.62
P (LB)	0.99	0.96 - 1.0	0.99	0.96 - 1.0	0.99	0.96 - 1.00
P (RAPT)	1.00	1.00 - 1.00	1.00	1.00 - 1.00	1.00	1.00- 1.00
P (SB)	0.69	0.56 - 0.81	0.69	0.56 - 0.81	0.69	0.56 - 0.81
Average Removal Time (days)						
$\bar{t}$ (BAT)	7.81	6.24 - 9.47	7.81	6.24 - 9.47	7.81	6.24 - 9.47
$\bar{t}$ (LB)	17.49	14.40 - 21.31	17.49	14.40 - 21.31	17.49	14.40 - 21.31
$\bar{t}$ (RAPT)	91.18	60.47 - 136.99	91.18	60.47 - 136.99	91.18	60.47 - 136.99
$\bar{t}$ (SB)	10.94	8.94 - 13.18	10.94	8.94 - 13.18	10.94	8.94 - 13.18
Probability of Available and Detected						
Bat	0.81	0.70 - 0.87	0.84	0.77 - 0.88	0.66	0.45 - 0.78
LB	0.94	0.93 - 0.95	0.94	0.93 - 0.95	0.94	0.93 - 0.95
RAPT	0.99	0.98 - 0.99	0.99	0.98 - 0.99	0.99	0.98 - 0.99
SB	0.85	0.80 - 0.89	0.85	0.80 - 0.89	0.85	0.80 - 0.89
Unadjusted Number of Fatalities						
Bat	3.0	1.0 - 6.0	33.0	15.0 - 52.0	82.0	42.0 - 129.05
LB	2.0	0.0 - 4.05	2.0	0.0 - 6.0	3.0	1.0 - 6.0
Bird	24.0	9.0 - 43.0	14.0	5.0 - 24.0	29.0	13.0 - 48.0
RAPT	1.0	0.0 - 3.0	0.00	0.00 - 0.00	1.0	0.0 - 3.0
SB	22.0	9.0 - 39.0	12.0	4.0 - 21.0	26.0	11.0 - 43.0
Observed Fatality Rates (Fatalities/Turbine/Season(s))						
Bat	0.30	0.10 - 0.60	3.30	1.50 - 5.20	8.20	4.20 - 12.90
LB	0.20	0.0 - 0.40	0.20	0.0 - 0.60	0.30	0.10 - 0.60
Bird	2.40	0.90 - 4.30	1.40	0.50 - 2.40	2.90	1.30 - 4.80
RAPT	0.10	0.0 - 0.30	0.00	0.00 - 0.00	0.10	0.0 - 0.30
SB	2.20	0.90 - 3.90	1.20	0.40 - 2.10	2.60	1.10 - 4.30
Adjusted Fatality Rates (Fatalities/Turbine/Seasons(s))						
Bat	0.37	0.12 - 0.74	3.95	1.79 - 6.22	12.52	6.41 - 19.70
LB	0.21	0.0 - 0.43	0.21	0.0 - 0.64	0.31	0.10 - 0.63
Bird	2.80	1.06 - 5.0	1.62	0.59 - 2.76	3.37	1.52 - 5.57
RAPT	0.10	0.0 - 0.30	0.00	0.00 - 0.00	0.10	0.0 - 0.30
SB	2.59	1.06 - 4.59	1.41	0.47 - 2.47	3.06	1.29 - 5.06
Adjusted Fatality Rates (Fatalities/Megawatt/Seasons(s))						
Bat	0.19	0.06 - 0.37	1.97	0.90 - 3.11	6.26	3.21 - 9.85
LB	0.10	0.0 - 0.21	0.11	0.0 - 0.32	0.16	0.05 - 0.31
Bird	1.40	0.53 - 2.50	0.81	0.29 - 1.38	1.69	0.76 - 2.79
RAPT	0.05	0.0 - 0.15	0.00	0.00 - 0.00	0.05	0.0 - 0.15
SB	1.29	0.53 - 2.30	0.71	0.24 - 1.24	1.53	0.65 - 2.53

LB = large bird; RAPT = raptor; SB = small bird; A = search area adjustment; P = observer detection rate

Appendix C2. Estimated fatality rates and correction factors, with 90% confidence intervals (CI), for road and pad studies conducted at the Red Pine Wind Energy Facility, Lincoln County, Minnesota, from March 18, 2018 to November 15, 2018.

	Spring – cleared plot		Summer – cleared plot		Fall – cleared plot	
Parameter	**Estimate**	**90% CI**	**Estimate**	**90% CI**	**Estimate**	**90% CI**
Search Area Adjustment						
A (Bat)	0.04	0.03 - 0.08	0.04	0.03 - 0.08	0.04	0.03 - 0.08
A (LB)	0.13	0.13 - 0.13	0.13	0.13 - 0.13	0.13	0.13 - 0.13
A (RAPT)	0.13	0.13 - 0.13	0.13	0.13 - 0.13	0.13	0.13 - 0.13
A (SB)	0.03	0.02 - 0.09	0.03	0.02 - 0.09	0.03	0.02 - 0.09
Observer Detection Rate						
P (Bat)	0.91	0.75 - 0.99	0.94	0.88 - 0.99	0.72	0.54 - 0.89
P (LB)	0.99	0.96 - 1.00	0.99	0.96 - 1.00	0.99	0.96 - 1.00
P (RAPT)	1.00	1.00 - 1.00	1.00	1.00 - 1.00	1.00	1.00 - 1.00
P (SB)	0.91	0.82 - 0.97	0.91	0.82 - 0.97	0.91	0.82 - 0.97
Mean Carcass Removal Time (days)						
$\bar{t}$ (BAT)	7.81	6.24 - 9.47	7.81	6.24 - 9.47	7.81	6.24 - 9.47
$\bar{t}$ (LB)	17.49	14.40 - 21.31	17.49	14.40 - 21.31	17.49	14.40 - 21.31
$\bar{t}$ (RAPT)	91.18	60.47 - 136.99	91.18	60.47 - 136.99	91.18	60.47 - 136.99
$\bar{t}$ (SB)	10.94	8.94 - 13.18	10.94	8.94 - 13.18	10.94	8.94 - 13.18
Probability of Available and Detected						
Bat	0.62	0.52 - 0.68	0.63	0.57 - 0.68	0.53	0.41 - 0.62
LB	0.82	0.78 - 0.85	0.82	0.78 - 0.85	0.82	0.78 - 0.85
RAPT	0.96	0.94 - 0.97	0.96	0.94 - 0.97	0.96	0.94 - 0.97
SB	0.70	0.64 - 0.75	0.70	0.64 - 0.75	0.70	0.64 - 0.75
Unadjusted Number of Fatalities						
Bat	0.00	0.00 - 0.00	6.00	2.00 - 10.00	28.00	19.00 - 37.00
SB	1.00	0.00 - 3.00	1.00	0.00 - 3.00	3.00	1.00 - 6.00
Observed Fatality Rates (Fatalities/Turbine/Season(s))						
Bat	0.00	0.00 - 0.00	0.15	0.05 - 0.25	0.70	0.47 - 0.92
SB	0.02	0.00 - 0.07	0.02	0.00 - 0.07	0.07	0.02 - 0.15
Adjusted Fatality Rates (Fatalities/Turbine/Seasons(s))						
Bat	0.00	0.00 - 0.00	5.31	1.77 - 8.85	29.40	19.95 - 38.85
SB	1.03	0.00 - 3.08	1.03	0.0 - 3.08	3.08	1.03 - 6.16
Adjusted Fatality Rates (Fatalities/Megawatt/Seasons(s))						
Bat	0.00	0.00 - 0.00	2.66	0.89 - 4.43	14.70	9.98 - 19.43
SB	0.51	0.0 0- 1.54	0.51	0.00 - 1.54	1.54	0.51 - 3.08

LB = large bird; RAPT = raptor; SB = small bird; A = search area adjustment; P = observer detection rate

Appendix D. Fatality Summary Tables for the Midwestern region of North America

Appendix D1. Wind energy facilities in the Midwestern region of North America with fatality data for all bird species.

Wind Energy Facility	Fatality Estimate[A]	No. of Turbines	Total MW
Red Pine,MN	**4.47 (cleared plot), 2.68 (road and pad)**	**100**	**200**
Macksburg, IA (2014 - 2015)	73.08	48	119.6
Lundgren, IA (2014 - 2015)	28.74	107	251.0
Walnut, IA (2014 - 2015)	21.69	102	153.0
Morning Light, IA (2014 - 2015)	20.19	44	101.2
Intrepid, IA (2015 - 2016)	18.37	122	175.5
Laurel, IA (2015 - 2016)	14.22	52	119.6
Adair, IA (2014 - 2015)	14.05	76	174.8
Wellsburg, IA (2015 - 2016)	12.3	60	140.8
Carroll, IA (2014 - 2015)	11.71	100	150.0
Macksburg, IA (2015-2016)	10.79	48	119.6
Charles City, IA (2015 - 2016)	10.41	50	75.0
Vienna II, IA (2015 - 2016)	10.28	19	44.6
Adams, IA (2015 - 2016)	10.08	64	154.3
Vienna I, IA (2015 - 2016)	9.09	45	105.6
Century, IA (2015 - 2016)	9.07	145	200.0
Lundgren, IA (2015 - 2016)	8.8	107	251.0
Highland, IA (2015 - 2016)	8.63	217	502.0
Wessington Springs, SD (2009)	8.25	34	51.00
Blue Sky Green Field, WI (2008; 2009)	7.17	88	145.00
Cedar Ridge, WI (2009)	6.55	41	67.60
Victory, IA (2014 - 2015)	6.48	66	99.0
Rolling Hills, IA (2015 - 2016)	6.3	193	443.9
Pomeroy, IA (2015-2016)	6.25	184	286.4
Rolling Hills, IA (2014 - 2015)	6.13	193	443.9
Buffalo Ridge, MN (Phase III; 1999)	5.93	138	103.50
Moraine II, MN (2009)	5.59	33	49.50
Barton I & II, IA (2010-2011)	5.50	80	160.00
Buffalo Ridge I, SD (2009-2010)	5.06	24	50.40
Black Oak Getty, MN (2017)	4.37	39	78.00
Buffalo Ridge, MN (Phase I; 1996)	4.14	73	25.00
Winnebago, IA (2009-2010)	3.88	10	20.00
Rugby, ND (2010-2011)	3.82	71	149.00
Cedar Ridge, WI (2010)	3.72	41	68.00
Elm Creek II, MN (2011-2012)	3.64	62	148.80
Eclipse, IA (2015)	3.62	87	200.1
Buffalo Ridge, MN (Phase II; 1999)	3.57	143	107.25
Buffalo Ridge, MN (Phase I; 1998)	3.14	73	25.00
Ripley, Ont (2008)	3.09	38	76.00
Fowler I, IN (2009)	2.83	162	301.00
Buffalo Ridge, MN (Phase I; 1997)	2.51	73	25.00
Buffalo Ridge, MN (Phase II; 1998)	2.47	143	107.25
PrairieWinds SD1, SD (2012-2013)	2.01	108	162.00
Buffalo Ridge II, SD (2011-2012)	1.99	105	210.00
Kewaunee County, WI (1999-2001)	1.95	31	20.46
PrairieWinds SD1, SD (2013-2014)	1.66	108	162.00
NPPD Ainsworth, NE (2006)	1.63	36	20.50
PrairieWinds ND1 (Minot), ND (2011)	1.56	80	115.50
Elm Creek, MN (2009-2010)	1.55	67	100
PrairieWinds ND1 (Minot), ND (2010)	1.48	80	115.50
Buffalo Ridge, MN (Phase I; 1999)	1.43	73	25.00

PrairieWinds SD1, SD (2011-2012)	1.41	108	162.00
Top Crop I & II (2012-2013)	1.35	68 phase I, 132 phase II	300 (102 phase I, 198 phase II)
Heritage Garden I, MI (2012-2014)	1.30	14	28.00
Wessington Springs, SD (2010)	0.89	34	51.00
Rail Splitter, IL (2012-2013)	0.84	67	100.50
Top of Iowa, IA (2004)	0.81	89	80.00
Big Blue, MN (2013)	0.60	18	36.00
Grand Ridge I, IL (2009-2010)	0.48	66	99.00
Top of Iowa, IA (2003)	0.42	89	80.00
Big Blue, MN (2014)	0.37	18	36.00
Pioneer Prairie I, IA (Phase II; 2011-2012)	0.27	62	102.30

A=number of bird fatalities/megawatt (MW)/year

Appendix D1 (*continued*). Wind energy facilities in the Midwestern region of North America with fatality data for all bird species. Data from the following sources.

Wind Energy Facility/Study	Fatality Estimate Citation	Wind Energy Facility/Study	Fatality Estimate Citation
Adair, IA (2015)	Bay et al. 2017a	Lundgren, IA (2015)	Bay et al. 2017a
Adams, IA (2016)	Bay et al. 2017b	Lundgren, IA (2016)	Bay et al. 2017a
Barton I & II, IA (2010-2011)	Derby et al. 2011b	Macksburg, IA (2015)	Bay et al. 2017a
Big Blue, MN (2013)	Fagen Engineering 2014	Macksburg, IA (2016)	Bay et al. 2017b
Big Blue, MN (2014)	Fagen Engineering 2015	Moraine II, MN (2009)	Derby et al. 2010f
Black Oak Getty, MN (2017)	Pickle et al. 2018	Morning Light, IA (2015)	Bay et al. 2017a
Blue Sky Green Field, WI (2008; 2009)	Gruver et al. 2009	NPPD Ainsworth, NE (2006)	Derby et al. 2007
Buffalo Ridge I, SD (2009-2010)	Derby et al. 2010d	Pioneer Prairie I, IA (Phase II; 2011-2012)	Chodachek et al. 2012
Buffalo Ridge II, SD (2011-2012)	Derby et al. 2012a	Pomeroy, IA (2016)	Bay et al. 2017b
Buffalo Ridge, MN (Phase I; 1996)	Johnson et al. 2000	PrairieWinds ND1 (Minot), ND (2010)	Derby et al. 2011d
Buffalo Ridge, MN (Phase I; 1997)	Johnson et al. 2000	PrairieWinds ND1 (Minot), ND (2011)	Derby et al. 2012d
Buffalo Ridge, MN (Phase I; 1998)	Johnson et al. 2000	PrairieWinds SD1, SD (2011-2012)	Derby et al. 2012c
Buffalo Ridge, MN (Phase I; 1999)	Johnson et al. 2000	PrairieWinds SD1, SD (2012-2013)	Derby et al. 2013
Buffalo Ridge, MN (Phase II; 1998)	Johnson et al. 2000	PrairieWinds SD1, SD (2013-2014)	Derby et al. 2014
Buffalo Ridge, MN (Phase II; 1999)	Johnson et al. 2000	Rail Splitter, IL (2012-2013)	Good et al. 2013b
Buffalo Ridge, MN (Phase III; 1999)	Johnson et al. 2000	Ripley, Ont (2008)	Jacques Whitford 2009
Carroll, IA (2015)	Bay et al. 2017a	Rolling Hills, IA (2015)	Bay et al. 2017a
Cedar Ridge, WI (2009)	BHE Environmental 2010	Rolling Hills, IA (2016)	Bay et al. 2017b
Cedar Ridge, WI (2010)	BHE Environmental 2010	Rugby, ND (2010-2011)	Derby et al. 2011c
Century, IA (2016)	Bay et al. 2017b	Top Crop I & II (2012-2013)	Good et al. 2013c
Charles City, IA (2016)	Bay et al. 2017b	Top of Iowa, IA (2003)	Jain 2005
Eclipse, IA (2015)	Bay et al. 2017a	Top of Iowa, IA (2004)	Jain 2005
Elm Creek II, MN (2011-2012)	BHE Environmental 2011	Victory, IA (2015)	Bay et al. 2017a
Elm Creek, MN (2009-2010)	Derby et al. 2010e	Vienna I, IA (2016)	Bay et al. 2017b
Fowler I, IN (2009)	Johnson et al. 2010a	Vienna II, IA (2016)	Bay et al. 2017b
Grand Ridge I, IL (2009-2010)	Derby et al. 2010a	Walnut, IA (2015)	Bay et al. 2017a
Heritage Garden I, MI (2012-2014)	Kerlinger et al. 2014	Wellsburg, IA (2016)	Bay et al. 2017b
Highland, IA (2016)	Bay et al. 2017b	Wessington Springs, SD (2009)	Derby et al. 2010c
Intrepid, IA (2016)	Bay et al. 2017b	Wessington Springs, SD (2010)	Derby et al. 2011a
Kewaunee County, WI (1999-2001)	Howe et al. 2002	Winnebago, IA (2009-2010)	Derby et al. 2010g
Laurel, IA (2016)	Bay et al. 2017b		

Appendix D2. Wind energy facilities in the Midwestern region of North America with fatality data for raptors.

Wind Energy Facility	Use Estimate[A]	Raptor Fatality Estimate[B]	No. of Turbines	Total MW
Red Pine, MN	**0.22**	**0.10 (cleared plots)**	**100**	**200**
Buffalo Ridge, MN (Phase I; 1999)	NA	0.47	73	25.00
Moraine II, MN (2009)	NA	0.37	33	49.50
Winnebago, IA (2009-2010)	NA	0.27	10	20.00
Buffalo Ridge I, SD (2009-2010)	NA	0.20	24	50.40
Pomeroy, IA (2016)	NA	0.19	184	286.4
Cedar Ridge, WI (2009)	NA	0.18	41	67.60
PrairieWinds SD1, SD (2013-2014)	NA	0.17	108	162.00
Top of Iowa, IA (2004)	NA	0.17	89	80.00
Cedar Ridge, WI (2010)	NA	0.13	41	68.00
Eclipse, IA (2015)	NA	0.12	87	200.1
Ripley, Ont (2008)	NA	0.10	38	76.00
Rolling Hills, IA (2016)	NA	0.08	193	443.9
Adair, IA (2015)	NA	0.07	76	174.8
Vienna II, IA (2016)	NA	0.07	19	44.6
Wessington Springs, SD (2010)	0.232	0.07	34	51.00
Rugby, ND (2010-2011)	NA	0.06	71	149.00
NPPD Ainsworth, NE (2006)	NA	0.06	36	20.50
Wessington Springs, SD (2009)	0.232	0.06	34	51.00
PrairieWinds ND1 (Minot), ND (2011)	NA	0.05	80	115.50
PrairieWinds ND1 (Minot), ND (2010)	NA	0.05	80	115.50
Rolling Hills, IA (2015)	NA	0.04	193	443.9
PrairieWinds SD1, SD (2012-2013)	NA	0.03	108	162.00
Vienna I, IA (2016)	NA	0.03	45	106.6
Intrepid, IA (2016)	NA	0.02	122	175.5
Macksburg, IA (2016)	NA	0.02	48	119.6
Century, IA (2016)	NA	0.01	145	200.0
Black Oak Getty, MN (2017)	NA	0	39	78.00
Elm Creek, MN (2009-2010)	NA	0	67	100
Rail Splitter, IL (2012-2013)	NA	0	67	100.50
Pioneer Prairie I, IA (Phase II; 2011-2012)	NA	0	62	102.30
Buffalo Ridge, MN (Phase III; 1999)	NA	0	138	103.50
Buffalo Ridge, MN (Phase II; 1998)	NA	0	143	107.25
Buffalo Ridge, MN (Phase II; 1999)	NA	0	143	107.25
Blue Sky Green Field, WI (2008; 2009)	NA	0	88	145.00
Elm Creek II, MN (2011-2012)	NA	0	62	148.80
Barton I & II, IA (2010-2011)	NA	0	80	160.00
PrairieWinds SD1, SD (2011-2012)	NA	0	108	162.00
Kewaunee County, WI (1999-2001)	NA	0	31	20.46
Buffalo Ridge II, SD (2011-2012)	NA	0	105	210.00
Buffalo Ridge, MN (Phase I; 1996)	NA	0	73	25.00
Buffalo Ridge, MN (Phase I; 1997)	NA	0	73	25.00
Buffalo Ridge, MN (Phase I; 1998)	NA	0	73	25.00
Fowler I, IN (2009)	NA	0	162	301.00
Big Blue, MN (2013)	NA	0	18	36.00
Big Blue, MN (2014)	NA	0	18	36.00
Top of Iowa, IA (2003)	NA	0	89	80.00
Grand Ridge I, IL (2009-2010)	0.195	0	66	99.00

A=number of raptors/plot/20-minute survey

B=number of fatalities/megawatt(MW)/year

Appendix D2 (*continued*). Wind energy facilities in the Midwestern region of North America with fatality data for raptors. Data from the following sources:

Wind Energy Facility/Study	Use Estimate Report Citation	Facility Estimate Report Citation	Wind Energy Facility/Study	Use Estimate Report Citation	Facility Estimate Report Citation
Adair, IA (2015)	-	Bay et al. 2017a	Kewaunee County, WI (1999-2001)	-	Howe et al. 2002
Barton I & II, IA (2010-2011)	-	Derby et al. 2011b	Macksburg, IA (2016)	-	Bay et al. 2017b
Big Blue, MN (2013)	-	Fagen Engineering 2014	Moraine II, MN (2009)	-	Derby et al. 2010f
Big Blue, MN (2014)	-	Fagen Engineering 2015	NPPD Ainsworth, NE (2006)	-	Derby et al. 2007
Black Oak Getty, MN (2017)	-	Pickle et al. 2018	Pioneer Prairie I, IA (Phase II; 2011-2012)	-	Chodachek et al. 2012
Blue Sky Green Field, WI (2008; 2009)	-	Gruver et al. 2009	Pomeroy, IA (2016)	-	Bay et al. 2017b
Buffalo Ridge I, SD (2009-2010)	-	Derby et al. 2010d	PrairieWinds ND1 (Minot), ND (2010)	-	Derby et al. 2011d
Buffalo Ridge II, SD (2011-2012)	-	Derby et al. 2012a	PrairieWinds ND1 (Minot), ND (2011)	-	Derby et al. 2012d
Buffalo Ridge, MN (Phase I; 1996)	-	Johnson et al. 2000	PrairieWinds SD1, SD (2011-2012)	-	Derby et al. 2012c
Buffalo Ridge, MN (Phase I; 1997)	-	Johnson et al. 2000	PrairieWinds SD1, SD (2012-2013)	-	Derby et al. 2013
Buffalo Ridge, MN (Phase I; 1998)	-	Johnson et al. 2000	PrairieWinds SD1, SD (2013-2014)	-	Derby et al. 2014
Buffalo Ridge, MN (Phase I; 1999)	-	Johnson et al. 2000	Rail Splitter, IL (2012-2013)	-	Good et al. 2013b
Buffalo Ridge, MN (Phase II; 1998)	-	Johnson et al. 2000	Ripley, Ont (2008)	-	Jacques Whitford 2009
Buffalo Ridge, MN (Phase II; 1999)	-	Johnson et al. 2000	Rolling Hills, IA (2015)	-	Bay et al. 2017a
Buffalo Ridge, MN (Phase III; 1999)	-	Johnson et al. 2000	Rolling Hills, IA (2016)	-	Bay et al. 2017b
Cedar Ridge, WI (2009)	-	BHE Environmental 2010	Rugby, ND (2010-2011)	-	Derby et al. 2011c
Cedar Ridge, WI (2010)	-	BHE Environmental 2011	Top of Iowa, IA (2003)	-	Jain 2005
Century, IA (2016)	-	Bay et al. 2017b	Top of Iowa, IA (2004)	-	Jain 2005
Eclipse, IA (2015)	-	Bay et al. 2017a	Vienna I, IA (2016)	-	Bay et al. 2017b
Elm Creek II, MN (2011-2012)	-	Derby et al. 2010e	Vienna II, IA (2016)	-	Bay et al. 2017b
Elm Creek, MN (2009-2010)	-	Derby et al. 2012b	Wessington Springs, SD (2009)	Derby et al. 2008	Derby et al. 2010c
Fowler I, IN (2009)	-	Johnson et al. 2010a	Wessington Springs, SD (2010)	-	Derby et al. 2011a
Grand Ridge I, IL (2009-2010)	Derby et al. 2009	Derby et al. 2010a	Winnebago, IA (2009-2010)	-	Derby et al. 2010g
Intrepid, IA (2016)	-	Bay et al. 2017b			

Appendix D3. Wind energy facilities in the Midwestern Region of North America with comparable activity and fatality data for bats. Activity estimate presented as number of bat passes per detector-night. Fatality estimate is number of fatalities per megawatt (MW) per year.

Wind Energy Facility	Bat Activity Estimate	Bat Activity Dates	Fatality Estimate	No. of Turbines	Total MW
Red Pine, MN	**4.91[D]**	**4/22 – 10/17 213**	**11.35 (cleared plot), 18.74 (road and pad)**	**100**	**200**
Macksburg, IA (2015)	NA	NA	73.08	48	119.6
Cedar Ridge, WI (2009)	9.97[A,B,C,D]	7/16/07-9/30/07	30.61	41	67.6
Black Oak Getty, MN – road and pads (2017)	8.3	04/16/12 – 10/31/12	29.88	39	78
Lundgren, IA (2015)	NA	NA	28.74	107	251.0
Blue Sky Green Field, WI (2008; 2009)	7.70[D]	7/24/07-10/29/07	24.57	88	145
Cedar Ridge, WI (2010)	9.97[A,B,C,D]	7/16/07-9/30/07	24.12	41	68
Walnut, IA (2015)	NA	NA	21.69	102	153.0
Morning Light, IA (2015)	NA	NA	20.19	44	101.2
Fowler I, II, III, IN (2011)	NA	NA	20.19	355	600
Fowler I, II, III, IN (2010)	NA	NA	18.96	355	600
Intrepid, IA (2016)	NA	NA	18.37	122	175.5
Forward Energy Center, WI (2008-2010)	6.97	8/5/08-11/08/08	18.17	86	129
Laurel, IA (2016)	NA	NA	14.22	52	119.6
Adair, IA (2015)	NA	NA	14.05	76	174.8
Black Oak Getty, MN – cleared plots (2017)	8.3	04/16/12 – 10/31/12	13.03	39	78
Top Crop I & II (2012-2013)	NA	NA	12.55	68 phase I, 132 phase II	300 (102 phase I, 198 phase II)
Wellsburg, IA (2016)	NA	NA	12.3	60	140.8
Carroll, IA (2015)	NA	NA	11.71	100	150.0
Rail Splitter, IL (2012-2013)	NA	NA	11.21	67	100.5
Harrow, Ont (2010)	NA	NA	11.13	24 (four 6-turbine facilities)	39.6
Macksburg, IA (2016)	NA	NA	10.79	48	119.6
Charles City, IA (2016)	NA	NA	10.41	50	75.0
Vienna II, IA (2016)	NA	NA	10.28	19	44.6
Top of Iowa, IA (2004)	35.70	5/26/04-9/24/04	10.27	89	80
Adams, IA (2016)	NA	NA	10.08	64	154.3
Pioneer Prairie I, IA (Phase II; 2011-2012)	NA	NA	10.06	62	102.3
Eclipse, IA (2015)	NA	NA	10.01	87	200.1
Vienna I, IA (2016)	NA	NA	9.09	45	105.6
Century, IA (2016)	NA	NA	9.07	145	200.0
Lundgren, IA (2016)	NA	NA	8.8	107	251.0
Highland, IA (2016)	NA	NA	8.63	217	502

Appendix D3. Wind energy facilities in the Midwestern Region of North America with comparable activity and fatality data for bats. Activity estimate presented as number of bat passes per detector-night. Fatality estimate is number of fatalities per megawatt (MW) per year.

Wind Energy Facility	Bat Activity Estimate	Bat Activity Dates	Fatality Estimate	No. of Turbines	Total MW
Fowler I, IN (2009)	NA	NA	8.09	162	301
Crystal Lake II, IA (2009)	NA	NA	7.42	80	200
Top of Iowa, IA (2003)	NA	NA	7.16	89	80
Victory, IA (2015)	NA	NA	6.48	66	99.0
Kewaunee County, WI (1999-2001)	NA	NA	6.45	31	20.46
Rolling Hills, IA (2016)	NA	NA	6.3	193	443.9
Pomeroy, IA (2016)	NA	NA	6.25	184	286.4
Rolling Hills, IA (2015)	NA	NA	6.13	193	443.9
Heritage Garden I, MI (2012-2014)	NA	NA	5.90	14	28
Ripley, Ont (2008)	NA	NA	4.67	38	76
Winnebago, IA (2009-2010)	NA	NA	4.54	10	20
Buffalo Ridge, MN (Phase II; 2001/Lake Benton I)	2.20[B]	6/15/01-9/15/01	4.35	143	107.25
Pioneer Prairie II, IA (2013)	NA	NA	3.83	62	102.3
Buffalo Ridge, MN (Phase III; 2001/Lake Benton II)	2.20[B]	6/15/01-9/15/01	3.71	138	103.5
Crescent Ridge, IL (2005-2006)	NA	NA	3.27	33	49.5
Fowler I, II, III, IN (2012)	NA	NA	2.96	355	600
Elm Creek II, MN (2011-2012)	NA	NA	2.81	62	148.8
Buffalo Ridge II, SD (2011-2012)	NA	NA	2.81	105	210
Buffalo Ridge, MN (Phase III; 1999)	NA	NA	2.72	138	103.5
Buffalo Ridge, MN (Phase II; 1999)	NA	NA	2.59	143	107.25
Moraine II, MN (2009)	NA	NA	2.42	33	49.5
Buffalo Ridge, MN (Phase II; 1998)	NA	NA	2.16	143	107.25
PrairieWinds ND1 (Minot), ND (2010)	NA	NA	2.13	80	115.5
Grand Ridge I, IL (2009-2010)	NA	NA	2.10	66	99
Big Blue, MN (2013)	NA	NA	2.04	18	36
Barton I & II, IA (2010-2011)	NA	NA	1.85	80	160
Fowler III, IN (2009)	NA	NA	1.84	60	99
Buffalo Ridge, MN (Phase III; 2002/Lake Benton II)	1.90[B]	6/15/02-9/15/02	1.81	138	103.5
Buffalo Ridge, MN (Phase II; 2002/Lake Benton I)	1.90[B]	6/15/02-9/15/02	1.64	143	107.25
Rugby, ND (2010-2011)	NA	NA	1.60	71	149
Elm Creek, MN (2009-2010)	NA	NA	1.49	67	100
Wessington Springs, SD (2009)	NA	NA	1.48	34	51
Big Blue, MN (2014)	NA	NA	1.43	18	36
PrairieWinds ND1 (Minot), ND (2011)	NA	NA	1.39	80	115.5
PrairieWinds SD1, SD (2011-2012)	NA	NA	1.23	108	162
NPPD Ainsworth, NE (2006)	NA	NA	1.16	36	20.5
PrairieWinds SD1, SD (2012-	NA	NA	1.05	108	162

Appendix D3. Wind energy facilities in the Midwestern Region of North America with comparable activity and fatality data for bats. Activity estimate presented as number of bat passes per detector-night. Fatality estimate is number of fatalities per megawatt (MW) per year.

Wind Energy Facility	Bat Activity Estimate	Bat Activity Dates	Fatality Estimate	No. of Turbines	Total MW
2013)					
Buffalo Ridge, MN (Phase I; 1999)	NA	NA	0.74	73	25
PrairieWinds SD1, SD (2013-2014)	NA	NA	0.52	108	162
Wessington Springs, SD (2010)	NA	NA	0.41	34	51
Buffalo Ridge I, SD (2009-2010)	NA	NA	0.16	24	50.4

A = Activity rate based on data collected at various heights all other activity rates are from ground-based units only

B = Activity rate was averaged across phases and/or years

C = Activity rate calculated by WEST from data presented in referenced report

D= Activity rate based on pre-construction monitoring; data for all other activity and fatality rates were collected concurrently

Appendix D3 (*continued*). Wind energy facilities in the Midwestern region of North America with comparable activity and fatality data for bats. Data from the following sources:

Wind Energy Facility/Study	Activity Estimate Report Citation	Fatality Estimate Report Citation	Wind Energy Facility/Study	Activity Estimate Report Citation	Fatality Estimate Report Citation
Adair, IA (2015)	NA	Bay et al. 2017a	Highland, IA (2016)	NA	Bay et al. 2017b
Adams, IA (2016)	NA	Bay et al. 2017b	Intrepid, IA (2016)	NA	Bay et al. 2017b
Barton I & II, IA (2010-2011)	NA	WEST 2011	Kewaunee County, WI (1999-2001)	NA	Howe et al. 2002
Big Blue, MN (2013)	NA	Fagen Engineering 2014	Laurel, IA (2016)	NA	Bay et al. 2017b
Big Blue, MN (2014)	NA	Fagen Engineering 2015	Lundgren, IA (2015)	NA	Bay et al. 2017a
Black Oak Getty, MN (2012, 2017)	Hamer Environmental 2012	Pickle et al. 2018	Lundgren, IA (2016)	NA	Bay et al. 2017b
Blue Sky Green Field, WI (2008; 2009)	Gruver 2008	Gruver et al. 2009	Macksburg, IA (2015)	NA	Bay et al. 2017a
Buffalo Ridge I, SD (2009-2010)	NA	Derby et al. 2010d	Macksburg, IA (2016)	NA	Bay et al. 2017b
Buffalo Ridge II, SD (2011-2012)	NA	Derby et al. 2012a	Moraine II, MN (2009)	NA	Derby et al. 2010f
Buffalo Ridge, MN (Phase I; 1999)	NA	Johnson et al. 2000	Morning Light, IA (2015)	NA	Bay et al. 2017a
Buffalo Ridge, MN (Phase II; 1998)	NA	Johnson et al. 2000	NPPD Ainsworth, NE (2006)	NA	Derby et al. 2007
Buffalo Ridge, MN (Phase II; 1999)	NA	Johnson et al. 2000	Pioneer Prairie I, IA (Phase II; 2011-2012)	NA	Chodachek et al. 2012
Buffalo Ridge, MN (Phase II; 2001/Lake Benton I)	Johnson et al. 2004	Johnson et al. 2004	Pioneer Prairie II, IA (2013)	NA	Chodachek et al. 2014
Buffalo Ridge, MN (Phase II; 2002/Lake Benton I)	Johnson et al. 2004	Johnson et al. 2004	Pomeroy, IA (2016)	NA	Bay et al. 2017b
Buffalo Ridge, MN (Phase III; 1999)	NA	Johnson et al. 2000	PrairieWinds ND1 (Minot), ND (2010)	NA	Derby et al. 2011d
Buffalo Ridge, MN (Phase III; 2001/Lake Benton II)	Johnson et al. 2004	Johnson et al. 2004	PrairieWinds ND1 (Minot), ND (2011)	NA	Derby et al. 2012d
Buffalo Ridge, MN (Phase III; 2002/Lake Benton II)	Johnson et al. 2004	Johnson et al. 2004	PrairieWinds SD1, SD (2011-2012)	NA	Derby et al. 2012c
Carroll, IA (2015)	NA	Bay et al. 2017a	PrairieWinds SD1, SD (2012-2013)	NA	Derby et al. 2013
Cedar Ridge, WI (2009)	BHE Environmental 2008	BHE Environmental 2010	PrairieWinds SD1, SD (2013-2014)	NA	Derby et al. 2014
Cedar Ridge, WI (2010)	BHE Environmental 2008	BHE Environmental 2011	Rail Splitter, IL (2012-2013)	NA	Good et al. 2013b
Century, IA (2016)	NA	Bay et al. 2017b	Ripley, Ont (2008)	NA	Jacques Whitford

Appendix D3 (*continued*). Wind energy facilities in the Midwestern region of North America with comparable activity and fatality data for bats. Data from the following sources:

Wind Energy Facility/Study	Activity Estimate Report Citation	Fatality Estimate Report Citation	Wind Energy Facility/Study	Activity Estimate Report Citation	Fatality Estimate Report Citation
					2009
Charles City, IA (2016)	NA	Bay et al. 2017b	Rolling Hills, IA (2015)	NA	Bay et al. 2017a
Crescent Ridge, IL (2005-2006)	NA	Kerlinger et al. 2007	Rolling Hills, IA (2016)	NA	Bay et al. 2017b
Crystal Lake II, IA (2009)	NA	Derby et al. 2010b	Rugby, ND (2010-2011)	NA	Derby et al. 2011c
Eclipse, IA (2015)	NA	Bay et al. 2017a	Top Crop I & II (2012-2013)	NA	Good et al. 2013c
Elm Creek II, MN (2011-2012)	NA	Derby et al. 2010e	Top of Iowa, IA (2003)	NA	Jain 2005
Elm Creek, MN (2009-2010)	NA	Derby et al. 2012b	Top of Iowa, IA (2004)	Jain 2005	Jain 2005
Forward Energy Center, WI (2008-2010)	Watt and Drake 2011	Grodsky and Drake 2011	Victory, IA (2015)	NA	Bay et al. 2017a
Fowler I, II, III, IN (2010)	NA	Good et al. 2011	Vienna I, IA (2016)	NA	Bay et al. 2017b
Fowler I, II, III, IN (2011)	NA	Good et al. 2012	Vienna II, IA (2016)	NA	Bay et al. 2017b
Fowler I, II, III, IN (2012)	NA	Good et al. 2013a	Walnut, IA (2015)	NA	Bay et al. 2017a
Fowler I, IN (2009)	NA	Johnson et al. 2010a	Wellsburg, IA (2016)	NA	Bay et al. 2017b
Fowler III, IN (2009)	NA	Johnson et al. 2010b	Wessington Springs, SD (2009)	NA	Derby et al. 2010c
Grand Ridge I, IL (2009-2010)	NA	Derby et al. 2010a	Wessington Springs, SD (2010)	NA	Derby et al. 2011a
Harrow, Ont (2010)	NA	NRSI 2011	Winnebago, IA (2009-2010)	NA	Derby et al. 2010g
Heritage Garden I, MI (2012-2014)	NA	Kerlinger et al. 2014			

Appendix D4. Fatality estimates for wind-energy facilities in the Midwestern region of North America.

Wind Energy Facility	Bird Fatalities (bird/MW/year)	Raptor Fatalities (raptors/MW/year)	Bat Fatalities (bats/MW/year)	Predominant Habitat Type	Fatality Report Citation
Adair, IA (2015)	4.64	0.07	14.05	agriculture	Bay et al. 2017a
Adams, IA (2016)	1.56	NA	10.08	agriculture	Bay et al. 2017b
Barton I & II, IA (2010-2011)	5.5	0	1.85	agriculture	Derby et al. 2011b
Big Blue, MN (2013)	0.6	0	2.04	agriculture	Fagen Engineering 2014
Big Blue, MN (2014)	0.37	0	1.43	agriculture	Fagen Engineering 2015
Black Oak Getty, MN (2017)	4.37	0	13.03	agriculture, grassland	Pickle et al. 2018
Blue Sky Green Field, WI (2008; 2009)	7.17	0	24.57	agriculture	Gruver et al. 2009
Buffalo Ridge I, SD (2009-2010)	5.06	0.2	0.16	agriculture/grassland	Derby et al. 2010d
Buffalo Ridge II, SD (2011-2012)	1.99	0	2.81	agriculture, grassland	Derby et al. 2012a
Buffalo Ridge, MN (Phase I; 1996)	4.14	0	NA	agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase I; 1997)	2.51	0	NA	agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase I; 1998)	3.14	0	NA	agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase I; 1999)	1.43	0.47	0.74	agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase II; 1998)	2.47	0	2.16	agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase II; 1999)	3.57	0	2.59	agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase II; 2001/Lake Benton I)	NA	NA	4.35	agriculture	Johnson et al. 2004
Buffalo Ridge, MN (Phase II; 2002/Lake Benton I)	NA	NA	1.64	agriculture	Johnson et al. 2004
Buffalo Ridge, MN (Phase III; 1999)	5.93	0	2.72	agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase III; 2001/Lake Benton II)	NA	NA	3.71	agriculture	Johnson et al. 2004
Buffalo Ridge, MN (Phase III; 2002/Lake Benton II)	NA	NA	1.81	agriculture	Johnson et al. 2004
Carroll, IA (2015)	3.55	NA	11.71	agriculture	Bay et al. 2017a
Cedar Ridge, WI (2009)	6.55	0.18	30.61	agriculture	BHE Environmental 2010
Cedar Ridge, WI (2010)	3.72	0.13	24.12	agriculture	BHE Environmental 2011
Century, IA (2016)	3.54	0.01	9.07	agriculture	Bay et al. 2017b
Charles City, IA (2016)	4.13	NA	10.41	agriculture	Bay et al. 2017b

Appendix D4. Fatality estimates for wind-energy facilities in the Midwestern region of North America.

Wind Energy Facility	Bird Fatalities (bird/MW/year)	Raptor Fatalities (raptors/MW/year)	Bat Fatalities (bats/MW/year)	Predominant Habitat Type	Fatality Report Citation
Crescent Ridge, IL (2005-2006)	NA	NA	3.27	agriculture	Kerlinger et al. 2007
Crystal Lake II, IA (2009)	NA	NA	7.42	agriculture	Derby et al. 2010b
Eclipse, IA (2015)	3.62	0.12	10.01	agriculture	Bay et al. 2017a
Elm Creek II, MN (2011-2012)	3.64	0	2.81	agriculture, grassland	Derby et al. 2010e
Elm Creek, MN (2009-2010)	1.55	0	1.49	agriculture	Derby et al. 2012b
Forward Energy Center, WI (2008-2010)	NA	NA	18.17	agriculture	Grodsky and Drake 2011
Fowler I, II, III, IN (2010)	NA	NA	18.96	agriculture	Good et al. 2011
Fowler I, II, III, IN (2011)	NA	NA	20.19	agriculture	Good et al. 2012
Fowler I, II, III, IN (2012)	NA	NA	2.96	agriculture	Good et al. 2013a
Fowler I, IN (2009)	2.83	0	8.09	agriculture	Johnson et al. 2010a
Fowler III, IN (2009)	NA	NA	1.84	agriculture	Johnson et al. 2010b
Grand Ridge I, IL (2009-2010)	0.48	0	2.1	agriculture	Derby et al. 2010a
Harrow, Ont (2010)	NA	NA	11.13	agriculture	Natural Resource Solutions Inc. (NRSI) 2011
Heritage Garden I, MI (2012-2014)	1.3	NA	5.9	agriculture	Kerlinger et al. 2014
Highland, IA (2016)	2.25	NA	8.63	agriculture	Bay et al. 2017b
Intrepid, IA (2016)	2.93	0.02	18.37	agriculture	Bay et al. 2017b
Kewaunee County, WI (1999-2001)	1.95	0	6.45	agriculture	Howe et al. 2002
Laurel, IA (2016)	2.96	NA	14.22	agriculture	Bay et al. 2017b
Lundgren, IA (2015)	2.91	NA	28.74	agriculture	Bay et al. 2017a
Lundgren, IA (2016)	3.37	NA	8.08	agriculture	Bay et al. 2017b
Macksburg, IA (2015)	3.38	NA	73.08	agriculture	Bay et al. 2017a
Macksburg, IA (2016)	4.94	0.02	10.79	agriculture	Bay et al. 2017b
Moraine II, MN (2009)	5.59	0.37	2.42	agriculture/grassland	Derby et al. 2010f
Morning Light, IA (2015)	2.36	NA	20.19	agriculture	Bay et al. 2017a
NPPD Ainsworth, NE (2006)	1.63	0.06	1.16	agriculture/grassland	Derby et al. 2007
Pioneer Prairie I, IA (Phase II; 2011-2012)	0.27	0	10.06	agriculture, grassland	Chodachek et al. 2012
Pioneer Prairie II, IA (2013)	NA	NA	3.83	agriculture	Chodachek et al. 2014

Appendix D4. Fatality estimates for wind-energy facilities in the Midwestern region of North America.

Wind Energy Facility	Bird Fatalities (bird/MW/year)	Raptor Fatalities (raptors/MW/year)	Bat Fatalities (bats/MW/year)	Predominant Habitat Type	Fatality Report Citation
Pomeroy, IA (2016)	2.76	0.19	6.25	agriculture	Bay et al. 2017b
PrairieWinds ND1 (Minot), ND (2010)	1.48	0.05	2.13	agriculture	Derby et al. 2011d
PrairieWinds ND1 (Minot), ND (2011)	1.56	0.05	1.39	agriculture, grassland	Derby et al. 2012d
PrairieWinds SD1, SD (2011-2012)	1.41	0	1.23	grassland	Derby et al. 2012c
PrairieWinds SD1, SD (2012-2013)	2.01	0.03	1.05	grassland	Derby et al. 2013
PrairieWinds SD1, SD (2013-2014)	1.66	0.17	0.52	grassland	Derby et al. 2014
Rail Splitter, IL (2012-2013)	0.84	0	11.21	agriculture	Good et al. 2013b
Ripley, Ont (2008)	3.09	0.1	4.67	agriculture	Jacques Whitford 2009
Rolling Hills, IA (2015)	1.79	0.04	6.13	agriculture	Bay et al. 2017a
Rolling Hills, IA (2016)	3.48	0.08	6.30	agriculture	Bay et al. 2017b
Rugby, ND (2010-2011)	3.82	0.06	1.6	agriculture	Derby et al. 2011c
Top Crop I & II (2012-2013)	1.35	NA	12.55	agriculture	Good et al. 2013c
Top of Iowa, IA (2003)	0.42	0	7.16	agriculture	Jain 2005
Top of Iowa, IA (2004)	0.81	0.17	10.27	agriculture	Jain 2005
Victory, IA (2015)	1.52	NA	6.48	agriculture	Bay et al. 2017a
Vienna I, IA (2016)	5.70	0.03	9.09	agriculture	Bay et al. 2017b
Vienna II, IA (2016)	3.57	0.07	10.28	agriculture	Bay et al. 2017b
Walnut, IA (2015)	2.88	NA	21.69	agriculture	Bay et al. 2017a
Wellsburg, IA (2016)	8.44	NA	12.30	agriculture	Bay et al. 2017b
Wessington Springs, SD (2009)	8.25	0.06	1.48	grassland	Derby et al. 2010c
Wessington Springs, SD (2010)	0.89	0.07	0.41	grassland	Derby et al. 2011a
Winnebago, IA (2009-2010)	3.88	0.27	4.54	agriculture/grassland	Derby et al. 2010g

MW = megawatt

Appendix D5. All post-construction monitoring studies, project characteristics, and select study methodology for wind-power plants in the Midwest region of North America.

Wind Energy Facility/Study	Total # of Turbines	Total MW	Tower Size (m)	Number Turbines Searched	Plot Size	Length of Study	Survey frequency
Adair, IA (2015)	76	174.8	2.3	76	Road/pad with 100m radius	1 year	Bimonthly (winter) and weekly (spring, summer, and fall)
Adams, IA (2016)	64	154.3	2.3/2.4	50 road/pad, 14 cleared plots (7 60x60m and 7 100x1100m)	60x60m and 100x100m (cleared plot), 100m radius (road/pad)	1 year	bimonthly (winter) and biweekly (spring, summer, and fall)
Barton I & II, IA (2010-2011)	80(35 (9 turbines were dropped in June 2010 due to landowner issues) 26 turbines were searched for the remainder of the study)	160	100	30	200 m x 200 m	1 year	weekly (spring, fall; migratory turbines), monthly (summer, winter; non-migratory turbines)
Big Blue, MN (2013)	18(18)	36	78 or 90 (according to Gamesa website)	18	200m diameter	NA	weekly, monthly (Nov and Dec)
Big Blue, MN (2014)	18(18)	36	78 or 90 (according to Gamesa website)	18	200m diameter	NA	weekly, monthly (Nov and Dec)
Black Oak Getty, MN (2017)	39	78	80	5 cleared plots, 34 road/pad	120 m x 120 m (cleared plot), 60 m radius (road/pad)	9 months (March 15, 2017 – November 16, 2017)	Cleared plots twice weekly, road/pads once weekly.
Blue Sky Green Field, WI (2008; 2009)	88(30)	145	80	30	160 m x 160 m	fall, spring	daily(10 turbines), weekly (20 turbines)
Buffalo Ridge, MN (1994-1995)	73(1994:10 plots (3 turbines/plot), 20 addition plots in Sept	25	37	1994:10 plots (3 turbines/plot), 20 addition plots in Sept	100 x 100m	20 months	varies. See number turbines searched or page 44 of report

Appendix D5. All post-construction monitoring studies, project characteristics, and select study methodology for wind-power plants in the Midwest region of North America.

Wind Energy Facility/Study	Total # of Turbines	Total MW	Tower Size (m)	Number Turbines Searched	Plot Size	Length of Study	Survey frequency
	& Oct 1994, 1995: 30 turbines search every other week (Jan-Mar), 60 searched weekly (Apr, July, Aug) 73 searched weekly (May-June and Sept-Oct), 30 searched weekly (Nov-Dec))			& Oct 1994, 1995: 30 turbines search every other week (Jan-Mar), 60 searched weekly (Apr, July, Aug) 73 searched weekly (May-June and Sept-Oct), 30 searched weekly (Nov-Dec)			
Buffalo Ridge, MN (Phase I; 1996)	73(21)	25	36	21	126 m x 126 m	1 year	bi-monthly (spring, summer, and fall)
Buffalo Ridge, MN (Phase I; 1997)	73(21)	25	36	21	126 m x 126 m	1 year	bi-monthly (spring, summer, and fall)
Buffalo Ridge, MN (Phase I; 1998)	73(21)	25	36	21	126 m x 126 m	1 year	bi-monthly (spring, summer, and fall)
Buffalo Ridge, MN (Phase I; 1999)	73(21)	25	36	21	126 m x 126 m	1 year	bi-monthly (spring, summer, and fall)
Buffalo Ridge, MN (Phase II; 1998)	143(40)	107.25	50	40	126 m x 126 m	1 year	bi-monthly (spring, summer, and fall)
Buffalo Ridge, MN (Phase II; 1999)	143(40)	107.25	50	40	126 m x 126 m	1 year	bi-monthly (spring, summer, and fall)
Buffalo Ridge, MN (Phase II; 2001/Lake Benton I)	143(83)	107.25	50	83	60 m x 60 m	summer, fall	bi-monthly
Buffalo Ridge, MN (Phase II; 2002/Lake Benton I)	143(103)	107.25	50	103	60 m x 60 m	summer, fall	bi-monthly
Buffalo Ridge, MN (Phase III; 1999)	138(30)	103.5	50	30	126 m x 126 m	1 year	bi-monthly (spring, summer, and fall)
Buffalo Ridge, MN (Phase III; 2001/Lake Benton II)	138(83)	103.5	50	83	60 m x 60 m	summer, fall	bi-monthly

Appendix D5. All post-construction monitoring studies, project characteristics, and select study methodology for wind-power plants in the Midwest region of North America.

Wind Energy Facility/Study	Total # of Turbines	Total MW	Tower Size (m)	Number Turbines Searched	Plot Size	Length of Study	Survey frequency
Buffalo Ridge, MN (Phase III; 2002/Lake Benton II)	138(103)	103.5	50	103	60 m x 60 m	summer, fall	bi-monthly
Buffalo Ridge I, SD (2009-2010)	24(24)	50.4	79	24	200 m x 200 m	1 year	weekly (migratory), monthly (non-migratory)
Buffalo Ridge II, SD (2011-2012)	105(65 (60 road and pad, 5 turbine plots))	210	78	65 (60 road and pad, 5 turbine plots)	100 x 100 m	1 year	weekly (spring, summer, fall), monthly (winter)
Carroll, IA (2015)	100	150.0	1.5	100	Road/pad with 100m radius	1 year	Bimonthly (winter) and weekly (spring, summer, and fall)
Cedar Ridge, WI (2009)	41(20)	67.6	80	20	160 m x 160 m	spring, summer, fall	daily, every 4 days; late fall searched every 3 days
Cedar Ridge, WI (2010)	41(20)	68	80	20	160 m x 160 m	1 year	Five turbines were surveyed daily, 15 turbines surveyed every 4 days in rotating groups each day. All 20 surveyed every three days during late fall
Century, IA (2016)	145	200.0	1.5/1.0	115 road/pad, 30 cleared plots (14 60x60m and 14 100x1100m)	60x60m and 100x100m (cleared plot), 100m radius (road/pad)	1 year	bimonthly (winter) and biweekly (spring, summer, and fall)
Charles City, IA (2016)	50	75.0	1.5	40 road/pad, 10 cleared 200x200m plot	200x200m (cleared plot), 100m radius (road/pad)	1 year	bimonthly (winter) and biweekly (spring, summer, and fall)
Crescent Ridge, IL (2005-2006)	33(33)	49.5	80	33	70-m radius	1 year	weekly (fall, spring)

Appendix D5. All post-construction monitoring studies, project characteristics, and select study methodology for wind-power plants in the Midwest region of North America.

Wind Energy Facility/Study	Total # of Turbines	Total MW	Tower Size (m)	Number Turbines Searched	Plot Size	Length of Study	Survey frequency
Crystal Lake II, IA (2009)	80(16 turbines through week 6, and then 15 for duration of study)	200	80	16 turbines through week 6, and then 15 for duration of study	100 m x 100 m	spring, summer, fall	3 times per week for 26 weeks
Eclipse, IA (2015)	87	200.1	2.3	87	Road/pad with 100m radius	1 year	Bimonthly (winter) and weekly (spring, summer, and fall)
Elm Creek, MN (2009-2010)	67(29)	100	80	29	200 m x 200 m	1 year	weekly, monthly
Elm Creek II, MN (2011-2012)	62(30)	148.8	80	30	200 x 200m (2 random migration search areas 100 x 100m)	1 year	20 searched every 28 days, 10 turbines every 7 days during migration)
Erie Shores, Ont (2006)	66(66)	99	80	66	40-m radius	2 years	weekly, bi-monthly, 2-3 times weekly (migration)
Forward Energy Center, WI (2008-2010)	86(29)	129	80	29	160 m x 160 m	2 years	11 turbines daily, 9 every 3 days, 9 every 5 days
Fowler I, IN (2009)	162(25)	301	78 (Vestas), 80 (Clipper)	25	160 m x 160 m	spring, summer, fall	weekly, bi-weekly
Fowler I, II, III, IN (2010)	355(36 turbines, 100 road and pads)	600	Vestas = 80, Clipper = 80, GE = 80	36 turbines, 100 road and pads	80 m x 80 m for turbines ; 40-m radius for roads and pads	spring, fall	daily, weekly
Fowler I, II, III, IN (2011)	355(177 road and pads (spring), 9 turbines & 168 roads and pads (fall))	600	Vestas = 80, Clipper = 80, GE = 80	177 road and pads (spring), 9 turbines & 168 roads and pads (fall)	turbines (80 m circular plot), roads and pads (out to 80 m)	spring, fall	daily, weekly
Fowler I, II, III, IN (2012)	355(118 roads and pads)	600	Vestas = 80, Clipper = 80, GE =	118 roads and pads	roads and pads (out to 80 m)	2.5 months	weekly

Appendix D5. All post-construction monitoring studies, project characteristics, and select study methodology for wind-power plants in the Midwest region of North America.

Wind Energy Facility/Study	Total # of Turbines	Total MW	Tower Size (m)	Number Turbines Searched	Plot Size	Length of Study	Survey frequency
			80				
Fowler III, IN (2009)	60(12)	99	78	12	160 m x 160 m	10 weeks	weekly, bi-weekly
Grand Ridge I, IL (2009-2010)	66(30)	99	80	30	160 m x 160 m	1 year	weekly, monthly
Harrow, Ont (2010)	24 (four 6-turb facilities)(12 in July, 24 Aug-Oct)	39.6	NA	12 in July, 24 Aug-Oct	50-m radius from turbine base	4 months	twice-weekly
Heritage Garden I, MI (2012-2014)	14(14)	28	90	14	120x120 m except one plot that was 280x280 m	1 years	weekly (spring, summer, and fall) and bi-weekly (winter)
Highland, IA (2016)	214	502	2.3	170 road/pad, 44 cleared plots (22 60x60m and 22 100x1100m)	60x60m and 100x100m (cleared plot), 100m radius (road/pad)	1 year	bimonthly (winter) and biweekly (spring, summer, and fall)
Intrepid, IA (2016)	122	175.5	1.5/1.0	96 road/pad, 26 cleared plots (13 60x60m and 13 100x1100m)	60x60m and 100x100m (cleared plot), 100m radius (road/pad)	1 year	bimonthly (winter) and biweekly (spring, summer, and fall)
Kewaunee County, WI (1999-2001)	31(31)	20.46	65	31	60 m x 60 m	2 years	bi-weekly (spring, summer), daily (spring, fall migration), weekly (fall, winter)
Lakefield Wind, MN (2012)	137(26)	205.5	80	26	100 m x 100 m	7.5 months	3 times per week
Laurel, IA (2016)	52	119.6	2.3	40 road/pad, 12 cleared plots (6 60x60m and 6 100x1100m)	60x60m and 100x100m (cleared plot), 100m	1 year	bimonthly (winter) and biweekly (spring, summer, and fall)

Appendix D5. All post-construction monitoring studies, project characteristics, and select study methodology for wind-power plants in the Midwest region of North America.

Wind Energy Facility/Study	Total # of Turbines	Total MW	Tower Size (m)	Number Turbines Searched	Plot Size	Length of Study	Survey frequency
					radius (road/pad)		
Lundgren, IA (2015)	107	251	2.3	107	Road/pad with 100m radius	1 year	Bimonthly (winter) and weekly (spring, summer, and fall)
Lundgren, IA (2016)	107	251	2.3	86 road/pad, 10 cleared 200x200m plots	200x200m (cleared plot), 100m radius (road/pad)	1 year	bimonthly (winter) and biweekly (spring, summer, and fall)
Macksburg, IA (2015)	51	119.6	2.3	51	Road/pad with 100m radius	1 year	Bimonthly (winter) and weekly (spring, summer, and fall)
Macksburg, IA (2016)	51	119.6	2.3	41 road/pad, 10 cleared 200x200m plots	200x200m (cleared plot), 100m radius (road/pad)	1 year	bimonthly (winter) and biweekly (spring, summer, and fall)
Melancthon, Ont (Phase I; 2007)	45(45)	NA	NA	45	35m radius	5 months	weekly, twice weekly
Moraine II, MN (2009)	33(30)	49.5	82.5	30	200 m x 200 m	1 year	weekly (migratory), monthly (non-migratory)
Morning Light, IA (2015)	44	101.2	2.3	44	Road/pad with 100m radius	1 year	Bimonthly (winter) and weekly (spring, summer, and fall)
NPPD Ainsworth, NE (2006)	36(36)	20.5	70	36	220 m x 220 m	spring, summer, fall	bi-monthly
Pioneer Prairie II, IA (2013)	62(62)	102.3	80	62	80x80 m (5 turbines), road and pad within 100 m of turbine (57 turbines)	NA	weekly
Pioneer Prairie I, IA	62(62 (57 road/pad) 5	102.3	80	62 (57 road/pad) 5	80 x 80m	1 year	weekly (spring and fall),

Appendix D5. All post-construction monitoring studies, project characteristics, and select study methodology for wind-power plants in the Midwest region of North America.

Wind Energy Facility/Study	Total # of Turbines	Total MW	Tower Size (m)	Number Turbines Searched	Plot Size	Length of Study	Survey frequency
(Phase II; 2011-2012)	cleared search plots)			cleared search plots			every two weeks (summer), monthly (winter)
Pioneer Trail, IL (2012-2013)	94(50)	150.5	NA	50	80x80m	fall, spring	weekly
Pomeroy, IA (2016)	184	286.4	1.5/2.3	146 road/pad, 38 cleared plots (19 60x60m and 19 100x1100m)	60x60m and 100x100m (cleared plot), 100m radius (road/pad)	1 year	bimonthly (winter) and biweekly (spring, summer, and fall)
Prairie Rose, MN (2014)	119(10)	200	80	10	100x100m	6 months	weekly
PrairieWinds SD1, SD (2012-2013)	108(50)	162	80	50	200 x 200m	1 year	bi-weekly
PrairieWinds SD1, SD (2013-2014)	108(45)	162	80	45	200 x 200m	1 year	twice monthly (spring, summer, fall), monthly (winter)
PrairieWinds ND1 (Minot), ND (2010)	80(35)	115.5	89	35	minimum of 100 m x 100 m	3 seasons	bi-monthly
PrairieWinds ND1 (Minot), ND (2011)	80(35)	115.5	80	35	minimum 100 x 100m	3 season	twice monthly
PrairieWinds SD1, SD (2011-2012)	108(50)	162	80	50	200 x 200m	1 year	twice monthly (spring, summer, fall), monthly (winter)
Rail Splitter, IL (2012-2013)	67(34)	100.5	80	34	60 m radius	1 year	weekly (spring, summer, and fall) and bi-weekly (winter)
Ripley, Ont (2008)	38(38)	76	64	38	80 m x 80 m	spring, fall	twice weekly for odd turbines; weekly for even turbines.

Appendix D5. All post-construction monitoring studies, project characteristics, and select study methodology for wind-power plants in the Midwest region of North America.

Wind Energy Facility/Study	Total # of Turbines	Total MW	Tower Size (m)	Number Turbines Searched	Plot Size	Length of Study	Survey frequency
Ripley, Ont (2008-2009)	38(38)	76	64	38	80 m x 80 m	6 weeks	twice weekly for odd turbines; weekly for even turbines.
Rolling Hills, IA (2015)	193	443.9	2.3	193	Road/pad with 100m radius	1 year	Bimonthly (winter) and weekly (spring, summer, and fall)
Rolling Hills, IA (2016)	193	443.9	2.3	153 road/pad, 40 cleared plots (20 60x60m and 20 100x1100m)	60x60m and 100x100m (cleared plot), 100m radius (road/pad)	1 year	bimonthly (winter) and biweekly (spring, summer, and fall)
Rugby, ND (2010-2011)	71(32)	149	78	32	200 m x 200 m	1 year	weekly (spring, fall; migratory turbines), monthly (non-migratory turbines)
Top Crop I & II (2012-2013)	68 (phase I) 132 (phase (II)(100)	300 (102 phase I, 198 phase II)	65 (phase I) 80 (phase II)	100	61 m radius	1 year	weekly (spring, summer, and fall) and bi-weekly (winter)
Top of Iowa, IA (2003)	89(26)	80	71.6	26	76 m x 76 m	spring, summer, fall	once every 2 to 3 days
Top of Iowa, IA (2004)	89(26)	80	71.6	26	76 m x 76 m	spring, summer, fall	once every 2 to 3 days
Victory, IA (2015)	66	99.0	1.5	66	Road/pad with 100m radius	1 year	Bimonthly (winter) and weekly (spring, summer, and fall)
Vienna, IA (2016)	45	105.6	2.3	35 road/pad, 10 cleared plots (5 60x60m and 5 100x1100m)	60x60m and 100x100m (cleared plot), 100m radius (road/pad)	1 year	bimonthly (winter) and biweekly (spring, summer, and fall)
Vienna II, IA (2016)	19	44.6	2.3	15 road/pad, 4	60x60m and	1 year	bimonthly (winter) and

Appendix D5. All post-construction monitoring studies, project characteristics, and select study methodology for wind-power plants in the Midwest region of North America.

Wind Energy Facility/Study	Total # of Turbines	Total MW	Tower Size (m)	Number Turbines Searched	Plot Size	Length of Study	Survey frequency
				cleared plots (2 60x60m and 2 100x1100m)	100x100m (cleared plot), 100m radius (road/pad)		biweekly (spring, summer, and fall)
Walnut, IA (2015)	102	153.0	1.5	102	Road/pad with 100m radius	1 year	Bimonthly (winter) and weekly (spring, summer, and fall)
Wellsburg, IA (2016)	60	140.8	2.3	48 road/pad, 12 cleared plots (6 60x60m and 6 100x1100m)	60x60m and 100x100m (cleared plot), 100m radius (road/pad)	1 year	bimonthly (winter) and biweekly (spring, summer, and fall)
Wessington Springs, SD (2009)	34(20)	51	80	20	200 m x 200 m	spring, summer, fall	bi-monthly
Wessington Springs, SD (2010)	34(20)	51	80	20	200 m x 200 m	8 months	bi-weekly (spring, summer, fall)
Winnebago, IA (2009-2010)	10(10)	20	78	10	200 m x 200 m	1 year	weekly (migratory), monthly (non-migratory)

Appendix D5 (*continued*). All post-construction monitoring studies, project characteristics, and select study methodology for wind-energy facilities in the Midwestern region of North America. Data from the following sources:

Project Name	Reference	Project Name	Reference
Adair, IA (2015)	Bay et al. 2017a		
Adams, IA (2016)	Bay et al. 2017b	Eclipse, IA (2015)	Bay et al. 2017a
Barton I & II, IA (2010-2011)	Derby et al. 2011b	Elm Creek, MN (2009-2010)	Derby et al. 2010e
Big Blue, MN (2013)	Fagen Engineering 2014	Elm Creek II, MN (2011-2012)	Derby et al. 2012b
Big Blue, MN (2014)	Fagen Engineering 2015	Erie Shores, Ont (2006)	James 2008
Black Oak Getty, MN (2017)	Pickle et al. 2018	Forward Energy Center, WI (2008-2010)	Grodsky and Drake 2011
Blue Sky Green Field, WI (2008; 2009)	Gruver et al. 2009	Fowler I, IN (2009)	Johnson et al. 2010a
Buffalo Ridge, MN (1994-1995)	Osborn et al. 1996, 2000	Fowler I, II, III, IN (2010)	Good et al. 2011
Buffalo Ridge, MN (Phase I; 1996)	Johnson et al. 2000	Fowler I, II, III, IN (2011)	Good et al. 2012
Buffalo Ridge, MN (Phase I; 1997)	Johnson et al. 2000	Fowler I, II, III, IN (2012)	Good et al. 2013a
Buffalo Ridge, MN (Phase I; 1998)	Johnson et al. 2000	Fowler III, IN (2009)	Johnson et al. 2010b
Buffalo Ridge, MN (Phase I; 1999)	Johnson et al. 2000	Grand Ridge I, IL (2009-2010)	Derby et al. 2010a
Buffalo Ridge, MN (Phase II; 1998)	Johnson et al. 2000	Harrow, Ont (2010)	Natural Resource Solutions 2011
Buffalo Ridge, MN (Phase II; 1999)	Johnson et al. 2000	Heritage Garden I, MI (2012-2014)	Kerlinger et al. 2014
Buffalo Ridge, MN (Phase II; 2001/Lake Benton I)	Johnson et al. 2004	Highland, IA (2016)	Bay et al. 2017b
Buffalo Ridge, MN (Phase II; 2002/Lake Benton I)	Johnson et al. 2004	Intrepid, IA (2016)	Bay et al. 2017b
Buffalo Ridge, MN (Phase III; 1999)	Johnson et al. 2000	Kewaunee County, WI (1999-2001)	Howe et al. 2002
Buffalo Ridge, MN (Phase III; 2001/Lake Benton II)	Johnson et al. 2004	Lakefield Wind, MN (2012)	MPUC 2012
Buffalo Ridge, MN (Phase III; 2002/Lake Benton II)	Johnson et al. 2004	Laurel, IA (2016)	Bay et al. 2017b
Buffalo Ridge I, SD (2009-2010)	Derby et al. 2010d	Lundgren, IA (2015)	Bay et al. 2017a
Buffalo Ridge II, SD (2011-2012)	Derby et al. 2012a	Lundgren, IA (2016)	Bay et al. 2017b
Carroll, IA (2015)	Bay et al. 2017a	Macksburg, IA (2015)	Bay et al. 2017a
Cedar Ridge, WI (2009)	BHE Environmental 2010	Macksburg, IA (2016)	Bay et al. 2017b
Cedar Ridge, WI (2010)	BHE Environmental 2011	Melancthon, Ont (Phase I; 2007)	Stantec Ltd. 2008
Crescent Ridge, IL (2005-2006)	Kerlinger et al. 2007	Moraine II, MN (2009)	Derby et al. 2010f
Century, IA (2016)	Bay et al. 2017b	Morning Light, IA (2015)	Bay et al. 2017a
Charles City, IA (2016)	Bay et al. 2017b	NPPD Ainsworth, NE (2006)	Derby et al. 2007
Crystal Lake II, IA (2009)	Derby et al. 2010b	Pioneer Prairie II, IA	Chodachek et al. 2014

Appendix D5 (*continued*). All post-construction monitoring studies, project characteristics, and select study methodology for wind-energy facilities in the Midwestern region of North America. Data from the following sources:

Project Name	Reference	Project Name	Reference
Pioneer Prairie I, IA (Phase II; 2011-2012)	Chodachek et al. 2012	(2013) Rolling Hills, IA (2016)	Bay et al. 2017b
Pioneer Trail, IL (2012-2013)	ARCADIS 2013	Rugby, ND (2010-2011)	Derby et al. 2011c
Pomeroy, IA (2016)	Bay et al. 2017b	Top Crop I & II (2012-2013)	Good et al. 2013c
Prairie Rose, MN (2014)	Chodachek et al. 2015	Top of Iowa, IA (2003)	Jain 2005
PrairieWinds SD1, SD (2012-2013)	Derby et al. 2013	Top of Iowa, IA (2004)	Jain 2005
PrairieWinds SD1, SD (2013-2014)	Derby et al. 2014	Victory, IA (2015)	Bay et al. 2017a
PrairieWinds ND1 (Minot), ND (2010)	Derby et al. 2011d	Vienna I, IA (2016)	Bay et al. 2017b
PrairieWinds ND1 (Minot), ND (2011)	Derby et al. 2012d	Vienna II, IA (2016)	Bay et al. 2017b
PrairieWinds SD1, SD (2011-2012)	Derby et al. 2012c	Walnut, IA (2015)	Bay et al. 2017a
Rail Splitter, IL (2012-2013)	Good et al. 2013b	Wellsburg, IA (2016)	Bay et al. 2017b
Ripley, Ont (2008)	Jacques Whitford 2009	Wessington Springs, SD (2009)	Derby et al. 2010c
Ripley, Ont (2008-2009)	Golder Associates 2010	Wessington Springs, SD (2010)	Derby et al. 2011a
Rolling Hills, IA (2015)	Bay et al. 2017a	Winnebago, IA (2009-2010)	Derby et al. 2010g

Appendix E. Distributions, Model Parameter and AIC Values for Small Bird and Bat Density Models

Appendix E1. Distributions, model parameters, and Akaike Information Criteria (AIC) values for models fit to bat fatality data collected at the Red Pine Wind Project

Distribution	Number of Parameters	Parameter 1	Parameter 2	AIC	Δ AIC
Gompertz	2	0.08	0	9294.10	0
norm	2	35.73	15.58	9588.75	294.65
Weibull	2	2.42	40.22	9816.33	522.23
Rayleigh	1	28.40	NA	9854.49	560.39
gamma	2	2.34	0.06	10049.53	755.43

Δ = delta

Appendix E2. Distributions, model parameters, and Akaike Information Criteria (AIC) values for models fit to small bird fatality data collected at the Red Pine Wind Project

Distribution	Number of Parameters	Parameter 1	Parameter 2	AIC	Δ AIC
Gompertz	2	0.07	0	2378.99	0
norm	2	43.88	16.65	2415.40	36.41
Weibull	2	3.05	49.16	2421.12	42.13
Rayleigh	1	36.81	NA	2459.93	80.94
gamma	2	4.20	0.09	2460.38	81.39

Δ = delta