MONTANA-DAKOTA
UTILITIES CO.
A Subsidiary of MDU Resources Group, Inc.

400 North Fourth Street
Bismarck, ND 58501
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February 12, 2020

Executive Secretary
ND Public Service Commission
State Capitol Building
Bismarck, ND 58505

Re: Case No. PU-15-592
Post Construction Monitoring

Montana-Dakota Utilities Co. (Montana-Dakota), herewith submits the Post-Construction Bat Fatality Monitoring Report for the Thunder Spirit Wind Energy Facility (TSWEF) located in Adams County, North Dakota.

The primary objective of this post-construction assessment was to evaluate impacts to bats attributable to collisions with wind turbines for the entire facility on an annual basis and evaluate if the estimated impacts were lower, similar, or higher than other reported regional and national estimates.

Montana-Dakota previously submitted the Post-Construction Bird and Bat Fatality Monitoring Report for TSWEF following completion and initial operation of Phase I of the project. That study's design was focused on estimating impacts on large raptors, specifically eagles, rather than what impacts the facility has on bats. The results of that study provided Montana-Dakota with an inflated estimate of bat fatalities/MW/year, entirely attributable to the design focus being on large raptors. Montana-Dakota determined that upon completion of Phase II of TSWEF, that another bat fatality monitoring would be conducted in the Summer and Fall of 2019 to gain a better understanding of bat mortality attributable to collisions with wind turbines at TSWEF.

The estimated adjusted bat fatality rate for this study was 2.68 bat fatalities/MW/year, significantly lower than the inflated estimate of 12.72 bat fatalities/MW/year for the Thunder Spirit I (TSI) Wind study. Compared to bat fatality estimates at other projects in the Midwest, the estimate of 2.68 bats/MW/year falls within the lower end of the range, ranking 35th out of 62 projects.

Please contact me at 701-222-7856 or at tamie.aberle@mdu.com with questions or follow up as necessary.

Sincerely,

Tamie A. Aberle
Director of Regulatory Affairs

cc. Andy McDonald
Joe Geiger
Abbie Krebsbach

Post-Construction Bat Fatality Monitoring for the Thunder Spirit Wind I and II Facility Adams County, North Dakota

Final Report

Prepared for:

Thunder Spirit Wind, LLC

400 North 4th Street
Bismarck, North Dakota 58501

Prepared by:

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December 3, 2019

EXECUTIVE SUMMARY

Thunder Spirit, LLC, a subsidiary of Montana-Dakota Utilities Co., has developed the Thunder Spirit Wind I and II Facility (Project) in Adams County, North Dakota. The Project is comprised of 43, 2.5-megawatt (MW) Nordex turbines and 16, 3.0-MW Nordex turbines, with a total capacity of 155.5 MW. Western EcoSystems Technology, Inc. was contracted to conduct surveys to estimate the bat fatality rates attributable to wind turbine operation during the summer and fall. Monitoring included 1) standardized carcass surveys of selected turbines, 2) searcher efficiency trials to estimate the percentage of carcasses found by searchers, 3) carcass persistence trials to estimate the length of time a carcass remains in the field for possible detection, and 4) analysis of estimated bat fatalities.

Fifteen turbines, representing 25% of all Project turbines were selected for surveys. Carcass searches were conducted twice per week from June 24 to September 26, 2019 within a full 100.0 x 100-meter (328 x 328-foot) plot centered on the turbine. Vegetation at all search plots was mowed to provide relatively uniform searching conditions across all search plots.

Twenty-three bat fatalities were found during standardized carcass surveys and five bat fatalities were found incidentally. Of these, 21 bat fatalities were retained for analysis based on location and time found. Hoary bat accounted for the majority of the bat fatalities found. No federal- or state-listed threatened, endangered, or candidate bat species were found.

Bat fatality estimates were calculated by adjusting search results for search area, carcass persistence and searcher efficiency biases, and only included carcasses found within the selected search plots. Using the Huso estimator, the overall estimated bat fatality rate for the Project was 6.96 bats/turbine/year or 2.68 bats/MW/year. The annual overall bat fatality estimate for the Project was relatively low compared to other wind energy facilities in the Midwest.

STUDY PARTICIPANTS

Kristen Chodachek	Project Manager
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Carmen Boyd	Data Manager
Guy DiDonato	Lead Client Analyst
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Alex Brazeal	Field Biologist
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REPORT REFERENCE

Chodachek, K. and Z. Gustafson. 2019. Post Construction Bat Fatality Monitoring for the Thunder Spirit I and II Facility, Adams County, North Dakota. Final Report. Prepared for Thunder Spirit Wind, LLC, Bismarck, North Dakota. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota. December 3, 2019

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INTRODUCTION

Thunder Spirit Wind, LLC (Thunder Spirit), a subsidiary of Montana-Dakota Utility Co., has developed the Thunder Spirit Wind I and II Facility (Project), located in Adams County, North Dakota. Thunder Spirit contracted Western EcoSystems Technology, Inc. to develop and implement a Tier 4 post-construction fatality monitoring survey (per the US Fish and Wildlife Service [USFWS] *Land-Based Wind Energy Guidelines* [USFWS 2012]) to estimate the bat fatality rates attributable to operation of the Project during summer and fall of 2019.

Monitoring included 1) standardized carcass surveys of selected turbines, 2) searcher efficiency trials to estimate the percentage of carcasses found by searchers, 3) carcass persistence trials to estimate the length of time a carcass remains in the field for possible detection, and 4) analysis of estimated bat fatalities.

This report presents the results of standardized bat fatality surveys within the Project conducted from June 24 through September 26, 2019. In addition to providing site-specific data collected at the Project, this report compares existing information and results from monitoring studies conducted at other wind energy facilities in the Midwest to contextualize the findings from this study.

STUDY AREA

The Project is located approximately eight kilometers (five miles) northeast of Hettinger, North Dakota (Figure 1). The topography is rolling to flat with several low buttes and ridges. The area is a mix of grassland and cultivated cropland (mainly spring wheat [*Triticum aestivum*] and corn [*Zea mays*]), with areas of wetlands (mainly freshwater ponds and ponds), shrubs and trees, and rural homes (USFWS National Wetlands Inventory 2017, US Department of Agriculture Cropland Data Layer 2018). Most of the historic short-grass prairie has been converted to crop production or is used for livestock grazing.

The Project consists of 59 Nordex wind turbine generators (Figure 2). Phase I of the Project has 43 2.5-megawatt (MW) turbines, each with an 80.0-meter (m; 262.5-feet [ft]) steel tubular towers and 100.0-m (328.0-ft) diameter rotors and 16 3.0-MW turbines, each with a 99.0-m (324.8-ft) steel tubular towers and 131.0-m (429.8-ft) diameter rotors.

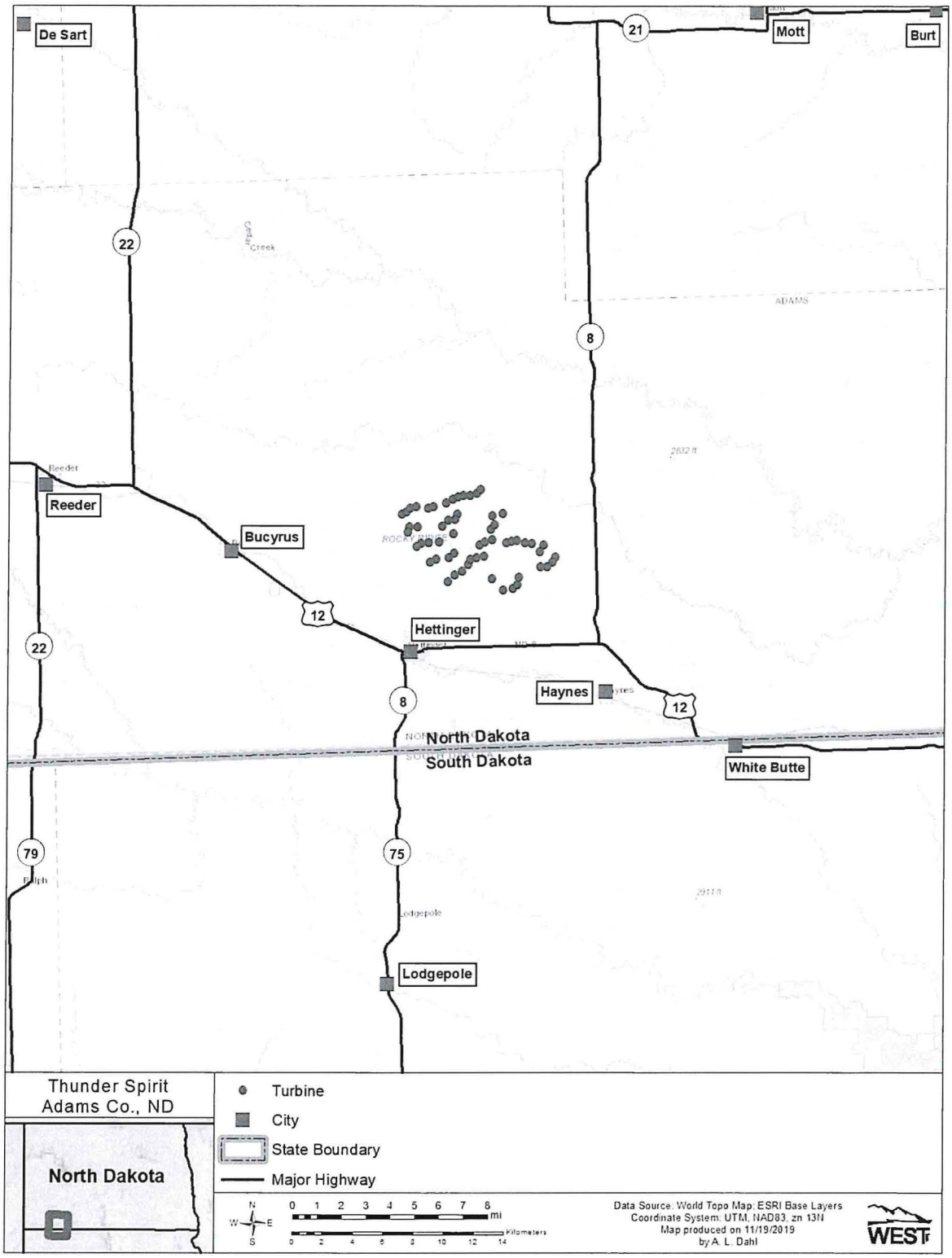

Figure 1. Location of the Thunder Spirit Wind I and II Facility, Adams County, North Dakota.

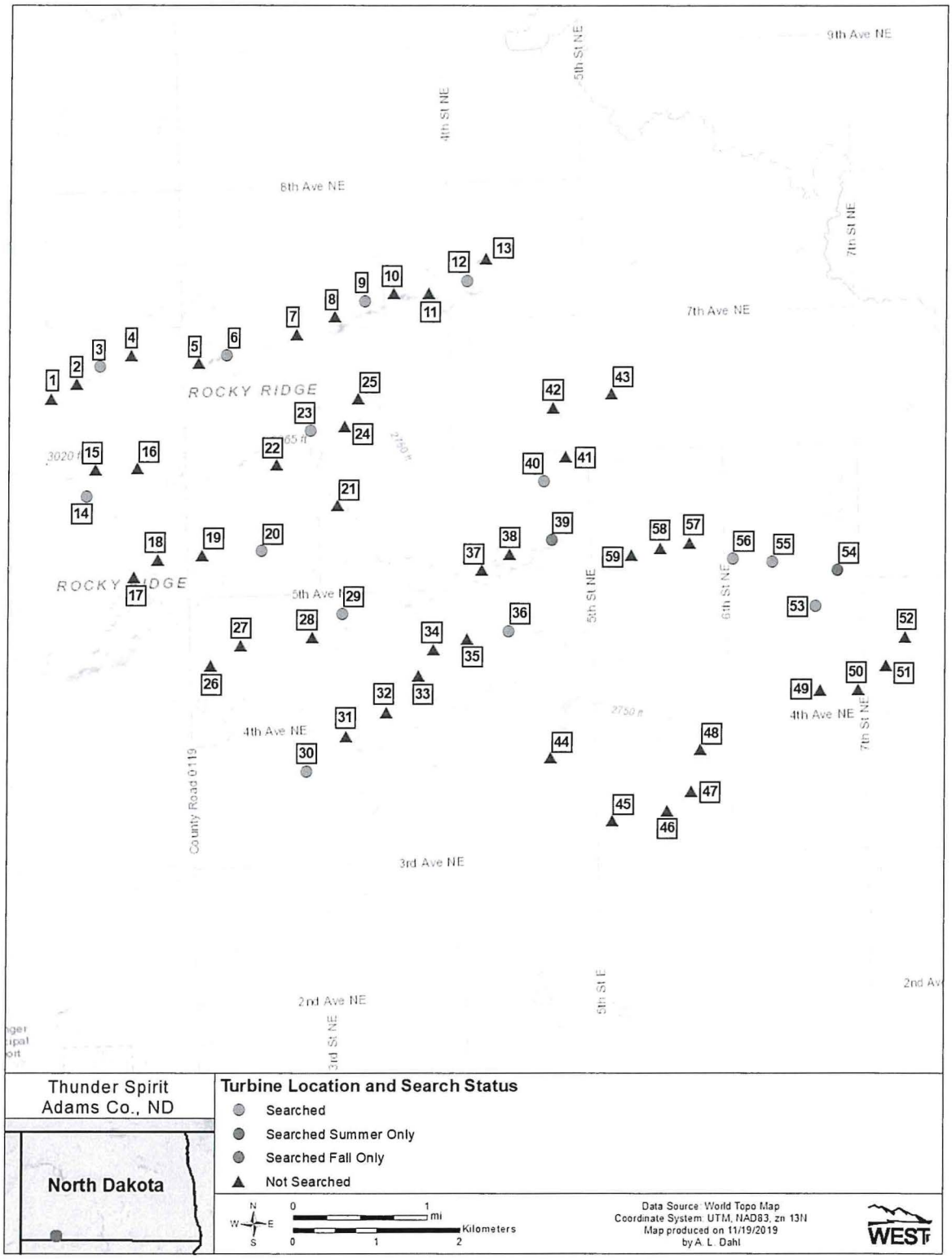

Figure 2. Location of turbines by search status at the Thunder Spirit Wind I and II Facility, Adams County, North Dakota, from June 24 to September 26, 2019.

METHODS

Bat Fatality Surveys

Sample Size, Search Area, and Search Frequency

Fifteen turbines, representing 25% of all Project turbines were selected for surveys in consultation with Thunder Spirit (Figure 2). Turbine 39 was initially selected for searches; however, at the end of summer, it was substituted with Turbine 54, for the remainder of the survey due to vegetation height. Searches were conducted within a 100-m x 100-m square plot centered on the turbine (Figure 3). Vegetation at all search plots was mowed on July 18 and August 6, 2019 to provide relatively uniform searching conditions across all search plots. To the extent possible, turbine searches were rotated throughout the day such that all daylight periods were surveyed (i.e., morning, mid-day, and afternoon). Monitoring began on June 24 and continued through September 26, 2019. Searches were twice per week during both seasons surveyed. The initial searches conducted the week of June 24, 2019 were to remove any carcasses outside of the search interval for surveys.

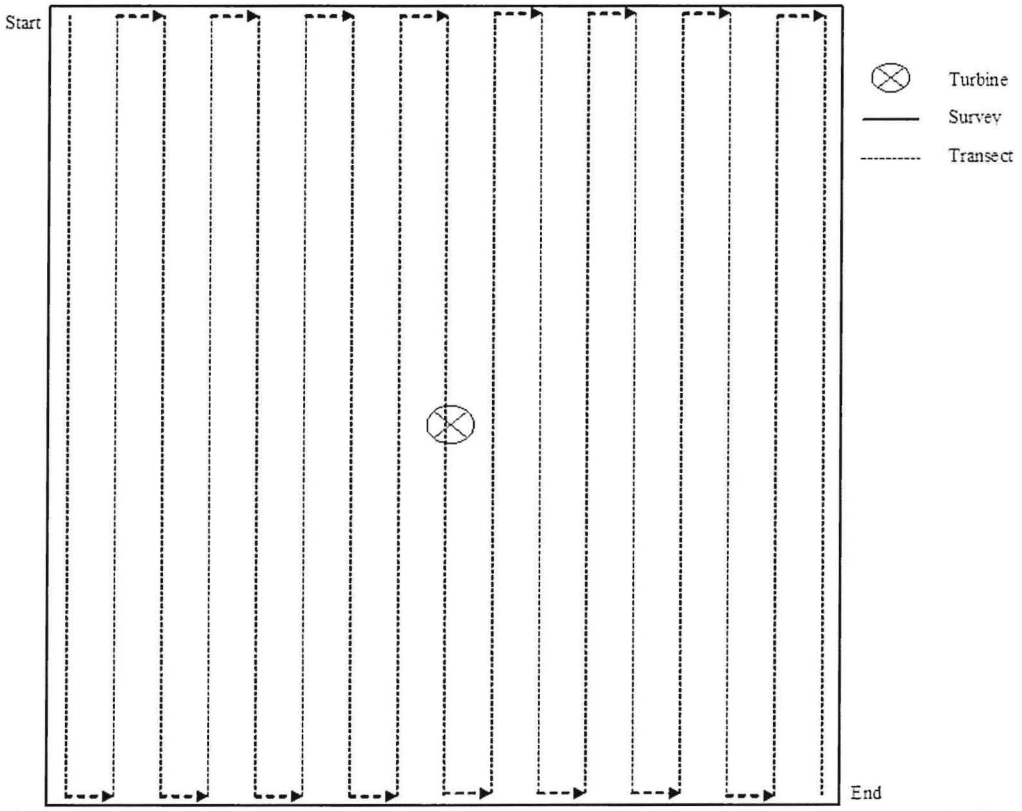

Figure 3. Example schematic of survey pattern (not to scale) for a cleared search plot of 100 x 100 meters (328 x 328 feet) at the Thunder Spirit Wind I and II Facility, Adams County, North Dakota.

Seasons

Historically, most bat fatalities have been documented at wind facilities in late summer and early fall, likely when pups are emerging and/or during fall migration for tree-roosting species such as hoary bat (*Lasiurus cinereus)* and eastern red bats (*Lasiurus borealis*; Johnson 2005, Arnett et al. 2008). This pattern was generally observed during surveys conducted in 2016 at the Thunder Spirit Wind I Facility, when most fatalities were found in mid-August (Derby et al. 2018). Given the focus of this study on bat fatality estimation, only the summer and fall periods were surveyed in 2019, using the following season dates: summer (June 24 to August 10) and fall migration (August 11 to September 30). Summer was further divided into Summer1 (June 24 to July 17) and Summer2 (July 18 to August 10), which is based on the mowing of vegetation at search turbines.

Standardized Carcass Searches

Personnel trained in proper search techniques conducted the carcass searches. Searchers looked for casualties while walking at a casual pace of approximately 45−60 m (148−197 ft) per minute and scanning the turbine pad, road, and transects spaced 10 m (33 ft) apart throughout each search plot (Figure 3).

All bat casualties located within the search plots were recorded, collected, and cause of death determined, if possible. For bat carcasses where the cause of death was not apparent, the assumption the fatality was a wind turbine collision fatality was made. Any injured bat observed in the search plots was recorded and treated as a fatality. All bat carcasses were given a unique identification code and data recorded included species, sex and age when possible, date and time collected, location, condition (i.e., intact, scavenged), and any comments that indicated possible cause of death. All bird fatalities were classified as incidental casualties and were not included in analysis. Casualties found outside the formal search time, but inside of search plots, were treated following the above protocol as closely as possible and were included in the fatality estimate analysis. Bat casualties found in non-search areas (e.g., a turbine not included as part of the systematic search effort) and all bird fatalities were coded as incidental discoveries and documented in a similar fashion as those found during standard searches, but these casualties were not included in the estimates of total fatalities.

Searcher Efficiency Trials

Searcher efficiency trials commenced with the start of carcass searches and were conducted on nine separate days throughout the survey period within the same areas as carcass searches at the Project. Searcher efficiency was estimated for bats by season (summer and fall). Estimates of searcher efficiency were used to adjust the total number of carcasses found for those missed by searchers, thereby correcting for detection bias.

The person placing the carcasses did not inform the searcher conducting the searches when the trial was being conducted or where trial carcasses were placed. Carcasses used for searcher efficiency trials were bats and house mouse (*Mus musculus*) as bat carcass surrogates.

All searcher efficiency trial carcasses were placed at random locations within the search plot, prior to that day's scheduled carcass survey. Each trial carcass was discreetly marked with a black zip tie so it could be identified as a trial carcass after it was found. The number and location of the searcher efficiency carcasses found during the carcass survey was recorded. Carcasses were dropped from waist height or higher and allowed to land in a random posture. To avoid attracting scavengers, no more than two carcasses were placed at any one turbine at any one time. The number of carcasses available for detection during each trial was determined immediately after the trial by the person responsible for distributing the carcasses.

Carcass Persistence Trials

The carcass persistence estimate predicted how many fatalities were removed before carcasses were found during scheduled carcass searches. Possible means of carcass removal included removal by predator, scavenger, insects, or agricultural practices, such as being plowed into a field. Estimates of carcass persistence were used to adjust fatality estimates.

Carcass persistence trials were conducted during both seasons to incorporate the effects of varying weather, climatic conditions, and scavenger densities. Carcass species composition was similar to that used for searcher efficiency trials. Persistence trial carcasses were placed randomly within a 100 x 100-m plot of turbines not searched during scheduled carcass searches. Carcasses were dropped from waist height or higher and allowed to land in a random posture. To avoid attracting scavengers, no more than two carcasses were placed at any one turbine at any one time. Persistence trial carcasses were marked with a black zip tie for recognition by searchers and other personnel.

Trial carcasses were monitored over a 14-day period according to the following schedule: every day for the first four days, and then on day seven, day 10, and day 14. This schedule varied somewhat depending on weather and coordination with the other survey work. At the end of the 14-day period, any remaining evidence of the carcass was removed.

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, legibility, and entered into a Microsoft® Structured Query Language (MSSQL) database. Any anomalous records from the MSSQL database were compared to the raw data forms and any errors detected were corrected. 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.

Data Compilation and Storage

As stated above, MSSQL database was developed to store, organize, and retrieve survey data. All electronic data files were retained for reference.

Carcasses Included in Fatality Estimation

Bat carcasses included in the fatality rate estimation were found within the search plots and had an estimated time of death within the survey period. All bird fatalities were recorded as incidentals and were excluded from statistical analyses.

Fatality Rate Estimation

Fatality estimates were calculated for bats by season and for the entire survey period using the Huso estimator (Huso 2011, Huso et al. 2015) which performs well under a broad range of conditions and has modeling flexibility with respect to carcass persistence. The Huso estimator (Huso 2011) requires censoring carcasses estimated to have been killed in a time period shorter than the search interval. The time between searches was calculated for each carcass in order to determine if the estimated time since death was less than the time since previous search. To obtain an overall estimate of fatality, each bat carcass included in the analysis was adjusted for searcher efficiency, carcass persistence, and a search area adjustment. Estimates and confidence intervals were calculated using 1,000 bootstrap samples for each individual category listed above, assuming more than five fatalities were detected.

Searcher Efficiency Estimation

Data collected during searcher efficiency trials were used to estimate the probability bat carcasses were detected by searchers. Estimates of searcher efficiency were used to adjust carcass counts for detection bias. Searcher efficiency estimated the probability of a carcass being detected by a searcher given the carcass was available to be found. Estimates were obtained separately using a logit regression model (Dalthorp et al. 2018). Season was the only covariate (explanatory variables of interest) included in the logit regression model. Model selection was done using an information theoretic approach known as corrected Akaike Information Criteria (AICc; Burnham and Anderson 2002). The best model was selected as the most parsimonious model within two AICc units of the model with the lowest AICc value.

Carcass Persistence Estimation

Data collected during carcass persistence trials were used to estimate the amount of time, in days, carcasses remained available to be located by the searcher. Estimates of carcass persistence were used to adjust carcass counts for removal bias. The carcass persistence adjustment estimated the average probability a bat carcass persisted through the search interval (i.e., the time between scheduled searches). The persistence of a bat carcass was modeled using an interval-censored survival regression for each size class using exponential, log-logistic, lognormal, and Weibull distributions (Kalbfleisch and Prentice 2002, Dalthorp et al. 2018). Covariates (explanatory variables of interest) were fit to each of the parameters of the distributions. The best model was selected as the most parsimonious model within two AICc units of the model with the lowest AICc value.

Search Area Adjustment Estimate

The search area adjustment accounted for unsearched areas beneath turbines and was calculated as a probability that ranged from zero to one. Unsearched areas were due to survey

obstacles such as ground cover (e.g., tall vegetation) or terrain. The area adjustment was estimated as the product of the unsearched area around each turbine and a carcass-density distribution. The carcass-density distribution predicts the likelihood a carcass fell a given distance from the turbine base.

A number of analysis methods exist to calculate the search area adjustment. The method used was determined by the number of carcasses found during surveys. There were not a sufficient number of bat carcasses found during searches, so truncated weighted maximum likelihood modeling approach (Khokan et al. 2013) could not be used. Therefore, to calculate the search area adjustment for bats, the maximum fall distance of carcasses for a given turbine height and rotor diameter was calculated using a physics-based model (Hull and Muir 2013) where the relative carcass-density distribution was assumed to follow a linear decrease from the turbine base out to the maximum predicted fall distance (Huso and Dalthorp 2014). The Project has two different turbine types; for this analysis, the larger turbine height and rotor diameter were used in the search area adjustment as to calculate a more conservative estimate.

RESULTS

Bat Fatality Surveys

Summary of Search Effort

Twenty-seven search visits, for 391 turbine searches, were conducted from June 24 to September 26, 2019. Twenty-eight bat fatalities were found during standardized carcass surveys or incidentally (Table 1). Four bird fatalities were recorded in the summer season and are not included in analysis (Appendix A). The number, species, location, other characteristics of the bat fatalities included in the analysis and fatality estimates, adjusted for searcher efficiency and carcass persistence biases, are discussed below. A full listing and description of bat and bird fatalities is presented in Appendix A.

Censored Carcasses

The Huso estimator requires bat carcasses with an estimated time since death longer than the search interval be censored (i.e., removed from the analysis). The average search interval for summer and fall were 3.62 days each. The inclusion/exclusion of any fatality is not based on the average search interval, but the turbine-specific time since the last search. As such, any carcasses with time since death estimated to be greater than the search interval immediately preceding their discovery were censored from analysis. Three bat fatalities, including one hoary bat, one eastern red bat, and one little brown bat (*Myotis lucifugus*) were censored from the Huso analysis (Table 1). Four hoary bat fatalities were excluded from analysis since they were located outside of the search plot (Table 1). Twenty-one bat fatalities were included in analysis (Table 1).

Table 1. Bat casualties (number of individuals and percent composition [% Comp]), including casualties found outside the survey period, found at the Thunder Spirit Wind I and II Facility, Adams County, North Dakota, from June 24, 2019 to September 26, 2019.

	Included in Analysis		Outside Search Plot		Outside Survey Period		Not Found in Prior Search Interval[1]		Other Excluded Carcasses		Total	
Species	**Total**	**% Comp[2]**	**Total**	**% Comp[2]**	**Total**	**% Comp[2]**	**Total**	**% Comp[2]**	**Total**	**% Comp[2]**	**Total**	**% Comp[2]**
hoary bat	7	33.3	4	100	0	0	1	33.3	0	0	12	42.9
silver-haired bat	7	33.3	0	0	0	0	0	0	0	0	7	25.0
eastern red bat	6	28.6	0	0	0	0	1	33.3	0	0	7	25.0
little brown bat	1	4.8	0	0	0	0	1	33.3	0	0	2	7.1
Overall	**21**	**100**	**4**	**100**	**0**	**0**	**3**	**100**	**0**	**0**	**28**	**100**

[1] Summer and fall search interval is 3.62 days.

[2] Sums of values may not precisely add to total value shown, due to rounding.

Bat Fatalities

Twenty-one bat fatalities representing four identifiable species were retained for analysis (Table 1). Hoary bat had the most fatalities (12 carcasses; 42.9% of all bat fatalities), followed by silver-haired bat (*Lasionycteris noctivagans*; seven carcasses; 25%), eastern red bats (seven carcasses; 25%), and little brown bat (two carcasses; 7.1%; Table 1, Appendix A).

Bat fatalities retained for analysis were located at nine turbines (Figures 4 and 5). Four fatalities were found at turbines 20 and 30, followed by three fatalities at Turbine 36, two fatalities at turbines 12, 14, 23, and 56, and one fatality at turbines 6 and 40 (Figure 4). Most of the bat fatalities were found in the western half of the Project (Figure 5). The majority of bat fatalities occurred from late summer to fall (Figure 6). Nearly all (90.5%) of bat fatalities had an estimated time since death of three days or less (Table 2).

Table 2. Estimated time of death for bat fatalities included in analysis found at the Thunder Spirit Wind I and II Facility Adams County, North Dakota, from June 24, 2019 to September 26, 2019.

Estimated Time of Death	Number of Fatalities	% Composition
last night	15	71.4
2–3 days	4	19.1
4–7 days	2	9.5

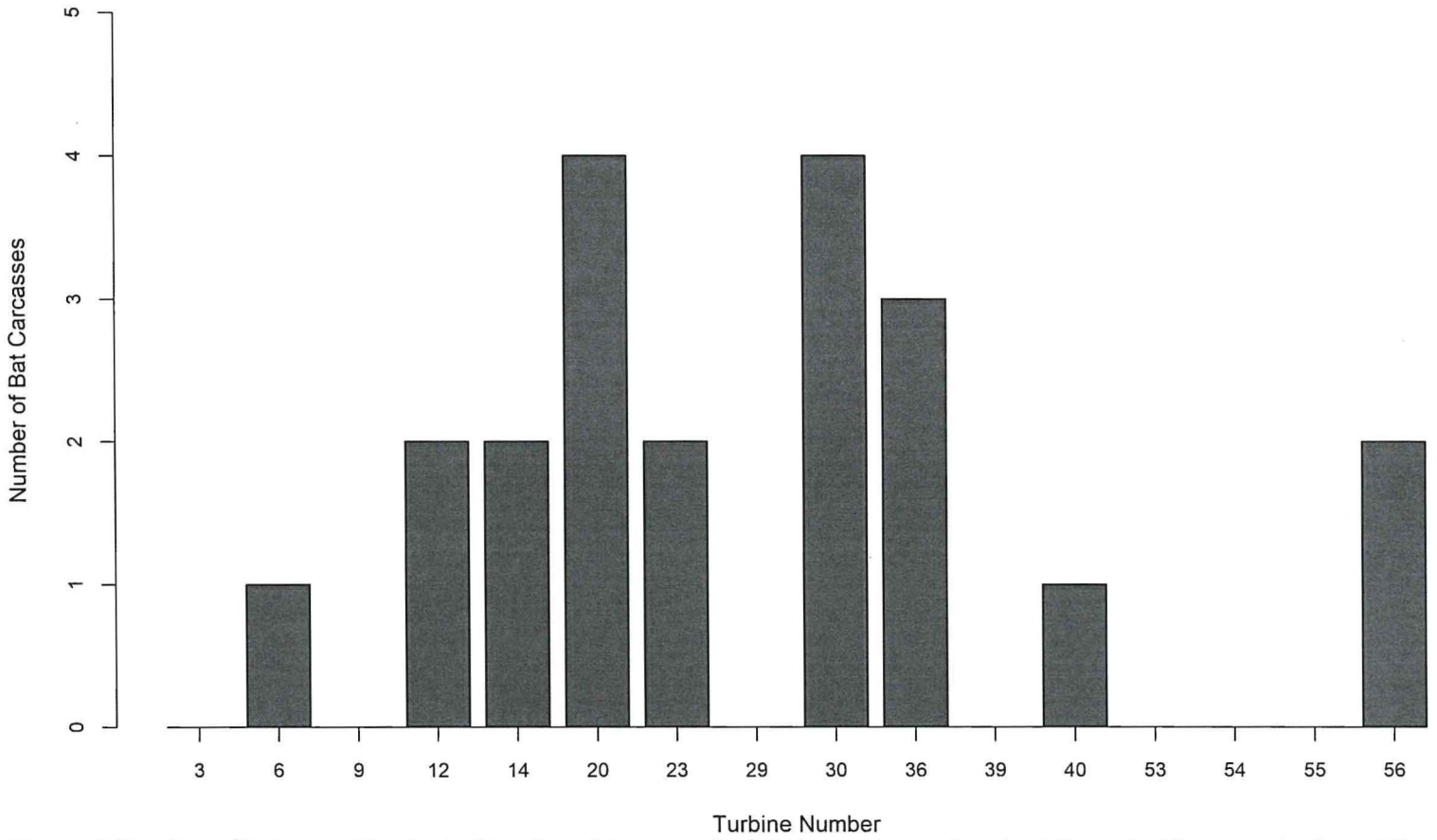

Figure 4. Number of bat casualties by turbine found during scheduled searches or incidentally on turbine search plots at the Thunder Spirit Wind I and II Facility, Adams County, North Dakota, from June 24, 2019 to September 26, 2019.

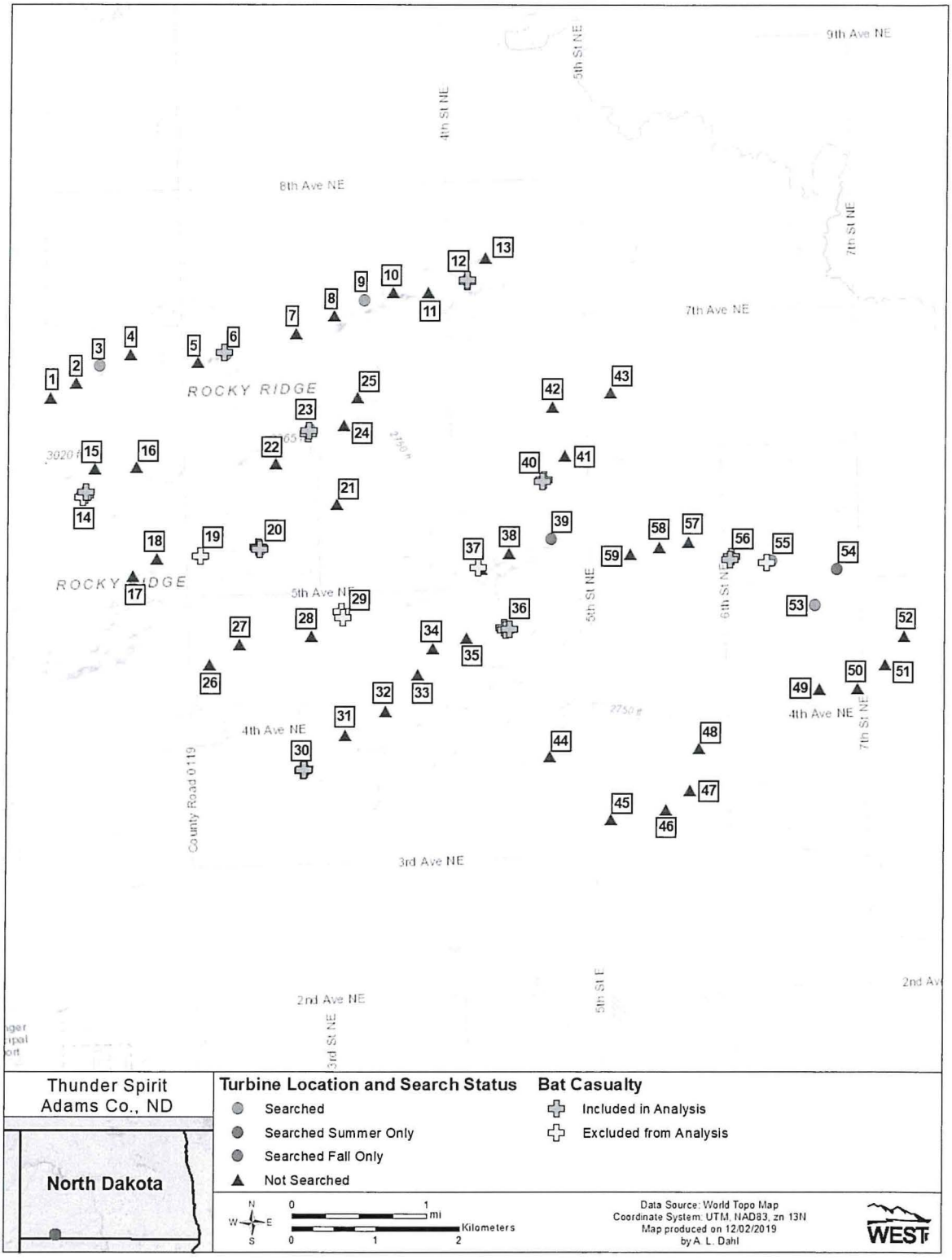

Figure 5. Location of all bat casualties found at the Thunder Spirit Wind I and II Facility, Adams County, North Dakota, from June 24 to September 26, 2019.

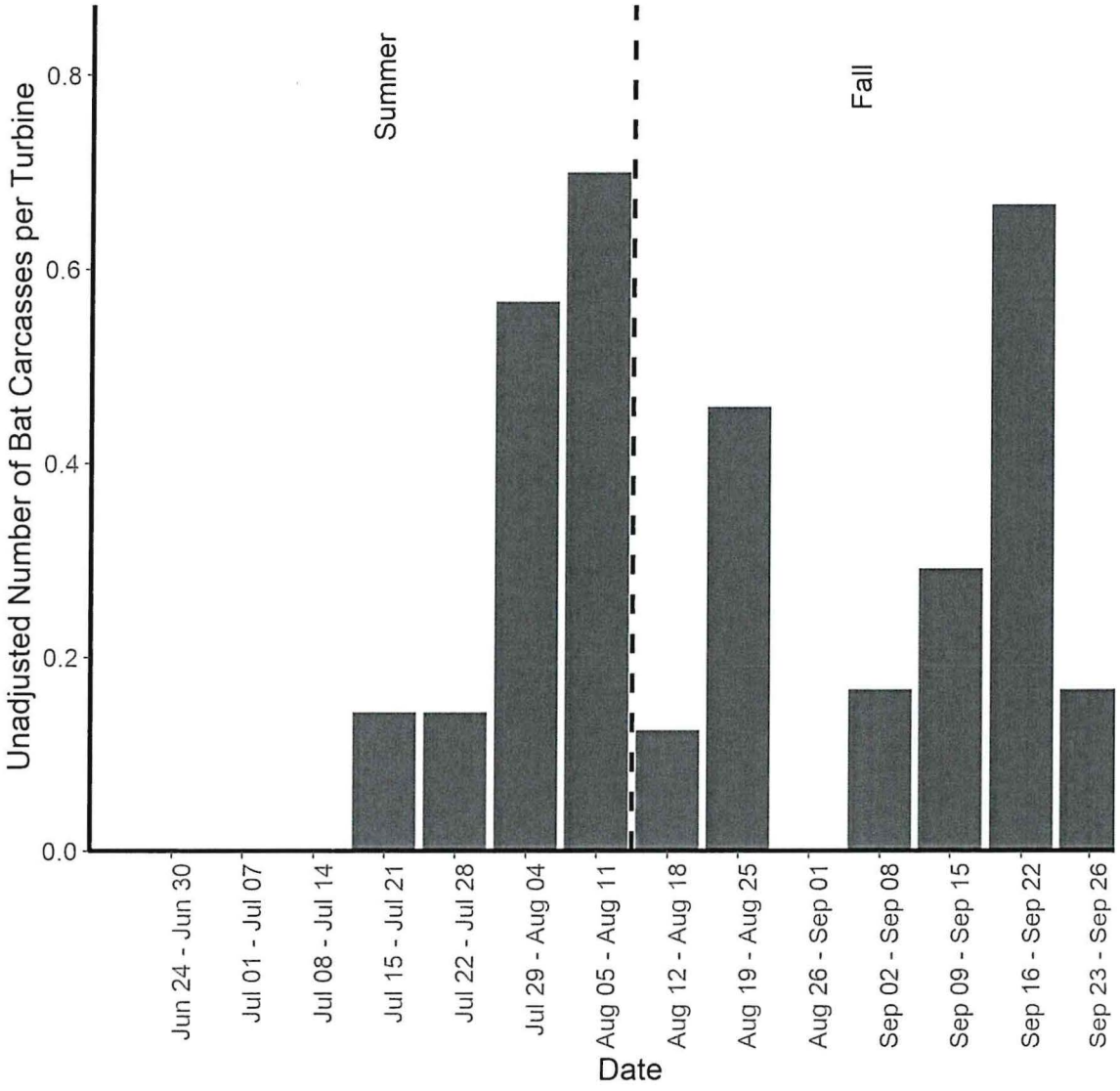

Figure 6. Timing of bat casualties found during scheduled searches or incidentally on turbine search plots at the Thunder Spirit Wind I and II Facility, Adams County, North Dakota, from June 24, 2019 to September 26, 2019.

Searcher Efficiency Trials

Forty-six bat (or their surrogate) carcasses were placed for trials in the Project, including 19 in summer and 27 in fall (Table 3). Efficiency rates were 42.9% in summer and 53.9% in fall. The searcher efficiency rate across seasons was 50% (Table 3).

Table 3. Searcher efficiency results as a function of season at the Thunder Spirit Wind I and II Facility, Adams County, North Dakota from June 24, 2019 to September 26, 2019.

Season	Number Placed	Number Available	Number Found	% Found
summer	19	14	6	42.9
fall	27	26	14	53.9
Overall	**46**	**40**	**20**	**50.0**

For the Huso estimator, models were fit to determine which explanatory variable (i.e., season or none) provided the best model for estimating searcher efficiency based on AICc values. The best model was selected as the most parsimonious model within two AICc units of the model with the lowest AICc value. The best model for bats included the one with no covariates (Table 4).

Table 4. AICc model results used to select the best model variable to include for estimating Huso bat searcher efficiency rates at the Thunder Spirit Wind I and II Facility, Adams County, North Dakota, from June 24, 2019 to September 26, 2019.

Explanatory Variables	AICc	Delta AICc	Selected Model
no covariate	57.56	0	✓
season	59.34	1.78	

AICc = Akaike Information Criteria.

Carcass Persistence Trials

Forty bat (or bat surrogate) carcasses were placed for carcass persistence trials, with 20 in summer and 20 in fall. By day two, approximately 48% of bat carcasses remained where they were placed (Figure 7). By day seven, roughly 22% of bat carcasses remained and by day 14, about 6% of bat (or bat surrogate) carcasses remained.

The average probability of a carcass persisting in the interval used in Huso (2011) was estimated by fitting combinations of distribution (i.e., Weibull, exponential, log-logistic, and lognormal) and explanatory variables (i.e., season or none) using season as the covariate. The best model was selected as the most parsimonious model within two AICc units of the model with the lowest AICc value (Table 5).

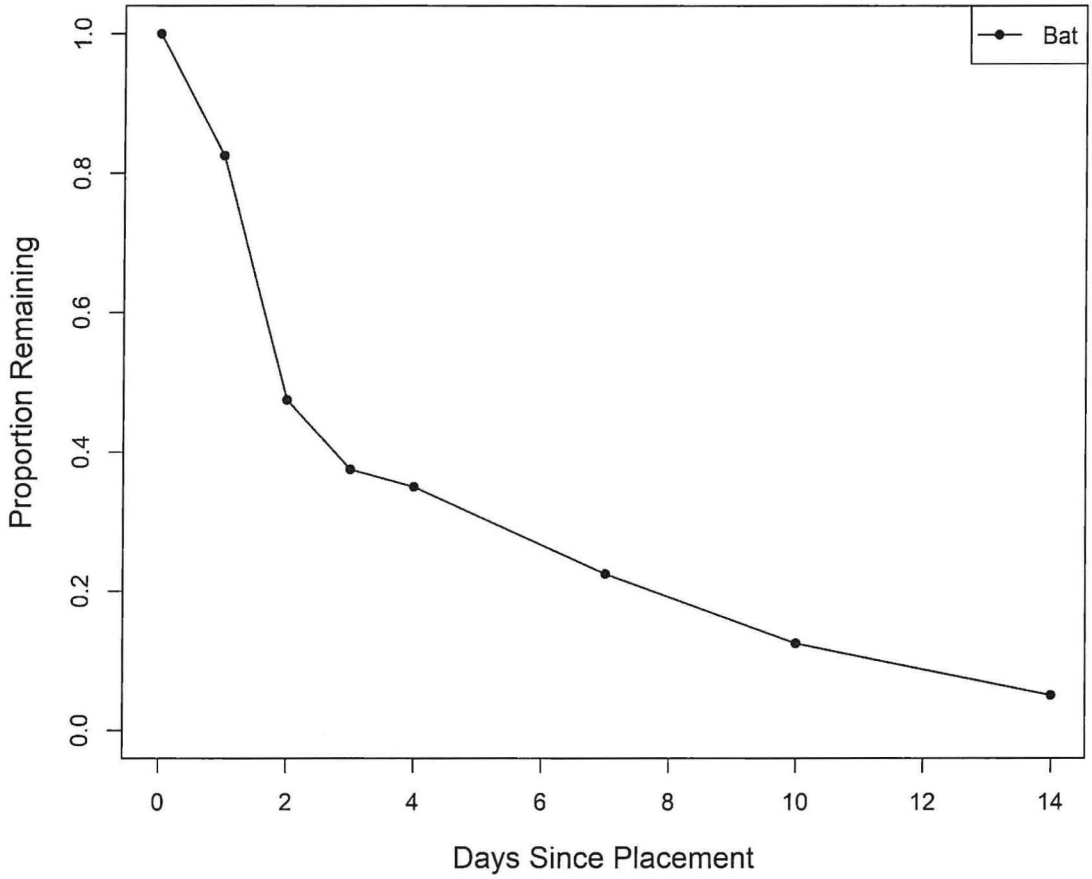

Figure 7. Carcass persistence rates for bats (or bat surrogate) carcasses at the Thunder Spirit Wind I and II Facility, Adams County, North Dakota, from June 24, 2019 to September 26, 2019.

Table 5. Carcass persistence modeling results for the Thunder Spirit Wind I and II Facility, Adams County, North Dakota, from June 24, 2019 to September 26, 2019

Distribution	Predicted Removal Time (days)	Predicted Scale
lognormal	2.48	1.13

Adjusted Fatality Estimates

Fatality estimates and 90% confidence intervals were calculated on a per turbine and per MW basis for bats. The fatality estimates were adjusted based on the corrections for searcher efficiency and carcass persistence bias and the search area adjustment (Appendix B). The overall estimated bat fatality rate for the Project was 6.96 bats/turbine/year or 2.68 bats/MW/year (Table 6).

Table 6. Overall bat fatality rates (Estimate) and lower and upper levels of 90% confidence intervals per turbine and per megawatt found at Thunder Spirit Wind I and II Facility, Adams County, North Dakota, from June 24, 2019 to September 26, 2019.

Per Turbine Estimates			Per Megawatt Estimates		
	90% Confidence Interval			90% Confidence Interval	
Estimate	Lower level	Upper level	Estimate	Lower level	Upper level
6.96	3.71	11.54	2.68	1.43	4.44

DISCUSSION

Overall, 28 bat fatalities were found during monitoring surveys, with 21 retained for analysis. The timing of bat fatalities in the Project (mid-August through mid-September) was consistent with results from other bat fatality studies in the US and Canada that have shown peak mortality from August to September and lower mortality in spring and early summer (Johnson 2005, Arnett et al. 2008). Most of the bat fatalities were likely fall migrants, based on the timing of fatalities and the lack of forest cover within the Project that might provide habitat for resident bats, which is the case at virtually all other wind energy facilities in North America (Johnson 2005, Arnett et al. 2008). Hoary bats and silver-haired bats accounted for the majority of bat fatalities included in the analysis; which is similar to the species composition of fatalities at most other wind energy facilities in the Midwest (Jain 2005, Arnett et al. 2008, Gruver et al. 2011). Based on Frick et al. (2019), wind development may pose a threat to populations of migratory bats. Evidence of declining hoary bat populations have been found in genetic and acoustic studies (Pylant et al. 2016; Rodhouse et al. 2019). Some projection model estimates show that the population size of hoary bats is expected to decline in future years (Frick et al. 2017, Friedenberg et al. 2019). The underlying reason(s) why bats approach turbines is still largely unknown (Cryan and Barclay 2009; Barclay et al. 2017).

Bat fatalities have been discovered at most wind energy facilities monitored in North America, with fatality estimates ranging from 0 to 60.60 bat fatalities/MW/year (American Wind Wildlife Institute [AWWI] 2018, MidAmerican Energy Company 2019). A summary of 202 studies at 137 wind energy facilities in the US found that the majority of wind energy facilities reported fewer than 5.00 bat fatalities/MW/year, with a nationwide median of 2.13 bat fatalities/MW/year (AWWI 2018). The estimated adjusted bat fatality rate for the Project was of 2.68 bat fatalities/MW/year (Table 6) is within this range and close to the nationwide median. Additionally, the bat fatality rate for the Project is lower than the fatality estimate of 12.72 bat fatalities/MW/year for the Thunder Spirit I (TSI) Wind Project (Figure 8). This can be attributed to a revised survey design for the Project from TSI, which focused on bats rather than a design that focused on eagles and large birds. Furthermore, the survey design for the Project provides a better estimate for the entire Project (i.e., Thunder Spirit I and II) versus TSI only. Compared to bat fatality estimates at other projects in the Midwest, the estimate of 2.68 bats/MW/year falls within the lower end of the range, ranking 35th out of 62 projects (Figure 8).

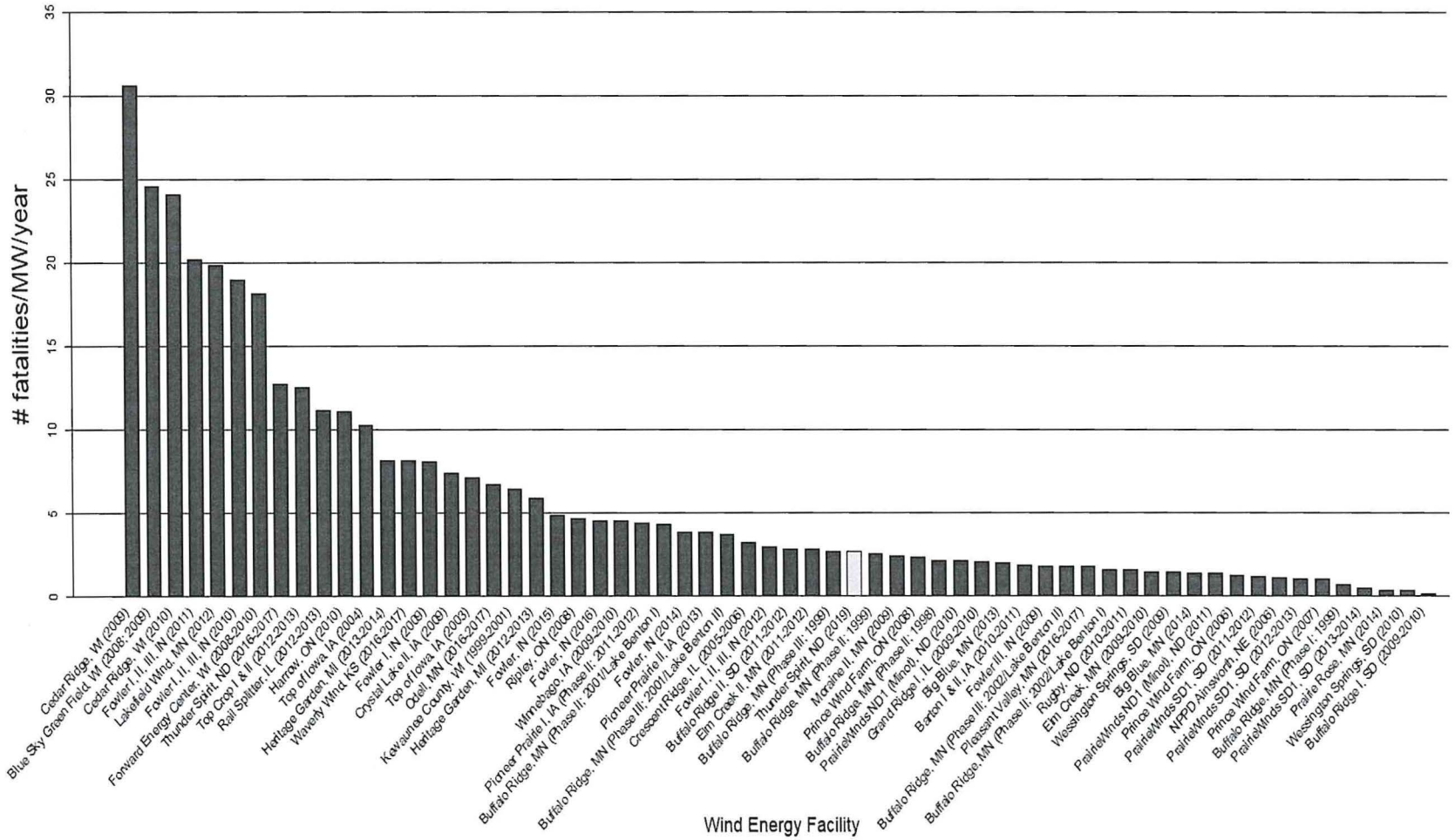

Figure 8. Bat fatality rates (number of bat fatalities per megawatt per year) from publicly available studies conducted at wind energy facilities in the Midwest region of North America.

Figure 8 (*continued*). Bat fatality rates (number of bat fatalities per megawatt per year) from publicly available studies at wind energy facilities in the Midwest and Northeast regions of North America. Data from the following sources:

Study	Reference	Study	Reference
Cedar Ridge, WI (2009)	BHE Environmental 2010	Buffalo Ridge II, SD (2011-2012)	Derby et al. 2012a
Blue Sky Green Field, WI (2008; 2009)	Gruver et al. 2009	Elm Creek II, MN (2011-2012)	Derby et al. 2012b
Cedar Ridge, WI (2010)	BHE Environmental 2011	Buffalo Ridge, MN (Phase III; 1999)	Johnson et al. 2000
Fowler I, II, III, IN (2011)	Good et al. 2012	Buffalo Ridge, MN (Phase II; 1999)	Johnson et al. 2000
Lakefield Wind, MN (2012)	Minnesota Public Utilities Commission 2012	Moraine II, MN (2009)	Derby et al. 2010f
Fowler I, II, III, IN (2010)	Good et al. 2011	Prince Wind Farm, ON (2008)	NRSI 2009
Forward Energy Center, WI (2008-2010)	Grodsky and Drake 2011	Buffalo Ridge, MN (Phase II; 1998)	Johnson et al. 2000
Top Crop I & II, IL (2012-2013)	Good et al. 2013c	PrairieWinds ND1 (Minot), ND (2010)	Derby et al. 2011d
Rail Splitter, IL (2012-2013)	Good et al. 2013b	Grand Ridge I, IL (2009-2010)	Derby et al. 2010a
Harrow, ON (2010)	Natural Resource Solutions Inc. (NRSI) 2011	Big Blue, MN (2013)	Fagen Engineering 2014
Top of Iowa, IA (2004)	Jain 2005	Barton I & II, IA (2010-2011)	Derby et al. 2011b
Heritage Garden, MI (2013-2014)	Kerlinger et al. 2014	Fowler III, IN (2009)	Johnson et al. 2010b
Waverly Wind, KS (2016-2017)	Tetra Tech 2017a	Buffalo Ridge, MN (Phase III; 2002/Lake Benton II)	Johnson et al. 2004
Fowler I, IN (2009)	Johnson et al. 2010a	Pleasant Valley, MN (2016-2017)	Tetra Tech 2017b
Crystal Lake II, IA (2009)	Derby et al. 2010b	Buffalo Ridge, MN (Phase II; 2002/Lake Benton I)	Johnson et al. 2004
Top of Iowa, IA (2003)	Jain 2005	Rugby, ND (2010-2011)	Derby et al. 2011c
Odell, MN (2016-2017)	Chodachek and Gustafson 2018	Elm Creek, MN (2009-2010)	Derby et al. 2010e
Kewaunee County, WI (1999-2001)	Howe et al. 2002	Wessington Springs, SD (2009)	Derby et al. 2010c
Heritage Garden, MI (2012-2013)	Kerlinger et al. 2014	Big Blue, MN (2014)	Fagen Engineering 2015
Fowler, IN (2015)	Good et al. 2016	PrairieWinds ND1 (Minot), ND (2011)	Derby et al. 2012d
Ripley, ON (2008)	Jacques Whitford 2009	Prince Wind Farm, ON (2006)	NRSI 2008
Fowler, IN (2016)	Good et al. 2017	PrairieWinds SD1, SD (2011-2012)	Derby et al. 2012c
Winnebago, IA (2009-2010)	Derby et al. 2010a	NPPD Ainsworth, NE (2006)	Derby et al. 2007
Pioneer Prairie I, IA (Phase II; 2011-2012)	Chodachek et al. 2012	PrairieWinds SD1, SD (2012-2013)	Derby et al. 2013
Buffalo Ridge, MN (Phase II; 2001/Lake Benton I)	Johnson et al. 2004	Prince Wind Farm, ON (2007)	NRSI 2008
Fowler, IN (2014)	Good et al. 2015	Buffalo Ridge, MN (Phase I; 1999)	Johnson et al. 2000
Pioneer Prairie II, IA (2013)	Chodachek et al. 2014	PrairieWinds SD1, SD (2013-2014)	Derby et al. 2014
Buffalo Ridge, MN (Phase III; 2001/Lake Benton II)	Johnson et al. 2004	Prairie Rose, MN (2014)	Chodachek et al. 2015
Crescent Ridge, IL (2005-2006)	Kerlinger et al. 2007	Wessington Springs, SD (2010)	Derby et al. 2011a
Fowler I, II, III, IN (2012)	Good et al. 2013a	Buffalo Ridge I, SD (2009-2010)	Derby et al. 2010d

REFERENCES

American Wind Wildlife Institute (AWWI). 2018. Bats and Wind Energy: Impacts, Mitigation, and Tradeoffs. AWWI, Washington, D. C. November 15, 2018. Available online: https://awwi.org/wp-content/uploads/2018/11/AWWI-Bats-and-Wind-Energy-White-Paper-FINAL.pdf

Arnett, E. B., K. Brown, W. P. Erickson, J. Fiedler, B. L. Hamilton, T. H. Henry, A. Jain, G. D. Johnson, J. Kerns, R. R. Koford, C. P. Nicholson, T. O'Connell, M. Piorkowski, and R. Tankersley, Jr. 2008. Patterns of Bat Fatalities at Wind Energy Facilities in North America. Journal of Wildlife Management 72(1): 61-78.

Barclay, R. M. R., E. F. Baerwald, and J. Rydell. 2017. Bats. Pp. 191-221. In: M. Perrow, ed. Wildlife and Wind Farms - Conflicts and Solutions, Volume 1. Onshore: Potential Effects. Pelagic Publishing, United Kingdom.

BHE Environmental, Inc. (BHE). 2010. Post-Construction Bird and Bat Mortality Study: Cedar Ridge Wind Farm, Fond Du Lac County, Wisconsin. Interim Report prepared for Wisconsin Power and Light, Madison, Wisconsin. Prepared by BHE Environmental, Inc. Cincinnati, Ohio. February 2010.

BHE Environmental, Inc. (BHE). 2011. Post-Construction Bird and Bat Mortality Study: Cedar Ridge Wind Farm, Fond Du Lac County, Wisconsin. Final Report. Prepared for Wisconsin Power and Light, Madison, Wisconsin. Prepared by BHE Environmental, Inc. Cincinnati, Ohio. February 2011.

Burnham, K. P. and D. R. Anderson. 2002. Model Selection and Multimodel Inference: A Practical Information-Theoretic Approach. Second Edition. Springer, New York, New York.

Chodachek, K., C. Derby, M. Sonnenberg, and T. Thorn. 2012. Post-Construction Fatality Surveys for the Pioneer Prairie Wind Farm I LLC Phase II, Mitchell County, Iowa: April 4, 2011 – March 31, 2012. Prepared for EDP Renewables, North America LLC, Houston, Texas. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota. August 27, 2012.

Chodachek, K., C. Derby, K. Adachi, and T. Thorn. 2014. Post-Construction Fatality Surveys for the Pioneer Prairie II Wind Energy Facility, Mitchell County, Iowa. Final Report: July 1 - October 18, 2013. Prepared for EDP Renewables, North America LLC, Houston, Texas. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota. April 2014.

Chodachek, K., K. Adachi, and G. DiDonato. 2015. Post Construction Fatality Surveys for the Prairie Rose Wind Energy Facility, Rock County, Minnesota. Final Report: April 15 to June 13, 2014, and August 15 to October 29, 2014. Prepared for Enel Green Power, North America, San Diego, California. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota. January 23, 2015. Available online: https://www.edockets.state.mn.us/EFiling/edockets/searchDocuments.do?method=showPoup&documentId=%7BF38C2FEC-ED84-4813-AF3E-5A397A954A34%7D&documentTitle=20152-107006-01

Chodachek, K. and Z. Gustafson. 2018. Tier 4 Post-Construction Mortality Monitoring Study for the Odell Wind Energy Project, Cottonwood and Jackson Counties, Minnesota. Final Fatality Report: December 2016 – December 2017. Prepared for Odell Wind Farm, LLC, Oakville, Ontario, Canada. Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota. March 15, 2018.

Cryan, P. and R. Barclay. 2009. Causes of bat fatalities at wind turbines: hypotheses and predictions. Journal of Mammalogy 90(6):1330-1340.

Dalthorp, D. H., L. Madsen, M. M. Huso, P. Rabie, R. Wolpert, J. Studyvin, J. Simonis, and J. M. Mintz. 2018. Genest Statistical Models—a Generalized Estimator of Mortality. US Geological Survey (USGS) Techniques and Methods. Vol. 7. Chap A2, Page 13. Available online: https://www.usgs.gov/software/genest-a-generalized-estimator-mortality

Derby, C., A. Dahl, W. Erickson, K. Bay, and J. Hoban. 2007. Post-Construction Monitoring Report for Avian and Bat Mortality at the NPPD Ainsworth Wind Farm. Unpublished report prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming, for the Nebraska Public Power District.

Derby, C., J. Ritzert, and K. Bay. 2010a. Bird and Bat Fatality Study, Grand Ridge Wind Resource Area, Lasalle County, Illinois. January 2009 - January 2010. Prepared for Grand Ridge Energy LLC, Chicago, Illinois. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota. July 13, 2010. Revised January 2011.

Derby, C., K. Chodachek, and K. Bay. 2010b. Post-Construction Bat and Bird Fatality Study Crystal Lake II Wind Energy Center, Hancock and Winnebago Counties, Iowa. Final Report: April 2009- October 2009. Prepared for NextEra Energy Resources, Juno Beach, Florida. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota. June 2, 2010.

Derby, C., A. Dahl, A. Merrill, and K. Bay. 2010c. 2009 Post-Construction Monitoring Results for the Wessington Springs Wind-Energy Facility, South Dakota. Final Report. Prepared for Wessington Wind Energy Center, LLC, Juno Beach, Florida. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota. August 19, 2010.

Derby, C., K. Chodachek, K. Bay, and A. Merrill. 2010d. Post-Construction Fatality Survey for the Buffalo Ridge I Wind Project. May 2009 - May 2010. Prepared for Iberdrola Renewables, Inc., Portland, Oregon. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota.

Derby, C., K. Chodachek, K. Bay, and A. Merrill. 2010e. Post-Construction Fatality Surveys for the Elm Creek Wind Project: March 2009- February 2010. Prepared for Iberdrola Renewables, Inc. (IRI), Portland, Oregon. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota.

Derby, C., K. Chodachek, K. Bay, and A. Merrill. 2010f. Post-Construction Fatality Surveys for the Moraine II Wind Project: March - December 2009. Prepared for Iberdrola Renewables, Inc. (IRI), Portland, Oregon. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota.

Derby, C., A. Dahl, K. Bay, and L. McManus. 2011a. 2010 Post-Construction Monitoring Results for the Wessington Springs Wind Energy Facility, South Dakota. Final Report: March 9 – November 16, 2010. Prepared for Wessington Wind Energy Center, LLC, Juno Beach, Florida. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota. November 22, 2011.

Derby, C., K. Chodachek, K. Bay, and S. Nomani. 2011b. Post-Construction Fatality Surveys for the Barton I and II Wind Project: Iri. March 2010 - February 2011. Prepared for Iberdrola Renewables, Inc. (IRI), Portland, Oregon. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota. Version: September 28, 2011.

Derby, C., K. Chodachek, K. Bay, and S. Nomani. 2011c. Post-Construction Fatality Surveys for the Rugby Wind Project: Iberdrola Renewables, Inc. March 2010 - March 2011. Prepared for Iberdrola Renewables, Inc. (IRI), Portland, Oregon. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota. Version: October 14, 2011.

Derby, C., K. Chodachek, T. Thorn, K. Bay, and S. Nomani. 2011d. Post-Construction Fatality Surveys for the Prairiewinds ND1 Wind Facility, Basin Electric Power Cooperative, March - November 2010. Prepared for Basin Electric Power Cooperative, Bismarck, North Dakota. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota. August 2, 2011.

Derby, C., K. Chodachek, and M. Sonnenberg. 2012a. Post-Construction Casualty Surveys for the Buffalo Ridge II Wind Project. Iberdrola Renewables: March 2011- February 2012. Prepared for Iberdrola Renewables, LLC, Portland, Oregon. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota. August 31, 2012.

Derby, C., K. Chodachek, and M. Sonnenberg. 2012b. Post-Construction Fatality Surveys for the Elm Creek II Wind Project. Iberdrola Renewables: March 2011-February 2012. Prepared for Iberdrola Renewables, LLC, Portland, Oregon. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota. October 8, 2012.

Derby, C., A. Dahl, and A. Merrill. 2012c. Post-Construction Monitoring Results for the Prairiewinds SD1 Wind Energy Facility, South Dakota. Final Report: March 2011 - February 2012. Prepared for Basin Electric Power Cooperative, Bismarck, North Dakota. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota. September 27, 2012.

Derby, C., K. Chodachek, T. Thorn, and A. Merrill. 2012d. Post-Construction Surveys for the Prairiewinds ND1 (2011) Wind Facility Basin Electric Power Cooperative: March - October 2011. Prepared for Basin Electric Power Cooperative, Bismarck, North Dakota. Prepared by Western Ecosystems Technology, Inc. (WEST), Bismarck, North Dakota. August 31, 2012.

Derby, C., A. Dahl, and D. Fox. 2013. Post-Construction Fatality Monitoring Studies for the Prairiewinds SD1 Wind Energy Facility, South Dakota. Final Report: March 2012 - February 2013. Prepared for Basin Electric Power Cooperative, Bismarck, North Dakota. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota. November 13, 2013.

Derby, C., A. Dahl, and G. DiDonato. 2014. Post-Construction Fatality Monitoring Studies for the Prairiewinds SD1 Wind Energy Facility, South Dakota. Final Report: March 2013 - February 2014. Prepared for Basin Electric Power Cooperative, Bismarck, North Dakota. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota.

Derby, C., D. Klostermeier, R. Tupling, and K. Moratz. 2018. Post-Construction Bird and Bat Fatality Monitoring for the Thunder Spirit Wind Energy Facility, Adams County, North Dakota. Final Fatality Report. Prepared for Thunder Spirit Wind, LLC, Bismarck, North Dakota. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota. March 1, 2018.

ESRI. 2019. World Imagery and Aerial Photos. (World Topo). ArcGIS Resource Center. Environmental Systems Research Institute (ESRI), producers of ArcGIS software. Redlands, California. Information online: http://www.arcgis.com/home/webmap/viewer.html?useExisting=1

Fagen Engineering, LLC. 2014. 2013 Avian and Bat Monitoring Annual Report: Big Blue Wind Farm, Blue Earth, Minnesota. Prepared for Big Blue Wind Farm. Prepared by Fagen Engineering, LLC. May 2014.

Fagen Engineering, LLC. 2015. 2014 Avian and Bat Monitoring Annual Report: Big Blue Wind Farm, Blue Earth, Minnesota. Prepared for Big Blue Wind Farm. Prepared by Fagen Engineering, LLC.

Frick, W. F., T. Kingston, and J. Flanders. 2019. A Review of the Major Threats and Challenges to Global Bat Conservation. Annals of the New York Academy of Sciences: doi: 10.1111/nyas.14045.

Frick, W. F., E. F. Baerwald, J. F. Pollock, R. M. R. Barclay, J. A. Szymanski, T. J. Weller, A. L. Russell, S. C. Loeb, R. A. Medellin, and L. P. McGuire. 2017. Fatalities at Wind Turbines May Threaten Population Viability of a Migratory Bat. Biological Conservation 209: 172-177. doi: 10.1016/j.biocon.2017.02.023.

Friedenberg, N., W. Frick, and C. Newman. 2019. Wind Build Out and Bat Fatality Reduction: Understanding the Risks to Hoary Bat Populations. Webinar: Updated Population Modeling Results for Hoary Bats. Presented by N. Friedenberg, organized by J. Page. Prepared by N. Friedenberg, Applied Biomathematics, W. Frick, Bat Conservation International, and C. Newman, Electric p\Power Research Institute (EPRI) Endangered Species Program. January 25, 2019.

Good, R. E., W. P. Erickson, A. Merrill, S. Simon, K. Murray, K. Bay, and C. Fritchman. 2011. Bat Monitoring Studies at the Fowler Ridge Wind Energy Facility, Benton County, Indiana: April 13 - October 15, 2010. Prepared for Fowler Ridge Wind Farm. Prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming. January 28, 2011. Available online: https://www.fws.gov/midwest/endangered/permits/hcp/FowlerRidge/pdf/AppendixA_FowlerRidgeWindFarmFinalHCP062713.pdf

Good, R. E., A. Merrill, S. Simon, K. Murray, and K. Bay. 2012. Bat Monitoring Studies at the Fowler Ridge Wind Farm, Benton County, Indiana: April 1 - October 31, 2011. Prepared for the Fowler Ridge Wind Farm. Prepared by Western EcoSystems Technology, Inc. (WEST), Bloomington, Indiana. January 31, 2012. Available online: http://batsandwind.org/pdf/Good%20et%20al.%202012_Fowler%20Report.pdf

Good, R. E., M. Sonnenburg, and S. Simon. 2013a. Bat Evaluation Monitoring Studies at the Fowler Ridge Wind Farm, Benton County, Indiana: August 1 - October 15, 2012. Prepared for the Fowler Ridge Wind Farm. Prepared by Western EcoSystems Technology, Inc. (WEST), Bloomington, Indiana. January 31, 2013. Available online: http://batsandwind.org/pdf/Good%20et%20al.%202013_Fowler%20Final%20%20Report%2031%20January%202013.pdf

Good, R. E., M. L. Ritzert, and K. Adachi. 2013b. Post-Construction Monitoring at the Rail Splitter Wind Farm, Tazwell and Logan Counties, Illinois. Final Report: May 2012 - May 2013. Prepared for EDP Renewables, Houston, Texas. Prepared by Western EcoSystems Technology, Inc. (WEST), Bloomington, Indiana. December 16, 2013.

Good, R. E., J. P. Ritzert, and K. Adachi. 2013c. Post-Construction Monitoring at the Top Crop Wind Farm, Gundy and Lasalle Counties, Illinois. Final Report: May 2012 - May 2013. Prepared for EDP Renewables, Houston, Texas. Prepared by Western EcoSystems Technology, Inc. (WEST), Bloomington, Indiana. December 13, 2013.

Good, R. E., G. Iskali, and K. Adachi. 2015. Bat Evaluation Monitoring Studies at the Fowler Ridge Wind Farm, Benton County, Indiana: August 4 - October 14, 2014. Prepared for Fowler Ridge Wind Farm. Prepared by Western EcoSystems Technology, Inc. (WEST), Bloomington, Indiana. January 30, 2015. Available online: https://www.fws.gov/midwest/endangered/permits/hcp/FowlerRidge/pdf/MonitoringReportYr2014FowlerRidge013015.pdf

Good, R. E., G. Iskali, and K. Nasman. 2016. Bat Evaluation Monitoring Studies at the Fowler Ridge Wind Farm, Benton County, Indiana: August 3 - October 14, 2015. Prepared for Fowler Ridge Wind Farm. Prepared by Western EcoSystems Technology, Inc. (WEST), Bloomington, Indiana. January 28, 2016. Available online: https://www.fws.gov/midwest/endangered/permits/hcp/FowlerRidge/pdf/MonitoringReport2015FowlerHCP28Jan2015.pdf

Good, R. E., A. Ciecka, G. Iskali, and K. Nasman. 2017. Bat Monitoring Studies at the Fowler Ridge Wind Farm, Benton County, Indiana: August 3 - October 12, 2016. Draft. Prepared for Fowler Ridge Wind Farm. Prepared by Western EcoSystems Technology, Inc. (WEST), Bloomington, Indiana. January 31, 2017. Available online: https://www.fws.gov/midwest/endangered/permits/hcp/FowlerRidge/pdf/MonitoringReportFowler2016Dated013117.pdf

Grodsky, S. M. and D. Drake. 2011. Assessing Bird and Bat Mortality at the Forward Energy Center. Final Report. Public Service Commission (PSC) of Wisconsin. PSC REF#:152052. Prepared for Forward Energy LLC. Prepared by Department of Forest and Wildlife Ecology, University of Wisconsin-Madison, Madison, Wisconsin. August 2011.

Gruver, J., M. Sonnenberg, K. Bay, and W. Erickson. 2009. Post-Construction Bat and Bird Fatality Study at the Blue Sky Green Field Wind Energy Center, Fond Du Lac County, Wisconsin July 21 - October 31, 2008 and March 15 - June 4, 2009. Unpublished report prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming. December 17, 2009.

Gruver, J., K. Bay, M. Kesterke, W. Erickson, K. Murray, and M. Ritzert. 2011. A Summary of Bat Studies and Fatalities from Wind Energy Facilities in the United States with an Emphasis on the Midwest. Oral Presentation (*invited*) given to the 2nd Joint Meeting Northeastern Bat Working Group, Midwest Bat Working Group, Southeastern Bat Diversity Network, and 21st Colloquium on the Conservation of Mammals in the Eastern United States, Louisville, Kentucky. February 23-25, 2011.

Howe, R. W., W. Evans, and A. T. Wolf. 2002. Effects of Wind Turbines on Birds and Bats in Northeastern Wisconsin. Prepared by University of Wisconsin-Green Bay, for Wisconsin Public Service Corporation and Madison Gas and Electric Company, Madison, Wisconsin. November 21, 2002. 104 pp.

Hull, C. L. and S. C. Muir. 2013. Behavior and Turbine Avoidance Rates of Eagles at Two Wind Farms in Tasmania, Australia. Wildlife Society Bulletin 37(1): 49-58. doi: 10.1002/wsb.254.

Huso, M. 2011. An Estimator of Wildlife Fatality from Observed Carcasses. Environmetrics 22(3): 318-329. doi: 10.1002/env.1052.

Huso, M., N. Som, and L. Ladd. 2015. Fatality Estimator User's Guide. US Geological Survey (USGS) Data Series 729. Version 1.1. December 2015. Available online: http://pubs.usgs.gov/ds/729/pdf/ds729.pdf

Huso, M. M. P. and D. Dalthorp. 2014. Accounting for Unsearched Areas in Estimating Wind Turbine-Caused Fatality. Journal of Wildlife Management 78(2): 347-358. doi: 10.1002/jwmg.663.

Jacques Whitford Stantec Limited (Jacques Whitford). 2009. Ripley Wind Power Project Postconstruction Monitoring Report. Project No. 1037529.01. Report to Suncor Energy Products Inc., Calgary, Alberta, and Acciona Energy Products Inc., Calgary, Alberta. Prepared for the Ripley Wind Power Project Post-Construction Monitoring Program. Prepared by Jacques Whitford, Markham, Ontario. April 30, 2009.

Jain, A. 2005. Bird and Bat Behavior and Mortality at a Northern Iowa Windfarm. Thesis. Iowa State University, Ames, Iowa. Available online: http://batsandwind.org/pdf/Jain_2005.pdf

Johnson, G. D., W. P. Erickson, M. D. Strickland, M. F. Shepherd, and D. A. Shepherd. 2000. Final Report: Avian Monitoring Studies at the Buffalo Ridge Wind Resource Area, Minnesota: Results of a 4-Year Study. Final report prepared for Northern States Power Company, Minneapolis, Minnesota, by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming. September 22, 2000. 212 pp.

Johnson, G. D., M. K. Perlik, W. P. Erickson, and M. D. Strickland. 2004. Bat Activity, Composition and Collision Mortality at a Large Wind Plant in Minnesota. Wildlife Society Bulletin 32(4): 1278-1288.

Johnson, G. D. 2005. A Review of Bat Mortality at Wind-Energy Developments in the United States. Bat Research News 46(2): 45-49.

Johnson, G. D., M. Ritzert, S. Nomani, and K. Bay. 2010a. Bird and Bat Fatality Studies, Fowler Ridge I Wind-Energy Facility Benton County, Indiana. Unpublished report prepared for British Petroleum Wind Energy North America Inc. (BPWENA) by Western EcoSystems Technology, Inc. (WEST).

Johnson, G. D., M. Ritzert, S. Nomani, and K. Bay. 2010b. Bird and Bat Fatality Studies, Fowler Ridge III Wind-Energy Facility, Benton County, Indiana. April 2 - June 10, 2009. Prepared for BP Wind Energy North America. Prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming.

Kalbfleisch, J. D. and R. L. Prentice. 2002. The Statistical Analysis of Failure Time Data. John Wiley & Sons, Hoboken, New Jersey.

Kerlinger, P., R. Curry, A. Hasch, and J. Guarnaccia. 2007. Migratory Bird and Bat Monitoring Study at the Crescent Ridge Wind Power Project, Bureau County, Illinois: September 2005 - August 2006. Final draft prepared for Orrick Herrington and Sutcliffe, LLP. May 2007.

Kerlinger, P., J. Guarnaccia, R. Curry, and C. J. Vogel. 2014. Bird and Bat Fatality Study, Heritage Garden I Wind Farm, Delta County, Michigan: 2012-2014. Prepared for Heritage Sustainable Energy, LLC. Prepared by Curry and Kerlinger, LLC, McLean, Virginia. November 2014.

Khokan, M. R., W. Bari, and J. A. Khan. 2013. Weighted Maximum Likelihood Approach for Robust Estimation: Weibull Model. Dhaka University Journal of Science 61(2): 153-156.

MidAmerican Energy Company. 2019. Final Habitat Conservation Plan. MidAmerican Energy Company Iowa wind energy project portfolio. Des Moines, Iowa.

Minnesota Public Utilities Commission (MPUC). 2012. Lakefield Wind Project Avian and Bat Fatality Monitoring. MPUC Site Permit Quarterly Report and USFWS Special Purpose – Utility (Avian Take Monitoring) 30-Day Report: April 1 – September 30, 2012. USFWS Permit No: MB70161A-0; MDNR Permit No: 17930; MPUC Permit No: IP-6829/WS-09-1239, Permit Special Condition VII.B. October 15, 2012. Available online: https://www.edockets.state.mn.us/EFiling/edockets/searchDocuments.do?method=showPoup&documentId={DEE3ABC0-1AD5-45CF-9451-EBF6F3C4C489}&documentTitle=201210-79566-01

Natural Resource Solutions Inc. (NRSI). 2008. 2007 Bird and Bat Mortality Monitoring, Prince Wind Power Project. Project No. 723. Prepared for Brookfield Renewable Power, Gatineau, Quebec. Prepared by NSRI, Waterloo, Ontario. February 2008.

Natural Resource Solutions Inc. (NRSI). 2009. 2006, 2007 and 2008 Bird and Bat Mortality Monitoring, Prince Wind Power Project. Project No. 821, D. Stephenson, Senior Biologist. Prepared for Brookfield Renewable Power, Gatineau, Quebec. Prepared by NSRI, Waterloo, Ontario. May 5, 2009.

Natural Resource Solutions Inc. (NRSI). 2011. Harrow Wind Farm 2010 Post-Construction Monitoring Report. Project No. 0953. Prepared for International Power Canada, Inc., Markham, Ontario. Prepared by NRSI, Waterloo, Ontario. August 2011.

North American Datum (NAD). 1983. NAD83 Geodetic Datum.

Pylant, C., D. Nelson, M. Fitzpatrick, J. Gates, and S. Keller. 2016. Geographic origins and population genetics of bats killed at wind-energy facilities. Ecological Applications 26(5): 1381-1395.

Rodhouse, T., R. Rodriguez, K. Banner, P. Ormsbee, J Barnett, and K. Irvine. 2019. Evidence of region-wide bat population decline from long-term monitoring and Bayesian occupancy models with empirically informed priors. Ecology and Evolution 9(19): 11078-11088.

Tetra Tech. 2017a. 2016-2017 Post-Construction Fatality Monitoring Annual Report: Waverly Wind Farm, Coffey County, Kansas. Prepared for Waverly Wind Farm, LLC. Prepared by Portland, Oregon. October 2017.

Tetra Tech. 2017b. 2016 - 2017 Post-Construction Mortality Monitoring Annual Report, Pleasant Valley Wind Farm, Mower and Dodge Counties, Minnesota. Prepared for Northern States Power Company-Minnesota, Xcel Energy. Prepared by Tetra Tech, Bloomington, Minnesota. June 2017. Available online: https://mn.gov/commerce/energyfacilities/Docket.html?Id=25724

US Department of Agriculture (USDA) National Agricultural Statistics Service (NASS). 2018. Cropscape - Cropland Data Layer. 2018 South Dakota Data. Accessed May 2018. USDA NASS homepage at: http://www.nass.usda.gov/; Cropscape CDL program data available online at: http://nassgeodata.gmu.edu/CropScape/

US Fish and Wildlife Service (USFWS). 2012. Land-Based Wind Energy Guidelines. March 23, 2012. 82 pp. Available online: http://www.fws.gov/cno/pdf/Energy/2012_Wind_Energy_Guidelines_final.pdf

US Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI). 2017. Seamless Wetlands Data by State. Last updated October 1, 2017. Accessed February 2018. Geodatabase and Shapefile data available online: http://www.fws.gov/wetlands/data/State-Downloads.html

Appendix A. Complete fatality listing for the Thunder Spirit I and II Facility, Adams County, North Dakota, from June 24, 2019 to September 26, 2019

Appendix A. Complete fatality listing for the Thunder Spirit Wind I and II Facility, Adams County, North Dakota, from June 24, 2019 to September 26, 2019.

Found Date	Common Name	Distance from Turbine (meter)	Search Location	Search Type[1]	Physical Condition
06/24/2019	unidentified bird (small)	50	6	incidental on plot	scavenged
06/25/2019	horned lark	50	9	incidental on plot	scavenged
07/01/2019	mallard	35	36	incidental on plot	scavenged
07/18/2019	hoary bat	47	23	carcass search	intact
07/24/2019	hoary bat	27	30	carcass search	intact
07/29/2019	gray partridge	37	3	incidental on plot	intact
07/31/2019	eastern red bat	31	6	carcass search	intact
07/31/2019	hoary bat	62	55	carcass search off plot	intact
08/01/2019	hoary bat	24	20	incidental on plot	intact
08/01/2019	hoary bat	50	20	carcass search	intact
08/01/2019	eastern red bat	45	36	carcass search	intact
08/07/2019	eastern red bat	23	56	carcass search	scavenged
08/07/2019	eastern red bat	29	56	carcass search	intact
08/09/2019	hoary bat	13	14	carcass search	intact
08/13/2019	hoary bat	32	36	carcass search	intact
08/14/2019	eastern red bat	18	29	carcass search	intact
08/14/2019	hoary bat	44	14	carcass search	intact
08/19/2019	little brown bat	20	40	carcass search	scavenged
08/20/2019	hoary bat	59	29	carcass search off plot	intact
08/20/2019	eastern red bat	33	36	carcass search	intact
08/20/2019	little brown bat	11	23	carcass search	intact
08/21/2019	hoary bat	18	37	incidental off plot	intact
08/22/2019	eastern red bat	23	20	carcass search	intact
09/04/2019	hoary bat	42	14	carcass search	intact
09/09/2019	silver-haired bat	29	30	carcass search	intact
09/10/2019	hoary bat	23	19	incidental off plot	intact
09/13/2019	silver-haired bat	10	12	carcass search	intact
09/16/2019	silver-haired bat	18	30	carcass search	intact
09/16/2019	silver-haired bat	23	30	carcass search	intact
09/16/2019	silver-haired bat	19	20	carcass search	intact
09/17/2019	silver-haired bat	9	40	carcass search	intact
09/24/2019	silver-haired bat	11	12	carcass search	intact

[1] Carcass search = regular scheduled weekly search; carcass search off plot = carcass was found during a search event at a search turbine, but was located outside of the searchable area; Incidental on plot = carcass was found outside of a search event at a search turbine and was located within the searchable area; Incidental off plot = carcass was found outside of a search event at a non-search turbine and was located outside of the searchable area.

Appendix B. Bat Fatality Rate Estimation at Thunder Spirit Wind I and II Facility, Adams County, North Dakota, from June 24, 2019 to September 26, 2019

Appendix B. Bat fatality estimates and 90 percent confidence intervals (90% CI)[1] Thunder Spirit Wind I and II Facility, Adams County, North Dakota, from June 24, 2019 to September 26, 2019.

	Summer1		Summer2		Fall	
Parameter	**Estimate**	**90% CI**	**Estimate**	**90% CI**	**Estimate**	**90% CI**
Search Area Adjustment						
Bats	0.89	*	0.79	*	0.61	*
Observer Detection Rate						
Bats	0.50	0.38-0.63	0.50	0.38-0.63	0.50	0.38-0.63
Probability of a Carcass Persisting Through the Search Interval						
Bats	0.65	0.56-0.72	0.65	0.56-0.72	0.65	0.56-0.72
Probability of Available and Detected						
Bats	0.32	0.23-0.41	0.32	0.23-0.41	0.32	0.23-0.41
Unadjusted Number of Fatalities						
Bats	0.09	*	0.54	0.13-1.07	0.80	0.40-1.20
Observed Fatality Rates (Fatalities/turbine/season)						
Bats	0.19	*	2.00	0.81−3.75	4.77	2.27−8.05
Adjusted Fatality Rates (Fatalities/Megawatt/seasons)						
Bats	0.07	*	0.77		1.44	

1. Confidence intervals denoted by * were not calculated due to small sample size.