# 2022 Annual Post-Construction Bat Mortality Monitoring Report

## High Prairie Renewable Energy Center

## Schuyler and Adair Counties, Missouri

**Incidental Take Permit (ITP) Level Monitoring (April 1 – October 31)**

**Project #193708256**

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# 1.0 Introduction

## 1.1 PROJECT DESCRIPTION AND HISTORY

Ameren Missouri's (Ameren) High Prairie Renewable Energy Center (Project or High Prairie) consists of 175 turbines with an approximate 400-megawatt (MW) operating capacity in Schuyler and Adair Counties, Missouri.

Due to the potential risk of take of the federally-endangered Indiana bat (*Myotis sodalis*) and federally-threatened northern long-eared bat (*Myotis septentrionalis*) during operations, Ameren applied for and received an Incidental Take Permit (ITP) for these species, as well as for the little brown bat (*Myotis lucifugus*).

During much of the 2022 bat active season, Ameren voluntarily implemented avoidance measures and the wind turbines ceased operation on a nightly basis from 45 minutes before sunset until 45 minutes after sunrise. In consultation with the United States Fish and Wildlife Service (USFWS) and the Missouri Department of Conservation (MDC), it was agreed that post-construction monitoring for bats need not occur during such curtailment periods (i.e., nighttime shut-down).

During the monitoring period, 1-10 of the turbines operated on select nights under limited nighttime operations, which is summarized below in Table 1-1 and shown on Figure 1.

**Table 1-1. Summary of operational protocols (from 45 minutes before sunset to 45 minutes after sunrise) from April 1 through October 31, 2022, at the High Prairie Renewable Energy Center, Schuyler and Adair Counties, Missouri.**

| Date(s) | Number of Turbines Operating | Number of Turbines Not Operating at Night |
|---|---|---|
| April 1 – August 9 | 0 | 175 |
| August 10 – August 27 | 1 | 174 |
| August 28 – September 18 | 0 | 175 |
| September 19 – September 29 | 5 | 170 |
| September 30 – October 11 | 0 | 175 |
| October 12 – October 16 | 5 | 170 |
| October 17 – October 31 | 10 | 165 |

## 1.2 PURPOSE AND OBJECTIVES OF THE MONITORING

Post-construction mortality monitoring activities at turbines operating at night adhered to the requirements outlined in the Project's HCP, specifically to evaluate the effectiveness of the minimization measures and ensure that take of the covered species remains within the take limits set forth in the ITP.

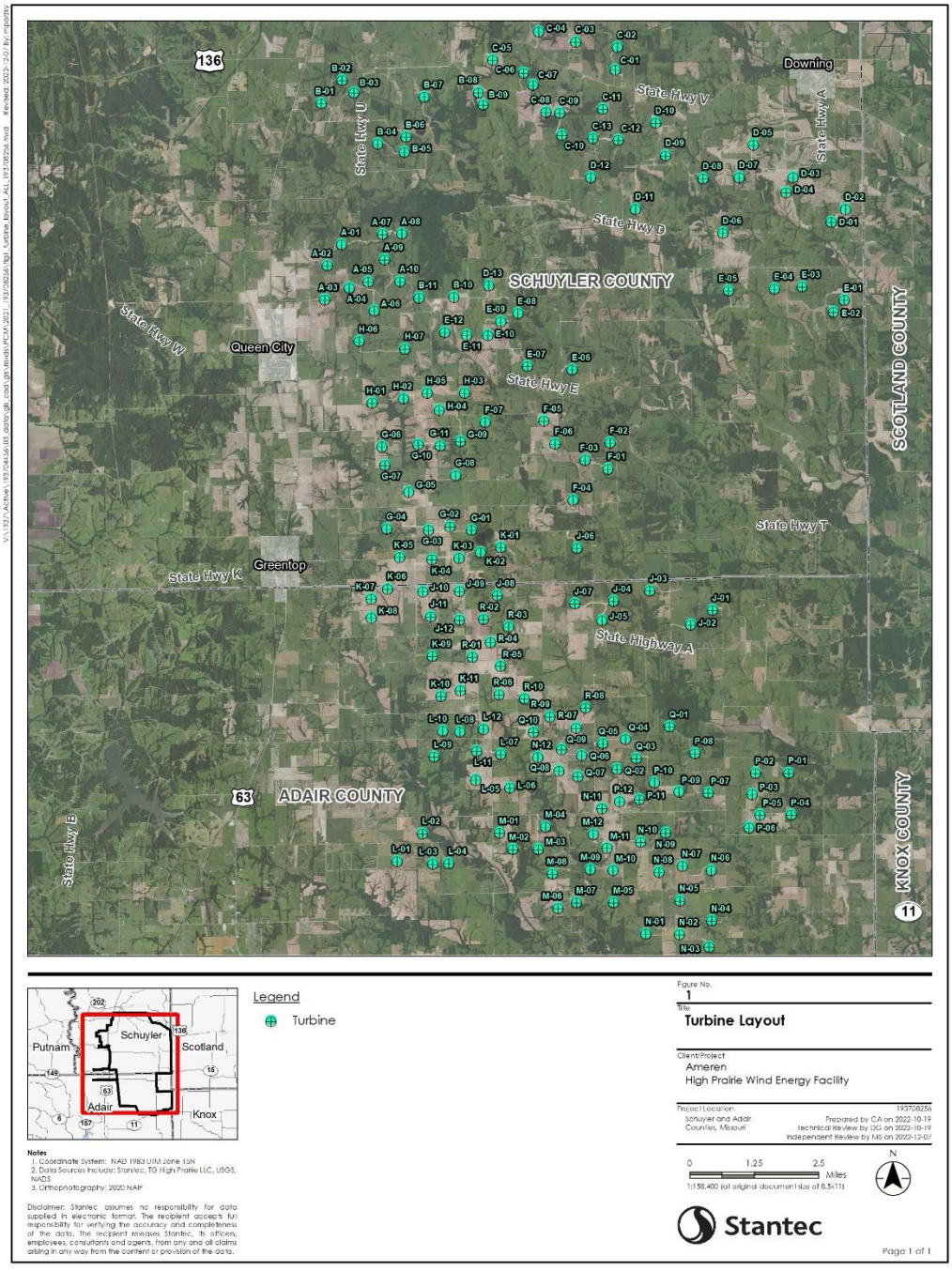



**Figure 1. Turbine Layout**

# 2.0 Methods

Post-construction monitoring included the following components:

1. Standardized carcass searches to systematically search plots at all turbines for bat casualties attributable to the turbines
2. Searcher efficiency trials to estimate the percentage of bat casualties that were found by the searcher(s)
3. Carcass removal trials to estimate the persistence time of carcasses on-site before scavengers removed them

## 2.1 FIELD METHODS

### 2.1.1 Standardized Carcass Searches

Post-construction monitoring was conducted at 100% of the turbines that operated at night between April 1 and October 31, 2022. All turbines were searched as full plots out to 197 ft (60 m) and were searched five times a week when possible (search interval of ~1.4 days).

Standardized carcass searches were conducted by qualified searchers trained in mortality search methods, including proper handling and reporting of carcasses. Searchers were familiar with and able to accurately identify bat species likely to be found in the project area. Preliminary bat species identifications were made in the field by qualified staff. When carcass condition allowed, sex and age of the carcass were recorded. For bat carcasses, forearm length was recorded to facilitate species identification. In addition to the carcass, photographs and data collected for each carcass were used to verify the species identification. Photos of any unknown bats discovered were sent to a Stantec permitted bat biologist for positive identification, and carcasses were kept on-site. Any unknown bat or suspected *Myotis* was identified by a Stantec senior bat biologist who holds a USFWS permit for threatened and endangered bats, and/or sent to the Northern Arizona University's Bat Ecology and Genetics Lab[1] for genetic testing.

During searches, searchers walked at a rate of approximately 2 miles per hour (mph; 45 to 60 m per minute) while searching 10 ft (3 m) on either side. For each carcass found (for the purposes of this analysis, live or injured bats were considered a carcass), the following data were recorded digitally within Survey123 (ESRI, Redlands, CA):

- Date and time
- Initial species identification [this information was updated as needed based on photos, dentition, or results of genetic testing]
- Sex, age, and reproductive condition (when possible) [sex was updated based on genetic testing, if applicable]
- Global positioning system (GPS) location

[1] https://in.nau.edu/bat-ecology-genetics/

- Distance and bearing to turbine
- Condition (intact, scavenged, decomposed)
- Any notes on presumed cause of death

A digital photograph of each carcass found was taken before the carcass was handled and removed. All bat carcasses were labeled, bagged, and stored in a freezer at the Project Operations and Maintenance Building. Bat carcasses were collected and retained under the ITP and Missouri Department of Conservation Wildlife Collector's Permits #19836, #19837, and #19838.

Bat carcasses found in non-search areas were coded as incidental finds and documented in a similar fashion to those found in standardized surveys when possible. These included carcasses found during non-search times or outside the monitoring plot. Incidental bat carcasses were collected and stored in the freezer with the carcasses found during standardized surveys. As per industry standard, incidental finds were not included in the fatality estimates.

### 2.1.2 Searcher Efficiency Trials

Searcher efficiency trials were used to estimate the probability of bat carcass detection by the searchers. The searchers did not know when during the monitoring periods the trials were being conducted, at which turbines trial carcasses were placed, or the location or number of trial carcasses placed in any given search plot. Commercially available brown mouse carcasses were used as trial carcasses to represent bats.

All searcher efficiency trial carcasses were randomly placed by a field lead within the search plots. These were placed either the evening before monitoring, or in the morning prior to the planned carcass surveys for that day and checked after the searcher efficiency trial to ensure they had not been scavenged. The number of trial carcasses found by the searcher during the mortality surveys in each plot was recorded and compared to the total number of trial carcasses placed in the plot and not scavenged prior to the mortality search.

### 2.1.3 Carcass Removal Trials

Carcass removal trials were conducted to estimate the average length of time carcasses remained in the search plots (i.e., were available to find) before being removed by scavengers. Mouse carcasses used during the searcher efficiency trials were left in place, and their locations were discretely marked; alternatively, sometimes separate mouse carcasses were placed for carcass removal trials alone. Searchers monitored the trial carcasses over a period of up to 30 days. During the carcass removal trial, carcasses were checked approximately every day for the first week, and then regularly checked until missing or 30 days had passed.

The condition of each carcass was recorded during each trial check. The conditions recorded were defined as follows:

- Intact – complete carcass with no body parts missing
- Scavenged – carcass with some evidence or signs of scavenging

- Fur spot – no carcass, but fur spot remaining
- Missing – no carcass or fur remaining

Any carcasses remaining at the end of the 30-day trial period were removed from the field.

## 2.2 DATA ANALYSIS - GENEST

Results include summaries of the raw data, including counts of species, the number of searches conducted, and the average search interval (calculated as the sum of the number of visits to a turbine divided by the number of days within a season).

The Generalized Estimator (GenEst; Dalthorp et al. 2018) was used for calculating bias correction factors (searcher efficiency, carcass persistence, and area adjustment).

### 2.2.1 Searcher Efficiency (p)

Searcher efficiency (p) represents the average probability that a carcass was detected by the searcher. The searcher efficiency rate was calculated using the data collected during searcher efficiency trials (Section 2.1.6) by dividing the number of trial carcasses the observer found by the total number which remained available during the trial (i.e., non-scavenged). Analysis, where applicable, includes an evaluation of whether searcher efficiency differed by searcher, season (spring, summer, fall), or plot type (roads and pads, full plots). Searcher efficiency decay (k) was fixed at 0.67. This value represents the decrease in searcher efficiency (p) on subsequent searches (i.e., if a carcass is missed the first time it is available, it is less likely to be found on subsequent searches than a "fresh" carcass).

GenEst returns numerous models depending on the number of variables included in the analysis, as well as Akaike information criterion (AIC) values for each model. The AIC value is a statistical score for the quality of a model fit, where smaller AIC values are considered better models. However, models within 3-4 ΔAIC (the difference between each models AIC and the AIC of the "best" model) are generally considered indistinguishable by this measure (Dalthorp et al. 2018). Therefore, the best model was chosen based on a manual review of models with the lowest AIC values, and a top model was chosen from the models within 3-4 ΔAIC of the top model based on AIC alone. Confidence intervals were generated using 1,000 bootstrapped iterations.

### 2.2.2 Carcass Persistence

Carcass persistence times modeled in GenEst include using censored exponential, Weibull, lognormal, and loglogistic survival models of the data collected as part of the carcass removal trial (Section 2.1.3). GenEst returns numerous models depending on the number of variables included in the analysis, as well as AIC values for each model. The best model was chosen based on a comparison of models with the lowest AIC values, though similar to searcher efficiency, models were also graphically evaluated to ensure that they are logical, and the top model was chosen from the models within 3-4 ΔAIC of the top model based on AIC alone. Confidence intervals were generated using 1,000 bootstrapped iterations.

### 2.2.3 Density-weighted Proportion (DWP)

Due to the lack of bat carcasses found in 2022, the density-weighted proportion (DWP) from 2021 was used, which was 73.2% for full plots. The DWP will be reviewed annually and updated as appropriate.

### 2.2.4 Adjusted Fatality Estimates (GenEst)

No adjusted fatality estimates were generated, as no bat carcasses were found during standardized monitoring.

## 2.3 DATA ANALYSIS – EVIDENCE OF ABSENCE

Evidence of Absence (EofA; Dalthorp et al. 2017) was used for estimating the overall detection probability (g) and the estimated take of the Covered Species (M and λ).

### 2.3.1 Estimation of Detection Probability (g)

For analysis of the 2022 data, the "Single Class Module" was used to evaluate data from full plots searched between August 10th and October 31st. Site-specific monitoring data were used to calculate the g-value for each search class, including the following inputs:

- Search interval (I), calculated as the average time between searches
- Number of searches, calculated as the average number of times each turbine was visited
- Spatial coverage (a) was set to 0.732 (73.2% of carcasses are expected to fall within 60-meter full plots)
- Temporal coverage (v), which is set to 1 since monitoring occurred during the entire period of risk
- Searcher efficiency, which was calculated using the "carcasses removed after one search" option and inputting the total number of carcasses available and the number of carcasses found across all searchers
- Factor by which searcher efficiency changes with each search (k) was fixed at 0.67
- Persistence distribution, which was calculated using field trials to estimate the parameters, and the top model was selected based on results from GenEst modeling

Once these inputs were complete, the "Estimate g" option was chosen, and the overall detection probability for the monitoring period was calculated. This detection probability is the same for all three Covered Species.

### 2.3.2 Evaluation of Adaptive Management Triggers

For analysis of the 2022 data, the "Multiple Years Module" was used with the results of the detection probability (g) obtained as described in Section 2.3.1, along with the number of observed mortalities of each of the Covered Species. This analysis was run separately for each Covered Species to determine the total estimated mortality (M), the annual fatality rate (λ), the projected future take over the 6-year permit term if current take rate trends continue, and to evaluate whether the short-term triggers described in Table 7-3 of the HCP had been exceeded. All analysis was done at a=0.5 and included the results from 2021 monitoring as well.

# 3.0 Results

## 3.1 ALL BATS

### 3.1.1 Carcass Searches

A total of 188 searches were conducted between August 10 and October 31 (Table 3-1).

**Table 3-1. Summary of post-construction monitoring conducted between April 1 and October 31, 2022, at the High Prairie Renewable Energy Center, Schuyler and Adair Counties, Missouri.**

| Turbine | Number of Searches Conducted | Average Search Interval[1] | Number of bats found |
|---|---|---|---|
| A | 12 | 1.3 | 0 |
| B | 11 | 1.5 | 0 |
| C | 24 | 1.3 | 0 |
| D | 23 | 1.4 | 0 |
| E | 37 | 1.4 | 0 |
| F | 12 | 1.3 | 0 |
| G | 12 | 1.3 | 0 |
| H | 24 | 1.3 | 0 |
| I | 23 | 1.4 | 0 |

| Turbine | Number of Searches Conducted | Average Search Interval[1] | Number of bats found |
|---|---|---|---|
| J | 11 | 1.5 | 0 |
| **Total** | **188** | **1.4** | **0** |

No bat carcasses were found during standardized carcass searches. One juvenile male big brown bat (*Eptesicus fuscus*) was found incidentally on July 23, 2022, at Turbine L-09.

### 3.1.2 Species Composition

No bats were found during standardized post-construction monitoring. One juvenile male big brown bat was found incidentally on July 23, 2022, at Turbine L-09.

### 3.1.3 Searcher Efficiency

Searcher efficiency trials were conducted during the post-construction monitoring during the fall, as standardized post-construction monitoring did not start until August 10th,. Trials were limited to full plots, as that was the only plot type utilized. Data were analyzed in GenEst, with searcher as a potential predictor variable. The selected model was for a constant searcher efficiency across the two searchers (Table 3-2). Selected model is shown in bold.

**Table 3-2. Model comparison results from the two models for searcher efficiency trials conducted in October 2022 at the High Prairie Renewable Energy Center, Schuyler and Adair Counties, Missouri. Selected model shown in bold.**

| Formula/Model | k | $AIC_c$ | $\Delta AIC_c$ |
|---|---|---|---|
| **p ~ constant** | **0.67** | **16.11** | **0** |
| p ~ Searcher | 0.67 | 18.4 | 2.29 |

Based on the results of the top model, searcher efficiency was estimated at 92.0% (90% CI: 77.4% to 97.5%). Searcher efficiency was tested using a total of 25 trial carcasses, all placed within full plots.

### 3.1.4 Carcass Persistence

Carcass persistence was tested across all three seasons and both plot types. The top five models for carcass persistence in GenEst included exponential and Weibull distributions, with effects of season and/or plot type (Table 3-3). Based on visual analysis of these models, the Weibull

distribution with season in the formula for location and a constant scale was selected as the model for carcass persistence.

**Table 3-3. Model comparison results from the top five models for carcass persistence trials conducted between April 1 and October 31, 2022, at the High Prairie Renewable Energy Center, Schuyler and Adair Counties, Missouri. Selected model is shown in bold.**

| Distribution | Location Formula | Scale Formula | $AIC_c$ | $\Delta AIC_c$ |
|---|---|---|---|---|
| Exponential | l ~ Season | n/a | 546.22 | 0 |
| Exponential | l ~ Season * PlotType | n/a | 546.37 | 0.15 |
| Exponential | l ~ Season + PlotType | n/a | 546.76 | 0.54 |
| **Weibull** | **l ~ Season** | **s ~ constant** | **548.28** | **2.06** |
| Weibull | l ~ Season * Plot Type | s ~ constant | 548.32 | 2.1 |

Carcass persistence was tested using 152 carcasses across the three seasons and varied by season but not by plot type. The shortest carcass persistence observed was in the fall, when carcass persistence averaged 1.45 days, compared to 2.52 days in the summer and 3.82 days in the spring (Table 3-4).

**Table 3-4. Carcass persistence during 2022 post-construction monitoring at the High Prairie Renewable Energy Center, Schuyler and Adair Counties, Missouri.**

| Season | Trial Carcasses | Carcass Persistence (90% CI) |
|---|---|---|
| Spring | 40 | 3.82 (2.90 – 5.05) |
| Summer | 47 | 2.52 (1.94 – 3.25) |
| Fall | 65 | 1.45 (1.15 – 1.83) |

### 3.1.5 Density-weighted Proportion (DWP)

Based on results from 2021, when carcasses were observed, the DWP for full plots was 73.2%.

### 3.1.6 Adjusted Fatality Estimates

No fatality rates were calculated, as GenEst cannot calculate a fatality rate when no carcasses are observed.

## 3.2 COVERED SPECIES

### 3.2.1 Bat-in-hand Triggers and Adaptive Management Responses Implemented

No Covered Species (Indiana bat, little brown bat, and northern long-eared bat) were found, and therefore no bat-in-hand triggers were met, and no adaptive management responses were implemented.

### 3.2.2 Evidence of Absence

Screenshots of the inputs for EofA are included in Appendix A and the results are summarized in the sections below. The "Single Class" module was used in EofA since full plots were the only plot type and searches were only conducted from August 10 to October 31.

For 2022, given that the Project was largely non-operational, and turbines that did operate at night were curtailed (8 m/s plus an acoustic-activated curtailment system triggered by any bat activity), it was assumed that the relative mortality rate ($\rho$) was 0.01 compared to 2021 ($\rho$=1) (i.e., a 99% reduction from the fatality rate observed in 2021).

#### 3.2.2.1 Detection Probability (g)

The detection probability for the standardized post-construction monitoring (August 10 – October 31) was 0.472 (95% CI: 0.394 – 0.551) [2].

#### 3.2.2.2 Fatality Estimates (M* and λ)

Analysis in the EofA "Multiple Years Module" included calculation of the following for each of the Covered Species, per Section 7.5.2 of the HCP:

- Number of Detected Fatalities (X)
- Annual Take Estimate ($M_{2022}$)
- Annual take rate (λ)
- Cumulative take estimate (includes 2021 fatality estimate)
- Projected Take Estimate (number estimated to have been killed to-date, plus the additional take likely to occur in the remaining years of the permit if the annual take rate stays the same)

[2] $B_a = 72.8505$. $B_b = 81.5256$

Screenshots of inputs are provided in Appendix A, and results are summarized in Table 3-5.

**Table 3-5. Summary of EofA outputs for the Covered Species from 2022 post-construction monitoring at the High Prairie Renewable Energy Center in Schuyler and Adair Counties, Missouri. Analysis done with a=0.5.**

| Species | Number of detected fatalities in 2022 (X) | Annual Take Estimate ($M_{2022}$) (95% CI) | Cumulative Take Estimate (2021-2022) | Annual Take Rate ($\lambda_{2022}$) (95% CI) | Projected Take Estimate[1] | Short term Trigger Met? |
|---|---|---|---|---|---|---|
| Indiana bat | 0 | 0 (0 – 3) | 61 (28 – 121) | 1.07 (<0.01 – 5.40) | 66.8 (34 – 112) | No, cannot infer $\lambda$ > 12 |
| Little brown bat | 0 | 0 (0 – 3) | 10 (1 - 33) | 1.07 (<0.01 – 5.40) | 12.9 (2 – 33) | No, cannot infer $\lambda$ > 16 |
| Northern long-eared bat | 0 | 0 (0 – 3) | 1 (0 – 16) | 1.07 (<0.01 – 5.40) | 3.8 (0 – 15) | No, cannot infer $\lambda$ > 3 |

[1]Projected take estimate assumes that detection probability (g) will be approximately 0.2 in future years, but assumes no operational changes that would reduce risk (i.e., this is the estimate for the Project operating under the same protocols as 2022 for the remaining 4 years of the permit)

No new adaptive management triggers were met in 2022.

## 3.3 DESIGN PROTOCOLS – FUTURE MONITORING

The HCP denotes a desired detection probability (g) of 0.2 over the 6-year permit term, however, 2021 monitoring fell short of this goal, and thus adjustments were made for 2022. The project detection probability (g) was greater than the 0.217 needed for 2022. Therefore, for 2023, a detection probability of at least 0.2 will be targeted.

To design this monitoring, the following assumptions were used:

- Searcher efficiency of 0.618 on full plots [based on results from 2021 when a full year of monitoring occurred at the full level of effort]
- Searcher efficiency of 0.911 on roads and pads [based on the lowest seasonal searcher efficiency on roads and pads in 2021 to be conservative]
- Carcass persistence of 2.6 days [average of 2022 values]

- Area adjustment of 0.732 for full plots and 0.06 for roads and pads

Monitoring under the HCP (April 1 – October 31) will be limited to turbines that operate at night (defined as 45 minutes before sunset to 45 minutes after sunset). Any turbines that remain shut-down at night for all or part of the bat active season (April 1 – October 31) will not require monitoring until such time that they become operational, and non-operational turbines will not be factored into calculations of g-value (which will be applied only to turbines and time periods of risk).

Because the operational plan remains flexible at this time, the post-construction monitoring plan will also remain flexible. Table 3-6 overviews the potential combinations of full plots to roads and pads and corresponding search intervals that would achieve a detection probability ≥ 0.2.

**Table 3-6. Overview of detection probability of potential post-construction monitoring protocols for 2023 for the High Prairie Renewable Energy Center in Schuyler and Adair Counties, Missouri. Bolded and green filled cells indicate protocols that achieve a detection probability of ≥0.2.**

| % Full Plots | % Roads and Pads | Search Interval 2X/week (I=3.5) | Search Interval 3X/week (I=2.5) | Search Interval 5X/week (I=1.5) |
|---|---|---|---|---|
| 100% | 0% | **0.265** | **0.321** | **0.400** |
| 90% | 10% | **0.251** | **0.300** | **0.376** |
| 80% | 20% | **0.235** | **0.283** | **0.349** |
| 70% | 30% | **0.216** | **0.257** | **0.319** |
| 60% | 40% | 0.196 | **0.234** | **0.287** |
| 50% | 50% | 0.173 | **0.205** | **0.252** |
| 40% | 60% | 0.149 | 0.177 | **0.215** |

At a minimum, post-construction monitoring will include 40% full plots and 60% roads and pads searched five times a week, or 70% full plots and 30% roads and pads searches twice weekly, though Ameren may voluntarily choose to monitor at a higher level of effort (and thus achieving a higher g-value).

Searcher efficiency and carcass persistence trials will take place seasonally (if monitoring is occurring), and the preliminary results of these trials will be provided to USFWS and MDC in the seasonal summaries. Carcass persistence trials will use ≥40 carcasses.

Section 8.1.3.2 of the HCP requires Ameren to contract with a 3rd party contractor to conduct the post-construction monitoring. In 2021, Ameren signed a contract with Stantec for Stantec to provide the 2021 and 2022 post-construction monitoring at the Project. Stantec is preparing a cost proposal for Ameren for 2023 post-construction monitoring and Ameren will update the surety accordingly.

# 4.0 Summary of 2022 Post-construction Bat Mortality Monitoring and Next Steps

- Post-construction monitoring occurred at a limited number of turbines that operated at night. No bats were found during this monitoring.
- No adaptive management was triggered in 2022. No Covered Species were found.
- The detection probability (g) in 2022 was 0.472; post-construction monitoring will be implemented in 2023 at operational turbines. The protocols chosen will be designed to achieve a goal detection probability ≥0.2.

# 5.0 Literature Cited

Dalthorp, D., M. Huso, and D. Dail. 2017. Evidence of Absence (v2.0) Software User Guide: U.S. Geological Survey Data Series 1055, 109 p.. https://doi.org/10.3133/ds1055.

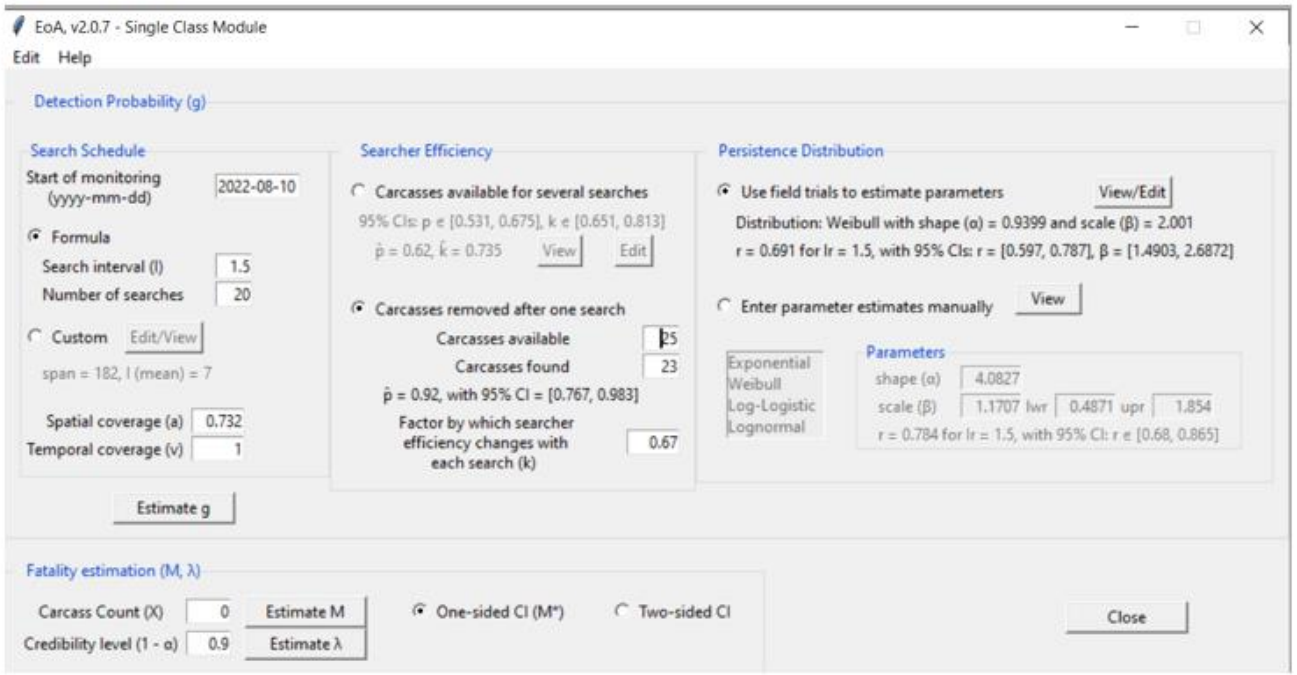
Dalthorp, D., L. Madsen, M.M. Huso, P.A. Rabie, R. Wolpert, J. Studyvin, J. Simonis, and J. Mintz. 2018. GenEst statistical models – A generalized estimator of mortality. No. 7-A2. U.S. Geological Survey, 2018.

# Appendix A Evidence of Absence Screenshots

Summaries and screenshots of inputs for estimation of detection probability (g) and fatality estimates (M and λ) are provided on the following pages.

2022 Inputs

- Start date of 8/10/2022
- Search interval of ~1.5 days (rounded up from 1.4 days)
- Number of searches 20 (based on ~average searches per turbine)
- Spatial coverage of 0.732 (based on DWP of full plots)
- Temporal coverage of 100% of the season
- 23/25 SE trials found for full plots
- K fixed at 0.67
- Field trial CP data from fall added, Weibull distribution chosen based on GenEst results




**RESULTS: g = 0.472** (Ba=72.8505, Bb=81.5256)

Adaptive Management Analysis - 2022 Inputs (Multiple Years Module)

- Input the beta parameters that were derived each year (2022 and 2021), ran model separately for Indiana bats (shown in screenshot below), little brown bats (1 fatality in 2021, none in 2022) and northern long-eared bats (no fatalities in either year)
- Used "Estimate M" and "track past mortality" with credibility set to 0.5 to estimate M* and λ
- Used "Estimate M" and "Projection of future mortality and estimates" to estimate projected fatality, assuming the same reduction in fatality rate (ρ=.01) as 2022, and a detection probability (g) of 0.2 (0.18-0.22) for a 6-year project with a mortality threshold of 72 Indiana bats, 96 little brown bats, or 18 northern long-eared bats
- Used "Estimate average annual fatality rate (λ)" and "short term rate (λ>τ)" for a term of 1 year and α=0.5 to determine if the short-term trigger had been exceeded, with an "Annual rate threshold (τ)" of 12 Indiana bats, 16 little brown bats, or 3 northern long-eared bats.