Post-Construction Bird and Bat Fatality Monitoring Study

Dakota Range I and II Wind Project

Grant and Codington Counties, South Dakota

Year 2: April – December 2023

Prepared for:

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WEST

EXECUTIVE SUMMARY

Northern States Power, a Minnesota corporation, d/b/a Xcel Energy, contracted Western EcoSystems Technology, Inc. to conduct a post-construction fatality monitoring (PCM) study at the Dakota Range I and II Wind Project (Project). The study was developed and implemented to estimate bird and bat fatality rates resulting from Project operations. This report presents the results of the second year of PCM, conducted from April 20 – December 15, 2023 (Year 2).

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 the first year of PCM at the Project as well as 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-two turbines were selected for carcass searches at the Project, with seasons defined as spring (April 20 – June 19), summer (June 20 – September 12) and fall (September 13 – December 15). Following search methods from the first year of PCM at the Project (Year 1), the 22 search turbines were intended to be searched as square plots beginning March 15 until vegetation (i.e., crops) obstructed visibility, at which time the 22 turbines would be searched as road and pad plots (during the crop-in period). Once crops were harvested, square plot searches would resume. The survey schedule during Year 2 was amended due to excessive snow in the spring of 2023 which prevented safe road access to the turbines until April 20. Furthermore, the snow cover and subsequent muddy field conditions prevented safe access to square plots until May 23. Therefore, road and pad searches were conducted at the 22 search turbines from April 20 – May 22, after which square plot searches were conducted until the crop-in period when searches switched back to road and pad surveys. Once crops were harvested in the fall, square plot searches resumed for the remainder of the study. Turbines 13, 22, 46, and 60 were searched as road and pad plots for the entire study period due to obstacles within the square plots that prevented safe access. Square plots consisted of a 150- x 150-meter (m; 492- x 492-foot [ft]) square centered on the turbine, and road and pad plots included all area on the gravel pads and access roads out to 100 m (328 ft) from the turbine.

During the study, 43 bird carcasses and 54 bat carcasses were found during searches or incidentally. Of these, eight bird carcasses and 11 bat carcasses were found outside of search areas, seven bird carcasses had an estimated time of death outside of the study period, and two bird carcasses were non-volant juveniles. Twenty-two identifiable bird species and four bat species were found as fatalities during the study. Three raptor species were found as fatalities, including one bald eagle, one red-tailed hawk, and one ferruginous hawk, all found in fall. One non-eagle unidentified raptor and one unidentified buteo were also found. The ferruginous hawk and non-eagle unidentified raptor were found outside of the search area, and the unidentified buteo was excluded from analysis because it was found during the first search at a square plot after switching from a road and pad plot (i.e., counted as a clearing search); therefore, only the

bald eagle and red-tailed hawk were included in the analysis. No federally- or state-listed threatened or endangered species were found as fatalities. Six sensitive species were found during the study (considered Species of Greatest Conservation Need), including American white pelican (four carcasses), ferruginous hawk (one), bald eagle (one), hoary bat (25), eastern red bat (17), and silver-haired bat (seven). The bald eagle is also protected by the Bald and Golden Eagle Protection Act.

Twenty-six bird carcasses and 43 bat carcasses were included in the analysis. The overall estimated bird fatality rate was 2.96 bird fatalities/megawatt (MW)/study period, which is similar to the Year 1 value (2.30). The overall estimated raptor fatality rate was 0.41 raptor fatalities/MW/study period (no raptor fatalities were included in the Year 1 analysis). The overall estimated bat fatality rate was 18.71 bat fatalities/MW/study period, which is slightly higher than the Year 1 value (14.19). The timing of bat fatalities at the Project (primarily documented from late July through late August) was slightly earlier than in Year 1 (primarily mid-August to early September). The estimated bird fatality rate by season was 0.57 bird fatalities/MW in spring, 1.90 in summer, and 0.44 in fall. The estimated bat fatality rate by season was 0.82 bat fatalities/MW in spring, 17.15 in summer, and 0.76 in fall.

STUDY PARTICIPANTS

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REPORT REFERENCE

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ACRONYMS AND ABBREVIATIONS

AICc	corrected Akaike Information Criterion
BGEPA	Bald and Golden Eagle Protection Act
cm	centimeter(s)
CI	confidence interval
CP	carcass persistence
CPT	carcass persistence trial
ft	feet or foot
GenEst	generalized estimator of fatality
in	inch(es)
k	detection reduction factor
km	kilometer(s)
m	meter(s)
MCP	minimum convex polygon
mi	mile(s)
MW	megawatt(s)
PCM	post-construction fatality monitoring
Project	Dakota Range I and II Wind Project
QA/QC	quality assurance/quality control
SDGFP	South Dakota Game, Fish, and Parks
SEEF	searcher efficiency
SEEF carcasses	SEEF trial carcasses
SGCN	Species of Greatest Conservation Need
TWL	truncated weighted maximum likelihood
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 (Xcel Energy) owns and operates the Dakota Range I and II Wind Project (Project), located in Grant and Codington counties, South Dakota (Figure 1). The Project became operational in 2022 with an installed nameplate capacity of 302 megawatts (MW). The Project consists of 72 wind turbines: one Vestas V120 2.2-MW turbine with an 80-meter (m; 262-feet [ft]) hub height and 120-m (394-ft) rotor diameter, seven Vestas V136 3.8-MW turbines, and 64 Vestas V136 4.3-MW turbines (Appendix A). All Vestas V136 turbines at the Project have an 82-m (269-ft) hub height and 136-m (446-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 Project's South Dakota Public Utilities Commission site permit (number EL18-003) requires two years of PCM to be conducted at the Project. WEST conducted the first year of PCM from March – December 2022 (Year 1; Chodachek et al. 2023). The PCM follows guidance described in Tier 4 of the US Fish and Wildlife Service (USFWS) *Land-Based Wind Energy Guidelines* (USFWS 2012).

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 the first year of PCM at the Project as well as 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 second-year study conducted within the Project from April 20 – December 15, 2023 (Year 2).

PROJECT LOCATION

The Project is located in northeast South Dakota within the Big Sioux Basin and Prairie Coteau 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. 1998). Topography is flat to gently rolling; elevations within a minimum convex polygon (MCP; Figure 2) of the turbine layout range from 567–629 m (1,860–2,064 ft; US Geological Survey [USGS] 2023).

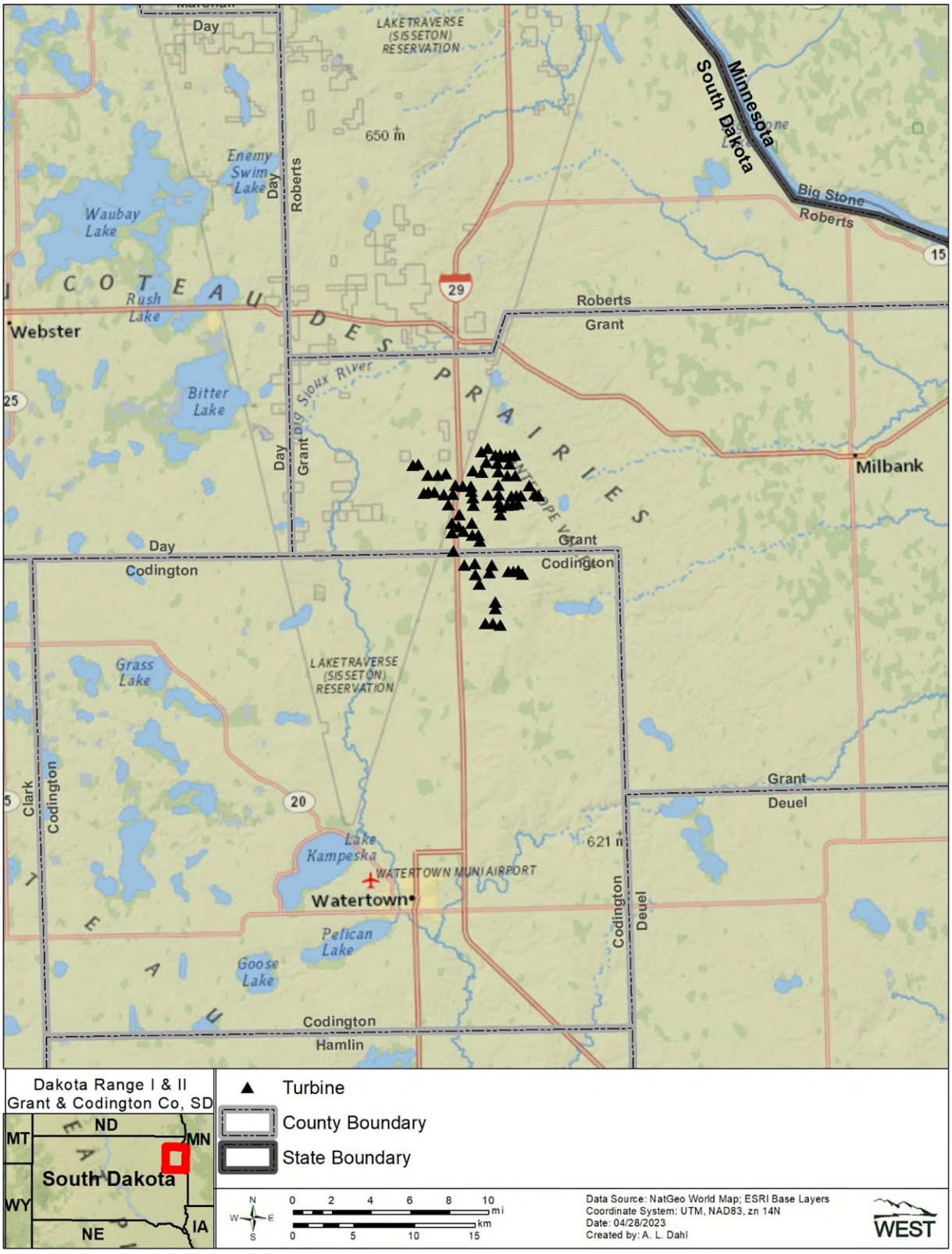

Figure 1. Location of the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota.

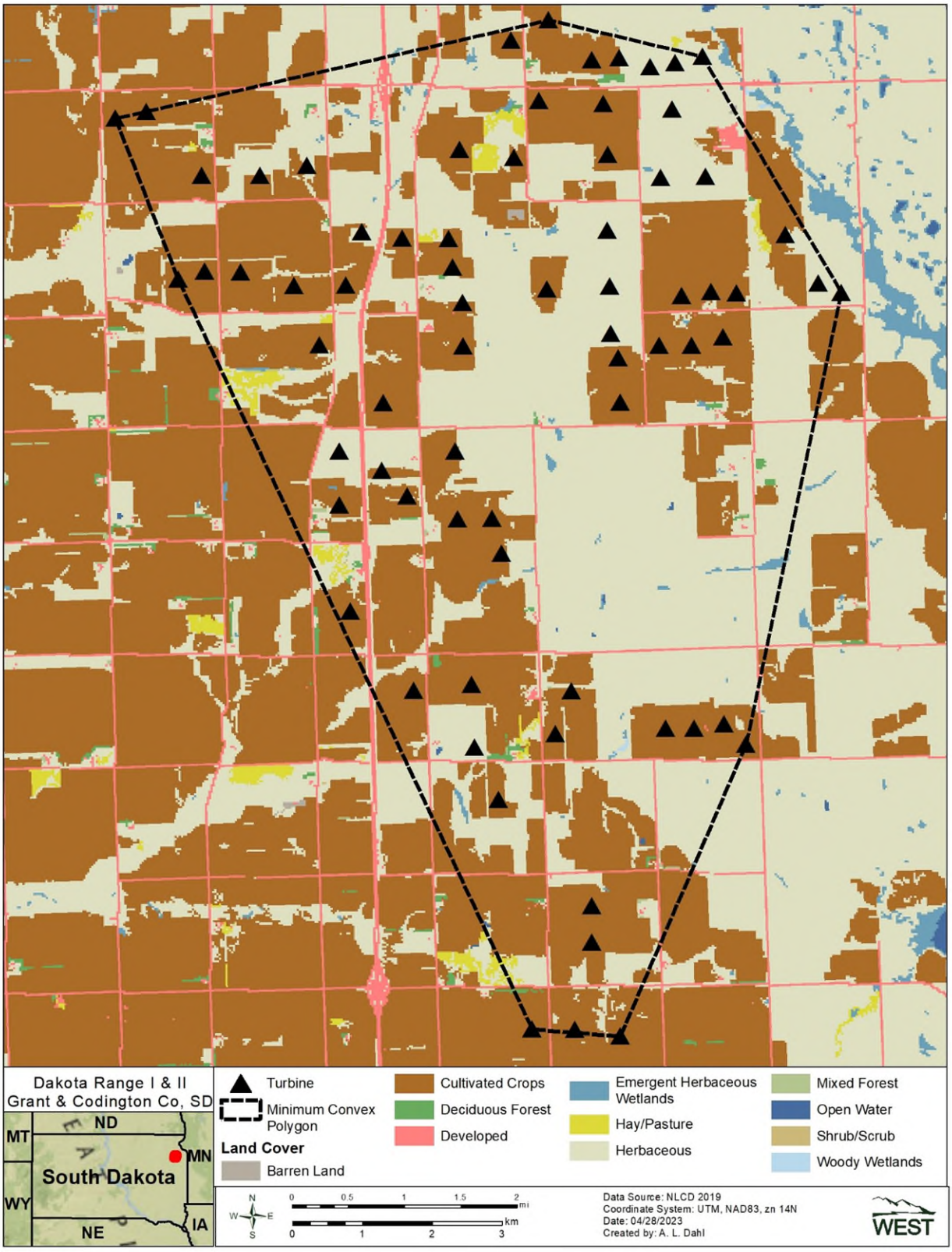

Figure 2. Land cover types within and adjacent to the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota.

The dominant land cover type in the MCP is herbaceous (48.2%), followed by cultivated crops (45.9%) and developed land (4.0%; National Land Cover Database 2019; Figure 2, Table 1). The cultivated crops consist mainly of soybeans (*Glycine max)* and corn (*Zea mays;* US Department of Agriculture 2022). Remaining land cover types each account for less than 1.0% of the MCP. Wetlands are relatively sparse but evenly distributed within the MCP and consist mainly of freshwater emergent and riverine wetlands (USFWS National Wetlands Inventory 2023).

Table 1. Land cover types, coverage, and percent (%) composition within the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota.[1]

Land Cover Type	Coverage (hectares)	Coverage (acres)	% Composition
Herbaceous	4,305.3	10,638.7	48.2
Cultivated Crops	4,099.1	10,129.2	45.9
Developed Land	354.8	876.8	4.0
Hay/Pasture	79.0	195.1	0.9
Emergent Herbaceous Wetlands	38.7	95.6	0.4
Deciduous Forest	34.2	84.4	0.4
Mixed Forest	7.8	19.3	<0.1
Barren Land	3.7	9.1	<0.1
Open Water	3.6	8.9	<0.1
Woody Wetlands	1.8	4.4	<0.1
Shrub/Scrub	0.5	1.3	<0.1
Total[2]	**8,928.6**	**22,063.0**	**100**

1. Land cover composition within the minimum convex polygon of turbines.

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

Source: National Land Cover Database 2019.

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 searchers found a carcass, and 3) carcass persistence (CP) trials (CPTs) 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 B.

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 (BGEPA; 1940), state-listed as endangered or threatened (South Dakota Game, Fish, and Parks [SDGFP] 2023b), or Species of Greatest Conservation Need (SGCN; SDGFP 2014, 2023a).

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

Survey Design

Search Turbines

The same twenty-two turbines (about 30% of total turbines) that were ultimately used for carcass searches at the Project during Year 1 were also used during this study (Figure 3). Turbines were selected using a geographically balanced random sample, which allowed for the turbine selection to be random, while also spatially representing the distribution of turbines within the Project. The survey schedule was intended to follow the first year of PCM at the Project (Chodachek et al. 2023): the 22 turbines would be searched as square plots at the start of the study (March 15 as per the Year 1 protocol) until vegetation (i.e., crops) obstructed visibility (mid-June; "crop-in period"), after which searches at the 22 turbines would switch to road and pad plots. The survey schedule during Year 2 was amended due to excessive snow in the spring of 2023 which prevented safe road access to the turbines until April 20. In addition, the snow cover and subsequent muddy field conditions prevented safe access to square plots until May 23. Therefore, searches began on April 20 as road and pad plots until May 22, after which square plot searches were conducted until the crop-in period. During the crop-in period, the 22 turbines were searched as road and pad plots. Once crops were harvested in the fall and plot visibility became unobstructed (mid-November), all search turbines except turbines 13, 22, 46, and 60 were searched as square plots through the end of the study period. Turbines 13, 22, 46, and 60 were searched as road and pad plots for the entire study due to obstacles (i.e, snow blocked roads, muddy roads, dense/tall vegetation, tall fence, etc.) within the square plots that prevented safe access.

Search Areas

Search areas consisted of square plots and road and pad plots. Square plots measured 150 x 150 m (492 x 492 ft) and were centered on the turbine (Figure 4). Road and pad plots included all areas on the gravel pads and access roads out to 100 m (328 ft) from the turbine (Figure 4).

Search Frequency

Carcass searches occurred between April 20 and December 15, 2023. Seasons were defined as: spring (April 20 – June 19), summer (June 20 – September 12) and fall (September 13 – December 15). Searches were conducted once every two weeks for the duration of the study. Searches were missed on occasion due to site access issues that created unsafe working conditions (e.g., turbine maintenance, extreme weather, or impassable roads).

Search Area Delineations

Technicians delineated road and pad plots by walking along the perimeter of each plot and collecting a digital boundary file with a sub-meter handheld global positioning system. The digital file was then converted to an ArcGIS layer. Square plot boundaries were created via desktop using ArcGIS.

Figure 3. Location of turbines and search areas at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 – December 15, 2023.

Figure 4. Schematic illustrating both search area types at an example turbine. The solid line outlines a 150-meter (492-foot) square area centered on the turbine used for square plot searches. Road and pad plot searches occurred within the turbine pad and access roads out to 100 meters (328 feet) from the center of the turbine.

Standardized Carcass Searches

Searchers 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 C and D); 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 unless they were deemed incapable of flight (e.g., non-volant juveniles). Furthermore, any injured birds or bats observed within search areas or elsewhere in the Project were recorded and considered as fatalities for the analysis. Data recorded for all carcasses included:

- an identification code
- species, sex, and age (when identifiable)
- date and time
- location (i.e., coordinates in decimal degrees)
- distance from turbine measured using a handheld rangefinder
- bearing from turbine determined using a handheld compass
- estimated time of death
- any comments that indicated possible cause of death
- photograph(s) of carcass as found
- condition (i.e., 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 19), and collection of bird carcasses was authorized under a Federal Migratory Bird Special Purpose – Utility Permit (permit number MBPER0021440). All collected bird and bat carcasses were placed in individual re-sealable plastic bags, labeled with a unique carcass identification number, turbine number, and date, and stored in a freezer on site. Leather and 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 (Kristina Hammond [USFWS permit number ES03495B-3] and Brenna Hyzy [ES26854C-2]) verified the identification of all sensitive bat species or suspected sensitive bat species.

Searcher Efficiency Trials

The objective of SEEF trials was to estimate the probability that searchers 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 searchers.

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; searchers 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). Commercially available brown-colored house mice (*Mus musculus*) were used as surrogates for bats.

The bias trial administrator placed SEEF carcasses in search areas at predetermined 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 (across all size classes) 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 searcher confirmed with the bias trial administrator whether any missed trial carcasses were available for detection.

Carcass Persistence Trials

The objective of CPTs was to estimate the probability that 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. CPTs 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.

The same species of large and small bird carcasses used for SEEF trials were used for CPTs, including non-protected, commercially available species. Large bird carcasses found during carcass

searches were also used for large bird CPTs. For the square plots, CPTs were placed at both searched and non-searched turbines throughout the study period. During periods of high vegetation height, square plot CPTs were placed at searched turbines. Road and pad plot CPTs were placed at non-searched turbines throughout the study period. Trial carcasses were placed randomly (random distance and direction from a turbine). 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.

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, 21, 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 tablet data entry procedures. All data collected were recorded on a tablet data form. Following each day of field surveys, technicians were responsible for inspecting data forms for completeness and accuracy. If errors or anomalies were found, follow-up measures were implemented including discussions and review of field data with technicians and/or project managers.

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 (i.e., all birds, large birds, diurnal 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).

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*"; see below), and a search area adjustment. Estimates and confidence intervals (CIs) were calculated using a parametric bootstrap (Dalthorp et al. 2018) 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 were 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 CPTs 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). Covariates were fit to each of the parameters of the distributions and the only covariate considered was season. 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 implied 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); this value was assumed in this study for bats and birds.

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 80 m (262 ft) away from the turbine on a square plot searched out to 75 m [246 ft] 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.

Search area adjustment analysis methods vary based on the number of carcasses observed and the carcass size. In general, at least 30 carcasses are required to use the truncated weighted maximum likelihood (TWL) modeling approach (Khokan et al. 2013). In this study, the TWL approach was used for bats. Large bird and small bird area adjustments were estimated using a physics-based model (Hull and Muir 2013). Using the Hull and Muir method, 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). Although the Project has turbines with multiple rotor diameters and hub heights, for this analysis, an 82-m hub height and the maximum rotor diameter (136 m) were used to calculate the Hull and Muir area corrections. 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 C, all carcasses found are presented in Appendix D, SEEF model selection is presented in Appendix E, CP data are presented in Appendix F, search area adjustment models are presented in Appendix G, and fatality estimates by season and plot type are presented in Appendix H.

Standardized Carcass Searches

In total 400 searches were conducted, including 278 carcass searches at road and pad plots from April 20 – December 15, 2023 and 122 searches at square plots from May 23 – December 15, 2023. Both search area types were searched in spring, summer, and fall. The average search interval was 12.2 days at both search plot types across the study period.

During the study, 43 bird carcasses and 54 bat carcasses were found (Table 2). Of these, eight bird carcasses and 11 bat carcasses were found outside of search areas, seven bird carcasses had an estimated time of death outside of the study period, and two bird carcasses were non-volant juveniles (cause of death was not related to a wind turbine collision); these 28 carcasses were excluded from the fatality estimate analyses. Twenty-six bird carcasses including two raptors and 43 bat carcasses were included in the analysis.

Table 2. Number and percent (%) of carcasses by species included and excluded from analysis at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 – December 15, 2023.

	Included in Analysis		Outside Search Area[1]		Outside Study Period[1]		Other[1,2]		Total	
Type/Species	**Total**	**%**	**Total**	**%**	**Total**	**%**			**Total**	**%**
Birds										
American white pelican	1	3.8	3	37.5	0	0	0	0	4	9.3
horned lark	3	11.5	0	0	0	0	0	0	3	7.0
mallard	2	7.7	1	12.5	0	0	0	0	3	7.0
house wren	2	7.7	0	0	1	14.3	0	0	3	7.0
marsh wren	2	7.7	0	0	1	14.3	0	0	3	7.0
ring-billed gull	1	3.8	1	12.5	0	0	0	0	2	4.7
yellow warbler	0	0	0	0	2	28.6	0	0	2	4.7
killdeer	0	0	0	0	0	0	2	100	2	4.7
bald eagle	1	3.8	0	0	0	0	0	0	1	2.3
cliff swallow	1	3.8	0	0	0	0	0	0	1	2.3
common grackle	1	3.8	0	0	0	0	0	0	1	2.3
eastern kingbird	1	3.8	0	0	0	0	0	0	1	2.3
ruby-crowned kinglet	1	3.8	0	0	0	0	0	0	1	2.3
red-tailed hawk	1	3.8	0	0	0	0	0	0	1	2.3
sedge wren	1	3.8	0	0	0	0	0	0	1	2.3
Townsend's warbler	1	3.8	0	0	0	0	0	0	1	2.3
turkey vulture	1	3.8	0	0	0	0	0	0	1	2.3
unidentified duck	1	3.8	0	0	0	0	0	0	1	2.3
unidentified passerine	1	3.8	0	0	0	0	0	0	1	2.3
unidentified sparrow	1	3.8	0	0	0	0	0	0	1	2.3
unidentified warbler	1	3.8	0	0	0	0	0	0	1	2.3
unidentified wren	1	3.8	0	0	0	0	0	0	1	2.3
vesper sparrow	1	3.8	0	0	0	0	0	0	1	2.3
ferruginous hawk	0	0	1	12.5	0	0	0	0	1	2.3
sora	0	0	1	12.5	0	0	0	0	1	2.3
unidentified raptor	0	0	1	12.5	0	0	0	0	1	2.3
American coot	0	0	0	0	1	14.3	0	0	1	2.3
dark-eyed junco	0	0	0	0	1	14.3	0	0	1	2.3
unidentified buteo	0	0	0	0	1	14.3	0	0	1	2.3
Overall Birds[2]	**26**	**100**	**8**	**100**	**7**	**100**	**2**	**100**	**43**	**100**
Bats										
hoary bat	18	41.9	7	63.6	0	0	0	0	25	46.3
eastern red bat	14	32.6	3	27.3	0	0	0	0	17	31.5

Table 2. Number and percent (%) of carcasses by species included and excluded from analysis at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 – December 15, 2023.

	Included in Analysis		Outside Search Area[1]		Outside Study Period[1]		Other[1,2]		Total	
Type/Species	**Total**	**%**	**Total**	**%**	**Total**	**%**			**Total**	**%**
silver-haired bat	7	16.3	0	0	0	0	0	0	7	13.0
big brown bat	4	9.3	1	9.1	0	0	0	0	5	9.3
Overall Bats	**43**	**100**	**11**	**100**	**0**	**0**	**0**	**0**	**54**	**100**

1. Carcasses not included in analysis.
2. Non-volant juveniles; cause of death was not from a wind turbine collision.
3. Sums can differ from total values shown due to rounding.

Sensitive Species

No federally or state-listed threatened or endangered species were found as fatalities. Sensitive species found as fatalities included three bird species and three bat species (considered SGCN). Sensitive species included American white pelican (four carcasses), bald eagle (one), ferruginous hawk (one), hoary bat (25), eastern red bat (17), and silver-haired bat (seven; Table 3, Appendices C and D). The bald eagle is also protected under the BGEPA.

The four American white pelican fatalities were found in early May, early June, and late October. Two of the four American white pelicans were found during searches at turbines 7 and 65, while two were found incidentally at turbines 3 and 52. The bald eagle fatality was found during a carcass search at Turbine 7 on November 29. The ferruginous hawk fatality was found during a carcass search at Turbine 22 on October 26. Seasonal and spatial trends in bat fatalities, including the three SGCN bat species, are included in the results and discussion below.

Table 3. Sensitive species found during post-construction fatality monitoring at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 – December 15, 2023.

Type/Common Name	Scientific Name	Status	Number of Fatalities
Birds			
American white pelican	*Pelecanus erythrorhynchos*	SGCN	4
bald eagle	*Haliaeetus leucocephalus*	SGCN; BGEPA	1
ferruginous hawk	*Buteo regalis*	SGCN	1
Bats			
hoary bat	*Lasiurus cinereus*	SGCN	25
eastern red bat	*Lasiurus borealis*	SGCN	17
silver-haired bat	*Lasionycteris noctivagans*	SGCN	7

SGCN = Species of Greatest Conservation Need, as designated in the South Dakota Wildlife Action Plan (SDGFP 2014, 2023a); BGEPA = Bald and Golden Eagle Protection Act (1940).

Bird Carcasses

Twenty-two identifiable bird species were found as fatalities during the study; carcasses of 16 species were included in the analysis (Table 2, Appendix C). Among bird species found as fatalities, American white pelican was the most common (four carcasses, 9.3% of total bird carcasses), followed by horned lark, house wren, mallard, and marsh wren (three carcasses each, 7.0% each; Table 2). The next three most common species found as fatalities included killdeer (determined to be too young to fly and not turbine-related), ring-billed gull, and yellow warbler (two carcasses each; 4.7% each). One fatality (2.3%) of each of the remaining identifiable bird species was found (Table 2).

Five raptors were found as fatalities during searches, with three species documented: one each of bald eagle, ferruginous hawk, and red-tailed hawk (Table 2). The bald eagle and red-tailed hawk were included in the analysis while the ferruginous hawk was excluded because it was found outside of the searched area. Two raptors could not be identified to species, including one non-eagle found outside the plot and one unidentified buteo found during the first search at a

square plot after a seasonal switch from a road and pad plot (i.e., counted as a clearing search); both were excluded from analysis.

Bird carcasses included in analysis were located at 77.3% of searched turbines (Figure 5). Bird carcasses were generally found throughout the Project (Figure 5). The highest number of bird carcasses were found at turbines 1, 3, 19, and 68 (three carcasses at each; Figure 5, Appendix D).

The first bird carcass detected during square plot searches and included in the analysis was found during the June 13 – 19 visit (Figure 6a). The first bird carcass detected during road and pad searches and included in the analysis was found during the May 11 – 12 visit (Figure 6b). Bird carcasses were generally found more often during summer compared to spring and fall (Figures 6a and 6b).

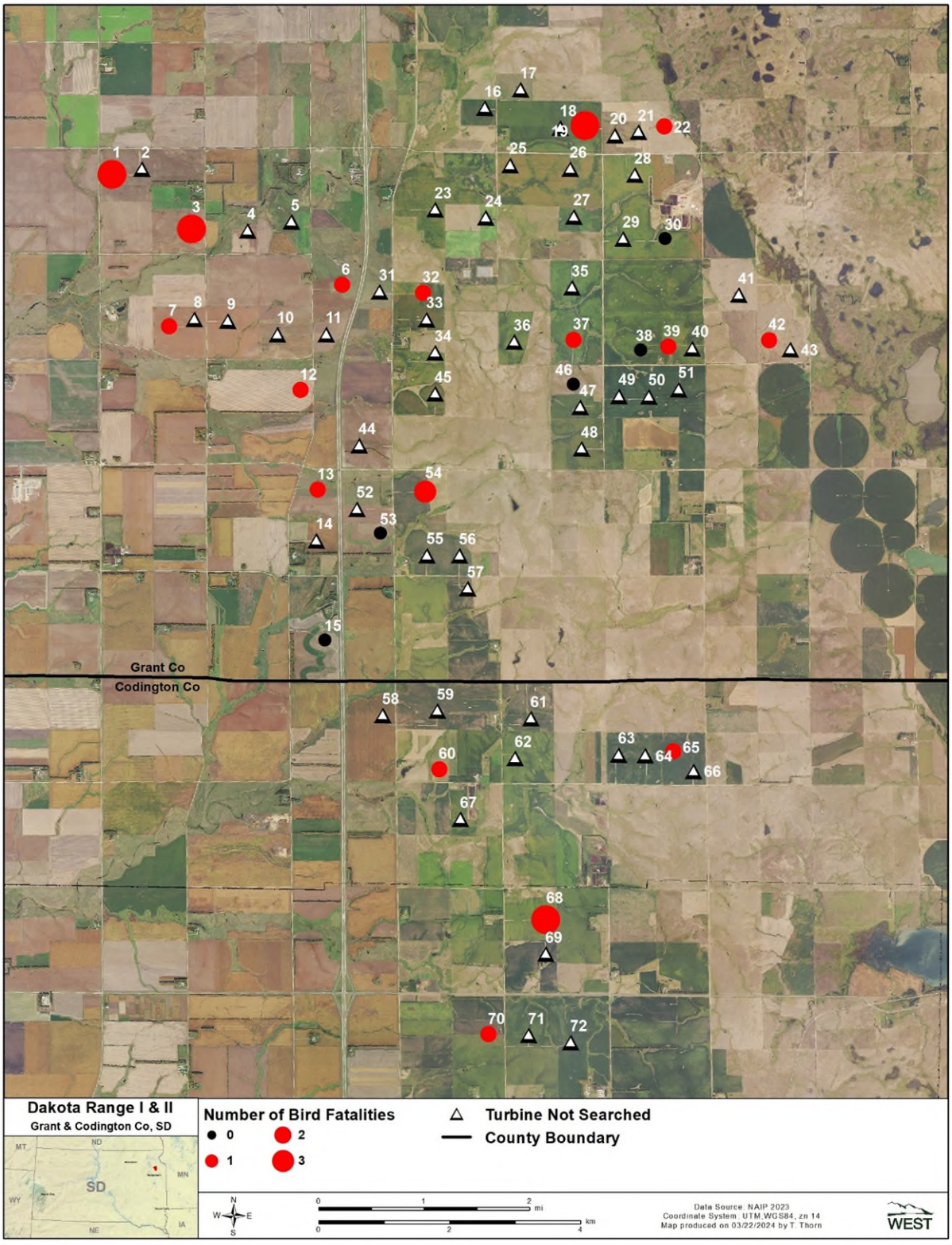

Figure 5. Location of all bird carcasses included in GenEst analysis found at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 – December 15, 2023.

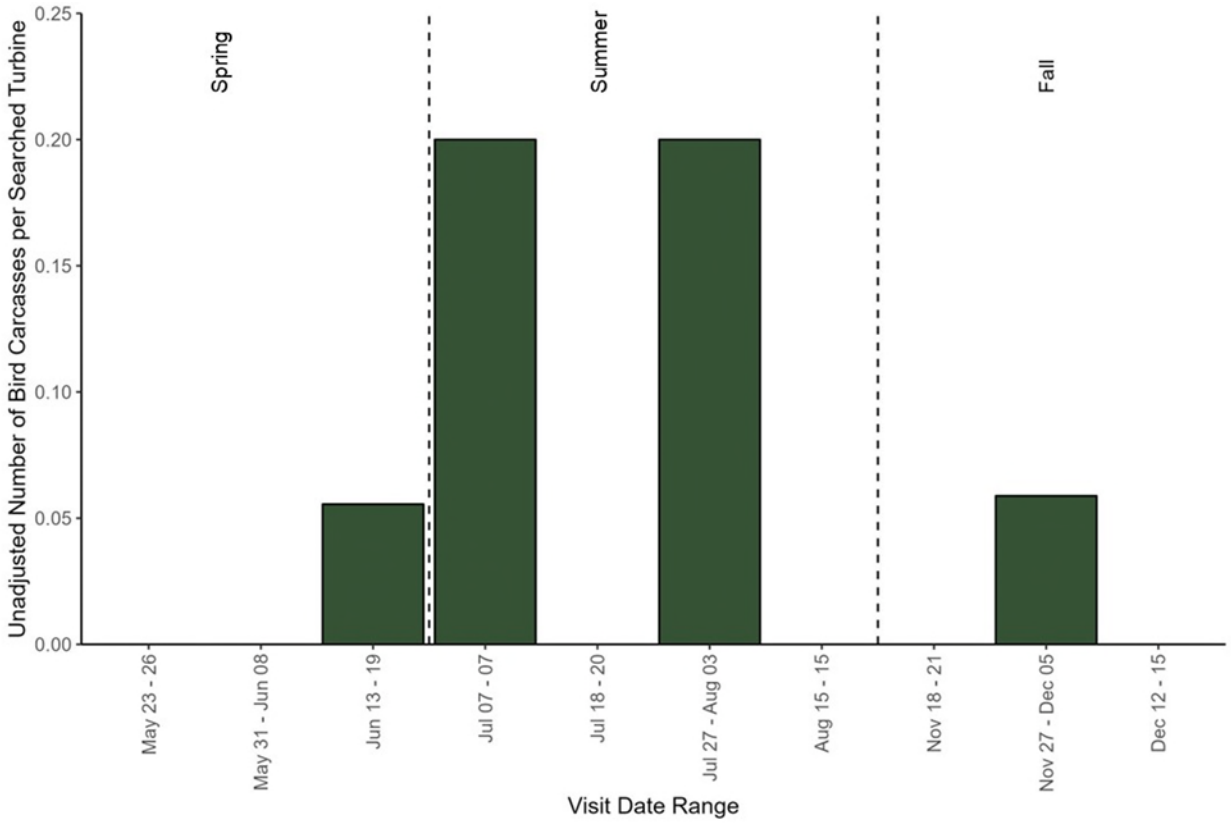

Figure 6a. Temporal distribution of bird carcasses per turbine searched included in GenEst analysis at square plots (unadjusted for searcher efficiency and carcass persistence) at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from May 23 – December 15, 2023.

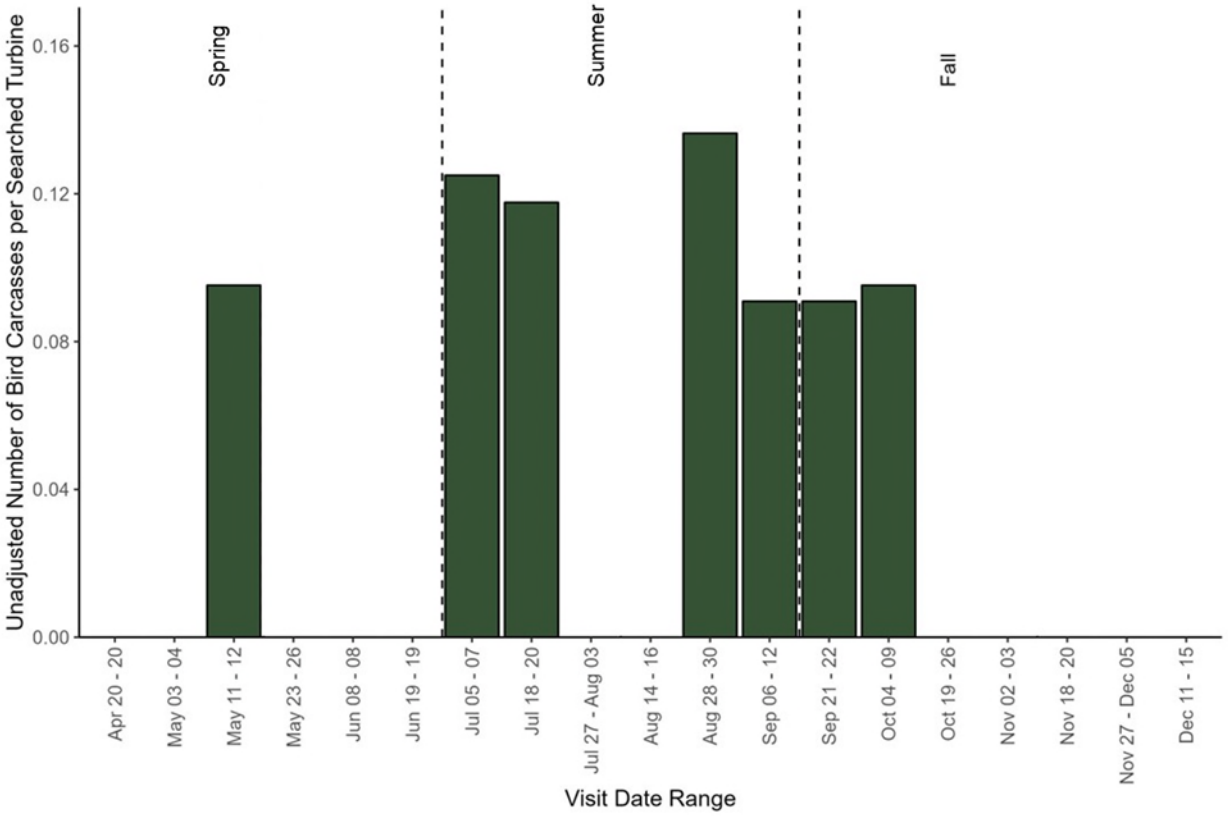

Figure 6b. Temporal distribution of bird carcasses per turbine searched (unadjusted for searcher efficiency and carcass persistence) included in GenEst analysis found at road and pad plots at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 – December 15, 2023.

Bat Carcasses

Four bat species were found as fatalities during the study and were included in analysis (Table 2, Appendix C). Hoary bat was the most common (25 carcasses, 46.3% of total bat carcasses), followed by eastern red bat (17; 31.5%), silver-haired bat (seven; 13.0%), and big brown bat (five, 9.3%; Table 2).

Bat carcasses included in analysis were found at 90.9% of searched turbines (Figure 7). The most bat carcasses were found at Turbine 7 (five carcasses), followed by Turbine 30 (four), and turbines 15, 38, 39, 42, and 65 (three at each one). Bat carcasses were generally found throughout the Project (Figure 7; Appendix D).

Most bat carcasses included in analysis were found in the latter part of summer (Figures 8a and 8b). The highest number of bat carcasses at square plots and road and pad plots were found during the July 27 – August 3 visit (Figures 8a and 8b).

Figure 7. Location of all bat carcasses included in GenEst analysis found at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, April 20 – December 15, 2023.

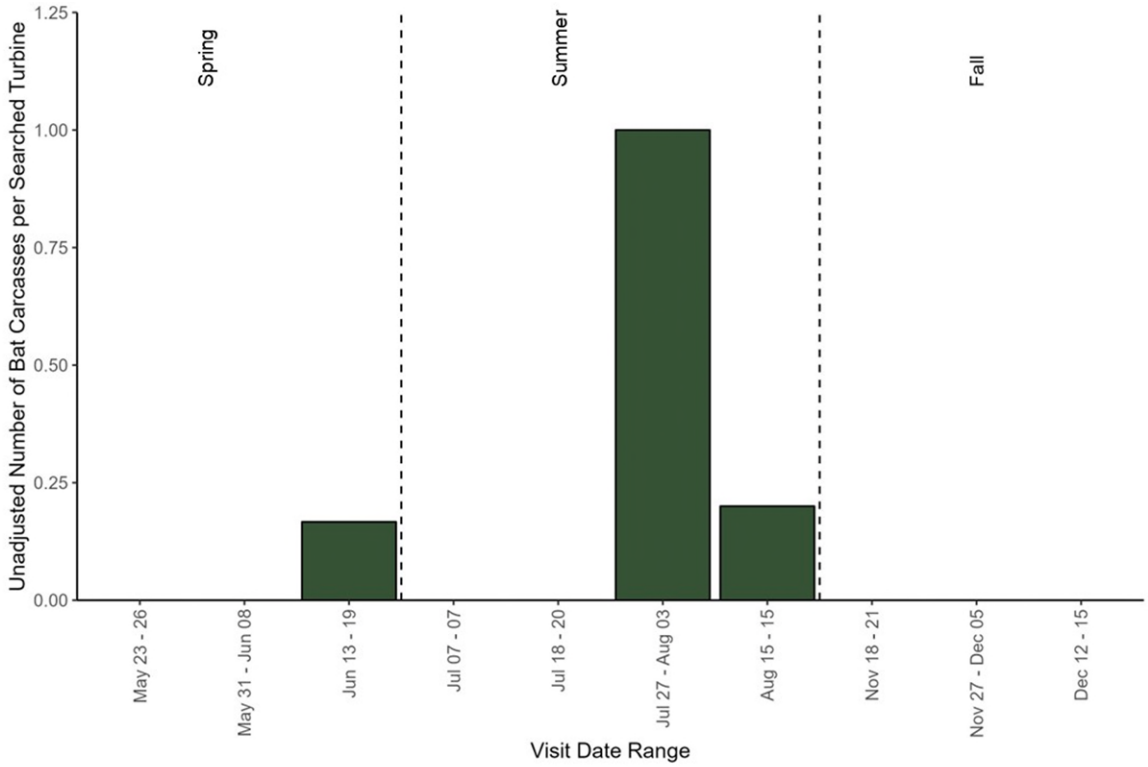

Figure 8a. Temporal distribution of bat carcasses per turbine searched included in GenEst analysis at square plots (unadjusted for searcher efficiency and carcass persistence) at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from May 23 – December 15, 2023.

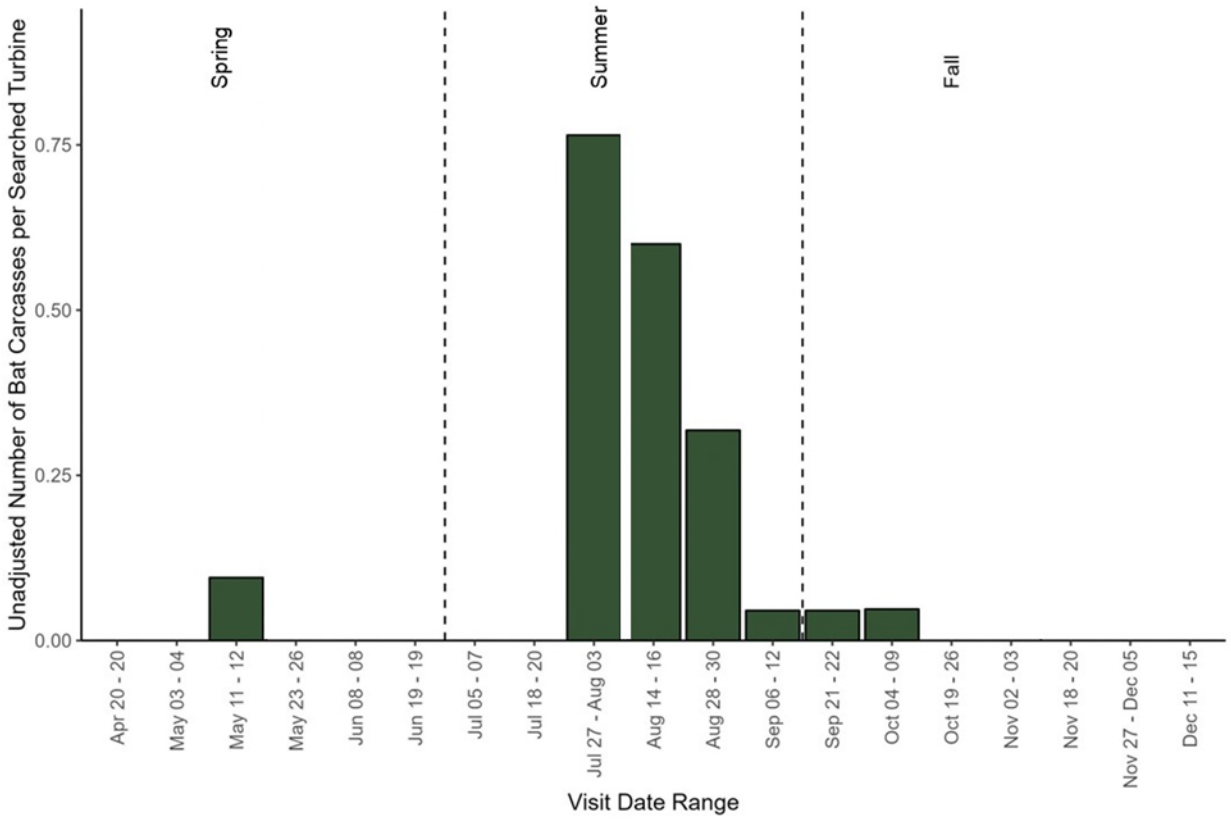

Figure 8b. Temporal distribution of bat carcasses per turbine searched (unadjusted for searcher efficiency and carcass persistence) included in GenEst analysis found at road and pad plots at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 – December 15, 2023.

Searcher Efficiency Trials

One hundred and four carcasses (32 large birds, 36 small birds, and 36 bat surrogates) were placed for SEEF trials in square plots. Ninety-five of those carcasses (31 large birds, 31 small birds, and 33 bat surrogates) remained available for the technician to find during scheduled searches (Table 4a). The technician found 83.9% of large bird carcasses, 41.9% of small bird carcasses, and 39.4% of bat carcasses.

At road and pad plots, 92 carcasses (29 large birds, 30 small birds, and 33 bat surrogates) were placed for SEEF trials. Eighty-six carcasses (28 large birds, 27 small birds, and 31 bat surrogates) remained available for the technician to find during scheduled searches (Table 4b). The technician found 100% of large bird carcasses, 92.6% of small bird carcasses, and 96.8% of bat carcasses.

Table 4a. Searcher efficiency results for square plots as a function of season and carcass size at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from May 23 – December 15, 2023.

Size Class	Season[1]	Number Placed	Number Available	Number Found	Percent Found
Large Bird	Spring	10	10	10	100
	Summer	10	10	7	70.0
	Fall	12	11	9	81.8
	Overall	**32**	**31**	**26**	**83.9**
Small Bird	Spring	15	12	6	50.0
	Summer	10	9	2	22.2
	Fall	11	10	5	50.0
	Overall	**36**	**31**	**13**	**41.9**
Bat	Spring	15	13	4	30.8
	Summer	10	9	4	44.4
	Fall	11	11	5	45.5
	Overall	**36**	**33**	**13**	**39.4**

[1] Spring = April 20 – June 19; Summer = June 20 – September 12; Fall = September 13 – December 15.

Table 4b. Searcher efficiency results for road and pad plots as a function of season and carcass size at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 – December 15, 2023.

Size Class	Season[1]	Number Placed	Number Available	Number Found	Percent Found
Large Bird	Spring	9	9	9	100
	Summer	10	9	9	100
	Fall	10	10	10	100
	Overall	**29**	**28**	**28**	**100**
Small Bird	Spring	10	8	7	87.5
	Summer	10	9	8	88.9
	Fall	10	10	10	100
	Overall	**30**	**27**	**25**	**92.6**
Bat	Spring	11	9	9	100
	Summer	12	12	12	100
	Fall	10	10	9	90.0
	Overall	**33**	**31**	**30**	**96.8**

[1] Spring = April 20 – June 19; Summer = June 20 – September 12; Fall = September 13 – December 15.

Models were fit for each carcass size class to determine whether season or plot type covariates provided the best model for estimating SEEF rates based on AICc values. A model with a plot type covariate provided the best fit for modeling large bird, small bird, and bat SEEF (Appendices E1–E3).

Estimated annual SEEF rates in square plots were 0.84 (90% CI: 0.70–0.92) for large birds and diurnal raptors, and 0.42 (90% CI: 0.28–0.57) for small birds (Appendix H1). On road and pad plots, SEEF rates were 0.98 (90% CI: 0.91–1.00) for large birds and diurnal raptors, and 0.93 (90% CI: 0.79–0.98) for small birds (Appendix H2). The annual SEEF rate in square plots for bats was 0.39 (90% CI: 0.27–0.54), and in road and pad plots the SEEF rate was 0.97 (0.85–0.99).

Carcass Persistence

In total, 181 carcasses (60 large birds, 61 small birds, and 60 bat surrogates) were placed for CPTs throughout the duration of the study (Appendix F1). Large bird and bat CP were best modeled with an intercept-only model, with a Weibull distribution (Appendices F2 and F4), meaning the median removal times did not vary substantially by season. An intercept-only model also provided the best fit for estimating small bird CP, using an exponential distribution (Appendix F3). Large bird median removal time for both plot types combined was 7.97 days (Appendix F5). The median removal time was 4.95 days for small birds and 2.98 days for bats (Appendix F5).

The average probability that large bird and diurnal raptor carcasses persisted through the search interval (once every two weeks) was 0.59 (90% CI: 0.51–0.67) across all seasons (Figure 9, Appendices H1 and H2). The average probability that a small bird carcass persisted through the search interval was 0.48 (90% CI: 0.41–0.54; Figure 9, Appendices H1 and H2). The average probability that a bat carcass persisted through the search interval was 0.37 (90% CI: 0.30–0.45; Figure 9, Appendices H1 and H2).

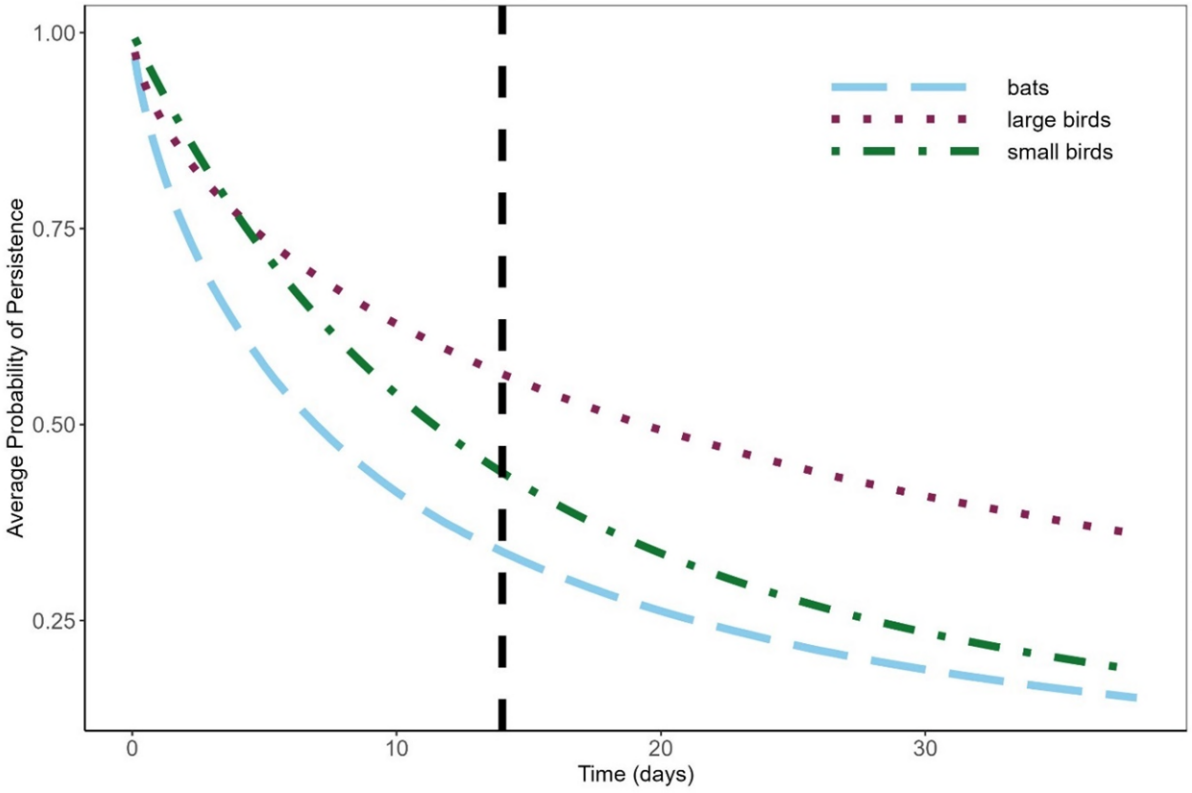

Figure 9. Average probability of carcass persistence as a function of time (days) for large birds, small birds, and bats at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 – December 15, 2023. The vertical black dashed line denotes the search interval (once every two weeks).

Search Area Adjustment

The search area adjustment model for large birds and small birds was calculated using the Hull and Muir (2013) method (Appendix G1). Although the Project has turbines with multiple rotor diameters and hub heights, for this analysis, an 82-m hub height and the maximum rotor diameter (136 m) were used to calculate the Hull and Muir area corrections. The large bird and small bird carcass-density distributions were estimated using the maximum fall distance of carcasses (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 raptor search area adjustment was calculated using the Hallingstad et al. (2018) method (Figure 11; Appendix G2).

The search area adjustment for bats was calculated using the TWL modeling approach (Figure 12; Appendix G3). A gamma distribution was the best fit for modeling the bat carcass-density distribution (Appendix G4).

The search area adjustment for square plots was 0.86 for large birds, 0.89 for diurnal raptors, 0.98 for small birds, and 0.71 (90% CI: 0–1.00) for bats (Appendix H1). The search area adjustment for road and pad plots was 0.15 for large birds, 0.03 for diurnal raptors, 0.21 for small birds, and 0.07 (90% CI: 0–0.12) for bats (Appendix H2).

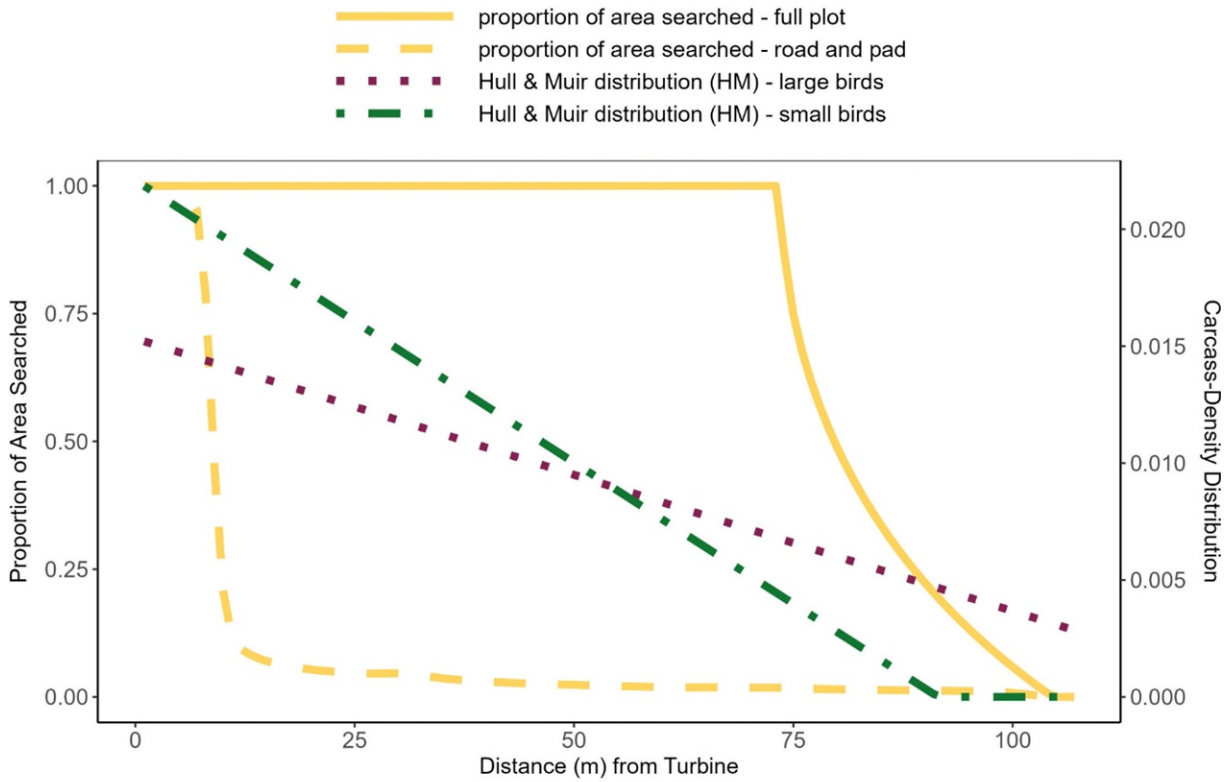

Figure 10. Estimated large and small bird carcass-density distributions, and proportion of area searched by distance from turbine for square plots and road and pad plots at Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 – December 15, 2023.

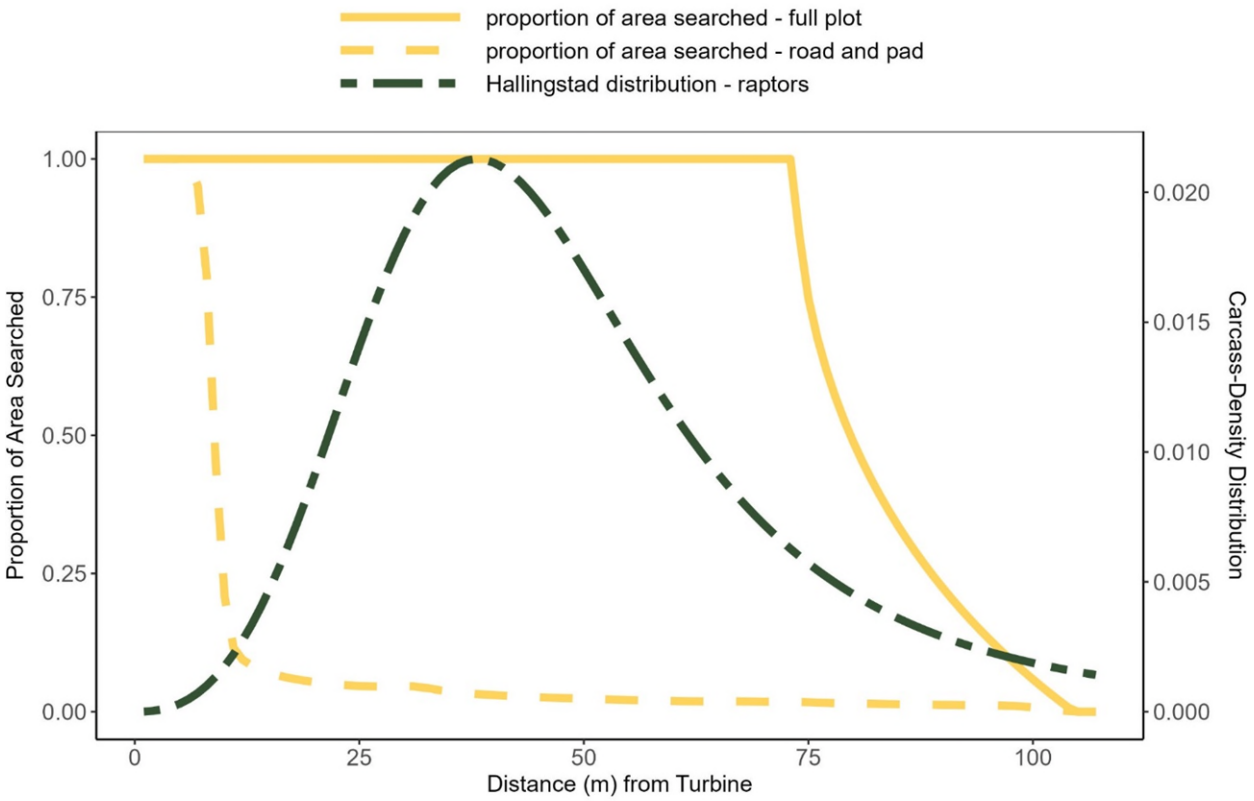

Figure 11. Estimated raptor carcass-density distribution, and proportion of area searched by distance from turbine for square plots and road and pad plots at Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 – December 15, 2023.

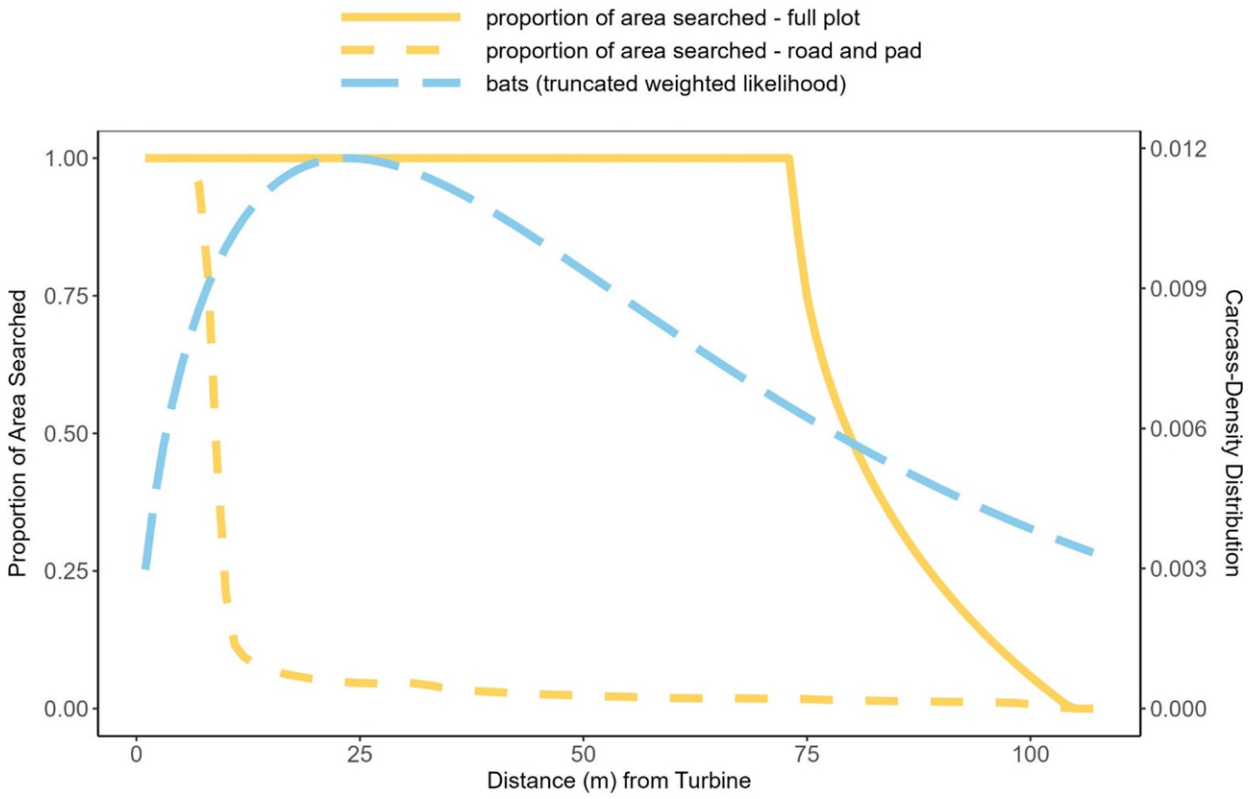

Figure 12. Estimated bat carcass-density distribution and proportion of area searched by distance from turbine for square plots and road and pad plots at Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 – December 15, 2023.

Estimated Fatality Rates

Estimated fatality rates and 90% CI were calculated on a per-MW and per-turbine basis for all birds, large birds, diurnal raptors, small birds, and bats using GenEst (Table 5). The average probability a carcass remained in the search area and was found by searchers is listed in Appendix H, which also contains separate estimated fatality rates for square plot and road and pad plot search types.

Table 5. GenEst estimated overall fatality rates per megawatt (MW) and per turbine at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 – December 15, 2023.

	Per MW Estimates		Per Turbine Estimates	
	Estimate	90% CI	Estimate	90% CI
All Bird	2.96	1.87–4.32	12.36	7.85–18.23
Large Bird	0.86	0.25–1.77	3.60	1.04–7.48
Diurnal Raptor	0.41	n/a*	1.76	n/a*
Small Bird	2.03	1.24–3.14	8.53	5.27–13.18
Bat	18.71	10.00–72.38	77.39	41.75–298.38

CI = confidence interval.

* Confidence interval not calculated because the observed carcass count is less than five.

All Birds

The overall estimated bird fatality rate was 2.96 bird fatalities/MW/study period (12.36 bird fatalities/turbine/study period), driven primarily by the small bird estimated fatality rate (2.03 fatalities/MW/study period [8.53 fatalities/turbine/study period]; Table 5). Bird fatalities included in analysis were documented during spring, summer, and fall. Estimated bird fatality rates for spring were 0.57 bird fatalities/MW (2.39 bird fatalities/turbine), in summer were 1.90 bird fatalities/MW (7.96 bird fatalities/turbine), and in fall were 0.44 bird fatalities/MW (1.82 bird fatalities/turbine; Appendix H5).

Diurnal Raptors

The overall estimated raptor fatality rate was 0.41 raptor fatalities/MW/study period (Table 5), driven entirely by raptor fatalities found during fall.

Bats

The overall estimated bat fatality rate was 18.71 bat fatalities/MW/study period (77.39 bat fatalities/turbine/study period; Table 5). Estimated bat fatality rates were calculated during spring (0.82 bat fatalities/MW [3.53 bat fatalities/turbine]), summer (17.15 bat fatalities/MW [70.73 bat fatalities/turbine] and fall (0.76 bat fatalities/MW [3.28 bat fatalities/turbine]; Appendix H5).

DISCUSSION

The overall goal for this study was to estimate the number of bird, raptor, and bat fatalities within the Project attributable to collisions with turbines. The primary objectives of PCM for all three fatality categories were to 1) document species occurring as fatalities, 2) estimate fatality rates

for the study period, 3) qualitatively evaluate spatial and temporal patterns of fatalities, 4) qualitatively compare data from the first year of PCM at the Project as well as data from PCM studies conducted at other wind energy facilities in South Dakota and neighboring states, and 5) document fatalities of sensitive species resulting from collisions with turbines at the Project.

Birds and Diurnal Raptors

Species Composition

Twenty-two identifiable bird species were documented as fatalities during the study. Overall species composition was similar between years, although, for unknown reasons, the number of total species recorded in Year 2 was about half of that in Year 1 (43; Chodachek et al. 2023). Similar to Year 1, American white pelican (four fatalities), mallard (three fatalities), house wren (three fatalities), and marsh wren (three fatalities) were the most abundant species found as fatalities during the study. These species are relatively common in this region of South Dakota (Knopf and Evans 2020; South Dakota Birds 2022a, 2022b; Sovada et al. 2013).

Similar to Year 1, no federally or state-listed threatened or endangered bird species were observed during surveys. There was one bald eagle fatality, a species protected under the BGEPA and SGCN. Two additional SGCN were found as fatalities including four American white pelicans and one ferruginous hawk.

During each year of PCM surveys at the Project, one bald eagle fatality was found during the fall period. As such, it is likely that both bald eagle fatalities were migrant eagles moving through the area. The bald eagle fatality in Year 1 was located at Turbine 56 in the central portion of the Project, and at Turbine 7 in Year 2, in the northwestern quadrant of the Project. Based on the habitat at these turbines and the surrounding area, there are no features that would serve as an attractant to bald eagles migrating through the area. During an eagle nest survey conducted for the Project in 2018 (Derby 2018), no eagle nests were documented within two miles of the Project area. The nearest bald eagle nest recorded during surveys was 3.05 km southeast of Project turbines.

American white pelicans are a relatively common species to find as a fatality at other wind energy facilities in the region (WEST 2023). American white pelican fatalities were found throughout the Project in each year of study, with fatalities documented at turbines 3 and 65 in both years. For both years of study, the majority (75% of fatalities in Year 2 and 67% in Year 1) of American white pelican fatalities occurred during May, June, and July, which are the migration and breeding seasons for pelicans in South Dakota (Sovada et al. 2013). During this time period, it is likely that pelicans are more active, making frequent trips to forage at waterbodies away from the breeding colony, thereby increasing the distribution of pelicans across the region. Bitter Lake, approximately 14 km (9 mi) to the northeast, is the closest large American white pelican breeding colony to the Project with approximately 22,000 pelicans (Sovada et al. 2013).

Ferruginous hawk, a SGCN, is one of the most common raptor fatalities in this region (WEST 2023). In South Dakota, ferruginous hawks are commonly found in grassland/prairie habitats in

central and western areas of the state (Audubon 2022, South Dakota Birds 2022c). They commonly nest in trees, on cliffs, and on the ground between April through June in South Dakota (South Dakota Birds 2024). Based on the timing of the one ferruginous hawk fatality found near the end of October 2023, it was likely a migrant.

Spatial and Temporal Patterns

Similar to Year 1 (Chodachek et al. 2023), bird fatalities included in Year 2 analysis were observed throughout the study period at many turbines throughout the Project with no apparent overall spatial pattern. The highest number of bird carcasses were found at Turbines 1, 3, 19 and 68 (three carcasses at each), but for reasons that are unclear, since the habitat at these turbines is similar to the surrounding turbines (i.e., agriculture; Figure 3). There are no unique features at these turbines that would be expected to attract birds; however, each of these turbines are on the periphery of the Project. In Year 1 the most fatalities were found at Turbine 15 (eight individuals) which is also on the Project periphery, although zero fatalities were recorded at this turbine in Year 2.

Waterbird and waterfowl carcasses included in the analysis were found mainly in the northern portion of the Project during both Year 1 and Year 2 of surveys. American white pelican (five fatalities) and mallard (four fatalities) made up most of these fatalities during Year 1 and Year 2 of surveys. A similar spatial pattern for raptor fatalities was observed between Year 1 and Year 2, with most raptor fatalities recorded at turbines in the northern portion of the Project.

The estimated Year 2 overall bird fatality rate was higher in summer compared to spring and fall (1.90, 0.57, and 0.44 bird fatalities/MW in spring, summer, and fall, respectively; Appendix H5) while in Year 1 the rates in spring and summer were relatively similar and both higher than for fall (0.98, 1.12, and 0.18 fatalities/MW/season, respectively; Chodachek et al. 2023). This suggests that although migrants passing through the area during spring and fall could potentially collide with turbines at the Project, some birds that remain in the area through the summer breeding season continue to have some exposure to risk (Arnold and Zink 2011; Longcore et al. 2013).

A similar temporal pattern between Year 1 and Year 2 was observed for two of the most common bird species found as fatalities at the Project. In each year the majority of American white pelican and mallard fatalities were found in May, June, and July, indicating these species are at greater risk of collision with turbines at the Project during late spring migration and the breeding season. During each year, raptor fatalities occurred in late fall (late October – early December), a timeframe that includes southward migration for many diurnal raptor species.

Comparison Data from Other Post-construction Fatality Monitoring Studies

Comparison figures to provide context for understanding the estimated bird fatality rates for this Project compared with other recent PCM projects at wind energy facilities in South Dakota, and the neighboring states of North Dakota, and Minnesota (Tristate Area) are provided below.

The estimated overall bird fatality rate of 2.96 bird fatalities/MW/study period (90% CI: 1.87–4.32) is in the mid- to lower range of fatality rates seen at other facilities in the Tristate Area with recently

conducted PCM studies and publicly available data; this rate is similar to the 2.30 bird fatalities/MW/study period estimated for Year 1 (Chodachek et al. 2023; Figure 13). Among other PCM studies in the Tristate Area, fatality rate estimates range from 0.41 (Crowned Ridge II, South Dakota [Chodachek et al. 2022]) to 12.18 (Blazing Star, Minnesota [Stucker et al. 2021b]). The references for the comparison projects shown in Figures 13 – 15, and referenced in this and the following text can be found in Appendix I.

No raptors were included in the Year 1 study and as such, no raptor fatality rate was calculated (Chodachek et al. 2023). The estimated fatality rate for diurnal raptors in Year 2 was 0.41 raptor fatalities/MW/study period, (Figure 14). Although the diurnal raptor fatality estimate during Year 2 is at the upper end of the range of other raptor fatality rates publicly reported from other facilities in the Tristate Area, the confidence intervals overlap the estimates of the other studies in Figure 14 and the lower bound of the confidence interval includes zero. The fatality estimates in Figure 14 ranged from zero raptor fatalities/MW/study period in 12 studies (two in South Dakota and ten in Minnesota; Appendix I2) to 0.46 (Lake Benton II, Minnesota; [Stucker et al. 2021a]).

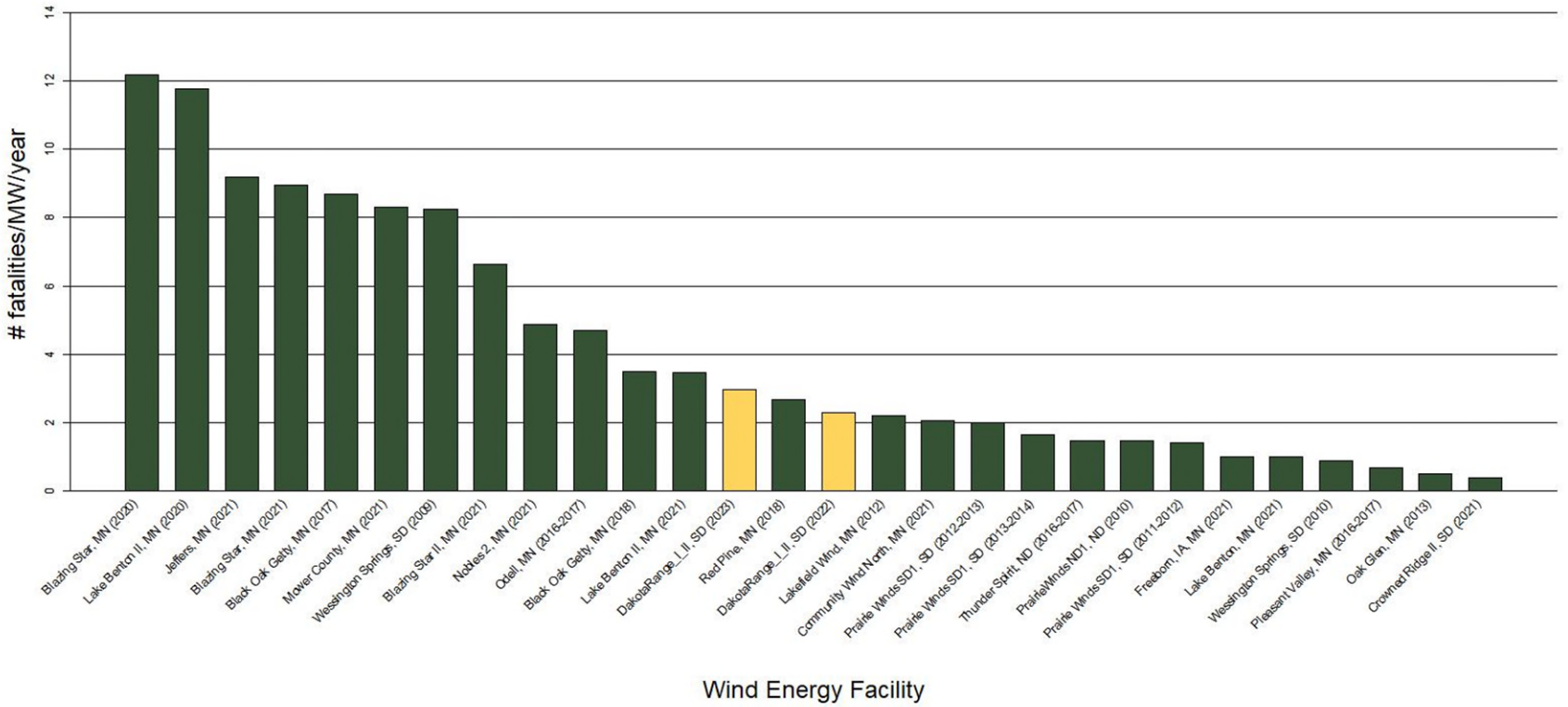

Figure 13. Estimated fatality rates for all birds (number of birds per megawatt [MW] per year) from recently conducted post-construction fatality monitoring studies at wind energy facilities in South Dakota, North Dakota, and Minnesota with publicly available data.

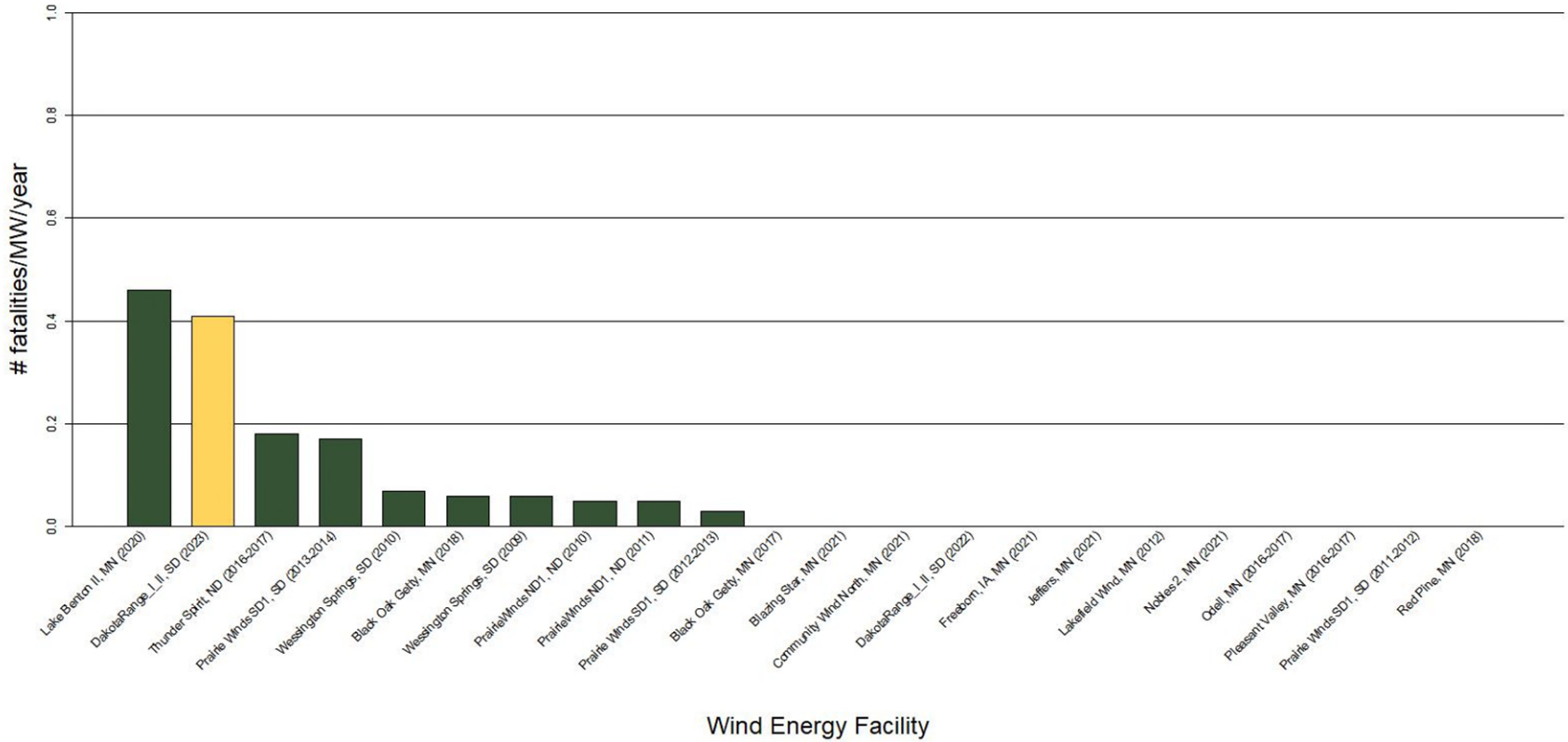

Figure 14. Estimated fatality rates for diurnal raptors (number of birds per megawatt [MW] per year) from recently conducted post-construction fatality monitoring studies at wind energy facilities in South Dakota, North Dakota, and Minnesota with publicly available data.

Bats

Species Composition

Four bat species were found as fatalities during the study. Hoary bat was the most common (25 carcasses, 46.3% of total bat carcasses), followed by eastern red bat (17, 31.5%), silver-haired bat (seven, 13.0%), and big brown bat (five, 9.3%). A similar number of bat fatalities were found in Year 2 (54) as Year 1 (52) with similar species composition. Among other wind energy facilities in the region, hoary bat, silver-haired bat, and eastern red bat are the top three most common bat species found as fatalities, respectively (WEST 2023). Each of these three species are designated as SGCN in South Dakota. No federally or state-listed threatened or endangered bat species were observed during surveys.

Spatial and Temporal Patterns

Bat fatalities were generally found throughout the Project. Habitat features near the six turbines with the most bat fatalities included in analysis (Turbine 7, followed by Turbine 30, and turbines 15, 38, 39, 42, and 65) appear to be similar to other areas within the Project. During the Year 1 study, most bat fatalities were documented in the northern portion of the Project. The three turbines with the majority of the bat fatalities during Year 1 included turbines 3, 30, and 46 (Chodachek et al. 2023). Turbine blade strikes have been indicated as the likely cause of most bat fatalities at wind farms (Lawson et al. 2020), although it is unknown why they collide with wind turbines (USGS 2016). Possible reasons for attraction include insect concentrations that act as a food source, mistaking the turbine for a potential roost location, or attraction to the sound produced by wind turbines (National Wind Coordinating Collaborative 2010).

Temporally, the estimated overall bat fatality rate was highest during the latter part of the study's summer season, although bat fatalities were documented from May to October. The timing of bat fatalities at the Project (primarily documented from late July through August) was slightly earlier than in Year 1 when the number of bat fatalities per searched turbine was twice as high in early September than in all other visits and the second highest in mid- to late August (Chodachek et al. 2023). For both years of study, the number of bat carcasses per searched turbine peaked in late summer to early fall, which suggests that many bats found as fatalities at the Project may have been migrating through the area to reach their hibernacula before winter. This pattern of increased fatalities during late summer and early fall is not unique to the Project, and has been documented consistently in South Dakota 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 18.71 bat fatalities/MW/study period (90% CI: 10.00–72.38; 77.39 bat fatalities/turbine/study period) is slightly higher than the Year 1 rate of 14.19 bat fatalities/MW/study period (Chodachek et al. 2023) and is within the mid-range of bat fatality rates at other wind energy facilities in the Tristate Area with recently conducted PCM studies and publicly available data (Figure 15). Fatality rates at the facilities shown in Figure 15 range from 0.41 (Wessington Springs, South Dakota [Derby et al. 2011]) to 37.59 (Black Oak Getty, Minnesota [Pickle et al. 2019]).

Estimated Fatality Rates

Numerous factors may contribute to both positive and negative biases in estimating fatality rates (Erickson 2006), and there are several potential sources of inherent bias that exist in field-based fatality monitoring studies. First, all carcasses found within search areas during a study are used in the analysis, including those found outside of scheduled search times. If these carcasses do not persist until the next carcass search, or are missed by searchers, this bias would result in an overestimate of fatality rates. Second, it is assumed all carcasses found during the study are due to collisions with wind turbines unless another cause of death was apparent, even though some could have occurred from natural causes (background fatality), resulting in a potential overestimate of fatality rates. Third, experimental carcasses used in SEEF trials and CPT are assumed to be representative of the actual species found as fatalities, but if the types of birds or bats used are larger or smaller, or are more or less cryptic than the actual carcasses found during the course of the study, this could lead to a positive or negative bias. In this study the spring season was shortened by about one month due to weather, and mice were used to represent bats in SEEF trials and CPT, both of which may have affected the estimated fatality rates.

In this study, the potential sources of bias noted above were either not thought to be highly influential or were unknown because 1) background fatality rates are unknown or expected to be minimal for both birds and bats, 2) the species used for SEEF trials and CPT are thought to be representative of the size range and physical characteristics of the bird and bat carcasses expected to be found as fatalities at the Project, and 3) the *k* value was not influential in this study. In general, an analysis is sensitive to *k* when persistence times are long relative to the search interval and SEEF values are low. This study demonstrated relatively average SEEF rates but persistence times that were shorter than the search intervals. In this situation, the influence of *k* is minimal. During the year 2 study the estimates of SEEF and CPT were less than half those observed in year 1.

Increased fatality estimates and associated confidence intervals for bats on road and pad plots compared to square plots may be attributed to the area correction factor, as there is both a larger correction (bigger increase) and a higher degree of uncertainty in the fatality rates compared to a square plot search, due to the small proportion of area under the turbine that is searched. Over half of all the bat carcasses included in the analysis were found on road and pad plots, which contributed to a larger than expected bat fatality rate (compare Appendix H3 to H4). In combination, these three bias estimates, SEEF, CPT and substantial area correction contributed

to both a larger estimate of bat fatalities with greater confidence intervals during year 2 than was expected based on the year 1 study (Chodachek et al. 2023).

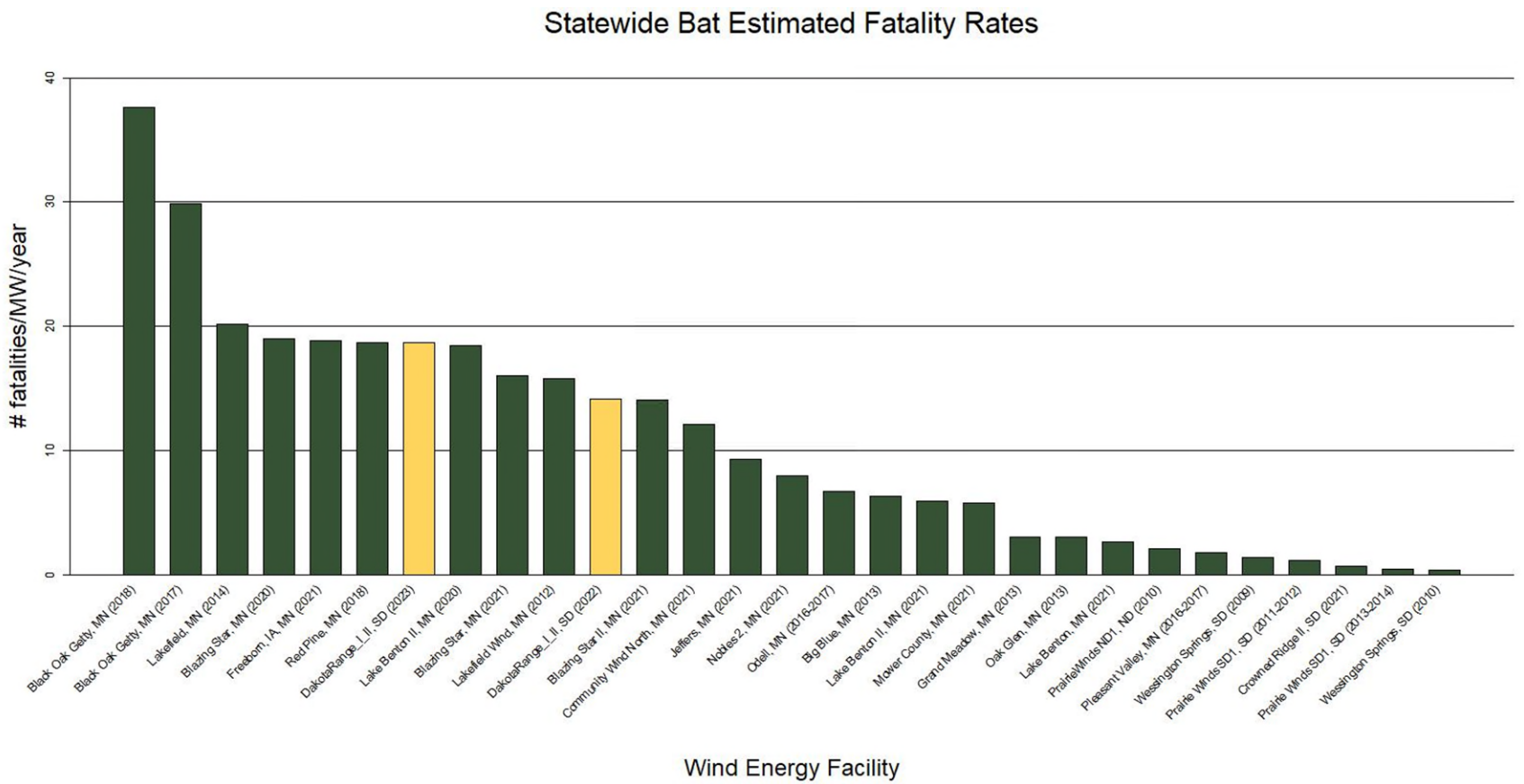

Figure 15. Estimated fatality rates for bats (number of bats per megawatt [MW] per year) from recently conducted post-construction fatality monitoring studies at wind energy facilities in South Dakota, North Dakota, and Minnesota with publicly available data.

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Appendix A. Overview of Study Design and Search Methods for Post-construction Fatality Monitoring at the Dakota Range I and II Wind Project, Grant and Codington Counties, South Dakota, from April 20 - December 15, 2023

Appendix A. Turbine specifications at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 – December 15, 2023.

Turbine Type	Megawatts	Hub Height (meters)	Rotor Diameter	Number of Turbines	Turbine Number
Vestas V120	2.2	80	120	1	24
Vestas V136	3.8	82	136	7	1, 7, 15, 22, 45, 67, 70
Vestas V136	4.3	82	136	64	2-6, 8-14, 16-21, 23, 25-44, 46-66, 68-69, 71-72

Appendix B. Overview of Study Design and Search Methods for Post-construction Fatality Monitoring at the Dakota Range I and II Wind Project, Grant and Codington Counties, South Dakota, from April 20 - December 15, 2023

Appendix B. Overview of study design and search methods for post-construction fatality monitoring at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 – December 15, 2023.

	Sampling Unit	
Design Component	**Square Plot[1]**	**Road and Pad Plot[1]**
Number of Plots (percent [%] of all turbines)	18 (82%) in spring 5 (23%) in summer 18 (82%) in fall	22 (100%) in spring 22 (100%) in summer 22 (100%) in fall
Size/Shape	150-m x 150-m square centered on turbine	100-m radius from turbine on gravel road and pad
Search Interval	Once every two weeks	Once every two weeks
Search Period	May 23 – December 15, 2023	April 20 – December 15, 2023
Searcher efficiency – seasons	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	Vestas V120 2.2-MW (1 turbine); Vestas V136 3.8-MW (7); Vestas V136 4.3-MW (64)	
Hub Height	80 m (Vestas V120); 82 m (Vestas V136)	
Rotor Diameter	120 m (Vestas V120); 136 m (Vestas 136)	
Blade serrations (Yes/No)	Yes	

[1] Twenty-two turbines were searched. All 22 turbines were initially searched as road and pad plots (three spring visits) due to excess snow and mud. On May 23 square plot searches were conducted at 18 plots until the end of the spring season. Four turbines were searched as road and pad plots for the entire study period due to inaccessibility and nonviability as square plots: 13, 22, 46, and 60. When vegetation obstructed visibility (beginning in summer), 17 square plots switched to road and pad plots until crops were harvested in fall. In mid-November and after crops were harvested, searches switched back to cleared square plots at 18 turbines.

m = meters; s = second; MW = megawatt

Appendix C. Common and Scientific Names of Species Found During Post-Construction Fatality Monitoring at the Dakota Range I and II Wind Project, Grant and Codington Counties, South Dakota, from April 20 – December 15, 2023

Appendix C. Species found during post-construction fatality monitoring at Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 – December 15, 2023.

Common Name	Scientific Name
American coot	*Fulica americana*
American white pelican	*Pelecanus erythrorhynchos*
bald eagle	*Haliaeetus leucocephalus*
cliff swallow	*Petrochelidon pyrrhonota*
common grackle	*Quiscalus quiscula*
dark-eyed junco	*Junco hyemalis*
eastern kingbird	*Tyrannus tyrannus*
ferruginous hawk	*Buteo regalis*
horned lark	*Eremophila alpestris*
house wren	*Troglodytes aedon*
killdeer	*Charadrius vociferus*
mallard	*Anas platyrhynchos*
marsh wren	*Cistothorus palustris*
red-tailed hawk	*Buteo jamaicensis*
ring-billed gull	*Larus delawarensis*
ruby-crowned kinglet	*Corthylio calendula*
sedge wren	*Cistothorus stellaris*
sora	*Porzana carolina*
Townsend's warbler	*Setophaga townsendi*
turkey vulture	*Cathartes aura*
vesper sparrow	*Pooecetes gramineus*
yellow warbler	*Setophaga petechia*
big brown bat	*Eptesicus fuscus*
eastern red bat	*Lasiurus borealis*
hoary bat	*Lasiurus cinereus*
silver-haired bat	*Lasionycteris noctivagans*

Appendix D. Complete Listing of Bird and Bat Carcasses Found During Post-construction Fatality Monitoring at the Dakota Range I and II Wind Project, Grant and Codington Counties, South Dakota, from April 20 – December 15, 2023

Appendix D. Complete listing of carcasses found at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 – December 15, 2023.

Found Date	Species	Distance from Turbine (meters)	Turbine	Search Type	Plot Type	Physical Condition
05/11/2023	silver-haired bat**	46	19	carcass search	road and pad	scavenged
05/12/2023	silver-haired bat**	9	39	carcass search	road and pad	scavenged
06/08/2023	hoary bat**	40	37	incidental	square plot	scavenged
06/14/2023	big brown bat	71	32	carcass search	square plot	scavenged
06/14/2023	silver-haired bat**	41	65	carcass search	square plot	scavenged
07/24/2023	eastern red bat**	48	44	incidental*	n/a	scavenged
07/24/2023	hoary bat**	20	44	incidental*	n/a	intact
07/26/2023	eastern red bat**	40	45	incidental*	n/a	scavenged
07/27/2023	big brown bat	8	13	carcass search*	road and pad	scavenged
07/27/2023	big brown bat	17	7	carcass search	road and pad	intact
07/27/2023	eastern red bat**	4	12	carcass search	road and pad	intact
07/27/2023	eastern red bat**	4	15	carcass search	road and pad	intact
07/27/2023	eastern red bat**	9	69	incidental*	n/a	scavenged
07/27/2023	eastern red bat**	16	7	carcass search	road and pad	scavenged
07/27/2023	hoary bat**	5	15	carcass search	road and pad	intact
07/27/2023	hoary bat**	6	17	incidental*	n/a	intact
07/27/2023	hoary bat**	0	30	carcass search	road and pad	scavenged
07/27/2023	hoary bat**	22	42	carcass search	road and pad	scavenged
07/27/2023	hoary bat**	1	42	carcass search	road and pad	injured
07/27/2023	hoary bat**	6	69	incidental*	n/a	scavenged
07/28/2023	eastern red bat**	26	60	carcass search	road and pad	scavenged
07/28/2023	eastern red bat**	5	68	carcass search	road and pad	scavenged
07/28/2023	hoary bat**	40	70	carcass search	road and pad	scavenged
08/01/2023	hoary bat**	4	31	incidental*	n/a	scavenged
08/01/2023	hoary bat**	7	31	incidental*	n/a	scavenged
08/01/2023	hoary bat**	11	31	incidental*	n/a	scavenged
08/01/2023	hoary bat**	8	47	incidental*	n/a	scavenged
08/02/2023	eastern red bat**	7	3	incidental	square plot	scavenged
08/02/2023	eastern red bat**	9	3	incidental	square plot	scavenged
08/02/2023	eastern red bat**	41	65	carcass search	square plot	scavenged
08/02/2023	hoary bat**	35	22	incidental	road and pad	scavenged
08/02/2023	hoary bat**	7	6	carcass search	square plot	scavenged
08/02/2023	hoary bat**	35	65	carcass search	square plot	scavenged
08/03/2023	hoary bat**	8	46	carcass search	road and pad	scavenged
08/04/2023	eastern red bat**	92	30	incidental	road and pad	scavenged
08/04/2023	hoary bat**	27	30	incidental	road and pad	scavenged
08/04/2023	silver-haired bat**	33	30	incidental	road and pad	scavenged
08/14/2023	hoary bat**	25	13	carcass search	road and pad	scavenged
08/14/2023	hoary bat**	8	60	carcass search	road and pad	scavenged
08/14/2023	hoary bat**	6	7	carcass search	road and pad	scavenged
08/14/2023	hoary bat**	6	7	carcass search	road and pad	scavenged
08/14/2023	hoary bat**	6	7	carcass search	road and pad	scavenged
08/15/2023	big brown bat	6	54	carcass search	square plot	scavenged
08/16/2023	hoary bat**	6	39	carcass search	road and pad	scavenged
08/21/2023	eastern red bat**	5	19	incidental	road and pad	scavenged
08/28/2023	big brown bat	6	22	carcass search	road and pad	scavenged
08/28/2023	eastern red bat**	7	15	carcass search	road and pad	scavenged
08/28/2023	eastern red bat**	13	38	carcass search	road and pad	scavenged
08/28/2023	silver-haired bat**	3	12	carcass search	road and pad	scavenged

Appendix D. Complete listing of carcasses found at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 – December 15, 2023.

Found Date	Species	Distance from Turbine (meters)	Turbine	Search Type	Plot Type	Physical Condition
08/28/2023	silver-haired bat**	6	38	carcass search	road and pad	scavenged
08/30/2023	silver-haired bat**	7	42	carcass search	road and pad	scavenged
09/12/2023	eastern red bat**	1	37	carcass search	road and pad	injured
09/22/2023	hoary bat**	38	39	carcass search	road and pad	injured
10/04/2023	eastern red bat**	32	38	carcass search	road and pad	scavenged
05/03/2023	American white pelican**	101	65	carcass search*	road and pad	scavenged
05/04/2023	American coot	4	19	carcass search	road and pad	intact
05/10/2023	American white pelican**	88	3	incidental	road and pad	dismembered
05/11/2023	cliff swallow	8	1	carcass search	road and pad	scavenged
05/11/2023	house wren	13	68	carcass search	road and pad	intact
05/11/2023	sora	49	68	carcass search*	road and pad	scavenged
05/23/2023	dark-eyed junco	52	68	carcass search	square plot	dismembered
05/23/2023	marsh wren	52	70	carcass search	square plot	dismembered
05/23/2023	yellow warbler	75	70	carcass search	square plot	intact
05/23/2023	yellow warbler	29	70	carcass search	square plot	intact
05/24/2023	house wren	66	1	carcass search	square plot	scavenged
05/30/2023	unidentified duck	3	70	incidental	square plot	scavenged
06/07/2023	mallard	46	37	carcass search	square plot	scavenged
06/08/2023	American white pelican**	76	52	incidental*	n/a	scavenged
06/14/2023	mallard	25	54	carcass search	square plot	scavenged
06/14/2023	marsh wren	71	32	carcass search	square plot	scavenged
06/15/2023	common grackle	22	3	carcass search	square plot	scavenged
07/05/2023	killdeer	114	13	carcass search*	road and pad	scavenged
07/05/2023	ring-billed gull	7	42	carcass search	road and pad	dismembered
07/05/2023	unidentified sparrow	78	19	carcass search	road and pad	scavenged
07/07/2023	horned lark	9	12	carcass search	road and pad	scavenged
07/07/2023	horned lark	13	54	carcass search	square plot	scavenged
07/14/2023	mallard	1	40	incidental*	n/a	scavenged
07/18/2023	killdeer	5	22	carcass search	road and pad	scavenged
07/19/2023	eastern kingbird	1	60	carcass search	road and pad	scavenged
07/20/2023	horned lark	7	1	carcass search	road and pad	scavenged
07/20/2023	turkey vulture	38	1	carcass search	road and pad	scavenged
07/31/2023	ring-billed gull	43	67	incidental*	n/a	scavenged
08/02/2023	vesper sparrow	18	3	incidental	square plot	scavenged
08/21/2023	Townsend's warbler	32	19	incidental	road and pad	scavenged
08/21/2023	red-tailed hawk	19	19	incidental	road and pad	scavenged
08/28/2023	house wren	28	39	carcass search	road and pad	scavenged
09/08/2023	unidentified passerine	44	68	carcass search	road and pad	scavenged
09/12/2023	marsh wren	18	13	carcass search	road and pad	scavenged
09/22/2023	sedge wren	38	6	carcass search	road and pad	scavenged
09/22/2023	unidentified warbler	40	22	carcass search	road and pad	scavenged
10/04/2023	ruby-crowned kinglet	70	65	carcass search	road and pad	scavenged
10/04/2023	unidentified wren	25	68	carcass search	road and pad	scavenged
10/26/2023	American white pelican**	25	7	carcass search*	road and pad	scavenged
10/26/2023	ferruginous hawk**	25	22	carcass search*	road and pad	scavenged
11/18/2023	unidentified buteo	21	54	carcass search	square plot	scavenged

Appendix D. Complete listing of carcasses found at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 – December 15, 2023.

Found Date	Species	Distance from Turbine (meters)	Turbine	Search Type	Plot Type	Physical Condition
11/29/2023	bald eagle**	42	7	carcass search	square plot	Feathers
12/11/2023	unidentified raptor	36	2	incidental*	n/a	scavenged

* Carcass was found outside the search area

** Species of Greatest Conservation Need, as designated in the South Dakota Wildlife Action Plan (South Dakota Game, Fish and Parks 2014, revised 2023).

n/a = not applicable.

Appendix E. Searcher Efficiency Model Selection for the Dakota Range I and II Wind Project, Grant and Codington Counties, South Dakota, from April 20 – December 15, 2023

Appendix E1. GenEst estimated searcher efficiency models for large birds (n = 59 searcher efficiency trial carcasses) from the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 – December 15, 2023.

Covariates	k Value	AICc	Delta AICc
Plot Search Type	k fixed at 0.67	32.62	0*
No Covariates	k fixed at 0.67	36.31	3.69
Season	k fixed at 0.67	37.23	4.61
Season * Plot Search Type	k fixed at 0.67	40.37	7.75

* Selected model

AICc = Corrected Akaike Information Criterion

Delta AICc = Change in AICc

Appendix E2. GenEst estimated searcher efficiency models for small birds (n = 58 searcher efficiency trial carcasses) from the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 – December 15, 2023.

Covariates	k Value	AICc	Delta AICc
Plot Search Type	k fixed at 0.67	60.64	0*
Season + Plot Search Type	k fixed at 0.67	62.69	2.05
Season * Plot Search Type	k fixed at 0.67	67.01	6.37
No Covariates	k fixed at 0.67	76.80	16.16
Season	k fixed at 0.67	79.57	18.93

* Selected model

AICc = Corrected Akaike Information Criterion

Delta AICc = Change in AICc

Appendix E3. GenEst estimated searcher efficiency models for bats (n = 64 searcher efficiency trial carcasses) from the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 – December 15, 2023.

Covariates	k Value	AICc	Delta AICc
Plot Search Type	k fixed at 0.67	57.28	0*
Season + Plot Search Type	k fixed at 0.67	61.28	4.00
Season * Plot Search Type	k fixed at 0.67	65.60	8.32
No Covariates	k fixed at 0.67	83.07	25.79
Season	k fixed at 0.67	85.95	28.67

* Selected model

AICc = Corrected Akaike Information Criterion

Delta AICc = Change in AICc

Appendix F. Carcass Persistence Trial Information for the Dakota Range I and II Wind Project, Grant and Codington Counties, South Dakota, from April 20 – December 15, 2023

Appendix F1. All carcasses placed for carcass persistence trials by date, season, species, and turbine at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 – December 15, 2023.

Date Placed	Season	Common Name	Turbine	Before Removal*	After Removal**
05/01/2023	Spring	rock pigeon	14	05/02/2023	05/03/2023
05/01/2023	Spring	northern bobwhite	72	05/04/2023	05/07/2023
05/01/2023	Spring	house mouse	11	05/04/2023	05/07/2023
05/01/2023	Spring	house mouse	8	05/03/2023	05/04/2023
05/01/2023	Spring	house mouse	69	05/01/2023	05/02/2023
05/01/2023	Spring	house mouse	72	05/10/2023	05/15/2023
05/01/2023	Spring	rock pigeon	14	05/04/2023	05/07/2023
05/01/2023	Spring	house mouse	69	05/01/2023	05/02/2023
05/01/2023	Spring	rock pigeon	8	05/11/2023	05/15/2023
05/01/2023	Spring	northern bobwhite	11	05/04/2023	05/07/2023
05/08/2023	Spring	house mouse	10	05/22/2023	05/29/2023
05/08/2023	Spring	northern bobwhite	9	05/15/2023	05/18/2023
05/08/2023	Spring	house mouse	27	05/08/2023	05/09/2023
05/15/2023	Spring	northern bobwhite	23	05/15/2023	05/15/2023
05/01/2023	Spring	northern bobwhite	34	05/01/2023	05/03/2023
05/08/2023	Spring	rock pigeon	29	05/08/2023	05/08/2023
05/15/2023	Spring	northern bobwhite	26	05/15/2023	05/15/2023
05/08/2023	Spring	rock pigeon	25	05/11/2023	05/11/2023
05/15/2023	Spring	house mouse	26	05/15/2023	05/15/2023
05/01/2023	Spring	rock pigeon	63	05/22/2023	05/30/2023
05/01/2023	Spring	house mouse	44	05/22/2023	05/30/2023
05/08/2023	Spring	rock pigeon	25	05/11/2023	05/11/2023
05/01/2023	Spring	northern bobwhite	34	05/15/2023	05/22/2023
05/08/2023	Spring	American white pelican	10	05/29/2023	06/06/2023
05/08/2023	Spring	northern bobwhite	47	05/22/2023	05/28/2023
05/15/2023	Spring	rock pigeon	23	05/15/2023	05/15/2023
05/08/2023	Spring	house mouse	18	05/08/2023	05/09/2023
05/01/2023	Spring	northern bobwhite	66	05/10/2023	05/15/2023
05/15/2023	Spring	rock pigeon	16	05/16/2023	05/18/2023
05/08/2023	Spring	northern bobwhite	10	05/11/2023	05/15/2023
05/01/2023	Spring	northern bobwhite	63	05/03/2023	05/04/2023
05/08/2023	Spring	house mouse	9	05/18/2023	05/29/2023
05/15/2023	Spring	rock pigeon	16	05/15/2023	05/16/2023
05/08/2023	Spring	northern bobwhite	71	05/08/2023	05/08/2023
05/01/2023	Spring	rock pigeon	66	05/10/2023	05/15/2023
05/08/2023	Spring	rock pigeon	18	05/09/2023	05/10/2023
05/08/2023	Spring	rock pigeon	64	05/18/2023	05/29/2023
05/08/2023	Spring	house mouse	71	05/08/2023	05/08/2023
05/08/2023	Spring	northern bobwhite	47	05/22/2023	05/29/2023
05/01/2023	Spring	northern bobwhite	2	05/07/2023	05/11/2023
05/08/2023	Spring	northern bobwhite	64	05/18/2023	05/29/2023
05/08/2023	Spring	rock pigeon	27	05/11/2023	05/18/2023
05/08/2023	Spring	northern bobwhite	29	05/08/2023	05/08/2023
05/15/2023	Spring	northern bobwhite	16	05/16/2023	05/18/2023
05/15/2023	Spring	house mouse	23	05/15/2023	05/15/2023
05/08/2023	Spring	rock pigeon	47	05/22/2023	05/29/2023
05/01/2023	Spring	rock pigeon	44	05/11/2023	05/15/2023
05/01/2023	Spring	house mouse	2	05/15/2023	05/22/2023
05/08/2023	Spring	house mouse	27	05/08/2023	05/09/2023
05/15/2023	Spring	northern bobwhite	49	05/18/2023	05/21/2023
05/15/2023	Spring	house mouse	51	05/16/2023	05/18/2023

Appendix F1. All carcasses placed for carcass persistence trials by date, season, species, and turbine at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 – December 15, 2023.

Date Placed	Season	Common Name	Turbine	Before Removal*	After Removal**
05/15/2023	Spring	northern bobwhite	58	05/15/2023	05/16/2023
05/15/2023	Spring	northern bobwhite	49	05/18/2023	05/21/2023
05/15/2023	Spring	house mouse	52	05/24/2023	05/29/2023
05/15/2023	Spring	rock pigeon	52	05/29/2023	06/05/2023
05/15/2023	Spring	rock pigeon	49	06/14/2023	06/14/2023
05/15/2023	Spring	house mouse	58	05/24/2023	05/29/2023
05/15/2023	Spring	house mouse	52	05/18/2023	05/22/2023
05/15/2023	Spring	rock pigeon	26	05/15/2023	05/15/2023
05/15/2023	Spring	northern bobwhite	58	05/24/2023	05/29/2023
05/15/2023	Spring	house mouse	51	05/18/2023	05/25/2023
07/10/2023	Summer	rock pigeon	16	08/16/2023	08/16/2023
07/10/2023	Summer	northern bobwhite	48	07/20/2023	07/24/2023
07/10/2023	Summer	northern bobwhite	8	07/11/2023	07/12/2023
07/10/2023	Summer	rock pigeon	16	08/16/2023	08/16/2023
07/10/2023	Summer	northern bobwhite	2	07/13/2023	07/17/2023
07/10/2023	Summer	house mouse	50	07/20/2023	07/24/2023
07/10/2023	Summer	house mouse	2	07/20/2023	07/24/2023
07/10/2023	Summer	house mouse	44	07/13/2023	07/17/2023
07/10/2023	Summer	rock pigeon	2	07/20/2023	07/24/2023
07/10/2023	Summer	northern bobwhite	27	07/13/2023	07/17/2023
07/10/2023	Summer	house mouse	50	07/20/2023	07/24/2023
07/10/2023	Summer	northern bobwhite	8	07/20/2023	07/24/2023
07/10/2023	Summer	northern bobwhite	27	07/11/2023	07/12/2023
07/10/2023	Summer	house mouse	8	07/13/2023	07/17/2023
07/10/2023	Summer	house mouse	16	07/12/2023	07/13/2023
07/10/2023	Summer	house mouse	44	07/17/2023	07/20/2023
07/10/2023	Summer	rock pigeon	44	08/16/2023	08/16/2023
07/10/2023	Summer	rock pigeon	27	07/11/2023	07/12/2023
07/10/2023	Summer	rock pigeon	50	08/16/2023	08/16/2023
07/10/2023	Summer	house mouse	48	07/17/2023	07/20/2023
07/31/2023	Summer	house mouse	58	08/07/2023	08/11/2023
07/31/2023	Summer	house mouse	51	08/04/2023	08/06/2023
07/31/2023	Summer	rock pigeon	31	08/29/2023	08/29/2023
07/31/2023	Summer	house mouse	25	07/31/2023	07/31/2023
07/31/2023	Summer	rock pigeon	49	08/29/2023	08/29/2023
07/31/2023	Summer	rock pigeon	51	08/15/2023	08/20/2023
07/31/2023	Summer	rock pigeon	25	07/31/2023	07/31/2023
07/31/2023	Summer	house mouse	43	08/04/2023	08/11/2023
07/31/2023	Summer	house mouse	29	07/31/2023	07/31/2023
07/31/2023	Summer	rock pigeon	67	08/01/2023	08/01/2023
07/31/2023	Summer	northern bobwhite	21	07/31/2023	07/31/2023
07/31/2023	Summer	rock pigeon	21	08/06/2023	08/11/2023
07/31/2023	Summer	northern bobwhite	26	07/31/2023	08/01/2023
07/31/2023	Summer	northern bobwhite	58	08/07/2023	08/11/2023
07/31/2023	Summer	northern bobwhite	31	07/31/2023	08/02/2023
07/31/2023	Summer	northern bobwhite	67	08/01/2023	08/01/2023
07/31/2023	Summer	northern bobwhite	29	07/31/2023	07/31/2023
07/31/2023	Summer	house mouse	26	08/02/2023	08/04/2023
07/31/2023	Summer	northern bobwhite	43	08/01/2023	08/02/2023
07/31/2023	Summer	house mouse	49	07/31/2023	07/31/2023
07/24/2023	Summer	turkey vulture	59	08/22/2023	08/22/2023

Appendix F1. All carcasses placed for carcass persistence trials by date, season, species, and turbine at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 – December 15, 2023.

Date Placed	Season	Common Name	Turbine	Before Removal*	After Removal**
07/24/2023	Summer	northern bobwhite	33	07/24/2023	07/26/2023
07/24/2023	Summer	rock pigeon	9	08/22/2023	08/22/2023
07/24/2023	Summer	northern bobwhite	66	08/07/2023	08/14/2023
07/24/2023	Summer	northern bobwhite	17	07/24/2023	07/24/2023
07/24/2023	Summer	rock pigeon	63	07/24/2023	07/24/2023
07/24/2023	Summer	house mouse	63	07/24/2023	07/24/2023
07/24/2023	Summer	rock pigeon	14	07/27/2023	07/28/2023
07/24/2023	Summer	rock pigeon	66	07/28/2023	07/31/2023
07/24/2023	Summer	house mouse	14	07/26/2023	07/27/2023
07/24/2023	Summer	house mouse	59	07/27/2023	07/28/2023
07/24/2023	Summer	northern bobwhite	9	08/22/2023	08/22/2023
07/24/2023	Summer	rock pigeon	69	08/07/2023	08/14/2023
07/24/2023	Summer	house mouse	45	07/24/2023	07/24/2023
07/24/2023	Summer	rock pigeon	69	07/27/2023	07/28/2023
07/24/2023	Summer	northern bobwhite	17	08/16/2023	08/22/2023
07/24/2023	Summer	rock pigeon	45	07/26/2023	07/27/2023
07/24/2023	Summer	northern bobwhite	66	07/27/2023	07/28/2023
07/24/2023	Summer	northern bobwhite	59	08/07/2023	08/14/2023
07/24/2023	Summer	house mouse	33	07/24/2023	07/24/2023
09/18/2023	Fall	house mouse	52	09/18/2023	09/18/2023
09/18/2023	Fall	house mouse	27	09/19/2023	09/19/2023
09/18/2023	Fall	rock pigeon	48	09/24/2023	09/30/2023
09/18/2023	Fall	house mouse	62	09/18/2023	09/18/2023
09/18/2023	Fall	rock pigeon	62	09/18/2023	09/19/2023
09/18/2023	Fall	northern bobwhite	58	09/19/2023	09/21/2023
09/18/2023	Fall	house mouse	48	09/19/2023	09/19/2023
09/18/2023	Fall	house mouse	58	09/21/2023	09/24/2023
09/18/2023	Fall	rock pigeon	18	10/18/2023	10/18/2023
09/18/2023	Fall	northern bobwhite	27	09/19/2023	09/19/2023
09/18/2023	Fall	northern bobwhite	10	10/08/2023	10/18/2023
09/18/2023	Fall	northern bobwhite	18	09/19/2023	09/19/2023
09/18/2023	Fall	rock pigeon	52	09/18/2023	09/19/2023
09/18/2023	Fall	rock pigeon	10	09/18/2023	09/19/2023
09/18/2023	Fall	northern bobwhite	14	09/18/2023	09/19/2023
10/16/2023	Fall	house mouse	64	10/16/2023	10/16/2023
10/16/2023	Fall	northern bobwhite	67	10/16/2023	10/17/2023
10/16/2023	Fall	house mouse	11	10/16/2023	10/16/2023
10/16/2023	Fall	rock pigeon	64	10/16/2023	10/16/2023
10/16/2023	Fall	northern bobwhite	50	10/16/2023	10/16/2023
10/16/2023	Fall	house mouse	72	10/16/2023	10/16/2023
10/16/2023	Fall	northern bobwhite	29	11/06/2023	11/14/2023
10/16/2023	Fall	northern bobwhite	69	10/16/2023	10/16/2023
10/16/2023	Fall	northern bobwhite	45	10/17/2023	10/17/2023
10/16/2023	Fall	rock pigeon	45	10/17/2023	10/17/2023
10/16/2023	Fall	rock pigeon	11	10/16/2023	10/16/2023
10/16/2023	Fall	rock pigeon	29	10/22/2023	10/26/2023
10/16/2023	Fall	house mouse	50	10/16/2023	10/16/2023
10/16/2023	Fall	rock pigeon	72	10/16/2023	10/17/2023
10/16/2023	Fall	house mouse	67	10/16/2023	10/17/2023
10/23/2023	Fall	house mouse	52	10/23/2023	10/25/2023
10/23/2023	Fall	northern bobwhite	59	10/29/2023	11/01/2023

Appendix F1. All carcasses placed for carcass persistence trials by date, season, species, and turbine at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 – December 15, 2023.

Date Placed	Season	Common Name	Turbine	Before Removal*	After Removal**
10/23/2023	Fall	house mouse	14	11/20/2023	11/20/2023
10/23/2023	Fall	northern bobwhite	14	11/05/2023	11/12/2023
10/23/2023	Fall	house mouse	9	10/26/2023	10/29/2023
10/23/2023	Fall	rock pigeon	14	11/05/2023	11/12/2023
10/23/2023	Fall	rock pigeon	52	11/12/2023	11/20/2023
10/23/2023	Fall	rock pigeon	59	10/24/2023	10/25/2023
10/23/2023	Fall	house mouse	59	10/24/2023	10/25/2023
10/23/2023	Fall	rock pigeon	9	11/05/2023	11/12/2023
10/23/2023	Fall	northern bobwhite	9	10/24/2023	10/25/2023
10/23/2023	Fall	northern bobwhite	52	10/29/2023	11/01/2023
10/23/2023	Fall	northern bobwhite	23	10/24/2023	10/26/2023
10/23/2023	Fall	rock pigeon	23	10/24/2023	10/26/2023
10/23/2023	Fall	house mouse	23	11/01/2023	11/06/2023
10/30/2023	Fall	house mouse	2	11/05/2023	11/08/2023
10/30/2023	Fall	rock pigeon	51	11/01/2023	11/03/2023
10/30/2023	Fall	rock pigeon	31	11/28/2023	11/28/2023
10/30/2023	Fall	house mouse	31	11/01/2023	11/02/2023
10/30/2023	Fall	northern bobwhite	25	11/02/2023	11/08/2023
10/30/2023	Fall	rock pigeon	25	11/19/2023	11/29/2023
10/30/2023	Fall	northern bobwhite	49	11/05/2023	11/08/2023
10/30/2023	Fall	house mouse	49	11/08/2023	11/12/2023
10/30/2023	Fall	northern bobwhite	31	11/05/2023	11/08/2023
10/30/2023	Fall	house mouse	25	11/02/2023	11/08/2023
10/30/2023	Fall	rock pigeon	49	11/12/2023	11/19/2023
10/30/2023	Fall	house mouse	51	11/01/2023	11/03/2023
10/30/2023	Fall	rock pigeon	2	11/19/2023	11/28/2023
10/30/2023	Fall	northern bobwhite	2	11/05/2023	11/08/2023
10/30/2023	Fall	northern bobwhite	51	11/01/2023	11/03/2023

* Last date checked before removal

** Date checked after removal

Appendix F2. Carcass persistence models with covariates and distributions for large birds (n = 60 carcass persistence trial carcasses) at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 – December 15, 2023.

Location Covariates	Scale Covariates	Distribution	AICc	Delta AICc
Season	No Covariates	Weibull	274.19	0
No Covariates	No Covariates	Weibull	276.02	1.83*
No Covariates	No Covariates	lognormal	276.18	1.99
No Covariates	Season	lognormal	276.29	2.10
No Covariates	Season	Weibull	276.38	2.19
No Covariates	No Covariates	loglogistic	276.48	2.29
Season	Season	Weibull	276.53	2.34
No Covariates	Season	loglogistic	277.04	2.85
Season	No Covariates	lognormal	277.48	3.29
Season	No Covariates	loglogistic	278.06	3.87
Season	Season	lognormal	278.52	4.33
Season	Season	loglogistic	279.57	5.38

Appendix F2. Carcass persistence models with covariates and distributions for large birds (n = 60 carcass persistence trial carcasses) at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 – December 15, 2023.

Location Covariates	Scale Covariates	Distribution	AICc	Delta AICc
Season	-	exponential	282.22	8.03
No Covariates	-	exponential	287.20	13.01

* 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 = change in AICc.

Appendix F3. Carcass persistence models with covariates and distributions for small birds (n = 61 carcass persistence trial carcasses) at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 – December 15, 2023.

Location Covariates	Scale Covariates	Distribution	AICc	Delta AICc
No Covariates	No Covariates	Weibull	264.33	0
No Covariates	-	exponential	265.29	0.96*
No Covariates	Season	Weibull	267.55	3.22
Season	No Covariates	Weibull	268.59	4.26
Season	-	exponential	269.26	4.93
No Covariates	No Covariates	lognormal	269.56	5.23
No Covariates	No Covariates	loglogistic	271.46	7.13
Season	Season	Weibull	272.25	7.92
No Covariates	Season	lognormal	273.64	9.31
Season	No Covariates	lognormal	273.94	9.61
No Covariates	Season	loglogistic	275.60	11.27
Season	No Covariates	loglogistic	275.62	11.29
Season	Season	lognormal	278.33	14.00
Season	Season	loglogistic	280.04	15.71

* 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 = change in AICc.

Appendix F4. GenEst estimated carcass persistence models with covariates and distributions for bats (n = 60 carcass persistence trial carcasses) at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 – December 15, 2023.

Location Covariates	Scale Covariates	Distribution	AICc	Delta AICc
No Covariates	No Covariates	Weibull	245.99	0*
No Covariates	Season	Weibull	248.05	2.06
Season	No Covariates	Weibull	249.40	3.41
No Covariates	-	exponential	250.45	4.46
Season	Season	Weibull	251.19	5.20
No Covariates	No Covariates	lognormal	252.32	6.33
Season	-	exponential	253.12	7.13
No Covariates	No Covariates	loglogistic	254.44	8.45
Season	No Covariates	lognormal	254.96	8.97
No Covariates	Season	lognormal	255.96	9.97

Appendix F4. GenEst estimated carcass persistence models with covariates and distributions for bats (n = 60 carcass persistence trial carcasses) at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 – December 15, 2023.

Location Covariates	Scale Covariates	Distribution	AICc	Delta AICc
Season	No Covariates	loglogistic	256.86	10.87
No Covariates	Season	loglogistic	258.15	12.16
Season	Season	lognormal	258.68	12.69
Season	Season	loglogistic	260.83	14.84

* 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 = change in AICc.

Appendix F5. Carcass persistence top models with covariates, distributions, and model parameters for all seasons and square and road and pad plots combined using GenEst for the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 – December 15, 2023.

Size Class	Distribution	Predicted Median Removal Times (days)	Parameter 1	Parameter 2
large birds	Weibull*	7.97	shape = 0.644	scale = 14.083
small birds	exponential*	4.95	rate_R = 0.140	–
bats	Weibull*	2.98	shape = 0.746	scale = 4.874

* Parameterization follows the base R parameterization for this distribution.

Appendix G. Search Area Adjustment Models for the Dakota Range I and II Wind Project, Grant and Codington Counties, South Dakota, from April 20 – December 15, 2023

Appendix G1. Search area adjustment estimates for the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 – December 15, 2023. Estimates were calculated using the maximum fall distance of carcasses for a given turbine height (82 meters [m]) and rotor diameter (136 m) estimated using a physics-based model (Hull and Muir 2013). The relative carcass-density distribution was assumed to follow a linear decrease from the turbine base out to the maximum predicted fall distance (Huso and Dalthorp 2014).

Size Class	Plot Type	Area Adjustment
Large Bird	road and pad	0.15
	square	0.86
Small Bird	road and pad	0.21
	square	0.98

Appendix G2. Area adjustment for raptors using the carcass-density distribution presented in Hallingstad et al. 2018 for the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota from April 20 – December 15, 2023.

Size Class	Plot Type	Area Adjustment
Raptor	Road and pad	0.03
	square	0.89

Appendix G3. GenEst estimated Truncated Weighted Maximum Likelihood search area adjustment estimates for bats at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota from April 20 – December 15, 2023 (n = 43 bat carcasses).

Plot Type	Distribution	Parameter 1	Parameter 2	Area Adjustment
road and pad	gamma	1.6246	0.0264	0.07
square	gamma	1.6246	0.0264	0.71

Appendix G4. GenEst estimated search area adjustment models for bats at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota from April 20 – December 15, 2023.

Distribution	AICc	Delta AICc
gamma	15,087.12	0*
Weibull	15,122.72	35.60
Gompertz	15,196.73	109.62
normal	15,196.76	109.64

* Selected model.

AICc = corrected Akaike Information Criterion; Delta AIC = change in AICc.

Appendix H. Bird and Bat Fatality Rates and Adjustment Factors for the Dakota Range I and II Wind Project, Grant and Codington Counties, South Dakota, from April 20 – December 15, 2023

Appendix H1. GenEst estimated fatality rates and adjustment factors with 90% confidence intervals (CI) for square plots during post-construction fatality monitoring at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from May 23 – December 15, 2023.

	Spring 18 turbines searched		Summer 5 turbines searched		Fall 18 turbines searched	
	Estimate	**90% CI[2]**	**Estimate**	**90% CI[2]**	**Estimate**	**90% CI[2]**
Search Area Adjustment						
Large Bird Non-Raptor	0.86		0.86		0.86	
Raptor	0.89		0.89		0.89	
Small Bird	0.98		0.98		0.98	
Bat	0.71	0–1.00	0.71	0–1.00	0.71	0–1.00
Searcher Efficiency						
Large Bird Non-Raptor	0.84	0.70–0.92	0.84	0.70–0.92	0.84	0.70–0.92
Raptor	0.84	0.70–0.92	0.84	0.70–0.92	0.84	0.70–0.92
Small Bird	0.42	0.28–0.57	0.42	0.28–0.57	0.42	0.28–0.57
Bat	0.39	0.27–0.54	0.39	0.27–0.54	0.39	0.27–0.54
Average Probability of a Carcass Persisting Through the Search Interval[1]						
Large Bird Non-Raptor	0.59	0.51–0.67	0.59	0.51–0.67	0.59	0.51–0.67
Raptor	0.59	0.51–0.67	0.59	0.51–0.67	0.59	0.51–0.67
Small Bird	0.48	0.41–0.54	0.48	0.41–0.54	0.48	0.41–0.54
Bat	0.37	0.30–0.45	0.37	0.30–0.45	0.37	0.30–0.45
Probability of Available and Detected						
Large Bird Non-Raptor	0.52	0.43–0.60	0.52	0.43–0.60	0.52	0.43–0.61
Raptor	0.52	0.43–0.60	0.52	0.43–0.60	0.52	0.43–0.61
Small Bird	0.21	0.14–0.30	0.21	0.14–0.30	0.21	0.14–0.30
Bat	0.16	0.10–0.23	0.16	0.10–0.23	0.16	0.10–0.23
Estimated Fatality Rates (Fatalities/Turbine/Season)						
All Bird	0.94	0.31–2.07	2.06	n/a	0.11	n/a
Large Bird	0.46	n/a	0	n/a	0.11	n/a
Large Bird Non-Raptor	0.46	n/a	0	n/a	0	n/a
Raptor	0	n/a	0	n/a	0.11	n/a
Small Bird	0.47	n/a	2.06	n/a	0	n/a
Bat	1.58	n/a	11.39	3.75–49.00	0	n/a
Estimated Fatality Rates (Fatalities/Megawatt/Season)						
All Bird	0.22	0.07–0.48	0.48	n/a	0.03	n/a
Large Bird	0.11	n/a	0	n/a	0.03	n/a
Large Bird Non-Raptor	0.11	n/a	0	n/a	0	n/a
Raptor	0	n/a	0	n/a	0.03	n/a
Small Bird	0.11	n/a	0.48	n/a	0	n/a
Bat	0.37	n/a	2.65	0.87–11.39	0	n/a

1. The search interval was once every two weeks.

2. Confidence interval not calculated because the observed carcass count is less than five.

n/a = not applicable.

Appendix H2. GenEst estimated fatality rates and adjustment factors with 90% confidence intervals (CI) for road and pad plots during post-construction fatality monitoring at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 - December 15, 2023.

	Spring 22 turbines searched		Summer 22 turbines searched		Fall 22 turbines searched	
	Estimate	**90% CI[2]**	**Estimate**	**90% CI[2]**	**Estimate**	**90% CI[2]**
Search Area Adjustment						
Large Bird Non-Raptor	0.15		0.15		0.15	
Raptor	0.03		0.03		0.03	
Small Bird	0.21		0.21		0.21	
Bat	0.07	0–0.12	0.07	0–0.12	0.07	0–0.12
Searcher Efficiency						
Large Bird Non-Raptor	0.98	0.91–1.00	0.98	0.91–1.00	0.98	0.91–1.00
Raptor	0.98	0.91–1.00	0.98	0.91–1.00	0.98	0.91–1.00
Small Bird	0.93	0.79–0.98	0.93	0.79–0.98	0.93	0.79–0.98
Bat	0.97	0.85–0.99	0.97	0.85–0.99	0.97	0.85–0.99
Average Probability of a Carcass Persisting Through the Search Interval[1]						
Large Bird Non-Raptor	0.59	0.51–0.67	0.59	0.51–0.67	0.59	0.51–0.67
Raptor	0.59	0.51–0.67	0.59	0.51–0.67	0.59	0.51–0.67
Small Bird	0.48	0.41–0.54	0.48	0.41–0.54	0.48	0.41–0.54
Bat	0.37	0.30–0.45	0.37	0.30–0.45	0.37	0.30–0.45
Probability of Available and Detected						
Large Bird Non-Raptor	0.58	0.50–0.66	0.58	0.50–0.66	0.58	0.51–0.66
Raptor	0.58	0.50–0.66	0.58	0.50–0.66	0.58	0.51–0.66
Small Bird	0.44	0.36–0.51	0.44	0.36–0.51	0.45	0.36–0.51
Bat	0.36	0.29–0.43	0.36	0.29–0.43	0.36	0.29–0.43
Estimated Fatality Rates (Fatalities/Turbine/Season)						
All Bird	3.21	n/a	8.84	4.44–15.02	1.73	n/a
Large Bird	0.96	n/a	3.15	n/a	0	n/a
Large Bird Non-Raptor	0.96	n/a	1.32	n/a	0	n/a
Raptor	0	n/a	1.96	n/a	0	n/a
Small Bird	2.17	n/a	5.45	2.66–9.60	1.73	n/a
Bat	2.11	n/a	82.84	43.08–320.23	3.28	n/a
Estimated Fatality Rates (Fatalities/Megawatt/Season)						
All Bird	0.76	n/a	2.10	1.06–3.55	0.42	n/a
Large Bird	0.22	n/a	0.76	n/a	0	n/a
Large Bird Non-Raptor	0.22	n/a	0.32	n/a	0	n/a
Raptor	0	n/a	0.45	n/a	0	n/a
Small Bird	0.52	n/a	1.29	0.63–2.28	0.42	n/a
Bat	0.49	n/a	20.15	10.54–78.13	0.76	n/a

1. The search interval was once every two weeks.

2. Confidence interval not calculated because the observed carcass count is less than five.

n/a = not applicable.

Appendix H3. GenEst estimated overall fatality rates per megawatt (MW) and per turbine for square plots for studies conducted at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from May 23 - December 15, 2023.

	Per MW Estimates		Per Turbine Estimates	
	Estimate	90% CI[1]	Estimate	90% CI[1]
All Bird	0.73	0.21–1.64	3.11	0.84–7.03
Large Bird	0.14	n/a	0.58	n/a
Large Bird Non-Raptor	0.11	n/a	0.46	n/a
Raptor	0.03	n/a	0.11	n/a
Small Bird	0.59	n/a	2.53	n/a
Bat	3.03	1.17–12.87	13.01	5.02–55.33

[1] Confidence interval not calculated because the observed carcass count is less than 5.

CI = confidence interval.

Appendix H4. GenEst estimated overall fatality rates per megawatt (MW) and per turbine for road and pad plots for studies conducted at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 - December 15, 2023.

	Per MW Estimates		Per Turbine Estimates	
	Estimate	90% CI[1]	Estimate	90% CI[1]
All Bird	3.29	1.98–5.15	13.87	8.27–21.63
Large Bird	1.00	n/a	4.24	n/a
Large Bird Non-Raptor	0.53	n/a	2.21	n/a
Raptor	0.45	n/a	1.96	n/a
Small Bird	2.24	1.23–3.76	9.47	5.19–15.90
Bat	21.48	11.21–84.31	88.93	46.30–348.19

[1] Confidence interval not calculated because the observed carcass count is less than 5.

CI = confidence interval; n/a = not applicable.

Appendix H5. GenEst estimated overall fatality rates and adjustment factors, with 90% confidence intervals (CIs) at overall search areas for studies conducted at the Dakota Range I and II Wind Project, Grant and Codington counties, South Dakota, from April 20 - December 15, 2023.

	Spring 22 turbines searched		Summer 22 turbines searched		Fall 22 turbines searched	
	Estimate	90% CI[1]	Estimate	90% CI[1]	Estimate	90% CI[1]
Estimated Fatality Rates (Fatalities/Turbine/Season)						
All Bird	2.39	1.16–4.20	7.96	4.15–13.00	1.82	n/a
Large Bird	0.89	0.25–1.97	2.56	n/a	0.09	n/a
Large Bird Non-Raptor	0.89	0.25–1.96	1.02	n/a	0	n/a
Raptor	0	n/a	1.66	n/a	0.09	n/a
Small Bird	1.42	n/a	5.16	2.67–8.71	1.73	n/a
Bat	3.53	0.78–15.05	70.73	36.96–273.50	3.28	n/a
Estimated Fatality Rates (Fatalities/MW/Season)						
All Bird	0.57	0.27–1.00	1.90	1.00–3.09	0.44	n/a
Large Bird	0.21	0.06–0.46	0.62	n/a	0.02	n/a
Large Bird Non-Raptor	0.21	0.06–0.46	0.25	n/a	0	n/a
Raptor	0	n/a	0.39	n/a	0.02	n/a
Small Bird	0.34	n/a	1.22	0.62–2.07	0.42	n/a
Bat	0.82	0.18–3.50	17.15	8.96–65.84	0.76	n/a

[1] Confidence interval not calculated because the observed carcass count is less than 5.

n/a = not applicable.

Appendix I. Regional Comparison Tables

Appendix I1. 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
Jeffers, MN (2021)	9.19	120 m x 120 m cleared, 100 m radius road/pad	GenEst	Cropland, Developed, Deciduous Tree, Pasture, Herbaceous	Heist et al. 2022e
Blazing Star, MN (2021)	8.94	120 m x 120 m cleared, 100 m radius road/pad	GenEst	Cropland, Wetlands	Stucker et al. 2022b
Black Oak Getty, MN (2017)	8.69	60 m radius road/pad	Huso	Cropland, Grassland, Wetlands	Pickle et al. 2018
Mower County, MN (2021)	8.31	120 m x 120 m cleared, 100 m radius road/pad	GenEst	Developed, Corn, Soybean	Heist et al. 2022c
Wessington Springs, SD (2009)	8.25	200 m x 200 m plot	Shoenfeld	Grassland	Derby et al. 2010
Blazing Star II, MN (2021)	6.64	120 m x 120 m cleared, 100 m radius road/pad	GenEst	Agriculture, Cropland, Pasture, Corn, Soybean, Herbaceous, Wetlands	Stucker et al. 2022a
Nobles 2, MN (2021)	4.88	120 m x 120 m cleared, 100 m radius road/pad	GenEst	Cropland, Developed, Deciduous Tree, Herbaceous, Wetlands	Heist et al. 2022d
Odell, MN (2016-2017)	4.69	120 m x 120 m cleared	Huso	Agriculture	Chodachek and Gustafson 2018
Black Oak Getty, MN (2018)	3.50	60 m radius road/pad	Huso	Cropland, Grassland, Wetlands	Pickle et al. 2019
Lake Benton II, MN (2021)	3.48	120 m x 120 m cleared, 100 m radius road/pad	GenEst	Agriculture, Cropland, Developed, Pasture, Corn, Soybean, Herbaceous, Wetlands	Stucker et al. 2022c
Dakota Range I &II, SD (2023)	2.96	150 m x 150 m, 100 m radius road/pad	GenEst	Cropland, Herbaceous, Pasture	This study
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
Dakota Range I &II, SD (2022)	2.30	150 m x 150 m, 100 m radius road/pad	GenEst	Cropland, Herbaceous, Pasture	Chodachek et al. 2023

Appendix I1. 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
Lakefield Wind, MN (2012)	2.22	100 m x 100 m plot	Shoenfeld	Agriculture	Minnesota Public Utilities Commission (MPUC) 2012
Community Wind North, MN (2021)	2.08	120 m x 120 m cleared, 100 m radius road/pad	GenEst	Cropland, Developed, Deciduous Tree, Pasture, Herbaceous, Wetlands	Heist et al. 2022a
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
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
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
Prairie Winds ND1, ND (2010)	1.48	200 m x 200 m plot	Shoenfeld	Agriculture, Grassland	Derby et al. 2011b
Prairie Winds SD1, SD (2011-2012)	1.41	200 m x 200 m plot	Shoenfeld	Grassland	Derby et al. 2012a
Freeborn, IA, MN (2021)	1.02	120 m x 120 m cleared, 100 m radius road/pad	GenEst	Cropland, Developed, Deciduous Tree, Pasture, Herbaceous, Wetlands	Heist et al. 2022b
Lake Benton, MN (2021)	1.02	100 m radius road/pad, 120 m x 120 m plot	GenEst	Cropland, Pasture, Herbaceous	Voth et al. 2022
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 cleared, 100 m radius road/pad	GenEst	Cropland, Developed, Pasture, Herbaceous	Chodachek et al. 2022

m = meters.

Appendix I2. Fatality rates for diurnal raptors (number of 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
Dakota Range I &II, SD (2023)	0.41	150 m x 150 m, 100 m radius road/pad	GenEst	Cropland, Herbaceous, Pasture	This study
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
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
Wessington Springs, SD (2009)	0.06	200 m x 200 m plot	Shoenfeld	Grassland	Derby et al. 2010
PrairieWinds ND1, ND (2010)	0.05	200 m x 200 m plot	Shoenfeld	Agriculture, Grassland	Derby et al. 2011b
PrairieWinds ND1, ND (2011)	0.05	200 m x 200 m plot	Shoenfeld	Agriculture, Grassland	Derby et al. 2012b
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
Blazing Star, MN (2021)	0	120 m x 120 m cleared, 100 m radius road/pad	GenEst	Cropland, Wetlands	Stucker et al. 2022b
Community Wind North, MN (2021)	0	120 m x 120 m cleared, 100 m radius road/pad	GenEst	Cropland, Developed, Deciduous Tree, Pasture, Herbaceous, Wetlands	Heist et al. 2022a
Dakota Range I &II, SD (2022)	0	150 m x 150 m, 100 m radius road/pad	GenEst	Cropland, Herbaceous, Pasture	Chodachek et al. 2023
Freeborn, IA, MN (2021)	0	120 m x 120 m cleared, 100 m radius road/pad	GenEst	Cropland, Developed, Deciduous Tree, Pasture, Herbaceous, Wetlands	Heist et al. 2022b
Jeffers, MN (2021)	0	120 m x 120 m cleared, 100 m radius road/pad	GenEst	Cropland, Developed, Deciduous Tree, Pasture, Herbaceous	Heist et al. 2022e

Appendix I2. Fatality rates for diurnal raptors (number of 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
Nobles 2, MN (2021)	0	120 m x 120 m cleared, 100 m radius road/pad	GenEst	Cropland, Developed, Deciduous Tree, Herbaceous, Wetlands	Heist et al. 2022d
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. 2012a
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 I3. 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
Freeborn, IA, MN (2021)	18.88	120 m x 120 m cleared, 100 m radius road/pad	GenEst	Cropland, Developed, Deciduous Tree, Pasture, Herbaceous, Wetlands	Heist et al. 2022b
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
Dakota Range I &II, SD (2023)	18.71	150 m x 150 m, 100 m radius road/pad	GenEst	Cropland, Herbaceous, Pasture	This study
Blazing Star, MN (2021)	16.06	120 m x 120 m cleared, 100 m radius road/pad	GenEst	Cropland, Wetlands	Stucker et al. 2022b
Lakefield Wind, MN (2012)	15.85	100 m x 100 m plot	Shoenfeld	Agriculture	Minnesota Public Utilities Commission (MPUC) 2012
Dakota Range I &II, SD (2022)	14.19	150 m x 150 m, 100 m radius road/pad	GenEst	Cropland, Herbaceous, Pasture	Chodachek et al. 2023
Blazing Star II, MN (2021)	14.07	120 m x 120 m cleared, 100 m radius road/pad	GenEst	Agriculture, Cropland, Pasture, Corn, Soybean, Herbaceous, Wetlands	Stucker et al. 2022a
Community Wind North, MN (2021)	12.18	120 m x 120 m cleared, 100 m radius road/pad	GenEst	Cropland, Developed, Deciduous Tree, Pasture, Herbaceous, Wetlands	Heist et al. 2022a
Jeffers, MN (2021)	9.35	120 m x 120 m cleared, 100 m radius road/pad	GenEst	Cropland, Developed, Deciduous Tree, Pasture, Herbaceous	Heist et al. 2022e
Nobles 2, MN (2021)	7.97	120 m x 120 m cleared, 100 m radius road/pad	GenEst	Cropland, Developed, Deciduous Tree, Herbaceous, Wetlands	Heist et al. 2022d

Appendix I3. 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
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
Lake Benton II, MN (2021)	5.96	120 m x 120 m cleared, 100 m radius road/pad	GenEst	Agriculture, Cropland, Developed, Pasture, Corn, Soybean, Herbaceous, Wetlands	Stucker et al. 2022c
Mower County, MN (2021)	5.82	120 m x 120 m cleared, 100 m radius road/pad	GenEst	Developed, Corn, Soybean	Heist et al. 2022c
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
Lake Benton, MN (2021)	2.68	100 m radius road/pad, 120 m x 120 m plot	GenEst	Cropland, Pasture, Herbaceous	Voth et al. 2022
Prairie Winds ND1, ND (2010)	2.13	200 m x 200 m plot	Shoenfeld	Agriculture, Grassland	Derby et al. 2011b
Pleasant Valley, MN (2016-2017)	1.80	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. 2010
Prairie Winds SD1, SD (2011-2012)	1.23	200 m x 200 m plot	Shoenfeld	Grassland	Derby et al. 2012a
Crowned Ridge II, SD (2021)	0.74	120 m x 120 m cleared, 100 m radius road/pad	GenEst	Cropland, Developed, Pasture, Herbaceous	Chodachek et al. 2022
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 I4. 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	Search Area Type	Survey Frequency	Length of Study (months)	Tower Size (m)	Citations
Big Blue, MN (2013)	18	36	10	square 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 II, MN (2021)	100	200	10, 60	cleared, road/pad	twice per week, weekly	8	90	Stucker et al. 2022a
Blazing Star, MN (2020)	100	200	5, 10, 33, 60	cleared, road/pad	twice per week, weekly	8		Stucker et al. 2021b
Blazing Star, MN (2021)	100	200	10, 60	cleared, road/pad	weekly, twice per week	7	80	Stucker et al. 2022b
Community Wind North, MN (2021)	12	26.4	5, 7	cleared, road/pad	weekly	8	87	Heist et al. 2022a
Crowned Ridge II, SD (2021)	88	200.6	27, 5, 22	cleared, road/pad	twice per month	9	80	Chodachek et al. 2022
Freeborn, IA, MN (2021)	100	200	4, 10, 20, 90	cleared, road/pad	weekly	7	80	Heist et al. 2022b
Grand Meadow, MN (2013)	67	101	13	square plot	daily	4	80	Chodachek et al. 2014
Jeffers, MN (2021)	20	44	5, 15	cleared, road/pad	weekly, twice per week	8	87	Heist et al. 2022e
Lake Benton II, MN (2020)	44	100	5, 39	cleared, road/pad	weekly	8	80	Stucker et al. 2021a
Lake Benton II, MN (2021)	44	100	5, 39	cleared, road/pad	weekly, twice per week	7	80	Stucker et al. 2022c
Lake Benton, MN (2021)	139	107.25	40, 10	road/pad, square plot	weekly	8	53	Voth et al. 2022
Lakefield Wind, MN (2012)	137	205.5	26	square plot	other	7.7	80	Minnesota Public Utilities Commission (MPUC) 2012
Lakefield, MN (2014)	137	205.5	26	cleared	other	4	80	Westwood 2015

Appendix I4. 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	Search Area Type	Survey Frequency	Length of Study (months)	Tower Size (m)	Citations
Mower County, MN (2021)	43	98.9	5, 4, 38, 39	cleared, road/pad	weekly	7	78.3	Heist et al. 2022c
Nobles 2, MN (2021)	74	250	15, 54	cleared, road/pad	twice per week	8	82	Heist et al. 2022d
Oak Glen, MN (2013)	24	44	10	square 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	square plot	twice per month, monthly	11.2	80	Derby et al. 2012a
Prairie Winds SD1, SD (2012-2013)	108	162	50, 37, 13	square plot, road/pad	twice per month, monthly	11.5	80	Derby et al. 2013
Prairie Winds SD1, SD (2013-2014)	108	162	9, 36	square plot, road/pad	twice per month, monthly	11.8	80	Derby et al. 2014
Prairie Winds ND1, ND (2010)	77	115.5	35	square plot	twice per month	7.6	80	Derby et al. 2011b
Prairie Winds ND1, ND (2011)	77	115.5	35, 17	square plot	twice per month	7.6	80	Derby et al. 2012b
Red Pine, MN (2018)	100	200	40	road/pad	weekly	8	80	Trana et al. 2019
Thunder Spirit, ND (2016-2017)	43	107.5	10, 33	square plot, road/pad	twice per month	10	75	Derby et al. 2018
Wessington Springs, SD (2009)	34	51	20	square plot	twice per month	8.5	80	Derby et al. 2010
Wessington Springs, SD (2010)	34	51	20	square plot	twice per month	8.4	80	Derby et al. 2011a

MW = megawatts; m = meters.

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