Post-Construction Bird and Bat Fatality Monitoring Study

Crowned Ridge II Wind Farm

Codington, Grant, and Deuel Counties, South Dakota

March – December 2021

Prepared for:

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WEST

EXECUTIVE SUMMARY

Xcel Energy contracted Western EcoSystems Technology, Inc. to conduct a post-construction bird and bat fatality monitoring (PCM) study at the Crowned Ridge II Wind Farm (Project). The study was developed and implemented to estimate bird and bat fatality rates resulting from Project operations. This report presents the results of one year of PCM conducted from March 17 – December 15, 2021.

The primary objectives of PCM were to 1) document species occurring as fatalities, 2) estimate bird and bat fatality rates for the study period, 3) qualitatively evaluate spatial and temporal patterns of bird and bat fatalities, 4) qualitatively compare data from PCM studies conducted at other wind energy facilities in South Dakota and neighboring states, and 5) document fatalities of sensitive species as a result of collisions with wind turbines at the Project.

Twenty-seven turbines were included in carcass searches from March 17 – December 15, with seasons defined as spring (March 17 – June 15), summer (June 16 – September 13), and fall (September 14 – December 15). All 27 turbines were searched as square plots until vegetation obstructed visibility, at which time five turbines within grassland were maintained as square plots and 22 turbines were searched as road and pad plots from June 11 – November 28. After vegetation (i.e., crops) was cleared in fall, and plot visibility was unobstructed, technicians searched all 27 turbines as square plots through the end of the study. The period from September 14 – November 27 was defined as “early fall” and November 28 – December 15 was defined as “late fall. Square plots consisted of a 120 x 120-meter (m; 394 x 394-foot [ft]) square centered on the turbine, and road and pad plots included all area on the gravel pads and access roads out to 60 m (197 ft) from the turbine.

During the study, 16 bird carcasses and seven bat carcasses were found during searches or incidentally. Seven bird carcasses and four bat carcasses were found outside of search areas and one bird carcass was found outside of the study period. Nine bird species and four bat species were identified as fatalities during the study. Three red-tailed hawks were the only raptors found as fatalities. Two sensitive species were found during the study, including American white pelican (four fatalities) and silver-haired bat (one carcass); both sensitive species are designated as Species of Greatest Conservation Need. No federally or state-listed threatened or endangered species were found as fatalities.

The overall estimated bird fatality rate was 0.41 bird fatalities/megawatt (MW)/study period, and the overall estimated bat fatality rate was 0.74 bat fatalities/MW/study period. The estimated bird fatality rate by season was 0.33 bird fatalities/MW in spring and 0.07 in late fall; no bird fatalities included in analysis were found during summer or early fall. The estimated bat fatality rate by season was 0.17 bat fatalities/MW in spring and 0.58 in summer; no bat fatalities included in analysis were found during early or late fall.

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ACRONYM LIST

Acronym	Definition
AICc	Corrected Akaike Information Criteria
cm	centimeter
CI	confidence intervals
CP	carcass persistence
CPT	carcass persistence trial
ft	feet or foot
GenEst	Generalized Estimator
k	Detection Reduction Factor
km	kilometer
m	meters
mi	miles
MW	megawatt
PCM	Post-construction Fatality Monitoring
Project	Crowned Ridge II Wind Farm
QA/QC	Quality Assurance/Quality Control
SDGFP	South Dakota Game, Fish, and Parks
SEEF	searcher efficiency
SGCN	Species of Greatest Conservation Need
TWL	Truncated Weighted Maximum Likelihood
turbines	wind turbine generators
USFWS	US Fish and Wildlife Service
USGS	US Geological Survey
WEST	Western EcoSystems Technology, Inc.
Xcel Energy	Northern States Power, a Minnesota corporation, d/b/a/ Xcel Energy

INTRODUCTION

Northern States Power, a Minnesota corporation, d/b/a/ Xcel Energy, owns and operates the Crowned Ridge II Wind Farm (Project), located in Codington, Grant, and Deuel counties, South Dakota (Figure 1). The Project became operational in 2020 with an installed nameplate capacity of 200.6 megawatts (MW). The Project consists of 79 GE 2.3 MW wind turbines (turbines) with a 90 meter (m; 295 feet [ft]) hub height and nine GE 2.1 MW turbines with an 80 m (262 ft) hub height. Both turbine models have a 116 m (381 ft) rotor diameter.

Xcel Energy contracted Western EcoSystems Technology, Inc. (WEST) to conduct post-construction fatality monitoring (PCM) at the Project to estimate bird and bat fatality rates resulting from Project operations. The PCM follows guidance described in Tier 4 of the US Fish and Wildlife Service (USFWS) *Land-Based Wind Energy Guidelines* (USFWS 2012) and Stage 5 of the *Eagle Conservation Plan Guidance* (USFWS 2013).

The overall goal for PCM was to estimate the number of bird and bat fatalities within the Project attributable to collisions with turbines. The primary objectives of PCM were to 1) document species occurring as fatalities, 2) estimate bird and bat fatality rates for the study period, 3) qualitatively evaluate spatial and temporal patterns of bird and bat fatalities, 4) qualitatively compare data from PCM studies conducted at other wind energy facilities in South Dakota and neighboring states, and 5) document fatalities of sensitive species (defined in the Methods' section) as a result of collisions with turbines at the Project. This report presents the results of the study conducted within the Project from March 17 – December 15, 2021.

PROJECT LOCATION

The Project is located in northeast South Dakota within the Prairie Coteau and Big Sioux Basin Level IV ecoregions of the Northern Glaciated Plains Level III Ecoregion (US Environmental Protection Agency 2013). The Prairie Coteau and Big Sioux Basin Level IV ecoregions encompass the majority of northeast South Dakota and into southwest Minnesota. The landscape in this ecoregion is composed of glacial drift and contains numerous seasonal and temporary prairie pothole wetlands that provide nesting and foraging habitat for waterfowl (Bryce et al. 1998). Historically, this ecoregion supported both tall- and short-grass prairies; however, these native grasslands have been extensively converted to agriculture (Bryce et al. 1996). Topography is flat to gently rolling, with elevations ranging from 547–619 meters (m; 1,795–2,031 feet [ft]; U.S. Geological Survey [USGS] 2020).

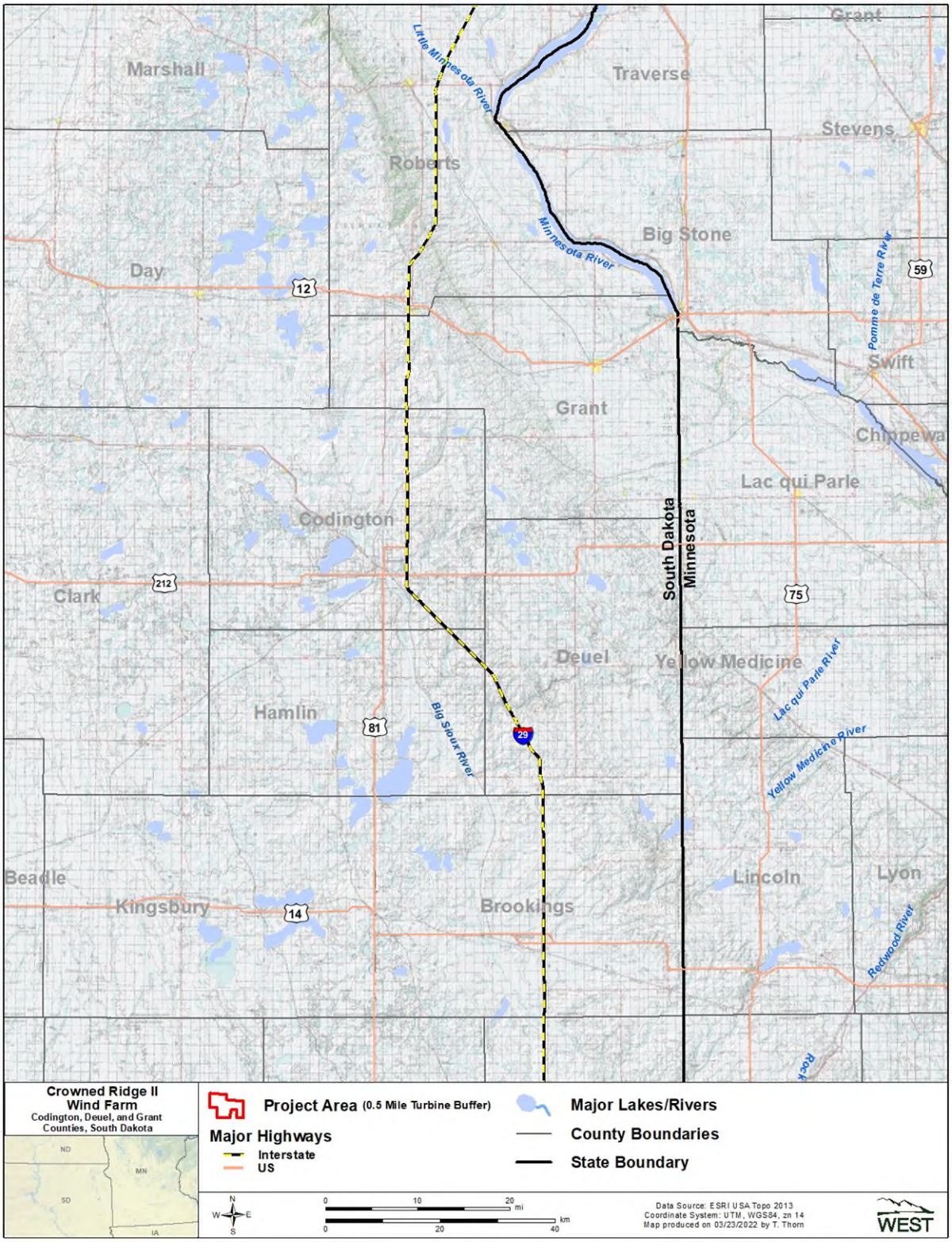

Figure 1. Location of the Crowned Ridge II Wind Farm, Codington, Grant, and Deuel counties, South Dakota.

According to the National Land Cover Database ([NLCD] 2019), the dominant land cover type in the Project (from within 0.5-mile [mi, 0.8-kilometer (km)] buffer of turbines) is cultivated crops (68.0%). The cultivated crops consist mainly of corn (*Zea mays*) and soybeans (*Glycine max;* US Department of Agriculture 2021), followed by herbaceous (26.6%) and developed (3.5%; NLCD 2019; Table 1, Figure 2). Remaining land cover types each compose less than 1.0% of the Project (NLCD 2019). Wetlands are relatively sparse within the Project and consist mainly of freshwater emergent wetlands (USFWS National Wetlands Inventory 2021).

Table 1. Land cover types, coverage, and percent (%) composition within the Crowned Ridge II Wind Farm, Codington, Grant, and Deuel counties, South Dakota[1].

Land Cover Type	Coverage (hectares)	Coverage (acres)	% Composition
Cultivated Crops	8,284.5	20,471.4	68.0
Herbaceous	3,236.8	7,998.3	26.6
Developed	427.6	1,056.6	3.5
Hay/Pasture	111.4	275.3	0.9
Trees/Forest	57.8	142.8	0.5
Wetland/Water	50.6	125.1	0.4
Barren Land	4.0	9.9	<0.1
Shrub/Scrub	1.9	4.7	<0.1
Total[2]	**12,174.6**	**30,084.1**	**100**

Source: National Land Cover Database 2019.

1. Land cover composition from within 0.5 mile (0.8 kilometer) buffer of turbines.

2. Sums can differ from total values shown due to rounding.

METHODS

PCM consisted of three primary survey components: 1) standardized carcass searches (carcass searches) of turbines, 2) searcher efficiency (SEEF) trials to estimate the probability technicians found a carcass, and 3) carcass persistence (CP) trials (CPT) to estimate the average length of time a carcass remained in the search area for possible detection. In addition, the searched areas were delineated to provide the basis for an area adjustment, which accounts for carcasses that fell outside of search areas. The methods for each of these survey components and associated analysis are described below. An overview of the study design and search methods are presented in Appendix A.

Sensitive species for the Project are defined as bird or bat species protected under the Endangered Species Act (1973) or Bald and Golden Eagle Protection Act (1940), state-listed as endangered or threatened (South Dakota Game, Fish, and Parks [SDGFP] 2020), or Species of Greatest Conservation Need (SGCN; SDGFP 2014).

Bird fatalities were classified based on size for PCM. Large birds generally included groups of species with a total length greater than 23 centimeters (cm; nine inches) in length and a wingspan greater than 46 cm (18 inches). Small birds generally included groups of species equal to or less than 23 cm in total length, with a wingspan less than 46 cm.

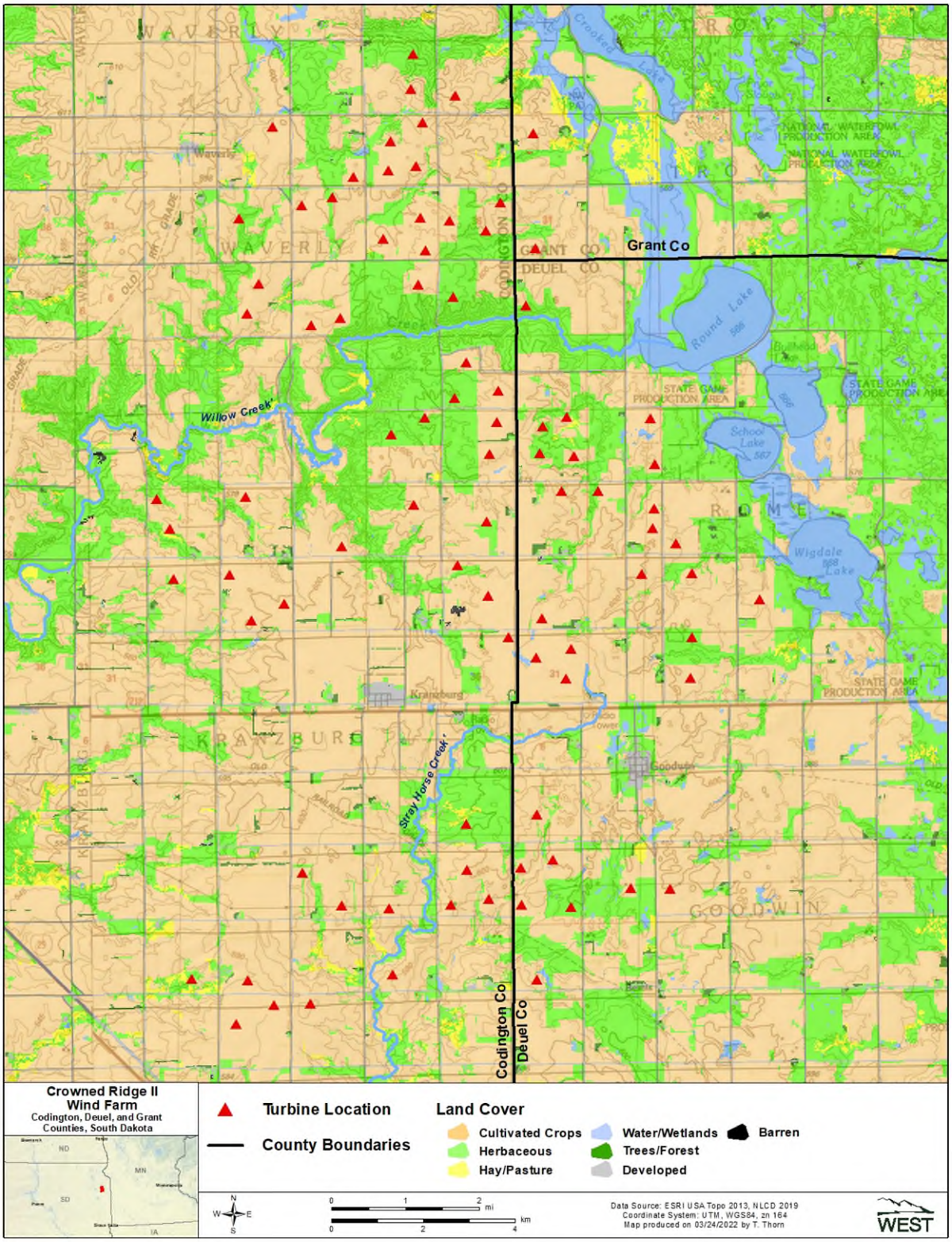

Figure 2. Land cover types within and adjacent to the Crowned Ridge II Wind Farm, Codington, Grant, and Deuel counties, South Dakota.

Survey Design

Search Turbines

Twenty-seven turbines (30% of total) at the Project were selected for carcass searches over the study period (Figure 3). At the start of the study, all 27 turbines were searched as square plots (discussed in *Search Areas*, below) until vegetation obstructed visibility, at which time five turbines within grasslands were maintained as square plots and the remaining 22 turbines were searched as a road and pad plot (discussed in *Search Areas*, below; Appendix A). After vegetation (i.e., crops) was cleared in fall, and plot visibility was unobstructed, all 27 turbines were searched as square plots through the end of the study. Excluding the five turbines searched as square plots for the entire study period, the remaining 22 turbines were searched as square plots from March 17 – June 20, 2021, as road and pad plots from June 21 – November 28, 2021, and again as square plots from November 29 – December 15, 2021.

Search Areas

Search areas consisted of square plots and road and pad plots. Square plots measured 120 x 120 m (394 x 394 ft) as a square area centered on the turbine (Figure 4). Road and pad plots included all area on the gravel pads and roads and a 5.0-m (16.4 ft) buffer on either side of the roads and pads out to 60 m (197 ft) from the turbine (Figure 4).

Search Frequency

Searches were conducted once every two weeks from March 17 – December 15, 2021, with seasons defined as spring (March 16 – June 15), summer (June 16 – September 13) and fall (September 14 – December 15). Searches were missed due to site access issues that created unsafe working conditions (e.g., turbine maintenance, extreme weather, or impassable roads).

Search Area Delineations

WEST technicians delineated unsearchable areas (e.g., fence lines, waterways, or other objects that altered the search) within square plots by walking the perimeter of the unsearchable area using a global positioning system with sub-meter accuracy. Technicians delineated square plots and road and pad plots by walking along the edge of the plots of a given turbine.

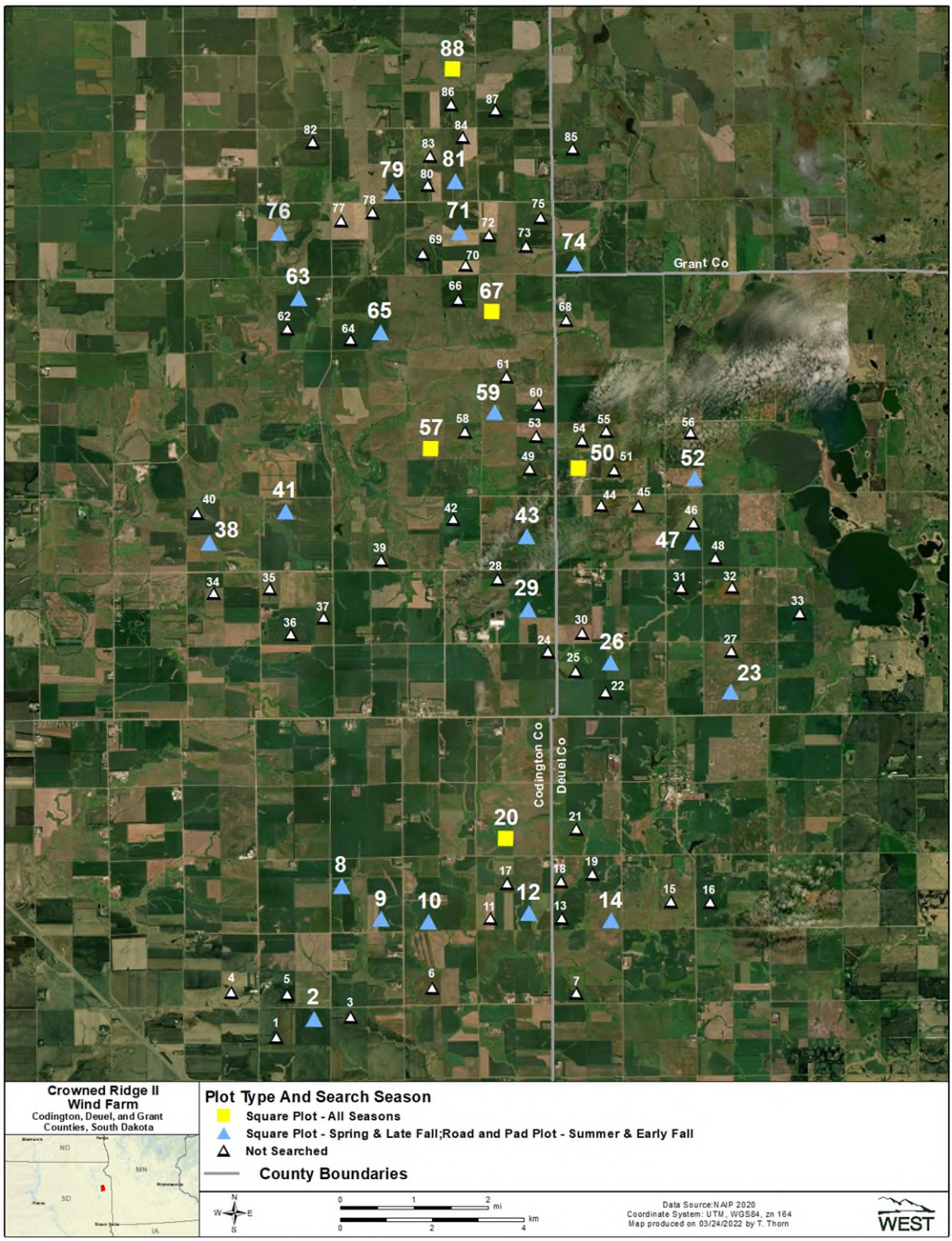

Figure 3. Location of search areas at the Crowned Ridge II Wind Farm, Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021. Note: 22 of the 27 turbines were searched as a road and pad plot from June 16 – November 27, 2021.

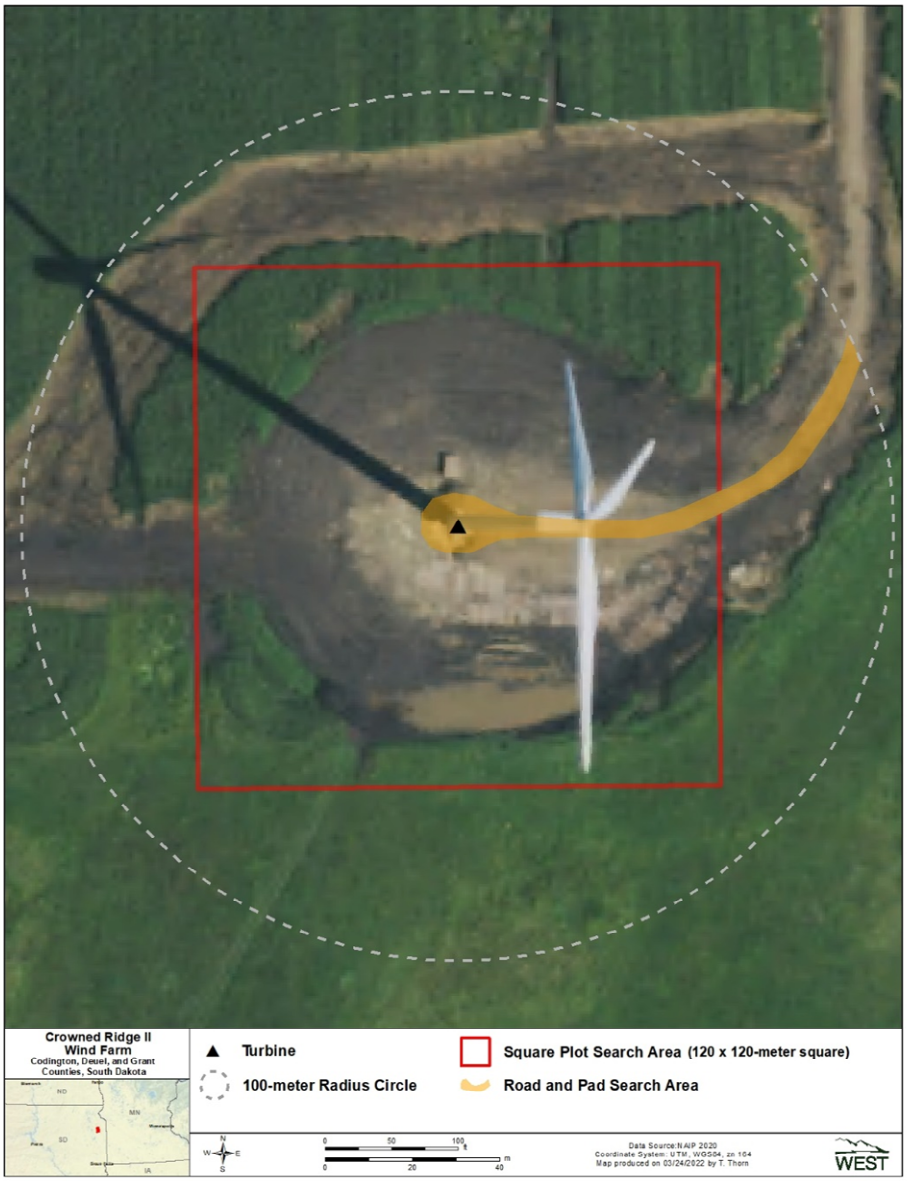

Figure 4. Schematic illustrating both search area types at an example turbine. The solid line outlines a 120-m (394-ft) square area used for square plot searches. Road and pad plot searches occurred within the turbine pad and access roads out to 60 meters (m; 197 feet [ft]).

Standardized Carcass Searches

Technicians looked for carcasses while walking transects spaced up to six m (20 ft) apart at a pace of approximately 45–60 m (148–197 ft) per minute within square plots and road and pad plots. During the first search of the study at each turbine, any carcasses found were recorded and included in the overall reported fatalities (Appendices B and C); however, these carcasses were excluded from the fatality rate estimation analysis.

All bird and bat carcasses found were recorded, and cause of death was assumed to be from collision with turbines. Furthermore, any injured bird or bats observed within search areas or elsewhere in the Project were recorded and considered as fatalities. Data recorded for all carcasses included:

- an identification code
- species, sex, age, and reproductive condition (when identifiable)
- date and time
- location (i.e., coordinates in decimal degrees)
- distance from turbine using a handheld rangefinder
- direction from turbine using a handheld compass
- estimated time of death
- any comments that indicated possible cause of death
- photograph(s) of carcass as found
- location of carcass plotted on map
- condition (e.g., intact, scavenged, dismembered, feather spot, injured)
    - Intact − a completely intact carcass, not badly decomposed, and shows no sign of being fed upon by a predator or scavenger
    - Scavenged – an entire carcass that shows signs of scavenging or is heavily infested by insects, or portion(s) of a carcass in one location (e.g., wings)
    - Dismembered – a carcass that has any major part of its body missing with no evidence of scavenging, or portions of the carcass are distributed in different locations
    - Feather Spot – 10 or more body feathers (or two or more primary feathers) at one location indicating predation or scavenging
    - Injured – a live bird or bat that is harmed, damaged, or impaired in some way

Bird and bat carcasses were collected under the SDGFP Scientific Collector's Permit (permit number 70), and collection of bird carcasses was authorized under a Federal Migratory Bird Special Purpose – Utility Permit (permit number MBPER0003874). All bird and bat carcasses were placed in a re-sealable plastic bag, labeled with a unique carcass identification number, turbine number, date, and stored in a freezer on site until the completion of the study. Leather and rubber or nitrile gloves were worn to process all carcasses to reduce the risk of possible injury or transmission of rabies or other diseases.

Biologists with experience identifying birds and bats to species verified identification of all bird and bat carcasses. Permitted bat biologists (Ashley Matteson [USFWS permit number TE19208C-0], Larisa Bishop-Boros [TE21829B-2and Brenna Hyzy [TE26854C-1]) verified the identification of all bat sensitive species or suspected bat sensitive species.

Searcher Efficiency Trials

The objective of SEEF trials was to estimate the probability technician's detected bird and bat carcasses. This effort accounted for biases associated with changes in conditions such as vegetation, topography, weather (e.g., rain, cloud cover, muddy plots), and technician variability that could have affected SEEF. Estimates of SEEF were used to adjust the total number of carcasses found to account for those missed by technicians.

SEEF trials commenced with the start of carcass searches and were conducted in the same search areas throughout the study period. SEEF trials were stratified by the type and size of carcass (large bird, small bird, or bat), by search area (road and pad plot, or square plot), and by season (spring, summer, or fall). A bias trial administrator placed SEEF trial carcasses (SEEF carcasses) in search areas; technicians were unaware of when and where the SEEF carcasses were placed. Bird carcasses used for the trials included non-protected, commercially available species (i.e., rock pigeons [*Columba livia* for large birds, and 6- to 8-day old northern bobwhite [*Colinus virginianus*] for small birds). Brown-colored house mice (*Mus musculus*) were used as surrogates for bats due to the limited number of bat carcasses available for use.

The bias trial administrator placed SEEF carcasses in search areas at random locations before that day's scheduled search. Prior to placement, each SEEF carcass was discreetly marked (e.g., beak or foot of carcass was marked with a small amount of nail polish) so it could be identified as a SEEF carcass. The administrator dropped SEEF carcasses from waist height or higher and allowed them to land in a random posture. To avoid attracting scavengers, no more than four SEEF carcasses were placed at a single road and pad plot turbine and no more than three SEEF carcasses were placed at a single square plot turbine during an individual trial. Technicians conducting carcass searches recorded the location of any SEEF carcasses found. Immediately following the trial, the bias trial administrator determined the number of SEEF carcasses that were available for detection during the trial.

Carcass Persistence Trials

The objective of CPT was to estimate the probability a bird or bat carcass remained available to be found during the search interval. The data collected were used to adjust for the potential bias of carcasses being removed between carcass searches. CPT were conducted throughout the study period to incorporate the effects of varying weather, climatic conditions, and scavenger densities. Possible means of carcass removal included predators, scavengers, insects, or agricultural practices, such as being plowed into a field. Estimates of bird and bat CP were used to adjust the total number of carcasses found to account for those removed from the search area.

The same type of bird carcasses used for SEEF trials were used for CPT and included non-protected, commercially available species (rock pigeons for large birds and 6- to 8-day old northern bobwhite quail for small birds). Brown-colored house mice (bat surrogates) were used for bat CPT. Trial carcasses were placed randomly (random distance and direction from a turbine) within search areas. Carcasses were discreetly marked (e.g., beak or foot of carcass was marked with a small amount of nail polish) for recognition by technicians and other personnel, and then

dropped from waist height or higher and allowed to land in a random posture within the search area.

CPT carcasses were monitored over a 30-day period according to the following schedule: every day for the first four days, then on days 7, 10, 14, 20, and 30. The condition of carcasses was recorded each time the CPT carcasses were checked. The schedule varied slightly depending on weather and coordination with other survey work. Following the 30-day period, any remaining evidence of carcasses was removed.

Quality Assurance and Quality Control

Quality assurance and quality control (QA/QC) measures were implemented at all stages of the study, including in the field, during data entry and analysis, and report writing. All WEST field staff were trained in proper survey techniques, and all data collected were recorded on a tablet data form. Following field surveys, technicians were responsible for inspecting data forms for completeness, accuracy, and legibility. If errors or anomalies were found, follow-up measures were implemented including discussions and review of field data with technicians and/or project managers.

WEST field staff were trained on proper tablet data entry procedures. System controls were implemented to ensure correct data were entered; however, if any errors, omissions, or problems were identified in later stages of analysis, they were traced back to the raw data where appropriate changes and measures were implemented. Data were incorporated into a Microsoft® SQL Server database and underwent QA/QC procedures throughout the course of the study. Statisticians provided an additional level of QA/QC to ensure proper protocols were followed and data collected were congruent with the objectives of the study.

WEST's reporting and review process included project management review, technical editing and content review, senior technical review, and a final review by the project manager before delivery to the client.

Statistical Analysis

Fatality Rate Estimation

Carcasses included in fatality rate estimation were found within the search areas and had an estimated time of death within the study period. Fatality estimates were calculated for all categories (all birds, large birds, raptors, small birds, and bats) by season and for the study period using GenEst (a generalized estimator of fatality; Dalthorp et al. 2018, Simonis et al. 2018). Due to the change in search area types due to vegetation height, the period from September 14 – November 27 was defined as "early fall" and November 28 – December 15 was defined as "late fall". Fatality estimates were calculated for each season (and for both parts of the fall season).

To obtain an overall estimate of fatality, each carcass included in the analysis was adjusted for SEEF, CP, a detection reduction factor (also referred to as "*k*"; GenEst only; see below), and a search area adjustment. Estimates and confidence intervals (CIs) were calculated using a

parametric bootstrap (Dalthorp et al. 2018) for GenEst, if five or more fatalities were detected. CIs were not calculated when the observed number of carcasses in a class was less than five because CIs from Horvitz-Thompson estimators can be unreliable when carcass counts are low (Korner-Nievergelt et al. 2011).

Searcher Efficiency Estimation

Data collected during SEEF trials were used to estimate the probability technicians detected bird and bat carcasses. Estimates of SEEF were used to adjust carcass counts for detection bias. SEEF estimated the probability of a searcher detecting a carcass given the carcass was available to be found. Estimates were obtained for each size class separately using a logit regression model (Dalthorp et al. 2018). Season and search area type were used as potential explanatory variables (covariates) for the logit regression models. Model selection was completed using an information theoretic approach known as AICc, or corrected Akaike Information Criterion (Burnham and Anderson 2002); models with lower AICc values are considered to have a better fit. The most parsimonious model (the model with the fewest variables) within two AICc units of the model with the lowest AICc value was selected as the best model.

Carcass Persistence Estimation

Data collected during CPT were used to estimate the amount of time, in days, that carcasses remained available to be located by the searcher. Estimates of CP were used to adjust carcass counts for removal bias. The CP adjustment estimated the average probability a carcass persisted through the search interval (i.e., the time between scheduled searches). The persistence of a carcass was modeled using an interval-censored survival regression for each size class using exponential, log-logistic, lognormal, and Weibull distributions (Kalbfleisch and Prentice 2002, Dalthorp et al. 2018). Models with and without season as a covariate were included in the modeling process to examine whether including season as a covariate improved model fit. Covariates were fit to each of the parameters of the distributions. The most parsimonious model within two AICc units of the model with the lowest AICc value was selected as the best model.

Detection Reduction Factor

The change in SEEF between successive searches was defined by a parameter called the detection reduction factor (*k*) that ranged from zero to one. When *k* is zero, it implies that a carcass missed on the first search would never be found on subsequent searches. A *k* of one implies SEEF remained constant no matter how many times a carcass is missed (i.e., a carcass missed on the first search would have an equal chance of being found on a subsequent search as any other newly available carcass). The detection reduction factor was a required parameter for GenEst; however, data were not collected to estimate *k*. A value for *k* of 0.67 has been found to be a reliable estimate for bats (Huso et al. 2017), and this value was assumed in this study for birds and bats.

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. For example, an area adjustment of 0.75 meant that an estimated 75% of carcasses fell within the search area. Areas could be

unsearchable due to survey obstacles such as ground cover (e.g., tall crops) or terrain, or there could be areas where carcasses fell outside the search area (e.g., a carcass landed 70 m [230 ft] away from the turbine on a square plot searched out to 60 m from the turbine base). 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. Separate area adjustments were estimated for large birds, small birds, raptors, and bats.

A number of analysis methods exist to calculate the search area adjustment. The number of carcasses found during surveys determined the method used. In general, at least 30 carcasses are required to use the truncated weighted maximum likelihood modeling approach (TWL; Khokan et al. 2013). For this study, there were an insufficient number of large, small bird, and bat carcasses included in analysis to use the TWL, so an area adjustment using a physics-based model (Hull and Muir 2013) was used. The relative carcass-density distribution for a given turbine height and rotor diameter was assumed to decrease linearly from the turbine base out to the maximum predicted fall distance (Huso and Dalthorp 2014). To calculate the search area adjustment for raptors, the carcass-density distribution from Hallingstad et al. 2018 was used.

RESULTS

The number, species, location, and other characteristics of bird and bat carcasses that were found during the study and were included in analysis for fatality estimates are discussed below. A full list of species (including common and scientific names) found during the study period is presented in Appendix B, all carcasses found are presented in Appendix C, SEEF model selection is presented in Appendix D, CP data are presented in Appendix E, search area adjustment models are presented in Appendix F, and fatality estimates by season and plot type are presented in Appendix G.

Standardized Carcass Searches

In total, 474 carcass searches were conducted from March 17 – December 15, 2021 at 27 turbines in the Project. At square plots, 239 searches were conducted (during spring, summer, and early and late fall) and at road and pad plots, 235 carcass searches were conducted (only during summer and early fall). Searches were missed on occasion due to site access issues that created unsafe working conditions (e.g., turbine maintenance, turbine blade icing, or impassable roads). The average search interval was 14.8 days at both search area types across the study period.

During the study, 16 bird carcasses and seven bat carcasses were found (Table 2). Of these, seven bird carcasses and four bat carcasses were found outside of search areas, and one bird carcass was found outside of the study period; these twelve carcasses were excluded from the fatality estimate analyses. Eight bird carcasses and three bat carcasses were included in analysis.

Table 2. Number and percent (%) of carcasses by species included and excluded from analyses using GenEst at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021.

	Included in Analysis		Outside Search Area[1]		Outside Study Period[1]		Total	
Type/Species	**Total**	**%**	**Total**	**%**	**Total**	**%**	**Total**	**%**
Birds								
American white pelican	0	0	4	57.1	0	0	4	25.0
mallard	3	37.5	0	0	0	0	3	18.8
red-tailed hawk	2	25.0	1	14.3	0	0	3	18.8
black-billed cuckoo	1	12.5	0	0	0	0	1	6.3
common redpoll	1	12.5	0	0	0	0	1	6.3
northern shoveler	1	12.5	0	0	0	0	1	6.3
turkey vulture	0	0	1	14.3	0	0	1	6.3
western meadowlark	0	0	1	14.3	0	0	1	6.3
European starling	0	0	0	0	1	100	1	6.3
Overall Birds	**8**	**100**	**7**	**100**	**1**	**100**	**16**	**100**
Bats								
big brown bat	1	33.3	1	25.0	0	0	2	28.6
hoary bat	0	0	2	50.0	0	0	2	28.6
eastern red bat	1	33.3	0	0	0	0	1	14.3
silver-haired bat	1	33.3	0	0	0	0	1	14.3
unidentified non-myotis	0	0	1	25.0	0	0	1	14.3
Overall Bats	**3**	**100**	**4**	**100**	**0**	**0**	**7**	**100**

[1.] Carcasses not included in analysis.

Sensitive Species

No federally or state-listed threatened or endangered species were found as fatalities. American white pelican and silver-haired bat, both SGCN, were the only sensitive species found during the study (Table 2, Appendix B).

Four American white pelicans were found incidentally at non-search turbines (54, 56, 66, and 69; Appendix B). These fatalities were generally found in the northern portion of the Project, from mid-May through the end of October.

One silver-haired bat fatality was found on August 31, 2021 during a search at a road and pad plot (Turbines 12).

Bird Carcasses

Nine bird species were identified as fatalities during the study, and eight carcasses were included in the analysis (Table 2, Appendix B). Among bird species found as fatalities, American white pelican was the most common (four carcasses, 25.0% of total bird carcasses), followed by mallard and red-tailed hawk (three each, 18.8%; Table 2). One fatality of each of the six remaining identifiable bird species was found (Table 2). Red-tailed hawk was the only raptor species found as a fatality.

Bird carcasses included in analysis were located at 22.2% of searched turbines and were generally found throughout the Project (Figure 5). The highest number of bird carcasses were found at turbines 14 and 79 (two carcasses each) in the southern and northern portions of the Project, respectively. The remaining four turbines where bird carcasses included in analysis were found each had one carcass (Appendix C).

All bird carcasses included in analysis were found at square plots (Appendix C). The first bird carcass included in the analysis was found during the April 27 – May 5 visit (Figure 6). The most bird carcasses were found during spring, specifically during the June 7 – 10 visit (Figure 6). No bird carcasses included in analysis were found during summer or fall, until the final visit of the study period on December 7 – 15 (Figure 6; Appendix C).

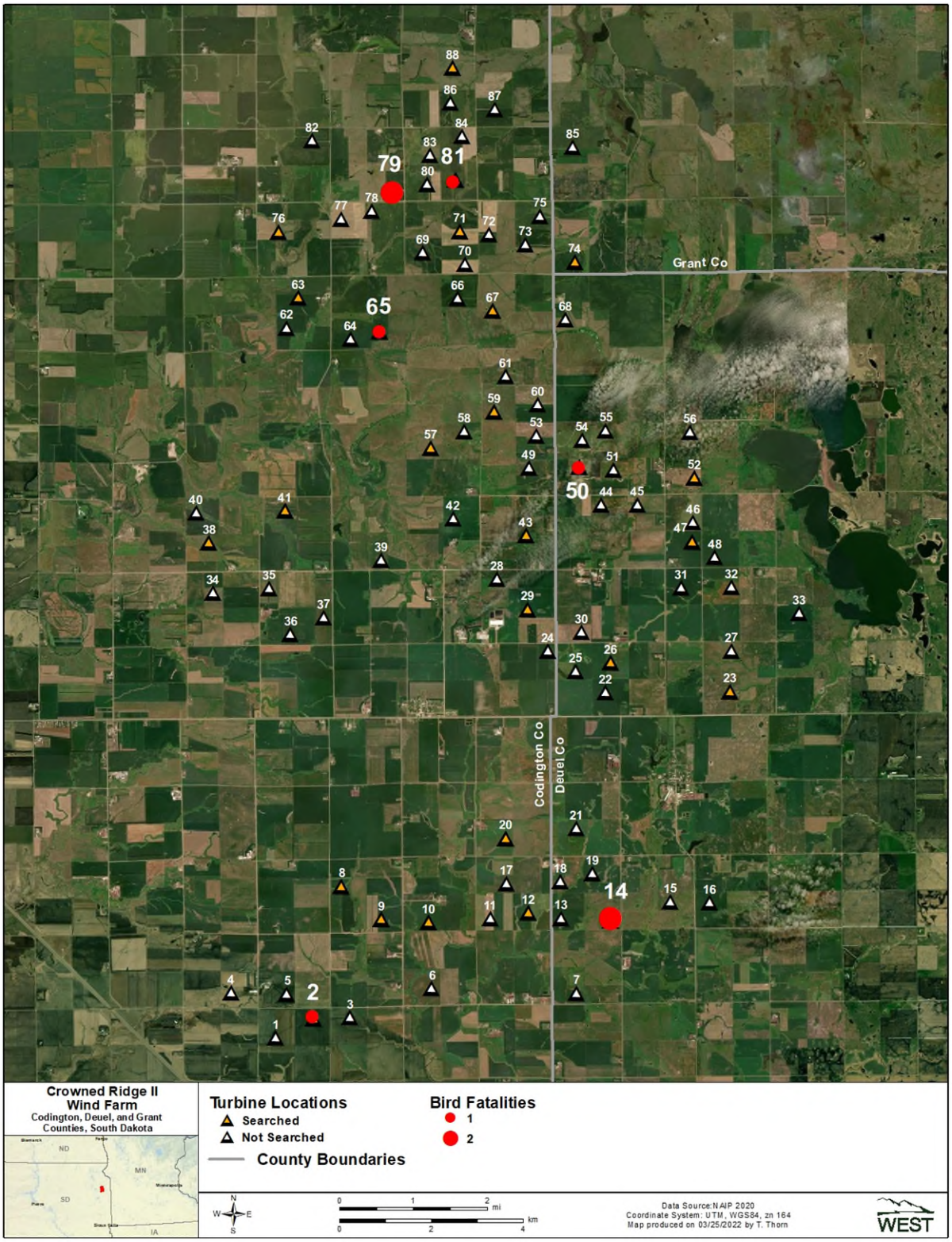

Figure 5. Location of all bird carcasses included in GenEst analysis found at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021.

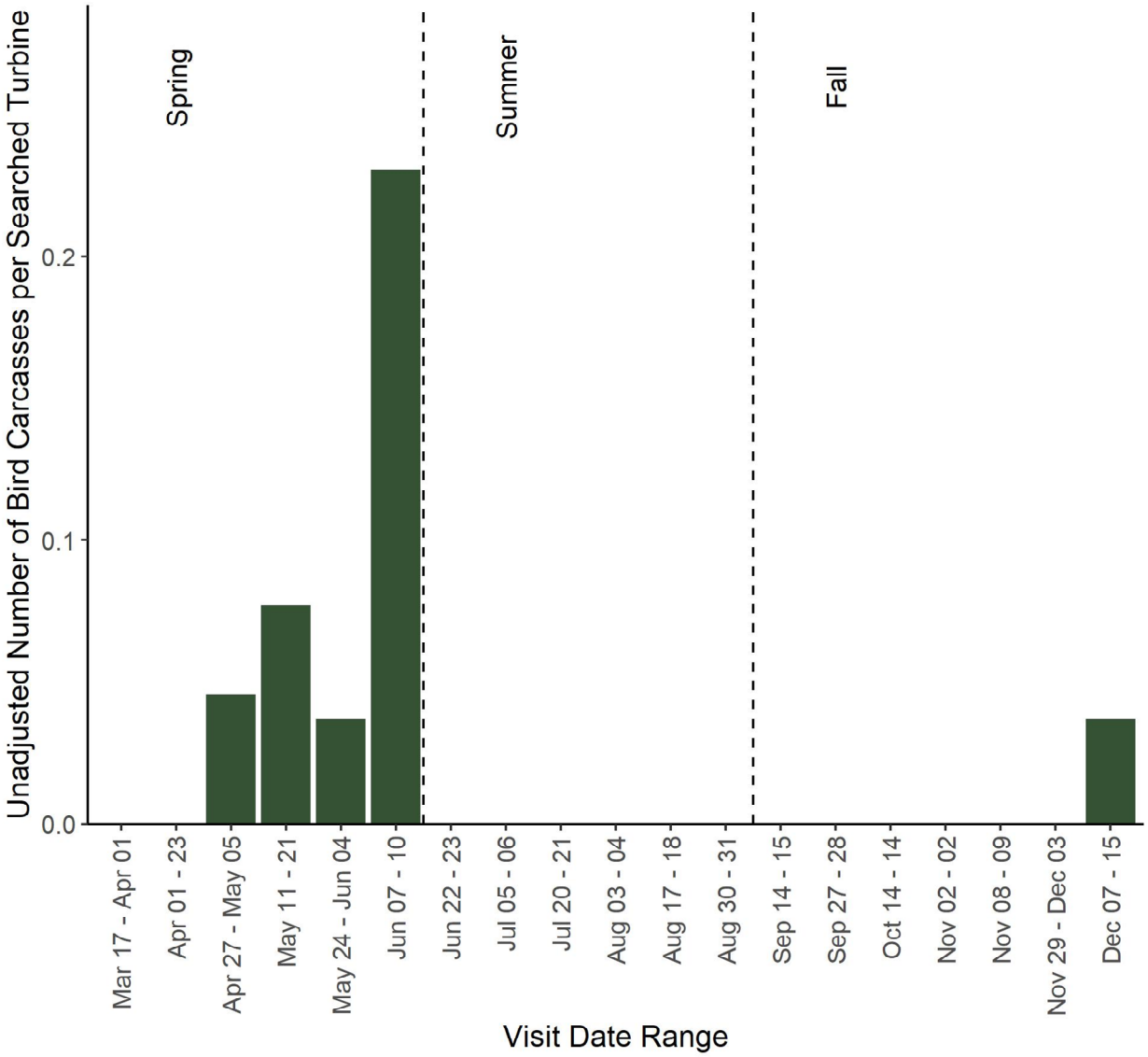

Figure 6. Temporal distribution of bird carcasses per turbine searched included in GenEst analysis at square plots (unadjusted for searcher efficiency and carcass persistence) at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021.

Bat Carcasses

Four identifiable bat species were found as fatalities during the study, and three carcasses were included in analysis (Table 2, Appendix B). Among identifiable bat species found as fatalities, big brown bat and hoary bat were the most common (two carcasses each, 28.6% of overall bat carcasses each); one carcass each of eastern red bat and silver-haired bat were found (14.3% each; Table 2).

Bat carcasses included in analysis were found at 11.1% of searched turbines (Figure 7). One bat carcass each was found at turbines 12, 23, and 43 in the south, east, and central portions of the Project, respectively (Figure 7; Appendix C).

The only bat carcass found in a square plot and included in analysis was found during the May 11 – 21 visit (Figure 8a). One bat carcass was found during the August 17 – 18 visit and another bat carcass was found during the August 30 – 31 visit, both found within road and pad plots (Figure 8b).

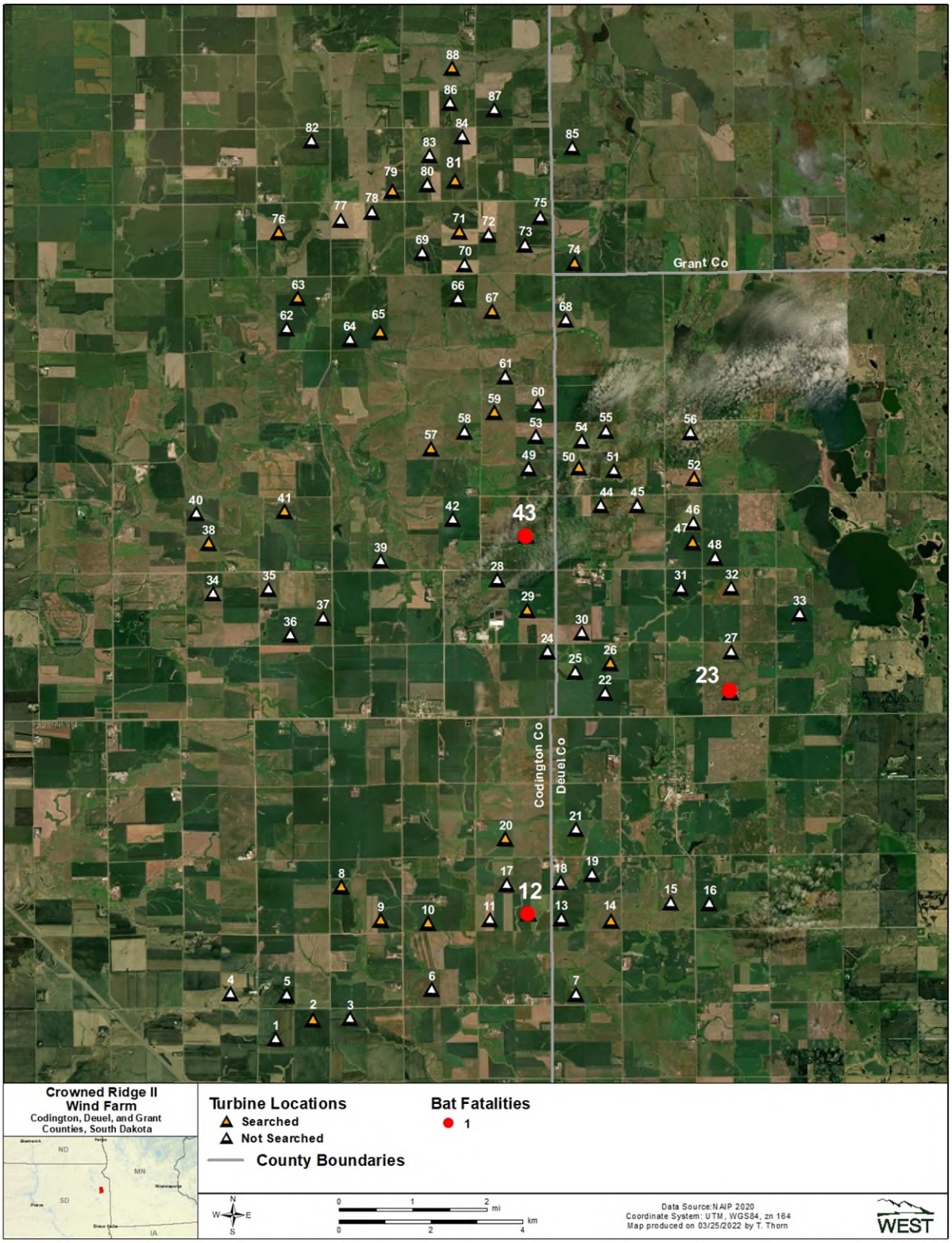

Figure 7. Location of all bat carcasses included in GenEst analysis found at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021.

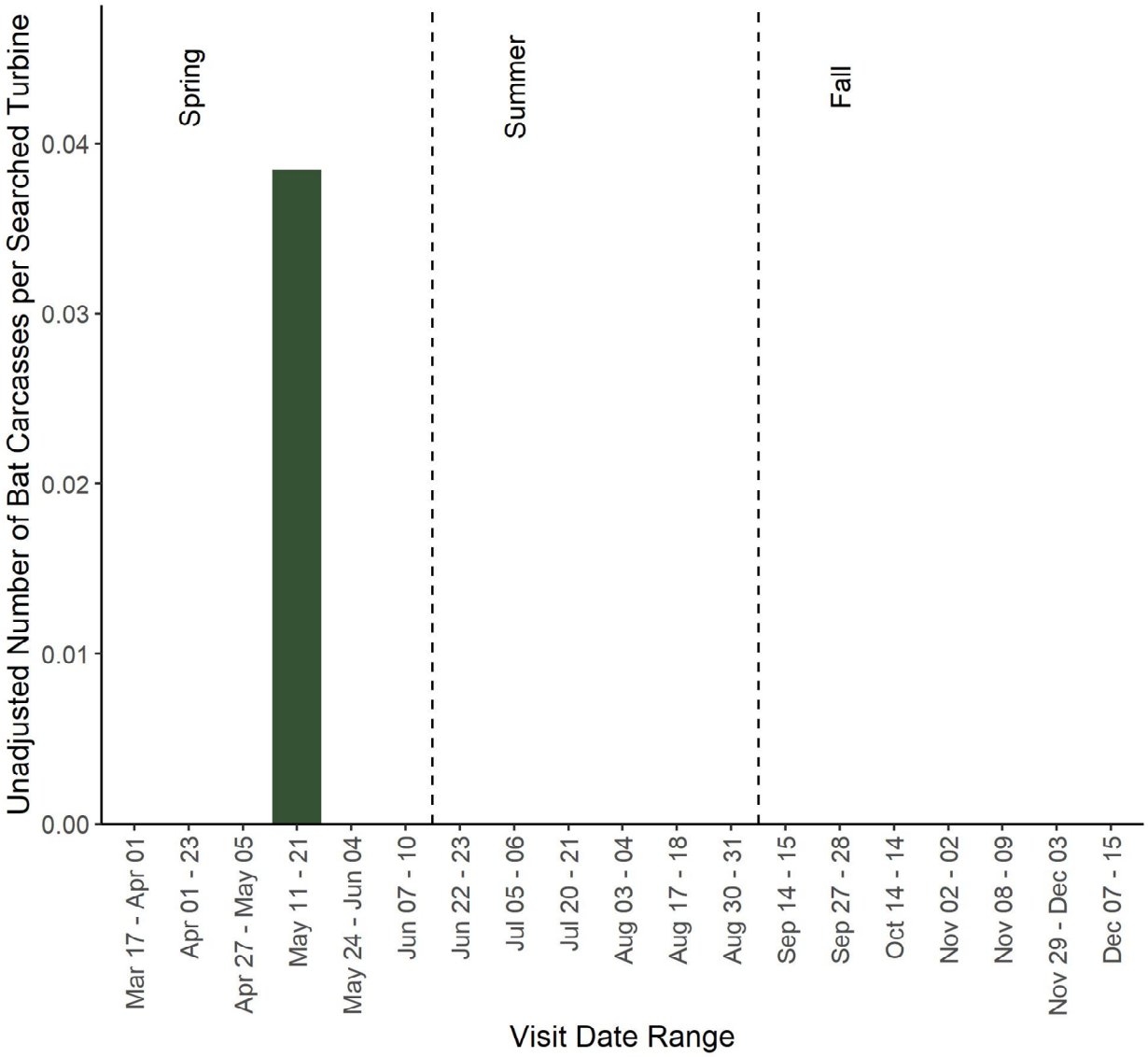

Figure 8a. Temporal distribution of bat carcasses per turbine searched included in GenEst analysis at square plots (unadjusted for searcher efficiency and carcass persistence) at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021.

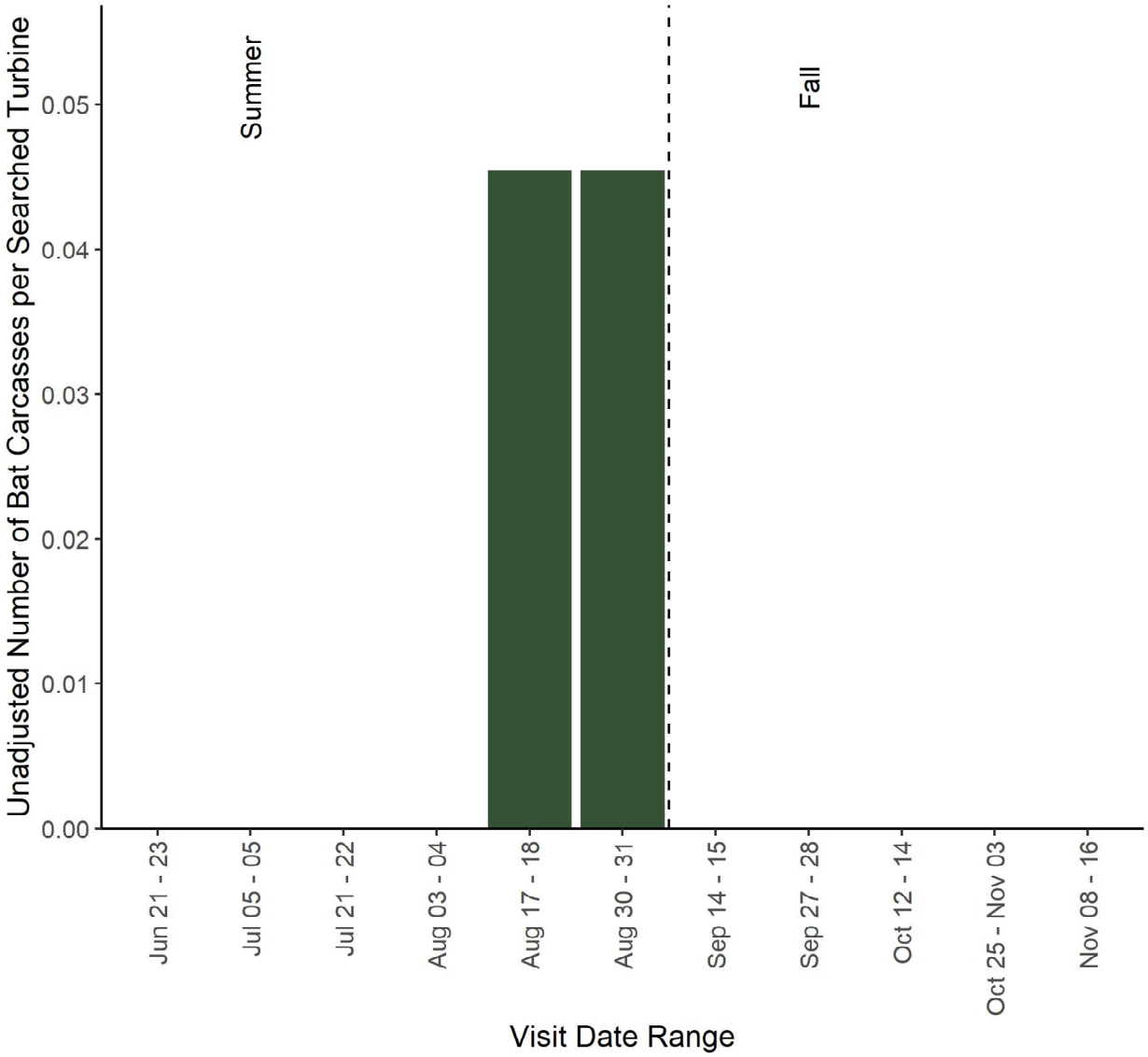

Figure 8b. Temporal distribution of bat carcasses per turbine searched included in GenEst analysis at road and pad plots (unadjusted for searcher efficiency and carcass persistence) at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021.

Searcher Efficiency Trials

One hundred and eleven carcasses (38 large birds, 38 small birds, and 35 mice [as bat surrogates]) were placed for SEEF trials in square plots, and each of the 111 carcasses remained available for the technician to find during scheduled searches (Table 3a). The technician found 79.0% of large bird carcasses, 44.7% of small bird carcasses, and 45.7% of mice carcasses.

At road and pad plots, 67 carcasses (21 large birds, 24 small birds, and 22 mice) were placed for SEEF trials, and 65 carcasses (21 large birds, 23 small birds, and 21 mice) remained available

for the technician to find during scheduled searches (Table 3b). The technician found 95.2% of large bird carcasses, 73.9% of small bird carcasses, and 81.0% of mice carcasses.

Table 3a. Square plot searcher efficiency results by size class and season at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021.

Size Class	Season[1]	# Placed	# Available	# Found	% Found
Large Bird	Spring	15	15	14	93.3
	Summer	11	11	6	54.6
	Fall	12	12	10	83.3
	Overall	**38**	**38**	**30**	**79.0**
Small Bird	Spring	15	15	9	60.0
	Summer	11	11	2	18.2
	Fall	12	12	6	50.0
	Overall	**38**	**38**	**17**	**44.7**
Bat	Spring	13	13	7	53.9
	Summer	10	10	4	40.0
	Fall	12	12	5	41.7
	Overall	**35**	**35**	**16**	**45.7**

[1.] Spring = March 16 – June 15; Summer = June 16 – September 13; Fall = September 14 – December 15.

Table 3b. Road and pad plot searcher efficiency results by size class and season at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021.

Size Class	Season[1]	# Placed	# Available	# Found	% Found
Large Bird	Summer	10	10	10	100
	Fall	11	11	10	90.9
	Overall	**21**	**21**	**20**	**95.2**
Small Bird	Summer	10	10	10	100
	Fall	14	13	7	53.9
	Overall	**24**	**23**	**17**	**73.9**
Bat	Summer	11	11	8	72.7
	Fall	11	10	9	90.0
	Overall	**22**	**21**	**17**	**81.0**

[1.] Summer = June 16 – September 13; Fall = September 14 – December 15.

Models were fit for each size class to determine whether season or search area type covariates provided the best model for estimating SEEF rates based on corrected AICc values. An intercept-only model provided the best fit for modeling large bird SEEF (Appendix D1). Large bird SEEF rates were assumed for raptors. For bats and small birds, a model using a search area type covariate provided the best fit for modeling SEEF (Appendix D2, D3).

Estimated annual SEEF rates in square plots and road and pad plots for large birds and raptors were 0.85 (90% CI: 0.75–0.91; Appendix G1). SEEF rates for small birds were 0.45 (90% CI: 0.32–0.58) in square plots and 0.74 (90% CI: 0.56–0.86) in road and pad plots. SEEF rates for bats were 0.46 (90% CI: 0.33–0.60) in square plots, and 0.81 (90% CI: 0.63–0.91) in road and pad plots (Appendix G).

Carcass Persistence

In total, 222 carcasses (74 carcasses each of large bird, small bird, and bat) were placed for CPT in search areas throughout the duration of the study (Appendix E). An intercept-only model provided the best fit for modeling large bird, raptor, small bird, and bat CP rates; large bird and bat CP rates were modeled using an exponential distribution and small birds were modeled using a lognormal distribution. The median removal time was 9.07 days for large birds, 5.14 days for small birds, and 4.58 days for bats (Appendix E). The average probability that a carcass persisted through the search interval (once every two weeks) was 0.60 (90% CI: 0.54–0.65) for large birds, 0.43 (90% CI: 0.37–0.48) for small birds, and 0.40 (90% CI: 0.34–0.46) for bats (Figure 9, Appendix G). The large bird CP rate was assumed for raptors.

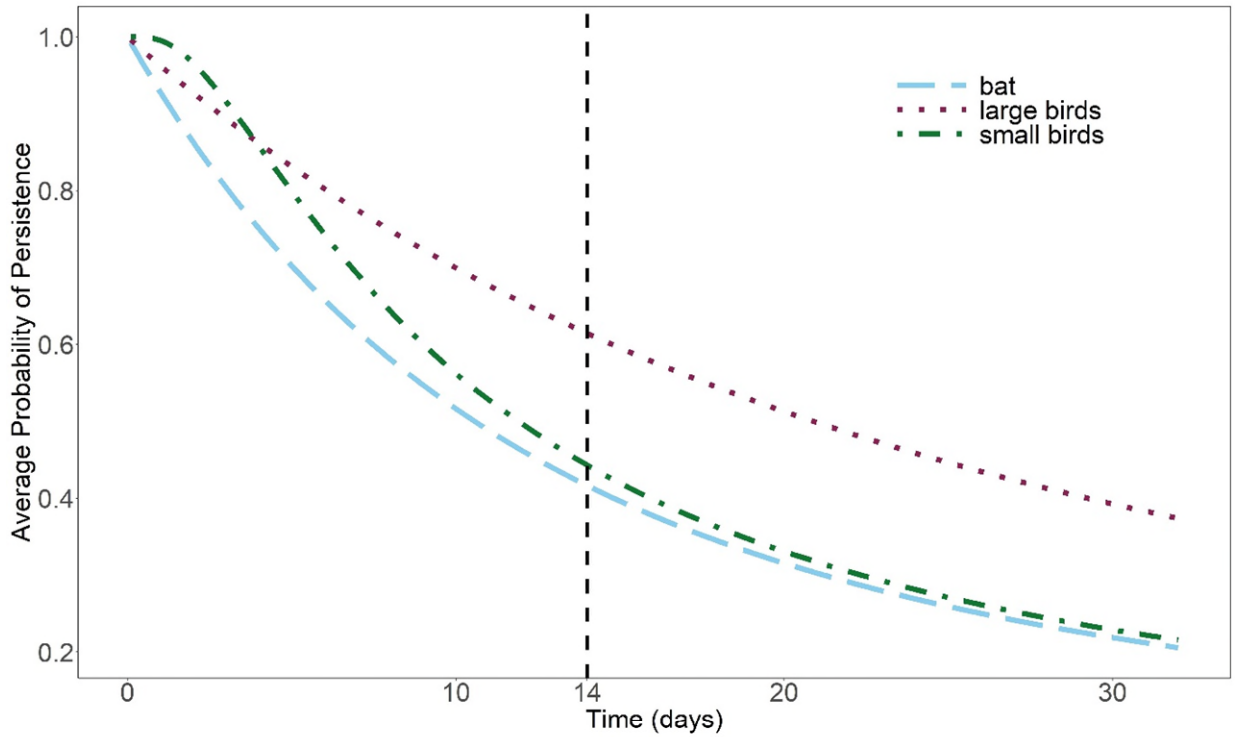

Figure 9. Carcass persistence by season for large bird, small bird, and bat carcasses placed at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota from March 17 – December 15, 2021. Carcass persistence modeled using GenEst. Carcass persistence trials were conducted for a 30 day period. The vertical black dashed line denotes the average search interval (once every two weeks) at square plots and road and pad plots.

Search Area Adjustment

The search area adjustment model for large birds, small birds, and bats was calculated using the Hull and Muir (2013) method (Appendix F). The large bird carcass-density distribution was estimated using the maximum fall distance of carcasses for a 90-m turbine tower height and a 116-m rotor diameter (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 estimated fall distance (Huso and Dalthorp 2014; Figure 10). The carcass-density distribution from Hallingstad

et al. (2018) was used to calculate the search area adjustment for raptors (Appendix F); the majority of the raptor carcass density distribution was included in square plots, whereas a relatively small proportion was included in road and pad plots (Figure 11).

The search area adjustment for square plots was 0.73 (90% CI: 0.73–0.73) for large birds, 0.78 (90% CI: 0.78–0.78) for raptors, 0.90 (90% CI: 0.90–0.90) for small birds, and 0.96 (90% CI: 0.96–96) for bats (Appendix G1). The search area adjustment for road and pad plots was 0.09 (90% CI: 0.09–0.09) for large birds, 0.02 (90% CI: 0.02–0.02) for raptors, 0.12 (90% CI: 0.12–0.12) for small birds, and 0.14 (90% CI: 0.14–0.14) for bats (Appendix G2).

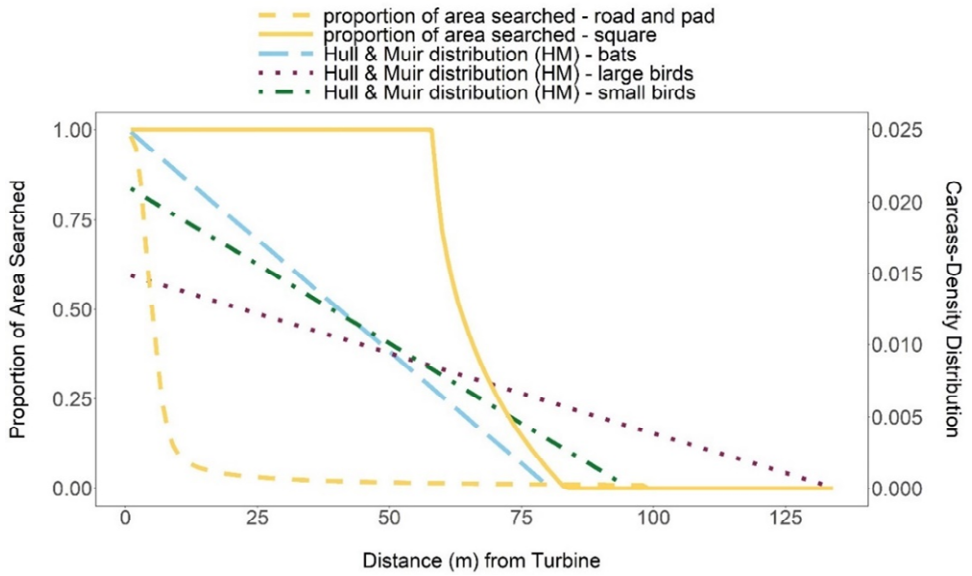

Figure 10. Estimated large bird, small bird, and bat carcass-density distributions, and proportion of area searched by distance from turbine for road and pad plots and square plots at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021. Modeled using GenEst.

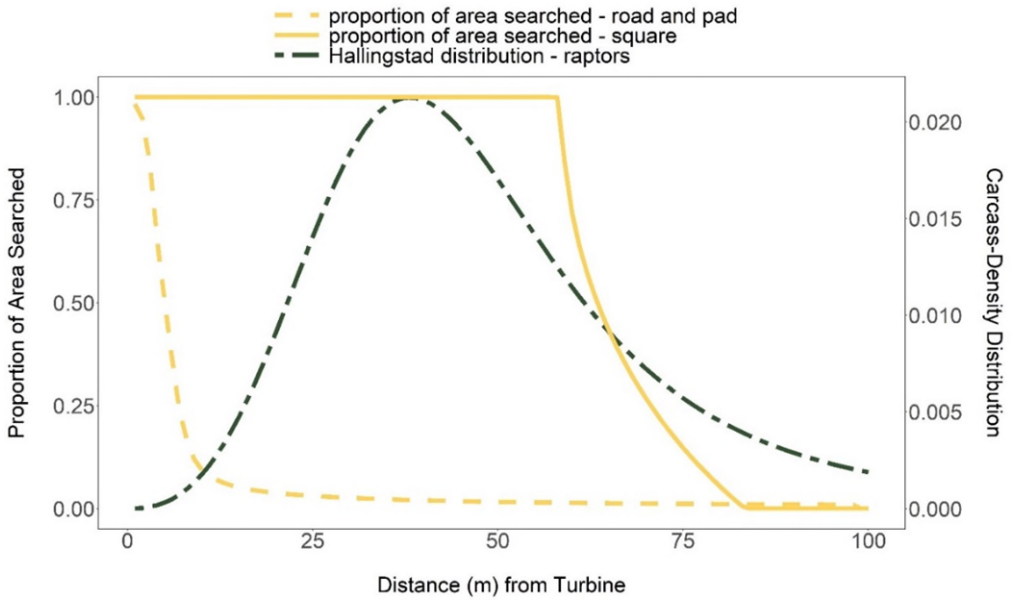

Figure 11. Estimated raptor carcass-density distribution, and proportion of area searched by distance from turbine for road and pad plots and square plots at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021.

Estimated Fatality Rates

Estimated fatality rates and 90% CI were calculated on a per MW and per turbine basis for all birds, large birds, large bird non-raptors, raptors, small birds, and bats using GenEst (Table 4) and by season (Appendix G). Estimated fatality rates calculated using GenEst are presented in text below, and associated CI are presented for all size classes with greater than five carcasses (Korner-Nievergelt et al. 2011). The average probability a carcass remained in the search area and was found by technicians is listed in Appendix G.

Table 4. GenEst estimated overall fatality rates per megawatt and per turbine for the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021.

	Fatalities Per Megawatt Per Study Period		Fatalities Per Turbine Per Study Period	
Size Class	**Estimate**	**90% CI[1]**	**Estimate**	**90% CI[1]**
All Bird	0.41	0.21 - 0.68	0.92	0.48 - 1.53
Large Bird	0.33	0.17 - 0.54	0.75	0.39 - 1.22
Large Bird Non-Raptor	0.24	0.10 - 0.43	0.56	0.24 - 1.00
Raptor	0.09	n/a	0.19	n/a
Small Bird	0.07	n/a	0.17	n/a
Bat	0.74	0.15 - 1.79	1.71	0.35 - 4.12

[1.]Confidence interval (CI) not calculated because the observed carcass count was less than five.

All Birds

The overall estimated bird fatality rate was 0.41 bird fatalities/MW/study period (0.92 bird fatalities/turbine/study period), driven primarily by the large bird non-raptor estimated fatality rate (0.24 fatalities/MW/study period [0.56 fatalities/turbine/study period]; Table 4).

As no bird fatalities included in analysis were documented during summer or early fall, estimated bird fatality rates were only calculated for spring (0.33 bird fatalities/MW [0.75 bird fatalities/turbine]) and late fall (0.07 bird fatalities/MW [0.17 bird fatalities/turbine]); Appendix G5).

Raptors

The overall estimated raptor fatality rate was 0.09 raptor fatalities/MW/study period (0.19 raptor fatalities/turbine/study period), estimated from two raptor fatalities (red-tailed hawks; Table 4); a CI was not estimated because there were too few observations.

Bats

The overall estimated bat fatality rate was 0.74 bat fatalities/MW/study period (1.71 bat fatalities/turbine/study period; Table 4). Estimated bat fatality rates were only calculated during spring (0.17 bat fatalities/MW [0.39 bat fatalities/turbine]) and summer (0.58 bat fatalities/MW [1.34 bat fatalities/turbine]; Appendix G5). No bat fatalities were included in analysis that were found during early or late fall, so a bat fatality estimate was not calculated for those seasons.

DISCUSSION

The overall goal for this study was to estimate the number of bird and bat fatalities within the Project attributable to collisions with turbines. The primary objectives of PCM were to 1) document species occurring as fatalities, 2) estimate bird and bat fatality rates for the study period, 3) qualitatively evaluate spatial and temporal patterns of bird and bat fatalities, 4) qualitatively compare data from PCM studies conducted at other wind energy facilities in South Dakota and neighboring states, and 5) document fatalities of sensitive species as a result of collisions with turbines at the Project.

Birds

Species Composition

Nine bird species were identified as fatalities during the study. Among the bird species documented during PCM, American white pelican was the most abundant (four fatalities, 25.0% of overall bird fatalities), followed by mallard and red-tailed hawk (three each, 18.8% each). Compared to other species found as fatalities at wind energy facilities in the Midwest, mallard, and red-tailed hawk are relatively common (WEST 2021).

No federally or state-listed threatened or endangered bird species were observed during surveys. American white pelican, a SGCN, was the only sensitive bird species documented as a fatality at the Project. American white pelicans have been documented as fatalities at other wind energy facilities in the region. A review of 47 recent (2010 – 2021) publicly available PCM studies at wind

energy facilities throughout Minnesota, North Dakota, and South Dakota found that of the 45 total American white pelican fatalities for these studies, six were found in eastern South Dakota (includes the four found at this Project; Derby et al. 2010, 2012) and 39 were found in western Minnesota (Heist 2022; Pickle et al. 2018, 2019, 2020; Stantec Consulting Services 2022; Stucker et al. 2021a, 2021b, 2022a, 2022b; Voth et al. 2022; WEST 2020; Westwood 2015).

American white pelicans primarily breed along the shorelines of inland lakes, often on islands, and can fly up to 100 km (62 mi) to forage in emergent wetlands, rivers, and marshlands (Knopf and Evans 2020). American white pelicans are relatively common in the region during the summer breeding season (eBird 2022). In South Dakota, there are two known main breeding colonies of American white pelicans: Bitter Lake and LaCreek National Wildlife Refuge (SDFP 2021). Bitter Lake, approximately 40 km (25 mi) northwest of the Project, is the closest large colony to the Project, with approximately 22,000 pelicans (Drilling 2013). While pelicans in the Dakotas are known to spend up to three days away from the colony during the incubation period, not all breeding-aged individuals nest every year (Sovada et al 2013), thereby increasing the distribution of pelicans across the region during and after nesting. The four American white pelican fatalities at the Project were found across seasons (discussed in *Spatial and Temporal Patterns*, below). The relatively high abundance of American white pelicans in the region throughout the breeding season increases the chance of a wind turbine collision compared to a species that is not as abundant during the breeding season.

Spatial and Temporal Patterns

Bird fatalities included in analysis were found throughout the Project with no apparent spatial pattern. The most bird fatalities were found at turbines 14 and 79 (two bird fatalities each) in the southern and northern portions of the Project, respectively. Although each of the four American white pelican fatalities were found at non-search turbines and excluded from analysis, they were found at turbines in the northern portion of the Project (turbines 54, 56, 66, and 69).

The estimated overall bird fatality rate, highest during spring, was only documented during spring and late fall. Although bird fatalities excluded from analysis were found during summer, considering only those included in analysis suggests that bird species found as fatalities are at greatest risk of colliding with turbines during spring migration, and risk of colliding with turbines during the summer breeding season and fall migration period is relatively low.

Comparison Data from other Post-construction Fatality Monitoring Studies

WEST provides comparison figures (see below) to provide context for understanding the estimated bird fatality rates for this Project with other recent PCM projects at wind energy facilities in South Dakota, North Dakota, and Minnesota.

The estimated overall bird fatality rate of 0.41 bird fatalities/MW/study period (90% CI: 0.21–0.68) is lower than fatality rates seen at other facilities in neighboring states with recently conducted PCM studies and publicly available data (Figure 12). Among other PCM studies in neighboring states, fatality rate estimates range from 0.51 (Oak Glen, Minnesota [Chodachek et al. 2014]) to 12.18 (Blazing Star, Minnesota [Stucker et al. 2021b]). The references for the comparison projects

shown in the Figures 12, 13, and 14, and referenced in the following text can be found in Appendix H.

The estimated raptor fatality rate of 0.09 raptor fatalities/MW/study period is within the range of raptor fatality rates seen at other facilities in neighboring states with recently conducted PCM studies and publicly available data (Figure 13). The raptor fatality rate at the Project is entirely attributed to two red-tailed hawk fatalities found during spring.

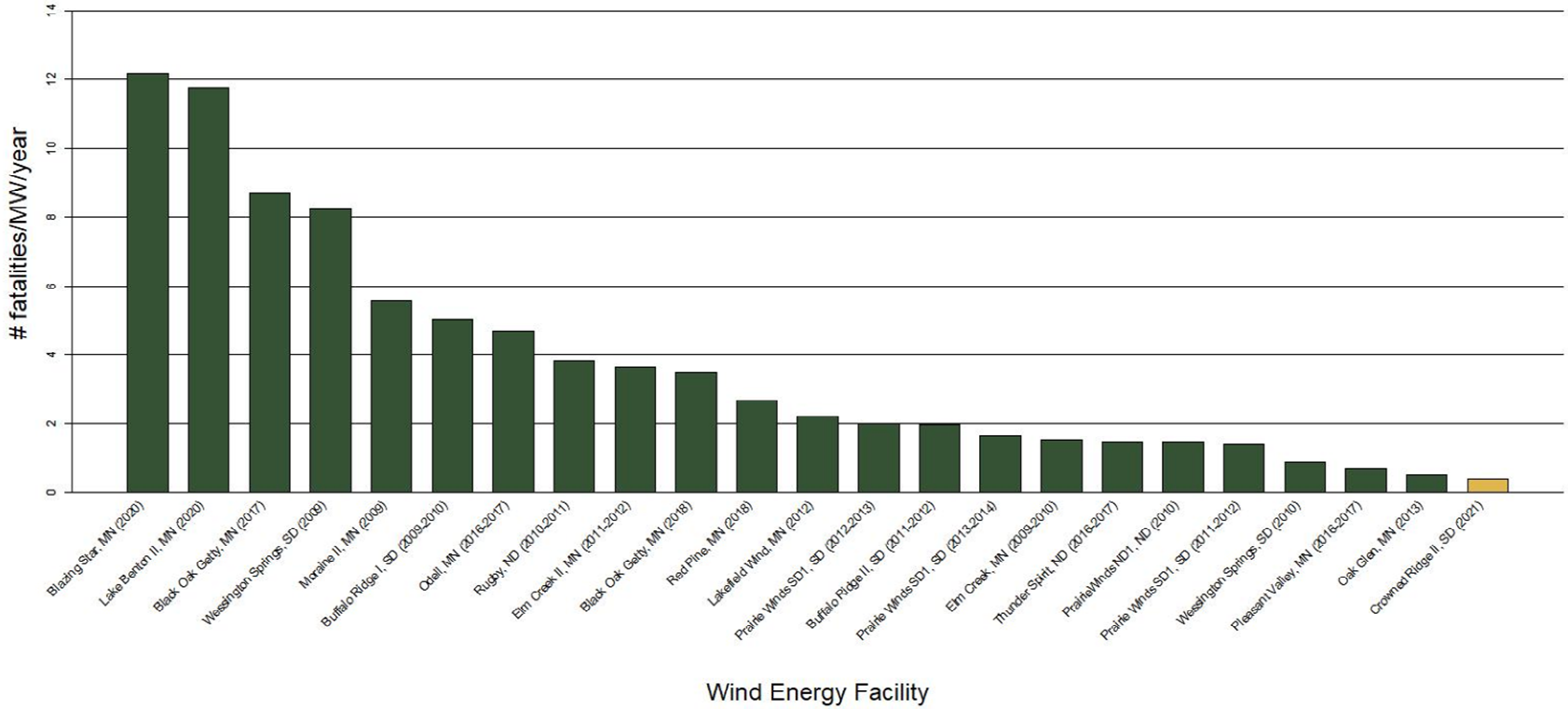

Figure 12. Estimated fatality rates for all birds (number of birds per megawatt [MW] per year) from recently conducted post-construction fatality monitoring studies at wind energy facilities in South Dakota, North Dakota, and Minnesota with publicly available data.

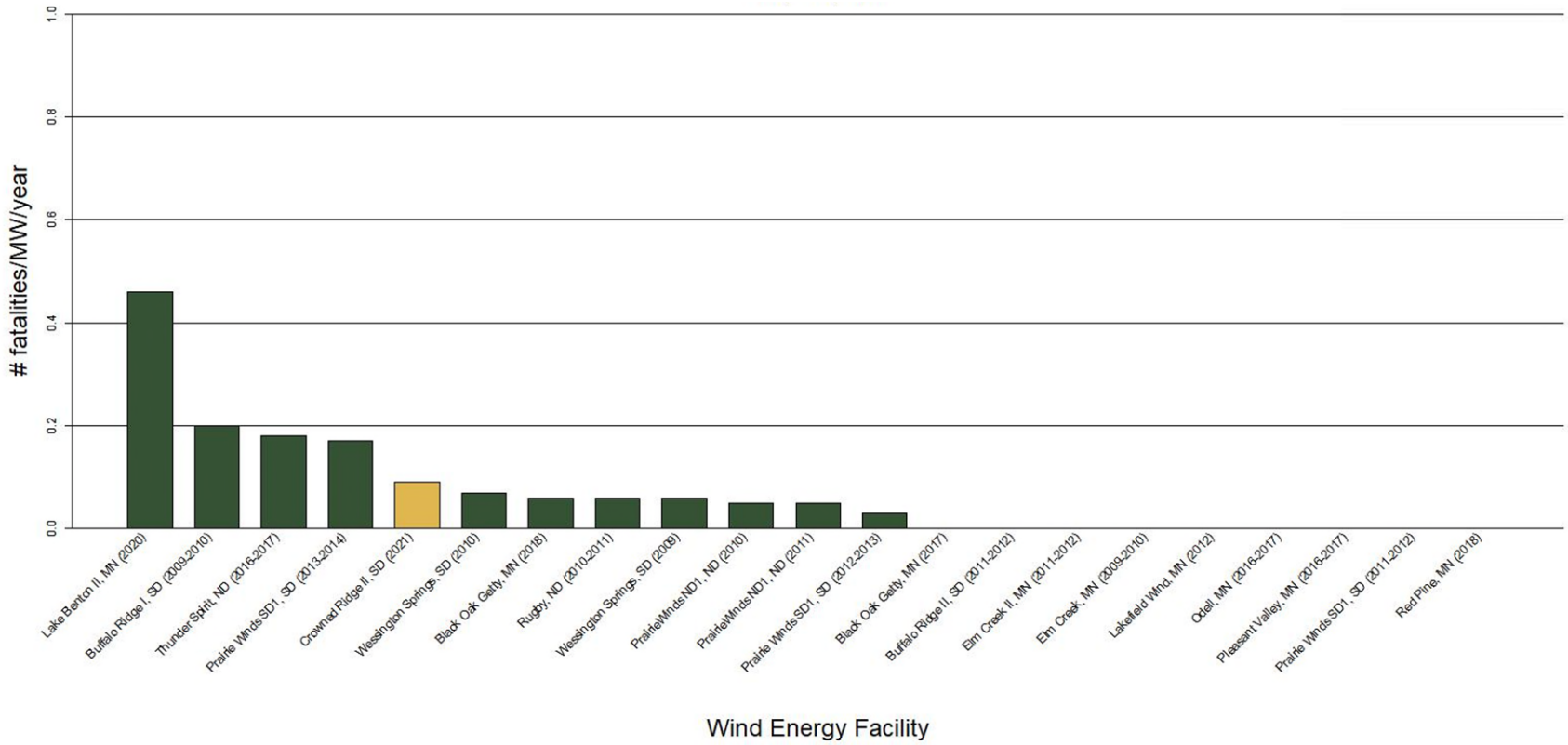

Figure 13. Estimated fatality rates for diurnal raptors (number of diurnal raptors per megawatt [MW] per year) from recently conducted post-construction fatality monitoring studies at wind energy facilities in South Dakota, North Dakota, and Minnesota with publicly available data.

Bats

Species Composition

Four identifiable bat species were found as fatalities during the study. Among the bat species documented during PCM, big brown bat and hoary bat were most common (two fatalities each [28.6% of overall each]). Among other wind energy facilities in the area (facilities in Iowa, Minnesota, North Dakota, South Dakota, and Wisconsin), hoary bat and big brown bat are the first and fourth most common bat species occurring as fatalities, respectively (WEST 2021).

No federally or state-listed threatened or endangered bat species were observed during surveys. Silver-haired bat (one fatality [14.3% of overall]) was the only sensitive bat species (designated as SGCN) found as a fatality. Although silver-haired bats have been a relatively common fatality at other wind energy facilities in nearby states, they are relatively uncommon to find as fatalities at other wind energy facilities in South Dakota (WEST 2021).

Spatial and Temporal Patterns

Three bat fatalities included in analysis were found at three turbines in the Project, with no apparent spatial pattern. Temporally, the estimated overall bat fatality rate was highest during summer (in August); as noted above, the three bats included in analysis were only documented in spring and summer. This suggests that bat species are at greatest risk of colliding with Project turbines during migration in late summer/early fall. This pattern of increased fatalities during late summer/early fall is not unique to this facility and has been documented consistently in the Midwest and elsewhere in the nation (American Wind Wildlife Institute 2020).

Comparison Data from other Post-construction Fatality Monitoring Studies

The estimated overall bat fatality rate of 0.74 bat fatalities/MW/study period (90% CI: 0.15–1.79) is lower than bat fatality rates at most other facilities in the area (facilities in South Dakota, North Dakota, and Minnesota) with recently conducted PCM studies and publicly available data (Figure 14). Fatality rates at the facilities shown in Figure 14 range from 0.41 (Wessington Springs, South Dakota [Derby et al. 2011]) to 37.59 (Black Oak Getty, Minnesota [Pickle et al. 2019]).

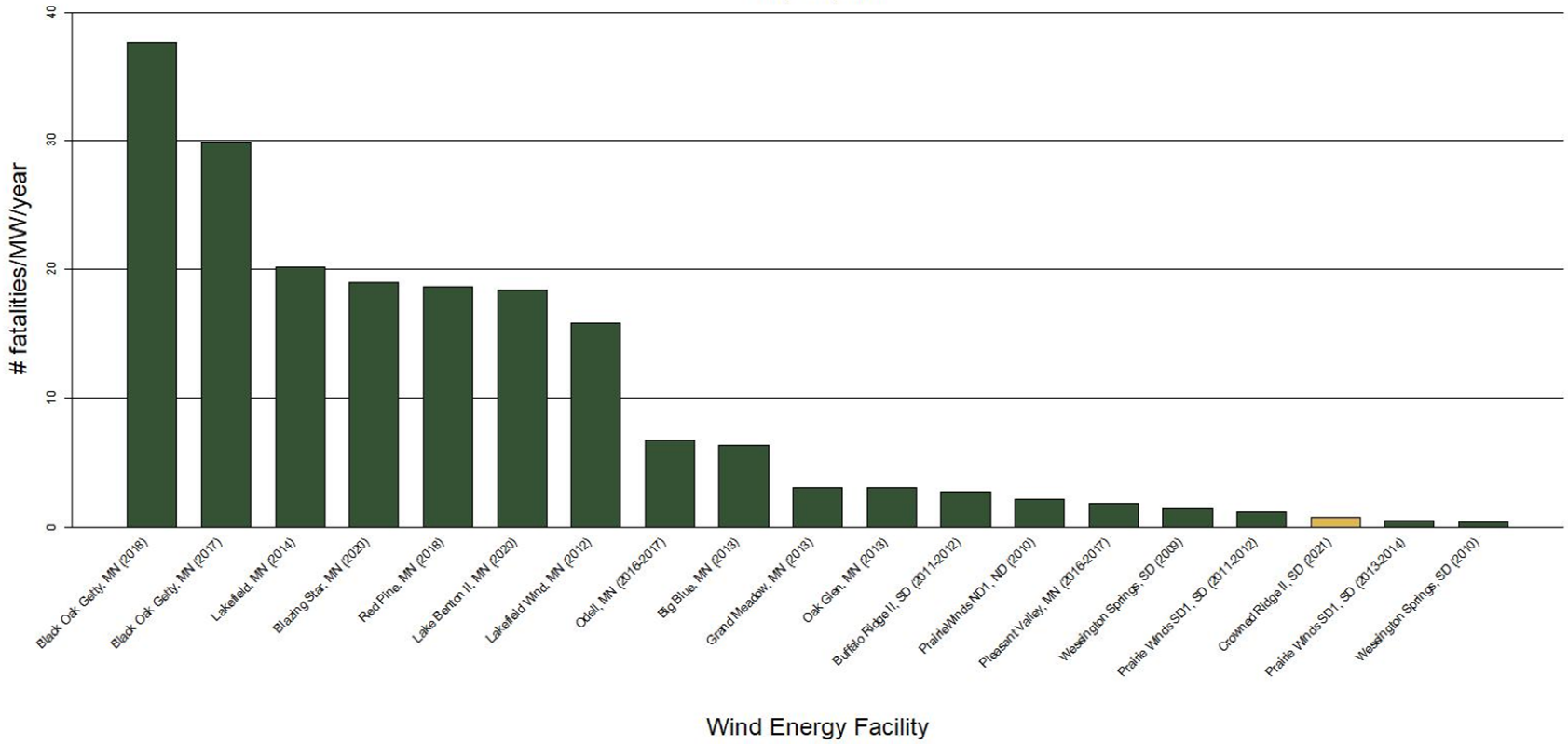

Figure 14. Estimated fatality rates for bats (number of bats per megawatt [MW] per year) from recently conducted post-construction fatality monitoring studies at wind energy facilities in South Dakota, North Dakota, and Minnesota with publicly available data.

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Appendix A. Overview of Study Design and Search Methods for Post-construction Fatality Monitoring at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel Counties, South Dakota, from March 17 – December 15, 2021

Appendix A. Overview of study design and search methods for post-construction fatality monitoring at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021.

Design component	Sampling Unit	Sampling Unit
Plot Type	Square Plot	Road and Pad Plot
Number of Plots (% all turbines)	27 (30%), 5 (6%)[1]	22 (25%)[1]
Size/Shape	120-m X 120-m square centered on turbine	60-m radius from turbine on gravel road and pad
Search Interval	Once every two weeks	Once every two weeks
Search Period	March 17 – December 15, 2021	June 21 – November 28, 2021
Searcher efficiency – season	spring, summer, fall	spring, summer, fall
Searcher efficiency – carcass sizes	bat (surrogate), small bird, large bird	bat (surrogate), small bird, large bird
Carcass persistence trials – seasons	spring, summer, fall	spring, summer, fall
Carcass persistence trials – carcass sizes	bat (surrogate), small bird, large bird	bat (surrogate), small bird, large bird
Turbine Specifications		
Turbine Model	GE 2.3 megawatt (MW; 79 turbines); GE 2.1 MW (nine turbines)	
Hub Height	90 m (GE 2.3 MW); 80 m (GE 2.1 MW)	
Rotor Diameter	116 m	
Blade serrations (Yes/No)	No	

[1.] Twenty-seven square plots were searched from the start of the study through June 20; 22 of the 27 square plots switched to road and pad plots from June 21 – November 28, while five remained as square plots; all 27 turbines were searched as square plots from November 29 – December 15.

m = meters; s = second; GE = General Electric; MW = megawatt

Appendix B. Common and Scientific Names of Species Found During Post-construction Fatality Monitoring at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel Counties, South Dakota, from March 17 – December 15, 2021

Appendix B. Species found during post-construction fatality monitoring at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021.

Common Name	Scientific Name
American white pelican[1]	*Pelecanus erythrorhynchos*
black-billed cuckoo	*Coccyzus erythropthalmus*
common redpoll	*Acanthis flammea*
European starling	*Sturnus vulgaris*
mallard	*Anas platyrhynchos*
northern shoveler	*Spatula clypeata*
red-tailed hawk	*Buteo jamaicensis*
turkey vulture	*Cathartes aura*
western meadowlark	*Sturnella neglecta*
big brown bat	*Eptesicus fuscus*
eastern red bat	*Lasiurus borealis*
hoary bat	*Lasiurus cinereus*
silver-haired bat[1]	*Lasionycteris noctivagans*

[1] Species of Greatest Conservation Need, as designated in the South Dakota Wildlife Action Plan (South Dakota Game, Fish and Parks 2014).

Appendix C. Complete Listing of Bird and Bat Carcasses Found During Post-construction Fatality Monitoring at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel Counties, South Dakota, from March 17 – December 15, 2021.

Appendix C. Complete listing of bird and bat carcasses found during post-construction fatality monitoring at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021.

Found Date	Common Name	Distance from Turbine	Search Location	Search Type	Plot Type	Physical Condition
Birds						
04/14/2021	European starling	19	23	carcass search	square	scavenged
04/15/2021	western meadowlark	80	88	carcass search[2]	square	scavenged
04/30/2021	northern shoveler	53	81	carcass search	square	scavenged
05/11/2021	American white pelican[1]	108	66	Incidental[2]	n/a	dismembered
05/11/2021	red-tailed hawk	68	79	carcass search	square	dismembered
05/17/2021	red-tailed hawk	16	50	carcass search	square	dismembered
05/21/2021	American white pelican[1]	9	56	Incidental[2]	n/a	dismembered
06/04/2021	mallard	5	65	carcass search	square	intact
06/07/2021	black-billed cuckoo	58	2	carcass search	square	intact
06/09/2021	mallard	38	14	Incidental	square	dismembered
06/09/2021	mallard	35	14	Incidental	square	dismembered
06/21/2021	turkey vulture	79	60	Incidental[2]	n/a	intact
08/03/2021	red-tailed hawk	15	46	Incidental[2]	n/a	feather spot
08/06/2021	American white pelican[1]	18	54	Incidental[2]	n/a	scavenged
10/25/2021	American white pelican[1]	17	69	Incidental[2]	n/a	scavenged
12/14/2021	common redpoll	12	79	carcass search	square	intact
Bats						
05/19/2021	big brown bat	43	23	carcass search	square	intact
06/16/2021	hoary bat	2	13	Incidental[2]	n/a	intact
07/23/2021	hoary bat	14	54	Incidental[2]	n/a	intact
08/05/2021	big brown bat	3	83	Incidental[2]	n/a	scavenged
08/06/2021	unidentified non-myotis	3	83	Incidental[2]	n/a	scavenged
08/18/2021	eastern red bat	3	43	carcass search	road and pad	intact
08/31/2021	silver-haired bat[1]	5	12	carcass search	road and pad	intact

[1] Species of Greatest Conservation Need, as designated in the South Dakota Wildlife Action Plan (South Dakota Game, Fish and Parks 2014).

[2] Carcass was found outside the search area.

Appendix D. Searcher Efficiency Model Selection for the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel Counties, South Dakota, from March 17 – December 15, 2021

Appendix D1. GenEst estimated searcher efficiency models for large birds (n = 59 searcher efficiency trial carcasses) at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021.

Covariates	*k* Value	AICc	Delta AICc
Plot Search Type	k fixed at 0.67	51.37	0
Season + Plot Search Type	k fixed at 0.67	51.44	0.07
No Covariates	k fixed at 0.67	52.47	1.10[1]
Season	k fixed at 0.67	54.65	3.28

[1.] Selected model.

AICc = corrected Akaike Information Criterion.

Delta AICc is the change from the minimum AICc.

Appendix D2. GenEst estimated searcher efficiency models for small birds (n = 61 searcher efficiency trial carcasses) at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021.

Covariates	*k* Value	AICc	Delta AICc
Plot Search Type	k fixed at 0.67	82.87	0[1]
Season + Plot Search Type	k fixed at 0.67	84.77	1.90
No Covariates	k fixed at 0.67	85.83	2.96
Season	k fixed at 0.67	89.91	7.04

[1.] Selected model.

AICc = corrected Akaike Information Criterion.

Delta AICc is the change from the minimum AICc.

Appendix D3. GenEst estimated searcher efficiency models for bats (n = 56 searcher efficiency trial carcasses) at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021.

Covariates	*k* Value	AICc	Delta AICc
Plot Search Type	k fixed at 0.67	72.94	0[1]
Season + Plot Search Type	k fixed at 0.67	76.48	3.54
No Covariates	k fixed at 0.67	77.91	4.97
Season	k fixed at 0.67	81.93	8.99

[1.] Selected model.

AICc = corrected Akaike Information Criterion.

Delta AICc is the change from the minimum AICc.

Appendix E. Carcass Persistence Trial Information for the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel Counties, South Dakota, from March 17 – December 15, 2021

Appendix E1. All carcasses placed for carcass persistence trials by date, season, species, and search location at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021.

Date Placed	Season	Common Name	Search Location	Before Removal[1]	After Removal[2]
04/05/2021	Spring	house mouse	15	04/06/2021	04/11/2021
04/05/2021	Spring	house mouse	16	04/06/2021	04/11/2021
04/05/2021	Spring	house mouse	24	04/05/2021	04/05/2021
04/05/2021	Spring	house mouse	3	04/06/2021	04/08/2021
04/05/2021	Spring	house mouse	3	04/27/2021	05/04/2021
04/05/2021	Spring	house mouse	32	04/11/2021	04/14/2021
04/05/2021	Spring	house mouse	37	04/19/2021	04/27/2021
04/05/2021	Spring	northern bobwhite	16	04/06/2021	04/11/2021
04/05/2021	Spring	northern bobwhite	18	04/06/2021	04/11/2021
04/05/2021	Spring	northern bobwhite	19	04/11/2021	04/14/2021
04/05/2021	Spring	northern bobwhite	28	04/08/2021	04/11/2021
04/05/2021	Spring	northern bobwhite	32	04/11/2021	04/14/2021
04/05/2021	Spring	northern bobwhite	34	04/07/2021	04/11/2021
04/05/2021	Spring	northern bobwhite	6	04/14/2021	04/19/2021
04/05/2021	Spring	rock pigeon	15	04/08/2021	04/11/2021
04/05/2021	Spring	rock pigeon	18	04/27/2021	05/04/2021
04/05/2021	Spring	rock pigeon	19	05/04/2021	05/04/2021
04/05/2021	Spring	rock pigeon	24	04/27/2021	05/04/2021
04/05/2021	Spring	rock pigeon	28	05/04/2021	05/04/2021
04/05/2021	Spring	rock pigeon	32	04/11/2021	04/14/2021
04/05/2021	Spring	rock pigeon	34	04/11/2021	04/14/2021
04/05/2021	Spring	rock pigeon	37	04/27/2021	05/04/2021
04/05/2021	Spring	rock pigeon	6	05/04/2021	05/04/2021
05/03/2021	Spring	house mouse	42	05/03/2021	05/04/2021
05/03/2021	Spring	house mouse	42	05/06/2021	05/10/2021
05/03/2021	Spring	house mouse	56	05/05/2021	05/05/2021
05/03/2021	Spring	house mouse	56	05/06/2021	05/10/2021
05/03/2021	Spring	house mouse	68	05/04/2021	05/04/2021
05/03/2021	Spring	house mouse	68	05/12/2021	05/16/2021
05/03/2021	Spring	house mouse	80	05/11/2021	05/13/2021
05/03/2021	Spring	house mouse	80	05/11/2021	05/13/2021
05/03/2021	Spring	northern bobwhite	35	05/06/2021	05/10/2021
05/03/2021	Spring	northern bobwhite	46	05/06/2021	05/10/2021
05/03/2021	Spring	northern bobwhite	58	05/03/2021	05/03/2021
05/03/2021	Spring	northern bobwhite	69	05/05/2021	05/05/2021
05/03/2021	Spring	northern bobwhite	83	05/05/2021	05/05/2021
05/03/2021	Spring	northern bobwhite	83	05/06/2021	05/11/2021
05/03/2021	Spring	northern bobwhite	84	05/05/2021	05/06/2021
05/03/2021	Spring	northern bobwhite	84	05/05/2021	05/06/2021
05/03/2021	Spring	rock pigeon	35	05/06/2021	05/10/2021
05/03/2021	Spring	rock pigeon	46	05/06/2021	05/10/2021
05/03/2021	Spring	rock pigeon	55	05/03/2021	05/03/2021
05/03/2021	Spring	rock pigeon	55	05/03/2021	05/03/2021
05/03/2021	Spring	rock pigeon	58	05/03/2021	05/03/2021
05/03/2021	Spring	rock pigeon	69	05/06/2021	05/11/2021
06/14/2021	Spring	house mouse	13	06/15/2021	06/15/2021
06/14/2021	Spring	house mouse	3	06/22/2021	06/28/2021
06/14/2021	Spring	house mouse	32	06/16/2021	06/16/2021
06/14/2021	Spring	house mouse	37	06/15/2021	06/16/2021
06/14/2021	Spring	house mouse	51	06/22/2021	06/28/2021

Appendix E1. All carcasses placed for carcass persistence trials by date, season, species, and search location at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021.

Date Placed	Season	Common Name	Search Location	Before Removal[1]	After Removal[2]
06/14/2021	Spring	house mouse	68	06/17/2021	06/21/2021
06/14/2021	Spring	house mouse	78	06/17/2021	06/21/2021
06/14/2021	Spring	house mouse	85	06/14/2021	06/14/2021
06/14/2021	Spring	northern bobwhite	13	06/15/2021	06/18/2021
06/14/2021	Spring	northern bobwhite	3	06/15/2021	06/18/2021
06/14/2021	Spring	northern bobwhite	32	06/22/2021	06/28/2021
06/14/2021	Spring	northern bobwhite	37	06/23/2021	06/28/2021
06/14/2021	Spring	northern bobwhite	51	06/15/2021	06/16/2021
06/14/2021	Spring	northern bobwhite	68	06/21/2021	06/22/2021
06/14/2021	Spring	northern bobwhite	78	06/22/2021	06/28/2021
06/14/2021	Spring	northern bobwhite	85	06/17/2021	06/20/2021
06/14/2021	Spring	rock pigeon	13	06/22/2021	06/28/2021
06/14/2021	Spring	rock pigeon	3	06/28/2021	07/04/2021
06/14/2021	Spring	rock pigeon	32	06/16/2021	06/16/2021
06/14/2021	Spring	rock pigeon	37	06/17/2021	06/18/2021
06/14/2021	Spring	rock pigeon	51	06/28/2021	07/04/2021
06/14/2021	Spring	rock pigeon	68	06/28/2021	07/04/2021
06/14/2021	Spring	rock pigeon	78	06/28/2021	07/04/2021
06/14/2021	Spring	rock pigeon	85	06/14/2021	06/14/2021
07/20/2021	Summer	house mouse	19	07/23/2021	07/26/2021
07/20/2021	Summer	house mouse	3	07/23/2021	07/26/2021
07/20/2021	Summer	house mouse	30	07/21/2021	07/22/2021
07/20/2021	Summer	house mouse	37	07/23/2021	07/27/2021
07/20/2021	Summer	house mouse	54	07/21/2021	07/22/2021
07/20/2021	Summer	house mouse	56	07/27/2021	07/31/2021
07/20/2021	Summer	house mouse	6	07/26/2021	07/31/2021
07/20/2021	Summer	house mouse	73	07/21/2021	07/23/2021
07/20/2021	Summer	house mouse	75	07/21/2021	07/21/2021
07/20/2021	Summer	house mouse	82	07/21/2021	07/23/2021
07/20/2021	Summer	northern bobwhite	19	07/23/2021	07/26/2021
07/20/2021	Summer	northern bobwhite	3	07/26/2021	07/31/2021
07/20/2021	Summer	northern bobwhite	30	07/21/2021	07/22/2021
07/20/2021	Summer	northern bobwhite	37	07/27/2021	07/31/2021
07/20/2021	Summer	northern bobwhite	54	07/31/2021	08/03/2021
07/20/2021	Summer	northern bobwhite	56	08/03/2021	08/10/2021
07/20/2021	Summer	northern bobwhite	6	07/23/2021	07/26/2021
07/20/2021	Summer	northern bobwhite	73	07/21/2021	07/23/2021
07/20/2021	Summer	northern bobwhite	75	07/21/2021	07/23/2021
07/20/2021	Summer	northern bobwhite	82	07/27/2021	07/31/2021
07/20/2021	Summer	rock pigeon	19	08/17/2021	08/17/2021
07/20/2021	Summer	rock pigeon	3	07/23/2021	07/26/2021
07/20/2021	Summer	rock pigeon	30	07/21/2021	07/21/2021
07/20/2021	Summer	rock pigeon	37	07/31/2021	08/02/2021
07/20/2021	Summer	rock pigeon	54	07/23/2021	07/27/2021
07/20/2021	Summer	rock pigeon	56	07/31/2021	08/03/2021
07/20/2021	Summer	rock pigeon	6	07/23/2021	07/26/2021
07/20/2021	Summer	rock pigeon	73	07/21/2021	07/23/2021
07/20/2021	Summer	rock pigeon	75	07/21/2021	07/21/2021
07/20/2021	Summer	rock pigeon	82	08/10/2021	08/18/2021
08/03/2021	Summer	house mouse	27	08/04/2021	08/06/2021

Appendix E1. All carcasses placed for carcass persistence trials by date, season, species, and search location at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021.

Date Placed	Season	Common Name	Search Location	Before Removal[1]	After Removal[2]
08/03/2021	Summer	house mouse	44	08/16/2021	08/24/2021
08/03/2021	Summer	house mouse	46	08/04/2021	08/06/2021
08/03/2021	Summer	house mouse	48	08/04/2021	08/06/2021
08/03/2021	Summer	house mouse	54	08/16/2021	08/24/2021
08/03/2021	Summer	house mouse	55	08/16/2021	08/24/2021
08/03/2021	Summer	house mouse	6	08/04/2021	08/05/2021
08/03/2021	Summer	house mouse	62	08/04/2021	08/05/2021
08/03/2021	Summer	house mouse	78	08/04/2021	08/05/2021
08/03/2021	Summer	house mouse	83	08/15/2021	08/23/2021
08/03/2021	Summer	northern bobwhite	27	08/24/2021	08/31/2021
08/03/2021	Summer	northern bobwhite	44	08/16/2021	08/24/2021
08/03/2021	Summer	northern bobwhite	46	08/16/2021	08/24/2021
08/03/2021	Summer	northern bobwhite	48	08/04/2021	08/06/2021
08/03/2021	Summer	northern bobwhite	54	08/04/2021	08/06/2021
08/03/2021	Summer	northern bobwhite	55	08/06/2021	08/16/2021
08/03/2021	Summer	northern bobwhite	6	08/04/2021	08/05/2021
08/03/2021	Summer	northern bobwhite	62	08/04/2021	08/05/2021
08/03/2021	Summer	northern bobwhite	78	08/04/2021	08/05/2021
08/03/2021	Summer	northern bobwhite	83	08/04/2021	08/05/2021
08/03/2021	Summer	rock pigeon	27	08/24/2021	08/31/2021
08/03/2021	Summer	rock pigeon	44	08/24/2021	08/31/2021
08/03/2021	Summer	rock pigeon	46	08/04/2021	08/06/2021
08/03/2021	Summer	rock pigeon	48	08/16/2021	08/24/2021
08/03/2021	Summer	rock pigeon	54	08/24/2021	08/31/2021
08/03/2021	Summer	rock pigeon	55	08/24/2021	08/31/2021
08/03/2021	Summer	rock pigeon	6	08/05/2021	08/16/2021
08/03/2021	Summer	rock pigeon	62	08/06/2021	08/15/2021
08/03/2021	Summer	rock pigeon	78	08/06/2021	08/15/2021
08/03/2021	Summer	rock pigeon	83	08/15/2021	08/24/2021
10/25/2021	Fall	house mouse	62	11/03/2021	11/07/2021
10/25/2021	Fall	house mouse	64	10/28/2021	11/03/2021
10/25/2021	Fall	house mouse	70	10/28/2021	11/01/2021
10/25/2021	Fall	house mouse	73	10/28/2021	10/28/2021
10/25/2021	Fall	house mouse	75	11/02/2021	11/07/2021
10/25/2021	Fall	house mouse	80	10/28/2021	11/03/2021
10/25/2021	Fall	house mouse	82	11/04/2021	11/16/2021
10/25/2021	Fall	house mouse	84	11/07/2021	11/16/2021
10/25/2021	Fall	house mouse	85	11/04/2021	11/16/2021
10/25/2021	Fall	house mouse	87	10/28/2021	10/29/2021
10/25/2021	Fall	northern bobwhite	64	10/28/2021	11/03/2021
10/25/2021	Fall	northern bobwhite	69	10/26/2021	10/28/2021
10/25/2021	Fall	northern bobwhite	70	10/28/2021	11/01/2021
10/25/2021	Fall	northern bobwhite	73	10/25/2021	10/26/2021
10/25/2021	Fall	northern bobwhite	75	11/02/2021	11/07/2021
10/25/2021	Fall	northern bobwhite	77	11/03/2021	11/07/2021
10/25/2021	Fall	northern bobwhite	78	10/28/2021	10/28/2021
10/25/2021	Fall	northern bobwhite	82	10/29/2021	11/04/2021
10/25/2021	Fall	northern bobwhite	85	10/29/2021	11/02/2021
10/25/2021	Fall	northern bobwhite	87	10/27/2021	10/29/2021
10/25/2021	Fall	rock pigeon	64	10/28/2021	11/03/2021

Appendix E1. All carcasses placed for carcass persistence trials by date, season, species, and search location at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021.

Date Placed	Season	Common Name	Search Location	Before Removal[1]	After Removal[2]
10/25/2021	Fall	rock pigeon	69	10/28/2021	11/01/2021
10/25/2021	Fall	rock pigeon	70	11/15/2021	11/15/2021
10/25/2021	Fall	rock pigeon	73	10/28/2021	10/28/2021
10/25/2021	Fall	rock pigeon	77	10/25/2021	10/25/2021
10/25/2021	Fall	rock pigeon	78	10/26/2021	10/28/2021
10/25/2021	Fall	rock pigeon	80	10/25/2021	10/26/2021
10/25/2021	Fall	rock pigeon	82	10/25/2021	10/25/2021
10/25/2021	Fall	rock pigeon	84	10/29/2021	11/04/2021
10/25/2021	Fall	rock pigeon	87	10/29/2021	11/04/2021
11/02/2021	Fall	house mouse	1	11/08/2021	11/17/2021
11/02/2021	Fall	house mouse	11	11/09/2021	11/17/2021
11/02/2021	Fall	house mouse	2	11/04/2021	11/06/2021
11/02/2021	Fall	house mouse	21	11/03/2021	11/03/2021
11/02/2021	Fall	house mouse	5	11/03/2021	11/03/2021
11/02/2021	Fall	northern bobwhite	1	11/17/2021	12/03/2021
11/02/2021	Fall	northern bobwhite	11	11/09/2021	11/17/2021
11/02/2021	Fall	northern bobwhite	13	11/09/2021	11/12/2021
11/02/2021	Fall	northern bobwhite	19	11/17/2021	12/03/2021
11/02/2021	Fall	northern bobwhite	2	11/08/2021	11/17/2021
11/02/2021	Fall	northern bobwhite	24	11/06/2021	11/09/2021
11/02/2021	Fall	northern bobwhite	27	11/06/2021	11/09/2021
11/02/2021	Fall	northern bobwhite	27	11/03/2021	11/03/2021
11/02/2021	Fall	northern bobwhite	32	11/03/2021	11/03/2021
11/02/2021	Fall	northern bobwhite	46	11/09/2021	11/16/2021
11/02/2021	Fall	northern bobwhite	46	11/09/2021	11/16/2021
11/02/2021	Fall	northern bobwhite	53	11/06/2021	11/08/2021
11/02/2021	Fall	northern bobwhite	54	11/03/2021	11/03/2021
11/02/2021	Fall	northern bobwhite	55	11/06/2021	11/08/2021
11/02/2021	Fall	northern bobwhite	68	11/04/2021	11/05/2021
11/02/2021	Fall	northern bobwhite	68	11/05/2021	11/08/2021
11/02/2021	Fall	rock pigeon	13	11/03/2021	11/04/2021
11/02/2021	Fall	rock pigeon	19	11/06/2021	11/09/2021
11/02/2021	Fall	rock pigeon	21	11/03/2021	11/06/2021
11/02/2021	Fall	rock pigeon	24	11/16/2021	12/03/2021
11/02/2021	Fall	rock pigeon	30	11/03/2021	11/04/2021
11/02/2021	Fall	rock pigeon	30	12/03/2021	12/03/2021
11/02/2021	Fall	rock pigeon	32	11/16/2021	12/03/2021
11/02/2021	Fall	rock pigeon	44	11/06/2021	11/08/2021
11/02/2021	Fall	rock pigeon	44	11/06/2021	11/08/2021
11/02/2021	Fall	rock pigeon	5	11/03/2021	11/03/2021
11/02/2021	Fall	rock pigeon	53	11/16/2021	12/02/2021
11/02/2021	Fall	rock pigeon	54	11/06/2021	11/08/2021
11/02/2021	Fall	rock pigeon	55	11/03/2021	11/03/2021
11/08/2021	Fall	house mouse	22	11/09/2021	11/10/2021
11/08/2021	Fall	house mouse	22	11/10/2021	11/16/2021
11/08/2021	Fall	house mouse	25	11/16/2021	11/18/2021
11/08/2021	Fall	house mouse	28	11/16/2021	11/18/2021
11/08/2021	Fall	house mouse	31	11/18/2021	11/30/2021
11/08/2021	Fall	house mouse	35	11/16/2021	11/18/2021
11/08/2021	Fall	house mouse	37	11/09/2021	11/09/2021

Appendix E1. All carcasses placed for carcass persistence trials by date, season, species, and search location at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021.

Date Placed	Season	Common Name	Search Location	Before Removal[1]	After Removal[2]
11/08/2021	Fall	house mouse	39	11/09/2021	11/09/2021
11/08/2021	Fall	house mouse	40	11/09/2021	11/09/2021
11/08/2021	Fall	house mouse	40	11/18/2021	11/30/2021
11/08/2021	Fall	house mouse	42	11/10/2021	11/16/2021
11/08/2021	Fall	house mouse	58	11/10/2021	11/15/2021
11/08/2021	Fall	house mouse	6	11/19/2021	11/30/2021
11/08/2021	Fall	house mouse	61	11/09/2021	11/10/2021
11/08/2021	Fall	house mouse	7	11/08/2021	11/08/2021
11/08/2021	Fall	house mouse	7	11/08/2021	11/09/2021
11/08/2021	Fall	northern bobwhite	34	11/18/2021	11/30/2021
11/08/2021	Fall	northern bobwhite	36	11/18/2021	12/09/2021
11/08/2021	Fall	northern bobwhite	39	11/09/2021	11/10/2021
11/08/2021	Fall	northern bobwhite	42	11/18/2021	12/09/2021
11/08/2021	Fall	northern bobwhite	58	11/09/2021	11/10/2021
11/08/2021	Fall	rock pigeon	25	11/16/2021	11/18/2021
11/08/2021	Fall	rock pigeon	28	11/30/2021	12/09/2021
11/08/2021	Fall	rock pigeon	31	11/29/2021	12/09/2021
11/08/2021	Fall	rock pigeon	34	11/30/2021	12/09/2021
11/08/2021	Fall	rock pigeon	35	11/18/2021	11/30/2021
11/08/2021	Fall	rock pigeon	36	11/10/2021	11/15/2021
11/08/2021	Fall	rock pigeon	37	12/09/2021	12/09/2021
11/08/2021	Fall	rock pigeon	61	11/09/2021	11/10/2021

[1] Last date checked before removal.

[2] Date checked after removal.

Appendix E2. GenEst estimated carcass persistence models and covariates for large birds (n = 74 carcass persistence trial carcasses) at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021.

Location Covariates	Scale Covariates	Distribution	AICc	Delta AICc
No Covariates	-	exponential	318.80	0[1]
No Covariates	No Covariates	Weibull	320.05	1.25
No Covariates	Season	Weibull	321.59	2.79
Season	-	exponential	322.41	3.61
Season	No Covariates	Weibull	323.85	5.05
No Covariates	No Covariates	lognormal	325.06	6.26
No Covariates	No Covariates	loglogistic	325.43	6.63
Season	Season	Weibull	325.44	6.64
No Covariates	Season	lognormal	325.92	7.12
No Covariates	Season	loglogistic	327.30	8.50
Season	No Covariates	lognormal	328.41	9.61
Season	No Covariates	loglogistic	328.42	9.62
Season	Season	lognormal	329.28	10.48
Season	Season	loglogistic	330.39	11.59

[1.] Selected model.

Location covariates = covariates that affect the shape of the distribution.

Scale covariates = covariates that affect the spread of the distribution.

AICc = corrected Akaike Information Criterion.

Delta AICc is the change from the minimum AICc.

Appendix E3. GenEst estimated carcass persistence models and covariates for small birds (n = 74 carcass persistence trial carcasses) at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021.

Location Covariates	Scale Covariates	Distribution	AICc	Delta AICc
No Covariates	No Covariates	lognormal	269.49	0[1]
No Covariates	Season	lognormal	272.05	2.56
No Covariates	No Covariates	Weibull	272.74	3.25
Season	No Covariates	lognormal	273.12	3.63
No Covariates	Season	Weibull	273.41	3.92
No Covariates	No Covariates	loglogistic	273.62	4.13
Season	No Covariates	Weibull	274.29	4.80
No Covariates	Season	loglogistic	275.72	6.23
Season	Season	lognormal	275.85	6.36
Season	Season	Weibull	276.00	6.51
Season	No Covariates	loglogistic	277.22	7.73
Season	Season	loglogistic	279.58	10.09
No Covariates	-	exponential	281.36	11.87
Season	-	exponential	284.38	14.89

[1.] Selected model.

Location covariates = covariates that affect the shape of the distribution.

Scale covariates = covariates that affect the spread of the distribution.

AICc = corrected Akaike Information Criterion.

Delta AICc is the change from the minimum AICc.

Appendix E4. GenEst estimated carcass persistence models and covariates for bats (n = 74 carcass persistence trial carcasses) at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021.

Location Covariates	Scale Covariates	Distribution	AICc	Delta AICc
No Covariates	-	exponential	294.36	0[1]
No Covariates	No Covariates	Weibull	294.40	0.04
No Covariates	No Covariates	lognormal	297.70	3.34
No Covariates	Season	Weibull	298.15	3.79
Season	-	exponential	298.35	3.99
Season	No Covariates	Weibull	298.50	4.14
No Covariates	Season	lognormal	300.76	6.40
Season	No Covariates	lognormal	301.49	7.13
No Covariates	No Covariates	loglogistic	301.60	7.24
Season	Season	Weibull	302.29	7.93
Season	Season	lognormal	304.80	10.44
Season	No Covariates	loglogistic	305.03	10.67
No Covariates	Season	loglogistic	305.18	10.82
Season	Season	loglogistic	308.73	14.37

[1.] Selected model.

Location covariates = covariates that affect the shape of the distribution.

Scale covariates = covariates that affect the spread of the distribution.

AICc = corrected Akaike Information Criterion.

Delta AICc is the change from the minimum AICc.

Appendix E5. Carcass persistence top models with covariates, distributions, and model parameters using GenEst at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021.

Size Class	Distribution	Predicted Median Removal Times (days)	Parameter 1	Parameter 2
Large Bird	exponential[1]	9.07	rate = 0.0764	–
Small Bird	lognormal[1]	5.14	meanlog = 1.638	sdlog = 0.795
Bat	exponential[1]	4.58	rate = 0.1515	–

[1.] Parameterization follows the base R parameterization for this distribution.

Appendix F. Search Area Adjustment Models for the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel Counties, South Dakota, from March 17 – December 15, 2021

Appendix F1. GenEst estimated Hull and Muir search area adjustment estimates at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021.

Size Class	Search Area Type	Hub Height (m)	Blade Radius (m)	Area Correction
Large Bird	road and pad plot	90	58	0.09
	square plot	90	58	0.73
Small Bird	road and pad plot	90	58	0.12
	square plot	90	58	0.90
Bat	road and pad plot	90	58	0.14
	square plot	90	58	0.96

m = meter.

Appendix F2. GenEst estimated search area adjustment estimates for raptors at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021. Modeled using the carcass-density distribution presented in Hallingstad et al. 2018.

Size Class	Search Area Type	Area Correction
Raptor	road and pad plot	0.02
	square plot	0.78

Appendix G. Bird and Bat Fatality Rates and Adjustment Factors for the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel Counties, South Dakota, from March 17 – December 15, 2021

Appendix G1. GenEst estimated fatality rates and adjustment factors with 90% confidence intervals (CI) for square plots during post-construction fatality monitoring at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021.

	Spring 27 turbines searched		Summer 5 turbines searched		Early Fall[1] 5 turbines searched		Late Fall[1] 27 turbines searched	
	Estimate	**90% CI[2]**	**Estimate**	**90% CI[2]**	**Estimate**	**90% CI[2]**	**Estimate**	**90% CI[2]**
Search Area Adjustment								
Large Bird	0.73	0.73 - 0.73	0.73	0.73 - 0.73	0.73	0.73 - 0.73	0.73	0.73 - 0.73
Raptor	0.78	0.78 - 0.78	0.78	0.78 - 0.78	0.78	0.78 - 0.78	0.78	0.78 - 0.78
Small Bird	0.90	0.90 - 0.90	0.90	0.90 - 0.90	0.90	0.90 - 0.90	0.90	0.90 - 0.90
Bat	0.96	0.96 - 0.96	0.96	0.96 - 0.96	0.96	0.96 - 0.96	0.96	0.96 - 0.96
Searcher Efficiency								
Large Bird	0.85	0.75 - 0.91	0.85	0.75 - 0.91	0.85	0.75 - 0.91	0.85	0.75 - 0.91
Raptor	0.85	0.75 - 0.91	0.85	0.75 - 0.91	0.85	0.75 - 0.91	0.85	0.75 - 0.91
Small Bird	0.45	0.32 - 0.58	0.45	0.32 - 0.58	0.45	0.32 - 0.58	0.45	0.32 - 0.58
Bat	0.46	0.33 - 0.60	0.46	0.33 - 0.60	0.46	0.33 - 0.60	0.46	0.33 - 0.60
Average Probability of a Carcass Persisting Through the Search Interval[3]								
Large Bird	0.60	0.54 - 0.65	0.60	0.54 - 0.65	0.60	0.54 - 0.65	0.60	0.54 - 0.65
Raptor	0.60	0.54 - 0.65	0.60	0.54 - 0.65	0.60	0.54 - 0.65	0.60	0.54 - 0.65
Small Bird	0.43	0.37 - 0.48	0.43	0.37 - 0.48	0.43	0.37 - 0.48	0.43	0.37 - 0.48
Bat	0.40	0.34 - 0.46	0.40	0.34 - 0.46	0.40	0.34 - 0.46	0.40	0.34 - 0.46
Probability of Available and Detected								
Large Bird	0.52	0.45 - 0.58	0.52	0.45 - 0.58	0.52	0.45 - 0.58	0.52	0.45 - 0.58
Raptor	0.52	0.45 - 0.58	0.52	0.45 - 0.58	0.52	0.45 - 0.58	0.52	0.45 - 0.58
Small Bird	0.20	0.14 - 0.26	0.20	0.14 - 0.26	0.20	0.14 - 0.26	0.20	0.14 - 0.26
Bat	0.19	0.13 - 0.25	0.19	0.13 - 0.25	0.19	0.13 - 0.25	0.19	0.13 - 0.25
Estimated Fatality Rates (Fatalities/Turbine/Season)								
All Bird	0.75	0.39 - 1.22	0	n/a	0	n/a	0.17	n/a
Large Bird	0.75	0.39 - 1.22	0	n/a	0	n/a	0	n/a
Large Bird Non-Raptor	0.56	0.24 - 1.00	0	n/a	0	n/a	0	n/a
Raptor	0.19	n/a	0	n/a	0	n/a	0	n/a
Small Bird	0	n/a	0	n/a	0	n/a	0.17	n/a
Bat	0.39	n/a	0	n/a	0	n/a	0	n/a
Estimated Fatality Rates (Fatalities/megawatt/Season)								
All Bird	0.33	0.17 - 0.54	0	n/a	0	n/a	0.07	n/a
Large Bird	0.33	0.17 - 0.54	0	n/a	0	n/a	0	n/a
Large Bird Non-Raptor	0.24	0.10 - 0.43	0	n/a	0	n/a	0	n/a
Raptor	0.09	n/a	0	n/a	0	n/a	0	n/a
Small Bird	0	n/a	0	n/a	0	n/a	0.07	n/a

Appendix G1. GenEst estimated fatality rates and adjustment factors with 90% confidence intervals (CI) for square plots during post-construction fatality monitoring at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021.

	Spring 27 turbines searched		Summer 5 turbines searched		Early Fall[1] 5 turbines searched		Late Fall[1] 27 turbines searched	
	Estimate	**90% CI[2]**	**Estimate**	**90% CI[2]**	**Estimate**	**90% CI[2]**	**Estimate**	**90% CI[2]**
Bat	0.17	n/a	0	n/a	0	n/a	0	n/a

[1.] Separate estimates were calculated for Early Fall and Late Fall due to a search area change on November 29: the 22 turbines being searched as road and pad plots during Summer and Early Fall switched to square plots during Late Fall.

[2.] Confidence interval not calculated when the observed carcass count is less than five.

[3.] The search interval was once every two weeks.

Appendix G2. GenEst estimated fatality rates and adjustment factors with 90% confidence intervals (CI) for road and pad plots during post-construction fatality monitoring at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021.

	Spring 0 turbines searched		Summer 22 turbines searched		Early Fall[1] 22 turbines searched		Late Fall[1] 0 turbines searched	
	Estimate	90% CI	Estimate	90% CI[2]	Estimate	90% CI[2]	Estimate	90% CI
Search Area Adjustment								
Large Bird	--	--	0.09	0.09 - 0.09	0.09	0.09 - 0.09	--	--
Raptor	--	--	0.02	0.02 - 0.02	0.02	0.02 - 0.02	--	--
Small Bird	--	--	0.12	0.12 - 0.12	0.12	0.12 - 0.12	--	--
Bat	--	--	0.14	0.14 - 0.14	0.14	0.14 - 0.14	--	--
Searcher Efficiency								
Large Bird	--	--	0.85	0.75 - 0.91	0.85	0.75 - 0.91	--	--
Raptor	--	--	0.85	0.75 - 0.91	0.85	0.75 - 0.91	--	--
Small Bird	--	--	0.74	0.56 - 0.86	0.74	0.56 - 0.86	--	--
Bat	--	--	0.81	0.63 - 0.91	0.81	0.63 - 0.91	--	--
Average Probability of a Carcass Persisting Through the Search Interval[3]								
Large Bird	--	--	0.60	0.54 - 0.65	0.60	0.54 - 0.65	--	--
Raptor	--	--	0.60	0.54 - 0.65	0.60	0.54 - 0.65	--	--
Small Bird	--	--	0.43	0.38 - 0.48	0.43	0.38 - 0.48	--	--
Bat	--	--	0.40	0.35 - 0.46	0.40	0.35 - 0.46	--	--
Probability of Available and Detected								
Large Bird	--	--	0.52	0.45 - 0.58	0.52	0.45 - 0.58	--	--
Raptor	--	--	0.52	0.45 - 0.58	0.52	0.45 - 0.58	--	--
Small Bird	--	--	0.32	0.24 - 0.39	0.32	0.24 - 0.39	--	--
Bat	--	--	0.32	0.25 - 0.39	0.32	0.25 - 0.39	--	--
Estimated Fatality Rates (Fatalities/Turbine/Season)								
All Bird	--	--	0	n/a	0	n/a	--	--
Large Bird	--	--	0	n/a	0	n/a	--	--
Large Bird Non-Raptor	--	--	0	n/a	0	n/a	--	--
Raptor	--	--	0	n/a	0	n/a	--	--
Small Bird	--	--	0	n/a	0	n/a	--	--
Bat	--	--	1.65	n/a	0	n/a	--	--
Estimated Fatality Rates (Fatalities/megawatt/Season)								
All Bird	--	--	0	n/a	0	n/a	--	--
Large Bird	--	--	0	n/a	0	n/a	--	--
Large Bird Non-Raptor	--	--	0	n/a	0	n/a	--	--
Raptor	--	--	0	n/a	0	n/a	--	--
Small Bird	--	--	0	n/a	0	n/a	--	--

Appendix G2. GenEst estimated fatality rates and adjustment factors with 90% confidence intervals (CI) for road and pad plots during post-construction fatality monitoring at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021.

	Spring 0 turbines searched		Summer 22 turbines searched		Early Fall[1] 22 turbines searched		Late Fall[1] 0 turbines searched	
	Estimate	**90% CI**	**Estimate**	**90% CI[2]**	**Estimate**	**90% CI[2]**	**Estimate**	**90% CI**
Bat	--	--	0.72	n/a	0	n/a	--	--

[1.] Separate estimates were calculated for Early Fall and Late Fall due to a search area change on November 29: the 22 turbines being searched as road and pad plots during Summer and Early Fall switched to square plots during Late Fall.

[2.] Confidence interval not calculated when the observed carcass count is less than five.

[3.] The search interval was once every two weeks.

Appendix G3. GenEst estimated overall fatality rates per megawatt and per turbine at square plots for studies conducted at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021.

	Per Megawatt Estimates		Per Turbine Estimates	
Size Class	**Estimate**	**90% CI[1]**	**Estimate**	**90% CI[1]**
All Bird	0.41	0.21 - 0.73	0.93	0.48 - 1.65
Large Bird	0.33	0.17 - 0.54	0.75	0.39 - 1.22
Large Bird Non-Raptor	0.24	0.10 - 0.43	0.56	0.24 - 1.00
Raptor	0.09	n/a	0.19	n/a
Small Bird	0.07	n/a	0.17	n/a
Bat	0.17	n/a	0.39	n/a

[1.] Confidence interval (CI) not calculated when the observed carcass count is less than five.

Appendix G4. GenEst estimated overall fatality rates per megawatt and per turbine at road and pad plots for studies conducted at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021.

	Per Megawatt Estimates		Per Turbine Estimates	
Size Class	**Estimate**	**90% CI[1]**	**Estimate**	**90% CI[1]**
All Bird	0	n/a	0	n/a
Large Bird	0	n/a	0	n/a
Large Bird Non-Raptor	0	n/a	0	n/a
Raptor	0	n/a	0	n/a
Small Bird	0	n/a	0	n/a
Bat	0.72	n/a	1.65	n/a

[1.] Confidence interval (CI) not calculated when the observed carcass count is less than five.

Appendix G5. GenEst estimated overall fatality rates and adjustment factors by season for all search areas, with 90% confidence intervals for studies conducted at the Crowned Ridge II Wind Farm in Codington, Grant, and Deuel counties, South Dakota, from March 17 – December 15, 2021.

	Spring 27 turbines searched		Summer 27 turbines searched		Early Fall[1] 27 turbines searched		Late Fall[1] 27 turbines searched	
	Estimate	90% CI[2]	Estimate	90% CI[2]	Estimate	90% CI[2]	Estimate	90% CI
Estimated Fatality Rates (Fatalities/Turbine/Season)								
All Bird	0.75	0.39 - 1.22	0	n/a	0	n/a	0.17	n/a
Large Bird	0.75	0.39 - 1.22	0	n/a	0	n/a	0	n/a
Large Bird Non-Raptor	0.56	0.24 - 1.00	0	n/a	0	n/a	0	n/a
Raptor	0.19	n/a	0	n/a	0	n/a	0	n/a
Small Bird	0	n/a	0	n/a	0	n/a	0.17	n/a
Bat	0.39	n/a	1.34	n/a	0	n/a	0	n/a
Estimated Fatality Rates (Fatalities/megawatt/Season)								
All Bird	0.33	0.17 - 0.54	0	n/a	0	n/a	0.07	n/a
Large Bird	0.33	0.17 - 0.54	0	n/a	0	n/a	0	n/a
Large Bird Non-Raptor	0.24	0.10 - 0.43	0	n/a	0	n/a	0	n/a
Raptor	0.09	n/a	0	n/a	0	n/a	0	n/a
Small Bird	0	n/a	0	n/a	0	n/a	0.07	n/a
Bat	0.17	n/a	0.58	n/a	0	n/a	0	n/a

[1.] Separate estimates were calculated for Early Fall and Late Fall due to a search area change on November 29: the 22 turbines being searched as road and pad plots during Summer and Early Fall switched to square plots during Late Fall.

[2.] Confidence interval (CI) not calculated when the observed carcass count is less than five.

Appendix H. Regional Comparison Tables

Appendix H1. Fatality rates for all birds (number of birds per megawatt [MW] per year), plot size, estimator, land cover, and study citation from recently constructed wind energy facilities in the South Dakota, North Dakota, and Minnesota with publicly available data.

Project	Fatality/MW/Year	Plot Size	Estimator	Land Cover	Citations
Blazing Star, MN (2020)	12.18	120 m x 120 m cleared, 100 m radius road/pad	GenEst	Cropland, Pasture, Corn, Soybean	Stucker et al. 2021b
Lake Benton II, MN (2020)	11.75	120 m x 120 m cleared, 100 m radius road/pad	GenEst	Cropland, Corn, Soybean, Herbaceous	Stucker et al. 2021a
Black Oak Getty, MN (2017)	8.69	60 m radius road/pad	Huso	Cropland, Grassland, Wetlands	Pickle et al. 2018
Wessington Springs, SD (2009)	8.25	200 m x 200 m plot	Shoenfeld	Grassland	Derby et al. 2010a
Moraine II, MN (2009)	5.59	200 m x 200 m plot, 200 m x 200 m mowed strips, 100 m x 100 m cleared	Shoenfeld	Agriculture, Grassland	Derby et al. 2010d
Buffalo Ridge I, SD (2009-2010)	5.06	200 m x 200 m plot, 200 m x 200 m mowed strips, 100 m x 100 m cleared	Shoenfeld	Agriculture, Grassland	Derby et al. 2010b
Odell, MN (2016-2017)	4.69	120 m x 120 m cleared	Huso	Agriculture	Chodachek and Gustafson 2018
Rugby, ND (2010-2011)	3.82	200 m x 200 m plot, 100 m x 100 m cleared, 200 m x 200 m mowed strips	Shoenfeld	Agriculture	Derby et al. 2011b
Elm Creek II, MN (2011-2012)	3.64	200 m x 200 m plot, 200 m x 200 m mowed strips, 100 m x 100 m cleared, 100 m radius road/pad	Shoenfeld	Agriculture, Grassland	Derby et al. 2012b
Black Oak Getty, MN (2018)	3.5	60 m radius road/pad	Huso	Cropland, Grassland, Wetlands	Pickle et al. 2019
Red Pine, MN (2018)	2.68	60 m radius road/pad	Huso	Cropland, Developed, Deciduous Tree, Open Water, Pasture, Woody Wetlands, Wetlands	Trana et al. 2019
Lakefield Wind, MN (2012)	2.22	100 m x 100 m plot	Shoenfeld	Agriculture	Minnesota Public Utilities Commission (MPUC) 2012
Prairie Winds SD1, SD (2012-2013)	2.01	200 m x 200 m plot, 200 m x 200 m road/pad	Shoenfeld	Grassland	Derby et al. 2013
Buffalo Ridge II, SD (2011-2012)	1.99	100 m x 100 m cleared, 100 m for roads and pads	Shoenfeld	Agriculture, Grassland	Derby et al. 2012a

Appendix H1. Fatality rates for all birds (number of birds per megawatt [MW] per year), plot size, estimator, land cover, and study citation from recently constructed wind energy facilities in the South Dakota, North Dakota, and Minnesota with publicly available data.

Project	Fatality/MW/Year	Plot Size	Estimator	Land Cover	Citations
Prairie Winds SD1, SD (2013-2014)	1.66	200 m x 200 m plot, 200 m x 200 m road/pad	Shoenfeld	Grassland	Derby et al. 2014
Elm Creek, MN (2009-2010)	1.55	100 m x 100 m cleared, 200 m x 200 m mowed strips	Shoenfeld	Agriculture	Derby et al. 2010c
Thunder Spirit, ND (2016-2017)	1.49	160 m x 160 m plot, 80 m radius road/pad	Huso	Agriculture, Grassland	Derby et al. 2018
PrairieWinds ND1, ND (2010)	1.48	200 m x 200 m plot	Shoenfeld	Agriculture, Grassland	Derby et al. 2011c
Prairie Winds SD1, SD (2011-2012)	1.41	200 m x 200 m plot	Shoenfeld	Grassland	Derby et al. 2012c
Wessington Springs, SD (2010)	0.89	200 m x 200 m plot	Shoenfeld	Grassland	Derby et al. 2011a
Pleasant Valley, MN (2016-2017)	0.68	160 m x 160 m cleared, 80 m radius road/pad	Huso	Agriculture, Grassland, Wetlands	Tetra Tech 2017
Oak Glen, MN (2013)	0.51	120 m x 120 m plot	Shoenfeld	Agriculture, Corn, Soybean	Chodachek et al. 2014
Crowned Ridge II, SD (2021)	0.41	120 m x 120 m square, 60 m road/pad	GenEst	Agriculture, Grassland	NA

m = meters.

Appendix H2. Fatality rates for diurnal raptors (number of diurnal raptors per megawatt [MW] per year), plot size, estimator, land cover, and study citation from recently constructed wind energy facilities in the South Dakota, North Dakota, and Minnesota with publicly available data.

Project	Fatality/MW/Year	Plot Size	Estimator	Land Cover	Citations
Lake Benton II, MN (2020)	0.46	120 m x 120 m cleared, 100 m radius road/pad	GenEst	Cropland, Corn, Soybean, Herbaceous	Stucker et al. 2021a
Buffalo Ridge I, SD (2009-2010)	0.2	200 m x 200 m plot, 200 m x 200 m mowed strips, 100 m x 100 m cleared	Shoenfeld	Agriculture, Grassland	Derby et al. 2010b
Thunder Spirit, ND (2016-2017)	0.18	160 m x 160 m plot, 80 m radius road/pad	Huso	Agriculture, Grassland	Derby et al. 2018
Prairie Winds SD1, SD (2013-2014)	0.17	200 m x 200 m plot, 200 m x 200 m road/pad	Shoenfeld	Grassland	Derby et al. 2014
Crowned Ridge II, SD (2021)	0.09	120 m x 120 m square, 60 m road/pad	GenEst	Agriculture, Grassland	NA
Wessington Springs, SD (2010)	0.07	200 m x 200 m plot	Shoenfeld	Grassland	Derby et al. 2011a
Black Oak Getty, MN (2018)	0.06	60 m radius road/pad	Huso	Cropland, Grassland, Wetlands	Pickle et al. 2019
Rugby, ND (2010-2011)	0.06	200 m x 200 m plot, 100 m x 100 m cleared, 200 m x 200 m mowed strips	Shoenfeld	Agriculture	Derby et al. 2011b
Wessington Springs, SD (2009)	0.06	200 m x 200 m plot	Shoenfeld	Grassland	Derby et al. 2010a
PrairieWinds ND1, ND (2010)	0.05	200 m x 200 m plot	Shoenfeld	Agriculture, Grassland	Derby et al. 2011c
PrairieWinds ND1, ND (2011)	0.05	200 m x 200 m plot	Shoenfeld	Agriculture, Grassland	Derby et al. 2012d
Prairie Winds SD1, SD (2012-2013)	0.03	200 m x 200 m plot, 200 m x 200 m road/pad	Shoenfeld	Grassland	Derby et al. 2013
Black Oak Getty, MN (2017)	0	120 m x 120 m cleared, 60 m radius road/pad	Huso	Cropland, Grassland, Wetlands	Pickle et al. 2018
Buffalo Ridge II, SD (2011-2012)	0	100 m x 100 m cleared, 100 m for roads and pads	Shoenfeld	Agriculture, Grassland	Derby et al. 2012a
Elm Creek II, MN (2011-2012)	0	200 m x 200 m plot, 200 m x 200 m mowed strips, 100 m x 100 m cleared, 100 m radius road/pad	Shoenfeld	Agriculture, Grassland	Derby et al. 2012b
Elm Creek, MN (2009-2010)	0	100 m x 100 m cleared, 200 m x 200 m mowed strips	Shoenfeld	Agriculture	Derby et al. 2010c

Appendix H2. Fatality rates for diurnal raptors (number of diurnal raptors per megawatt [MW] per year), plot size, estimator, land cover, and study citation from recently constructed wind energy facilities in the South Dakota, North Dakota, and Minnesota with publicly available data.

Project	Fatality/MW/Year	Plot Size	Estimator	Land Cover	Citations
Lakefield Wind, MN (2012)	0	100 m x 100 m plot	Shoenfeld	Agriculture	Minnesota Public Utilities Commission (MPUC) 2012
Odell, MN (2016-2017)	0	120 m x 120 m cleared	Huso	Agriculture	Chodachek and Gustafson 2018
Pleasant Valley, MN (2016-2017)	0	160 m x 160 m cleared, 80 m radius road/pad	Huso	Agriculture, Grassland, Wetlands	Tetra Tech 2017
Prairie Winds SD1, SD (2011-2012)	0	200 m x 200 m plot	Shoenfeld	Grassland	Derby et al. 2012c
Red Pine, MN (2018)	0	60 m radius road/pad	Huso	Cropland, Developed, Deciduous Tree, Open Water, Pasture, Woody Wetlands, Wetlands	Trana et al. 2019

m = meters.

Appendix H3. Fatality rates for all bats (number of bats per megawatt [MW] per year), plot size, estimator, land cover, and study citation from recently constructed wind energy facilities in South Dakota, North Dakota, and Minnesota with publicly available data.

Project	Fatality/MW/Year	Plot Size	Estimator	Land Cover	Citation
Black Oak Getty, MN (2018)	37.59	60 m radius road/pad	Huso	Cropland, Grassland, Wetlands	Pickle et al. 2019
Black Oak Getty, MN (2017)	29.88	60 m radius road/pad	Huso	Cropland, Grassland, Wetlands	Pickle et al. 2018
Lakefield, MN (2014)	20.19	100 m x 100 m cleared	Huso	Cropland, Conservation Reservation Program	Westwood 2015
Blazing Star, MN (2020)	19.06	120 m x 120 m cleared, 100 m radius road/pad	GenEst	Cropland, Pasture, Corn, Soybean	Stucker et al. 2021b
Red Pine, MN (2018)	18.74	60 m radius road/pad	Huso	Cropland, Developed, Deciduous Tree, Open Water, Pasture, Woody Wetlands, Wetlands	Trana et al. 2019
Lake Benton II, MN (2020)	18.44	120 m x 120 m cleared, 100 m radius road/pad	GenEst	Cropland, Corn, Soybean, Herbaceous	Stucker et al. 2021a
Lakefield Wind, MN (2012)	15.85	100 m x 100 m plot	Shoenfeld	Agriculture	Minnesota Public Utilities Commission (MPUC) 2012
Odell, MN (2016-2017)	6.74	120 m x 120 m cleared	Huso	Agriculture	Chodachek and Gustafson 2018
Big Blue, MN (2013)	6.33	120 m x 120 m plot	Shoenfeld	Agriculture, Corn, Soybean	Chodachek et al. 2014
Grand Meadow, MN (2013)	3.11	120 m x 120 m plot	Shoenfeld	Agriculture, Corn, Soybean	Chodachek et al. 2014
Oak Glen, MN (2013)	3.09	120 m x 120 m plot	Shoenfeld	Agriculture, Corn, Soybean	Chodachek et al. 2014
Buffalo Ridge II, SD (2011-2012)	2.81	100 m x 100 m cleared, 100 m for roads and pads	Shoenfeld	Agriculture, Grassland	Derby et al. 2012a
PrairieWinds ND1, ND (2010)	2.13	200 m x 200 m plot	Shoenfeld	Agriculture, Grassland	Derby et al. 2011c
Pleasant Valley, MN (2016-2017)	1.8	160 m x 160 m cleared, 80 m radius road/pad	Huso	Agriculture, Grassland, Wetlands	Tetra Tech 2017
Wessington Springs, SD (2009)	1.48	200 m x 200 m plot	Shoenfeld	Grassland	Derby et al. 2010a
Prairie Winds SD1, SD (2011-2012)	1.23	200 m x 200 m plot	Shoenfeld	Grassland	Derby et al. 2012c

Appendix H3. Fatality rates for all bats (number of bats per megawatt [MW] per year), plot size, estimator, land cover, and study citation from recently constructed wind energy facilities in South Dakota, North Dakota, and Minnesota with publicly available data.

Project	Fatality/MW/Year	Plot Size	Estimator	Land Cover	Citation
Crowned Ridge II, SD (2021)	0.74	120 m x 120 m square, 60 m road/pad	GenEst	Agriculture, Grassland	NA
Prairie Winds SD1, SD (2013-2014)	0.52	200 m x 200 m plot, 200 m x 200 m road/pad	Shoenfeld	Grassland	Derby et al. 2014
Wessington Springs, SD (2010)	0.41	200 m x 200 m plot	Shoenfeld	Grassland	Derby et al. 2011a

m = meters.

Appendix H4. Wind energy projects, project characteristics, and study citations from publicly available wind energy facilities in South Dakota, North Dakota, and Minnesota with publicly available data.

Project	Total Turbines	Total MW	Number Turbines searched	Plot Type	Survey Frequency	Length of Study	Tower Size (m)	Citations
Black Oak Getty, MN (2017)	39	78	34	road/pad	weekly	8	80	Pickle et al. 2018
Black Oak Getty, MN (2018)	39	78	18, 17	road/pad	weekly, twice per week	7	80	Pickle et al. 2019
Blazing Star, MN (2020)	100	200	5, 10, 33, 60	cleared, road/pad	twice per week, weekly	8		Stucker et al. 2021b
Big Blue, MN (2013)	18	36	10	full plot	daily	4	120	Chodachek et al. 2014
Black Oak Getty, MN (2017)	39	78	34, 5, 34	road/pad, cleared, road/pad	weekly, twice per week, weekly	8	80	Pickle et al. 2018
Black Oak Getty, MN (2018)	39	78	18, 17	road/pad	weekly, twice per week	7	80	Pickle et al. 2019
Blazing Star, MN (2020)	100	200	5, 10, 33, 60	cleared, road/pad	twice per week, weekly	8		Stucker et al. 2021b
Buffalo Ridge I, SD (2009-2010)	24	50.4	6, 5, 2	full plot, mowed strips, cleared	monthly, weekly	11.9	80	Derby et al. 2010b
Buffalo Ridge II, SD (2011-2012)	105	210	5, 60	cleared, road/pad	weekly, monthly	11.5	78	Derby et al. 2012a
Elm Creek II, MN (2011-2012)	62	148.8	20, 8, 2, 10	full plot, mowed strips, cleared, road/pad	monthly, weekly	11.1	80	Derby et al. 2012b

Appendix H4. Wind energy projects, project characteristics, and study citations from publicly available wind energy facilities in South Dakota, North Dakota, and Minnesota with publicly available data.

Project	Total Turbines	Total MW	Number Turbines searched	Plot Type	Survey Frequency	Length of Study	Tower Size (m)	Citations
Elm Creek, MN (2009-2010)	67	100.5	3, 16, 10	cleared, mowed strips	monthly, weekly	12.1	80	Derby et al. 2010c
Grand Meadow, MN (2013)	67	101	13	full plot	daily	4	80	Chodachek et al. 2014
Lake Benton II, MN (2020)	44	100	5, 39	cleared, road/pad	weekly	8	80	Stucker et al. 2021a
Lakefield Wind, MN (2012)	137	205.5	26	full plot	other	7.7	80	Minnesota Public Utilities Commission (MPUC) 2012
Lakefield, MN (2014)	137	205.5	26	cleared	other	4	80	Westwood 2015
Moraine II, MN (2009)	33	49.5	4, 1, 15, 7, 2	full plot, mowed strips, cleared	monthly, weekly	9.1	64.7	Derby et al. 2010d
Oak Glen, MN (2013)	24	44	10	full plot	daily	4	80	Chodachek et al. 2014
Odell, MN (2016-2017)	100	200	15	cleared	monthly, weekly	12	80	Chodachek and Gustafson 2018
Pleasant Valley, MN (2016-2017)	100	200	5, 92, 95	cleared, road/pad	weekly, monthly, weekly	12	80	Tetra Tech 2017
Prairie Winds SD1, SD (2011-2012)	108	162	50	full plot	twice per month, monthly	11.2	80	Derby et al. 2012c
Prairie Winds SD1, SD (2012-2013)	108	162	50, 37, 13	full plot, road/pad	twice per month, monthly	11.5	80	Derby et al. 2013
Prairie Winds SD1, SD (2013-2014)	108	162	9, 36	full plot, road/pad	twice per month, monthly	11.8	80	Derby et al. 2014
PrairieWinds ND1, ND (2010)	77	115.5	35	full plot	twice per month	7.6	80	Derby et al. 2011c
PrairieWinds ND1, ND (2011)	77	115.5	35, 17	full plot	twice per month	7.6	80	Derby et al. 2012d
Red Pine, MN (2018)	100	200	40	road/pad	weekly	8	80	Trana et al. 2019
Rugby, ND (2010-2011)	71	149	22, 10, 1, 3, 28, 6, 32	full plot, cleared, mowed strips	monthly, weekly	12	80	Derby et al. 2011b
Thunder Spirit, ND (2016-2017)	43	107.5	10, 33	full plot, road/pad	twice per month	10	75	Derby et al. 2018
Wessington Springs, SD (2009)	34	51	20	full plot	twice per month	8.5	80	Derby et al. 2010a

Appendix H4. Wind energy projects, project characteristics, and study citations from publicly available wind energy facilities in South Dakota, North Dakota, and Minnesota with publicly available data.

Project	Total Turbines	Total MW	Number Turbines searched	Plot Type	Survey Frequency	Length of Study	Tower Size (m)	Citations
Wessington Springs, SD (2010)	34	51	20	full plot	twice per month	8.4	80	Derby et al. 2011a

MW = megawatt; m = meters.

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