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:

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WEST Inc.

EXECUTIVE SUMMARY

Odell Wind Farm, LLC (Odell) operates the Odell Wind Energy Project (Project) located in Cottonwood and Jackson counties, Minnesota. Odell contracted Western EcoSystems Technology, Inc. (WEST) to implement the Tier 4 post-construction mortality (PCM) monitoring study designed in the Avian and Bat Protection Plan (ABPP). As committed to in the ABPP, WEST quantified the direct impacts of the Project on birds and bats through PCM monitoring during the first year of operation.

The primary objective of the study was to estimate the level of bird and bat mortality attributable to collisions with wind turbines at the Project. The fatality study consists of four primary components: 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 that a carcass remains in the field for possible detection, and 4) adjusted fatality estimates for birds and bats calculated using the results from searcher efficiency trials and carcass persistence trials to estimate the approximate level of bird and bat mortality within the Project.

Fifteen turbines, representing 15% of all Project turbines were randomly selected to be searched. Searches were conducted within a full 120- x 120-meter (m; 394- x 394-foot [ft]) plot centered on the turbine. Vegetation at all search plots were regularly mowed to maintain a height of 10 centimeters (four inches) or less, providing relatively uniform searching conditions across all cleared 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 December 20, 2016, and continued through December 10, 2017. Searches were once a month during the winter (November 15 – March 14) and weekly during spring (March 15 – May 14), summer (May 15 – July 31), and fall (August 1 – November 14).

During the study, a total of 14 bird and 11 bat fatalities were documented during fatality searches and incidentally. Of these, 10 bird and 10 bat fatalities were included in the analysis. One bald eagle fatality was found outside of the search plot during the initial clearing search in December 2016 and was excluded from analysis since it was located outside of the search plot. No federal- or state-listed threatened, endangered, or candidate bird or bat species were found.

Searcher efficiency trials were conducted to estimate the proportion of casualties found by searchers. A combined total of 138 carcasses (58 large bird carcasses, 74 small bird carcasses and six bat or bat surrogate carcasses [i.e., house mouse]) were used for searcher efficiency trials. Searcher efficiency rates were 83.3% for large birds, 53.4% for small birds, and 80.0% for bats.

Carcass persistence trials were conducted to estimate the length of time that a carcass remained in the field for possible detection by searchers. A total of 112 carcasses (42 large birds, 53 small birds, and 17 bats or bat surrogates [house mouse]) were placed throughout the

study period for persistence trials. Approximately 55% of large bird carcasses, 35% small bird carcasses, and no bat carcasses remained by day four; and by day 10, approximately 25% of all large bird carcasses and 10% of small bird carcasses remained.

Fatality estimates were calculated by adjusting search results for carcass persistence and searcher efficiency bias, and only included carcasses found within selected search plots. Two estimators, Huso and Shoenfeld, were used to calculate the fatality estimates for birds and bats. Bird fatality estimates were calculated for all four seasons, while bat fatality estimates were only calculated for the spring, summer, and fall seasons. The estimated fatality rates for all birds and bats were lower when using the Huso estimator compared to the Shoenfeld estimator. Using the Huso estimator all bird fatalities were estimated to be 9.38 bird fatalities per turbine per year (4.69 bird fatalities per megawatt [MW] per year) compared to 12.28 bird fatalities/turbine/year (6.14 bird fatalities/MW/year) using the Shoenfeld estimator. Using the Huso estimator, the bat fatality rate was estimated to be 13.48 bat fatalities/turbine/year (6.74 bat fatalities/MW/year) compared to 17.12 bat fatalities/turbine/year (8.56 bat fatalities/MW/year).

STUDY PARTICIPANTS

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INTRODUCTION

Odell Wind Farm, LLC (Odell) owns and operates the Odell Wind Energy Project (Project), located in Cottonwood and Jackson counties, Minnesota. Odell contracted Western EcoSystems Technology, Inc. (WEST), to implement the Tier 4 post-construction mortality (PCM) monitoring study (per the US Fish and Wildlife Service [USFWS] *Land-Based Wind Energy Guidelines* [USFWS 2012]) designed in the Avian and Bat Protection Plan (ABPP). As committed to in the ABPP, direct impacts of the Project on birds and bats were quantified through PCM monitoring during the first year of operation.

The primary objective of the PCM monitoring study was to estimate the level of bird and bat mortality attributable to collisions with wind turbines in the Project. The study consisted of four primary components: 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 that a carcass remains in the field for possible detection, and 4) calculation of adjusted fatality estimates for birds and bats using the results from searcher efficiency trials and carcass persistence trials.

This report presents the results of standardized avian and bat fatality surveys at the Project conducted from December 20, 2016, through December 10, 2017. 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 in Cottonwood and Jackson counties, Minnesota, approximately 4.0 kilometers (km; 2.5 miles [mi]) north of the City of Mountain Lake (Figure 1). Using the MDNR Ecological Classification System, the Project is located within the Minnesota River Prairie Subsection (MDNR 2018), which has largely been converted to agricultural lands. The Project is characterized by generally flat topography, with elevation ranges from approximately 382-430 meters (m; 1,076-1,411 feet [ft]) above mean sea level.

Figure 1. Location of the Odell Wind Energy Project in Cottonwood and Jackson counties, Minnesota.

METHODS

Sample Size, Search Area, and Search Frequency

The Project consists of 100 Vestas V110-2.0-megawatt (MW) IEC IIIA wind turbines, for a total capacity of 200 MW of electricity. Fifteen of the 100 Project turbines were selected for surveys in consultation with Odell. Turbines were selected for sampling using a systematic design with a random start, and adjusted, if necessary, to ensure search effort was spread throughout the entire facility (Figure 2). Turbines 2 and 81 were initially selected for searches; however after the winter survey, they were substituted with Turbine 3 and Turbine 80 respectively, for the remainder of the study due to access issues. Searches were conducted within a 120-m x 120-m (394-ft x 394-ft) square plot centered on the turbine (Figure 3). Vegetation at all search plots was regularly mowed to maintain a height of 10 centimeters (cm; four inches [in]) or less, providing relatively uniform searching conditions across all cleared 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 December 20, 2016, and continued through December 10, 2017. Searches were once a month during the winter (November 15 – March 14) and weekly during spring (March 15 – May 14), summer (May 15 – July 31), and fall (August 1 – November 14).

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 (about 158-197 ft) per minute and scanning the turbine pad, road, and transect spaced 10 m (33 ft) apart throughout each plot (Figure 3). All turbines were searched once prior to the formal start of the study to clear them of any bird and bat carcasses.

All bird and bat casualties located within the search areas were recorded and cause of death determined, if possible, based on field inspection of the carcass. For bird carcasses where the cause of death was not apparent, the assumption that the fatality was a wind turbine collision fatality was made for the analysis. All carcasses were given a unique identification code and data recorded included species, sex and age when possible, date and time collected, Global Positioning System (GPS) location, condition (i.e., intact, scavenged, feather spot), and any comments that indicated possible cause of death. All casualties were photographed as found and plotted on a map.

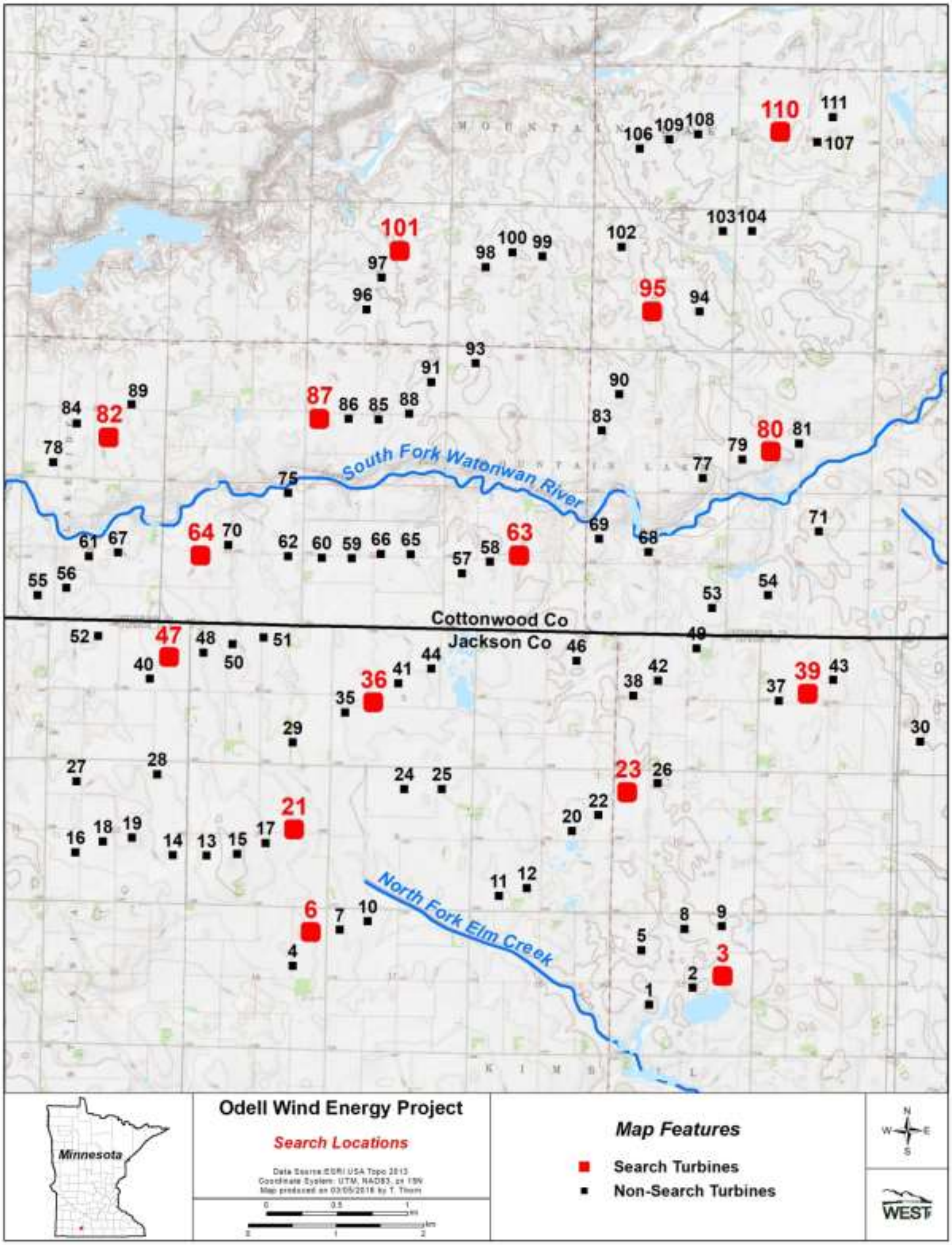

Figure 2. Location of carcass search turbines at the Odell Wind Energy Project in Cottonwood and Jackson counties, Minnesota.

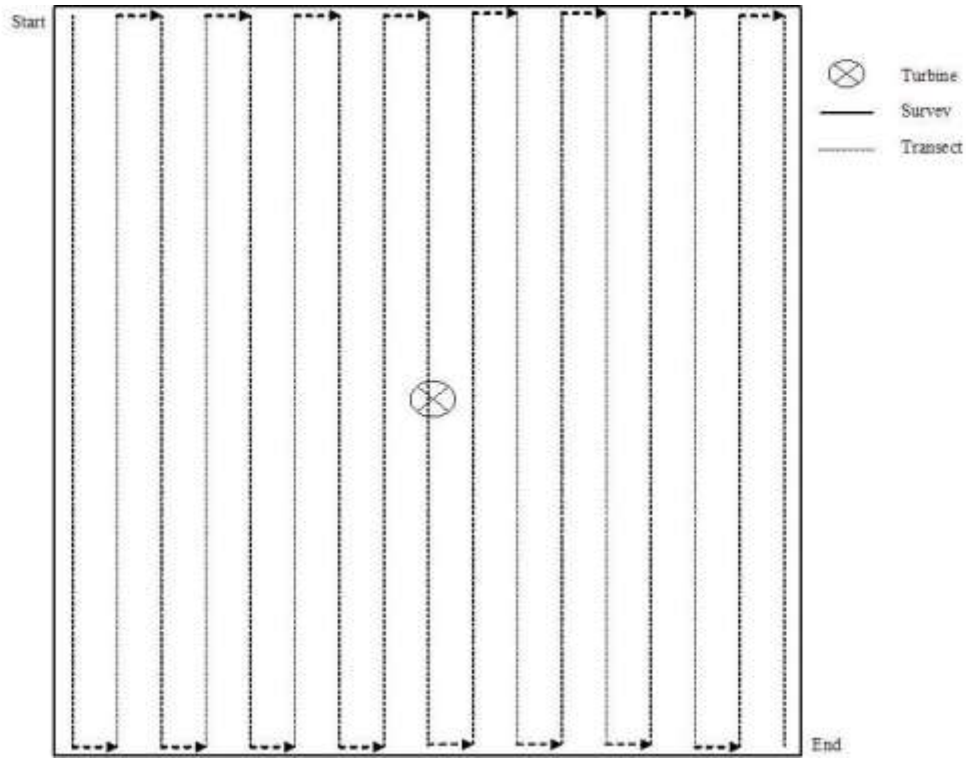

Figure 3. Example schematic of survey pattern (not to scale) for a cleared search plot of 120 x 120 meters (394 x 394 feet) at the Odell Wind Energy Project in Cottonwood and Jackson counties, Minnesota.

Fatalities found outside of the standardized search plot or within a search plot on a day when a scheduled search was not taking place were recorded following the above protocol. All fatalities found outside of the search areas were treated as incidental finds and were not included in fatality estimates. All fatalities found inside of full search plots, whether found during standardized searches or incidentally, were included in the analysis.

Bat carcasses were collected and frozen for future reference and possible necropsy following the guidelines provided in the MDNR Scientific Collector's Permit. A freezer tag documenting discovery date, observer, carcass identification, species, and location (i.e., turbine number) was placed in a bag with the bat carcass. Because a federal salvage permit was not obtained, all bird fatalities were spray painted and left in place to minimize recounting.

Plotting of Search Plot Boundaries

The boundaries of all cleared plots were recorded using GPS technology. All of the search plots were located within corn (*Zea mays*) or soybean (*Glycine max*) fields and were regularly mowed to maintain a height of 10 centimeters (four inches) or less, providing relatively uniform searching conditions across all cleared plots.

Searcher Efficiency Trials

The objective of searcher efficiency trials was to estimate the percentage of bird and bat casualties found by searchers. Efficiency trials commenced with the start of carcass searches and were conducted on eight separate days throughout the study period within the same areas as carcass searches at the Project. Searcher efficiency trials were stratified by the type of carcass (bird or bat), size of bird carcass (large or small bird), and season. Estimates of searcher efficiency were used to adjust the total number of carcasses found for those missed by searchers, thereby correcting for detection bias.

Searchers conducting carcass searches did not know when the trials were being conducted or the locations where the trial carcasses were placed in a search plot. A total of 138 carcasses (58 large birds, 74 small birds, and six bats or bat surrogate) were placed in the Project for searcher efficiency trials. Bird carcasses used for searcher efficiency trials included non-native/non-protected or commercially available species, including rock pigeons (*Columba livia*) for large birds, and house sparrows (*Passer domesticus*) and 2-week old common quail (*Coturnix coturnix*) for small birds. Additionally, house mouse (*Mus musculus*) as bat carcass surrogates and non-protected bat species collected at the facility under the MDNR Scientific Collector's permit were used for searcher efficiency trials.

All searcher efficiency trial carcasses were placed at random locations within the search area prior to that day's scheduled carcass survey. Each trial carcass was discreetly marked with a black zip tie around one leg prior to placement so that it could be identified as a trial carcass. 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 and location of carcasses found during the subsequent carcass search was recorded. The number of carcasses available for detection during each trial was determined the same day following the trial.

Carcass Persistence Trials

The objective of carcass persistence trials was to estimate the percentage of bird or bat carcasses which remained available to be found, as a function of time on the ground. Possible means of carcass removal included removal by predators, scavengers, insects, or agricultural practices, such as being plowed into a field. Estimates of bird and bat carcass persistence were used to adjust the total number of carcasses found for those removed from the study.

Carcass persistence trials began when the fatality searches started and were conducted throughout the year to incorporate the effects of varying weather, climatic conditions, and scavenger densities. Trial carcasses were placed randomly (random distance and direction from a turbine or random location within a plot) within a 120-m x 120-m (394-ft x 394-ft) plot surrounding turbines not being used for regularly scheduled carcass searches. Carcass species composition was similar to that used for searcher efficiency trials. A total of 112 carcasses (42 large birds, 53 small birds, and 17 mice [or bat surrogates]) were placed. Trial carcasses were dropped from waist height. Persistence trial carcasses were marked discreetly with a black zip tie around one leg for recognition by searchers and other wind farm 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. The schedule varied slightly 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. Irregular codes or data suspected as questionable were discussed with the observer 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.

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 Excluded from Fatality Estimation

Carcasses found outside of the search area, regardless if they were found at a search turbine, were excluded from analysis.

Fatality Rate Estimation

All carcasses located within surveyed areas were recorded. To determine the rate at which bird and bat fatalities occurred, the number of carcasses found in each search plot was tallied. However, carcasses persisted for variable amounts of time and could have been detected with varying levels of success based on carcass characteristics and ground cover (i.e., cleared plots versus roads and pads). To account for these variables, statistical analyses were used to adjust the observed count of bird and bat carcasses based on:

1) Observed number of bird or bat carcasses found in search plots during the study period for which the cause of death is either unknown or is probably facility-related;
2) Searcher efficiency, expressed as the proportion of trial carcasses found by searchers during searcher efficiency trials; and
3) Carcass persistence rates, expressed as the estimated average probability a bird or bat carcass is expected to remain in the study area and be available for detection by the searchers during persistence trials.

Fatality estimates were calculated for large birds, small birds, all birds, and bats by season and for the study period. As committed to in the ABPP, both the Huso (2011, Huso et al. 2015) and Shoenfeld (2004) estimators were used. The Huso estimator is presented within the body of the report since it performs well under a broad range of conditions and has modeling flexibility with respect to carcass persistence. The Shoenfeld estimator is included in Appendix C.

Huso Method Estimator

Definition of Variables

The following variables were used in the equations for the Huso estimator (Huso 2011, Huso et al. 2015):

c_i	total number of carcasses in category *i* (e.g., combinations of size, visibility, season, search interval, etc.)
n	number of turbines sampled at the Project
k	number of carcass categories
I_i	time interval between the previous search and discovery for category *i*
$\hat{\tilde{I}}_i$	effective search interval for carcasses in category *i*
$\hat{r}_i$	average probability of persistence for carcass in category *i*
$\hat{p}_i$	probability of detection for carcass in category *i*
$\hat{\pi}$	the estimated probability that a carcass is both available to be found during a search and was found, as determined by the searcher efficiency trials and persistence trials
$\hat{F}_i$	per turbine mortality for category *i*
$\hat{m}$	total per turbine mortality

Censored Carcasses

The Huso method (Huso 2011) requires censoring carcasses of birds or bats that are estimated to have been killed in a time period longer than the search interval. The time between searches was calculated for each carcass in order to determine if a carcass was found within the 7-day or 30-day search interval. Carcasses were excluded if the estimated time of death was greater than the time since previous search.

Estimation of Searcher Efficiency Rates

Searcher efficiency rates, $\hat{p}_i$, were estimated separately for each size class (i.e., large or small bird or bat) using a logistic regression model (Agresti 2007). Potential covariates for this logistic model included season and an intercept-only model. The logistic regression modeled the natural logarithm of the odds of finding an available carcass potentially as a function of the above covariates. The model assumed that searchers have a single opportunity to discover a carcass. The best model was selected using AICc, or corrected Akaike Information Criterion (Burnham and Anderson 2002). All models within two AICc values of the top model with the lowest AICc value were considered.

Estimation of Carcass Persistence Rates

Estimates of carcass persistence rates were used to adjust carcass counts for removal bias. Carcass persistence was modeled separately for each size class. The average probability of persistence of a carcass ($\widehat{r_i}$) through the effective search interval was estimated from an interval censored survival regression (Huso 2011, Kalbfleisch and Prentice 2002). The effective search interval was 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, log-logistic, log-normal, and Weibull distributions were fit by size class and the best model was selected using an information theoretic approach known as AICc.

Adjusted Facility-Related Fatality Rates

The estimated probability that a carcass in category *i* was available and detected was calculated as:

$$\widehat{\pi_i} = \widehat{p_i} \cdot \widehat{r_i} \cdot \hat{v}_i$$

where $\widehat{v_i}$ = min(1, $\hat{\hat{I}}_i/I_i$). The model assumed that searchers had a single opportunity to find each carcass, even though some carcasses might have persisted through multiple searches before being detected. Therefore, a carcass was included in adjusted fatality estimates if it had been available since the last search, and not longer. The probable time since death, recorded in the field, was used to evaluate each carcass for inclusion in the final fatality estimates.

The total number of fatalities ($\widehat{f_i}$) in category *i*, based on the number of carcasses found in category *i,* was given by:

$$\widehat{f_i} = \frac{c_i}{\widehat{\pi_i}}.$$

The total per turbine fatality rate *($\widehat{m}$)* was estimated by:

$$\widehat{m} = \frac{\sum_{i=1}^{k} \widehat{m}_i}{n}$$

The per-MW rate was estimated by dividing the per turbine fatality rate ($\widehat{m}$) by the MW rating of the turbine. If the observed number of carcasses found in a season was fewer than five, a confidence interval (CI) was not reported for the season (Manly 1997). A total of 1,000 bootstrap samples were used. The standard deviation of the bootstrap estimates was the estimated standard error. The lower 5th and upper 95th percentiles of the 1,000 bootstrap samples were estimates of the lower limit and upper limit of 90% CIs.

Shoenfeld Method Estimator

Definition of Variables

The following variables were used in the equations below for the Shoenfeld estimator:

- c_i the number of carcasses detected at plot *i* for the study period of interest (e.g., one monitoring year), for which the cause of death was either unknown or attributed to the facility
- *n* the number of search plots
- *k* the number of turbines searched (including the turbines centered within each search plot)
- $\bar{c}$ the average number of carcasses observed per turbine per monitoring period
- *s* the number of carcasses used in persistence trials
- s_c the number of carcasses in persistence trials that remained in the study area after 14 days
- t_j the time (in days) the carcass *j* persisted in the study area before it was removed, as determined by the persistence trials
- $\bar{t}$ the average time (in days) a carcass remained in the study area before it was removed, as determined by the persistence trials
- *p* the estimated proportion of detectable carcasses found by searchers, as determined by the searcher efficiency trials
- *i* the average interval between standardized carcass searches, in days
- A proportion of carcasses expected to land in searched area
- $\hat{\pi}$ the estimated probability that a carcass was both available to be found during a search and was found, as determined by the persistence trials and the searcher efficiency trials
- *m* the estimated annual average number of fatalities per turbine per year, adjusted for persistence and searcher efficiency bias

Observed Number of Carcasses

The estimated average number of carcasses ($\bar{c}$) observed per turbine per monitoring year was:

$$\bar{c} = \frac{\sum_{i=1}^{n} c_i}{k \cdot A}$$

Estimation of Mean Carcass Persistence Time

Estimates of carcass persistence were used to adjust carcass counts for persistence bias. Mean carcass persistence time ($\bar{t}$) was the average number of days a bird or bat carcass remained in the study area before it was removed:

$$\bar{t} = \frac{\sum_{j=1}^{s} t_j}{s - s_c}$$

Estimation of Searcher Efficiency Rates

Searcher efficiency rates were expressed as *p,* the proportion of trial carcasses that were detected by searchers in the searcher efficiency trials. These rates were estimated using the same methods as described above for the Huso estimator.

Estimation of Facility-Related Casualty Rates

The estimated per turbine annual fatality rate (*m*) was calculated by:

$$m = \frac{\bar{c}}{\hat{\pi}}$$

where $\hat{\pi}$ included adjustments for both carcass persistence (from scavenging and other means) and searcher efficiency bias. If not statistically different across seasons or plot types, data for carcass persistence and searcher efficiency bias was pooled across the study to estimate $\hat{\pi}$

$\hat{\pi}$ was calculated as follows:

$$\hat{\pi} = \frac{\bar{t} \cdot p}{I} \cdot \left[\frac{\exp\left({}^{I}/_{\bar{t}}\right) - 1}{\exp\left({}^{I}/_{\bar{t}}\right) - 1 + p} \right]$$

Confidence Interval Calculation

The standard errors and 90% CIs were calculated using bootstrapping (Manly 1997). Bootstrapping is a computer simulation technique that is useful for calculating point estimates, variances, and CIs for complicated test statistics. For each bootstrap sample, $\bar{c}$, t, *p*, and *m* were calculated. One thousand bootstrap samples were used. The standard deviation of the bootstrap estimates was the estimated standard error. The lower 5th and upper 95th percentiles of the 1,000 bootstrap estimates were estimates of the lower limit and upper limit of 90% CIs (Manly 1997).

RESULTS

Standardized Carcass Surveys

Summary of Search Effort

Forty-two search visits, for a total of 557 turbine searches, were conducted from December 20, 2016, through December 10, 2017. A total of 14 bird and 11 bat fatalities were found during standardized carcass surveys or incidentally (Table 1). The number, species, location, other characteristics of the bird and bat fatalities included in the analysis and fatality estimates, adjusted for searcher efficiency and carcass persistence biases, are discussed below. A full listing of fatalities is presented in Appendix A.

Censored Carcasses

The Huso method requires that carcasses of birds and bats with an estimated time since death longer than the search interval be censored. The average search interval for spring, summer, and fall was 7.61 days, 7.69 days, and 8.27 days, respectively, and 36.58 days for the winter. The search interval was larger than the proposed 7- and 30-day interval as a result of inclement weather and turbine maintenance. All carcasses with time since death estimated to be greater than the search interval immediately preceding their discovery were censored from analysis. Two small bird fatalities, including one red-eyed vireo (*Vireo olivaceus*) and one unidentified sandpiper, and one eastern red bat (*Lasiurus borealis*) fatality were censored from the Huso analysis (Table 1). Two bird casualties, including one bald eagle (*Haliaetus leucocephalus*) and one mallard (*Anas platyrhynchos*), were excluded from the analysis due to being found off of a search plot or during the clearing search (Table 1). A total of 10 birds and 10 bats were included in analysis (Table 1).

Table 1. Summary of bird and bat casualties and the composition* of casualties discovered at the Odell Wind Energy Project in Cottonwood and Jackson counties, Minnesota, from December 20, 2016 – December 10, 2017.

	Casualties Included in Analysis		Casualties Off Plot		Casualties Censored for Huso Estimator		Total	
Species	**Total**	**% Comp.**	**Total**	**% Comp.**	**Total**	**% Comp.**	**Total**	**% Comp.**
Bird								
killdeer	2	20.0	0	0	0	0	2	14.3
red-eyed vireo	2	20.0	0	0	1	50.0	3	21.4
sora	2	20.0	0	0	0	0	2	14.3
European starling	1	10.0	0	0	0	0	1	7.1
greater yellowlegs	1	10.0	0	0	0	0	1	7.1
wood thrush	1	10.0	0	0	0	0	1	7.1
yellow rail	1	10.0	0	0	0	0	1	7.1
bald eagle[1]	0	0	1	50.0	0	0	1	7.1
mallard	0	0	1	50.0	0	0	1	7.1
unidentified sandpiper	0	0	0	0	1	50.0	1	7.1
Overall Birds	**10**	**100**	**2**	**100**	**2**	**100**	**14**	**100**
Bat								
eastern red bat	2	20.0	0	0	1	100	3	27.3
evening bat	1	10.0	0	0	0	0	1	9.1
hoary bat	4	40.0	0	0	0	0	4	36.4
silver-haired bat	2	20.0	0	0	0	0	2	18.2
unidentified bat	1	10.0	0	0	0	0	1	9.1
Overall Bats	**10**	**100**	**0**	**0**	**1**	**100**	**11**	**100**

* Sums may not equal values shown due to rounding
[1] – Bald eagle was found both off plot and during the initial clearing search

Bird Fatalities

Bird fatalities retained for the analysis included 10 identifiable bird species. Three species made up the majority of bird fatalities used in the analysis, including killdeer (*Charadrius vociferus*; two individuals; 20.0%), red-eyed vireo (two; 20.0%), and sora (*Porzana carolina*; two; 20.0%) (Table 1, Appendix A). One raptor, a bald eagle, was found off plot during the December 2016 clearing search, and as such was excluded from analysis (Table 1, Appendix A).

Overall, bird fatalities included in analysis were located at six turbines (Figure 4). Three fatalities were found at Turbine 110; two fatalities at Turbine 3 and Turbine 63; and one fatality each at Turbine 23, Turbine 64, and Turbine 80 (Figure 4). No spatial pattern of bird mortality was evident at the Project (Figure 4).

Bird fatalities were found between zero and 80 m (262 ft) of the turbines, with 80% of birds being found within 50 m (164 ft) of turbines (Table 2). Bird fatalities were found throughout the year, with the majority of bird fatalities found in the fall (Figure 5).

For the estimated time since death, 12 bird fatalities were included. Approximately 66.7% of all large birds and all small birds had an estimated time of death of “last night” (Table 3).

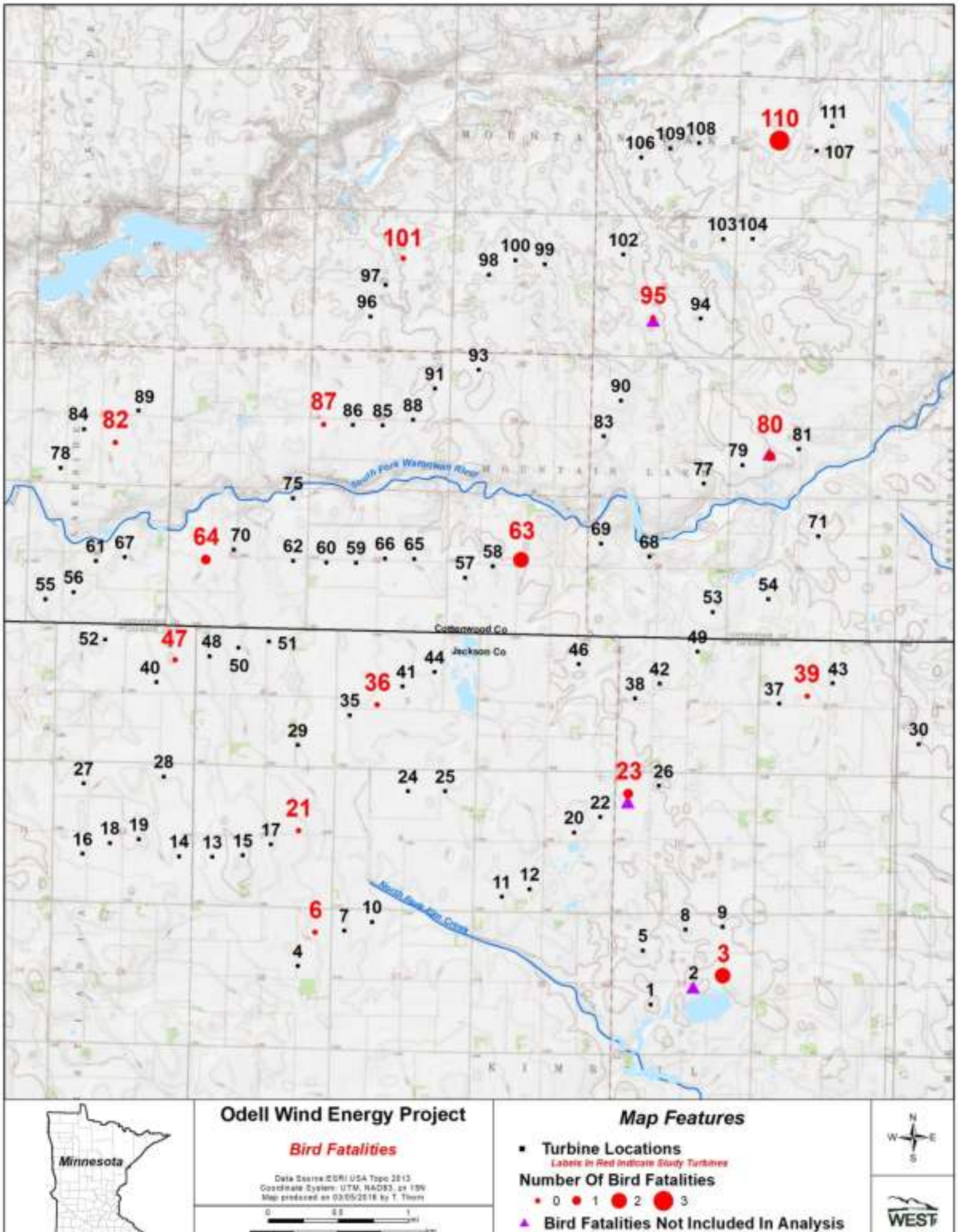

Figure 4. Location of all bird casualties included in the Huso analysis that were found at the Odell Wind Energy Project in Cottonwood and Jackson counties, Minnesota, from December 20, 2016 – December 10, 2017.

Table 2. Distribution of distances from turbines of bird casualties included in the Huso analysis that were found at the Odell Wind Energy Project in Cottonwood and Jackson counties, Minnesota, from December 20, 2016 – December 10, 2017.

Distance to Turbine (m)	Number of Bird Casualties	% Bird Casualties
0 to 10	0	0
11 to 20	0	0
21 to 30	3	30.0
31 to 40	3	30.0
41 to 50	2	20.0
51 to 60	0	0
61 to 70	0	0
71 to 80	2	20.0

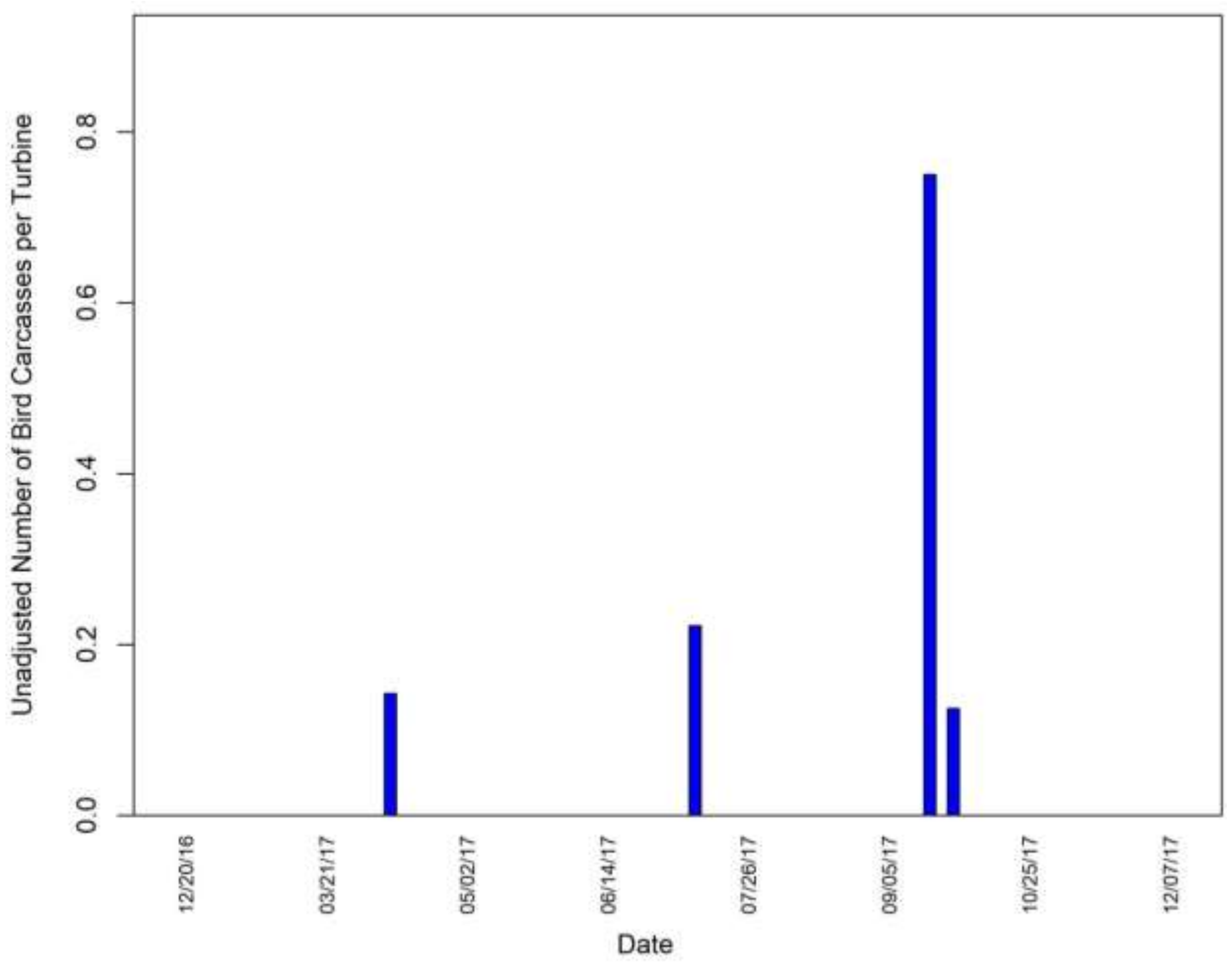

Figure 5. Timing of bird fatalities included in the Huso analysis that were found during scheduled searches or incidentally at the Odell Wind Energy Project in Cottonwood and Jackson counties, Minnesota, from December 20, 2016 – December 10, 2017.

Table 3. Estimated time since death of bird fatalities for the Huso analysis at the Odell Wind Energy Project in Cottonwood and Jackson counties, Minnesota, from December 20, 2016 – December 10, 2017.

	Large Bird		Small Bird	
Estimated Time Since Death	**Number of Fatalities**	**Percent Composition**	**Number of Fatalities**	**Percent Composition**
last night	2	66.7	6	66.7
2-3 days	0	0.0	1	11.1
4-7 days	1	33.3	0	0.0
8-14 days	0	0.0	2	22.2
> 2 weeks	0	0.0	0	0.0
> 1 month	0	0.0	0	0.0
unknown	0	0.0	0	0

Bat Fatalities

A total of 10 bat fatalities composed of four identifiable bat species were retained for the analysis (Table 1). Hoary bat (*Lasiurus cinereus*) had the most fatalities (four fatalities; 40.0%), followed by two eastern red bats (20.0%), two silver-haired bats (*Lasionycteris noctivagans*; 20.0%), one evening bat (*Nycticeius humeralis*; 10.0%), and one unidentified bat (10.0%; Table 1, Appendix A). One eastern red bat found at Turbine 48 was excluded from analysis due to estimated time of death being greater than the search interval (Table 1).

Bat fatalities retained for analysis were located at seven turbines (Figure 6). Four bat fatalities were discovered at Turbine 47; one fatality each was discovered at turbines 23, 63, 64, 80, 82, and 101 (Figure 6). No spatial pattern in bat fatalities was evident at the Project (Figure 6).

All of bat fatalities were found within 40 m (131 ft) of turbines (Table 4). Bat fatalities occurred in late summer through fall (Figure 7).

For those bats retained in the analysis, 72.8% had an estimated time since death of three days or less (Table 5).

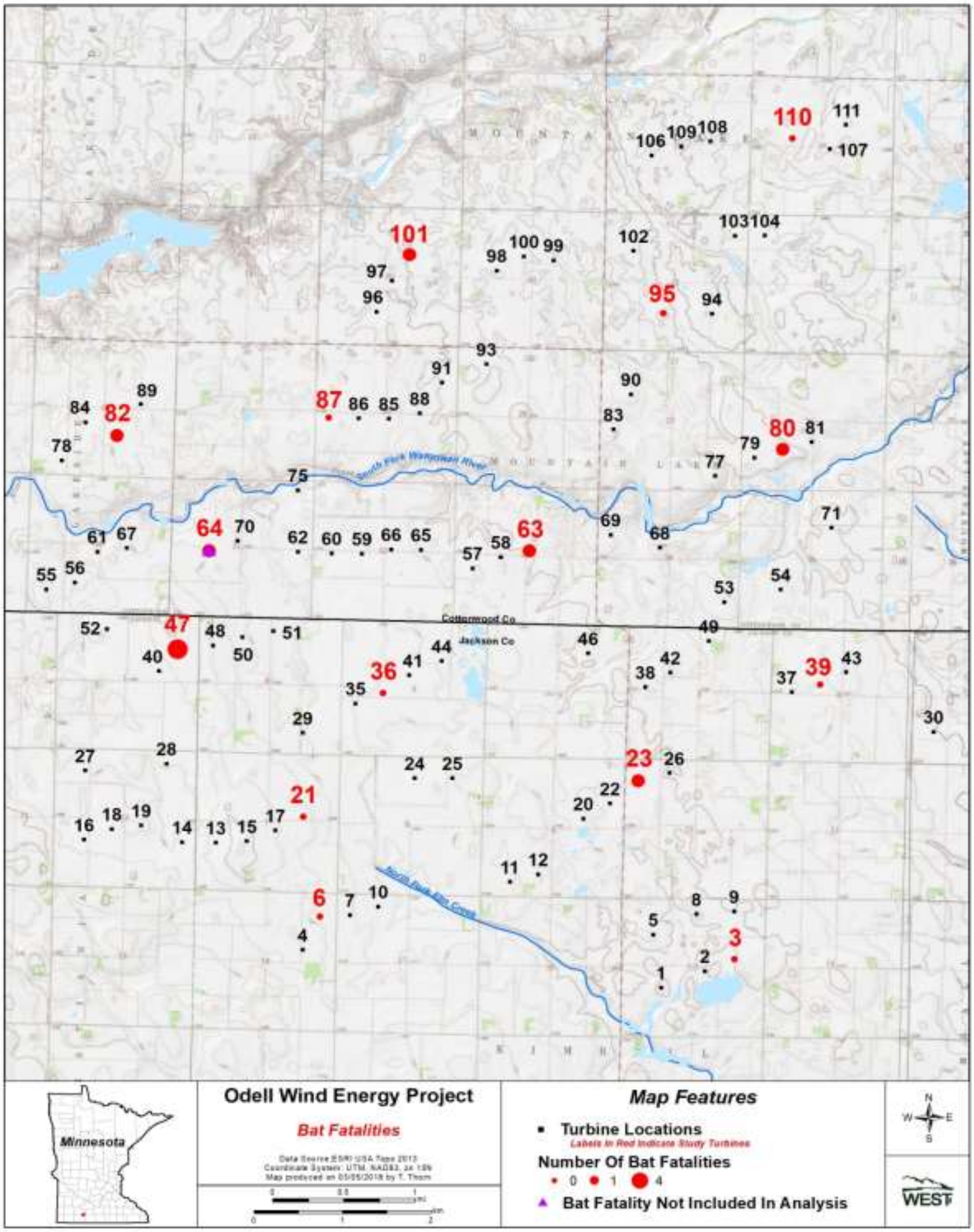

Figure 6. Location of all bat casualties included in the Huso analysis that were found at the Odell Wind Energy Project in Cottonwood and Jackson counties, Minnesota, from December 20, 2016 – December 10, 2017.

Table 4. Distribution of distances from turbines of bat casualties included in the Huso analysis that were found at the Odell Wind Energy Project in Cottonwood and Jackson counties, Minnesota, from December 20, 2016 – December 10, 2017.

Distance to Turbine (m)	Number of Bat Casualties	% Bat Casualties
0 to 10	1	10.0
11 to 20	3	30.0
21 to 30	3	30.0
31 to 40	3	30.0
41 to 50	0	0.0
51 to 60	0	0.0
61 to 70	0	0.0

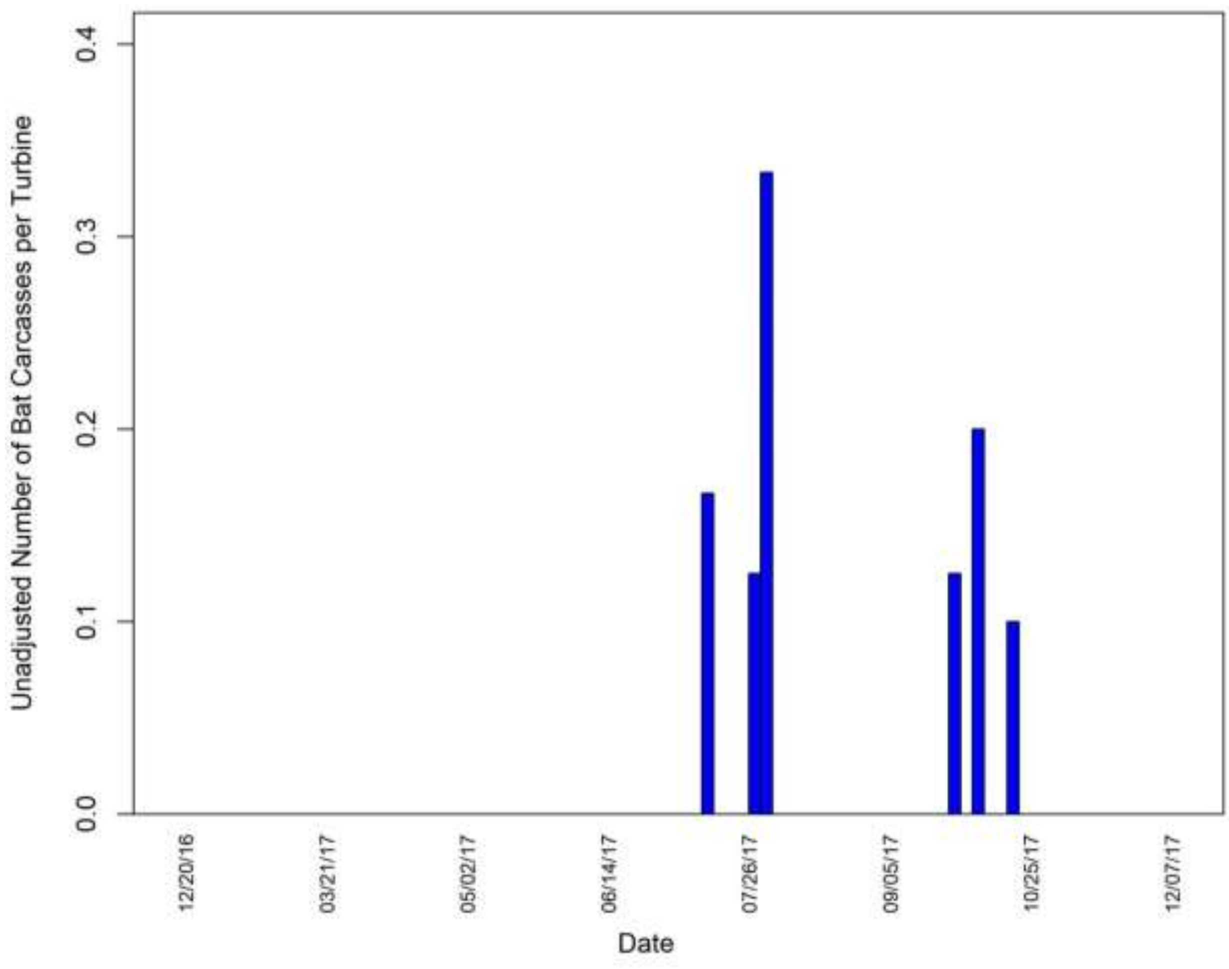

Figure 7. Timing of bat fatalities included in the Huso analysis that were found at the Odell Wind Energy Project in Cottonwood and Jackson counties, Minnesota, from December 20, 2016 – December 10, 2017.

Table 5. Estimated time since death of bat fatalities for the Huso analysis at the Odell Wind Energy Project in Cottonwood and Jackson counties, Minnesota, from December 20, 2016 – December 10, 2017.

Estimated Time Since Death	Number of Bat Fatalities	Percent Composition
last night	4	36.4
2-3 days	4	36.4
4-7 days	2	18.2
8-14 days	1	9.0

Searcher Efficiency Trials

A total of 58 large birds, 74 small birds, and six bats or bat surrogates (house mouse) were placed for searcher efficiency trials at the Project (Table 6). Searcher efficiency trials were conducted for bats during the summer and fall only, while large and small bird trials were conducted during each of the four seasons throughout the year (Table 6). Efficiency rates were 83.3% for large birds, 53.4% for small birds, and 80.0% for bats (Table 6).

Table 6. Searcher efficiency results as a function of season and carcass size at the Odell Wind Energy Project in Cottonwood and Jackson counties, Minnesota, from December 20, 2016 – December 10, 2017.

Size Class	Season	# Placed	# Available	# Found	% Found[2]
Large Bird	Winter	24	22	17	77.3
	Spring	9	9	8	88.9
	Summer	17	15	15	100.0
	Fall	8	8	5	62.5
	Overall	**58**	**54**	**45**	**83.3**
Small Bird	Winter	30	20	16	80.0
	Spring	12	11	5	45.5
	Summer	21	18	9	50.0
	Fall	11	9	1	11.1
	Overall	**74**	**58**	**31**	**53.4**
Bat[1]	Summer	3	3	3	100.0
	Fall	3	2	1	50.0
	Overall	**6**	**5**	**4**	**80.0**

[1] House mouse was used as a surrogate for bats

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

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. Due to small bat/bat surrogate sample sizes across seasons during fatality surveys, results from the small bird class were pooled for the bat searcher efficiency model. The best model for small birds and bats included a seasonal effect, while the best model for large bird searcher efficiency was the intercept-only model (Table 7).

Table 7. AICc model results to test the best model variable to include for estimating Huso searcher efficiency rates at the Odell Wind Energy Project in Cottonwood and Jackson counties, Minnesota, from December 20, 2016 – December 10, 2017.

Size Class	Explanatory Variables	AICc	ΔAICc	Model Used
Large Birds	Intercept only + Season	49.26	0.00	No
	Intercept only*	50.74	1.47	Yes
Small Birds	Intercept only + Season*	75.16	0.00	Yes
	Intercept only	82.20	7.04	No
Bats[1, 2]	Intercept only + Season*	82.98	0.00	Yes
	Intercept only	88.62	5.65	No

[1] House mouse was used as a surrogate for bats

[2] To increase the statistical robustness, searcher efficiency results for small birds and bats were combined for summer and fall in the searcher efficiency mode

Carcass Persistence Trials

A total of 112 carcasses were placed in the Project area throughout the duration of the monitoring period for carcass persistence trials (42 large birds, 53 small birds, and 17 bats and mice). Searcher efficiency trials were conducted for bats during the summer, fall, and winter; while large and small birds were conducted during each of the four seasons throughout the study period. By day four, approximately 55% of large bird carcasses, 35% of small bird carcasses, and no bat/bat surrogate carcasses remained (Figure 8). By day 10, approximately 25% of large bird carcasses remained and 10% of small bird carcasses remained (Figure 8).

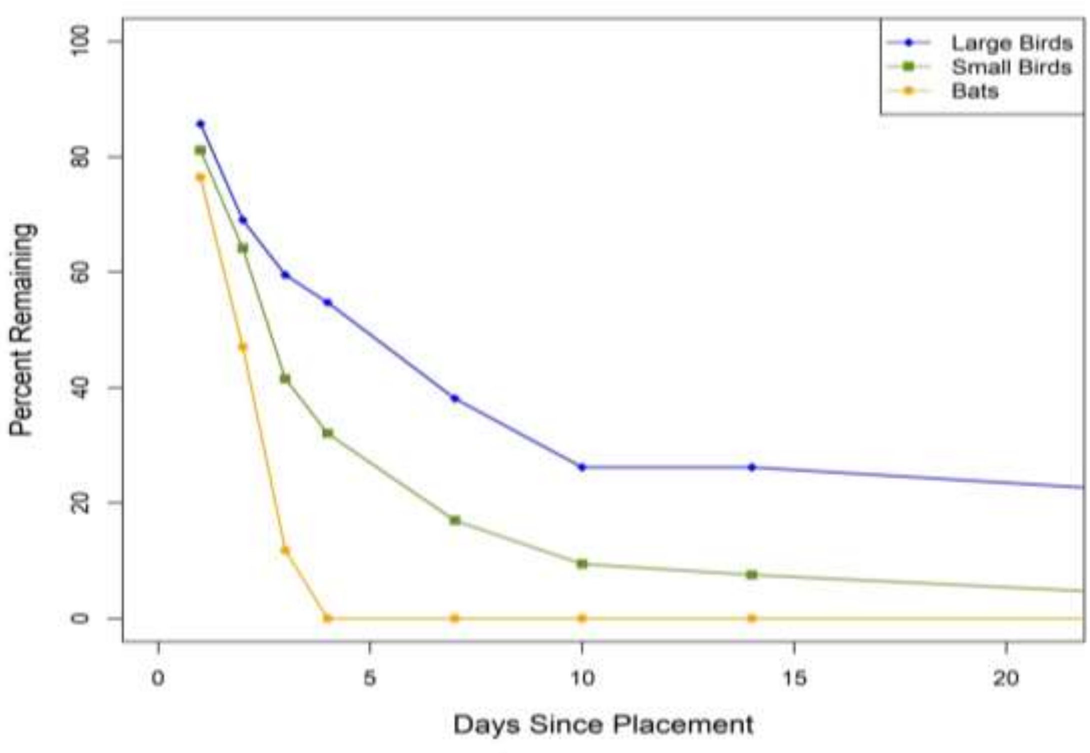

Figure 8. Carcass persistence rates for large bird, small bird, and bat/bat surrogate carcasses placed at the Odell Wind Energy Project in Cottonwood and Jackson counties, Minnesota, from December 20, 2016 – December 10, 2017.

The average probability of a carcass persisting in the interval used in Huso (2011) was estimated by fitting exponential, log-logistic, log-normal, and Weibull distributions with a seasonal explanatory variable. The best model for each size class was selected based on AICc (Table 8). For large bird carcasses, the log-logistic model with no covariates provided the best fit, while for small birds and bats, the exponential model with no covariates provided the best fit (Table 8).

Table 8. AICc values from models to determine the best explanatory variable and distribution to use for estimating carcass persistence time for the Huso estimator at the Odell Wind Energy Project in Cottonwood and Jackson counties, Minnesota, from December 20, 2016 – December 10, 2017.

Size Class	Explanatory Variables	Distribution	AICc	ΔAICc	Model Used
Large Bird	Intercept Only + Season	Weibull	155.88	0.00	No
	Intercept only	Loglogistic	156.19	0.31	Yes
	Intercept only	Lognormal	156.68	0.80	No
	Intercept only	Exponential	156.90	1.02	No
	Season	Lognormal	158.75	2.87	No
	Intercept only	Loglogistic	159.07	3.19	No
	Season	Weibull	160.31	4.43	No
	Season	Exponential	170.15	14.27	No
Small Bird	Intercept only	Exponential	188.21	0.00	Yes
	Intercept only	Weibull	189.76	1.55	No
	Intercept only + Season	Exponential	190.47	2.26	No
	Intercept only	Loglogistic	190.70	2.49	No
	Intercept only	Lognormal	190.88	2.67	No
	Intercept only + Season	Weibull	192.82	4.61	No
	Intercept only + Season	Loglogistic	193.21	5.0	No
	Intercept only + Season	Lognormal	193.79	5.58	No
Bat[1]	Intercept only	Weibull	40.87	0.00	No
	Intercept only	Exponential	41.91	1.04	Yes
	Intercept only	Lognormal	44.18	3.31	No
	Intercept only	Loglogistic	44.95	4.08	No

[1] House mouse was used as a surrogate for bats

Adjusted Fatality Estimates

Fatality estimates and 90% CIs were calculated on a per turbine and per MW basis for large birds, small birds, all birds, and bats using both the Huso and Shoenfeld estimators (Tables 9 and 10, Appendices B and C). The fatality estimates were adjusted based on the corrections for carcass persistence and searcher efficiency bias (Appendices B and C).

Table 9. Adjusted bird and bat fatality estimates using the Huso estimator for the Odell Wind Energy Project in Cottonwood and Jackson counties, Minnesota, from December 20, 2016 – December 10, 2017.

	# Fatalities/Turbine/year		# Fatalities/MW/year	
	Mean	**90 % CI**	**Mean**	**90% CI**
Large Birds	0.38	0.00 – 0.84	0.19	0.00 – 0.42
Small Birds	9.00	2.49 – 16.82	4.50	1.42 – 8.64
All Birds	9.38	2.83 – 17.27	4.69	1.24 – 8.64
Bats	13.48	4.90 – 24.95	6.74	2.45 – 12.47

Table 10. Adjusted bird and bat fatality estimates using the Shoenfeld estimator for the Odell Wind Energy Project in Cottonwood and Jackson counties, Minnesota, from December 20, 2016 – December 10, 2017.

	# Fatalities/Turbine/year		# Fatalities/MW/year	
	Mean	**90 % CI**	**Mean**	**90% CI**
Large Birds	0.51	0.00 – 1.18	0.26	2.94 – 15.16
Small Birds	11.77	5.23 – 19.62	5.89	0.00 - 0.59
All Birds	12.28	5.57 – 19.79	6.14	2.79 – 9.90
Bats	17.12	5.88 – 30.33	8.56	2.62 – 9.81

Large Birds

The estimated fatality rate for large birds was similar between the Huso and Shoenfeld estimators. Using the Huso estimator, the large bird fatality rate was estimated to be 0.38 large bird fatalities/turbine/year (0.19 large bird fatalities/MW/year; Table 9). Using the Shoenfeld estimator, the large bird fatality rate was 0.51 large bird fatalities/turbine/year (0.26 large bird fatalities/MW/year; Table 10).

Small Birds

The estimated fatality rate for small birds was lower when using the Huso estimator compared to the Shoenfeld estimator. Using the Huso estimator, the small bird fatality rate was estimated to be 9.00 small bird fatalities/turbine/year (4.50 small bird fatalities/MW/year; Table 9) compared to 11.77 small bird fatalities/turbine/year (5.89 small bird fatalities/MW/year; Table 10) using the Shoenfeld estimator.

All Birds

The estimated fatality rate for all birds was lower when using the Huso estimator compared to the Shoenfeld estimator. The overall bird estimate using the Huso estimator was 9.38 bird fatalities/turbine/year (4.69 bird fatalities/MW/year; Table 9) compared to 12.28 bird fatalities/turbine/year (6.14 bird fatalities/MW/year) using the Shoenfeld estimator (Table 10).

Bats

Similarly, the estimated fatality rate for bats was lower with the Huso estimator compared to the Shoenfeld estimator. Estimated fatality rates for bats were calculated during the spring, summer, and fall periods only (Appendices B and C). Using the Huso estimator, the bat fatality rate was estimated to be 13.48 bat fatalities/turbine/year (6.74 bat fatalities/MW/year; Table 9) compared to 17.12 bat fatalities/turbine/year (8.56 bat fatalities/MW/year) using the Shoenfeld estimator (Table 10).

DISCUSSION

Bird and Bat Fatalities: Regional Comparisons

It is important to contextualize findings from the Project with respect to other operating wind facilities in the region. Project results were compared with data from other operations in the Midwest that provided publicly available information on their fatality rates (Figures 9 and 10). The publicly available comparison studies were of similar survey length (e.g., three or four seasons), methodology (e.g., full plots or roads and pads, search efficiency trials, carcass persistence trials), landscape, vegetation composition (e.g., primarily combinations of grasslands and agricultural areas), and bird and bat assemblages. Results from this study and other publicly available studies are typically based on one year of PCM mortality surveys. Fatality estimates may be influenced by annual variation in weather, bird and bat migration routes, and bird and bat population levels.

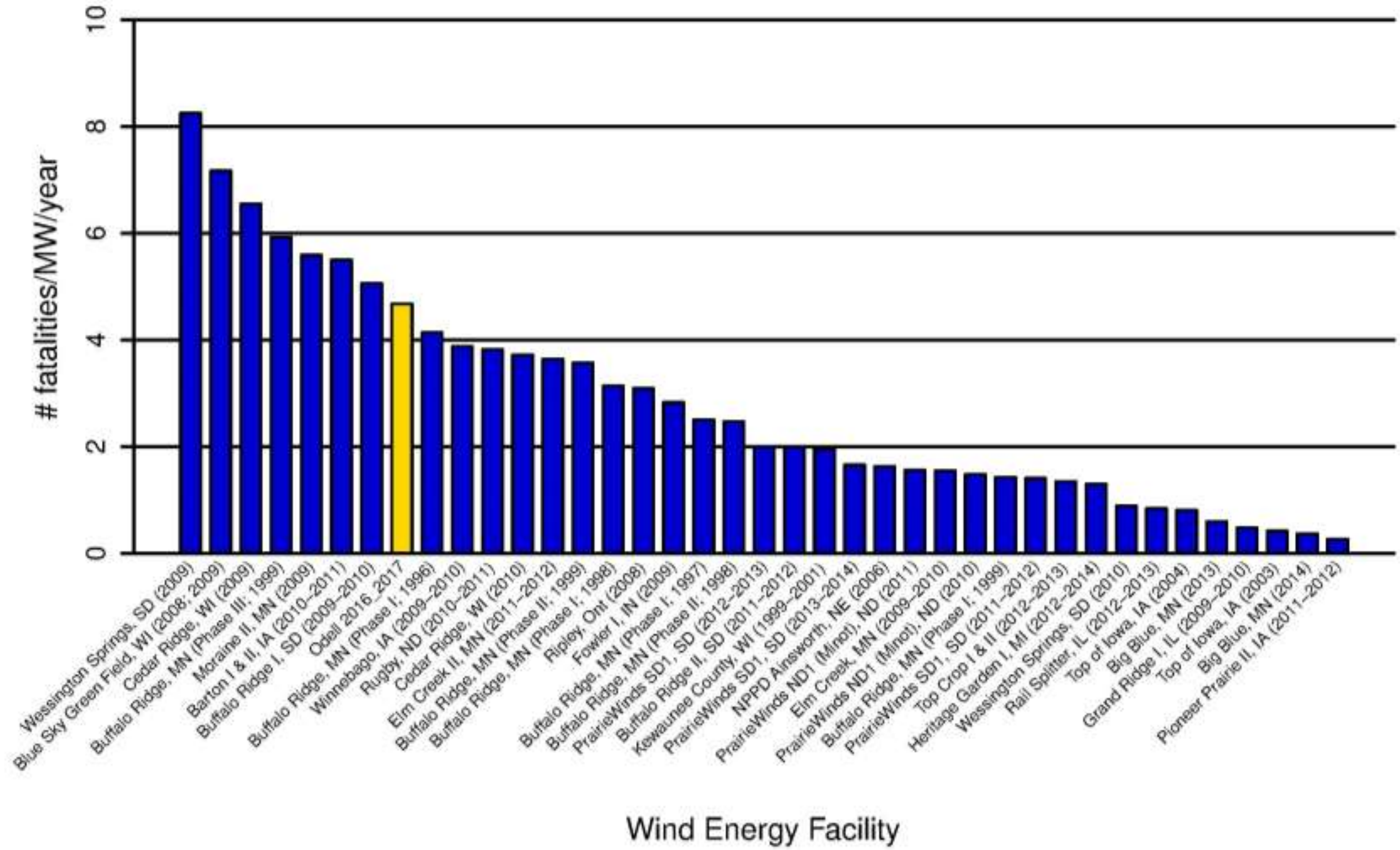

Figure 9. Fatality rates for all birds (number of birds per megawatt per year) from publicly available studies at wind energy facilities in the Midwest Region of North America.

Figure 9 (*continued*). Fatality rates for all birds (number of bird fatalities per megawatt per year) from publicly available studies at wind energy facilities in the Midwest Region of North America.

Data from the following sources:

Wind Energy Facility	Fatality Reference	Wind Energy Facility	Fatality Reference
Odell, MN (16-17)	This study.		
Wessington Springs, SD (09)	Derby et al. 2010c	Buffalo Ridge II, SD (11-12)	Derby et al. 2012a
Blue Sky Green Field, WI (08; 09)	Gruver et al. 2009	Kewaunee County, WI (99-01)	Howe et al. 2002
Cedar Ridge, WI (09)	BHE Environmental 2010	PrairieWinds SD1, SD (13-14)	Derby et al. 2014
Buffalo Ridge, MN (Phase III; 99)	Johnson et al. 2000	NPPD Ainsworth, NE (06)	Derby et al. 2007
Moraine II, MN (09)	Derby et al. 2010f	PrairieWinds ND1, ND (11)	Derby et al. 2012d
Barton I & II, IA (10-11)	Derby et al. 2011b	Elm Creek, MN (09-10)	Derby et al. 2010e
Buffalo Ridge I, SD (09-10)	Derby et al. 2010d	PrairieWinds ND1, ND (10)	Derby et al. 2011d
Buffalo Ridge, MN (Phase I; 96)	Johnson et al. 2000	Buffalo Ridge, MN (Phase I; 99)	Johnson et al. 2000
Winnebago, IA (09-10)	Derby et al. 2010g	PrairieWinds SD1, SD (11-12)	Derby et al. 2012c
Rugby, ND (10-11)	Derby et al. 2011c	Top Crop I & II (12-13)	Good et al. 2013c
Cedar Ridge, WI (10)	BHE Environmental 2011	Heritage Garden I, MI (12-14)	Kerlinger et al. 2014
Elm Creek II, MN (11-12)	Derby et al. 2012b	Wessington Springs, SD (10)	Derby et al. 2011a
Buffalo Ridge, MN (Phase II; 99)	Johnson et al. 2000	Rail Splitter, IL (12-13)	Good et al. 2013b
Buffalo Ridge, MN (Phase I; 98)	Johnson et al. 2000	Top of Iowa, IA (04)	Jain 2005
Ripley, Ont (08)	Jacques Whitford 2009	Big Blue, MN (13)	Fagen Engineering 2014
Fowler I, IN (09)	Johnson et al. 2010a	Grand Ridge I, IL (09-10)	Derby et al. 2010a
Buffalo Ridge, MN (Phase I; 97)	Johnson et al. 2000	Top of Iowa, IA (03)	Jain 2005
Buffalo Ridge, MN (Phase II; 98)	Johnson et al. 2000	Big Blue, MN (14)	Fagen Engineering 2015
PrairieWinds SD1, SD (12-13)	Derby et al. 2013	Pioneer Prairie II, IA (11-12)	Chodachek et al. 2012

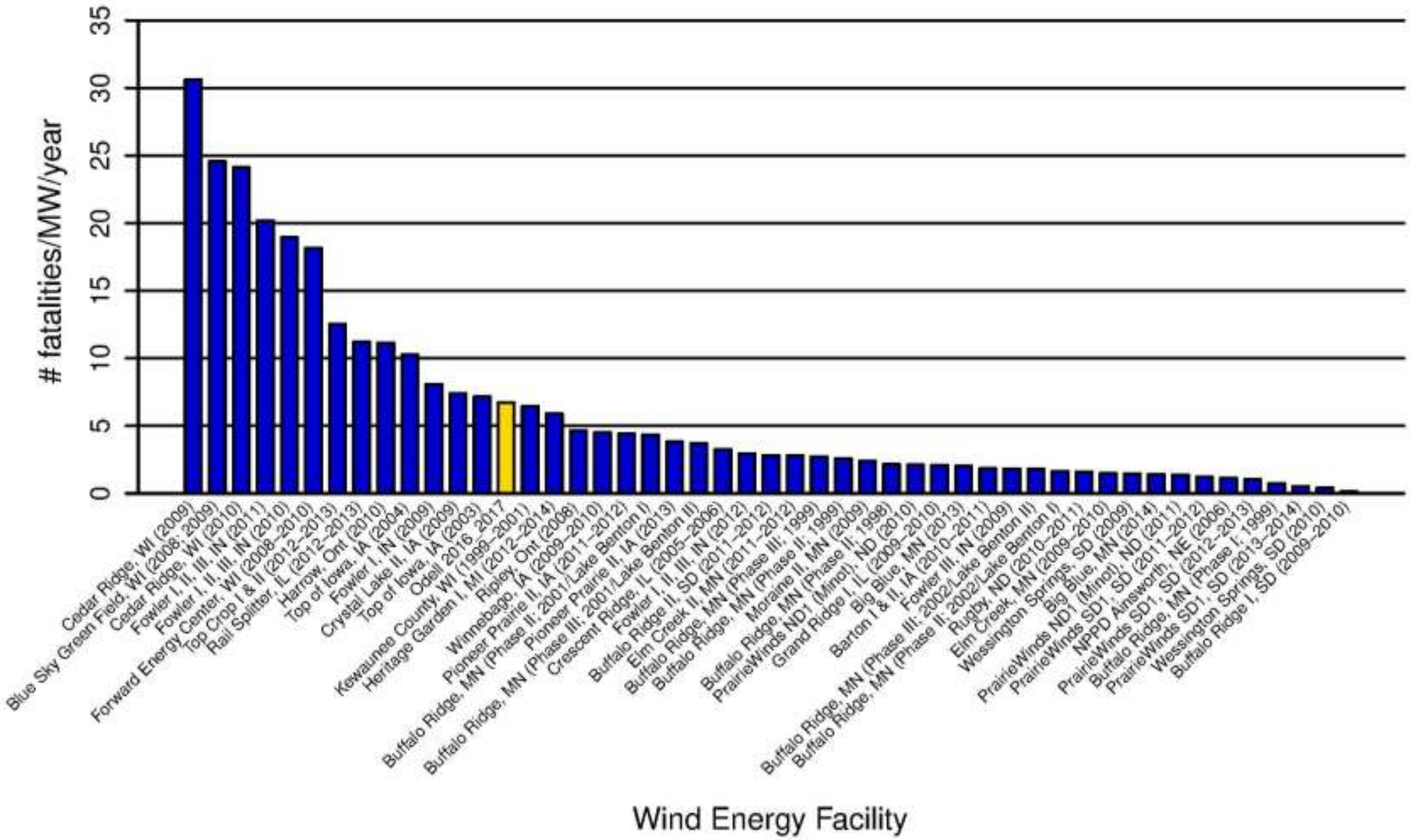

Figure 10. Fatality rates for bats (number of bat fatalities per megawatt per year) from publicly available studies at wind energy facilities in the Midwest region of North America.

Figure 10 (continued). Fatality rates for bats (number of bat fatalities per megawatt per year) from publicly available wind energy facilities in the Midwest Region of North America.

Data from the following sources:

Facility	Fatality Estimate	Facility	Fatality Estimate
Odell, MN (16-17)	This study.		
Cedar Ridge, WI (09)	BHE Environmental 2010	Elm Creek II, MN (11-12)	Derby et al. 2012b
Blue Sky Green Field, WI (08; 09)	Gruver et al. 2009	Buffalo Ridge, MN (Phase III; 99)	Johnson et al. 2000
Cedar Ridge, WI (10)	BHE Environmental 2011	Buffalo Ridge, MN (Phase II; 99)	Johnson et al. 2000
Fowler I, II, III, IN (11)	Good et al. 2012	Moraine II, MN (09)	Derby et al. 2010f
Fowler I, II, III, IN (10)	Good et al. 2011	Buffalo Ridge, MN (Phase II; 98)	Johnson et al. 2000
Forward Energy Center, WI (08-10)	Grodsky and Drake 2011	PrairieWinds ND1 (Minot), ND (10)	Derby et al. 2011d
Top Crop I & II, IL (12-13)	Good et al. 2013c	Grand Ridge I, IL (09-10)	Derby et al. 2010a
Rail Splitter, IL (12-13)	Good et al. 2013b	Big Blue, MN (13)	Fagen Engineering 2014
Harrow, Ont (10)	Natural Resource Solutions Inc. (NRSI) 2011	Barton I & II, IA (10-11)	Derby et al. 2011b
Top of Iowa, IA (04)	Jain 2005	Fowler III, IN (09)	Johnson et al. 2010b
Fowler I, IN (09)	Johnson et al. 2010a	Buffalo Ridge, MN (Phase III; 02/Lake Benton II)	Johnson et al. 2004
Crystal Lake II, IA (09)	Derby et al. 2010b	Buffalo Ridge, MN (Phase II; 02/Lake Benton I)	Johnson et al. 2004
Top of Iowa, IA (03)	Jain 2005	Rugby, ND (10-11)	Derby et al. 2011c
Kewaunee County, WI (99-01)	Howe et al. 2002	Elm Creek, MN (09-10)	Derby et al. 2010e
Heritage Garden I, MI (12-14)	Kerlinger et al. 2014	Wessington Springs, SD (09)	Derby et al. 2010c
Ripley, Ont (08)	Jacques Whitford 2009	Big Blue, MN (14)	Fagen Engineering 2015
Winnebago, IA (09-10)	Derby et al. 2010g	PrairieWinds ND1 (Minot), ND (11)	Derby et al. 2012d
Pioneer Prairie II, IA (11-12)	Chodachek et al. 2012	PrairieWinds SD1, SD (11-12)	Derby et al. 2012c
Buffalo Ridge, MN (Phase II; 01/Lake Benton I)	Johnson et al. 2004	NPPD Ainsworth, NE (06)	Derby et al. 2007
Pioneer Prairie II, IA (13)	Chodachek et al. 2014	PrairieWinds SD1, SD (12-13)	Derby et al. 2013
Buffalo Ridge, MN (Phase III; 01/Lake Benton II)	Johnson et al. 2004	Buffalo Ridge, MN (Phase I; 99)	Johnson et al. 2000
Crescent Ridge, IL (05-06)	Kerlinger et al. 2007	PrairieWinds SD1, SD (13-14)	Derby et al. 2014
Fowler I, II, III, IN (12)	Good et al. 2013a	Wessington Springs, SD (10)	Derby et al. 2011a
Buffalo Ridge II, SD (11-12)	Derby et al. 2012a	Buffalo Ridge I, SD (09-10)	Derby et al. 2010d

Birds

The timing and composition of bird fatalities at the Project (spring and fall) is consistent with the spring and fall movement patterns of migratory birds (Erickson et al. 2014, Strickland et al. 2011, NWCC 2010). The estimated overall bird fatality rate of 4.69 bird fatalities/MW/year is within the range of fatality rates seen at other facilities in the Midwest (Figure 9); where fatality rate estimates range from 0.29 bird fatalities/MW/year (Pioneer Prairie II, Iowa; Chodachek et al. 2012) to 8.25 bird fatalities/MW/year at Wessington Springs Facility in South Dakota (2009; Derby et al. 2010c).

Bats

The timing of bat fatalities at the Project (July through September) is consistent with results from other fatality studies in the US which have shown a peak in mortality in August and September, and generally lower mortality in spring and early summer (Johnson 2005, Arnett et al. 2008).

Based on the timing of fatalities for the found species and the lack of forest cover that might provide habitat for resident bats, most of the fatalities were likely fall migrants through the site, as is the case at virtually all other wind energy facilities in North America (Johnson 2005, Arnett et al. 2008). Hoary bats composed the majority of bat fatalities, which is similar to the species composition of fatalities at most other wind energy facilities in the Midwest (Jain 2005; Gruver et al. 2009, 2011). The estimated bat fatality rate of 6.74 bat fatalities/MW/year is within the range of bat fatality rates documented at other facilities in the Midwest with publicly available data that range from 0.16 bat fatalities/MW/year (Buffalo Ridge I, South Dakota; Derby et al. 2010d) to 30.61 bat fatalities/MW/year (Cedar Ridge, Iowa [2009]; BHE Environmental 2010; Figure 10).

Sensitive Species

No federal or state endangered, threatened, or candidate species were found as fatalities at the Project.

SUMMARY

The estimated bird and bat fatality rates at the Project are within the range of other publicly available projects in the Midwest, as shown in Figures 9 and 10, respectively. No fatalities of state or federally endangered or threatened bird or bat species were encountered during the study.

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Appendix A. Complete Fatality Listing for the Odell Wind Energy Project, Cottonwood and Jackson counties, Minnesota, from December 20, 2016 – December 10, 2017

Appendix A. Complete fatality listing for the Odell Wind Energy Project in Cottonwood and Jackson counties, Minnesota, from December 20, 2016 – December 10, 2017.

Date	Common Name	Search Location	Distance from Turbine (m)	Type of Find	Included in Analysis	Condition
2016-12-29	bald eagle	23	90	Carcass search	No	Dismembered
2017-04-13	greater yellowlegs	80	44	Carcass search	Yes	Scavenged
2017-06-13	mallard	2	5	Incidental	No	Scavenged
2017-07-10	killdeer	3	77	Carcass search	Yes	Intact
2017-07-10	killdeer	3	74	Carcass search	Yes	Intact
2017-07-11	hoary bat	82	1	Carcass search	Yes	Intact
2017-07-27	hoary bat	63	30	Carcass search	Yes	Intact
2017-08-03	hoary bat	47	35	Carcass search	Yes	Intact
2017-08-03	hoary bat	47	30	Carcass search	Yes	Dismembered
2017-08-03	eastern red bat	64	60	Carcass search	No	Intact
2017-08-03	evening bat	64	13	Carcass search	Yes	Intact
2017-08-03	eastern red bat	101	20	Carcass search	Yes	Intact
2017-08-03	eastern red bat	80	13	Carcass search	Yes	Intact
2017-09-04	red-eyed vireo	80	26	Carcass search	No	Dismembered
2017-09-26	European starling	64	37	Carcass search	Yes	Intact
2017-09-26	wood thrush	110	32	Carcass search	Yes	Intact
2017-09-26	sora	110	29	Carcass search	Yes	Intact
2017-09-26	red-eyed vireo	110	21	Carcass search	Yes	Intact
2017-09-26	sora	63	24	Carcass search	Yes	Intact
2017-09-26	red-eyed vireo	63	32	Carcass search	Yes	Intact
2017-10-03	yellow rail	23	46	Carcass search	Yes	Intact
2017-10-03	silver-haired bat	47	29	Carcass search	Yes	Intact
2017-10-09	silver-haired bat	23	36	Carcass search	Yes	Intact
2017-10-16	unidentified sandpiper	95	25	Carcass search	No	Scavenged
2017-10-17	unidentified bat	47	40	Carcass search	Yes	Intact

Appendix B. Bird and Bat Fatality Estimates using the Huso Estimator for the Odell Wind Energy Project in Cottonwood and Jackson counties, Minnesota, from December 20, 2016 – December 10, 2017

Appendix B. Bird and Bat Fatality Estimates using the Huso Estimator for the Odell Wind Energy Project in Cottonwood and Jackson counties, Minnesota, from December 20, 2016 – December 10, 2017.

	Winter 2016[1]		Spring		Summer		Fall		Winter 2017[2]	
Parameter	**Estimate**	**90% CI**	**Estimate**	**90% CI**	**Estimate**	**90% CI**	**Estimate**	**90% CI**	**Estimate**	**Estimate**
Observer Detection Rate										
Large birds	0.83	0.75 - 0.91	0.83	0.75 - 0.91	0.83	0.75 - 0.91	0.83	0.75 - 0.91	0.83	0.75 - 0.91
Small Birds	0.80	0.65 - 0.94	0.45	0.18 - 0.73	0.50	0.31 - 0.70	0.11	0.09 - 0.33	0.80	0.65 - 0.94
Bats	0.80	0.64 - 0.94	0.45	0.18 - 0.73	0.57	0.41 - 0.74	0.18	0.08 - 0.36	0.80	0.64 - 0.94
Probability of a Carcass Persisting Through the Search Interval										
Large birds	0.26	0.18 - 0.35	0.57	0.48 - 0.66	0.57	0.47 - 0.66	0.55	0.46 - 0.64	0.57	0.48 - 0.66
Small birds	0.10	0.08 - 0.13	0.44	0.35 - 0.51	0.43	0.35 - 0.51	0.41	0.33 - 0.49	0.44	0.35 - 0.51
Bats	0.05	0.03 - 0.06	0.22	0.16 - 0.28	0.22	0.16 - 0.27	0.20	0.15 - 0.26	0.22	0.16 - 0.28
Probability of Available and Detected										
Large birds	0.22	0.15 - 0.30	0.48	0.38 - 0.56	0.47	0.38 - 0.56	0.46	0.37 - 0.55	0.47	0.38 - 0.56
Small birds	0.08	0.06 - 0.11	0.20	0.08 - 0.31	0.22	0.13 - 0.31	0.05	0.04 - 0.13	0.35	0.26 - 0.44
Bats	0.04	0.02 - 0.05	0.10	0.04 - 0.16	0.13	0.08 - 0.18	0.04	0.02 - 0.05	0.18	0.12 - 0.23
Unadjusted Number of Fatalities										
Large birds	-	-	1.00	0.00 - 3.00	2.00	0.00 - 6.00	0.00	0.00 - 0.00	-	-
Small birds	-	-	0.00	0.00 - 0.00	0.00	0.00 - 0.00	7.00	2.00 - 13.00	-	-
Bats	-	-	0.00	0.00 - 0.00	2.00	0.00 - 4.00	8.00	2.00 - 16.00	-	-
Observed Fatality Rates (Fatalities/Turbine/Season)										
Large birds	-	-	0.07	0.00 - 0.20	0.13	0.00 - 0.40	0.0	0.00 - 0.00	-	-
Small birds	-	-	0.00	0.00 - 0.00	0.00	0.00 - 0.00	0.47	0.13 - 0.87	-	-
Bats	-	-	0.00	0.00 - 0.00	0.13	0.00 - 0.27	0.53	0.13 - 1.07	-	-
Adjusted Fatality Rates (Fatalities/Turbine/Season)										
Large birds	-	-	0.15	0.00 - 0.45	0.23	0.00 - 0.69	0.0	0.00 - 0.00	-	-
Small birds	-	-	0.00	0.00 - 0.00	0.00	0.00 - 0.00	9.00	2.49 - 16.82	-	-
All birds	-	-	0.15	0.00 - 0.45	0.23	0.00 - 0.69	9.00	2.49 - 16.82	-	-
Bats	-	-	0.00	0.00 - 0.00	1.41	0.00 - 3.63	12.07	3.27 - 23.93	-	-
Adjusted Fatality Rates (Fatalities/MW/Season)										
Large birds	-	-	0.07	0.00 - 0.22	0.11	0.00 - 0.34	0.0	0.00 - 0.00	-	-
Small birds	-	-	0.00	0.00 - 0.00	0.00	0.00 - 0.00	4.50	1.24 - 8.41	-	-
All birds	-	-	0.07	0.00 - 0.22	0.11	0.00 - 0.34	4.50	1.24 - 8.41	-	-
Bats	-	-	0.00	0.00 - 0.00	0.71	0.00 - 1.81	6.03	1.64 - 11.97	-	-

[1] No bird or bat fatalities were found during the winter 2016 survey period
[2] No bird or bat fatalities were found during the winter 2017 survey period

Appendix C. Bird and Bat Fatality Estimates using the Shoenfeld Estimator for the Odell Wind Energy Project in Cottonwood and Jackson counties, Minnesota, from December 20, 2016 – December 10, 2017

Appendix C. Bird and Bat Fatality Estimates using the Shoenfeld Estimator for the Odell Wind Energy Project in Cottonwood and Jackson counties, Minnesota, from December 20, 2016 – December 10, 2017.

	Winter 2016[1]		Spring		Summer		Fall		Winter 2017[2]	
Parameter	**Estimate**	**90% CI**	**Estimate**	**90% CI**	**Estimate**	**90% CI**	**Estimate**	**90% CI**	**Estimate**	**Estimate**
Observer Detection Rate										
Large birds	0.83	0.75 - 0.91	0.83	0.75 - 0.91	0.83	0.75 - 0.91	0.83	0.75 - 0.91	0.83	0.75 - 0.91
Small Birds	0.80	0.64 - 0.95	0.45	0.20 - 0.73	0.50	0.29 - 0.70	0.11	0.09 - 0.33	0.80	0.64 - 0.95
Bats	0.80	0.63 - 0.94	0.45	0.20 - 0.73	0.57	0.39 - 0.74	0.18	0.08 - 0.40	0.80	0.63 - 0.94
Probability of Available and Detected										
Large birds	0.37	0.08 - 0.52	0.39	0.08 - 0.52	0.10	0.08 - 0.52	0.40	0.08 - 0.52	0.39	0.08 - 0.52
Small birds	0.34	0.07 - 0.43	0.21	0.04 - 0.32	0.05	0.04 - 0.32	0.06	0.01 - 0.15	0.36	0.07 - 0.43
Bats	0.16	0.03 - 0.22	0.10	0.02 - 0.16	0.03	0.02 - 0.17	0.04	0.00 - 0.08	0.18	0.03 - 0.22
Unadjusted Number of Fatalities										
Large birds	-	-	1.00	0.00 - 3.00	2.00	0.00 - 6.00	0.00	0.00 - 0.00	-	-
Small birds	-	-	0.00	0.00 - 0.00	0.00	0.00 - 0.00	9.00	4.00 - 15.00	-	-
All Birds	-	-	1.00	0.00 - 3.00	2.00	0.00 - 6.00	9.00	4.00 - 15.00	-	-
Bats			0.00	0.00 - 0.00	2.00	0.00 - 4.00	9.00	3.00 - 16.05		
Observed Fatality Rates (Fatalities/Turbine/Season)										
Large birds	-	-	0.07	0.00 - 0.20	0.13	0.00 - 0.40	0.00	0.00 - 0.00	-	-
Small birds	-	-	0.00	0.00 - 0.00	0.00	0.00 - 0.0	0.60	0.27 - 1.00	-	-
All Birds	-	-	0.07	0.00 - 0.20	0.13	0.00 - 0.40	0.60	0.27 - 1.00	-	-
Bats			0.00	0.00 - 0.00	0.13	0.00 - 0.27	0.60	0.20 - 1.07		
Adjusted Fatality Rates (Fatalities/Turbine/Season)										
Large birds	-	-	0.17	0.00 - 0.51	0.34	0.00 - 1.02	0.00	0.00 - 0.00	-	-
Small birds	-	-	0.00	0.00 - 0.00	0.00	0.00 - 0.0	11.77	5.23 - 19.62	-	-
All birds	-	-	0.17	0.00 - 0.51	0.34	0.00 - 1.02	11.77	5.23 - 19.62	-	-
Bats	-	-	0.00	0.00 - 0.00	1.06	0.00 - 2.12	16.06	5.35 - 28.63	-	-
Adjusted Fatality Rates (Fatalities/MW/Season)										
Large birds	-	-	0.08	0.00 - 0.25	0.17	0.0 - 0.51	0.00	0.0 - 0.0	-	-
Small birds	-	-	0.00	0.00 - 0.00	0.00	0.0 - 0.0	5.89	2.62 - 9.81	-	-
All birds	-	-	0.08	0.00 - 0.25	0.17	0.0 - 0.51	5.89	2.62 - 9.81	-	-
Bats	-	-	0.00	0.00 - 0.00	0.53	0.0 - 1.06	8.03	2.68 - 14.32	-	-

[1] No bird or bat fatalities were found during the winter 2016 survey period
[2] No bird or bat fatalities were found during the winter 2017 survey period