

**Bat Evaluation Monitoring Studies at the
Fowler Ridge Wind Farm
Benton County, Indiana**

April 1 – October 15, 2022



**Prepared for:
Fowler Ridge Wind Farm**

**Prepared by:
Rhett E. Good, Kristen Nasman, and Anna Ciecka**
Western EcoSystems Technology, Inc.
408 West 6th Street
Bloomington, Indiana 47404

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EXECUTIVE SUMMARY

The Fowler Ridge Wind Farm (FRWF or Project) collectively includes Fowler Ridge Wind Farm LLC, Fowler Ridge II Wind Farm LLC, Fowler Ridge III Wind Farm LLC, and Fowler Ridge IV Wind Farm LLC. The FRWF consists of 420 wind turbines in four phases in Benton County, Indiana. Western EcoSystems Technology, Inc. conducted post-construction fatality studies of bats within Phases I, II, and III in the fall of 2009 and 2010, when two Indiana bat carcasses were found. The FRWF worked with the US Fish and Wildlife Service and developed a Habitat Conservation Plan (HCP) for the Indiana bat, designed to minimize Indiana bat fatalities during the fall migration period. The FRWF received an Incidental Take Permit (ITP) for Indiana bats in August 2014.

Standardized carcass searches were completed weekly at 114 turbines during both the spring (April 1 – May 15) and fall (August 1 – October 15) of 2022, corresponding with migration periods of Indiana bats as required by the ITP. The search area was restricted to the gravel roads and pads within 80 meters (262 feet) of each turbine included in the study in both seasons. Searcher efficiency and carcass persistence trials were also conducted during each season to correct for detection and removal bias.

No Indiana bat or other *Myotis* species were found. Sixty bat carcasses of five known species were found during searches and incidentally. Two evening bats, a state-endangered species, were found on May 11, 2022 and August 2, 2022. The most commonly found bat species were silver-haired bat and eastern red bat, followed by hoary bat and big brown bat.

Estimated bat fatality rates were calculated based on the number of carcasses found, the results of bias trials, and adjustments for bats that did not fall on roads and pads. The combined spring and fall bat fatality rate in 2022 was estimated to be 7.41 bat fatalities/turbine/study period (90% confidence interval: 5.21–9.93). The results of monitoring during 2022 provide evidence that operational strategies exceeded the objective of reducing bat fatality rates by 50%, compared to fatality estimates from turbines operating normally in 2010 and 2011. Within-season and end-of-season adjustments of minimization strategies were not required in 2022 because bat fatality rates were below adaptive management thresholds.

STUDY PARTICIPANTS

Rhett Good	Project Manager
Anna Ciecka	Field Supervisor and Report Compiler
Kristen Nasman	Statistician
Elyse Coffey-Wick	GIS Technician
Travis Brown	Permitted Bat Biologist
Bethany Laffoon	Field Technician
Katelyn Garrett	Field Technician
Kendra Cummings	Field Technician
Sanketh Menon	Field Technician

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INTRODUCTION

The Fowler Ridge Wind Farm (FRWF or Project) collectively includes Fowler Ridge Wind Farm LLC, Fowler Ridge II Wind Farm LLC, Fowler Ridge III Wind Farm LLC, and Fowler Ridge IV Wind Farm LLC. The FRWF consists of 420 wind turbines in four phases in Benton County, Indiana. A post-construction fatality study of bats was conducted by Western EcoSystems Technology, Inc. (WEST) within Phases I, II, and III in 2009 (Johnson et al. 2010a, 2010b), when an Indiana bat (*Myotis sodalis*) carcass was found. Subsequent studies were conducted in 2010, 2011, 2012 and 2013 (Good et al. 2011, 2012, 2013, and 2014) under Scientific Research and Recovery Permits (TE15075A in 2010, TE15075A-2 in 2011, and TE73598A-0 in 2012 and 2013) within Phases I, II, and III. A second Indiana bat carcass was found in 2010 (Good et al. 2011). The results of this research were used by FRWF to design a strategy for reducing Indiana bat fatality rates.

The FRWF worked with the US Fish and Wildlife Service (USFWS) and developed a Habitat Conservation Plan (HCP) for the Indiana bat designed to minimize Indiana bat fatalities by feathering turbine blades when winds are at 5.0 meters per second (m/s; 16.4 feet per second [ft/s]) or lower, on a nightly basis from sunset to sunrise during the fall migration period from August 1 – October 15. The FRWF received an Incidental Take Permit (ITP) for Indiana bats in August 2014 (TE95012A-0) based on the HCP. The HCP and ITP include requirements for monitoring the effectiveness of minimization measures.

The first two years of evaluation phase monitoring were completed at Phases I, II, and III during the fall migration season for Indiana bats in 2014 and 2015 (Good et al. 2015, 2016). Construction of Phase IV was completed in December 2015, and the required two years of evaluation phase monitoring were conducted during the fall migration season for Indiana bats in 2016 and 2017 (Good et al. 2017, 2018). Because the estimated Indiana bat fatality rate was estimated to be below adaptive management thresholds for all phases during their respective evaluation years, as outlined in the HCP, implementation phase monitoring began in the fall of 2016 at Phases I, II, and III, and in the fall of 2018 at Phase IV, and will continue unless adaptive management thresholds are exceeded in the future (Good et al. 2018, 2019, 2020).

Indiana bats were not believed to be at risk during the spring migration period (April 1 – May 15) when the original HCP was prepared and the ITP was issued. Since that time, new evidence indicates Indiana bats may be at risk of take during the spring migration period as well (Pruitt and Reed 2018). The HCP was amended to account for spring take of Indiana bats and an amendment to the ITP was granted on March 22, 2018 (TE95012A-1). To minimize Indiana bat take during the spring migration period, turbine blades are feathered below a cut-in speed of 3.5 m/s (11.5 ft/s) on a nightly basis from sunset to sunrise from April 1 – May 15. As per the amended HCP and ITP, two years of spring evaluation phase monitoring were conducted in 2018 (Good et al. 2019) and 2019 (Good et al. 2020) at the FRWF. Because the estimated Indiana bat fatality rate was estimated to be below adaptive management thresholds during the spring of 2018 and 2019,

implementation phase monitoring began in 2020 and will continue unless adaptive management thresholds are exceeded in the future.

This report describes the results of the 2022 spring and fall fatality monitoring required under the HCP and ITP.

STUDY AREA

The FRWF has a total energy capacity of 750 megawatts (MW). Phase I consists of 122, Vestas V82 1.65-MW turbines and 40, Clipper C96 2.50-MW turbines with a combined 301 MW of energy capacity. Phase II consists of 133, 1.50-MW General Electric (GE) SLE turbines with a capacity of 199.5 MW. Phase III consists of 60, Vestas V82 1.65-MW turbines with a total 99 MW of capacity. Phase IV consists of 65, Siemens SWT-2.3-108 2.30-MW turbines with a capacity of 150 MW. Turbine characteristics are listed in Table 1.

Table 1. Turbine characteristics at the Fowler Ridge Wind Farm, Benton County, Indiana.

Turbine Model	Megawatt	Turbine Height (meters)	Rotor Diameter (meters)	Standard cut-in speed (meters/second)
General Electric SLE	1.50	80	77	3.5
Vestas V82	1.65	80	82	3.5
Siemens SWT-2.3-108	2.30	80	108	3.5
Clipper C96	2.50	80	96	3.5

Phases I and III were constructed in 2008 and became operational during January 2009. Phase II was constructed in 2009 and became operational by December 31, 2009. Phase IV was constructed in 2015 and became operational in December 2015.

The Project is dominated by cultivated crops, consisting primarily of corn (*Zea mays*) and soybeans (*Glycine max*; Figure 1). Within 0.8 kilometers (0.5 mile) of turbine locations, cultivated crops compose 92.5% of the land use in the 61,075 -acre (24,716-hectare) study area (Table 2). After cultivated crops, the next most common land uses within the FRWF are developed areas (e.g., houses, buildings, and open space), which compose 5.9% of the total. Forested areas, grasslands (herbaceous), and wetlands are rare within the study area (National Land Cover Database 2019).

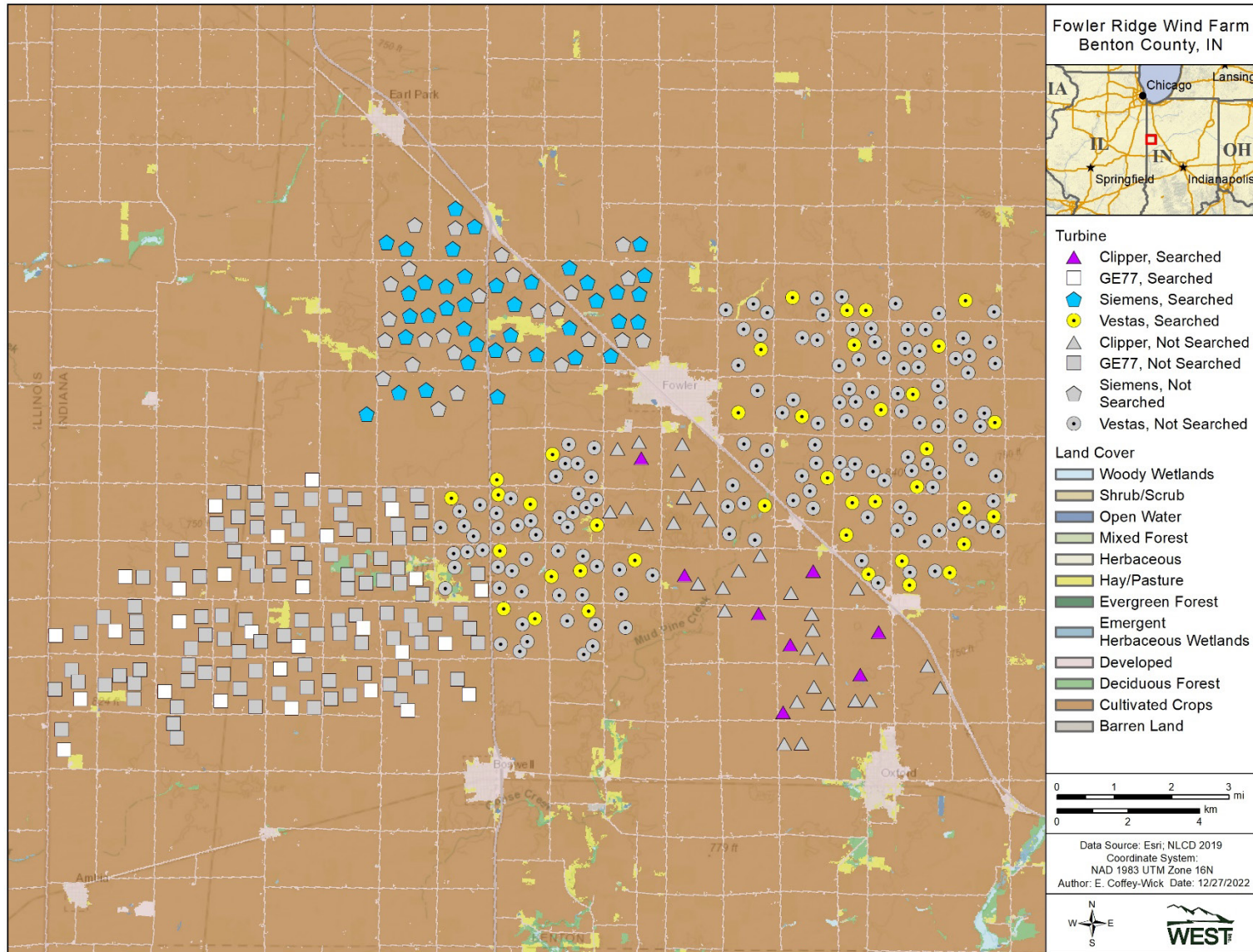


Figure 1. Land cover types and locations of Phase I-IV turbines searched from April 1 – May 15 and August 1 – October 15, 2022, at the Fowler Ridge Wind Farm, Benton County, Indiana.

Table 2. Land cover types, coverage, and percent composition within 0.5 mile of turbine locations within the Fowler Ridge Wind Farm, Benton County, Indiana.

Land Cover Types	Coverage (acres)	Percent Composition
Cultivated Crops	56,514.7	92.5
Developed, Low Intensity	1,817.2	3.0
Developed, Open Space	1,055.7	1.7
Hay/Pasture	695.0	1.1
Developed, Medium Intensity	610.0	1.0
Deciduous Forest	173.1	0.3
Developed, High Intensity	113.8	0.2
Open Water	29.1	<0.1
Mixed Forest	21.8	<0.1
Herbaceous	14.0	<0.1
Barren Land	12.4	<0.1
Emergent Herbaceous Wetlands	12.0	<0.1
Woody Wetlands	5.6	<0.1
Evergreen Forest	0.4	<0.1
Total	61,074.9	100

Source: National Land Cover Database 2019

METHODS

Standardized Carcass Searches

All phases of the FRWF are in the implementation phase of HCP monitoring for both spring and fall monitoring periods. Seventy-five turbines at Phases I, II, and III, and 39 turbines at Phase IV were searched from April 1 – May 15 and August 1 – October 15, 2022 (Figure 1).

Carcass searches were conducted along access roads and on turbine pads within 80 m (262 ft) of the selected turbines once per week. The spring and fall search intervals in 2022 were determined based on carcass persistence measured during 2021. Carcass persistence times were 12.8 days during the spring and 10.6 days in the fall of 2021 (Good et al. 2022). The HCP recommends monitoring be conducted weekly if the prior year persistence rates are greater than seven days.

Technicians trained in proper search techniques conducted the carcass searches. Searches occurred along transects on the roads and pads of a sampled turbine within 80 m of the tower. Searchers walked at a rate of approximately 45–60 m (148–197 ft) per minute along each transect, looking for bat and bird carcasses. Transects were spaced at approximately 3 m (10-ft) intervals, and searchers scanned the area on both sides out to 1.5 m (5.0 ft) for carcasses as they walked. All bat carcasses were recorded and collected. Bird carcasses were recorded, but left in the field. Searches began after 0700 hours each morning and were completed before sunset.

The condition of each carcass found was recorded using the following categories:

- Intact – a carcass that is complete, shows little to no decomposition, and 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, skeletal remains)
- Dismembered – an entire carcass, but found in more than one piece, where the pieces are separated by more than 5.0 m (16.4 ft)
- Injured – a live bird or bat that is harmed, damaged, or impaired in some way
- Feather Spot (for bird carcasses only) – 10 or more feathers (or two or more primary feathers) at one location indicating predation or scavenging

Data recorded for each carcass included date and time collected, turbine number, species, sex and age when identifiable, carcass location as latitude and longitude, distance and azimuth from turbine, condition (live, intact, scavenged, dismembered, feather spot), and any comments regarding possible cause of death or scavenging. Digital photographs were taken of the carcass, any visible injuries, and surrounding habitat. Time since death for all carcasses was also estimated and recorded (e.g., last night, two to three days). Criteria used to determine time since death are listed in Appendix A.

Bat carcasses were collected under the Project's ITP (TE95012A-1), WEST's Federal Native Endangered and Threatened Species Recovery permit (TE234121-9), and WEST's State Endangered Species Incidental Take Permit Amendment for evening bat and Special Purpose Salvage Permit from the Indiana Department of Natural Resources (2229; IDNR). Any carcass with the potential to be a state- or federally listed endangered or threatened species was reported to the appropriate agency within 48 hours. A permitted bat biologist verified the species identification of all bat carcasses, a subset of which were delivered to the USFWS Bloomington Field Office at the end of the study, along with any tissue and fur samples taken from carcasses that were not submitted in their entirety. Each bat carcass and samples were identified with the unique casualty identification number.

Carcasses found in non-search areas (e.g., near a turbine not selected for standardized carcass searches or outside of the search boundary for a selected turbine) were recorded as incidental discoveries and documented in a similar fashion as those found during standard searches. In addition to carcasses, all injured bats and birds were recorded and treated as a fatality for the purpose of the analyses, but left in place.

Turbine Operation Schedule

Turbines were feathered below manufacturer's cut-in speed (3.5 m/s) during the spring and 5.0 m/s during the fall. Increasing cut-in speed and feathering turbine blades below cut-in speed were both implemented on a nightly basis from sunset to sunrise, and adjusted for sunset/sunrise times weekly. Turbines were monitored and controlled based on wind speed on an individual basis (i.e., the entire facility did not alter cut-in speed at the same time; rather, operational changes were based on wind speed conditions specific to each turbine). Turbines began operating under normal

conditions when the 5- to 10-minute rolling average wind speed was above 5.0 m/s during the fall and 3.5 m/s during the spring; turbines were feathered again if the 5- to 10-minute rolling average wind speed dropped below the specified cut-in speed during the course of the night.

Bias Trials

Searcher Efficiency Trials

The objective of searcher efficiency trials was to estimate the probability that a carcass was found by searchers, to account for detection bias in the bat fatality estimates. When possible, freshly killed bats conclusively identified as non-*Myotis* or non-evening bat (*Nycticeius humeralis*) were used for searcher efficiency and carcass persistence trials. Big brown bat (*Eptesicus fuscus*) carcasses obtained from Indiana State University were used for bias trials when not enough fresh carcasses were available, e.g. during the spring season.

Multiple searcher efficiency trials were conducted in each season to measure potential changes in plot conditions and other factors on searcher efficiency over time. Seventy-six bats were placed on six separate days, from zero to seven days prior to searches in the spring, and 82 bats were placed on eight separate days, from zero to seven days prior to searches in the fall to estimate the overall probability that a bat carcass was available and detected (empirical π). We conducted two sets of trials, including one set placed the day of the search to estimate day of search efficiency rates; carcasses not found during the day of search trial were checked for availability and collected at the end of the day. A second set of trials were completed, where carcasses were placed from 1 – 7 days ahead of the search. These carcasses were left in the field if missed on the first search until found on subsequent searches, or removed by scavengers. The first day a searcher discovered a carcass was recorded to estimate the overall probability that a carcass was available and detected. Bat carcasses were placed throughout each study season by a technician not involved in the carcass search effort, and were randomly placed within a turbine's searchable area using distances derived from a random number generator. Searchers had no knowledge of the number, location, or timing of carcasses placed at turbines. Data recorded for each trial carcass included date of placement, species, turbine number, the distance and azimuth from the turbine, and date the carcass was found. Carcasses were identified as bias trial carcasses through the placement of a small, indistinct black zip tie on the bat's forearm and were collected when found.

Carcass Persistence Trials

The objective of carcass persistence trials was to estimate the average length of time (in days) a carcass persisted in the field (i.e., before a carcass was no longer available for detection). Carcasses could be removed by scavenging or rendered undetectable by typical farming or wind farm maintenance activities. Carcass persistence trials were conducted when carcass searches occurred.

Persistence trials were conducted during both spring and fall to incorporate the effects of varying weather conditions and scavenger densities. Technicians monitored 40 trial carcasses over a 24-day period according to the following schedule as closely as possible. Carcasses were checked on

days 1, 2, 4, 6, 8, 10, 12, 18, and 24 after placement, where day 1 was defined as the day after a carcass was placed. Trial carcasses were left at the placement location until they were removed by scavenging or other means, completely decomposed, or the end of the carcass persistence trial, whichever occurred first. Any evidence of carcasses that remained at the end of the 24-day period was removed.

Quality Assurance and Quality Control

WEST implemented quality assurance and quality control (QA/QC) measures at all stages of the study, including in the field, during data entry and analysis, and report writing. All WEST field staff were trained in proper survey techniques and all data collected were recorded in a tablet, electronically. Data were reviewed before they were submitted for data entry. If errors or anomalies were found, follow-up measures were implemented including discussions and review of field data with searchers 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 entered into a MS SQL database and were QA/QC'd throughout the course of the study. Statisticians provided an extra level of QA/QC to ensure proper protocols were followed and data collected were congruent with the objectives of the study.

Statistical Analysis

Bat Fatality Rate Estimation

Fatality estimates for bats were calculated based on:

- Observed number of bat carcasses found in search areas estimated to have been killed during the monitoring period
- Persistence rates combined with searcher efficiency, expressed as the estimated average probability a bat carcass is expected to be available for detection and was detected by the searchers during combined bias trials
- The search area adjustment factor for bat carcasses landing outside of searched roads and pads

Carcasses found in a search area were included in the fatality analysis if the bat was estimated to have perished during either monitoring period (i.e., on or after the evening of March 31 for spring surveys and July 31 for fall surveys), regardless of whether they were found during a scheduled search or incidentally at some other time. We assumed that all carcasses found incidentally in a search area would be found at the next scheduled search. Carcasses found outside of search areas were not included in fatality estimates.

The probability of carcass availability and detection ($\hat{\pi}$) was calculated based on the results of combined bias trials measuring searcher efficiency and carcass persistence. Trial carcasses were placed in search areas throughout each monitoring period and left until they were either found by

searchers or removed by some other means, such as scavenging. The ratio of the number found to the number placed was calculated for each number of days prior to the search the trial carcass was placed. The average of the ratios was used as an empirical pi estimate of the probability of availability and detection.

An adjustment factor (r) of 6.56 was used to adjust for carcasses estimated to occur outside of searched roads and pads for Fowler Ridge I–III Wind Farms (Fowler I–III), to determine total estimated bat fatality during the spring and fall migration periods. This area adjustment factor was an average of the road and pad adjustment factors from 2011 and 2012 at Phases I, II, and III of the FRWF (Good et al. 2011, 2012).

The road and pad area of each turbine at Phase IV is smaller compared to Phases I, II, and III, and required a different adjustment factor in order to accurately estimate bat fatality rates. An adjustment factor (r) of 26.38 was used to adjust for carcasses that likely occurred outside the searched road and pad area for Fowler Ridge IV Wind Farm (Fowler IV) to determine the total estimated bat fatality rate during the spring and fall migration periods (Good et al. 2018).

The adjusted estimate for the number of fatalities per turbine was calculated as follows:

$$m = \frac{(\text{observed fatalities})}{(\text{number of search plots}) * \hat{\pi}} * r$$

Due to the differences in MW ratings for each turbine type, bat fatality rates were calculated for each type of turbine present, and a weighted average was used to calculate the facility-wide bat fatality rate (bats/turbine/study period and bats/MW/study period). The proportion of each turbine type at the FRWF were used as weights for calculating the overall bat fatality rate for the Project.

Carcass Persistence Rates

Definition of Variables

The following variables were used to calculate carcass persistence rates:

- s the number of carcasses used in persistence trials
- s_c the number of carcasses in persistence trials that remain in the study area after 24 days
- t_j the time (in days) carcass j remains in the study area before it is removed, as determined by the persistence trials
- \bar{t} the average time (in days) a carcass remains in the study area before it is removed, as determined by the persistence trials

Mean carcass persistence time (\bar{t}) was calculated as the average length of time, in days, a carcass remained in the study area before it was removed:

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

Between Years Comparisons

Percent change in fatality rates between 2022 (spring and fall combined) and the baseline years (2010 and 2011) was calculated as the percent difference between estimates, and compared to the anticipated 50% reduction in fatality rates due to applied minimization measures.

RESULTS

The following sections contain the results of studies conducted under ITP permit TE95012A-1. Per the requirements of this permit, information regarding the date, locations, and species of bats (and birds) encountered can be found in Appendix B.

Bat and Bird Carcass Surveys

There were 1,900 surveys conducted on roads and pads at 114 turbines from April 1 – May 15, and from August 1 – October 15, 2022. Due to turbine maintenance, accessibility, or severe weather, 38 surveys (2.0%) were missed. Overall, 60 bat carcasses and 18 bird carcasses were found during the survey (Table 3, Appendix B).

Species Composition

No Indiana bats or other *Myotis* species were found during the study. The most commonly found bat species were silver-haired bat (*Lasionycteris noctivagans*; 28 carcasses; 46.7%), eastern red bat (*Lasiurus borealis*; 21 carcasses; 35.0%), and hoary bat (*Lasiurus cinereus*; seven carcasses; 11.7%). Two big brown bat carcasses (3.3%) and two evening bat carcasses (3.3%) were also found (Table 3).

Eighteen bird carcasses were found during the survey period representing 13 known bird species or bird groups (Table 4). No bird species listed as threatened or endangered by IDNR (2020), or the federal Endangered Species Act of 1973 were found (USFWS 2019). One bald eagle carcass was reported by turbine workers at turbine S57, a turbine that is normally searched, but the carcass was found outside the search area, on April 5, 2022. IDNR and USFWS were immediately notified and under the direction of IDNR, the carcass was collected for temporary storage until it could be retrieved by IDNR personnel.

Table 3. Total number and percent composition of bat carcasses found at the Fowler Ridge Wind Farm from April 1 – May 15 and August 1 – October 15, 2022.

Species	Number Included in Fatality Estimate	Percent Composition Included in Fatality Estimate	Number Found Outside Plot	Percent Composition Found Outside Plot¹	Number with Estimated Time of Death Outside Study Period	Percent Composition with Estimated Time of Death Outside Study Period	Number of All Carcasses Found	Percent Composition of All Carcasses Found
silver-haired bat	25	55.6	3	33.3	0	0	28	46.7
Eastern red bat	15	33.3	3	33.3	3	50.0	21	35.0
hoary bat	3	6.7	2	22.2	2	33.3	7	11.7
big brown bat	1	2.2	1	11.1	0	0	2	3.3
evening bat	1	2.2	0	0	1	16.7	2	3.3
Totals	45	100	9	100	6	100	60	100

¹ Totals may not add to 100% due to rounding.

Table 4. Total number and percent composition of bird carcasses found at the Fowler Ridge Wind Farm from April 1 – May 15 and August 1 – October 15, 2022.

Species	Number	Percent Composition¹
mourning dove	3	16.7
unidentified Passerine	3	16.7
killdeer	2	11.1
American crow	1	5.6
American redstart	1	5.6
bald eagle	1	5.6
Eastern kingbird	1	5.6
house sparrow	1	5.6
house wren	1	5.6
red-tailed hawk	1	5.6
ruby-throated hummingbird	1	5.6
Cooper's hawk	1	5.6
Dickcissel	1	5.6
unidentified raptor (non-eagle)	1	5.6
white-eyed vireo	1	5.6
Totals	18	100

¹ Totals may not add to 100% due to rounding.

Timing of Bat Carcasses

Silver-haired bat carcasses found in search areas peaked in early September (Figure 2) while the number of Eastern red bat carcasses found in search areas peaked in early August (Figure 3). One hoary bat was found in late April while the remainder were found in early August (Figure 4).

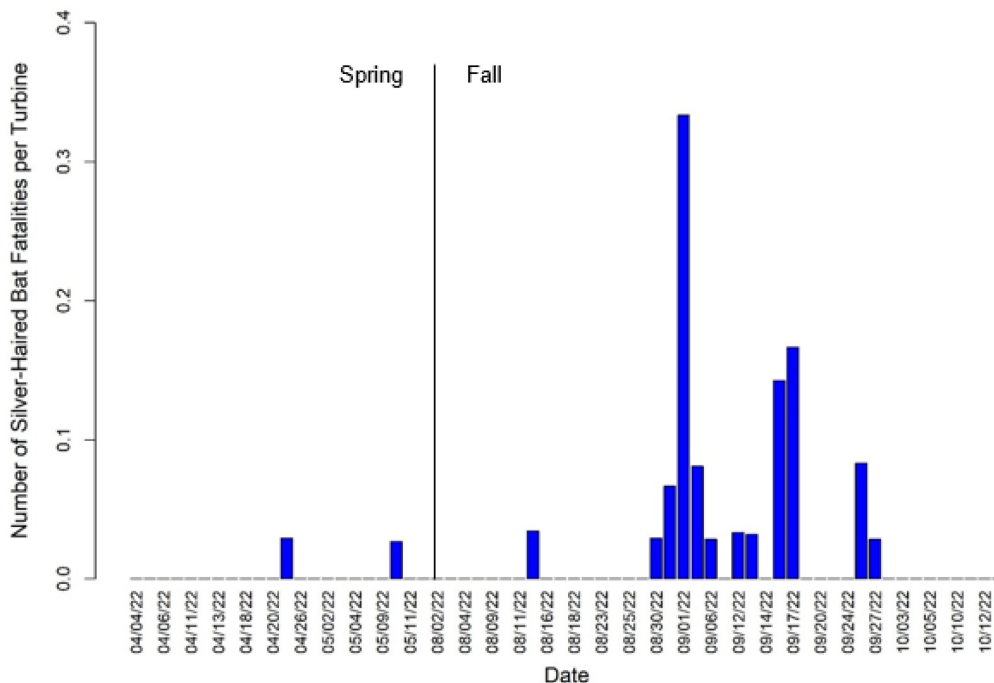


Figure 2. Timing of silver-haired bat carcasses found on search plots during scheduled searches at the Fowler Ridge Wind Farm from April 1 – May 15 and August 1 – October 15, 2022, that were included in fatality estimates.

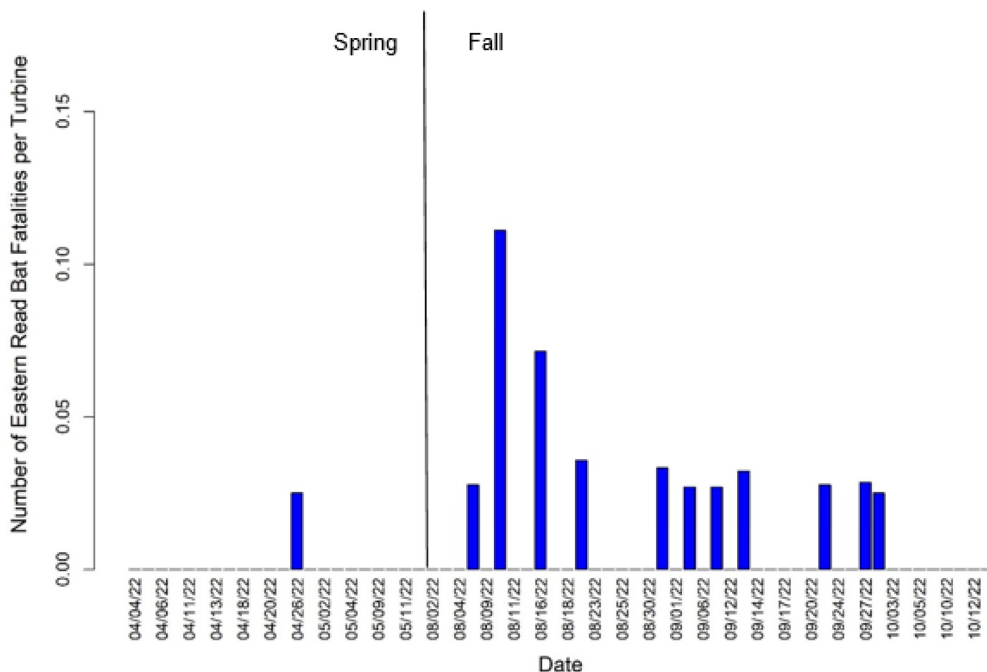


Figure 3. Timing of Eastern red bat carcasses found on search plots during scheduled searches at the Fowler Ridge Wind Farm from April 1 – May 15 and August 1 – October 15, 2022, that were included in fatality estimates.

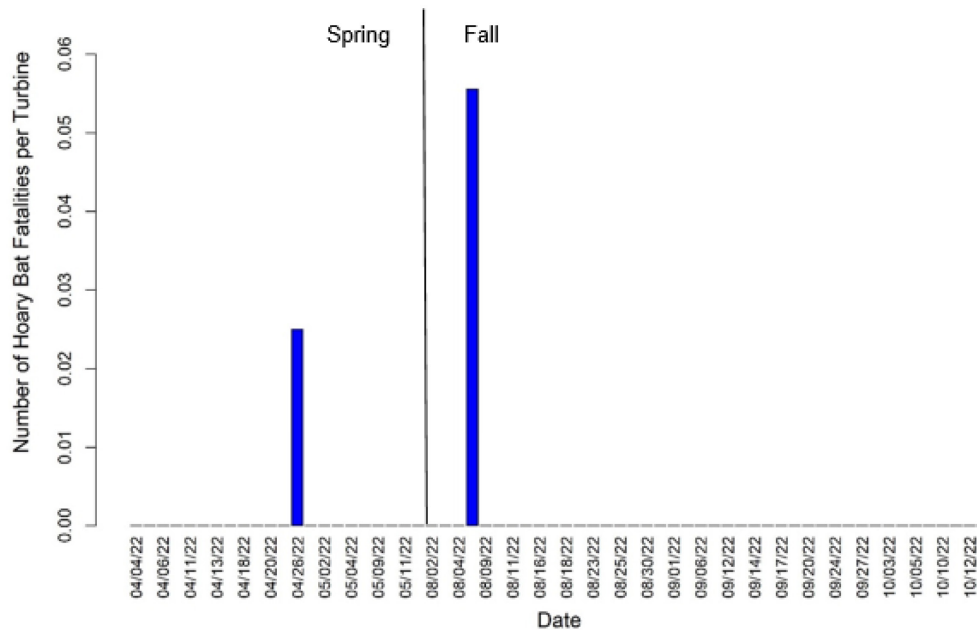


Figure 4. Timing of hoary bat carcasses found on search plots during scheduled searches at the Fowler Ridge Wind Farm from April 1 – May 15 and August 1 – October 15, 2022, that were included in fatality estimates.

Bias Trials

Searcher Efficiency Trials

During the spring season, 48 of the 76 carcasses placed for bias trials were found during the first scheduled search, with one additional bat carcass found after multiple searches, resulting in an overall probability of a carcass being available and detected of 59.0% (Table 5). The percent found for the season was calculated as an average across the number of days prior to search values. During the fall season, 48 of 82 bias trial carcasses placed were found during the first scheduled search, with no additional bats found after multiple searches, resulting in an overall probability of a carcass being available and detected of 52.0% (Table 5).

Table 5. Searcher efficiency based on empirical pi methodology for post-construction fatality monitoring at the Fowler Ridge Wind Farm from April 1 – May 15 and August 1 – October 15, 2022.

Number of Days Prior to Search	Number Placed	Number Found on First Search	Total Found	Percent Found
Spring				
0	20	18	18	90.0
1	8	6	7	88.0
2	8	7	7	88.0
3	9	6	6	67.0
4	7	2	2	29.0
5	8	2	2	25.0
6	8	5	5	63.0
7	8	2	2	25.0
Total	76	48	49	59.0
Fall				
0	20	17	17	85.0
1	13	11	11	85.0
2	7	6	6	86.0
3	8	6	6	75.0
4	8	2	2	25.0
5	6	1	1	17.0
6	13	4	4	31.0
7	7	1	1	14.0
Total	82	48	48	52.0

Carcass Persistence Trials

Forty bat carcasses were used to measure carcass persistence rates, split between the spring and fall seasons. The average length of persistence for bat carcasses in 2022 was 11.8 days in the spring and 5.4 days in the fall. Carcass persistence in the spring of 2022 was similar to the spring of 2021 (12.8 days) and previous spring seasons. Fall persistence rates in 2022 was shorter than in 2021 (10.6 days) and similar to rates recorded in 2018 and 2019 at the Project. A summary of carcass persistence at FRWF over the past 13 years shows year-to-year variation (Table 6).

Table 6. Carcass persistence rates reported at the Fowler Ridge Wind Farm from April 1 – May 15 (Spring) and August 1 – October 15 (Fall) from 2010 – 2022.

Year	Spring (days)	Fall (days)
2010	–	10.3
2011	–	15.1
2012	–	–
2013	–	5.8
2014	–	19.4
2015	–	13.9
2016	–	20.8
2017	–	10.7
2018	13.4	6.8
2019	8.5	4.1
2020	4.2	11.5
2021	12.8	10.6
2022	11.8	5.4

Estimated Fatality Rates

All five bat carcasses found during the spring survey period were included in the analyses. For the fall surveys, 40 bat carcasses were included in the analyses and fifteen bat carcasses were excluded because they were either incidental finds at non-searched turbines (n = 5), found outside the search area at a normally searched turbine (n = 4) or were estimated to have died prior to night of August 1 (n=6; Appendix B).

An observed fatality rate of 0.04 bat per turbine was calculated for the spring (Table 7) and 0.35 bat per turbine in the fall (Table 8). The observed fatality rate was then divided by the empirical probability of availability and detection (0.59 for spring and 0.52 for fall). This value was multiplied by the road and pad area adjustment factor (6.56 for Fowler I–III, 26.38 for Fowler IV) to obtain the per turbine adjusted fatality estimate for each type of turbine.

Table 7. Number of bat fatalities per turbine per study period for the Fowler Ridge Wind Farm from April 1 – May 15, 2022.

Estimator		Point Estimate	Standard Deviation	90% Confidence Interval	
				Lower Limit	Upper Limit
Area Adjustment	Fowler I–III	6.56	–	–	–
	Fowler IV	26.38	–	–	–
Observed fatalities per turbine		0.04	0.02	0.02	0.08
Empirical pi		0.59	0.05	0.51	0.67
Adjusted number of fatalities per turbine		0.68	0.31	0.24	1.25

Table 8. Number of bat fatalities per turbine per study period for the Fowler Ridge Wind Farm from August 1 – October 15, 2022.

Estimator		Point Estimate	Standard Deviation	90% Confidence Interval	
				Lower Limit	Upper Limit
Area Adjustment	Fowler I–III	6.56	–	–	–
	Fowler IV	26.38	–	–	–
Observed fatalities per turbine		0.35	0.06	0.25	0.46
Empirical pi		0.52	0.05	0.44	0.59
Adjusted number of fatalities per turbine		6.74	1.41	4.55	9.26

The adjusted fatality estimate for the facility was weighted by the number of each turbine type present in the FRWF. The adjusted fatality estimate for the spring was 0.68 bat fatalities/turbine/study period, or 0.40 bat fatality/MW/study period (Table 9). The adjusted fatality estimate for the fall was 6.74 bat fatalities/turbine/study period or 3.42 bat fatalities/MW/study period (Table 10).

The facility-wide fatality rate was calculated using a weighted average across turbine types due to differences in MW ratings between the three types of turbines. Past studies at FRWF have suggested that bat fatality rates may vary by MW ratings, how they operate, rotor swept area, or a combination of factors (Good et al. 2012). The reasons for why fatality rates may vary between turbine types are unclear. Previous research at the Project, and the current monitoring study, were not designed to conclusively determine if certain brands of turbines, or other potential causal factors, result in higher or lower mortality. Survey methodology may also explain the differences observed. For example, two different methods were used to calculate area corrections at Phases I, II and III (which contain three turbine types), compared to the area correction method used to estimate Phase IV mortality rates (contains one turbine type). All turbines operate under the same basic principles, and it is inappropriate to conclude that certain turbine brands have higher or lower mortality rates based on the results of monitoring at FRWF.

Table 9. Adjusted bat fatality estimates (empirical pi) for different turbine types within the Fowler Ridge Wind Farm from April 1 – May 15, 2022. ¹

Turbine Type	Mean	90% Confidence Interval²
Number of fatalities/turbine/year		
GE (1.50 MW)	1.19	–
Siemens (2.3 MW)	1.14	–
Vestas (1.65 MW)	0.28	–
Clipper (2.50 MW)	0	–
All Turbines	0.68	0.24 – 1.25
Number of fatalities/megawatt/year³		
GE (1.50 MW)	0.79	–
Siemens (2.3 MW)	0.50	–
Vestas (1.65 MW)	0.17	–
Clipper (2.50 MW)	0	–
All Turbines	0.40	0.15 – 0.74

¹ This study was not designed to determine if bat fatality rates differ between turbine models, and this table should not be used to inform management actions or assessments at other wind-energy facilities

² Confidence intervals not calculated for turbine types due to the small number of carcasses found

³ Estimates are calculated by turbine type due to differences in MW ratings by turbine type

Table 10. Adjusted bat fatality estimates (empirical pi) for different turbine types within the Fowler Ridge Wind Farm from August 1 – October 15, 2022. ¹

Turbine Type	Mean	90% Confidence Interval
Number of fatalities/turbine/year		
Siemens (2.30 MW)	23.36	12.40 – 35.56
Clipper (2.50 MW)	4.72	–
Vestas (1.65 MW)	4.19	2.29 – 6.59
GE (1.50 MW)	2.70	0.94 – 4.69
All Turbines	6.74	4.55 – 9.26
Number of fatalities/megawatt/year²		
Siemens (2.30 MW)	10.15	5.39 – 15.46
Clipper (2.50 MW)	1.89	–
Vestas (1.65 MW)	2.54	1.39 – 4.00
GE (1.50 MW)	1.80	0.63 – 3.13
All Turbines	3.42	2.35 – 4.61

¹ This study was not designed to determine if bat fatality rates differ between turbine models, and this table should not be used to inform management actions or assessments at other wind-energy facilities

² Estimates are calculated by turbine type due to differences in MW ratings by turbine type

End-of-year Adaptive Management Threshold

The end-of-year adaptive management threshold, as described within the HCP, is 19.64 bat fatalities/turbine/year, which is based on the upper 90% confidence interval (CI) of the average of 2010 and 2011 spring and fall bat mortality estimates, reduced by 50% (39.28 bat fatalities/turbine/year ÷ 2). The 2022 fatality estimate with turbines feathered until wind speeds reached 3.5 m/s in the spring and 5.0 m/s in the fall was 7.41 bat fatalities/turbine/study period (90% CI 5.21, 9.93), which was 62% lower than the end-of-year adaptive management threshold, and 81% lower than the mean spring and fall fatality estimate from 2010 and 2011 with turbines

that operated at manufacturer cut-in speed. The end-of-year threshold for triggering adaptive management was not met in 2022 (Figure 5).

Within-season Adaptive Management

The HCP includes an active adaptive management approach that facilitates responsiveness in management actions based on results from annual take compliance monitoring to ensure permit compliance. Within-season adaptive management thresholds were calculated to serve as an early indicator if adjustments to minimization efforts were necessary before the conclusion of the monitoring year. Per the HCP, within-season adaptive management thresholds were based on the predicted number of bat carcasses that would be found that would equal the upper quartile (i.e., 75th percentile) of estimated spring and fall bat mortality in 2010 and 2011 at control turbines with minimization measures in place, which equals 11.8 Indiana bats per year for the entire facility.

The HCP prescribes a sampling approach utilizing roads and pads to calculate fatality estimates. Per the HCP, to determine the number of bat carcasses of all species found that would equate to the adaptive management threshold for within-season Indiana bat fatality, bias correction factors from the previous year's monitoring results were applied (Tables 11a and 11b). The within-season adaptive management threshold for 2022 was 107 bat carcasses, spring and fall combined. There were 55 bat carcasses found on search plots that were estimated to have been killed during the study's two monitoring periods. Figure 6 illustrates the within-season tracking tool that was used to determine if a fatality was approaching within-season adaptive management thresholds. The weekly 2022 estimated bat fatality rate shown in Figure 6 was a prediction calculated using the 2021 bias trial data. The final 2022 bat fatality estimate was based on 2022 bias trial results. Adaptive management thresholds were not exceeded at any time during the study, and no changes to minimization efforts were required during 2022.

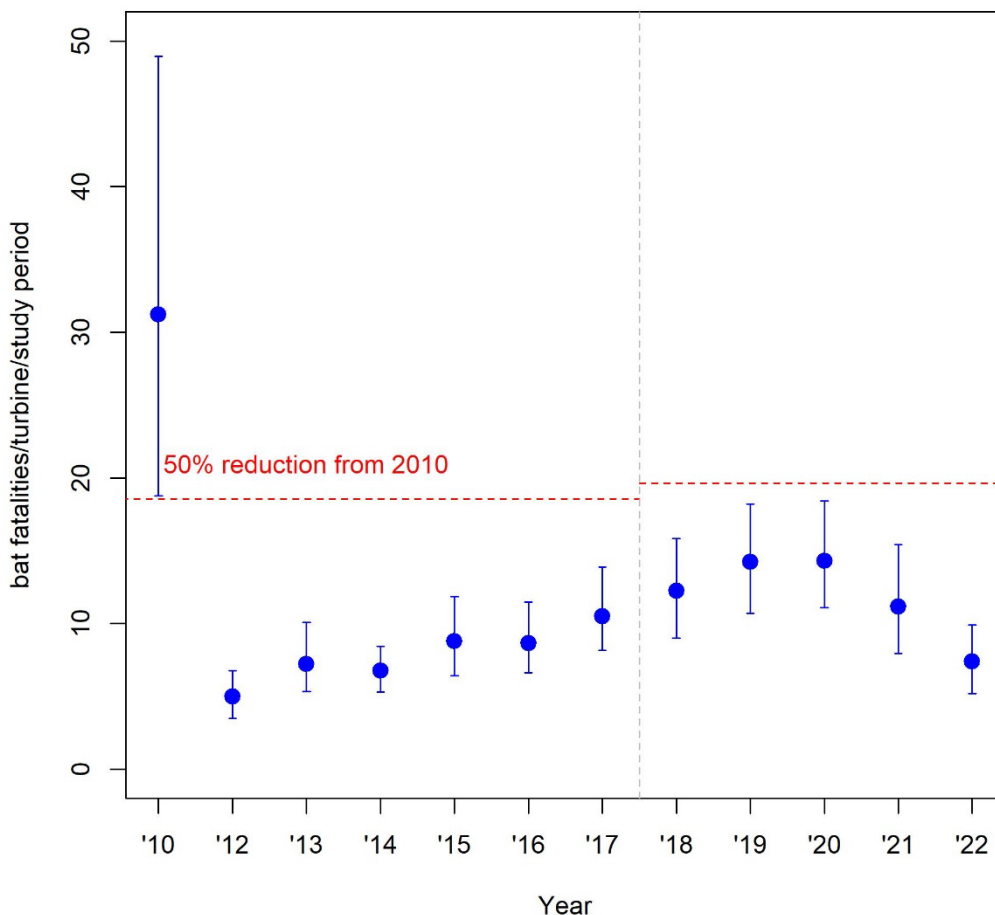


Figure 5. A comparison of estimated bat fatality rates and 90% confidence intervals (CIs) for the Fowler Ridge Wind Farm.

Note: The 2010 and 2011 combined spring and fall estimate represents turbines operating at manufacturer cut-in speeds. The 2012 – 2017 estimates represent data collected at turbines feathered below 5.0 meters/second (m/s) in the fall only. The 2018 – 2022 estimates represent turbines feathered below 5.0 m/s in the fall and 3.5 m/s in the spring. The red dotted line represents the end-of-year adaptive management thresholds, which is a 50% reduction of the upper 90% CI of bat fatality rates compared to the 2010 and 2011 combined fatality estimates.

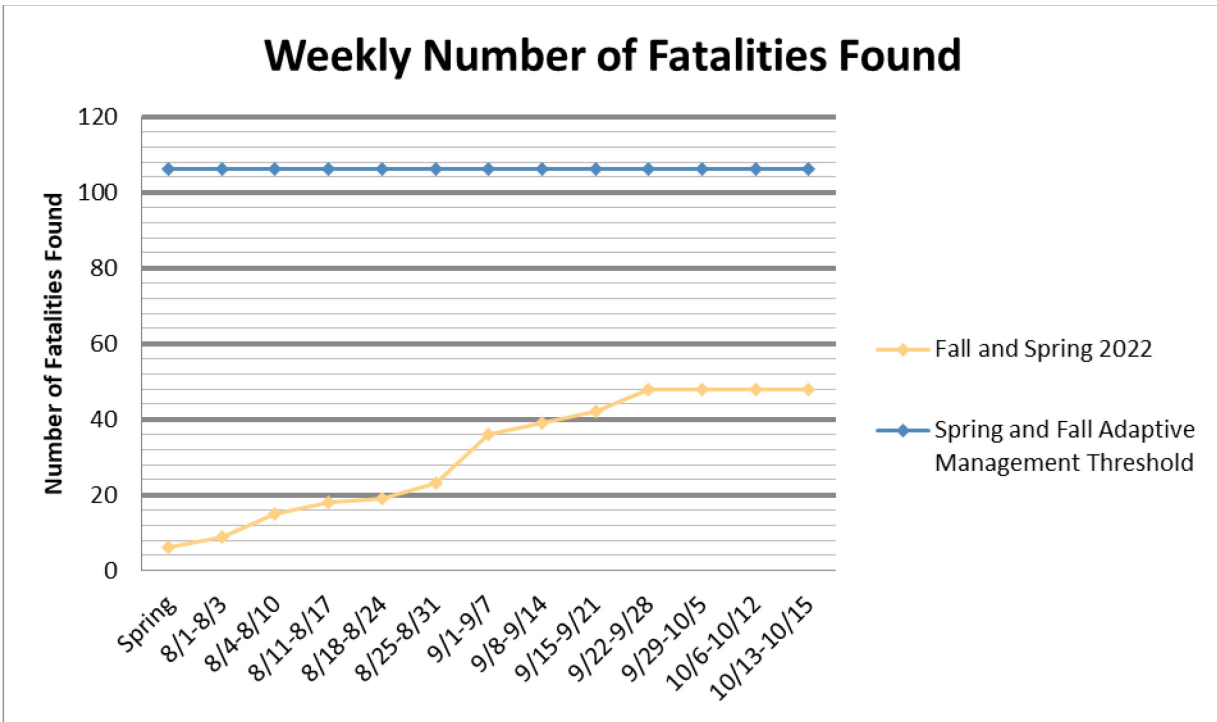


Figure 6. Weekly per-turbine fatality rates (number of bat carcasses found per turbine) at the Fowler Ridge Wind Farm in 2022. This graph was used to determine if weekly fatality rates were approaching the 50% adaptive management threshold. Fatality rates for 2022 shown above were based on 2022 bias trial results.

Table 11a. Variables used to calculate the within-season adaptive management threshold for 420 operational turbines in spring 2022 (Phases I, II, III, and IV).

Parameter	Fowler I–III	Fowler IV	Descriptions of Data Sources
Adaptive management threshold for Indiana bats	0.60		Upper quartile (i.e., 75 th percentile) of estimated spring bat mortality in 2010 and 2011 at control turbines with minimization measures in place.
Percent of all Indiana bat fatalities	0.16		Percentage based on total number of Indiana bats found during searches over total bats found, as described within the Habitat Conservation Plan.
Estimated upper quartile of total fatalities during the period for which adaptive management thresholds are based	378		Calculated—0.60/0.0016
Number of turbines	355	65	Fowler Phases I, II, III, and IV.
Estimated upper quartile of all bat fatality rates per turbine during the period for which adaptive management thresholds are based	0.90		Estimated by dividing the bat mortality count (378) by the number of operational turbines (420).
Empirical pi estimate	0.49		Estimated probability of carcasses being available and detected based on Fowler 2021 empirical bias trials from weekly road and pad searches; will be adjusted annually for subsequent years.
Road and pad correction factor	6.56	26.38	Phases I, II, and III estimated based on number of bats found on road and pads of cleared plots in relation to the total number of bats found at cleared plots in 2010 and 2011. Phase IV based on road and pad area searched measured at Phase IV and modeled carcass density distribution based on carcass distance data collected at Fowler from 2012 – 2016 on roads and pads.
Predicted upper quartile of number of bats found per searched turbine during the period for which adaptive management thresholds are based	0.07	0.02	Predicted based on estimated fatality rate per turbine (0.90), multiplied by the 2021 empirical pi (0.49), and divided by road and pad correction factor (6.56 or 26.38).
Total bats found in one spring season based on turbines searched	5.07	0.66	Predicted based on estimated number of bats found per turbine (0.07 or 0.02) multiplied by the number of turbines searched (75 or 39). Calculated value represents adaptive management threshold for 2022.
Total Bats Found Threshold	5.73		Sum of expected bat mortality from Phases I, II, III, and IV during the Spring

Table 11b. Variables used to calculate the within-season adaptive management threshold for 420 operational turbines in fall 2022 (Phases I, II, III, and IV).

Parameter	Fowler I–III		Fowler IV	Descriptions of Data Sources
Adaptive management threshold for Indiana bats	11.22			Upper quartile (i.e., 75 th percentile) of estimated fall bat mortality in 2010 and 2011 at control turbines with minimization measures in place.
Percent of all Indiana bat fatalities	0.16			Percentage based on total number of Indiana bats found during searches over total bats found, as described within the Habitat Conservation Plan.
Estimated upper quartile of total fatalities during the period for which adaptive management thresholds are based	7,016			Calculated—11.22/0.0016
Number of turbines	355	65		Fowler Phases I, II, III, and IV.
Estimated upper quartile of all bat fatality rates per turbine during the period for which adaptive management thresholds are based	16.70			Estimated by dividing the bat mortality count (7,016) by the number of operational turbines (420).
Empirical pi estimate	0.47			Estimated probability of carcasses being available and detected based on Fowler 2021 empirical bias trials from road and pad searches every 7 days; will be adjusted annually for subsequent years
Road and pad correction factor	6.56	26.38		Phases I, II, and III based on number of bats found on road and pads of cleared plots in relation to the total number of bats found at cleared plots in 2010 and 2011. Phase IV based on road and pad area searched measured at Phase IV and modeled carcass density distribution based on carcass distance data collected at Fowler from 2012 – 2016 on roads and pads.
Predicted upper quartile of number of bats found per searched turbine during the period for which adaptive management thresholds are based	1.19	0.30		Predicted based on estimated fatality rate per turbine (16.7), multiplied by empirical pi (0.47), and divided by road and pad correction factor (6.56 or 26.38).
Total bats found in one fall season based on turbines searched	89.38	11.56		Predicted based on estimated number of bats found per turbine (1.45 or 0.36) multiplied by the number of turbines searched (75 or 39). Calculated value represents adaptive management threshold for 2022.
Total Bats Found Threshold	100.93			Sum of expected bat mortality from Phases I, II, III, and IV.

End-of-season Indiana Bat Take Estimate

The estimated number of Indiana bat fatalities that occurred during 2022 was calculated based on the overall estimated bat fatality rate during 2022, and the relative percent of Indiana bat carcasses compared to all bat carcasses found during the fall of 2009, 2010, and 2011 (0.16%). In the spring of 2022, 0.46 Indiana bat fatalities were estimated to have occurred, and an estimated 4.53 Indiana bat fatalities in the fall for a combined total of 4.98 (90% CI: 3.50, 6.67; Table 12). The total estimated number of Indiana bat fatalities was lower than the number that was predicted to occur as fatalities within the HCP after minimization. The end-of-year adaptive management threshold is equal to the upper bound of the 90% CI of Indiana bat mortality predicted within the HCP. Per the terms of the HCP, no changes to minimization efforts are required for 2022.

Table 12. The estimated number of Indiana bat fatalities compared to the number of predicted Indiana bat fatalities at the Fowler Ridge Wind Farm.

Year	Number of Operating Turbines	Estimated Number of Indiana Bat Fatalities	Predicted Number of Indiana Bat Fatalities to Occur within the HCP after Minimization		
			Mean	Lower 90% CI	Upper 90% CI
2014	355	4.1	8.6	7.0	10.6
2015	355	5.2	8.6	7.0	10.6
2016	420	5.8	10.9	8.8	13.4
2017	420	7.1	10.9	8.8	13.4
2018-Spring	420	0.7	0.7	–	–
2018-Fall	420	7.6	10.9	8.8	13.4
2019-Spring	420	0.8	0.7	–	–
2019-Fall	420	9.0	10.9	8.8	13.4
2020-Spring	420	0.8	0.7	–	–
2020-Fall	420	8.8	10.9	8.8	13.4
2021-Spring	420	0.49	0.7	–	–
2021-Fall	420	7.5	10.9	8.8	13.4
2022-Spring	420	0.46	0.7	–	–
2022-Fall	420	4.53	10.9	8.8	13.4

HCP=Habitat Conservation Plan; CI=confidence interval; The HCP does not include a confidence interval for the spring take prediction.

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**Appendix A. Estimated Time of Death Information Sheet for Fowler Ridge Wind Farm
Benton County, Indiana**

Estimated Time of Death Information Sheet

Last Night

- **Eyes will be round and fluid filled, or slightly dehydrated**
 - Bat eyes dry much slower than bird eyes
 - Bird eyelids usually closed, open to check eyes
- **No decomposition, no smell**
- **No infestation beyond flies and eggs**
 - Possible to have very small maggots if carcass found after noon
- **Joints of body flexible**
 - Bat wing membranes flexible

2–3 Days

- **Eyes sunken or missing**
 - Bat eyes may still be intact
- **May be infested with small–medium sized maggots, beetles, flies, and ants**
- **Strong smell of decomposition**
- **Small holes in skin or body from insects (if no infestation noticed)**

4–7 Days

- **Eyes missing**
- **Internal scavenging evident**
 - Carcass may be full of large maggots (days 4–5) or only a shell with a few large maggots remaining (days 6–7) (during warm days)
- **Carcass may be hollow**
- **Fur may have begun to fall off and appear as “fluff” around bat**
 - Typically if carcass was rained on and then dried

7–14 Days

- **Mostly skin, feathers, and bones**
- **Skin tightened to skeletal system**
- **Mostly devoid of insects**
 - Possibly a beetle, no maggots

Greater than 2 Weeks

- **Body desiccated (mummified in appearance)**

**Appendix B. Bat and Bird Casualties Found at the Fowler Ridge Wind Farm, Benton
County, Indiana, between April 1 – May 15 and August 1 – October 15, 2022**

Appendix B. Bat and bird casualties found at Fowler Ridge Wind Farm between April 1 – May 15 and August 1- October 15, 2022.

Date	Common Name	Location	Turbine Type	Outside of Search Plot?	Estimated to have Died Outside of Study Period?	Included in Fatality Estimate?
4/5/2022	bald eagle	S57	Siemens	Yes	No	No
4/6/2022	red-tailed hawk	161	Vestas	Yes	Yes	No
4/6/2022	unidentified raptor-non eagle	226	Vestas	No	Yes	No
4/7/2022	unidentified passerine	S30	Siemens	No	No	No
4/12/2022	unidentified passerine	61	GE	Yes	No	No
4/25/2022	silver-haired bat	448	Vestas	No	No	Yes
4/25/2022	house wren	420	Vestas	No	No	No
4/26/2022	hoary bat	118	GE	No	No	Yes
4/26/2022	eastern red bat	52	GE	No	No	Yes
5/9/2022	white-eyed vireo	639	Clipper	No	No	No
5/9/2022	ruby-throated hummingbird	371	Vestas	No	No	No
5/10/2022	silver-haired bat	83	GE	No	No	Yes
5/11/2022	evening bat	S55	Siemens	No	No	Yes
8/1/2022	hoary bat	229	Vestas	No	Yes	No
8/1/2022	hoary bat	375	Vestas	Yes	No	No
8/2/2022	evening bat	605	Clipper	No	Yes	No
8/2/2022	hoary bat	87	GE	No	Yes	No
8/2/2022	hoary bat	256	Vestas	Yes	No	No
8/2/2022	eastern red bat	101	GE	No	Yes	No
8/4/2022	eastern red bat	S57	Siemens	No	Yes	No
8/4/2022	eastern red bat	S32	Siemens	Yes	No	No
8/4/2022	unidentified passerine	S16	Siemens	No	Yes	No
8/4/2022	eastern red bat	S32	Siemens	No	Yes	No
8/9/2022	American crow	195	Vestas	No	Unknown	No
8/9/2022	mourning dove	52	GE	No	No	No
8/9/2022	eastern kingbird	156	Vestas	No	No	No
8/8/2022	hoary bat	624	Clipper	No	No	Yes
8/8/2022	eastern red bat	398	Vestas	No	No	Yes
8/8/2022	hoary bat	251	Vestas	No	No	Yes
8/10/2022	eastern red bat	S40	Siemens	No	No	Yes
8/10/2022	eastern red bat	S59	Siemens	No	No	Yes
8/10/2022	eastern red bat	S23	Siemens	No	No	Yes
8/15/2022	silver-haired bat	627	Clipper	No	No	Yes
8/16/2022	eastern red bat	101	GE	No	Yes	No
8/16/2022	eastern red bat	87	GE	No	No	Yes
8/17/2022	big brown bat	S23	Siemens	No	No	Yes
8/22/2022	eastern red bat	348	Vestas	No	No	Yes
8/24/2022	big brown bat	353	Vestas	Yes	No	No
8/30/2022	silver-haired bat	251	Vestas	No	No	Yes
8/31/2022	silver-haired bat	S50	Siemens	No	No	Yes
8/31/2022	silver-haired bat	S25	Siemens	Yes	No	No
8/31/2022	silver-haired bat	68	GE	No	No	Yes
8/31/2022	eastern red bat	S45	Siemens	No	No	Yes
9/1/2022	silver-haired bat	S1	Siemens	No	No	Yes
9/1/2022	silver-haired bat	S57	Siemens	No	No	Yes
9/1/2022	silver-haired bat	S31	Siemens	No	No	Yes
9/1/2022	silver-haired bat	S46	Siemens	No	No	Yes
9/1/2022	silver-haired bat	S31	Siemens	No	No	Yes
9/1/2022	silver-haired bat	S31	Siemens	No	No	Yes

Appendix B. Bat and bird casualties found at Fowler Ridge Wind Farm between April 1 – May 15 and August 1- October 15, 2022.

Date	Common Name	Location	Turbine Type	Outside of Search Plot?	Estimated to have Died Outside of Study Period?	Included in Fatality Estimate?
9/1/2022	silver-haired bat	S40	Siemens	No	No	Yes
9/5/2022	silver-haired bat	425	Vestas	No	No	Yes
9/5/2022	eastern red bat	423	Vestas	No	No	Yes
9/5/2022	silver-haired bat	411	Vestas	No	No	Yes
9/5/2022	killdeer	458	Vestas	No	No	No
9/5/2022	silver-haired bat	388	Vestas	No	No	Yes
9/6/2022	silver-haired bat	129	GE	No	No	Yes
9/7/2022	eastern red bat	S41	Siemens	No	No	Yes
9/12/2022	silver-haired bat	459	Vestas	No	No	Yes
9/13/2022	mourning dove	195	Vestas	No	No	No
9/13/2022	silver-haired bat	260	Vestas	No	No	Yes
9/13/2022	eastern red bat	198	Vestas	No	No	Yes
9/15/2022	eastern red bat	319	Vestas	Yes	No	No
9/15/2022	eastern red bat	314	Vestas	Yes	No	No
9/16/2022	silver-haired bat	S10	Siemens	No	No	Yes
9/17/2022	silver-haired bat	S49	Siemens	No	No	Yes
9/17/2022	silver-haired bat	S48	Siemens	Yes	No	No
9/21/2022	eastern red bat	S49	Siemens	No	No	Yes
9/26/2022	silver-haired bat	624	Clipper	No	No	Yes
9/26/2022	silver-haired bat	616	Clipper	Yes	No	No
9/26/2022	silver-haired bat	369	Vestas	No	No	Yes
9/26/2022	silver-haired bat	329	Vestas	No	No	Yes
9/27/2022	eastern red bat	118	GE	No	No	Yes
9/27/2022	silver-haired bat	46	GE	No	No	Yes
9/27/2022	killdeer	52	GE	No	No	No
9/28/2022	American redstart	S45	Siemens	No	No	No
9/28/2022	eastern red bat	S46	Siemens	No	No	Yes
10/3/2022	mourning dove	53	GE	No	No	No
10/5/2022	house sparrow	S50	Siemens	No	No	No