Operational Monitoring at the Hoopeston Wind Project Vermilion County, Illinois

April – October 2021

Prepared for:

Hoopeston Wind, LLC

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WEST

EXECUTIVE SUMMARY

Western EcoSystems Technology, Inc. (WEST) estimated bat fatalities during the spring, summer, and fall of 2021 at the Hoopeston Wind Project (Project) located in Vermilion County, Illinois. Methods used to monitor and estimate the number of fatalities were consistent with the Hoopeston Habitat Conservation Plan (HCP) and Incidental Take Permit (ITP) TE54252C-0 for Indiana bats and northern long-eared bats. The study objectives were to estimate Indiana bat and northern long-eared bat take using the Species Composition Approach and Evidence of Absence (EoA) framework as outlined in the HCP, and determine if adaptive management was triggered.

WEST completed three years of intensive monitoring at Hoopeston from 2018 – 2020. Estimated levels of Indiana and northern long-eared bat mortality were within the permitted level of take outlined in the HCP and adaptive management was not triggered. The level of monitoring in 2021 was reduced for annual monitoring per the HCP, and consisted of weekly searches of roads and pads at all turbines from April 1 to October 15, 2021.

Indiana bat and northern long-eared bat mortality was estimated using the Species Composition Approach and EoA framework, as described in the HCP. Overall bat fatality estimates for the entire study were calculated using GenEst (a generalized estimator of fatality), as agreed upon with USFWS, and used to estimate the Species Composition Approach estimates. Searcher efficiency, carcass persistence, and area adjustment estimates used to determine the overall bat fatality and EoA framework estimates were calculated from data collected during intensive monitoring in 2018–2020, as outlined in the HCP.

No Indiana bats or northern long-eared bats, or any other federally or state-listed bat or bird species, were found during the study or incidentally. The EoA framework estimated that zero Indiana bats and zero northern long-eared bats were killed during 2021, using the 50% credible estimate. Similarly, take estimates for 2021 using the Species Composition Approach and based on GenEst were zero Indiana bat and one northern long-eared bat.

The estimated fatality rates of Indiana bat and northern long-eared bat take over the last three years of monitoring (2019 – 2021) were within levels authorized within the ITP, using EoA estimates and/or Species Composition Approach. The projected level of take for the remainder of the Project operation is lower than limits authorized by the HCP and ITP, assuming similar levels of mortality in future years. Therefore, no adaptive management was required to reduce potential take of Indiana or northern long-eared bats.

STUDY PARTICIPANTS

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REPORT REFERENCE

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INTRODUCTION

Western EcoSystems Technology, Inc. (WEST) completed operational post-construction fatality monitoring during the spring, summer, and fall of 2021 at the Hoopeston Wind Project (Project) in Vermilion County, Illinois. The monitoring was completed in accordance with the Hoopeston Habitat Conservation Plan (HCP) and Incidental Take Permit (ITP) TE54252C-0 for Indiana bats (*Myotis sodalis*) and northern long-eared bats (*M. septentrionalis*). This was the fourth year of monitoring under the Project's ITP. The study objectives were to estimate Indiana bat and northern long-eared bat take using the Species Composition Approach and Evidence of Absence (EoA) framework as outlined in the HCP, and determine if adaptive management was triggered.

PROJECT DESCRIPTION

The Project is in the Central Corn Belt Plains Ecoregion, which encompasses a large portion of central Illinois (Woods et al. 2007). This ecoregion is composed primarily of vast glaciated plains. Tall-grass prairie originally dominated much of the region, and scattered groves of trees and marshes occurred on level uplands. Today, the dominant land use within the Project is tilled agriculture, consisting primarily of corn (*Zea mays*), soybeans (*Glycine max*), and winter wheat (*Triticum spp*.). In addition, there are scattered residences, and small areas of pasture, grasslands, and shelterbelts (Figure 1; National Land Cover Database 2019). Fatality monitoring was completed at 100% of the turbines, as shown in Figure 1 and as described in the Methods section below.

The Project is composed of 49 2.0-megawatt (MW) wind turbines capable of generating up to 98 MW. All turbines are V 100 Vestas turbines with a 100-m (328-ft) hub height and 49-m (161-ft) blade length.

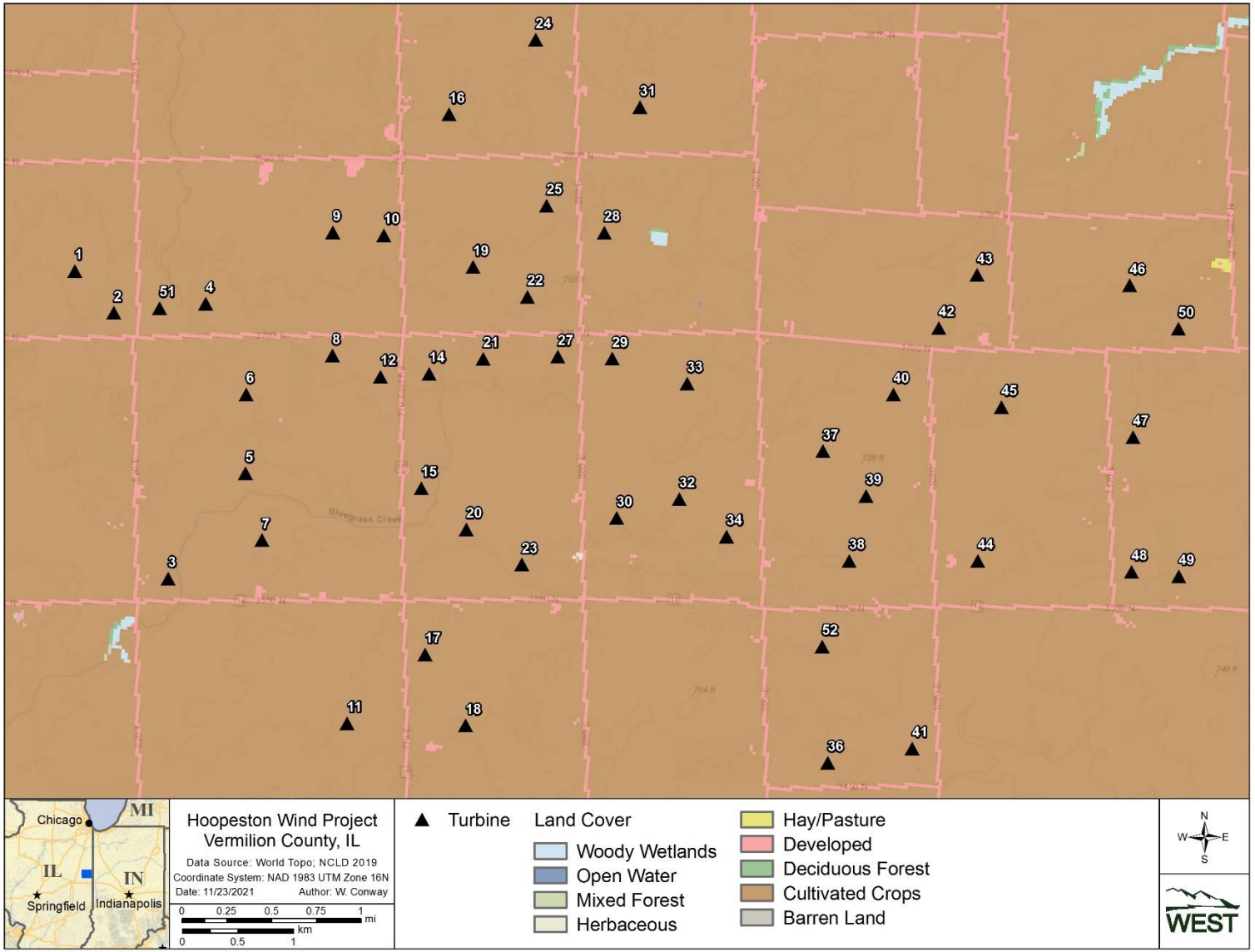

Figure 1. Land cover and turbine layout at the Hoopeston Wind Project in Vermilion County, Illinois.

METHODS

The study contained one field component: standardized carcass searches. Carcasses were found under two possible scenarios: 1) during standardized carcass surveys on roads and pads, or 2) incidentally (i.e., outside of the search plot). Searcher efficiency and carcass persistence was determined using data collected from 2018–2020, when the Project completed intensive monitoring as outlined in the HCP.

Field Methods

Standardized Carcass Searches

Spring, summer, and fall monitoring was completed in accordance with the monitoring methods described for annual monitoring in the HCP. All carcass searches were conducted by WEST technicians trained to follow the Project's carcass search protocols, including proper handling and reporting of carcasses.

In all seasons, technicians searched the gravel roads and pads at all 49 turbines weekly by starting 95 m (312 ft) from the turbine, walking towards and around the turbine, and then back towards their vehicle. Technicians walked at a rate of approximately 45–60 m (148–197 ft) per minute and scanned the ground out to 2.5 m (8.2 ft) on either side of the transect.

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

- Live/Injured— a live or injured bat or bird
- Intact— a carcass that was completely intact, was not badly decomposed, and showed no sign of being fed upon by a predator or scavenger
- Scavenged— an entire carcass, which showed signs of being fed upon by a predator or scavenger, or a portion(s) of a carcass in one location (e.g., wings, skeletal remains, portion of a carcass), or a carcass that was heavily infested by insects
- Feather Spot (for bird carcasses only)—10 or more feathers (not including down) at one location indicating predation or scavenging

The following information was recorded for each carcass found during standardized surveys:

- Date and time
- Initial species identification
- Sex, and age (if identifiable)
- Geographic coordinate
- Distance and bearing to turbine

- Substrate/ground cover
- Carcass condition (intact, scavenged, injured)
- Estimated time since death (number of days)

Technicians collected bat carcasses in accordance with WEST's Illinois Department of Natural Resources (IDNR) Scientific Permits (2021), WEST's IDNR Endangered and Threatened Species Permit (12208), WEST's US Fish and Wildlife Service (USFWS) Native Endangered and Threatened Species Recovery Permit (TE234121-9), and the Project's ITP (TE54252C-0). Due to delays in permitting, changes in personnel, and because permits were issued to the individual technicians by IDNR, bat carcasses were not collected on dates[1] without permit coverage. However, all bats were identified in the field and confirmed via photographs by a permitted bat biologist during the period when collection was not permitted. A USFWS-permitted bat biologist (TE62046D-0) verified the identification of all collected bats in person at the end of the study. Bird carcasses were recorded but left in place, and all bird carcasses were verified by WEST biologists experienced with bird identification via photos.

Statistical Analysis

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. Following field surveys, technicians were responsible for inspecting data forms for completeness, accuracy, and legibility. Potentially erroneous data were identified using a series of database queries. Irregular codes or data suspected as questionable were discussed with the technician and/or Project Manager. Errors, omissions, or problems identified in later stages of analysis were traced back to the raw data forms, and appropriate changes were made in all affected steps.

Data Compilation and Storage

A Microsoft SQL server database was developed to store, organize, and retrieve survey data. Data were entered into the electronic database using a pre-defined format to facilitate subsequent QA/QC and data analysis. All electronic data files were retained for reference.

Fatality Estimates

Fatality estimates were calculated for bats using GenEst (a generalized estimator of fatality; Dalthorp et al. 2018, Simonis et al. 2018). Fatality estimates were based on:

- Observed number of carcasses found within standardized search plots during the monitoring period.

[1] Dates where carcasses could not be collected were: May 18 – May 23, May 25 – July 12, July 14 – July 21, 2021, August 17 – 30, 2021, and September 8 – 13, 2021

- Searcher efficiency rates, expressed as the probability that a carcass was found by searchers during searcher efficiency trials.
- Persistence rates, expressed as the estimated average probability a carcass was expected to persist in the search area and be available for detection by the searchers during carcass persistence trials.
- Area adjustment estimates, expressed as the carcass-density weighted proportion of area searched adjustment for carcasses that fell outside of the search areas.

Each carcass included in the analysis was adjusted for searcher efficiency, carcass persistence, a detection reduction factor (also referred to as "*k*"; see below), and a search area adjustment to obtain an overall fatality estimate.

Confidence intervals (CIs) surrounding estimates for each season were calculated using a parametric bootstrap for GenEst (Dalthorp et al. 2018) by season and overall. Bootstrapping is a computer simulation technique that is useful for calculating variances and CIs for complicated test statistics. One thousand bootstrap samples were used. The lower 5th and upper 95th percentiles of the 1,000 bootstrap estimates were estimates of the lower limit and upper limit of 90% CIs.

Carcasses Excluded from Fatality Estimation

All carcasses found within the mapped search plot boundaries were included in the fatality rate if they had an estimated time of death within the season when the search plot was monitored (i.e., carcasses found outside of search plots or estimated to have died before the beginning of the season were omitted from the analysis).

Estimation of Searcher Efficiency

Searcher efficiency estimated the probability of a carcass being detected by a searcher given the carcass was available to be found. Searcher efficiency estimates were based on data collected from 2018 through 2020 on roads and pads (Iskali and Pham 2019; Rodriguez et al. 2020, 2021). A logistic regression model (Dalthorp et al. 2018) was fit to the 2018 – 2020 data and used to obtain an average estimate of searcher efficiency while accounting for *k* (see below). Season was the only potential covariate, or explanatory variable of interest used for the searcher efficiency models. Models were selected using an information theoretic approach known as AICc, or corrected Akaike Information Criterion (Burnham and Anderson 2002). The selected model was the most parsimonious model within two AICc units of the model with the lowest AICc value.

Detection Reduction Factor

The change in searcher efficiency between successive searches was defined by a parameter called the detection reduction factor (*k*) that ranged from zero to one. When *k* is estimated or assumed to be zero, it implies that a carcass missed on the first search would never be found on subsequent searches. A *k* of one implies searcher efficiency remained constant no matter how many times a carcass was missed. The detection reduction factor was a required parameter for GenEst, and a value of $k = 0.8$ was used in accordance with the HCP.

Estimation of Carcass Persistence Rates

Estimates of carcass persistence were used to adjust carcass counts for removal bias. Carcass persistence estimates were based on data collected in 2018, 2019, and 2020 (Iskali and Pham 2019; Rodriguez et al. 2020, 2021). The average probability a carcass persisted through the search interval (i.e., the time between scheduled searches) was estimated using an interval-censored survival regression using one of four distributions: exponential, log-logistic, lognormal, or Weibull (Kalbfleisch and Prentice 2002, Dalthorp et al. 2018). Previous analyses did not control for differences in carcass persistence rates across plot types; therefore, carcass persistence rates from roads and pads, cleared, and uncleared plots were used to inform average carcass persistence. Season was the only potential covariate considered in carcass persistence models. The most parsimonious model within two AICc units of the model with the lowest AICc value was selected as the best model.

Area Adjustment

The search area adjustment accounted for carcasses falling outside of plot boundaries. The proportion of carcasses estimated to have fallen within plots was calculated as the mean of the area adjustment values on 95-m roads and pads from 2018 through 2020 (Iskali and Pham 2019; Rodriguez et al. 2020, 2021). The result was an estimate of the proportion of bat carcasses expected to land within search areas.

Indiana Bat and Northern Long-Eared Bat Take and Detection Probability Estimates

The fall season was the only season with potential risk to covered species per the HCP; therefore, Indiana and northern long-eared bat fatality estimates were based on fall data using the Species Composition Approach and EoA framework, as outlined in the Project's HCP. ITP compliance was assessed using three metrics for each covered species: the annual take rate estimate using the Species Composition Approach, the EoA short-term trigger, and the EoA projected mortality estimate. The Species Composition annual take rate and the EoA short-term trigger were based on the three most recent monitoring years. The EoA projected mortality estimate relied on all monitoring to date.

Species Composition Approach

Indiana bat and northern long-eared bat fatalities were estimated for the fall using the Species Composition Approach. The Species Composition Approach assumes that Indiana bat and northern long-eared bat fatalities can be estimated as a proportion of the total number of bat fatalities at the Project. The HCP specified baseline values for fatalities of Indiana bat and northern long-eared bat as 0.29% and 0.24%, respectively (Hoopeston Wind 2017); however, the Project proposed updated species composition rates of 0.03% for Indiana bats and 0.06% for northern long-eared bats based on updated, publicly available post-construction monitoring data collected after the spread of white nose syndrome (Rodriguez and Studyvin 2020). The USFWS approved the use of these updated rates for 2020 and the years to follow on November 6, 2020 (A. Schorg, USFWS, pers comm.). Therefore, species composition rates were estimated using the updated species composition rates of 0.03% for Indiana bats and 0.06% for northern long-eared bats. An average take estimate for both Indiana bat and northern long-eared bat was calculated across 2018 – 2021 using Huso estimates reported in 2018 (Iskali and Pham 2019), the GenEst

estimates reported in 2019 and 2020 (Rodriguez et al. 2020, 2021) and a GenEst estimate calculated in 2021.

Evidence of Absence

The EoA framework (Dalthorp et al. 2014, 2017) uses a Bayesian model to estimate the actual number of fatalities, the estimated mortality rate (λ), and the cumulative 30-year projected mortality based on λ. The inputs to the model are the number of found carcasses and the *g* distribution, or the site-wide probability that a carcass was available to be found and detected. The estimate for *g* was based on:

- The monitoring search schedule, expressed as number of search and the interval of the searches.
- Searcher efficiency expressed as the proportion of available carcasses found by searchers (see Estimation of Searcher Efficiency Rates on page 5).
- Carcass persistence rates expressed as the estimated average probability a carcass was expected to remain in the study area (see Estimation of Carcass Persistence Rates on page 5).
- Search area adjustment based on the estimated carcass-density distribution weighted by the proportion of area searched (see Area Adjustment section on page 6).
- Detection reduction factor (*k*), expressed as the fraction to which searcher efficiency was reduced with each successive search (see Detection Reduction Factor section on page 5). The factor *k* was assumed to equal 0.8, as outlined in the HCP.

The site-wide probability of detection (*g)* in each year was estimated using the Single Class Module and Multiple Class Module from the EoA software (Dalthorp 2019). Monitoring in 2021 occurred in the fall only with a single plot type (a single stratum). Therefore, the Multiple Class Module in EoA was not necessary to combine across strata.

EoA projections of mortality into the future rely on the annual take rate estimated using the three most recent monitoring years' data. Therefore, two probabilities of detection for EoA were required: the rolling average probability of detection over the past three years of monitoring, and the cumulative average probability of detection over the past four years.

Rolling Average Probability of Detection

The HCP specifies that the fatality rate of Indiana bat and northern long-eared bat is tested based on a rolling-average detection probability including the most recent three years of monitoring events. At present, that monitoring window includes 2019 – 2021. Detection probabilities from 2019 – 2021 were combined into the rolling average detection probability using the per-study *g* estimates and the relative weights (ρ) for each study (Dalthorp et al. 2017). This detection probability was used to estimate the rolling average take rate based on the monitoring data available to date. In year four of the permit (current 2021 study) and beyond, the EoA annual take

rate trigger was evaluated as a hypothesis test. The hypothesis tests: was annual take rate greater than 2 at 90% confidence (e.g., $Pr(\lambda > 2) > 0.9$), which equates to a one-sided hypothesis test at $\alpha = 0.1$. EoA generates a posterior distribution for the annual take rate estimate, which was used to test the hypothesis. The full posterior distribution was also used in the EoA mortality projection tool, by drawing samples from the distribution to propagate uncertainty via Monte Carlo simulation (see Projected Mortality for the Remainder of the Project Incidental Take Permit, below).

Cumulative Probability of Detection

The HCP does not require estimates of cumulative mortality to date (*M*). However, the EoA mortality projection tool used the estimate of *M* as the starting point for simulations. Therefore, detection probabilities from 2018 – 2021 were combined into the cumulative (to date) detection probability using the per-year *g* estimates and the relative weights (ρ) for each year (Dalthorp et al. 2017). This detection probability was used in the EoA mortality projection tool.

Projected Mortality

The Multiple Years Module was used to calculate the annual take rate (λ), the cumulative mortality (*M*), and projected mortality. The Multiple Years Module requires the Beta distribution parameters for detection probability in each year and weights (ρ), which were all assumed to be one because there were no changes in facility operations (such as cut-in speed) that would have resulted in different weights. The rolling average probability of detection was used to estimate the annual take rate. The cumulative probability of detection was used to estimate the cumulative mortality to date.

The EoA Multiple Years Module used a Monte Carlo simulation approach to project future cumulative mortality. Current estimated take was simulated as 10,000 samples from the estimated posterior distribution for cumulative take to date (*M* from EoA). Future take was simulated using 10,000 samples from the posterior distribution of the annual take rate that was estimated using the previous three years (2019–2021). Each of the 10,000 annual take rate samples were applied for the remaining 26 years of the permit term and mortality in each year was sampled from a Poisson distribution with the annual take rate specified as the rate parameter. Mortality simulations in each year were summed over the 26 years, resulting in 10,000 realizations of projected mortality from year 2022 to the end of the permit term. The vector of current take estimate samples and the vector of projected mortality samples were summed element-wise to generate a 10,000 sample distribution of cumulative mortality at the end of the permit term. The median of this distribution was used to evaluate adaptive management. The EoA mortality projection tool provided projections of actual mortality (i.e., how many fatalities are expected to occur at the project in each year) and projections of estimated take (i.e., how many fatalities would be estimated by EoA in each year, given a pre-defined detection probability and the projection of actual mortality). Projections of estimated take require inputting detection probabilities for future years and are not relevant for ITP compliance. Therefore, the projections of actual mortality were used.

RESULTS

Standardized Carcass Searches

A total of 1,341 searches of roads and pads were completed from April 1 to October 15, 2021. Thirty-three searches (2.5%) were missed due to turbine maintenance and weather constraints.

No Indiana bat or northern long-eared bat carcasses, or carcasses of other federally or state threatened or endangered bat or bird species, were found during the study. Details of all carcasses found during the study are presented in Appendix A.

Overall Fatalities

Fifty-two bat carcasses belonging to five species were found during scheduled carcass searches. Eastern red bat (*Lasiurus borealis*; n=20, 38.5%) was the most common species fatality, followed by silver-haired bat (*Lasionycteris noctivagans*; n=17, 32.7%), hoary bat (*Lasiurus cinereus*; n=9, 17.3%), big brown bat (*Eptesicus fuscus*; n=5, 9.6%), and tri-colored bat (*Perimyotis subflavus*; n=1, 1.9%). Eleven bird carcasses of 10 known species were found during the study (Table 1).

Table 1. Total number of carcasses and percent composition of carcasses discovered at the Hoopeston Wind Project, Vermilion County, Illinois, from April 1 to October 15, 2021.

	Included in GenEst Fatality Estimate		Outside Search Area[1]		Outside Study Period[1]		Total	
Species	**Total**	**%**	**Total**	**%**	**Total**	**%**	**Total**	**%**
eastern red bat	20	38.5	0	0	0	0	20	38.5
silver-haired bat	17	32.7	0	0	0	0	17	32.7
hoary bat	9	17.3	0	0	0	0	9	17.3
big brown bat	5	9.6	0	0	0	0	5	9.6
tri-colored bat	1	1.9	0	0	0	0	1	1.9
Overall Bats[2]	**52**	**100**	**0**	**0**	**0**	**0**	**52**	**100**
ring-necked pheasant	0	0	0	0	0	0	2	18.2
Baltimore oriole	0	0	0	0	0	0	1	9.1
dickcissel	0	0	0	0	0	0	1	9.1
European starling	0	0	0	0	0	0	1	9.1
golden-crowned kinglet	0	0	0	0	0	0	1	9.1
house finch	0	0	0	0	0	0	1	9.1
horned lark	0	0	0	0	0	0	1	9.1
purple martin	0	0	0	0	0	0	1	9.1
yellow-billed cuckoo	0	0	0	0	0	0	1	9.1
red-winged blackbird	0	0	1	100	0	0	1	9.1
Overall Birds[2,3]	**0**	**0**	**1**	**100**	**0**	**0**	**11**	**100**

[1] Carcasses were not included in the analysis.

[2] Sums may not equal total values shown due to rounding.

[3] Birds were not included in the fatality estimates.

Carcasses for Analysis

All bat carcasses were found within the search area and during the study period; therefore, all bat carcasses were included in the analysis.

Timing and Distribution of Bat Fatalities

The composition of bat fatalities varied by season; only the eastern red bat was found in the spring, while three additional species were found in both the summer and fall (silver-haired bat, hoary bat, and big brown bat; Table 2). The vast majority of bat carcasses were found in the fall, with a peak in mid- to late August (Figure 2; Appendix A).

Table 2. Species composition by season for bat carcasses found at the Hoopeston Wind Project, Vermilion County, Illinois, from April 1 to October 15, 2021.

	Spring		Summer		Fall	
Species	**# of Carcasses**	**%**	**# of Carcasses**	**%**	**# of Carcasses**	**%**
big brown bat	0	0	2	28.6	3	7.0
eastern red bat	2	100	1	14.3	17	39.5
hoary bat	0	0	1	14.3	8	18.6
silver-haired bat	0	0	2	28.6	15	34.9
tri-colored bat	0	0	1	14.3	0	0
Total[1]	**2**	**100**	**7**	**100**	**43**	**100**

[1] Sums may not equal total values shown due to rounding.

m = meter

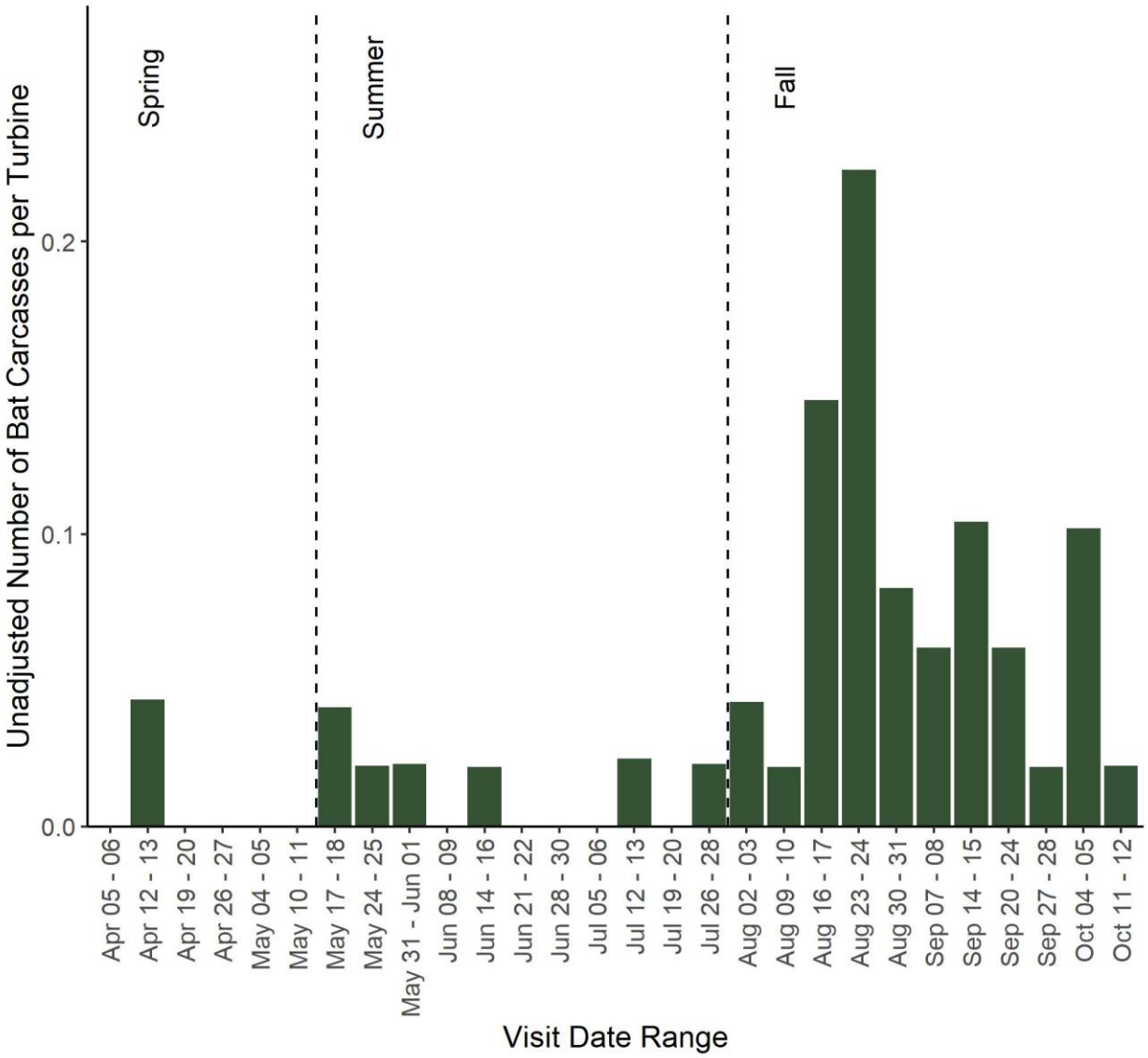

Figure 2. Timing of bat carcasses for carcasses included in the GenEst fatality estimates at the Hoopeston Wind Project, Vermilion County, Illinois, from April 1 to October 15, 2021.

Bat carcasses were found at 29 of the 49 study turbines. Twice as many bat fatalities (six) were recorded at the northernmost turbine (Turbine 24) than at any other turbine. Although relatively fewer fatalities were found in the central western portion of the Project and relatively more occurred in the north and eastern Project area, the low overall fatality rate makes it difficult to distinguish spatial patterns.

Searcher Efficiency Trials

A total of 133 bat carcasses were placed for human technicians on roads and pads between 2018 – 2020. Raw searcher efficiency ranged from 80% to 100% depending on year and season (Table 3). The best fit model was an intercept-only model that suggested searcher efficiency did not vary by season (Appendix B). The estimated searcher efficiency rate, which was used in determining fatality and take estimates, was 0.95 (90% CI: 0.90–0.97).

Table 3. Bat searcher efficiency results for roads and pads by season at the Hoopeston Wind Project, Vermilion County, Illinois, 2018 – 2020.

Year	Season	# Placed	# Available	# Found	% Found
2018	Spring	12	12	12	100
	Summer	12	12	11	91.7
	Fall	16	16	14	87.5
	Overall 2018	**40**	**40**	**37**	**92.5**
2019	Spring	10	10	9	90
	Summer	12	12	12	100
	Fall	10	10	8	80.0
	Overall 2019	**32**	**32**	**29**	**90.6**
2020	Spring	21	21	21	100
	Summer	20	20	20	100
	Fall	20	16	15	93.8
	Overall 2020	**61**	**57**	**56**	**98.2**
Overall		**133**	**129**	**122**	**94.6**

Carcass Persistence Trials

One-hundred-thirty-six bat carcasses were placed for persistence trials and used to estimate carcass persistence rates from 2018 to 2020 (Appendix B). The best-fit model was an exponential distribution with no covariates, suggesting that carcass persistence did not vary by season (Appendix B). The estimated median bat carcass persistence time was 10.43 days (Appendix B). The average probability that a bat carcass persisted through a 7-day search interval was 0.80 (90% CI: 0.77, 0.83).

Area Adjustment Using Project-Specific Data

There were no turbines with routinely unsearchable areas. The mean area adjustment from 2018 – 2020 estimated that approximately 6% of bats fell within the search area of 95-m roads and pads (Table 4).

Table 4. Three-year mean area adjustment for 95-meter roads and pads at the Hoopeston Wind Project, Vermilion County, Illinois, 2018 – 2020.

Year	Area Adjustment
2018	0.08
2019	0.04
2020	0.07
Overall Average	**0.06**

Adjusted Overall Bat Fatality Estimates

Bat fatality estimates were calculated for the year, per the HCP. Fatality estimates were highest in the fall, and the overall estimate for the study was 10.74 bats per MW (90% CI: 8.41–13.43; Table 5). Inputs used to calculate fatality estimates are presented in Appendix C.

Table 5. Seasonal and overall bat fatality rates per turbine and megawatt (MW) using GenEst for studies conducted at the Hoopeston Wind Project, Vermilion County, Illinois, from April 1 to October 15, 2021.

Season	Bat Fatality Estimate per Turbine	90% Confidence Interval	Bat Fatality Estimate per MW	90% Confidence Interval
Spring	0.88	0.05–2.15	0.44	0.03–1.07
Summer	2.93	1.26–4.96	1.46	0.63–2.48
Fall	17.57	13.38–22.28	8.78	6.69–11.14
Overall	**21.49**	**16.82–26.86**	**10.74**	**8.41–13.43**

Indiana Bat and Northern Long-Eared Bat Take Estimates

Species Composition Approach

Take estimates for Indiana bat and northern long-eared bat were based on fall fatality estimates (Table 5) and the species composition percentages approved by USFWS. Bat fatality rates included fractions of bats; however, a fraction of a bat cannot be taken in a given year. Therefore, the rates calculated in Tables 6 and 7 were rounded to whole integers to calculate take estimates. Zero Indiana bats and one northern long-eared bats were estimated to be taken in 2021, based on the updated species composition percentages (Table 6). The 3-year average of Species Composition take estimates determined that less than two Indiana bats and two northern long-eared bats were taken per year (Table 7). The 3-year average take rates for each species are less than two (Table 7); therefore no adaptive management action is necessary as per the HCP.

Table 6. Indiana bat and northern long-eared bat fatality estimates using the Species Composition Approach for studies conducted at the Hoopeston Wind Project, Vermilion County, Illinois, from August 1 to October 15, 2021.

Bat Species	Bats per Megawatt (Fall)	Estimated Total Bats	Species Composition	Bats per Year	Take Estimate
Indiana bat	8.78	860.86	0.0003	**0.26**	**0**
Northern long-eared bat	8.78	860.86	0.0006	**0.52**	**1**

Table 7. Three-year average of Indiana bat and northern long-eared bat fatality estimates using the Species Composition Approach for studies conducted at the Hoopeston Wind Project, Vermilion County, Illinois, 2019 – 2021.

Year	Estimator	Indiana Bats Per Year	Northern Long-Eared Bats Per Year
2019[1]	GenEst	3.87	3.20
2020[2]	GenEst	0.29	0.59
2021[2]	GenEst	0.26	0.52
Overall Average		**1.47**	**1.43**

[1] Species composition estimates from 2019 were based on percentages described within the Habitat Conservation Plan; Indiana bat fatalities were expected to represent 0.29% of all fatalities and northern long-eared bat were expected to represent 0.24% of all fatalities. These percentages were based in large part on data collected during or prior to the spread of white-nose syndrome, which over represents the current composition of *Myotis* fatalities at Hoopeston.

[2] Species composition estimates from 2020 and 2021 were 0.03% for Indiana bat and 0.06% for northern long-eared bat, which were approved by the US Fish and Wildlife Service in October 2020. The estimates were updated with more recent data from post-construction monitoring studies at Hoopeston and other Midwest facilities after the spread of white-nose syndrome.

Probability of Detection

The overall probability of detecting a single bat carcass (*g*), such as an Indiana bat or northern long-eared bat, during the fall 2021 was 0.05 (95% CI: 0.047–0.052; Table 8). The rolling average *g* was 0.24 (95% CI: 0.19–0.29). The cumulative *g* over the past four years of monitoring was 0.21 (95% CI 0.18–0.25; Table 8). The rolling average is higher because it omits the first year of intensive monitoring where *g* = 0.13, which is the second lowest *g*-value achieved to-date, and retains the two highest *g*-values. Variables used to estimate *g* are presented in Appendix D.

Table 8. Annual, rolling average, and cumulative probabilities of detection (*g*), Ba, Bb, and ρ for the Hoopeston Wind Project, Vermilion County, Illinois, from 2018 – 2021.

Year	Ba[1]	Bb[1]	ρ[2]	*g*	95% Confidence Interval
2018	181.13	1208.6	1	0.13	0.11–0.15
2019	10.06	29.23	1	0.26	0.13–0.40
2020	645.15	924.52	1	0.41	0.39–0.44
2021	1374.31	26468.23	1	0.05	0.047–0.052
Rolling Average (Last 3 Years)	79.76	254.23	NA	0.24	0.19–0.29
Cumulative	113.62	423.12	NA	0.21	0.18–0.25

[1] Ba and Bb are the parameters for the beta distribution used to characterize the probability of detection. The *g* value is the mean of that distribution.

[2] ρ is the weight in the weighted average that was used to combine the probability of detection distributions across years**.**

Cumulative Mortality to Date

The EoA cumulative mortality estimates with 50% credibility (which is equivalent to the median value) were that one Indiana bat and one northern long-eared bat fatalities occurred during the 2018 – 2021 study period (Table 9).

Table 9. Cumulative median take estimates to date using Evidence of Absence and Project-specific area correction for studies conducted at the Hoopeston Wind Project, Vermilion County, Illinois, from 2018 – 2021.

Estimate Type	Carcass Count	Bat Fatality Estimate	Permitted Take
EoA - Indiana bat (50% credible bound)	0	1	60
EoA - Northern long-eared bat (50% credible bound)	0	1	60

EoA= Evidence of Absence

Annual Take Rate

Using the Multiple Years Module in the EoA software, the estimated fatality rates (λ) for Indiana bat and northern long-eared bat were calculated based on the *g* values from the fall seasons of 2019 – 2021 (Table 8). The estimated annual fatality rates for Indiana bat and northern long-eared bat were 0.32 bats per year for either species (Table 10), which is below the expected annual take rate of two Indiana bats and two northern long-eared bats per year reported in the HCP. The short-term trigger assesses the probability that the estimated take rate exceeds the expected take rate, $Pr(\lambda > \tau)$. At a 90% confidence level ($\alpha = 0.1$), $Pr(\lambda > \tau)$ must be greater than or equal to 0.90

for the short-term trigger to fire. The Pr(λ > τ) was below 0.90, and therefore, the short term-trigger was not met for either species and adaptive management was not triggered (Table 10).

Table 10. Estimated median fatality rate (λ) of Indiana and northern long-eared bats using Evidence of Absence and the Project-specific area correction based on studies conducted at the Hoopeston Wind Project, Vermilion County, Illinois, from 2019 – 2021.

Estimate Type	Carcass Count	Estimated Median Fatality Rate (λ)	Expected Take Rate (τ)	Pr(λ > τ)
EoA - Indiana bat (50th credible bound)	0	0.32	2	0.093
EoA - Northern long-eared bat (50th credible bound)	0	0.32	2	0.093

EoA= Evidence of Absence

Projected Mortality for Remainder of the Project Incidental Take Permit

No Indiana bat or northern long-eared bat carcasses occurred during any year of monitoring at the Project. EoA provides potential estimates of Indiana bat and northern long-eared bat mortality based on the level of monitoring and probabilities of detecting a carcass if one occurred. The cumulative median 30-year mortality projection at a 50% credible interval for both Indiana bat and northern long-eared bat was 10 Indiana bat and 11 northern long-eared bat fatalities (Table 11), which is below the permitted take of 60 individuals of each species described within the Project's HCP. Therefore, the projected mortality did not trigger adaptive management.

Table 11. Cumulative median 30-year projected bat fatalities using Evidence of Absence for studies conducted at the Hoopeston Wind Project, Vermilion County, Illinois.

Estimate Type	Carcass Count	Permitted Take	Cumulative Median Projected Mortalities (30 years; *M*)
EoA - Indiana bat (α = 0.5)	0	60	10
EoA - Northern long-eared bat (α = 0.5)	0	60	11

EoA= Evidence of Absence

Summary of Incidental Take Permit Compliance

The estimated median Indiana bat and northern long-eared bat annual take based on monitoring studies from 2019 – 2021 were below levels authorized within the ITP, using EoA estimates or the Species Composition Approach and projected mortality over the 30-year life of the Project (Table 7, Table 11). The projected level of take for the remainder of the Project operation is lower than limits authorized by the HCP and ITP; therefore, no adaptive management is required in 2022 (Table 12).

Table 12. Summary of Incidental Take Permit compliance based on projected and estimated Indiana bat and northern long-eared bat fatalities using Species Composition Approach and Evidence of Absence at the Hoopeston Wind Project, Vermilion County, Illinois.

Compliance Metric	Adaptive Management Trigger	Indiana Bat Take Estimate[1]	Northern Long-Eared Bat Take Estimate[1]	Adaptive Management Required?
3-year average of Species Composition fatality rate	between 2-4 (or greater than 4)	1.47	1.43	No
		OR		
Estimated median 3-year fatality rate (λ)	Pr(λ > 2) > 0.9	0.093	0.093	No
		AND		
Projected mortality for the remainder of the Project	>60 individuals	10	11	No
Overall				**No**

[1] Summary from Tables 7 and 11

DISCUSSION

The study objectives were to estimate Indiana bat and northern long-eared bat take using the Species Composition Approach and Evidence of Absence (EoA) framework as outlined in the HCP, and determine if adaptive management was triggered. No federally or state-listed bats or birds were found during four years of monitoring at the Project. The estimated level of Indiana bat and northern long-eared bat take was below the levels permitted within the Project ITP and described within the HCP.

The purpose of adaptive management is to ensure the Project will not exceed the level of take allowed by the ITP. No Indiana bat or northern long-eared bat carcasses were found during four years of monitoring at the Project. The average fatality rate for Indiana bat and northern long-eared bat is estimated as less than two bats each using both the Species Composition Approach and EoA, and the projection of future mortalities indicates that cumulative take is not expected to be exceeded; therefore no adaptive management was required to reduce potential take rates.

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Appendix A. Complete List of Carcasses Found at the Hoopeston Wind Project during 2021

Appendix A. Carcasses found at the Hoopeston Wind Project, Vermillion County, Illinois, from April 1 to October 15, 2021.

Date Found	Species	Distance from Turbine (m)	Turbine ID	Search Area Type	Physical Condition
Bats					
04/13/2021	eastern red bat	15	24	roads and pads	scavenged
04/13/2021	eastern red bat	6	24	roads and pads	scavenged
05/17/2021	silver-haired bat	36	28	roads and pads	scavenged
05/18/2021	silver-haired bat	51	52	roads and pads	injured
05/24/2021	tri-colored bat	44	20	roads and pads	intact
05/31/2021	eastern red bat	1	21	roads and pads	injured
06/16/2021	hoary bat	5	45	roads and pads	scavenged
07/13/2021	big brown bat	5	46	roads and pads	scavenged
07/26/2021	big brown bat	22	31	roads and pads	dismembered
08/02/2021	hoary bat	19	31	roads and pads	scavenged
08/03/2021	hoary bat	5	42	roads and pads	intact
08/09/2021	eastern red bat	5	3	roads and pads	intact
08/16/2021	eastern red bat	34	17	roads and pads	intact
08/16/2021	silver-haired bat	12	3	roads and pads	scavenged
08/17/2021	big brown bat	8	44	roads and pads	scavenged
08/17/2021	eastern red bat	43	29	roads and pads	scavenged
08/17/2021	eastern red bat	1	31	roads and pads	scavenged
08/17/2021	hoary bat	7	33	roads and pads	scavenged
08/17/2021	hoary bat	65	45	roads and pads	scavenged
08/23/2021	big brown bat	5	21	roads and pads	intact
08/23/2021	eastern red bat	25	24	roads and pads	scavenged
08/23/2021	eastern red bat	22	6	roads and pads	scavenged
08/23/2021	eastern red bat	2	7	roads and pads	scavenged
08/23/2021	hoary bat	7	17	roads and pads	scavenged
08/23/2021	silver-haired bat	39	15	roads and pads	scavenged
08/24/2021	eastern red bat	44	28	roads and pads	scavenged
08/24/2021	eastern red bat	5	32	roads and pads	scavenged
08/24/2021	eastern red bat	34	38	roads and pads	dismembered
08/24/2021	hoary bat	7	33	roads and pads	scavenged
08/24/2021	hoary bat	34	38	roads and pads	scavenged
08/30/2021	eastern red bat	0	11	roads and pads	injured
08/30/2021	eastern red bat	25	12	roads and pads	scavenged
08/30/2021	eastern red bat	0	7	roads and pads	injured
08/31/2021	hoary bat	30	48	roads and pads	scavenged
09/07/2021	eastern red bat	84	24	roads and pads	scavenged
09/07/2021	eastern red bat	90	25	roads and pads	intact
09/07/2021	silver-haired bat	1	8	roads and pads	intact
09/14/2021	silver-haired bat	2	24	roads and pads	injured
09/15/2021	silver-haired bat	58	46	roads and pads	scavenged
09/15/2021	silver-haired bat	19	49	roads and pads	injured
09/15/2021	silver-haired bat	8	49	roads and pads	injured
09/15/2021	silver-haired bat	23	50	roads and pads	injured
09/20/2021	big brown bat	12	14	roads and pads	intact
09/24/2021	silver-haired bat	25	30	roads and pads	feather spot
09/24/2021	silver-haired bat	2	32	roads and pads	scavenged
09/28/2021	silver-haired bat	1	44	roads and pads	injured
10/04/2021	silver-haired bat	77	24	roads and pads	scavenged
10/05/2021	eastern red bat	30	38	roads and pads	scavenged
10/05/2021	eastern red bat	18	42	roads and pads	dismembered

Appendix A. Carcasses found at the Hoopeston Wind Project, Vermillion County, Illinois, from April 1 to October 15, 2021.

Date Found	Species	Distance from Turbine (m)	Turbine ID	Search Area Type	Physical Condition
10/05/2021	silver-haired bat	1	40	roads and pads	intact
10/05/2021	silver-haired bat	53	50	roads and pads	scavenged
10/12/2021	silver-haired bat	6	50	roads and pads	scavenged
Birds					
05/10/2021	European starling	56	6	roads and pads	dismembered
05/10/2021	red-winged blackbird	9	12	roads and pads[1]	scavenged
05/18/2021	Baltimore oriole	7	42	roads and pads	intact
05/24/2021	ring-necked pheasant	3	12	roads and pads	intact
05/25/2021	house finch	6	37	roads and pads	intact
05/31/2021	dickcissel	1	8	roads and pads	scavenged
06/08/2021	yellow-billed cuckoo	52	21	roads and pads	intact
08/16/2021	purple martin	43	16	roads and pads	scavenged
08/17/2021	horned lark	39	32	roads and pads	scavenged
09/07/2021	ring-necked pheasant	2	12	roads and pads	intact
10/04/2021	golden-crowned kinglet	40	31	roads and pads	scavenged

[1] Carcass was found outside the search area

ID = identification

Appendix B. Searcher Efficiency and Carcass Persistence Modeling Estimates and Results for the Hoopeston Wind Project

Table B1. Searcher efficiency models for bats from the Hoopeston Wind Project, Vermilion County, Illinois, from spring, summer, and fall (April 1 to October 15) post-construction monitoring efforts, 2018 – 2020 (n = 129).

Covariates	*k* Value	AICc	Delta AICc
Season	*k* fixed at 0.8	55.90	0
No Covariates	*k* fixed at 0.8	56.44	0.54*

* Selected model

AICc= corrected Akaike Information Criteria

Table B2. Carcass persistence models with covariates and distributions for bats at the Hoopeston Wind Project, Vermilion County, Illinois, from spring, summer, and fall (April 1 to October 15) post-construction monitoring efforts, 2018 – 2020 (n = 136).

Location Covariates	Scale Covariates	Distribution	AICc	Delta AICc
No Covariates	No Covariates	Weibull	590.76	0
No Covariates	No Covariates	loglogistic	590.91	0.15
No Covariates	Season	loglogistic	591.00	0.24
No Covariates	No Covariates	lognormal	591.04	0.28
No Covariates	-	exponential	591.37	0.61*
No Covariates	Season	lognormal	591.61	0.85
No Covariates	Season	Weibull	591.62	0.86
Season	No Covariates	Weibull	593.88	3.12
Season	-	exponential	594.27	3.51
Season	No Covariates	loglogistic	595.06	4.30
Season	Season	Weibull	595.16	4.40
Season	No Covariates	lognormal	595.20	4.44
Season	Season	loglogistic	595.26	4.50
Season	Season	lognormal	595.82	5.06

* Selected model

AICc= corrected Akaike Information Criteria

Table B3. Carcass persistence top models with covariates, distributions, and model parameters for the Hoopeston Wind Project, Vermilion County, Illinois, from spring, summer, and fall (April 1 to October 15) post-construction monitoring efforts, 2018 – 2020.

Size Class	Distribution	Estimated Median Removal Times (days)	Parameter 1	Parameter 2
Bat	Exponential[1]	10.43	rate = 0.0665	–

[1] The distribution follows base R parameterization.

Appendix C. Inputs Used to Calculate Bat Fatality Rates at the Hoopeston Wind Project Using the GenEst Fatality Estimator

Appendix C. Estimated bat fatality rates and adjustment factors, with 90% confidence intervals (CI) at the Hoopeston Wind Project, Vermillion County, Illinois, from April 1 to October 15, 2021.

	Spring		Summer		Fall	
	Estimate	Estimate	90% CI	90% CI	Estimate	90% CI
Search Area Adjustment	0.06	-	0.06	-	0.06	-
Searcher Efficiency	0.95	0.90–0.97	0.95	0.90–0.97	0.95	0.90–0.97
Average Probability of a Carcass Persisting Through the Search Interval	0.8	0.77–0.83	0.8	0.77–0.83	0.8	0.77–0.83
Probability of Available and Detected	0.77	0.75–0.81	0.77	0.75–0.81	0.77	0.75–0.81
Estimated Fatality Rates (Fatalities/Turbine/Seasons(s))	0.88	0.05–2.15	2.93	1.26–4.96	17.57	13.38–22.28
Estimated Fatality Rates (Fatalities/MW/Seasons(s))	0.44	0.03–1.07	1.46	0.63–2.48	8.78	6.69–11.14

Appendix D. Inputs and Results for the Single Class Module in Evidence of Absence

Appendix D1. Inputs needed to run Evidence of Absence: Single Class Module for the Hoopeston Wind Project, Vermilion County, Illinois, from August 1 to October 15, 2021.

Season	Search Area Type	Search Interval (I)	Number of Searches[1]	Spatial Coverage (a)	Temporal Coverage (v)	Searcher Efficiency[3]		Carcass Persistence[3]			
						Carcasses Available	Carcasses Found	Shape (α)	Scale (β)	Scale Lower Limit (β)	Scale Upper Limit (β)
fall	95-m roads and pads	7	12	0.064	1	129	122	Null	15.044	12.478	18.156

[1] Includes one additional search beyond what was conducted in the field to account for the Evidence of Absence graphical user interface assumption that a clearing search is included in the number of searches.

[2] k = 0.8

[3] An exponential distribution was used for carcass persistence distribution on the roads and pads.

Appendix D2. Results from the Evidence of Absence: Single Class Module for the Hoopeston Wind Project, Vermilion County, Illinois, from August 1 to October 15, 2021.

Year	*g*[1]	95% Confidence Interval	Ba[2]	Bb[2]
2021	0.049	0.047 – 0.052	1,374.3	26,468.2

[1]*g*=the probability of detection.

[2]Ba is the shape 1 parameter for the Beta distribution. Bb is the shape 2 parameter for the Beta distribution.