Post-Construction Monitoring Study for the Great Pathfinder Wind Project Boone and Hamilton Counties, Iowa

April 1– May 15 and August 1–October 15, 2023

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WEST

EXECUTIVE SUMMARY

Great Pathfinder Wind, LLC, is operating the Great Pathfinder Wind Project (Project) in Boone and Hamilton counties, Iowa. Commercial operation of the Project began in February 2023. The Project consists of 66 General Electric 140 3.4-megawatt (MW) turbines with a total generating capacity of approximately 225 MW. This report details the first year of post-construction monitoring (PCM) study conducted in 2023, consistent with Section 6.4 of the Project's Habitat Conservation Plan (HCP) and Incidental Take Permit (ITP; ESPER0627303) for Indiana bats and northern long-eared bats (Covered Species). Following the operational minimization plan in the HCP, turbines were feathered below manufacturer cut-in speed of 3.0 meter (m; 16.9 feet [ft]) per second (s) in the spring (April 1 – May 15) and summer (May 15 – July 31), and 5.0 m/s (16.4 ft/s) per second in fall (August 1 – October 15) to minimize direct impacts to Covered Species.

PCM was completed in accordance with the Year 1 Post-construction Monitoring Study Plan for the Great Pathfinder Wind Farm (Study Plan), which was provided to the US Fish and Wildlife Service on March 17, 2023. The Study Plan was designed to achieve a probability of detection, or *g*, of 0.2. The overall goal of this post-construction study was to monitor for fatalities of the Covered Species and to evaluate compliance with the incidental take authorization granted under the Project's ITP. This Year 1 study was designed to comply with the post-construction fatality monitoring requirements for Indiana bat and northern long-eared bat as outlined in the Project's HCP and ITP, and provide the necessary data to determine if adaptive management is triggered.

Standardized searches were completed for bat carcasses at three plot types: road and pad plots searched to 100 m (328 ft) from the turbine, as well as cleared and uncleared 70 m- (230-ft) radius circular plots. Technicians searched road and pad plots at all 66 turbines once per week during spring (April 1 – May 15), and road and pad plots at 56 turbines twice per week in the fall (August 1 – October 15). Detection-dog teams also searched seven cleared circular plots and three uncleared circular plots twice per week during the fall. Searcher efficiency and carcass persistence trials were conducted across plot types during each study season to correct for detection bias and removal bias.

No Covered Species were found at the Project during the 2023 study period. A total of 225 bats were found during the study, and 182 bats were included in analysis to calculate area adjustment factors for EoA. The most commonly found bat species was eastern red bat (66.2%), followed by big brown bat (12.4%), hoary bat (12%), and silver-haired bat (7.8%).

The overall *g* value for 2023 was 0.11 (95% confidence interval: 0.10–0.12). No adaptive management actions were triggered because no Covered Species were found in Year 1, and triggers based on annual take rates of Covered Species will not be assessed until Year 3 per the HCP.

STUDY PARTICIPANTS

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REPORT REFERENCE

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INTRODUCTION

Great Pathfinder Wind, LLC (Great Pathfinder) is operating the Great Pathfinder Wind Project (Project) in Boone and Hamilton counties, Iowa. The Project became fully operational in February 2023, and consists of 66 GE-140 3.4-megawatt (MW) turbines, with a total generating capacity of approximately 225 MW. Turbine towers are approximately 98 meters (m; 322 feet [ft]) in height and the rotor diameter is 140 m (460 ft), with a maximum height from tower base to highest blade tip of 168 m (551 ft).

On April 10, 2023, Great Pathfinder obtained an Incidental Take Permit (ITP; ESPER0627303) for the federally listed as endangered Indiana bat (*Myotis sodalis*) and northern long-eared bat (*M. septentrionalis*; hereafter, Covered Species) from the US Fish and Wildlife Service (USFWS). Post-construction monitoring (PCM) is required by the ITP to determine if the level of take of the Covered Species complies with the authorized take and to evaluate if adaptive management measures are triggered.

Following the operational minimization plan in the HCP, project turbines were feathered at wind speeds below the manufacturer's rated cut-in speed (3.0 m/s [9.8 ft/s]) from sunset to sunrise from March 15 – July 31 and October 16 – November 15 when the temperature was above 10 degrees (°) Celsius (C; 50 ° Fahrenheit [F]). Project turbines were feathered below wind speeds of 5.0 m/s (16.4 ft/s) from sunset to sunrise during the fall bat migration season (August 1 – October 15) when the temperature was above 10 °C to minimize impacts to migrating Covered Species.

Western EcoSystems Technology, Inc. (WEST) completed a post-construction monitoring (PCM) study designed to achieve a probability of detection, or *g*, of 0.2, consistent with the Project's Habitat Conservation Plan (HCP). The objective of this study was to comply with the post-construction fatality monitoring requirements for Indiana bat and northern long-eared bat as outlined in the Project's HCP and ITP and determine if adaptive management thresholds were triggered. This report presents the results of the first year (Year 1) of the PCM conducted at the Project from April 1 – May 15 and August 1 – October 15, 2023.

PROJECT AREA

The Project is located in Boone and Hamilton counties, Iowa, 2.0 miles (3.2 kilometers) southeast of Stratford, Iowa (Figure 1). The Project's Permit Area covers 19,690 acres (ac; 7,968 hectares [ha]) in northern Boone and southern Hamilton counties. According to the National Land Cover Database (2019), the primary land cover type within the Permit Area is cultivated crops, which covers 90.2% of the Permit Area or 17,792 ac (7,200 ha), followed by hay/pasture (3.8%), developed land (3.6%), and herbaceous cover (1.0%). All other land cover types individually account for 1.0% or less of the Permit Area (Table 1).

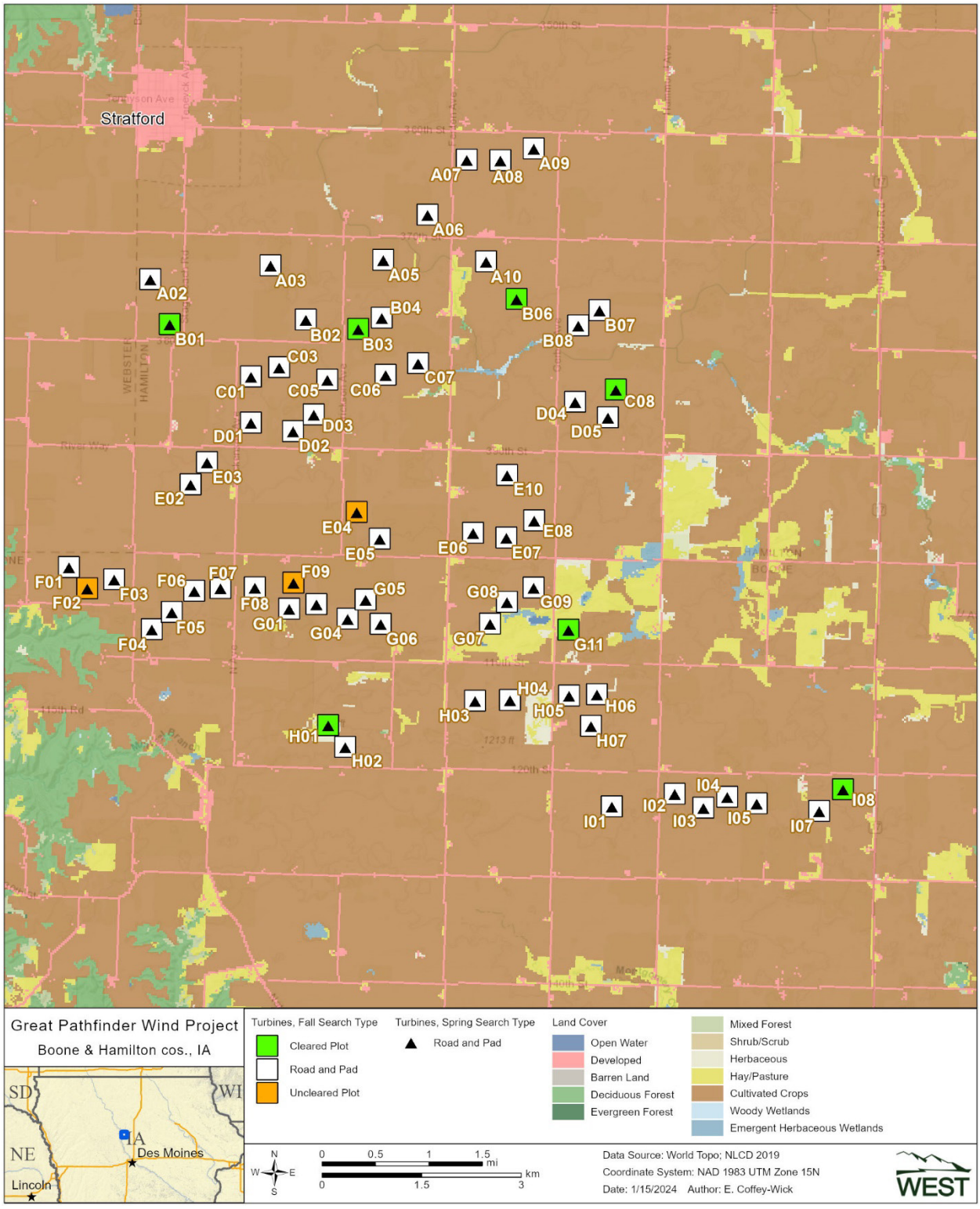

Figure 1. Land cover types and turbine locations by season and plot type, within and around the Great Pathfinder Wind Project, Boone and Hamilton counties, Iowa.

Table 1. Land cover types, acreages, and percent (%) composition within the Great Pathfinder Wind Project, Boone and Hamilton counties, Iowa.

Land Cover Class	Acres	% Composition
Cultivated Crops	17,792	90.2
Hay/Pasture	751	3.8
Developed[1]	705	3.6
Herbaceous	188	1.0
Deciduous Forest	124	0.6
Emergent Herbaceous Wetlands	85	0.4
Mixed Forest	19	0.1
Open Water	14	0.1
Woody Wetlands	10	0.1
Barren Land	0.7	<0.1
Total	**19,690**	**100**

[1]Includes developed, open space; developed, low intensity; developed, medium intensity; and developed, high intensity.

Sums may not equal total values shown due to rounding.

Source: National Land Cover Database 2019

METHODS

This PCM study consisted of three primary survey components: 1) carcass searches of turbines, 2) searcher efficiency trials to estimate the probability a carcass was found by searchers, and 3) carcass persistence trials to estimate the average length of time a carcass remained in the search area for possible detection. In addition, a search area adjustment was estimated to account for carcasses that fell outside of search areas.

Great Pathfinder developed monitoring protocols for the first year of post-construction monitoring in the Project's HCP. The study plan was designed to target a *g* value of 0.2 across spring and fall using assumed values for searcher efficiency, carcass persistence, and area adjustment based on prior studies in the region. WEST submitted the study plan to the USFWS on March 17, 2023.

Standardized Carcass Searches

Standardized carcass searches (carcass searches) varied by season and were scheduled to maximize the search effort when the take of Covered Species was considered most likely to occur. Searches were conducted within three search plot types: road and pad, cleared circular, and uncleared circular plots. A round of clearing searches was conducted prior to the spring monitoring period on March 28 and 29, 2023, with the exception of tower D03, which was not surveyed until the first round of searches on April 3 due to turbine maintenance. The purpose of the clearing searches was to remove any carcasses that may be found on the plots before the searches to minimize bias resulting from fatalities occurring prior to the study. In the fall, searches at road and pads and uncleared plots started on August 1, 2023, but searches at cleared plots were delayed by vegetation clearing. Because initial fall searches were conducted after the start of the study period, carcasses that were estimated to have occurred prior to the start of the fall monitoring period were removed from analysis.

Search Methods

Human technicians conducted searches in road and pad plots, and detection-dog teams conducted searches in the cleared and uncleared circular plots. All personnel were trained to follow the Project's Study Plan, including proper handling and reporting of carcasses. Carcass searches were conducted during the day, beginning as early as first light.

Technician Searches

During road and pad searches, the technician started at 100 m from the turbine and walked the access road at a rate of approximately 45–60 m (150–200 ft) per minute toward the turbine on one side of the road, around the back of the turbine, then traversed the gravel crane pad multiple times and walked back to the starting point on the other side of the road. The technician searched out to 1.0 m (3.3 ft) on each side as they walked until the entire road and pad were searched to ensure full visual coverage of each plot.

Detection-dog Team

Detection-dog teams searched cleared and uncleared 70 m radius circular plots. Prior to each search, dog-handlers determined the start point and the number of transects needed to cover the plot after considering wind speed and direction, as well as crop row direction and density (when applicable). Dog-handlers oriented the detection dog to start searches perpendicular to the wind to maximize scent detection. Both windspeed and crop density can affect dispersal of the target odor (i.e., bat carcasses) across the plot. To maximize detection rates during an olfactory search, transect width varied with vegetation density, ranging from five to 10 m (16–33 ft) apart in densely vegetated areas to 10–15 m (33–49 ft) in shorter vegetation.

Number of Turbines Sampled, Search Frequency, and Plot Size

Road and Pad Plots

Technicians conducted carcass searches on road and pad plots at all 66 turbines once per week from April 1 – May 15, 2023 (spring), and at 56 turbines twice per week from August 1 – October 15, 2023 (fall; Table 2; Appendix A). In fall, the 10 turbines without road and pad searches had circular plot searches (below). Road and pad plots included the turbine pad and access road(s) out to 100 m (328 ft) from the turbine base.

Cleared and Uncleared Circular Plots

All circular search plots were searched by a detection-dog team. Circular plots included seven plots cleared of vegetation (cleared plots) and three plots where low-growing crops (soybeans [*Glycine max*]) were grown during the study period (uncleared plots). Uncleared plots had access channels (two perpendicular 1.5 m- [5.0 ft-] wide strips mowed across the plot allowing the detection-dog team to traverse more easily the plot) maintained during the fall.

Table 2. Search effort by season and plot type at Great Pathfinder Wind Project, Boone and Hamilton counties, Iowa, April 1 – May 15 and August 1 – October 15, 2023.

Season	Plot Type	Search Interval	Number of Turbines	Searched By
Spring (April 1 – May 15)	100-m road and pad	Once per week	66	Technician
Fall (August 1 – October 15)	100-m road and pad	Twice per week	56	Technician
	70-m cleared circular plot	Twice per week	7	Detection-dog team
	70-m uncleared circular plot	Twice per week	3	Detection-dog team

m = meter

Data Collection

For each scheduled search, the searcher (either technician or dog-handler) recorded the date, start and end times, searcher name, turbine number, type of search, aided search type ("none" for technicians or "dog" for detection-dog teams), and if any fatalities were found. When a fatality was found, a flag was placed near it and the search continued. After searching the entire area, the searcher returned to record information for each fatality on a fatality data sheet, including the date and time, species, sex and age (when possible), searcher name, turbine number, measured distance from turbine, azimuth from turbine, location of carcass as Universal Transverse Mercator or decimal degree coordinates, land cover surrounding carcass, condition of carcass (i.e., intact, scavenged, dismembered, injured), and estimated time of death (e.g., less than one day, two days). All fatalities had their location plotted on a map of the search area. Carcasses found in non-search areas (e.g., outside of a plot boundary) or outside of the scheduled study period, were recorded as incidental discoveries and documented following the same protocol for those found during standard searches.

Although the Covered Species were the focal interest of the study, all bird and bat carcasses that were detected were recorded. The condition of each carcass found was recorded using the following categories:

- Intact—a carcass that is complete, not badly decomposed, and shows no sign of being fed upon by a predator or scavenger.
- Scavenged—an entire carcass that shows 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 has been heavily infested by insects.
- Dismembered—a carcass found in multiple pieces distributed more than 1 m apart from one another due to scavenging or other reasons.
- Injured—a bat or bird found alive.

Digital photographs were taken of each fatality, including any visible injuries, and surrounding habitat. No bird carcasses were collected; these carcasses were left in place but marked to avoid duplicate counting. Bat carcasses were collected under the Project's ITP (ESPER0627303),

WEST's Federal Native Endangered and Threatened Species Recovery Permit (ES234121), and WEST's Iowa Wildlife Salvage Permit (SC895). Technicians or dog handlers placed all bat carcasses in a re-sealable plastic bag labeled with the unique carcass identification number, turbine number, and date, for storage in a freezer on site. Leather and latex gloves were used to handle all bat carcasses to eliminate possible transmission of rabies or other zoonotic diseases.

Carcasses found in non-search areas (e.g., outside of a plot boundary) or outside of the scheduled study period, were recorded as incidental discoveries and documented following the same protocol as those found during standard searches but incidental discoveries were not included in the analysis. Carcasses found either during scheduled searches or incidental observations (within the plots) between scheduled searches were included in the analysis.

Carcass Identification and Agency Notification

Field identification of bird carcasses was reviewed, via photographs, by biologists with extensive field experience in identification of Midwestern birds and feathers. Federally permitted bat biologists, Brenna Hyzy (ES26854C-2) and Pallavi Sirajuddin (TE62046D), provided an initial identification of all potential *Myotis* carcasses via photographs. Tissue samples were collected from all bat carcasses and submitted to a USFWS-approved laboratory in three separate batches on August 16, September 5, and October 17, 2023. After DNA samples were taken, carcasses were retained in a freezer onsite or used in bias trials.

Bias Trials

Searcher Efficiency Trials

The objective of searcher efficiency trials was to estimate the probability that a carcass was found by a technician or detection dog. Searcher efficiency trials were conducted in the same areas where carcass searches occurred. Technicians conducting carcass searches did not know when searcher efficiency trials were being conducted or the location of the trial carcasses. Trial carcasses consisted of bats found during carcass searches and commercially available dark-colored mice (*Mus musculus*). Bats were used for all circular plot trials (42 bats) and some road and pad trials (11 bats). Mice were used for road and pad trials (26 mice) when bats were not available. Bats used in bias trials included eastern red bats (*Lasiurus borealis*), big brown bats (*Eptesicus fuscus*), hoary bats (*L. cinereus)* and silver-haired bats (*Lasionycteris noctivagans*).

Seventy-nine bat and mice carcasses were placed across all seasons and plot types to account for differences in search conditions by plot type and season. Searcher efficiency trials were conducted separately per plot type (road and pad, cleared, and uncleared) and per season (spring and fall). Trials were conducted on multiple dates in each season to account for potential changes in plot conditions on searcher efficiency over time. Each trial carcass was discreetly marked with a tabbed black zip-tie with a unique number around the upper forelimb for identification as a trial carcass after it was found. Carcasses were dropped from waist-height or higher and allowed to land in a random posture. The trial administrator walked in a meandering path and dropped trials for detection-dog teams in the early morning prior to the search to allow time for a scent cone to develop prior to scheduled searches.

Searchers had one chance to locate the trial carcass after carcass placement. The number and location of trial carcasses placed were recorded, and whether each trial carcass was found or missed. Immediately following the search, any carcasses that were missed were checked to confirm availability. A trial administrator oversaw the placement and recording of availability for each trial.

Carcass Persistence Trials

The objective of carcass persistence trials was to estimate the length of time (in days) a carcass would persist or be available for detection in the field. Carcasses could be removed by scavengers or rendered undetectable by farming activities. Carcass persistence trials used different carcasses than those used for searcher efficiency trials. In the spring, 20 trial mouse carcasses were placed on road and pad search areas. In the fall, 20 trial mouse carcasses were placed on road and pad search areas, 20 trial carcasses (15 bats and five mice) were placed on cleared circular plots, and 12 trial carcasses (nine bats and three mice) were placed on uncleared circular plots. The lower number of carcasses at uncleared plots was to avoid concentrating carcasses on the limited number of plots (3), which could potentially attract scavengers. These carcasses were placed throughout the seasons to incorporate the effects of varying weather and scavenger densities on carcass persistence. No more than three trial carcasses at a time were placed in any one search area to avoid potential over-seeding and attracting scavengers.

Technicians monitored the trial carcasses over a 30-day period according to the following schedule as closely as possible. Carcasses were checked daily for the first four days, then on days 7, 10, 14, 20 and 30. Trial carcasses were monitored until they were completely removed, or the trial period ended, whichever occurred first. At the end of the 30-day period, any remaining carcasses were removed. Detection-dog teams were used to determine when carcasses were removed from the circular plots, whereas technicians determined the status of carcasses placed on road and pad plots.

Search Area Mapping

Technicians delineated the boundaries of all search areas using a Juniper Geode sub-meter Global Positioning System unit. Unsearchable areas within plot boundaries were also mapped. Plot boundaries were then used to verify if carcasses were found inside the search areas and to inform an area adjustment based on the spatial distribution of carcasses.

Quality Assurance and Quality Control

Quality assurance and quality control measures were implemented at all stages of the study, including in the field, during data entry and analysis, and report writing. Following searches, 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 and measures were implemented. A Microsoft® SQL

database was developed to store, organize, and retrieve search data. All data forms and electronic data files were retained for reference.

Statistical Analysis

The EoA (Dalthorp et al. 2017) modeling framework was used to estimate detection probability (*g*). Data used in the EoA model included spatial distribution of all bat carcasses found during the study, and the results of searcher efficiency and carcass persistence trials.

Searcher Efficiency Estimation

Searcher efficiency was estimated separately for technicians and detection-dog teams to account for different modes of detection (i.e., technicians use sight whereas dogs use scent). EoA uses raw searcher efficiency data (e.g., number of found and available trial carcasses) to inform overall probability of detection. However, to determine if searcher efficiency data should be pooled, or separated by strata such as season and/or plot type, searcher efficiency was modeled using logistic regression. Season was included as a potential covariate for the technician model, and plot type was included as a potential covariate for the detection-dog team model. For both the technician and detection-dog team models, selection was completed using an information theoretic approach known as AICc, or corrected Akaike Information Criterion (Burnham and Anderson 2002). The best-supported model was selected as the most parsimonious model (fewest parameters) within two AICc units of the model with the lowest AICc value. Searcher efficiency values were input into the EoA software according to the model selection results.

The change in searcher efficiency between successive searches was defined by a parameter called the detection reduction factor (*k*) that can range from zero to one. When *k* is zero, it implies a carcass that was 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. Huso et al. (2017) estimated a value of k = 0.67 for bats, and this value was used to calculate estimates for the Covered Species in EoA.

Carcass Persistence Rate Estimation

Data collected during carcass persistence trials were used to estimate the amount of time, in days, that carcasses remained available to be located by the technician or detection-dog team. 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 with four potential distributions: exponential, log-logistic, lognormal, and Weibull (Kalbfleisch and Prentice 2002, Dalthorp et al. 2018). As with searcher efficiency, carcass persistence models were estimated separately by search team (i.e., technicians versus detection-dog teams) to account for different modes of detection. Season was included as a potential covariate for the technician model, and plot type was included as a potential covariate for the detection-dog model. The best-supported model was selected as the most parsimonious model within two AICc units of the model with the lowest AICc value. The parameter estimates of the selected model (shape and scale, including the 95% confidence interval [CI] of scale) were used as inputs in the EoA Single Class module.

Search Area Adjustment

The search area adjustment was calculated to determine the distribution of bat carcasses and the proportion of bat carcasses occurring within the search areas. The search area adjustment accounted for unsearched areas beneath turbines and was calculated as a probability that ranged from zero to one. The area adjustment was estimated as the product of the searched area around each turbine and a carcass-density distribution. A truncated weighted maximum likelihood (TWL) modeling approach (Khokan et al. 2013) was used to estimate the carcass-density distribution using site-specific fatality locations. The TWL approach uses weight based probability of detection and the proportion of area searched in each 1-m annulus around the turbine. Distributions considered were normal, gamma, Gompertz, and Weibull (parameterized according to R Development Core Team [2016] and Yee [2010]). Although the spring and fall seasons have the potential to have different carcass density distributions due to differences in turbine operation, there was insufficient sample size in the spring to examine these effects. Therefore, the only models considered were those that pooled data from both turbine operation regimes and seasons. The best-supported model was selected using AICc. The proportion of area searched was calculated in a geographic information system as the amount of area searched divided by the total area searched at each 1-m annulus around the turbine.

Carcasses Excluded from Area Adjustment

Fatalities were excluded from the area adjustment used in EoA when the carcass was discovered outside of the spatial and temporal scope of the study design. For example, carcasses found outside a designated plot were not included in the analysis because the area adjustment accounts for the carcass by adjusting for unsearched areas. Carcasses found prior to the start of searches (e.g., a carcass found on a plot in the summer that was not searched until the fall) were also excluded because the carcass occurred outside of the study period. Note that carcasses found on a plot incidentally were included in the analysis if that plot had a scheduled search during the next round of searches. If a fatality of a Covered Species had been found outside of the spatial or temporal scope of the study design, it would still be excluded from the area adjustment estimate but would be included in the EoA fatality estimate following Dalthorp et al. (2020).

Covered Species Detection Probability Estimates

The probability of detection (g) was estimated using bias corrections for searcher efficiency, carcass persistence, and area searched, as well as the assumed seasonality of risk for the Covered Species, which was 11% in spring and 89% in fall per the Project's Study Plan. The EoA Single Class module was used to estimate the distribution of detection probability in each search stratum, and area adjustment was included in the Single Class module for each stratum. This resulted in alpha and beta parameters that defined the Beta distribution of detection probability in each stratum. The EoA Multiple Class Module was then used to combine detection probability distributions across strata within a season, with weights for each class defined by the sampling fraction for each plot type. The Multiple Class Module was used again to combine the strata across seasons using arrival proportions to define the weights for each class to get a single annual Beta distribution. Per the HCP, adaptive management triggers will not be evaluated using EoA until Year 3; "bat in hand" adaptive management triggers that could apply in Years 1 and 2 are discussed below.

RESULTS

Standardized Carcass Searches

In the spring, 506 searches were completed, and 1,346 searches were completed in the fall (Table 3). A total of 128 searches (6.5%) were missed due to ground conditions at cleared plots, turbine maintenance, weather constraints, and safety hazards. For example, initial searches at some cleared circular plots were delayed in the fall due to clearing and all circular plot searches were paused from August 9 – 16, 2023 due to the remaining vegetation stalks and stumps after mowing, which presented a safety concern to the detection-dog team. Two hundred twenty-five bat carcasses and 38 bird carcasses were found during searches and incidentally. No Covered Species were found, and no other federally or state-listed species were recorded during the study.

Table 3. Number of searches per plot type at the Great Pathfinder Wind Project, Boone and Hamilton counties, Iowa, April 1 – May 15 and August 1 – October 15, 2023.

Season	Plot Type	Search Interval (days)	Number of Searches
Spring (April 1 – May 15)	100-m road and pad	7.5	506
Fall (August 1 – October 15)	100-m road and pad	4.0	1,174
	70-m cleared plot	4.0	115
	70-m uncleared plot	4.0	57

m = meter.

Species Composition

Ten bats were found during the spring and 215 bats were found during the fall. The most commonly found bat species were eastern red bats (66% of carcasses) followed by big brown bat (12%), hoary bat (12%), and silver-haired bat (8%). One evening bat (*Nycticeius humeralis*), one Seminole bat (*Lasiurus seminolus*), and one tricolored bat (*Perimyotis subflavus;* a species proposed for listing as endangered under the ESA) were also found.

Thirty-seven bats were excluded from analysis because they were found during clearing searches (none during spring clearing searches and 37 during fall clearing searches) and six bats were excluded because they were found outside of search areas (Table 4). A total of 182 bats were used in analysis to estimate the spatial distribution of bat carcasses to produce area adjustment factors for EoA.

Table 4. Number and percent (%) of carcasses, by species, included and excluded from analysis at the Great Pathfinder Wind Project, Boone and Hamilton counties, Iowa, from April 1 – May 15 and August 1 – October 15, 2023.

	Included in Analysis		Outside Search Area*		Outside Study Period[1]		Total	
Species	Total	%	Total	%	Total	%	Total	%
big brown bat	20	11.0	0	0.0	8	21.6	28	12.4
eastern red bat	123	67.6	3	50.0	23	62.2	149	66.2
evening bat	1	0.6	0	0.0	0	0.0	1	0.4
hoary bat	24	13.2	2	33.3	1	2.7	27	12.0

Table 4. Number and percent (%) of carcasses, by species, included and excluded from analysis at the Great Pathfinder Wind Project, Boone and Hamilton counties, Iowa, from April 1 – May 15 and August 1 – October 15, 2023.

	Included in Analysis		Outside Search Area*		Outside Study Period[1]		Total	
Species	**Total**	**%**	**Total**	**%**	**Total**	**%**	**Total**	**%**
Seminole bat	1	0.6	0	0.0	0	0.0	1	0.4
silver-haired bat	12	6.6	1	16.7	5	13.5	18	8.0
tricolored bat	1	0.6	0	0.0	0	0.0	1	0.4
Overall Bats	**182**	**100**	**6**	**100**	**37**	**100**	**225**	**100**

[1] Carcasses not included in analysis.

Bias Trials

Searcher Efficiency Trials

A total of 79 bats and mice were placed for searcher efficiency trials on 17 separate dates across all plot types and months of the study; 78 of these were available for searchers to find (Appendix B). Detection-dog teams found 78.0% of available carcasses (32 out of 41) on circular plots and technicians found 91.9% of available carcasses (34 out of 37) on road and pad plots (Appendix B).

The selected model for searcher efficiency at circular plots did not include plot type as a covariate, indicating there was not a significant difference in searcher efficiency rates between cleared and uncleared plots for detection-dog teams. The selected model for searcher efficiency at roads and pad plots did not include season as a covariate, indicating there was no significant difference in searcher efficiency rates between spring and fall for human searchers (Appendix B).

Carcass Persistence Trials

A total of 72 carcasses were placed to estimate carcass persistence. The selected model for road and pad plots included season as a covariate, indicating different persistence times for spring and fall (Appendix C). For roads and pads the estimated median carcass persistence was 6.9 days in the spring and 2.9 days in the fall. The selected model for circular plots included plot type as a covariate, indicating persistence differed between cleared and uncleared plots (Appendix C), with estimated median carcass persistence of 9.6 days at cleared plots and 3.7 days at uncleared plots. Both top selected models had an exponential distribution.

Statistical Analysis

Area Adjustment

Forty-three of the 225 bats found during the study were excluded from modeling the area adjustment for EoA (Appendix D). The best-fit model for the distribution of bats with respect to distance from turbine was a normal distribution (Appendix D). The estimated TWL area adjustments for bats were 0.08 for road and pad plots and 0.69 for circular plots.

Probability of Detection

The overall probability of detecting a bat carcass (*g*) during the 2023 study period was 0.11 (95% CI: 0.10–0.12; Table 5). Inputs required to run the EoA Single Class module and stratum-specific *g* distribution values and inputs are presented in Appendix E.

Table 5. Probability of detection (*g*), Ba, and Bb for the Great Pathfinder Wind Project in Boone and Hamilton counties, Iowa, April 1 – May 15 and August 1 – October 15, 2023

Year	Ba[1]	Bb[1]	*g*	95% Confidence Interval
2023	374.6	3173.6	0.11	0.10–0.12

[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.

DISCUSSION

The Year 1 study objectives were to comply with the post-construction fatality monitoring requirements for Indiana bat and northern long-eared bat as outlined in the Project's HCP and ITP and determine if adaptive management thresholds were triggered.

No Covered Species, and no other federally or state-listed bats or birds were found during the study. No adaptive management actions were triggered because no Covered Species were found in Year 1, and triggers based on annual take rates of Covered Species will not be assessed until Year 3.

The target detection probability (*g*) for the first three years of monitoring at the Project is *g* = 0.2. The estimate *g*-value achieved in Year 1 was lower than what was anticipated, primarily due to differences between the assumed area adjustment used to design the study (modeled after results in the Hoopeston 2020 report; Rodriguez et al. 2021) and the area adjustment estimated from carcass data collected during Year 1 at the Project. In other words, the public data used underestimated the proportion of carcasses that fell within the search areas. The study plan for Year 2 will be updated based on Year 1 EoA input values for spatial coverage, searcher efficiency, and carcass persistence estimated from Year 1 data (Appendix E1) to strive to meet the Year 2 detection probability.

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Appendix A. Overview of Study Design and Search Methods

Appendix A. Overview of study design and search methods for post-construction monitoring for the Great Pathfinder Wind Project, in Boone and Hamilton counties, Iowa, April 1 – May 15, and August 1 – October 15, 2023

Design Component	Sampling Unit
Plot type	Cleared and uncleared plots; road and pad searches
Number of plots (percent of all turbines)	66 (100%)
Size/Shape	70-meter (m) radius circle centered on turbine; 100-m road and pad searches
Search interval	Road and Pads once weekly in Spring. Road and Pads and Circular Plots twice weekly in Fall
Detection-dog team	Yes for Circular
Search period	April 1 – May 15 and August 1 – October 15, 2023.
Spring dates	April 1 – May 15, 2023
Fall dates	August 1 – October 15, 2023
Searcher efficiency – seasons	Spring and Fall
Searcher efficiency – carcass sizes	Bat
Carcass persistence trials – seasons	Spring and Fall
Carcass persistence trials – carcass sizes	Bat
Turbine Specifications	
Turbine model	General Electric (GE)-140 3.4-megawatt (66 turbines)
Hub height	98 m
Rotor diameter	140 m
Blade serrations (Yes/No)	Yes

Appendix B. Searcher Efficiency Results and Models

Appendix B1. Searcher efficiency results for all search areas at the Great Pathfinder Wind Project, Boone and Hamilton counties, Iowa, from April 1 – May 15 and August 1 – October 15, 2023, as a function of season and carcass size.

Size Class	Season	Search Area Type	# Placed	# Available	# Found	% Found	Aided Search Type
Bat	Spring	weekly road and pad	20	20	18	90.00	–
Bat	Fall	twice per week road and pad	17	17	16	94.12	–
Bat	Fall	twice per week 70-m cleared plot	20	20	15	75.00	yes*
Bat	Fall	twice per week 70-m uncleared plot	22	21	17	80.95	yes*

* dog aided search.

Appendix B2. Searcher efficiency models for bats on 100-meter road and pads from the Great Pathfinder Wind Project, Boone and Hamilton counties, Iowa, from April 1 – May 15 and August 1 – October 15, 2023 (n = 37).

Covariates	k Value	AICc	Delta AICc
No Covariates	k fixed at 0.67	22.94	0*
Season	k fixed at 0.67	24.96	2.02

* Selected model

AICc = corrected Akaike Information Criterion; Delta AICc = Change in AICc

Appendix B3. Searcher efficiency models for bats on 70-meter plots, dog-aided from the Great Pathfinder Wind Project, Boone and Hamilton counties, Iowa, from August 1 – October 15, 2023 (n = 41).

Covariates	k Value	AICc	Delta AICc
No Covariates	k fixed at 0.67	45.26	0*
Plot Cover Type	k fixed at 0.67	47.26	2

* Selected model

AICc = Corrected Akaike Information Criterion; Delta AICc = Change in AICc

Appendix C. Carcass Persistence Modeling Results and Trial Data

Appendix C1. Carcass persistence models with covariates and distributions for bats on 100-meter road and pads at the Great Pathfinder Wind Project, Boone and Hamilton counties, Iowa, from April 1 – May 15 and August 1 – October 15, 2023. (n = 40).

Location Covariates	Scale Covariates	Distribution	AICc	Delta AICc
Season	–	exponential	160.87	0*
Season	No Covariates	Weibull	162.19	1.32
Season	Season	Weibull	164.24	3.37
No Covariates	No Covariates	Weibull	164.47	3.60
No Covariates	Season	Weibull	165.13	4.26
No Covariates	–	exponential	165.61	4.74
No Covariates	No Covariates	Lognormal	171.32	10.45
No Covariates	Season	Lognormal	171.37	10.50
Season	No Covariates	Lognormal	171.79	10.92
Season	Season	Lognormal	172.68	11.81
No Covariates	No Covariates	Loglogistic	173.27	12.40
Season	No Covariates	Loglogistic	173.33	12.46
No Covariates	Season	Loglogistic	173.62	12.75
Season	Season	Loglogistic	174.51	13.64

* Selected model

AICc = corrected Akaike Information Criterion; Delta AICc = Change in AICc

Appendix C2. Carcass persistence top models with covariates, distributions, and model parameters for the Great Pathfinder Wind Project, Boone and Hamilton counties, Iowa, from April 1 – May 15 and August 1 – October 15, 2023.

Size Class	Season	Distribution	Predicted Median Removal Times (days)	Parameter 1	Parameter 2	Aided Search Type
Bat	Spring road and pad	exponential*	6.91	rate = 0.1004	–	none
Bat	Fall road and pad	exponential*	2.92	rate = 0.2374	–	none
Bat	Fall 70m cleared plot	exponential*	9.61	rate = 0.0722	–	dog
Bat	Fall 70m uncleared plot	exponential*	3.73	rate = 0.1860	–	dog

* Parameterization follows the base R parameterization for this distribution.

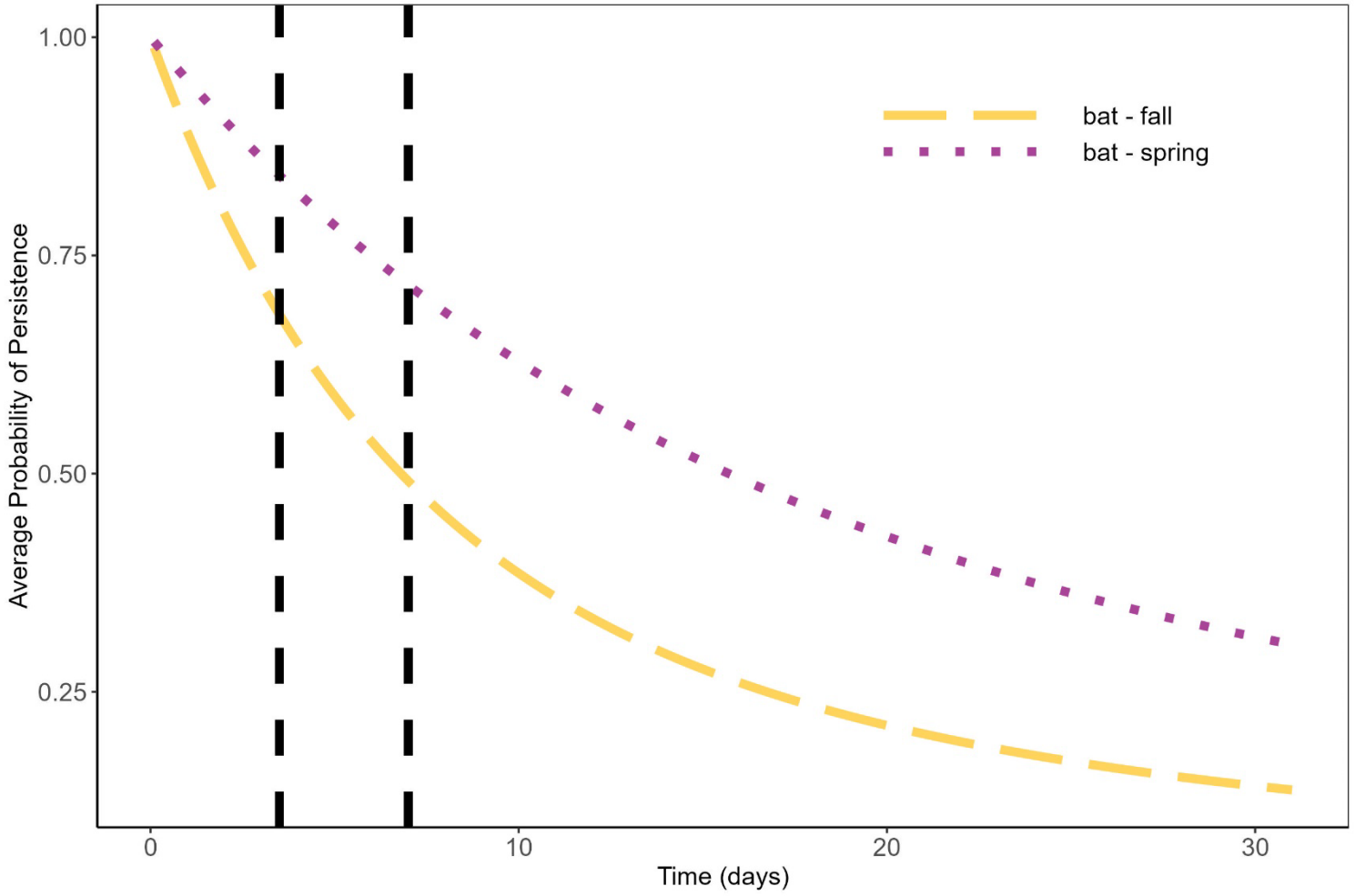
** Parameterization follows the FAdist parameterization for this distribution.

Appendix C3. Carcass persistence models with covariates and distributions for bats on dog-aided searches on 70-meter plots at the Great Pathfinder Wind Project, Boone and Hamilton counties, Iowa, from August 1 – October 15, 2023. (n = 32).

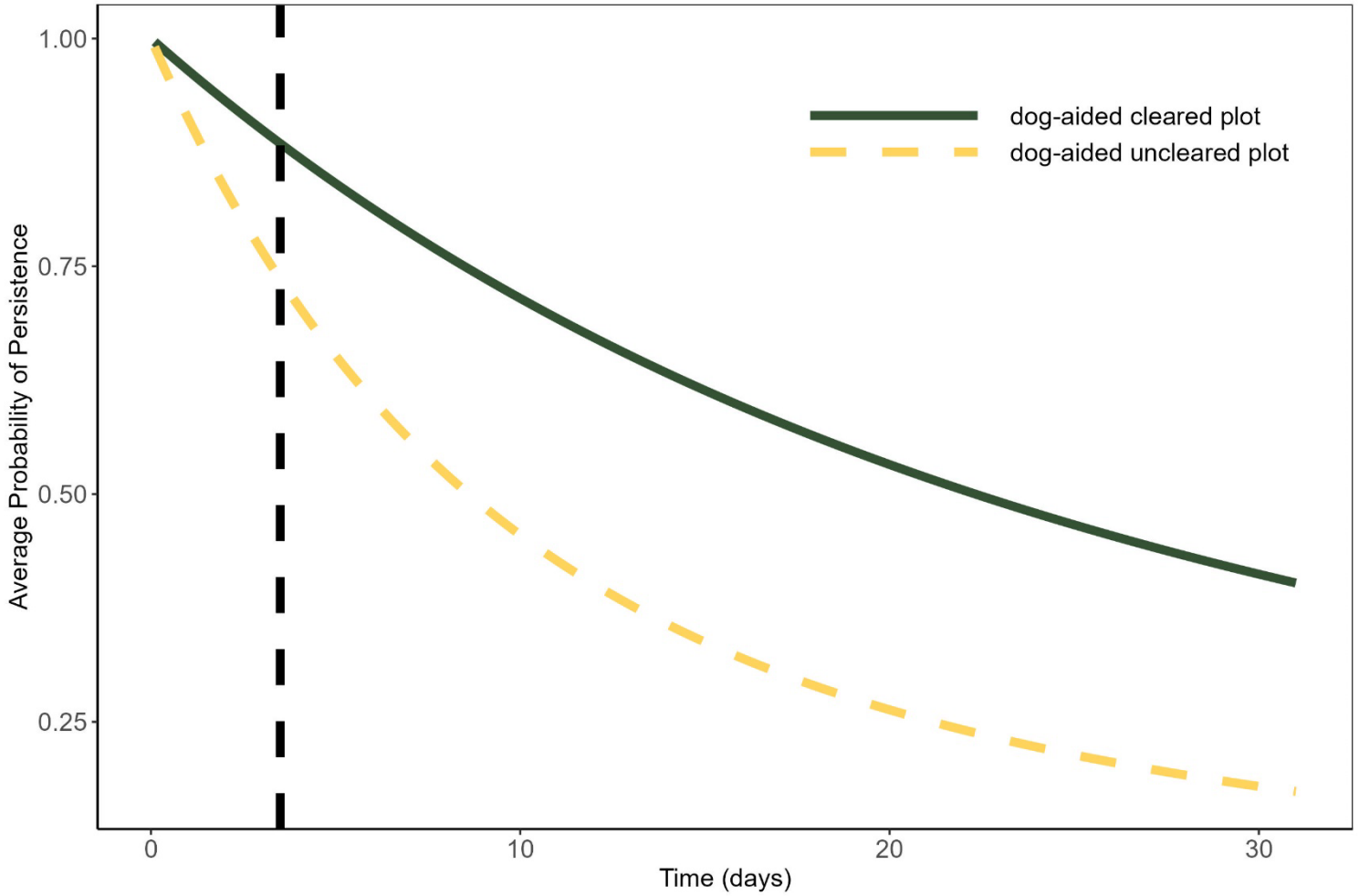
Location Covariates	Scale Covariates	Distribution	AICc	Delta AICc
Plot Type	–	exponential	141.35	0*
Plot Type	No Covariates	loglogistic	142.15	0.80
Plot Type	No Covariates	lognormal	142.88	1.53
Plot Type	No Covariates	Weibull	143.52	2.17
Plot Type	Plot Type	loglogistic	144.01	2.66
No Covariates	No Covariates	loglogistic	144.40	3.05
No Covariates	No Covariates	lognormal	144.47	3.12
Plot Type	Plot Type	lognormal	144.62	3.27
No Covariates	–	exponential	144.75	3.40
No Covariates	No Covariates	Weibull	145.98	4.63
Plot Type	Plot Type	Weibull	146.11	4.76
No Covariates	Plot Type	lognormal	146.33	4.98
No Covariates	Plot Type	loglogistic	146.43	5.08
No Covariates	Plot Type	Weibull	148.25	6.90

* Selected model

AICc = Corrected Akaike Information Criterion; Delta AICc = Change in AICc



Appendix C4. Average probability of carcass persistence as a function of time (days) for bat carcasses placed on 100-meter road and pads at the Great Pathfinder Wind Project, Boone and Hamilton counties, Iowa, from April 1 – May 15 and August 1 – October 15, 2023. Note: scheduled search interval was 7.0 days in spring, 3.5 days in fall, as represented by vertical dashed lines on the figure.



Appendix C5. Average probability of carcass persistence as a function of time (days) for bat carcasses placed at cleared 70-meter plots and uncleared 70-meter plots at the Great Pathfinder Wind Project, Boone and Hamilton counties, Iowa, from August 1 – October 15, 2023. Note: scheduled search interval was 3.5 days, as represented by a vertical dashed line on the figure.

Appendix C6. Bat carcasses placed for carcass persistence trials by date, season, species, and turbine at the Great Pathfinder Wind Project, Boone and Hamilton counties, Iowa, from April 1 – May 15 and August 1 – October 15, 2023.

Date Placed	Season	Species	Turbine	*Before Removal	**After Removal
04/10/2023	Spring	mouse	A07	04/10/2023	04/10/2023
04/10/2023	Spring	mouse	E04	04/10/2023	04/10/2023
04/10/2023	Spring	mouse	B02	04/10/2023	04/11/2023
04/10/2023	Spring	mouse	A03	04/14/2023	04/16/2023
04/10/2023	Spring	mouse	B08	04/19/2023	04/23/2023
04/10/2023	Spring	mouse	D02	04/19/2023	04/23/2023
04/10/2023	Spring	mouse	E10	04/16/2023	04/19/2023
04/10/2023	Spring	mouse	C06	04/23/2023	04/30/2023
04/17/2023	Spring	mouse	I04	04/17/2023	04/17/2023
04/17/2023	Spring	mouse	G06	04/17/2023	04/17/2023
04/17/2023	Spring	mouse	F05	04/30/2023	05/07/2023
04/17/2023	Spring	mouse	G02	05/07/2023	05/16/2023
04/17/2023	Spring	mouse	F08	04/30/2023	05/07/2023
04/17/2023	Spring	mouse	F02	04/17/2023	04/18/2023
04/17/2023	Spring	mouse	I01	04/20/2023	04/24/2023
04/24/2023	Spring	mouse	E07	05/07/2023	05/14/2023
04/24/2023	Spring	mouse	E02	05/14/2023	05/24/2023
04/24/2023	Spring	mouse	B03	05/08/2023	05/15/2023
04/24/2023	Spring	mouse	A08	04/24/2023	04/24/2023
04/24/2023	Spring	mouse	D05	05/07/2023	05/14/2023
08/14/2023	Fall	mouse	G11	08/17/2023	08/20/2023
08/14/2023	Fall	mouse	B01	08/20/2023	08/23/2023
08/14/2023	Fall	mouse	F02	08/16/2023	08/17/2023
08/14/2023	Fall	mouse	B06	08/14/2023	08/14/2023
08/14/2023	Fall	mouse	B07	08/15/2023	08/15/2023
08/14/2023	Fall	mouse	A02	08/15/2023	08/16/2023
08/14/2023	Fall	mouse	D05	08/18/2023	08/21/2023
08/14/2023	Fall	mouse	E04	08/14/2023	08/16/2023
08/14/2023	Fall	mouse	A09	08/16/2023	08/18/2023
08/14/2023	Fall	mouse	A06	08/15/2023	08/15/2023
08/14/2023	Fall	mouse	F09	08/14/2023	08/16/2023
08/14/2023	Fall	mouse	B03	08/18/2023	08/24/2023
08/14/2023	Fall	mouse	C08	09/13/2023	09/13/2023
08/28/2023	Fall	eastern red bat	E04	08/30/2023	09/01/2023
08/28/2023	Fall	big brown bat	F09	08/28/2023	08/29/2023
08/28/2023	Fall	eastern red bat	I08	08/29/2023	08/29/2023
08/28/2023	Fall	eastern red bat	F02	08/30/2023	08/30/2023
08/28/2023	Fall	eastern red bat	H01	09/03/2023	09/06/2023
08/28/2023	Fall	big brown bat	B06	09/01/2023	09/03/2023
08/28/2023	Fall	silver-haired bat	G11	09/03/2023	09/06/2023
08/28/2023	Fall	mouse	H03	09/06/2023	09/17/2023
08/28/2023	Fall	mouse	H04	09/03/2023	09/06/2023
08/28/2023	Fall	mouse	G07	08/28/2023	08/29/2023
08/28/2023	Fall	mouse	H07	09/06/2023	09/10/2023
09/11/2023	Fall	mouse	C06	09/18/2023	09/21/2023
09/11/2023	Fall	mouse	E07	09/15/2023	09/18/2023
09/11/2023	Fall	eastern red bat	F09	09/11/2023	09/11/2023
09/11/2023	Fall	big brown bat	B06	10/10/2023	10/10/2023
09/11/2023	Fall	mouse	E06	09/15/2023	09/18/2023
09/11/2023	Fall	eastern red bat	H01	09/25/2023	10/02/2023
09/11/2023	Fall	big brown bat	B03	10/10/2023	10/10/2023

Appendix C6. Bat carcasses placed for carcass persistence trials by date, season, species, and turbine at the Great Pathfinder Wind Project, Boone and Hamilton counties, Iowa, from April 1 – May 15 and August 1 – October 15, 2023.

Date Placed	Season	Species	Turbine	*Before Removal	**After Removal
09/11/2023	Fall	eastern red bat	I08	09/12/2023	09/13/2023
09/11/2023	Fall	big brown bat	B01	09/13/2023	09/15/2023
09/11/2023	Fall	hoary bat	F02	09/15/2023	09/18/2023
09/11/2023	Fall	mouse	E03	09/12/2023	09/12/2023
09/11/2023	Fall	hoary bat	F09	09/14/2023	09/18/2023
09/11/2023	Fall	mouse	C07	09/15/2023	09/18/2023
09/18/2023	Fall	mouse	F04	09/19/2023	09/19/2023
09/18/2023	Fall	mouse	G06	09/19/2023	09/19/2023
09/18/2023	Fall	mouse	F01	09/19/2023	09/19/2023
09/18/2023	Fall	mouse	G02	09/21/2023	09/25/2023
09/18/2023	Fall	mouse	F05	09/19/2023	09/19/2023
09/18/2023	Fall	mouse	G05	09/20/2023	09/25/2023
09/18/2023	Fall	big brown bat	H01	10/01/2023	10/08/2023
09/18/2023	Fall	eastern red bat	B03	09/27/223	10/01/2023
09/18/2023	Fall	eastern red bat	B06	10/01/2023	10/08/2023
09/18/2023	Fall	hoary bat	F02	09/21/2023	09/24/2023
09/18/2023	Fall	eastern red bat	G11	09/20/2023	09/21/2023
09/18/2023	Fall	big brown bat	F09	09/27/2023	10/01/2023
09/18/2023	Fall	hoary bat	I08	09/21/2023	09/25/2023
09/18/2023	Fall	hoary bat	F09	10/08/2023	10/18/2023
09/18/2023	Fall	eastern red bat	C08	10/09/2023	10/18/2023

* Last date checked before removal

** Date checked after removal

Appendix D. Area Adjustment Modeling Results

Appendix D1. Search area adjustment models for bats from the Great Pathfinder Wind Project, Boone and Hamilton counties, Iowa, from April 1 – May 15 and August 1 – October 15, 2023.

Distribution	AICc	Delta AICc
normal	17,380.30	0*
Weibull	17,382.31	2.01
gamma	17,390.94	10.64
Gompertz	17,413.48	33.18

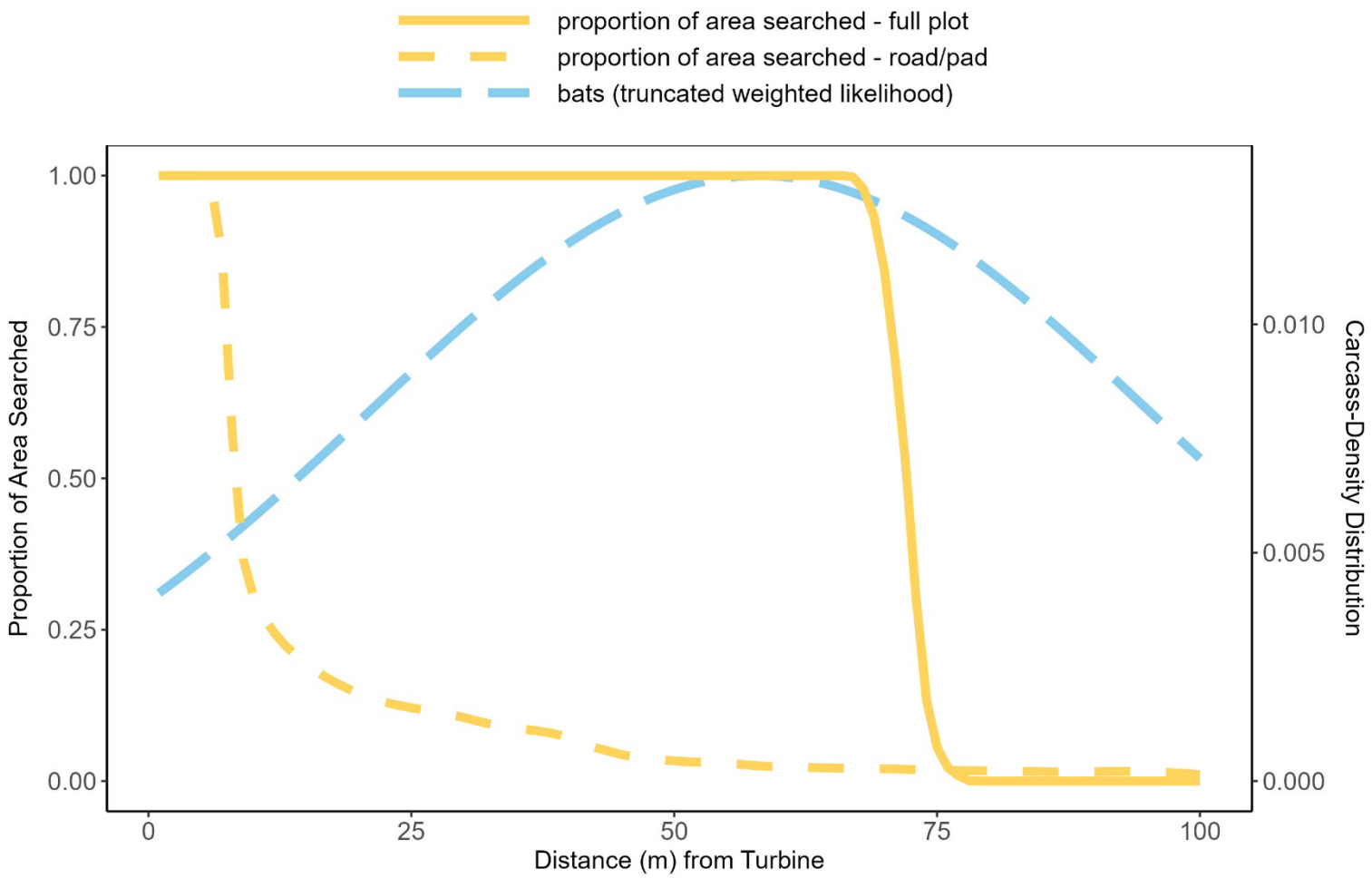
* Selected model

AICc = Corrected Akaike Information Criterion; Delta AICc = Change in AICc

Appendix D2. Truncated weighted maximum likelihood search area adjustment estimates for the Great Pathfinder Wind Project, Boone and Hamilton counties, Iowa, from April 1 – May 15 and August 1 – October 15, 2023 (Bat n = 182).

Size Class	Area Adjustment	Search Area Type	Distribution	Parameter 1	Parameter 2
Bat	0.69	70-m dog-aided plot	normal	58.1086	37.3376
	0.08	100-m road and pad	normal	58.1086	37.3376

m = meter.



Appendix D3. Estimated bat carcass-density distribution, and proportion of area searched by distance from turbine for all search areas at Great Pathfinder Wind Project, Boone and Hamilton counties, Iowa, from April 1 – May 15 and August 1 – October 15, 2023.

Appendix E. Evidence of Absence Inputs for Single Class and Multiple Class Modules and Geographical User Interface Input and Output Screenshots

Appendix E1. Inputs needed to run Evidence of Absence (EoA): Single Class Module for the Great Pathfinder Wind Project, Boone and Hamilton counties, Iowa, April 1 – May 15 and August 1 – October 15, 2023.

Season	Plot Type	Search interval (I)	Number of searches[2]	Spatial Coverage (a)	Searcher Efficiency		Carcass Persistence[1]			
					Carcasses available	Carcasses found	Shape (α)	Scale (β)	Scale Lower Limit (β)	Scale Upper Limit (β)
spring	100-m road and pad	7.5	8	0.08	37	34	–	9.96	6.40	15.52
fall	100-m road and pad	4.0	22	0.08	37	34	–	4.21	2.69	6.60
fall	70-m cleared plots	4.0	18	0.69	41	32	–	13.86	8.59	22.33
fall	70-m uncleared plots	4.0	18	0.69	41	32	–	5.38	3.02	9.55

[1] An exponential distribution was used for the carcass persistence distributions at all plot types.

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

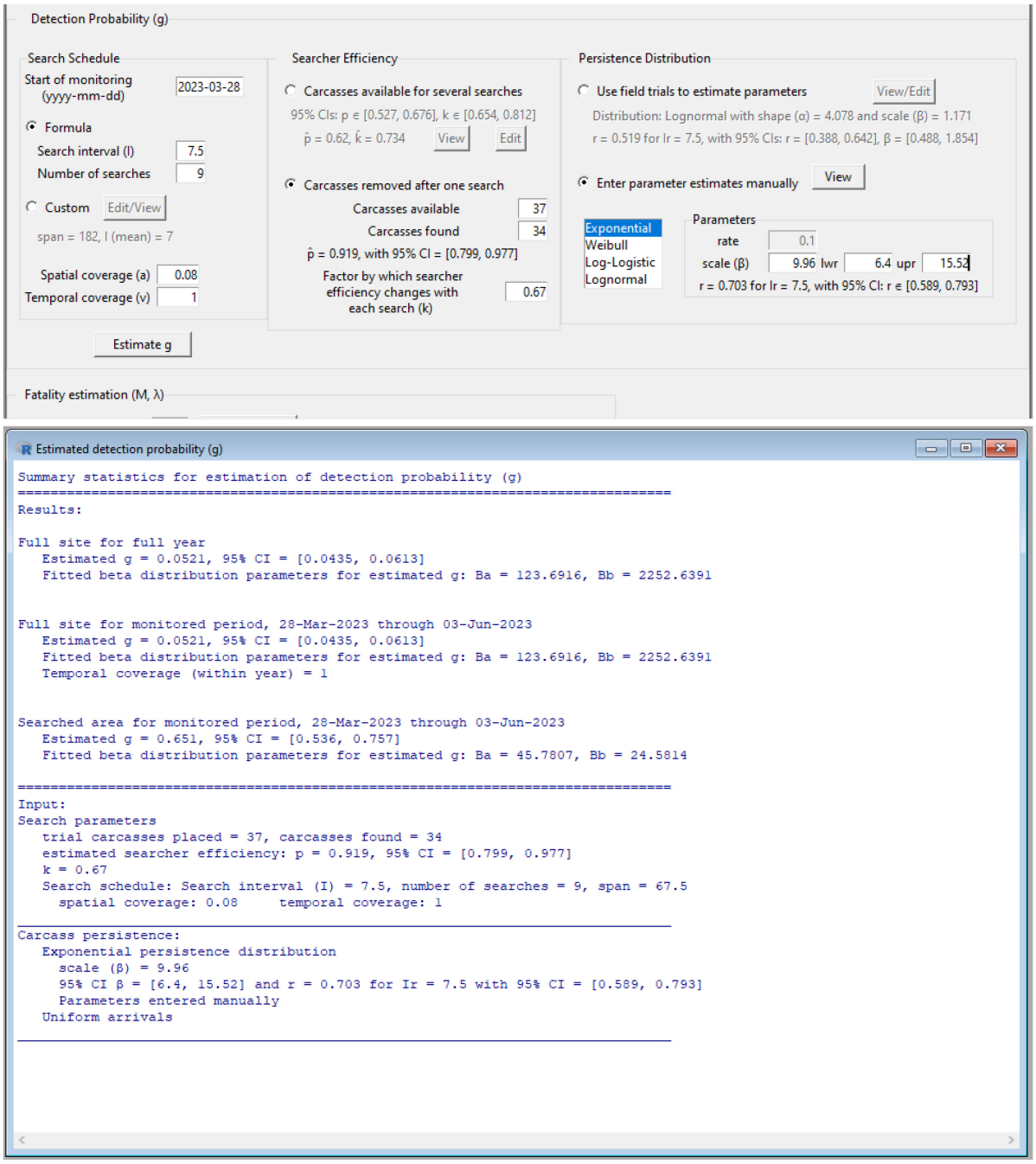
m = meters.

Appendix E2. Inputs needed to run Evidence of Absence: Multiple Class Module for Fall plot types for the Great Pathfinder Wind Project, Boone and Hamilton counties, Iowa, April 1 – May 15 and August 1 – October 15, 2023.

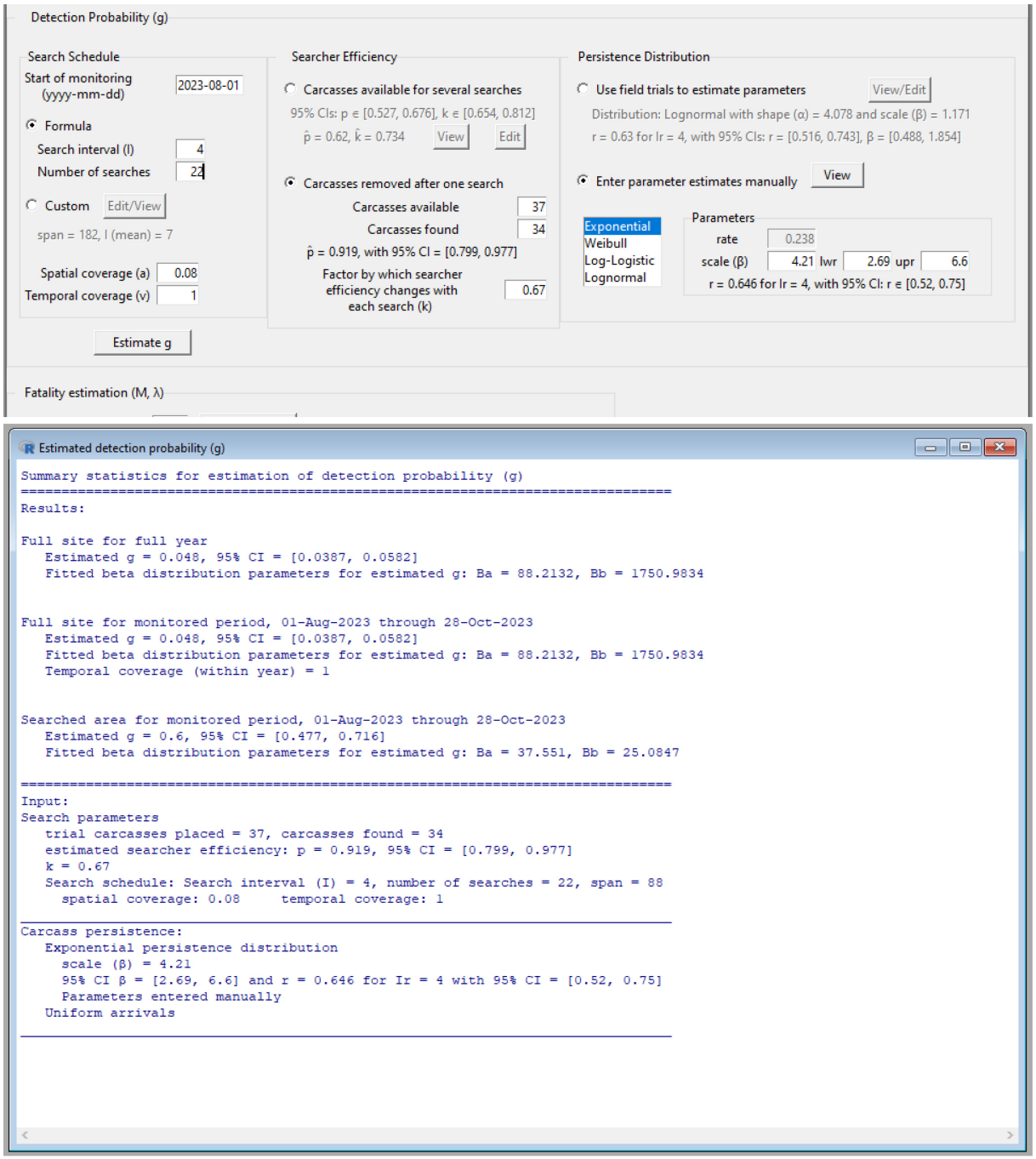
Season	Plot Type	Ba	Bb	Within-Season Sampling Fraction	Temporal Coverage (v)	Within Season Weights (ρ)
spring*	100-m road and pad	123.35	2384.34	1.00	1	1
fall	100-m road and pad	89.6	1901.59	0.85	1	0.85
fall	70-m cleared plot	121.08	108.16	0.11	1	0.11
fall	70-m uncleared plots	35.44	52.38	0.05	1	0.05

* The spring season had a single plot type, and no combination of detection probabilities was required during this step for the spring. The spring road and pad strata information is included for transparency.

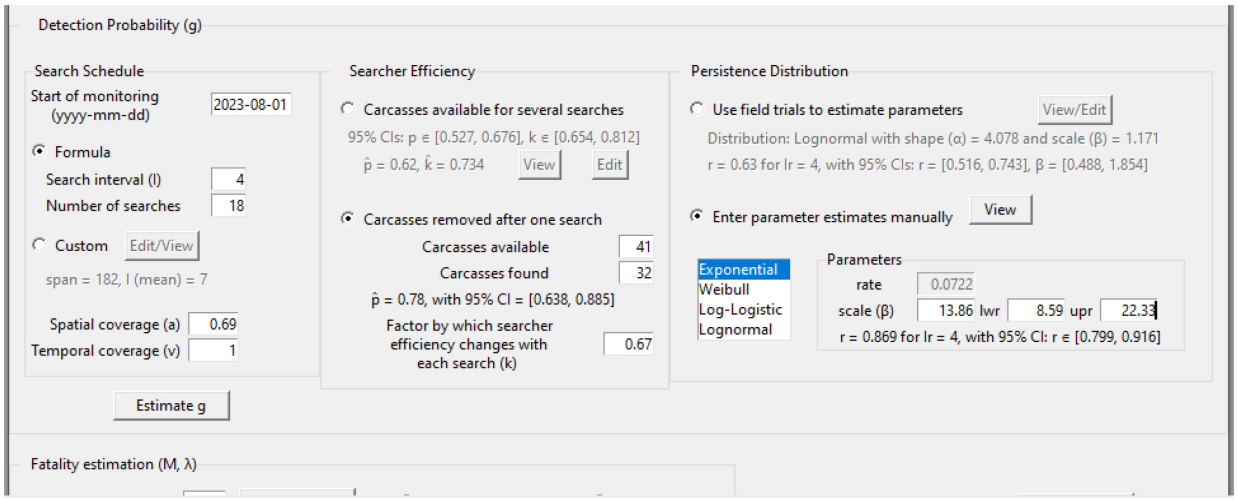
m = meter.

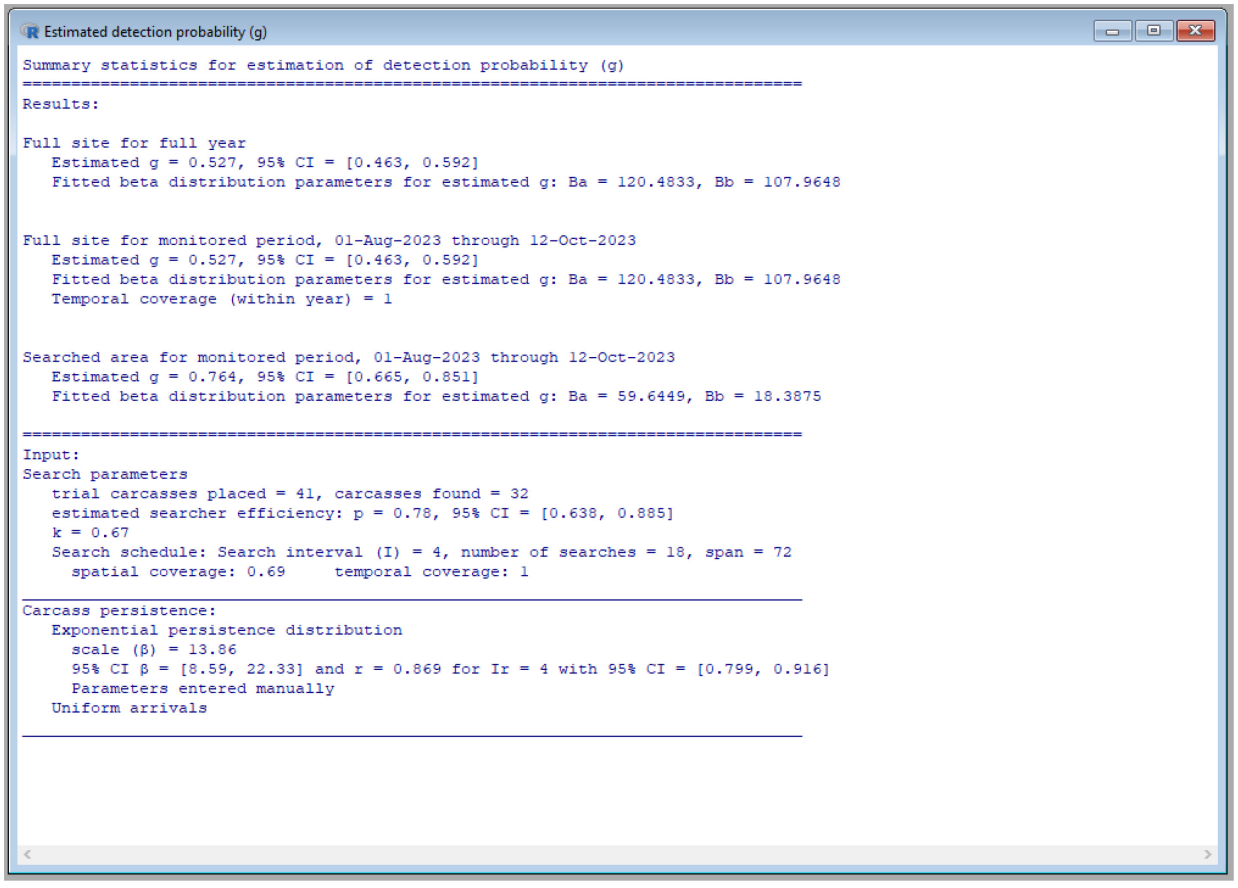


Appendix E3. Screen shot of Evidence of Absence (v2.0.7) graphical user interface, Single Class Module inputs for Spring 2023, 100-meter road and pad searches at 66 turbines, searched at a 7-day interval.

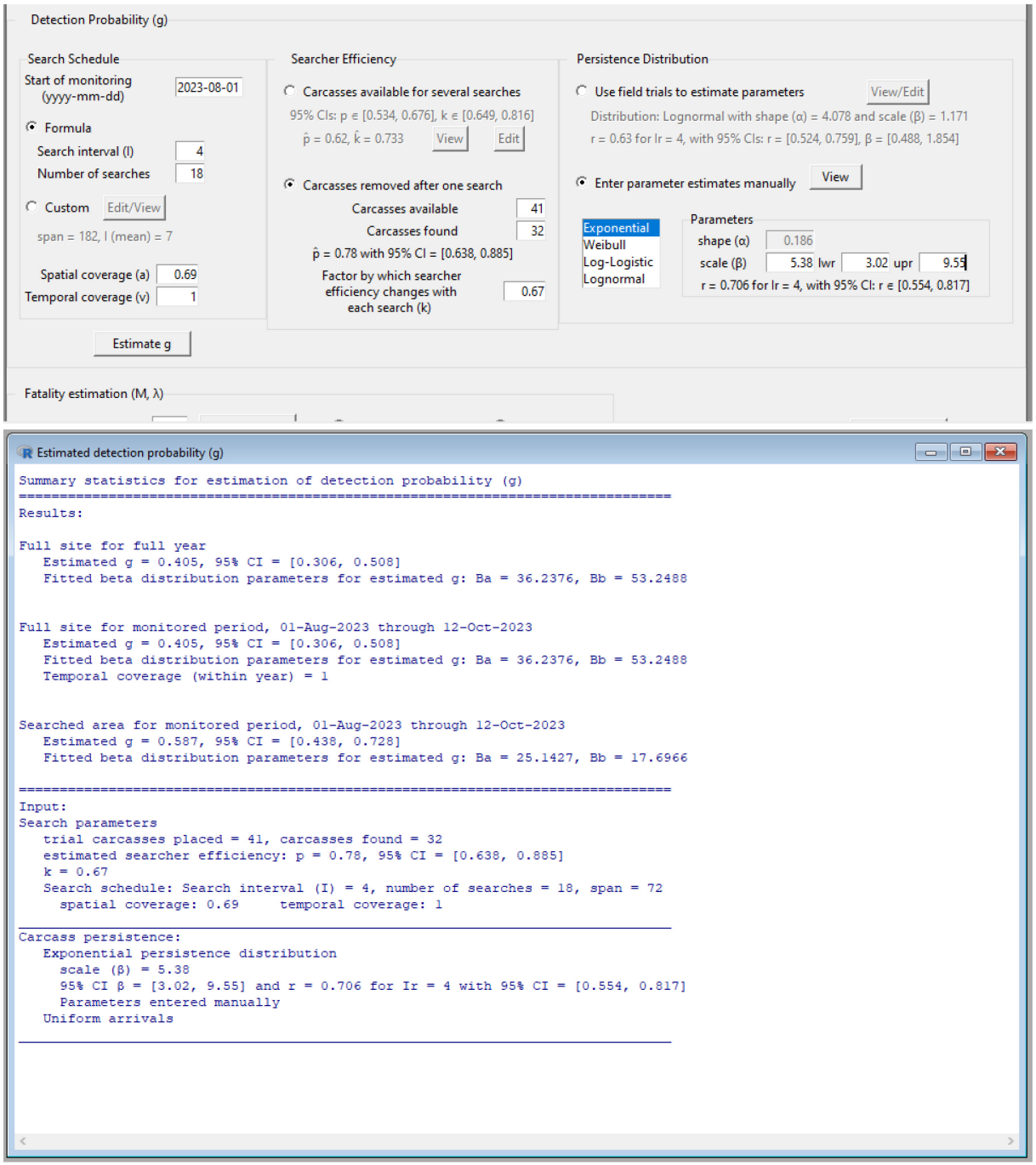


Appendix E4. Screen shot of Evidence of Absence (v2.0.7) graphical user interface, Single Class Module inputs for Fall 2022, 100-meter road and pad searches at 56 turbines searched at a 4-day interval.

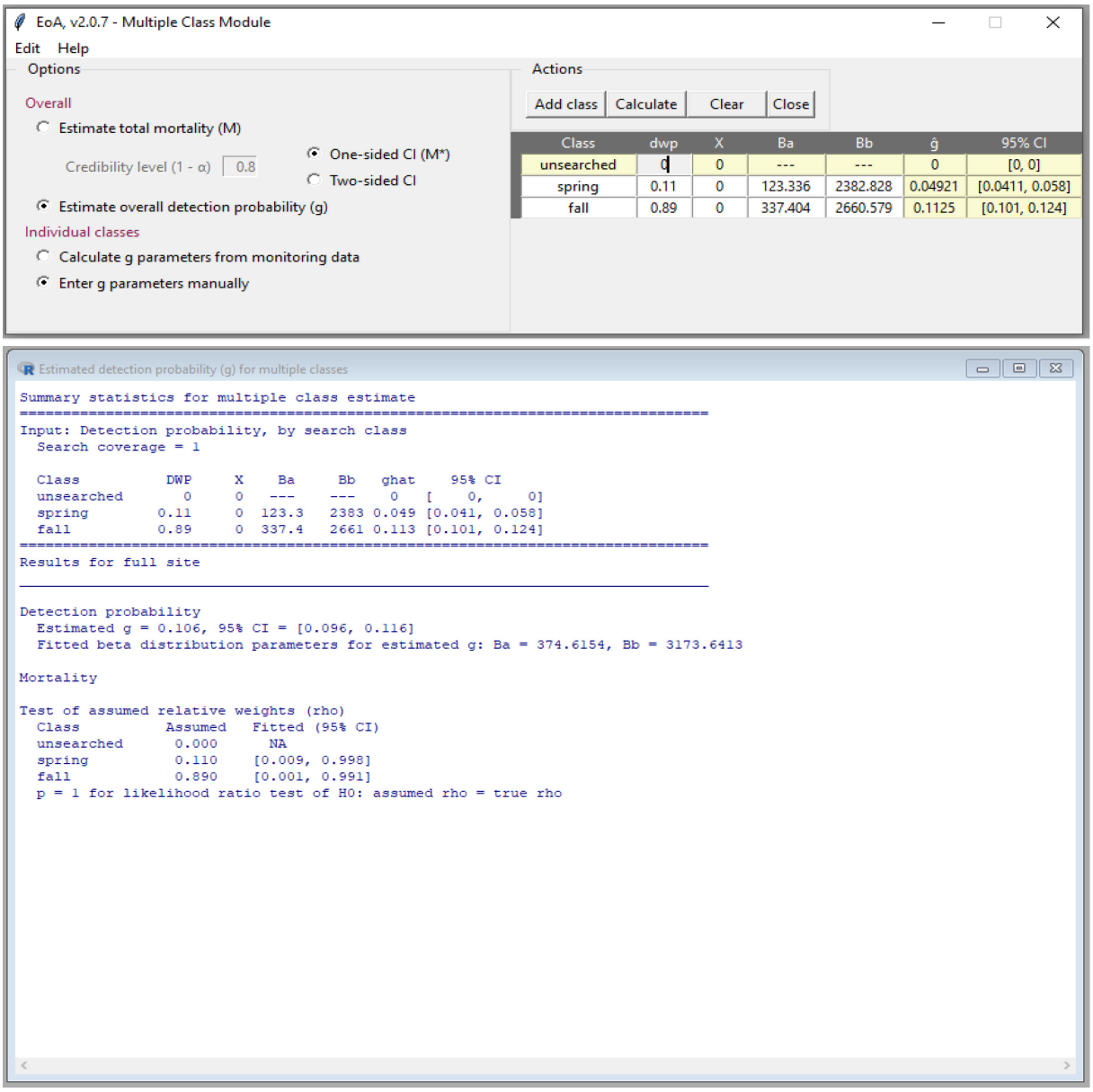




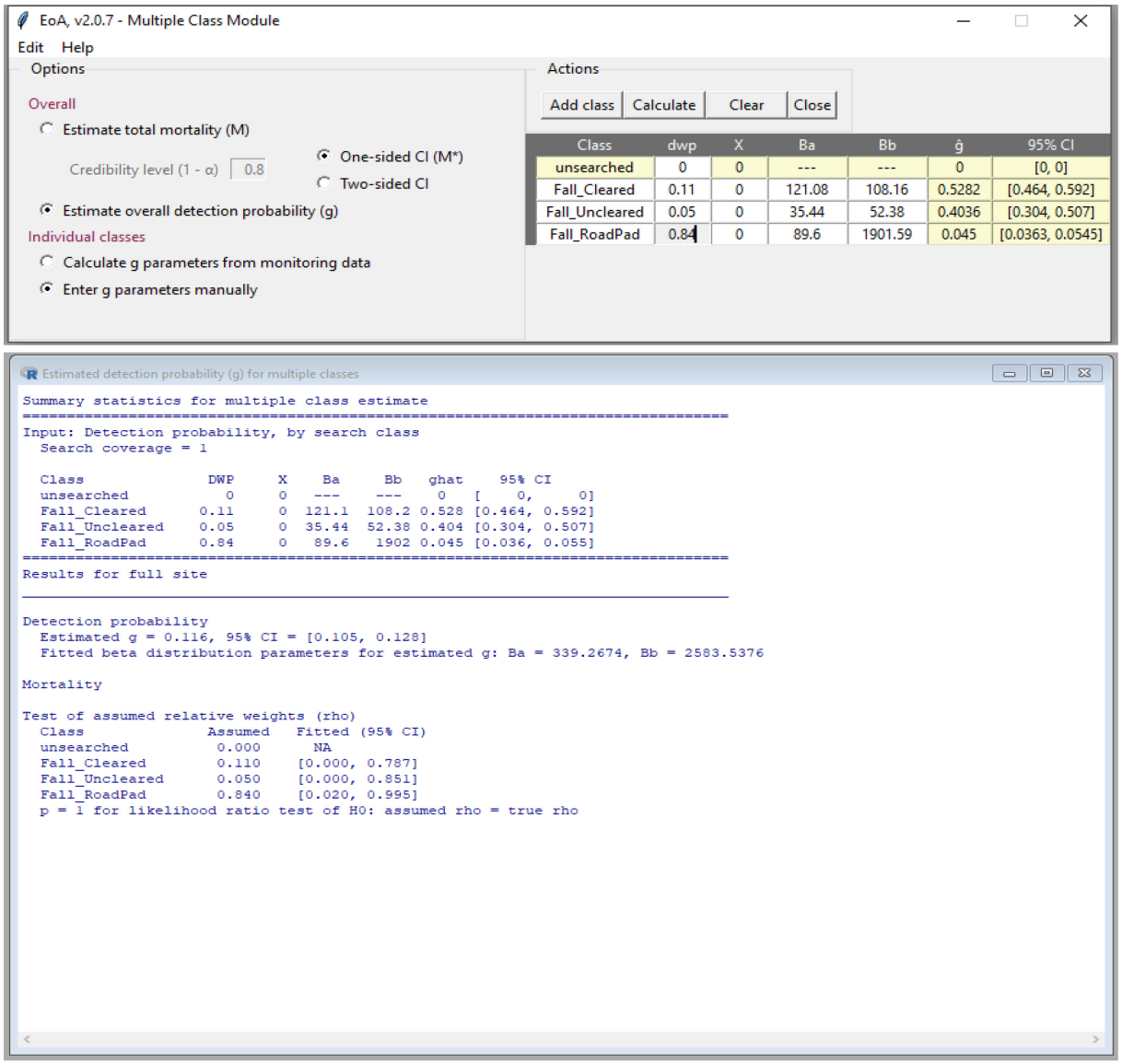
Appendix E5. Screen shot of Evidence of Absence (v2.0.7) graphical user interface, Single Class Module inputs for Fall 2023, 70-meter cleared plot searches at seven turbines searched at a 4-day interval.



Appendix E6. Screen shot of Evidence of Absence (v2.0.7) graphical user interface, Single Class Module inputs for Fall 2023, 70-meter uncleared plot searches at three turbines searched at a 4-day interval.



Appendix E7. Screen shot of Evidence of Absence (v2.0.7) graphical user interface, Multiple Class Module inputs for all plot types 2023, (n = 66), searched at a 7-day interval for 100-meter roads and pads in spring, and a 4-day interval for 100-m road and pads and all 70-meter plot types in fall.



Appendix E8. Screen shot of Evidence of Absence (v2.0.7) graphical user interface, Multiple Class Module inputs for seasonal detection probabilities 2023, (n = 66) searched at a 4-day interval in the fall for 100-meter roads and pads and for all 70-meter plot types.