Stantec

Post-Construction Monitoring Report Year 2, Antrim Wind Project, 2021

Antrim, New Hampshire

January 28, 2022

Prepared for:

Antrim Wind Energy, LLC
TransAlta Corporation
155 Fleet Street
Portsmouth, NH 03801

Prepared by:

Stantec Consulting Services Inc.
30 Park Drive
Topsham, ME 04086

Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Executive Summary

The Antrim Wind Project (Project) is a 9-turbine 28.8-megawatt (MW) facility located in the town of Antrim in Hillsborough County, New Hampshire. The Project is owned by Antrim Wind Energy, LLC (AWE), a subsidiary of TransAlta Corporation (TransAlta). The project consists of nine 3.2-MW Siemens SWT-3.2-113 wind turbines. Eight turbines are on 92.5-meter (m) towers and one turbine is on a 79.5-m tower. The Project's Commercial Operation Date was December 24, 2019. A Bird and Bat Post-Construction Monitoring Study Plan was designed to address the objectives of the Project's Bird and Bat Conservation Strategy (BBCS), the New Hampshire Site Evaluation Committee conditions, and the Project's memorandum of understanding between New Hampshire Audubon (NHA) and the New Hampshire Fish and Game Department (NHFGD). Methods were also developed in consultation with NHFGD, NHA, and the U.S. Fish and Wildlife Service (USFWS). TransAlta contracted Stantec Consulting Services Inc. (Stantec) to conduct post-construction bird and bat fatality surveys during the first three years of operation at the Project. Bird and bat fatality surveys conducted in 2021 (Year 2 of operation) represent the second year of required studies. In addition to post-construction monitoring of bird and bat fatalities, a second year of common nighthawk (*Chordeiles minor*) surveys were conducted following NHA protocols.

Stantec conducted fatality searches from April 15 to October 15, 2021. Weather and site maintenance activities permitting, all nine turbines were searched once every five days. During the 2021 study period, 333 of 333 (100%) scheduled searches were completed. Thirteen carcasses were found: five birds and eight bats. Four bird species were found, all belonging to the passerine (*Passeriformes*) subgroup. Four bat species were found, including two long-distance migratory species and two cave-hibernating species. One *Myotis* species was found: the state-endangered little brown bat (*Myotis lucifugus*; n=2).

Fatality data, searcher efficiency data, and carcass persistence data were used to estimate bird and bat fatality rates (with a correction factor for area searched) in 2021 using the Huso fatality estimator. Searcher efficiency for birds and bats was 56% and 64%, respectively, and carcass persistence for birds and bats was 10.73 days and 7.37 days, respectively. Based on the Huso estimator, estimates of bird fatalities were 1.72 birds per turbine per year. The estimates of fatality for bats were 2.60 bats per turbine per year. Estimates of bird and bat fatality by rated power were 0.54 birds per MW per year and 0.81 bats per MW per year.

The 2021 bird fatality estimate at the Project is lower than other wind facilities in New Hampshire: Lempster (5.95 birds/turbine/year in fall of 2009 and 4.12 birds/turbine/year in fall of 2010) and Granite Reliable (2.0–2.8 birds/turbine/year in 2012). The Project's bat fatality estimate is equal to or lower than the three other New Hampshire wind facilities. Bat fatality estimates ranged from 2.60 (Granite Reliable, 2012) to 7.13 (Lempster, 2010) bats per turbine per year. It is important to note that the other New Hampshire wind projects did not implement a curtailment program, so the Project's bat fatality estimate cannot be directly compared to the results from other New Hampshire wind facilities.

In 2021, proposed operational curtailment measures were applied to all Project turbines from June 1 to September 30, 2021, as part of the continued program to reduce potential impacts to bats. The process of

monitoring, evaluating options, consulting with agencies, and implementing revised curtailment operations for the Project is detailed in the BBCS and reflective of efforts to work collaboratively with regulatory agencies. AWE applied curtailment operations from 30 minutes after sunset until sunrise, when wind speeds were less than 4.0 m/s. The decision to curtail turbines in 2021 during this period was based on the curtailment study conducted during Year 1 (2020) at the Project, which showed a significant decrease in bat fatalities at curtailed turbines. Following discussions with NHFGD and USFWS in spring 2021, the Project agreed to lengthen the curtailment season to October 15 (compared to ending on September 30 in 2020) using the cut-in speed of 4.0 m/s for *all* turbines. For comparison, in 2020, curtailment was applied to five turbines from July 15–September 30 below a cut-in wind speed of 5.0 m/s. The other four turbines were allowed to operate under normal manufacturer's specifications. After a documented *Myotis* fatality in late September at Turbine 1, a more conservative cut-in speed of 5.0 m/s was applied specifically to Turbine 1 from October 1 to October 15.

In 2021, turbines were curtailed effectively (minimum 10-minute turbine rotor speed below 1 rpm) during 80.5% of 13,317 10-minute periods in which curtailment conditions were met. Unfortunately, turbine curtailment was not implemented as designed from October 1 to October 15, 2021, due to a curtailment control error. Excluding the October 1–15 period, turbines were effectively curtailed during 10,186 of 10,643 (95.7%) 10-minute periods meeting curtailment conditions indicating that curtailment performed as designed from June 1 to September 30. Based on the 2021 estimated bat fatality rates, curtailment was effective at maintaining a low bat fatality rate at the Project.

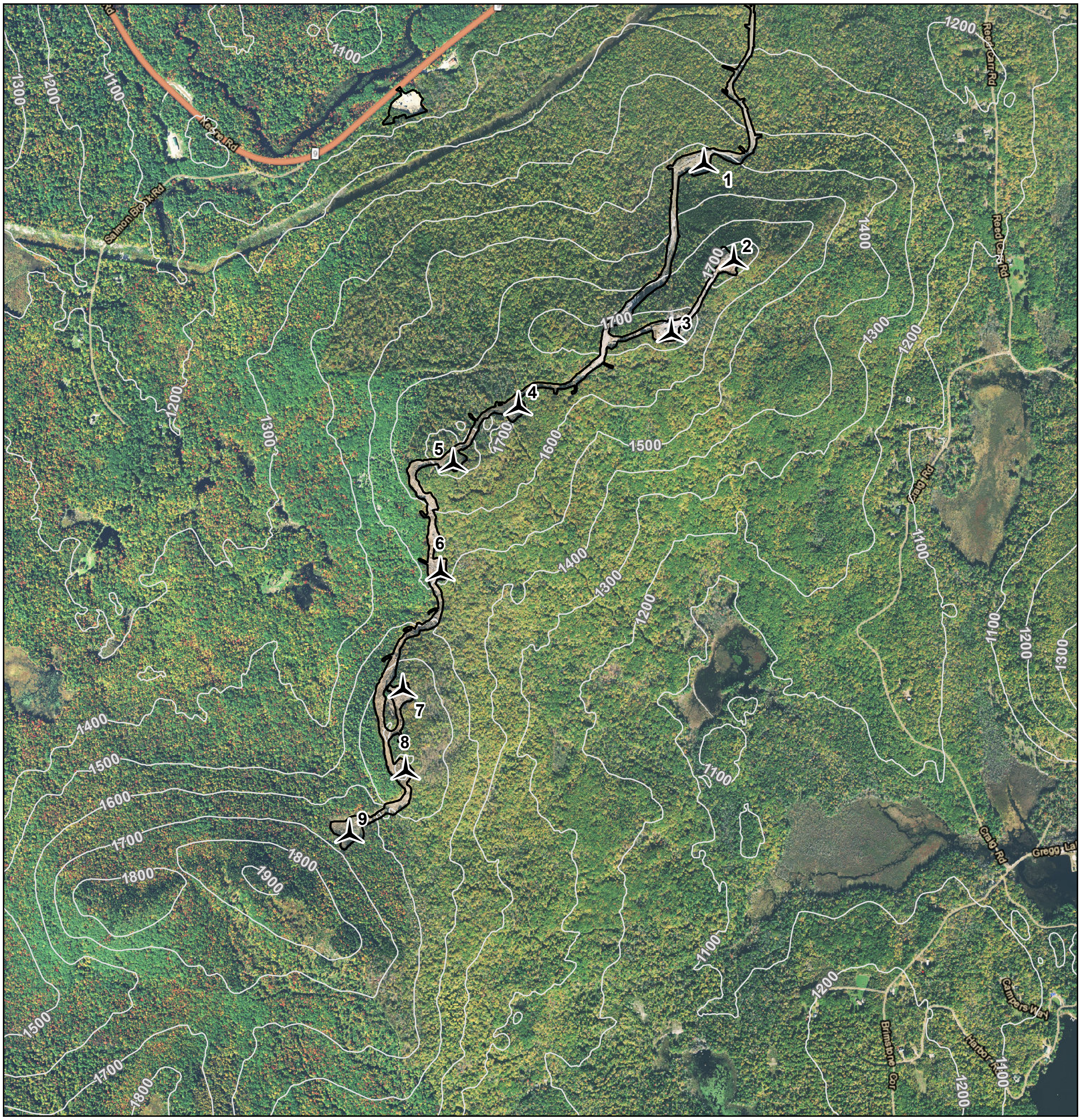
Fatality estimates for bird and bats from 2021 compared to 2020 were lower. In 2021, the fatality estimate for birds was 1.72 fatalities per turbine per year compared to 3.65 fatalities per turbine per year in 2020. In 2021, the fatality estimate for bats was 2.60 fatalities per turbine per year compared to 5.21 fatalities per turbine per year at the five experimental (curtailed) turbines in 2020 and 14.07 fatalities per turbine per year at the four control (non-curtailed) turbines in 2020. The searcher efficiency rate for birds improved from 46% in 2020 to 56% in 2021. The searcher efficiency rate for bats was similar between years: 65% in 2020 and 64% in 2021. Carcass persistence rates for birds and bats in 2021 (10.73 days for birds and 7.37 days for bats) were lower than 2020 (16.95 days for birds and 10.46 days for bats).

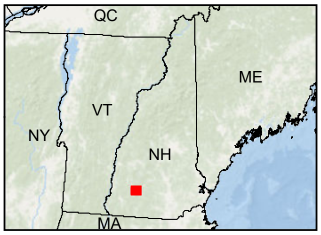
Common nighthawk (*Chordeiles minor*) surveys were conducted on three separate occasions at the Project during the summer months of June and July. Surveys covered all nine turbines and were focused on visually scanning open areas either near or between turbines or listening for individual birds. Surveys covered the crepuscular period when common nighthawk activity/detectability is greatest; occurring from 8:00 pm to 9:30 pm and 3:30 am to 5:00 am, when temperatures were above 65°F, wind speeds were below 10 miles per hour, and there was no rain. Over the course of 18 hours of surveys, common nighthawks were not seen or heard.

1.0 INTRODUCTION

1.1 PROJECT DESCRIPTION

TransAlta Corporation (TransAlta), through its subsidiary Antrim Wind Energy, LLC (AWE), has developed the Antrim Wind Project (Project) located in the town of Antrim in Hillsborough County, New Hampshire (Figure 1-1). The project consists of nine 3.2-Megawatt (MW) Siemens SWT-3.2-113 wind turbines with a wind generating capacity of 28.8 MW. Eight turbines (#1 through #8) are on 92.5-meter (m) towers and one turbine (#9) is on a 79.5-m tower. The Project's Commercial Operation Date (COD) was December 24, 2019.





Notes
1. Coordinate System: NAD 1983 UTM Zone 19N
2. Data Sources: Stantec, Antrim, USGS
3. Background: NAIP 2018 Orthophoto; ESRI World Transportation web mapping service.

Legend

Turbine Location

Limit of Disturbance

100-ft Contours

0 2,000 Feet

(At original document size of 8.5x11)
1:24,000

N

Stantec

Project Location Antrim, New Hampshire	Prepared by HT on 2020-11-06 TR Review by KWH on 2020-11-09 IR Review by AP on 2020-XX-XX
Client/Project TransAlta Corporation Antrim Wind Project	195601919

Figure No.
1-1

Title
Project Layout

V:\1956\active\195601919\03_data\gis_cad\GIS\mxd\PCM\01919_ProjectLayout.mxd Revised: 2020-11-09 By: hturner

1.2 POST-CONSTRUCTION MONITORING BACKGROUND AND OBJECTIVES

TransAlta has contracted Stantec Consulting Services Inc. (Stantec) to conduct post-construction bird and bat monitoring surveys during the first three years of operation at the Project (2020, 2021, and 2022). Survey methods were designed to address the objectives of the Project's Bird and Bat Conservation Strategy (BBCS), conditions of the New Hampshire Site Evaluation Committee order and certificate of site and facility, and the Project's memorandum of understanding (MOU) between New Hampshire Audubon (NHA) and the New Hampshire Fish and Game Department (NHFGD). Methods were also developed in consultation with NHFGD, U.S. Fish and Wildlife Service (USFWS), and NHA. The Antrim Wind Energy Bird and Bat Post-Construction Monitoring Study Plan (Study Plan) was first submitted for review on March 26, 2020. Additional discussions on revisions to the Study Plan occurred with agencies on April 7, 2020 and April 24, 2020. In addition, NH Audubon and Stantec participated in a field visit at the Project site on May 20, 2020 to finalize the survey methodology for common nighthawks. A final Study Plan was submitted on June 3, 2020, which integrated comments related to common nighthawk surveys (required to occur in June and July) and was approved on June 10, 2020.

As specified in the BBCS, the objectives of the Project's 'evaluation phase' (first three years following COD) post-construction bird and bat monitoring are to:

- Establish baseline (Years 1, 2, and 3) fatality rates for birds and bats at the Project;
- Help establish suitable thresholds of fatality that will inform the adaptive management process;
- Correlate bat activity levels measured at rotor height to corresponding bat fatality levels; and
- Assess the effectiveness of optimized cut-in speeds (curtailment) at reducing bat fatality.

Progress was made to achieve these objectives by following and completing the components outlined in the Study Plan during 2021 (Stantec 2020). The components of the Study Plan are explained in further detail in the Methods section of this report. As part of this 'evaluation phase' for the Project, results from Year 1 monitoring were evaluated and used to propose a revised curtailment strategy for Year 2. Consistent with the BBCS and an adaptive approach to managing bird and bat risk, the revised curtailment strategy was discussed, and ultimately approved, with NHFGD, USFWS, and NHA in spring 2021. A similar effort, and further evolution of curtailment operations if required, is expected to occur during the preparation for Year 3 (2022) monitoring activities.

2.0 METHODS

2.1 FATALITY SEARCHES

Surveys occurred between April 15 to October 15, 2021, to cover the peak wildlife activity periods of the following groups:

- Bat species, including long-distance migratory bats;
- Nocturnally migrating birds and breeding birds, including common nighthawks (*Chordeiles minor*);
- Diurnally migrating raptors, and;
- Bald eagles (*Haliaeetus leucocephalus*) and golden eagles (*Aquila chrysaetos*)

Stantec conducted fatality searches at all nine turbines once every five days (a 5-day search interval). Turbines T06 through T09 were searched one day and turbines T01 through T05 were searched the following day. Searches were not conducted during unsafe conditions such as lightning, icing on blades, or turbine maintenance activities. Search areas aimed to cover a 60-m radius from turbines, which is consistent with search areas utilized on forested ridgeline topographies in New England, as well as at other New Hampshire wind projects. The search areas included turbine pads and portions of the access roads (Appendix B). The search area at each turbine was variable in terms of ground conditions and amount of cleared forested area. Some areas were not searched due to unsafe conditions for the surveyor (e.g., steep slopes or hazardous walking conditions), forested areas, or areas with thick and tall brush. Transects were spaced approximately 5m apart and generally oriented following the cardinal directions (e.g., north-south or west-east). Transects were marked with flagging on rocks, rock piles, trees, or stakes, and numbered to ensure easy navigation and consistent searches of the search area.

Searches took place between sunrise and up to eight hours after sunrise. The turbine search order was randomized so that the turbines were not searched at the same time of day on consecutive search days throughout the survey period. During searches, the surveyor walked slowly along each transect and scanned the ground for bird and bat fatalities. Fatalities (intact bird or bat carcasses, or scavenged carcasses such as a cluster of feathers representing more than a molt, or a patch of skin and bone) found along or between transects were marked and then documented after the turbine search was completed. Fatalities found outside of standardized search times, or outside of defined search areas, were considered incidental and documented as such.

For each carcass found, including incidental carcasses, multiple pictures were taken of distinguishing features as well as the location it was found in the field and in relation to the turbine. The following information was recorded on standardized data sheets or entered into the ArcGIS Survey123™ app[1] for each carcass:

- Date and time discovered

[1] https://www.esri.com/en-us/arcgis/products/arcgis-survey123/overview

- Surveyor
- If the carcass was found during a search or incidentally
- Turbine number
- Distance of carcass from turbine (determined with a laser range finder)
- Carcass azimuth (compass direction) from turbine and a global positioning system (GPS) location
- Ground condition where carcass was found (vegetation type and vegetation visibility class)
- Carcass identification (species, age, and sex) and body position when found
- Carcass condition (fatality or live, fresh or stage of decomposition, and intact or scavenged)
- Evidence of scavenger activity
- Additional notes as necessary

Each carcass was collected in a re-sealable plastic bag, labeled with a unique carcass identification number, and stored in a freezer kept at the Project's operations and maintenance building in accordance with the NHFGD Scientific License and USFWS Special Purpose Utility Permit (#MB74664D). Stantec's project manager confirmed species identification of carcasses that were collected by the surveyor through pictures and email. If a listed species (state or federal) was found, Stantec notified AWE immediately with relevant information and followed the Project's Immediate Alert Procedure (IAP). The IAP required notification of a biologically significant event (defined below) to the NHFGD and USFWS within 48 hours of discovery. Defined in the BBCS, biologically significant events are:

- The individual injury or death of a federally or state-listed bird (including common nighthawks per MOU conditions) or bat species, or an eagle; or
- Large scale mortality events (i.e., 20 or more carcasses of birds and/or bats found across the Project area in one search day, and all are assumed to have collided on the same night).

Weather information was observed and recorded prior to each turbine search. On nights prior to scheduled searches, the surveyor recorded cloud type, percent cloud cover, ceiling height, and moon phase from a nearby location.

2.2 VEGETATION MAPPING

Ground cover types within search area plots were recorded during each turbine search. The ground cover components recorded were vegetation type, visibility class, and vegetation height. The visibility class was determined using the descriptions in Table 2-1. Ground cover was observed throughout the survey period, and changes in dominant vegetation type, visibility class, or height were recorded on data sheets. A GPS was used through the ArcGIS Collector™ app[2] once during the 2021 survey period to map the ground cover types at each turbine at the height of the growing season. The mapped search area plots are provided in Appendix B.

[2] https://www.esri.com/en-us/arcgis/products/arcgis-collector/overview

Table 2-1. Ground Cover Visibility Class Descriptions.

Visibility Class	% Vegetation Cover	Vegetation Height
1 (easy)	> 90% bare ground	< 6 inches
2 (moderate)	> 25% bare ground	< 6 inches
3 (difficult)	< 25% bare ground	< 25% of cover > 12 inches in height
4 (very difficult)	< 5% bare ground	> 75% of cover > 12 inches in height

2.3 SEARCHER EFFICIENCY TRIALS

Searcher efficiency trials were conducted throughout the survey period to quantify searcher efficiency (i.e., a searcher's ability to find a fatality) rates of birds and bats. Trials targeted the total placement of 25 bird and 25 bat carcasses over the entire monitoring period. Trials were conducted multiple times during the survey period to reach the target number of carcasses, and they took place during three different seasons (spring, summer, and fall) to cover varying ground cover types and vegetative heights during the growing season. The same trial carcasses were re-used throughout the study period until they became too decomposed. Due to the limited number of native carcasses found onsite, mice and quail were obtained from a feed supply lab and used in place of birds and bats as needed.

On the day of scheduled trials, Stantec's project manager placed carcasses prior to sunrise at turbines that were scheduled to be searched that day. The surveyor being tested was unaware of trial dates and carcass locations. Carcasses were discretely marked with string or twine so they could be identified as trial carcasses upon inspection. They were placed at random distances and azimuths from the turbines and across different ground cover types. The project manager recorded the following information after placing each carcass:

- Date, time of set up, and surveyor being tested
- Turbine number
- Species
- Carcass identification number if the carcass being used was found onsite
- Carcass distance and direction from turbine, and GPS location
- Vegetation type and visibility class where carcass was placed

Trial carcasses found by the surveyor were documented, and the surveyor notified the project manager of the number of carcasses found after all searches were completed. The project manager picked up carcasses that were not found, if any, by the surveyor once searches were completed and noted the number of carcasses found and not found, as well as if carcasses had been scavenged during the trial.

2.4 CARCASS PERSISTENCE TRIALS

Carcass persistence trials were conducted to estimate the carcass persistence rate, or the average length of time carcasses remained in the search area before being removed by scavengers or weather. The study targeted the placement of 25 bird carcasses and 25 bat carcasses throughout the survey period, and trials took place during the spring, summer, and fall to account for seasonal changes in scavenger activities. Due to the limited number of native carcasses found onsite, mice and quail obtained from a feed supply lab were used in place of birds and bats as needed.

Trial carcasses were randomly placed at multiple turbines throughout the search areas. Only fresh carcasses, or carcasses in ‘excellent’ or ‘good’ conditioned were used. Trial carcasses were checked for the first seven days after they were placed, and then on day 10 and day 14. The trials ended after day 14. On each day that a trial carcass was checked, the surveyor or project manager indicated whether the carcass was present (intact, or partially scavenged but easily detectable) or absent (completely removed, or with so few feathers or tissue that it was not easily detectable). The following information was also recorded on standardized datasheets for each trial carcass:

- Date, time of set up, and trial coordinator/surveyor
- Turbine number
- Species
- Carcass identification number if the carcass being used was found onsite
- Carcass distance and direction from turbine, and/or GPS location
- Vegetation type, visibility class, and vegetation height where carcass was placed
- Detailed notes describing scavenging, evidence of scavenger, and stage of decomposition

After the end of the 14-day trial period, trial carcasses were collected and buried in the woods onsite.

2.5 CURTAILMENT EVALUATION STUDY

The objectives of the curtailment evaluation study during Year 1 (2020) were to investigate the level of reduction of bat mortality from the experimental operational controls applied during the study and investigate an appropriate operational control program to balance the Project’s financial viability while minimizing bat mortality at the Project. Between 2020 and 2021, a curtailment program was designed by Stantec based on results from the Year 1 and agreed upon by AWE. In spring 2021, the proposed curtailment program was presented to the NHFGD, USFWS, and NHA for review and discussion prior to implementation during the 2021 season.

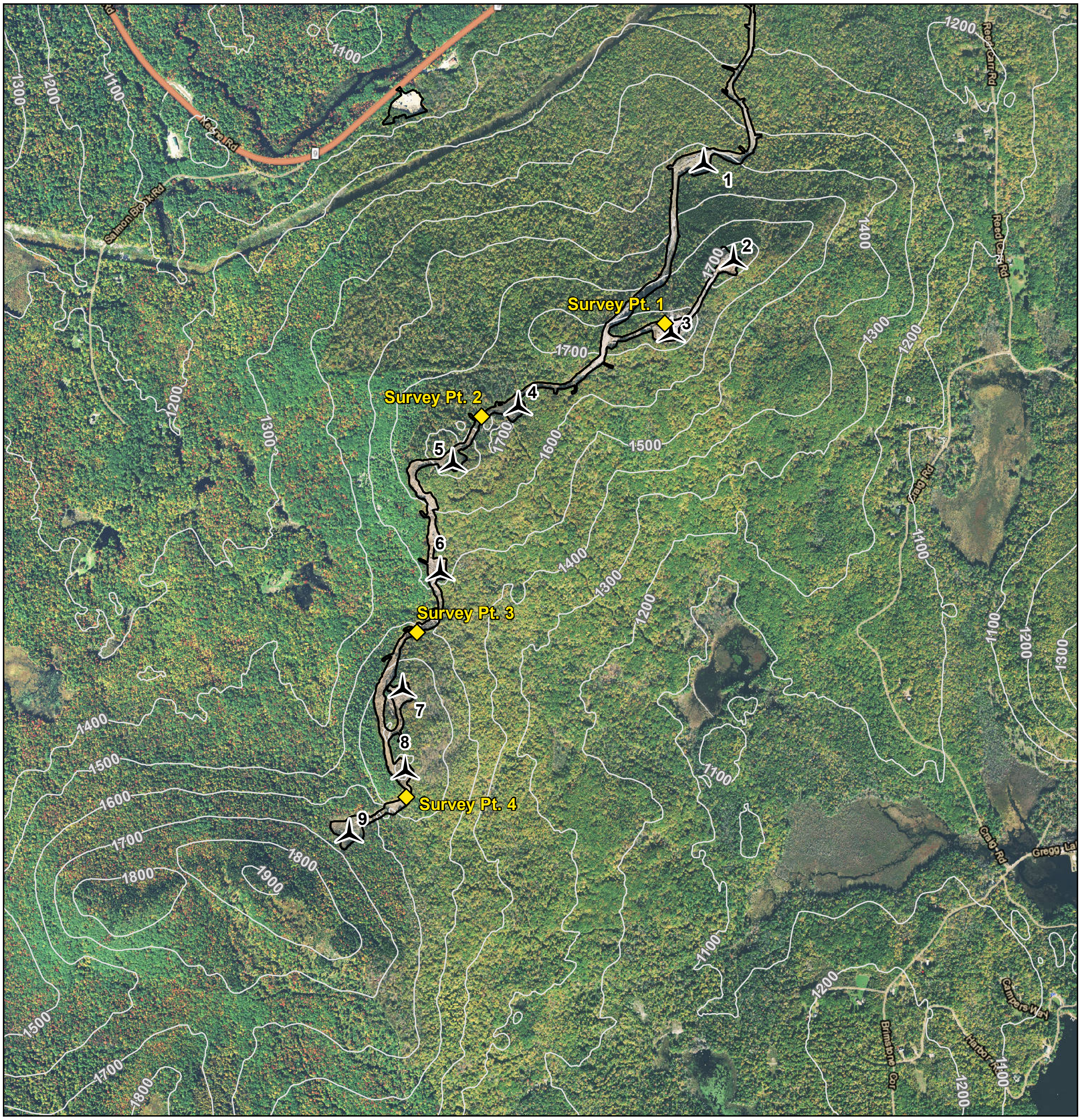
During the 2021 survey period, all turbines operated under a curtailment program designed to reduce impacts to bats. As originally proposed, AWE recommended curtailment operations between June 1 and September 30, from 30 minutes after sunset until sunrise, when wind speeds were less than 4.0 m/s and average nightly temperatures were above 50F. Following spring 2021 discussions with NHFGD and USFWS, the 4.0 m/s cut-in speed was extended through October 15 for all turbines with an agreement to notify the agencies of all bat fatalities biweekly. Additionally, fatality of any listed bat species would result in discussion with agencies on the need for further curtailment. On September 28, 2021, the fatality of a state-listed little brown bat occurred at Turbine 1. In response, the Project increased the cut-in speed for this turbine to 5.0 m/s through October 15, which was supported by the agencies.

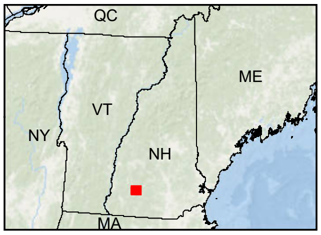
Wind speed measurements recorded at the nacelle of each turbine were used to trigger curtailment, with wind speed and turbine rotor speed (rotations per minute [rpm]) data recorded at 10-minute intervals (min, mean, and max). Time-stamped mean wind speed measurements recorded at each turbine were used to categorize each 10-minute period as meeting or not meeting curtailment conditions, and categorized periods as curtailed if conditions were met and minimum turbine rpm was less than one. Curtailment performance was evaluated as the percent of 10-minute periods meeting conditions in which minimum rpm (based on 10-minute data) was less than one. It is important to note that curtailment response is not instantaneous as turbine blades have a "lag" period as they slow down RPMs. This is required to reduce the potential for turbine damage from abrupt stops and starts.

2.6 COMMON NIGHTHAWK SURVEYS

Stantec conducted common nighthawk surveys in 2021 per the New Hampshire Site Evaluation Committee conditions and the MOU with NHA. Consistent with the Year 1 survey methods, each survey was conducted over three consecutive days, usually on the days of scheduled fatality searches. A total of three common nighthawk surveys were conducted throughout the survey period, with one survey conducted during each of the following three periods: June 1–15, June 18–July 6, and July 10–25. These periods, per NHA protocol, covered all aspects of the common nighthawk breeding period. Courtship behavior from males is detectable in early June, and this is also when nests are established. Surveys in mid-June cover the incubation period and when females are on nests. Surveys in mid- to late July cover hatching and fledging of the young. Surveys did not occur less than 14 days apart and took place during crepuscular periods between the hours of 3:30 am and 5:00 am and 8:00 pm and 9:30 pm when nighthawks are known to be most active. Surveys were only conducted when temperatures were above 65°F, wind speeds were 10 miles per hour (mph) or less, and there was no rain.

Four survey points were scouted and previously approved by the NHA in May 2020. The four survey points (Figure 2-2) covered enough area to be able to detect potential nighthawks at all nine turbines. The breakdown of the turbines covered by each point is listed in Table 2-2. Generally, surveys were conducted the night before the first scheduled fatality search, the morning of the first fatality search, the night of the first fatality search, and the morning of the second fatality search.





Legend

- Common Nighthawk Survey Point
- Turbines Location
- Limit of Disturbance
- 100-ft Contours

0 2,000 Feet

(At original document size of 8.5x11)
1:24,000

N

Notes

1. Coordinate System: NAD 1983 UTM Zone 19N
2. Data Sources: Stantec, Antrim, USGS
3. Background: NAIP 2018 Orthophoto; ESRI World Transportation web mapping service.

Stantec

Project Location
Antrim,
New Hampshire

Prepared by GC on 2020-06-02
Reviewed by AP on 2020-06-02

Client/Project
TransAlta Corporation
Antrim Wind Project

195601919

Figure No.
2-1

Title
Common Nighthawk Survey Points

V:\1956\active\195601919\03_data\gis_cad\GIS\mxd\AvianBat\01919_03_NighthawkWorkplan.mxd Revised: 2020-06-03 By: gcarpentier

Table 2-2. Turbines Observed at Each Common Nighthawk Survey Point.

Survey Point	Turbines Observed
1	T01, T02, and T03
2	T04 and T05
3	T06 and T07
4	T08 and T09

Surveys consisted of 90-minute stationary surveys in which the surveyor watched the designated turbines for common nighthawk displays or calls. If a common nighthawk was seen or heard, the surveyor:

1. Documented the location that the common nighthawk was seen or heard;
2. Notified NHFGD within 48 hours;
3. Conducted three searches within one week of the initial observation to attempt to locate the common nighthawk nest; and
4. Worked with AWE to implement curtailment of the turbine closest to the nest.

2.7 STATISTICAL ANALYSIS

2.7.1 Temporal Distribution

The seasonal timing of bird and bat fatalities was summarized in both tabular and graphical form and is provided in section 3.1.2.

2.7.2 Spatial Distribution

The range of distances that birds and bats were found from the turbines, the average distances birds and bats were found from the turbines, and the distribution of fatalities at the turbines were summarized. Distances and azimuths of carcasses from turbines are plotted on a scatterplot diagram (Figure 3-3) within 10-m concentric distance increments.

2.7.3 Bird and Bat Fatality Estimates

The Huso estimator, developed in 2010 (and updated in 2012) is one of the leading methods for developing fatality rates in the United States (U.S.) and is available in a U.S. Geological Survey software application. This estimator has been developed and thoroughly tested with simulated data by leading statisticians and is geared specifically for estimating fatalities at wind turbines. The model is suitable for fatality studies because it is stochastic, meaning it can generate estimates of probability distributions of potential results by allowing for random variation in one or more model inputs over a period of time. As such, the Huso estimator was used to estimate fatality at the Project for 2020 and 2021. Only carcasses found during standardized turbine searches were included in estimates of fatality due to bias that may be introduced into the model by carcasses found incidentally. A detailed description of the software is available in Huso 2010 and Huso et al. 2012. The software, available at http://pubs.usgs.gov/ds/729/, was run with the statistical program R (R Core 2016).

The Huso estimator assumes carcass equilibrium between search intervals, where all carcasses are either found by searchers or scavenged prior to the next search. The estimator assumes a zero probability of searchers observing a carcass on a subsequent search if it was missed on the first search. However, field data indicate that some carcasses do persist on the ground for longer than a single interval and that searchers find some of these carcasses. To account for this bias in the model, Huso recommends that only those carcasses that died since the previous search (based on stage of decomposition) be input into the model. Otherwise, the software could overestimate fatality rates because the proportion of older carcasses are separately accounted for in the measurement of searcher efficiency (i.e., if searcher efficiency is determined to be 50% then there is a 50% probability of a carcass being missed on the first search). Therefore, only those carcasses believed to have died since the last search at a turbine were input into the model for this analysis. However, if the age of the carcass was unknown (e.g., only feathers present or too few remains to determine age), the carcass was assumed to have died within the last search interval and included in the model.

The formula for Huso's model is available in Bernardino et al. 2013:

$$\hat{M} = \frac{1}{\pi} \frac{C}{p\left[\frac{\bar{t}(1-e^{-i/\bar{t}})}{d}\right]v}$$

- $\hat{M}$ is the estimated dead animal population size (including variance parameters).
- C is the actual (unadjusted) number of dead animals found.
- π is defined as the product of the proportion of actual fatalities contained in the searchable area of the plot, and the probability of including that plot in the sample.
- p is the average probability that the carcass is detected by the searchers.
- $\bar{t}$ is the mean carcass persistence time.
- d = min(i, $\tilde{\iota}$), with $\tilde{\iota}$ representing the length of time beyond which a the probability of a carcass persisting is ≤ 1% (i.e., $\tilde{\iota}$ is such that P[T > $\tilde{\iota}$] ≤ 0.01.
- $\tilde{\iota}$ can be estimated as $\tilde{\iota}$ = -log(0.01)x$\bar{t}$ (based on exponential distribution [e]).
- v is the effective search interval, where v = min (1, $\tilde{\iota}$ /i) with i representing the interval between searches (i is measured in days).

Because turbine towers were not centered within turbine clearings at the Project, and carcasses may have landed over forested areas, the empirical distribution of bird and bat carcass distances was determined to apply a density-weighted proportion (DWP) area searched value in the model (the value for π). Area corrections were based on methods proposed by Korner-Nievergelt et al. 2015 and Huso and Dalthorp 2014. The proportion of the total birds and bats found during searches was determined per 10-m concentric distance increment radiating out from tower bases. The proportion of the area that was searchable (i.e., not cut off by forest edge) within each of these distance bands was determined. The percent area searched per distance band was multiplied by the proportion of bat and bird carcasses found within each distance band to find a DWP value per distance band. The DWP value for each band was summed to find a value for each turbine for birds and for bats. Turbine-specific DWP values were input into the model to adjust the number of carcasses by the proportion of carcasses found within the proportion of the plots that was searchable. This DWP analysis provides a per-turbine adjustment for the total number of bird and bat carcasses that would have been found out to 120 m (the maximum distance searched from towers along turbine access roads or pad), had that entire area at each plot been available to be searched. It should be noted that a small sample size of carcasses found does not allow for a robust estimate of DWP.

For the Huso estimator to calculate estimates of fatality for birds and bats separately, a sample size of at least 10 bird and 10 bat carcasses for both the searcher efficiency and carcass persistence trials is required. The results of searcher efficiency trials were input into the model as 1 (if trial carcass was found) and 0 (if trial carcass was not found). These values are distributed as binary random variables within the model, with 'Found' indicated by the highest numeric value. A generalized linear model of the binary response is fit to the data, with a modeled response of loge (odds of observing a carcass = loge (p/1-p)).

The results of carcass persistence trials were input into the model based on the following trial outcomes:

- Carcass gone at first check on 'Day 1' of trial, left censoring = 2
- Carcass still present (visible) on last day of trial, right censoring = 0
- Carcass was removed between checks, interval censoring = 3

Carcass persistence times are modeled with a log-linear parametric accelerated failure time model and are assumed to follow a probability distribution. When persistence time is not known or is censored, the model is appropriately modified. Each time the model is run, one of the following distributions of carcass persistence must be selected by the user for the model: Exponential, Loglogistic, Lognormal, or Weibull. Huso recommends running trials of the dataset with each distribution to compare values of Akaike information criterion (AIC), the measure of the relative goodness of fit of the model, where *k* is the number of parameters in the statistical model, and *L* is the maximized value of the likelihood function for the estimated model.

$$AIC = 2k - \ln(L)$$

The preferred distribution for the model is the one with the minimum AIC value. For this analysis, carcass persistence was modeled using Loglogistic distribution for bats and Exponential distribution for birds.

Since detection bias, persistence bias, and proportion of carcasses within search areas are estimated, the Huso estimator uses a bootstrapped estimate of variance based on methods proposed by Erickson et al. 2004, where the fatality adjustment (π) and total fatality (M) are calculated for each bootstrapped sample. This analysis used 5,000 bootstrap resample iterations, as recommended by Huso et al. 2012. The alpha value was defined as 0.05; therefore, all confidence intervals were calculated at 95%.

2.7.4 Weather Conditions and Fatality Events

The following weather conditions for nights when fatalities were believed to have occurred (the nights prior to when ‘fresh’ carcasses were found) were summarized:

- Nightly mean wind speed (m/s);
- Nightly mean temperature (°C);
- Moon phase; and
- Sky conditions (precipitation events).

Nightly wind speed, temperature, and rotor rpm in 10-min increments for turbines were plotted for when fatalities were believed to have occurred.

2.7.5 Curtailment and Fatality Events

The objectives specified in the BBCS and previously listed in the Introduction of this report were addressed by preparing the following summaries:

- Determining if and when bat fatalities were documented during the curtailment period (June 1, 2021, through October 15, 2021);
- Summarizing operations data for the night prior to fresh carcass discovery from the specific turbine where a carcass was found;
- Summarizing the distribution of fatalities compared to the proportion of time turbines were curtailed, and;
- Comparing fatality at the Project to other regional wind projects.

3.0 RESULTS

3.1 FATALITY SEARCHES

3.1.1 Fatalities Discovered

A total of 13 fatalities were documented in 2021 (Appendix A Table 1). One of the 13 fatalities, a red-breasted nuthatch (*Sitta canadensis*; (Table 3-1)), was found incidentally (outside of the standard searches). Of the 13 fatalities, five were birds. Passerines represented 100% of the birds found and included four different species (Table 3-1).

The remaining eight fatalities were bats. Four species of bats were found. Silver-haired bats (*Lasionycteris noctivagans*; n=3) represented 37.5% of the bats found. The other species included big brown bats (*Eptesicus fuscus*; n=2), little brown bats (*Myotis lucifugus*; n=2) and a hoary bat (*Lasiurus cinereus*; n=1). The little brown bat is listed as an endangered species in New Hampshire. The Project's Immediate Alert Procedure, as described in the Study Plan, was followed for both *Myotis* carcasses found.

Table 3-1. Total Number and Species Composition of Bird and Bat Fatalities Found at Antrim Wind Project, 2021.

Species		Number of Carcasses	Percent of Carcasses
Birds			
common yellowthroat	*Geothlypis trichas*	1	20.0%
palm warbler	*Setophaga palmarum*	1	20.0%
red-breasted nuthatch*	*Sitta canadensis*	1	20.0%
red-eyed vireo	*Vireo olivaceus*	2	40.0%
Total Birds		**5**	**100.0%**
Bats			
big brown bat	*Eptesicus fuscus*	2	25.0%
hoary bat	*Lasiurus cinereus*	1	12.5%
little brown bat	*Myotis lucifugus*	2	25.0%
silver-haired bat	*Lasionycteris noctivagans*	3	37.5%
Total Bats		**8**	**100%**

*found incidentally

Based on carcass condition, most of the birds found (n=3; 60.0%) were estimated to have died the night prior to discovery. Most of the bats found (n=5; 62.5%) were estimated to have died two to three days prior to discovery (Table 3-2).

Table 3-2. Estimated Time of Death for Bird and Bat Carcasses Found at Antrim Wind Project, 2021.

Species Type	Estimated Time of Death	Number of Carcasses	Percent of Carcasses
Birds	Last night	3	60.0%
	2–3 days	1	20.0%
	4–7 days	0	0.0%
	7–14 days	1	20.0%
Bats	Last night	3	37.5%
	2–3 days	5	62.5%
	4–7 days	0	0.0%
	7–14 days	0	0.0%

3.1.2 Temporal Distribution of Fatalities

All birds were found during typical spring and fall migration months. The majority of the birds were found during October (n=3; 60.0%) followed by September (n=1; 20.0%) and May (n=1; 20.0%). No birds were found during the summer months of June-August (Table 3-3; Figure 3-1).

Table 3-3. Seasonal Timing of Bird Fatalities, Antrim Wind Project, 2021.

Month	Number of Birds	Percent Total
April	0	0.0%
May	1	20.0%
June	0	0.0%
July	0	0.0%
August	0	0.0%
September	1	20.0%
October	3	60.0%
Total	**5**	**100.0%**

Bats were found throughout the late spring, late summer, and fall migration months. The first two bats were found at the end of May (Appendix A Table 1). A majority of the bats were found during August (n=4; 50.0%) followed by May (n=2; 25.0%) (Table 3-4; Figure 3-1).

Table 3-4. Seasonal Timing of Bat Fatalities, Antrim Wind Project, 2021.

Month	Number of Bats	Percent Total
April	0	0.0%
May	2	25.0%
June	1	12.5%
July	0	0.0%
August	4	50.0%
September	1	12.5%
October	0	0.0%
Total	**8**	**100.0%**

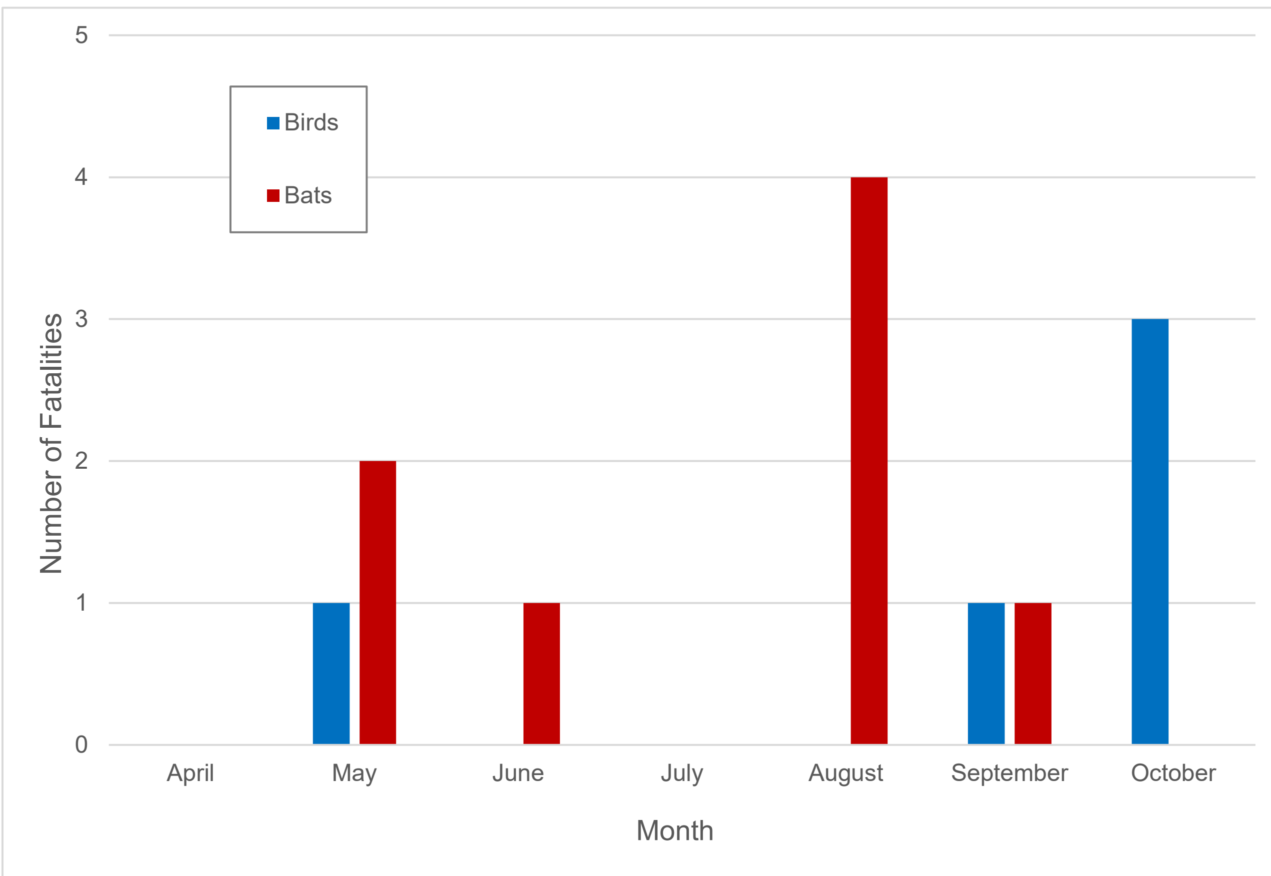


Figure 3-1. Seasonal Timing of Bird and Bat Fatalities, Antrim Wind Project, 2021.

3.1.3 Spatial Distribution of Fatalities

The number of birds found at individual turbines ranged from zero to one bird. The number of bats found at individual turbines ranged from zero (T02, T03, T04, and T07) to four bats (T01). Bird fatalities were relatively evenly distributed across the nine turbines at the Project. However, 50% of the total bat fatalities were found at T01 (n=4) and close to 40% of the overall fatalities (birds and bats combined) were found at this turbine (n=5; 38.5%; Table 3-5).

Table 3-5. Number of Bird and Bat Fatalities Found at Each Turbine.

Turbine	Number of Bird Fatalities	Number of Bat Fatalities	Percent of Fatalities
T01	1	4	38.5%
T02	0	0	0.0%
T03	1	0	7.7%
T04	0	0	0.0%
T05	1	1	15.4%
T06	0	1	7.7%
T07	0	0	0.0%
T08	1	1	15.4%
T09	1	1	15.4%
Total	**5**	**8**	**100.0%**

The distance that birds were found from turbine bases ranged from 7 m to 70 m (approximately 23 feet [ft] to 230 ft). The average distance a bird fatality was found from the base of a turbine was 33.4 m (109 ft). The distance that bats were found from the turbine bases ranged from 16 m to 48 m (approximately 52 ft to 157 ft). The average distance a bat fatality was found from the base of a turbine was 30.9 m (101 ft). Figure 3-2 shows the distribution of bird and bat fatalities found within 10-m distance increments from the base of turbines. Over half (n=7; 53.8%) of bird and bat fatalities were found between 11 m and 30 m (36 ft to 99 ft). Over half of the bat fatalities (n=5; 62.5%) and bird fatalities (n=3; 60%) were found in the 0 m to 30 m range (Figure 3-2).

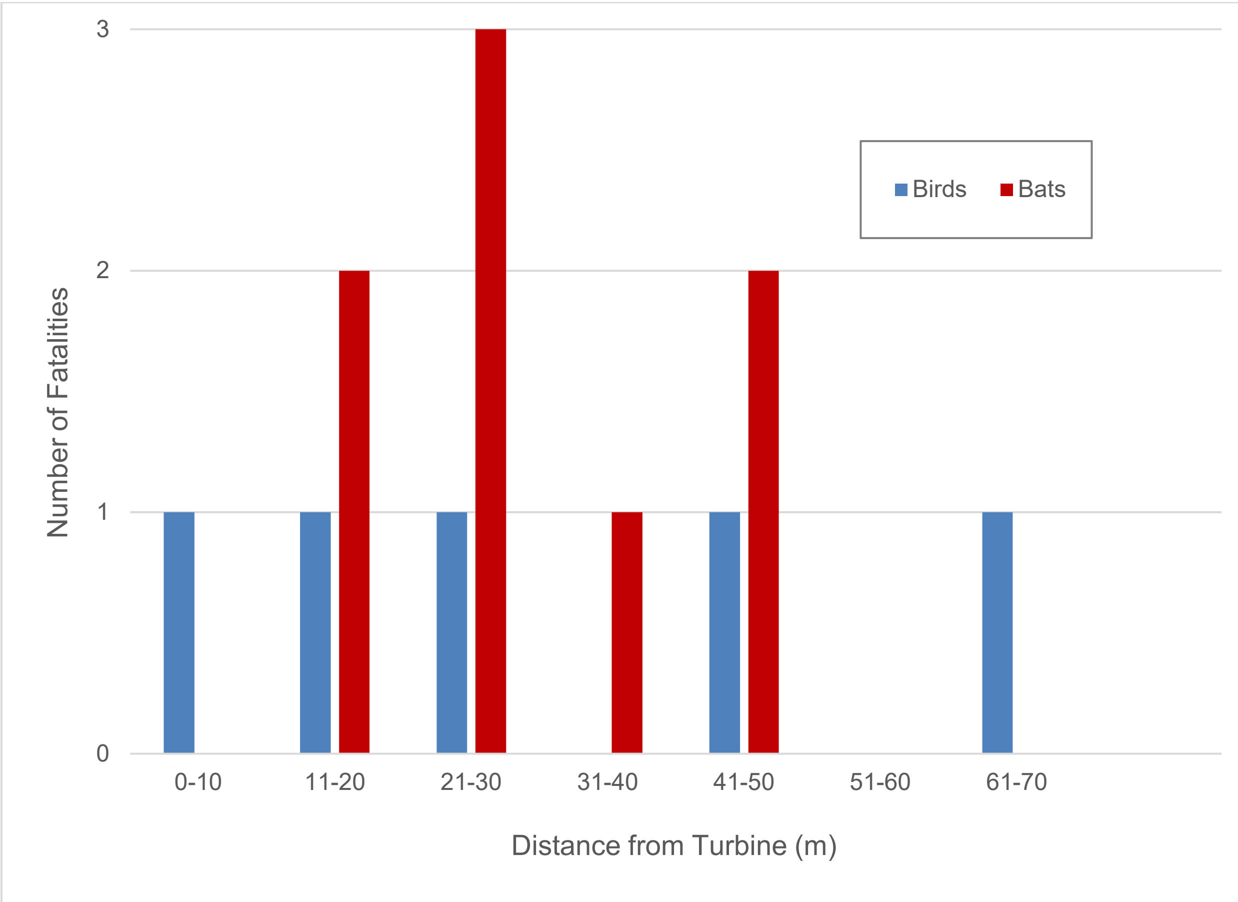


Figure 3-2. Distribution of Bird and Bat Fatalities Found in 10-m Distance Increments from Turbines, Antrim Wind Project, 2021.

Figure 3-3 shows the locations of bird and bat fatalities found within search plots at 10 m distance increments from turbine bases. Bird fatalities were found in the northwest and northeast quadrants of the search plots. Bat fatalities were found in the northwest, northeast, and southeast quadrants of the search plots. All fatalities were found 70 m or less from turbine bases (Figure 3-3).

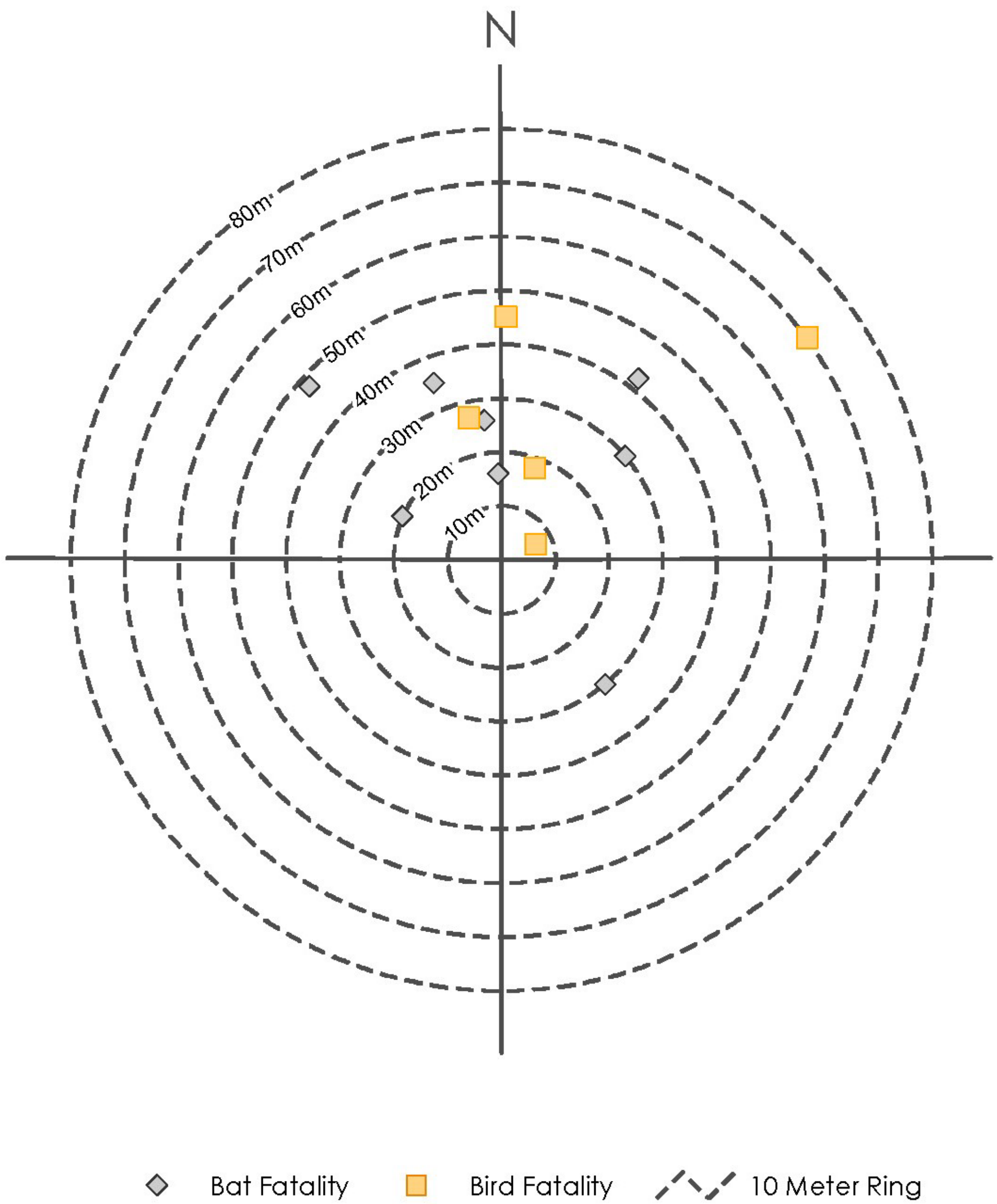


Figure 3-3. Distribution of Bird and Bat Carcasses Found at Antrim Wind Project, 2021.

3.1.4 Search Area Corrections

The proportion of carcasses found per 10-m distance bin, and the DWP values for birds and bats factored into the fatality estimates, are provided in Table 3-6 and Table 3-7, respectively.

Table 3-6. Number and Proportion of Bird and Bat Carcasses Found per 10-m Annuli for all Turbines Combined (Does Not Include Incidental Fatalities), Antrim Wind Project, 2021.

Distance Bin	Number birds found	Proportion all birds per bin	Distance bin	Number bats found	Proportion all bats per bin
0–10	0	0.000	0–10	0	0.000
11–20	1	0.250	11–20	2	0.250
21–30	1	0.250	21–30	3	0.375
31–40	0	0.000	31–40	1	0.125
41–50	1	0.250	41–50	2	0.250
51–60	0	0.000	51–60	0	0.000
61–70	1	0.250	61–70	0	0.000
Total	**4**		**Total**	**8**	

Table 3-7. Density-Weighted Proportion (DWP) Area Searched Values for Birds and Bats, Antrim Wind Project, 2021.

Turbine Number	DWP Value	
	Birds	Bats
T01	0.627	0.872
T02	0.507	0.749
T03	0.582	0.824
T04	0.497	0.754
T05	0.494	0.737
T06	0.500	0.743
T07	0.419	0.663
T08	0.538	0.809
T09	0.718	0.908

3.1.5 Bird and Bat Fatality Estimates

Estimates for bird and bat fatalities were generated with area corrections using the Huso estimator. The fatality estimate for birds in 2021 was 1.72 birds/turbine/year, or 15 birds/year (Table 3-8)[3]. The fatality estimates for bats in 2021 was 2.60 bats/turbine/year, or 23 bats/year (Table 3-9).

Table 3-8. Huso Estimates of Bird Fatality with Area Corrections, Antrim Wind Project, 2021.

Results	Birds, Area Corrected
Number carcasses found	4
Adjusted fatality/turbine/year	**1.72**
95% CI lower	1.23
95% CI upper	2.73
Adjusted fatality/year	**15**
95% CI lower	11
95% CI upper	25
Adjusted fatality/MW/year	**0.54**

Table 3-9. Huso Estimates of Bat Fatality with Area Corrections, Antrim Wind Project, 2021.

Results	Bats, Area Corrected
Number carcasses found	8
Adjusted fatality/turbine/year	**2.60**
95% CI lower	1.33
95% CI upper	5.20
Adjusted fatality/year	**23**
95% CI lower	12
95% CI upper	47
Adjusted fatality/MW/year	**0.81**

3.1.6 Weather Conditions and Fatality Events

There were three nights where a bird carcass was documented as ‘fresh’ (no signs of decomposition) upon discovery and was determined to have died the prior night (Table 3-10). The mean nightly wind speed for these three nights was 4.4 m/s and the mean nightly temperature was 14.8°C. The moon was a waxing crescent for two of the three nights (66.7% of nights), and the sky condition was partly cloudy to clear on the two nights prior to finding the bird fatalities (Table 3-10).

[3] Fatality estimates are presented as individuals/turbine/year for consistency with other studies. In all cases, the use of “year” covers the period when active fatality monitoring occurred (i.e., April to October for Antrim). As a result, fatality estimates are comparable between other projects.

In three cases, bat carcasses were documented as fresh upon discovery and were determined to have died the prior night. Wind speed, temperature, moon condition and other information for these nights are shown in Table 3-10. Since the timing of a fatality within a night cannot be estimated based on discovery of a carcass and wind speeds fluctuate considerably within nights, the mean nightly wind speed does not necessarily reflect conditions when the fatality occurred. Figure 3-4 shows the suspected night of bird and bat fatalities at the Project with average nightly weather conditions during the study period.

Table 3-10. Date of Suspected Mortality and Weather Conditions for 'Fresh' Bird and Bat Carcasses Found, Antrim Wind Project, 2021

Date Found	Suspected Date of Collision	Number Birds and/or Bats	Nightly Mean Wind Speed (m/s)[1]	Nightly Mean Temperature (°C)[1]	Moon Phase[2]	Sky Condition / Precipitation[3]
5/8/2021	5/7/2021	1 bird	3.5	9.0	Waning Crescent	Unknown[4]
8/18/2021	8/17/2021	1 bat	7.4	22.3	Waxing Quarter	Mostly cloudy
8/28/2021	8/27/2021	1 bat	6.9	20.8	Waning Gibbous	Partly cloudy
9/28/2021	9/27/2021	1 bat	7.6	18.8	Waning Gibbous	Mostly cloudy
10/8/2021	10/7/2021	1 bird	6.0	18.3	Waxing Crescent	Partly cloudy
10/12/2021	10/11/2021	1 bird	3.6	16.3	Waxing Crescent	Clear

[1] Data were downloaded from weather stations on nacelles of turbine towers.

[2] Data were downloaded from www.timeanddate.com/moon/phases/.

[3] Data were recorded nights prior to searches by observer at a location proximal to the Project.

[4] Data not recorded since standardized searches did not occur the following day; carcass found incidentally during carcass persistence trial check.

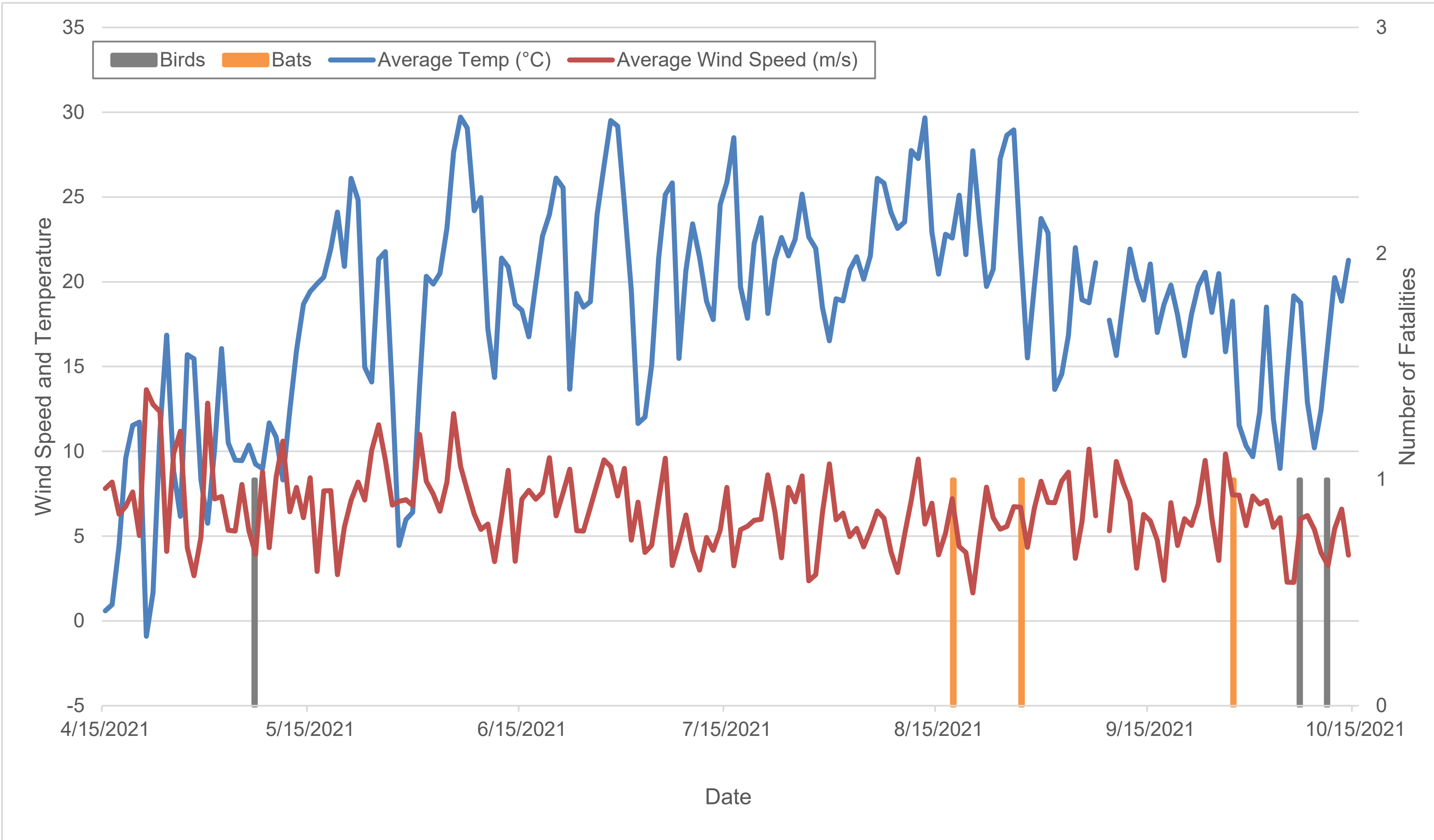


Figure 3-4. Timing and Number of "Fresh" Bird and Bat Carcasses Found in Relation to Average Nightly Wind Speed and Air Temperature, Antrim Wind Project, 2021.

3.2 SEARCHER EFFICIENCY TRIALS

Searcher efficiency trials were conducted each month throughout the survey period on the following dates:

- 5/6/2021
- 6/9/2021
- 7/15/2021
- 8/4/2021
- 9/3/2021

A total of 27 native birds were placed for all searcher efficiency trials combined. Of the 27 birds placed, 15 were found. The mean searcher efficiency rate for birds was 56% (Table 3-11).

Table 3-11. Searcher Efficiency Rate (SE) for Trial Birds, 95% Confidence Interval, Antrim Wind Project, 2021.

Number of trial birds placed	27
Number of trial birds found	15
Mean SE	0.56
Lower SE	0.37
Upper SE	0.74

A total of 25 bats were placed for all searcher efficiency trials combined. Of the 25 bats placed, 16 were found. The mean searcher efficiency rate for bats was 64% (Table 3-12).

Table 3-12. Searcher Efficiency Rate (SE) for Trial Bats, 95% Confidence Interval, Antrim Wind Project, 2021.

Number of trial bats placed	25
Number of trial bats found	16
Mean SE	0.64
Lower SE	0.44
Upper SE	0.80

3.3 CARCASS PERSISTENCE TRIALS

Carcass persistence trials were conducted throughout the survey period on the following dates:

- 5/6/2021
- 7/15/2021
- 9/2/2021

There were a total of 27 birds (1 native bird and 26 quail surrogates) placed for all carcass persistence trials combined. The mean number of days a trial bird carcass persisted was 10.73 days (Table 3-13), which is beyond the 5-day search interval.

Table 3-13. Bird Carcass Persistence (CP) Estimates, 95% Confidence Interval, Antrim Wind Project, 2021.

Number of trial birds placed	27
Mean number of days CP	10.73
Lower number of days CP	6.52
Upper number of days CP	17.63
Mean CP rate	0.80
Lower CP rate	0.70
Upper CP rate	0.87

There were a total of 27 bats (4 bats and 23 mice surrogates) placed for all carcass persistence trials combined. The mean number of days a trial bat persisted was 7.37 days (Table 3-14), which is beyond the 5-day search interval.

Table 3-14. Bat Carcass Persistence (CP) Estimates, 95% Confidence Interval, Antrim Wind Project, 2021.

Number of trial bats placed	27
Mean number of days CP	7.37
Lower number of days CP	3.50
Upper number of days CP	14.94
Mean CP rate	0.63
Lower CP rate	0.49
Upper CP rate	0.74

3.4 CURTAILMENT EVALUATION STUDY

All nine turbines were curtailed from 30 minutes after sunset to sunrise from June 1 to September 30, 2021, at wind speeds below 4.0 m/s and when average nightly temperatures were above 50F per the operational control program. Following the spring 2021 discussions with NHFGD and USFWS, the 4.0 m/s cut-in speed was extended through October 15 for all turbines. As previously noted, the cut-in speed was programmed to increase to 5.0 m/s at Turbine 1 for the period between October 1-15 after a *Myotis* fatality on September 28, 2021. Unfortunately, due to a programming error, the October 1–15 curtailment extension did not occur as planned and all turbines operated without curtailment after September 30. No bat fatalities were noted in 2021 during the period between October 1-15. Project staff are reviewing what occurred and are committed to making sure this type of error does not occur in subsequent years. Operational data were available between June 1 and October 15, representing 7,257 to 7,321 (average of 7,314) 10-minute periods per turbine between sunset and sunrise. Curtailment conditions were met for 1,103 to 2,209 (average of 1,480) 10-minute periods per turbine. Curtailment occurred during 77.9 to 82.2% of these periods among turbines, or 80.5% overall (Table 3-15). Excluding October 1–15, when curtailment was not implemented as planned, turbines were effectively curtailed (rotor speed < 1 rpm) for 95.7% of periods in which curtailment conditions were met. On a monthly basis, curtailment conditions were met for 1,168 to 3,476 (average of 2,663) 10-minute periods per month (including the first half of October) out of 8,415 to 16,478 10-minute periods per month between sunset and sunrise. Curtailment occurred during 20.2-92.2% of these periods (Table 3-16). Graphical comparison of median turbine rpm as a function of wind speed at day and night illustrates the operational difference between night and daytime for each turbine (Figure 3-5) and month (Figure 3-6) during the 2021 survey period.

Table 3-15. Percent of Possible Periods Curtailed at Each Turbine During the Curtailment Period.

Turbine	Number of 10-minute Periods	Number of Periods Meeting Curtailment Conditions	Number of Periods Curtailed (%)*
Turbine 1	7,321	2,209	1,763 (79.8)%
Turbine 2	7,320	1,136	909 (80.0.%)
Turbine 3	7,321	1,103	859 (77.9%)
Turbine 4	7,257	1,431	1,159 (81.0%)
Turbine 5	7,321	1,104	883 (80.0%)
Turbine 6	7,321	1,975	1,605 (81.3%)
Turbine 7	7,321	1,266	1,034(81.7%)
Turbine 8	7,321	1,240	990 (79.8%)
Turbine 9	7,321	1,853	1,523 (82.2%)
Total	**65,824**	**13,317**	**10,725 (80.5%)****

*Curtailment conditions reflected in this table were based on independent simulations of curtailment using 10-minute wind speed (mean) and turbine rotor speed data (minimum) whereas actual turbine curtailment was triggered based on real-time data recorded at each turbine. Turbine curtailment does not occur instantly, and large turbine rotors take time to stop spinning. Accordingly, turbine performance is not expected to match simulations exactly (i.e., 100% overlap with periods meeting curtailment conditions).

**Curtailment data from October, when curtailment was not programmed due to software error, is included in this table, affecting the overall curtailment percentage.

Table 3-16. Percent of Possible Periods Curtailed Each Month During the Curtailment Period.

Month	Number of 10-minute Periods	Number of Periods Meeting Curtailment Conditions	Number of Periods Curtailed (%)*
June	12,356	1,168	1,077(92.2%)
July	13,311	3,476	3,293 (94.7)
August	15,264	3,083	2,952 (95.8)
September	16,478	2,916	2,864 (92.2)
October (1-15)	8,415	2,674	539 (20.2)
Total	**65,824**	**13,317**	**10,725 (80.5)**

*Curtailment conditions reflected in this table were based on independent simulations of curtailment using 10-minute wind speed (mean) and turbine rotor speed data (minimum) whereas actual turbine curtailment was triggered based on real-time data recorded at each turbine. Turbine curtailment does not occur instantly, and large turbine rotors take time to stop spinning. Accordingly, turbine performance is not expected to match simulations exactly (i.e., 100% overlap with periods meeting curtailment conditions).

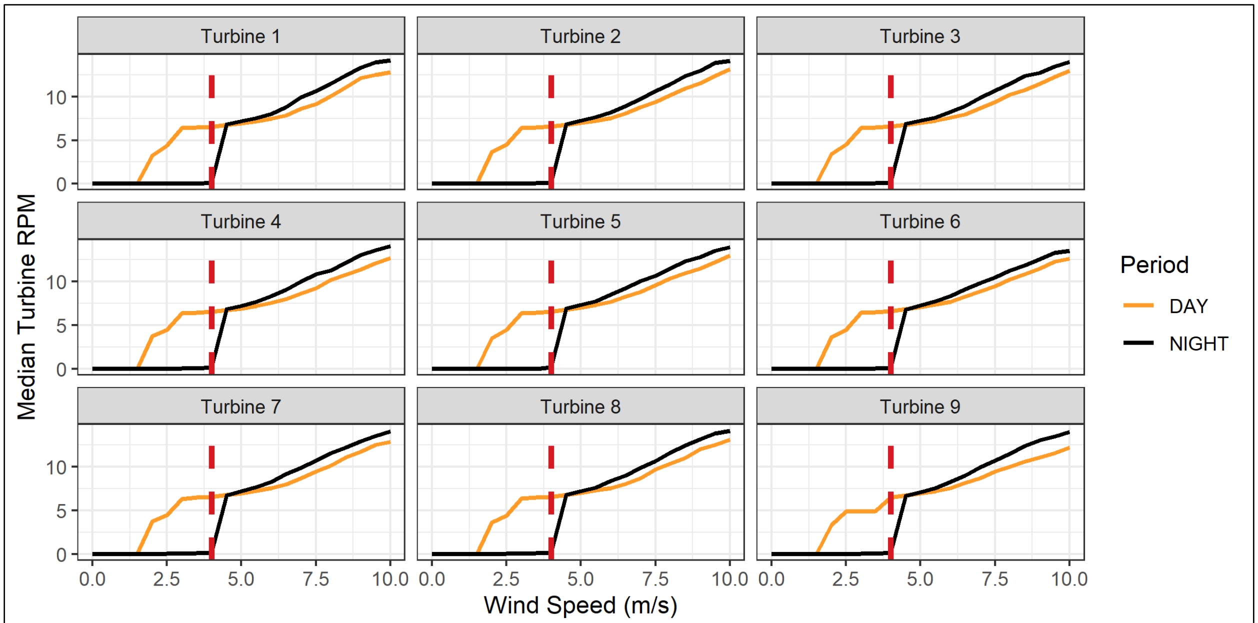


Figure 3-5. Median Turbine RPM During the Day and Night as a Function of Wind Speed for Treatment Turbines During the Curtailment Period.

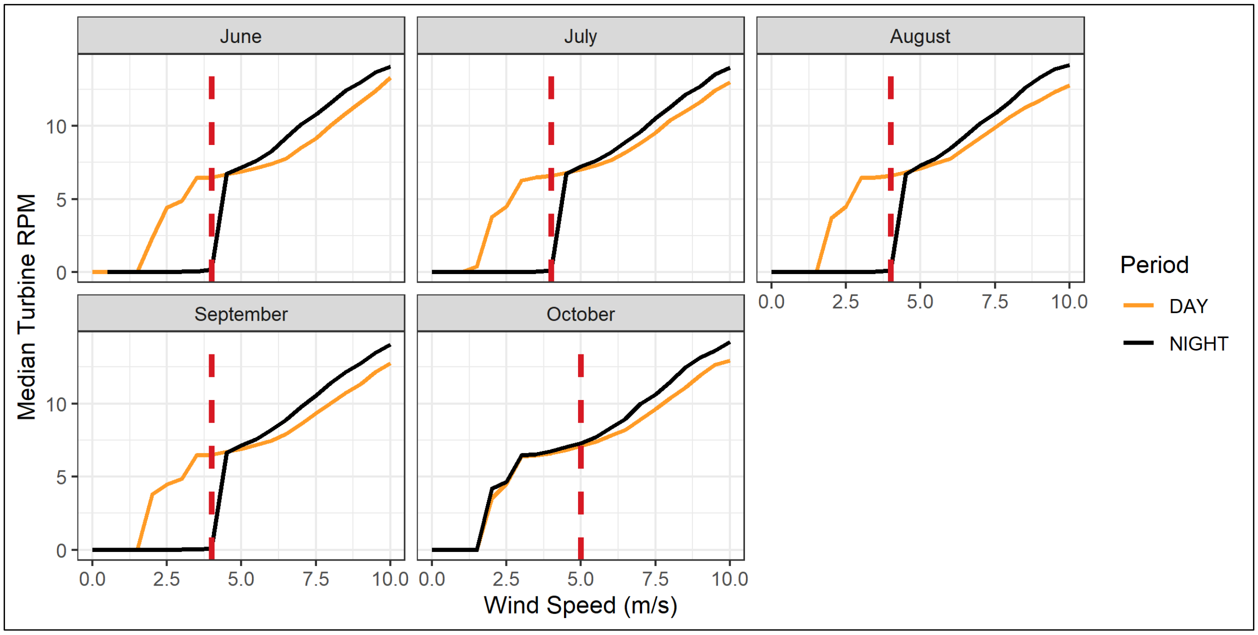


Figure 3-6. Median Turbine RPM During the Day and Night as a Function of Wind Speed for All Turbines During Each Month of the Curtailment Period.

The curtailment period took place during the peak period of bat collision risk. Most bat carcasses were found during the curtailment period; however, two bat carcasses were also found before the curtailment period. No bat carcasses were found in October. Three fresh bat carcasses (time of death estimated to be the previous night) were found during the curtailment period. The previous night's curtailment activity is summarized in Table 3-17 for the turbines where the three fresh bat carcasses were found.

Table 3-17. Summary of Fresh Bat Carcasses Found and Turbine Activity the Previous Night, Antrim Wind Project, 2021.

Turbine	Night of:	Species	Total Number of Periods	Periods Meeting Curtailment Conditions	Periods Curtailed	Percent Curtailed
T09	8/17/2021	silver-haired bat	55	3	0	0.00%[1]
T08	8/27/2021	silver-haired bat	57	1	1	100.00%[1]
T01	9/27/2021	little brown bat	67	0	0	N/A

[1] As noted, there is a lag time associated with turbines ramping down once conditions for curtailment are met. It is also unknown when exactly the fatality occurred over night. Periods are identified as 10-minute intervals and it is possible the fatality occurred during a period that did not meet curtailment conditions.

3.5 COMMON NIGHTHAWK SURVEYS

Common nighthawk surveys were conducted on three separate occasions during the survey period (Table 3-18). The four survey points were in open areas with no canopy cover, ranged from 15 m to 35 m from the forest edge, and all had the same vegetation characteristics (Table 3-19). All surveys were conducted during the required weather conditions (Table 3-20). There were no nighthawks seen or heard during the surveys

Table 3-18. Common Nighthawk Survey Dates, Antrim Wind Project, 2021.

Survey Number	Dates
1	6/4/21 – 6/5/21
2	6/18/21 – 6/20/21
3	7/14/21 – 7/16/21

Table 3-19. Vegetation Characteristics of Each Survey Point.

Survey Point	Percent Canopy Cover	Distance to Forest Edge (m)	Other Notes
1	0%	35	Mixed forest, forest edge, man-made clearing, recently disturbed
2	0%	20	Mixed forest, forest edge, man-made clearing, recently disturbed
3	0%	20	Mixed forest, forest edge, man-made clearing, recently disturbed
4	0%	15	Mixed forest, forest edge, man-made clearing, recently disturbed

Table 3-20. Weather Conditions During Each Common Nighthawk Survey Conducted.

Survey Point	Date	Sky	Wind Speed (mph)	Temperature (°F)	Morning (M)/ Night (N)
1	6/5/2021	Clear, few clouds	8	64	M
2	6/5/2021	Partly cloudy	5	73-76	N
3	6/4/2021	Mostly clear, few clouds	2	73	N
4	6/4/2021	Overcast	4	66-67	M
1	6/20/2021	Partly cloudy	8	65	M
2	6/19/2021	Mostly clear	8	68	M
3	6/19/2021	Partly cloudy	5	75-77	N
4	6/18/2021	Mostly cloudy	4	71-73	N
1	7/15/2021	Clear	4	67	M
2	7/14/2021	Mostly cloudy, variable	2	72	N
3	7/15/2021	Clear, few clouds	5-6	75	N
4	7/16/2021	Clear	4	70	M

4.0 DISCUSSION

4.1 FATALITY ESTIMATES

Passerines made up the entirety of bird fatalities found at the Project in 2021. Migrant passerine carcasses are the most common order of bird found around man-made structures, including wind turbines (Erickson et al. 2002). This group is particularly susceptible to collisions with man-made structures during spring and fall migrations, especially during inclement weather when birds may fly at lower heights and may become disoriented by sources of artificial light (Erickson et al. 2005). The 2021 estimated bird fatality rate at the Project was 1.72 birds/turbine/year, or 15 birds/year. Compared to other wind projects in New Hampshire, this estimated bird fatality for the Project is low. Estimated bird fatalities at the Lempster wind project were 81 birds/year [6.75 birds/turbine/year] and 63 birds/year [5.25 birds/turbine/year] in 2009 and 2010, respectively, and estimated bird fatalities at the Granite Reliable wind project were 66 to 92 birds/year [2 to 2.78 birds/turbine/year] in 2012 (Curry and Kerlinger 2013; Tidhar et al. 2010 and 2011).

More bat fatalities were found than bird fatalities at the Project in 2021 (Table 3-1). Bat fatalities found at the Project consisted of two long-distance migratory species (hoary bat and silver-haired bat) and two cave-hibernating species (big brown bat and little brown bat). Silver-haired bats (n=3) made up 37.5% of the total bat fatalities found at the Project. The same number of long-distance migratory species (n=4) and cave-hibernating species (n=4) were found (Table 3-1). The 2021 estimated bat fatality rate at the Project was 2.60 bats/turbine/year [0.81 bats/MW/year], or 23 bats/year. The fatality estimate is lower than the Lempster project (73 bats/year [3.04 bats/MW] in 2009 and 86 bats/year [3.58 bats/MW] in 2010), the Granite Reliable project (86–99 bats/year [0.86-1 bats/MW] in 2012), and the Groton Project (63 bats/year [1.31 bats/MW] in 2013, 78 bats/year [1.63 bats/MW] in 2014, and 84 bats/year [1.75 bats/MW] in 2015). It is important to note that the Lempster, Granite Reliable, and Groton projects were not required to curtail turbines.

Two little brown bats were found at the Project in 2021, which is a higher number of *Myotis* species than what has been documented at other New Hampshire projects. One little brown bat fatality was discovered at the Lempster project in 2009, and no *Myotis* species were taken from the Granite Reliable or Groton projects. Both species are listed as endangered in New Hampshire, so a loss of either of the species is concerning; however, these few fatalities documented are unlikely to have a significant effect on the overall populations and recovery of the species.

During the 2021 study period, most bird carcasses were found during the fall migration period of September through October. One bird carcass was discovered during the spring migration month of May. Seasonal concentration of bird fatalities during the spring and fall migration periods is typical (Choi et al. 2020). Bat fatalities were found at the Project from May to September, with no fatalities found in April, July, or October. Similar to birds, these results are consistent with results at other U.S. wind projects and wind projects in the Northeast. Most bat fatalities occur between July and October (Choi et al. 2010; Thompson et al. 2017). Increased bat activity and fatalities have been correlated with low wind speeds and high temperatures (Arnett et al. 2013). This relationship is not clearly understood, but some supporting factors include more efficient bat migration in lower wind speeds, and reduced foraging during high winds, low temperatures, and rain (Arnett et al. 2013). The sample size of fresh bat and bird carcasses is very small, so it is difficult to make a correlation between weather, species composition patterns, and fatalities at the Project.

4.2 FATALITY ESTIMATOR

The Huso estimator model is subject to less bias when searcher efficiency and carcass persistence rates remain constant over time; however, when these rates vary over time, the estimator results in greater bias. The estimator tends to overestimate fatality for sites with short persistence time (<4.2 days) and short search intervals (1 to 7 days). At the Project, carcasses persisted for long periods (10.73 days for birds and 7.37 days for bats, Table 3-13 and Table 3-14, respectively), but the search interval (5 days) is categorized as short according to the Huso model. As such, estimates of fatality for the Project may be slightly overestimated.

4.3 2021 AND 2020 COMPARISON

Standardized post-construction fatality monitoring at the Project followed the same survey methods in both 2021 and 2020. As outlined in the Study Plan, all nine turbines were searched every five days, and carcass persistence and searcher efficiency trials occurred throughout both survey years. Surveys in 2021 included the same plot boundaries as in 2020 except for a minor adjustment to the search area at Turbine 9 (Appendix B) to avoid a steep slope and risk of falling. The excluded area was still searched periodically throughout the study period. The ground cover in 2021 was generally similar to the ground cover in 2020 with some areas classified as bare in 2020 re-classified as grass in 2021. These areas, and some others, were re-classified as a moderate or difficult visibility rating because the vegetation grew taller in 2021 as compared to 2020. Some areas classified as boulders were re-classified as difficult due to deep crevasses between the boulders.

Species composition was similar for birds between both survey years. In 2021 and 2020, bird fatalities consisted of primarily passerines. The bird fatality rate was lower in 2021 (1.72 fatalities/turbine/year) than in 2020 (3.65 fatalities/turbine/year). Species composition for bats, however, differed between 2021 and 2020. In 2020, bat fatalities consisted of primarily long-distance migratory species, whereas in 2021 there was an equal number of long-distance migratory and cave-hibernating species found. Bat fatality rates were lower in 2021 (2.60 fatalities/turbine/year) than fatality rates at both experimental and control turbines in 2020 (5.21 fatalities/turbine/year at experimental turbines and 14.07 fatalities/turbine/year at control turbines) (Table 4-1).

The searcher efficiency rate for birds in 2021 (56%) improved compared to the searcher efficiency rate in 2020 (46%). The searcher efficiency rate for bats in 2021 (64%) remained consistent with the searcher efficiency rate in 2020 (65%) (Table 4-1). Carcass persistence rates for birds were lower in 2021 (10.73 days) compared to 2020 (16.95 days). Carcass persistence rates for bats were lower in 2021 (7.37 days) compared to 2020 (10.46 days) (Table 4-1).

The lower fatality estimate for bats in 2021 was lower than the estimate for curtailed turbines in 2020, suggesting that curtailment remains effective. The lower fatality estimate for birds in 2021 compared to 2020 may also be attributed to method-related factors including changes in vegetation height and lower carcass persistence rates. The lower carcass persistence rate for birds in 2021 compared to 2020 could be due to a higher number of surrogates used in trials which might have produced unrealistic carcass persistence data; however, the lower carcass persistence rates indicate a greater presence of scavengers onsite in 2021.

Table 4-1. Comparison of Fatality, Searcher Efficiency, and Carcass Persistence Rates Between Year 2 (2021) and Year 1 (2020), Antrim Wind Project, 2021.

	2020	2021
survey period	4/16–10/12	4/15–10/15
no. searches	333	333
no. bird fatalities	8 (1 incidental)	5 (1 incidental)
no. bat fatalities	43 (1 incidental)	8 (0 incidental)
bird SE	0.46	0.56
bat SE	0.65	0.64
bird CP	16.95	10.73
bat CP	10.46	7.37
bird fatality rate (adjusted fatality/turbine/year)	3.65	1.72
bat fatality rate (adjusted fatality/turbine/year)	control group: 14.07 experimental group: 5.21	2.60

4.4 CURTAILMENT EVALUATION STUDY

The fatality estimate for bats in 2021 was 2.60 bats per turbine per year, which is lower than the 2020 fatality estimates at the Project for both uncurtailed turbines (14.07 bats per turbine per year) and turbines curtailed according under the previous curtailment strategy (5.21 bats per turbine per year). Fatality rates can vary among years, and the absence of control turbines in 2021 precludes direct calculation of the effectiveness of the 2021 curtailment strategy and normally operating turbines. Nevertheless, the low bat fatality estimate in 2021 compared to 2020 suggests that the revised curtailment strategy was at least as effective or more effective than the 2020 strategy, even with the unintended absence of curtailment during October. Data from the Project in 2021 continue to support the broad pattern that operational controls to prevent turbine operation at low wind speeds is an effective method for reducing bat fatalities at wind facilities, which was first documented by Baerwald et al. in 2009 and Arnett et al. in 2011.

4.5 COMMON NIGHTHAWK SURVEYS

Common nighthawks are listed as endangered in the state of New Hampshire (NHFGD 2020). Their population has declined in North America in recent years, but the reason for their decline is not well known. Some hypotheses include declining insect populations (their primary food source), habitat loss and destruction, and an increase in crows which target common nighthawk eggs (Latta and Latta 2015). Common nighthawk habitat is generally in open areas including but not limited to forest clearings and open pine-forests (Audubon n.d.). They are most active around dusk and dawn, foraging for insects. Common nighthawks breed during the spring and summer, and male nighthawks can be observed circling in the air calling and diving to attract females.

Avian surveys were conducted at the Project site as part of initial site evaluation with no nighthawks observed and no nests found. Additionally, common nighthawks have not been seen or heard during surveys or found during fatality searches during Year 1 (2020) or Year 2 (2021). Per the BBCS, however, continued nighthawk surveys will occur for the duration of the Project's operations. While open clearings along the site's forested ridgeline may provide habitat for this species, attraction to the Project from construction activities appears unlikely. At the neighboring Lempster Wind, where the only nighthawk fatalities have occurred in New England, this species was documented to be nesting at the site during preliminary avian studies. Common nighthawks are known to be most active around dawn and dusk when Project surveys occurred. Despite targeted surveys and weekly transect surveys at all turbines, no individuals were documented. During transect searches, technicians were actively walking through open areas of habitat and would likely have encountered any nesting individuals. Finally, onsite operations staff were also trained on common behavior of nighthawks and instructed to reporting any sightings. Nesting nighthawk activity does not seem to occur at the Project based on Year 1 and Year 2 data.

5.0 REFERENCES

Arnett, E.B., W.K. Brown, W.P. Erickson, J.K. Fielder, B.L. Hamilton, T.H. Henry, A. Jain, G.D. Johnson, J. Kerns, R.R. Koford, C.P. Nicholson, T.J. O'Connell, M.D. Piorkowski, R.D. Tankersley, Jr. 2008. Patterns of bat fatalities at wind energy facilities in North America. Journal of Wildlife Management 72:61-78.

Arnett, E.B., M.M.P. Huso, M.R. Schirmacher, and J.P. Hayes. 2011. Altering Turbine Speed Reduces Bat Mortality at Wind-Energy Facilities. Frontiers in Ecology and the Environment 9: 209–214.

Arnett, E.B., G.D. Johnson, W.P. Erickson, and C.D. Hein. 2013. A synthesis of operational mitigation studies to reduce bat fatalities at wind energy facilities in North America. A report submitted to the National Renewable Energy Laboratory. Bat Conservation International. Austin, Texas, USA.

Baerwald, E.F., J. Edworthy, M. Holder, and R.M.R. Barclay. 2009. A large-scale mitigation experiment to reduce bat fatalities at wind energy facilities. Journal of Wildlife Management, 73: 1077-1081.

Bernardino, J., R. Bispo, H. Costa, and M. Mascarenhas. 2013. Estimating bird and bat fatality at wind farms: a practical overview of estimators, their assumptions and limitations, New Zealand Journal of Zoology, 40:1, 63-74.

Choi, D.Y., T.W. Wittig, and B.M. Kluever. 2020. An evaluation of bird and bat mortality at wind turbines in the northeastern United States. PLoS One. 15(8).

Curry and Kerlinger. 2013. Post-construction mortality study Granite Reliable Power Wind Park, Coos County, New Hampshire, Annual Report January 2013. Prepared for Granite Reliable Power, LLC.

Erickson, W., G. Johnson, D. Young, D. Strickland, R. Good, M. Bourassa, K. Bay, and K. Sernka. 2002. Synthesis and Comparison of Baseline Bird and Bat Use, Raptor Nesting and Mortality Information from Proposed and Existing Wind Developments. Western EcoSystems Technology, Inc. Cheyenne, Wyoming, USA.

Erickson, W.P., J. Jeffrey, K. Kronner, and K. Bay. 2004. Stateline Wind Project wildlife monitoring final report: July 2001 - December 2003. Prepared for FPL Energy, Stateline Technical Advisory Committee, and the Oregon Energy Facility Siting Council. Prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, USA and Walla Walla, Washington, USA and Northwest Wildlife Consultants, Pendleton, Oregon, USA.

Erickson, W.P., G.D. Johnson, and D.P. Young. 2005. A summary and comparison of bird mortality from anthropogenic causes with an emphasis on collision. USDA Forest Service Gen Tech Rep PSW-GTR-191. 1029-1042.

Huso, M.M.P. 2010. An Estimator of Wildlife Fatality from Observed Carcasses. Environmetrics. Wiley Blackwell. DOI:10.1002/env.1052

Huso, M., N. Som, and L. Ladd. 2012. Fatality estimator user's guide: U.S. Geological Survey Data Series 729, 22 p.

Huso, M.M.P., and D. Dalthorp. 2014. Accounting for Unsearched Areas in Estimating Wind Turbine-Caused Fatality. Journal of Wildlife Management 78(2), pp. 347–358.

Kerns, J., and P. Kerlinger. 2004. A study of bird and bat collision fatalities at the mountaineer wind energy center, Tucker County, West Virginia: annual report for 2003. Curry & Kerlinger, LLC. 1-39.

Kerns, J., W.P. Erickson, and E.B. Arnett. 2005. Bat and Bird Fatality at Wind Energy Facilities in Pennsylvania and West Virginia. In: E.B. Arnett (Eds). Relationships between Bats and Wind Turbines in Pennsylvania and West Virginia: An Assessment of Bat Fatality Search Protocols, Patterns of Fatality, and Behavioral Interactions with Wind Turbines. Bat Conservation International. Austin, Texas, USA.

Korner-Nievergelt, F., O. Behr, R. Brinkmann, M.A. Etterson, M.M.P Huso, D. Dalthorp, P. Korner-Nievergelt, T. Roth, and I. Niermann. 2015. Mortality estimation from carcass searches using the R-package carcass – a tutorial. Wildlife Biology 21, p. 30–43

Latta, S.C., and K.N. Latta. 2015. Do urban American crows (*Corvus brachyrhnchos*) contribute to population declines of the common nighthawk (*Chordeiles minor*)? Wilson J Ornithol. 127(3): 528-533

National Audubon Society (Audubon). n.d. Common nighthawk. Available from: https://www.audubon.org/field-guide/bird/common-nighthawk.

New Hampshire Fish and Game Department (NHFGD). 2020. Endangered and Threatened Wildlife of NH. https://www.wildlife.state.nh.us/nongame/endangered-list.html

Preston, E., J. Veilleux, and D.S. Reynolds. 2015. New Hampshire wildlife action plan appendix A mammals. Available from: https://wildlife.state.nh.us/wildlife/profiles/wap/mammals-easternsmallfootedbat.pdf.

R Core Team. 2016. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available at https://www.R-project.org/.

Stantec Consulting Services Inc. (Stantec). 2020. Antrim Wind Energy Bird and Bat Post-Construction Monitoring Study Plan. Prepared for TransAlta Corporation, Antrim Wind Energy, LLC.

Thompson, M., J.A. Beston, M. Etterson, J.E. Diffendorfer, and S.R. Loss. 2017. Factors associated with bat mortality at wind energy facilities in the United States. Biol Conserv. 215: 241-245.

Tidhar, D., W. Tidhar, and M. Sonnenberg. 2010. Post-Construction Fatality Surveys for Lempster Wind Project. Prepared for Lempster Wind, LLC.

Tidhar, D., W. Tidhar, L. McManus, and Z. Courage. 2011. 2010 Post-Construction Fatality Surveys for Lempster Wind Project. Prepared for Lempster Wind, LLC.

United States Geological Survey (USGS). 2015. Declines and slow recovery in little brown bat populations predicted. Available from: https://www.usgs.gov/news/declines-and-slow-recovery-little-brown-bat-populations-predicted.

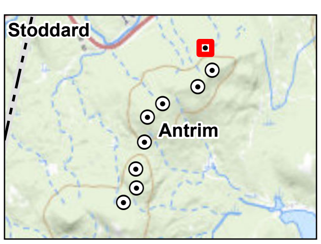
APPENDICES

APPENDIX A LIST OF FATALITIES

Appendix A Table 1. List of Fatalities Found During the Survey Period, Antrim Wind Project, 2021

Date	Turbine	Common Name	Scientific Name	Subgroup	Age	Sex	Condition	Estimated Time Since Death	Position	Distance (m)	Azimuth
5/8/2021	T03	red-breasted nuthatch	*Sitta canadensis*	passerine	adult	male	fresh	last night	face up	7	65
5/20/2021	T01	little brown bat	*Myotis lucifugus*	cave-dwelling bat	adult	female	decomposing - early	2-3 days	face up	20	294
5/20/2021	T06	hoary bat	*Lasiurus cinereus*	tree-roosting bat	adult	female	decomposing - late	2-3 days	face up	16	358
6/9/2021	T01	big brown bat	*Eptesicus fuscus*	cave-dwelling bat	adult	male	decomposing - early	2-3 days	face up	26	353
8/28/2021	T08	silver-haired bat	*Lasionycteris noctivagans*	tree-roosting bat	adult	female	fresh	last night	face up	48	312
8/29/2021	T01	silver-haired bat	*Lasionycteris noctivagans*	tree-roosting bat	adult	male	decomposing - late	2-3 days	face up	42	37
8/18/2021	T09	silver-haired bat	*Lasionycteris noctivagans*	tree-roosting bat	unknown	unknown	decomposing - early	last night	face up	30	140
8/19/2021	T05	big brown bat	*Eptesicus fuscus*	cave-dwelling bat	unknown	unknown	decomposing - early	2-3 days	face down	30	50
9/28/2021	T01	red-eyed vireo	*Vireo olivaceus*	passerine	unknown	unknown	decomposing - early	7-14 days	on side	18	20
9/28/2021	T01	little brown bat	*Myotis lucifugus*	cave-dwelling bat	juvenile	female	fresh	last night	face up	35	339
10/8/2021	T05	common yellowthroat	*Geothlypis trichas*	passerine	adult	male	fresh	last night	on side	27	347
10/12/2021	T08	palm warbler	*Setophaga palmarum*	passerine	adult	unknown	decomposing - early	2-3 days	face down	70	54
10/12/2021	T09	red-eyed vireo	*Vireo olivaceus*	passerine	adult	unknown	fresh	last night	face up	45	1

APPENDIX B TURBINE SEARCH PLOTS



Legend
- Clover
- Grass
- Mulch/Grass
- Pad/Gravel
- Search Plot

Visibility Rating
1 = Easy
2 = Moderate
3 = Difficult

0 100 Feet
(At original document size of 8.5x11)
1:1,200

N

Notes
1. Coordinate System: NAD 1983 UTM Zone 19N
2. Data Sources: Stantec
3. Background: National Agriculture imagery Program (NAIP) New Hampshire 2018

Stantec

Project Location
Antrim, New Hampshire

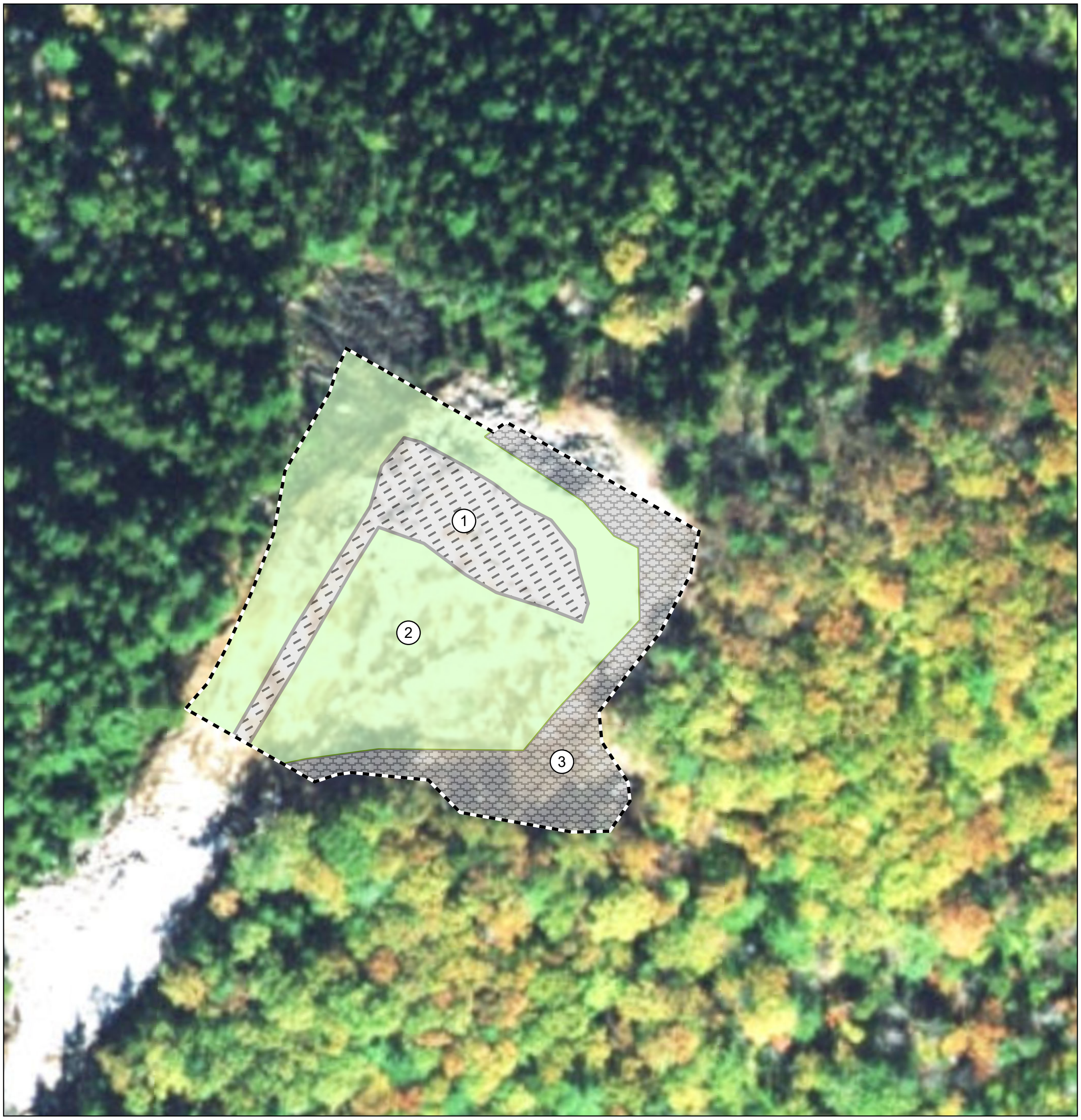
Prepared by HCT on 2021-12-07
IR Review by AP on 2021-12-07

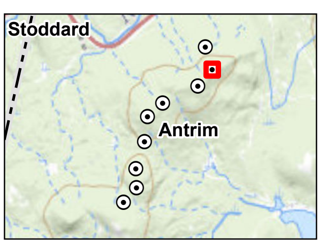
Client/Project
195601919
Antrim Wind Project
Post Construction Monitoring

Figure No.
1 of 9

Title
2021 Vegetation Mapping
T1

V:\1956\active\195601919\03_data\gis_cad\GIS\mxd\PCM\2021\PCMVegMapping2021\PCMVegMapping2021.aprx Revised: 2022-01-28 By: hturner





Legend

- Grass
- Pad/Gravel
- Rocks/Boulders
- Search Plot

Visibility Rating

1 = Easy
2 = Moderate
3 = Difficult

0 100 Feet
(At original document size of 8.5x11)
1:1,200

N

Stantec

Project Location
Antrim, New Hampshire

Prepared by HCT on 2021-12-07
IR Review by AP on 2021-12-07

Client/Project
Antrim Wind Project
Post Construction Monitoring

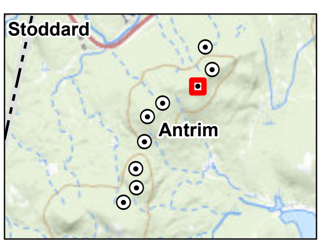
195601919

Figure No.
2 of 9

Title
2021 Vegetation Mapping
T2

Notes
1. Coordinate System: NAD 1983 UTM Zone 19N
2. Data Sources: Stantec
3. Background: National Agriculture imagery Program (NAIP) New Hampshire 2018

V:\1956\active\195601919\03_data\gis_cad\GIS\mxd\PCM\2021\PCMVegMapping2021\PCMVegMapping2021.aprx Revised: 2022-01-28 By: hturner



Legend

- Grass
- Pad/Gravel
- Rocks/Boulders
- Search Plot

Visibility Rating

1 = Easy
2 = Moderate
3 = Difficult

0 100 Feet

(At original document size of 8.5x11)
1:1,200

N

Notes

1. Coordinate System: NAD 1983 UTM Zone 19N
2. Data Sources: Stantec
3. Background: National Agriculture imagery Program (NAIP) New Hampshire 2018

Stantec

Project Location
Antrim, New Hampshire

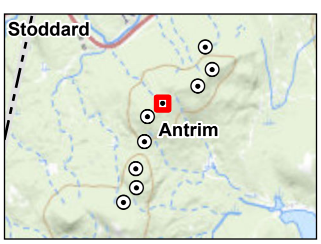
Prepared by HCT on 2021-12-07
IR Review by AP on 2021-12-07

Client/Project
195601919
Antrim Wind Project
Post Construction Monitoring

Figure No.
3 of 9

Title
2021 Vegetation Mapping
T3

V:\1956\active\195601919\03_data\gis_cad\GIS\mxd\PCM\2021\PCMVegMapping2021\PCMVegMapping2021.aprx Revised: 2022-01-28 By: hturner



Legend
- Boulders
- Clover
- Grass
- Pad/Gravel
- Search Plot

Visibility Rating
1 = Easy
2 = Moderate
3 = Difficult

0 100 Feet
(At original document size of 8.5x11)
1:1,200

N

Stantec

Notes
1. Coordinate System: NAD 1983 UTM Zone 19N
2. Data Sources: Stantec
3. Background: National Agriculture imagery Program (NAIP) New Hampshire 2018

Project Location
Antrim, New Hampshire

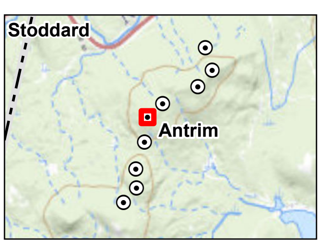
Prepared by HCT on 2021-12-07
IR Review by AP on 2021-12-07

Client/Project
195601919
Antrim Wind Project
Post Construction Monitoring

Figure No.
4 of 9

Title
2021 Vegetation Mapping
T4

V:\1956\active\195601919\03_data\gis_cad\GIS\mxd\PCM\2021\PCMVegMapping2021\PCMVegMapping2021.aprx Revised: 2022-01-28 By: hturner



Legend
- Boulders
- Grass
- Pad/Gravel
- Search Plot

Visibility Rating
1 = Easy
2 = Moderate
3 = Difficult

0 100 Feet
(At original document size of 8.5x11)
1:1,200

N

Stantec

Project Location
Antrim, New Hampshire

Prepared by HCT on 2021-12-07
IR Review by AP on 2021-12-07

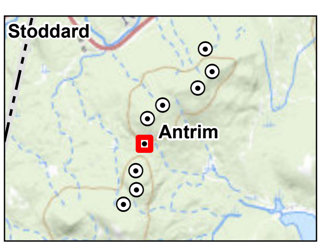
Client/Project
195601919
Antrim Wind Project
Post Construction Monitoring

Figure No.
5 of 9

Title
2021 Vegetation Mapping
T5

Notes
1. Coordinate System: NAD 1983 UTM Zone 19N
2. Data Sources: Stantec
3. Background: National Agriculture imagery Program (NAIP) New Hampshire 2018

V:\1956\active\195601919\03_data\gis_cad\GIS\mxd\PCM\2021\PCMVegMapping2021\PCMVegMapping2021.aprx Revised: 2022-01-28 By: hturner



Legend
- Clover
- Grass
- Pad/Gravel
- Rocks/Boulders
- Search Plot

Visibility Rating
1 = Easy
2 = Moderate
3 = Difficult

0 100 Feet
(At original document size of 8.5x11)
1:1,200

N

Stantec

Project Location
Antrim, New Hampshire

Prepared by HCT on 2021-12-07
IR Review by AP on 2021-12-07

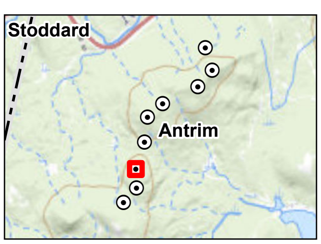
Client/Project
195601919
Antrim Wind Project
Post Construction Monitoring

Figure No.
6 of 9

Title
2021 Vegetation Mapping
T6

Notes
1. Coordinate System: NAD 1983 UTM Zone 19N
2. Data Sources: Stantec
3. Background: National Agriculture imagery Program (NAIP) New Hampshire 2018

V:\1956\active\195601919\03_data\gis_cad\GIS\mxd\PCM\2021\PCMVegMapping2021\PCMVegMapping2021.aprx Revised: 2022-01-28 By: hturner



Legend
- Boulders
- Clover
- Grass
- Pad/Gravel
- Search Plot

Visibility Rating
1 = Easy
2 = Moderate
3 = Difficult

0 100 Feet
(At original document size of 8.5x11)
1:1,200

N

Notes
1. Coordinate System: NAD 1983 UTM Zone 19N
2. Data Sources: Stantec
3. Background: National Agriculture imagery Program (NAIP) New Hampshire 2018

Stantec

Project Location
Antrim, New Hampshire

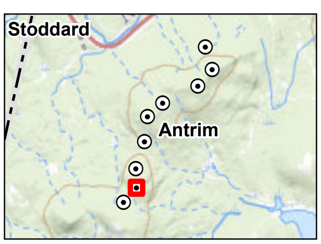
Prepared by HCT on 2021-12-07
IR Review by AP on 2021-12-07

Client/Project
195601919
Antrim Wind Project
Post Construction Monitoring

Figure No.
7 of 9

Title
2021 Vegetation Mapping
T7

V:\1956\active\195601919\03_data\gis_cad\GIS\mxd\PCM\2021\PCMVegMapping2021\PCMVegMapping2021.aprx Revised: 2022-01-28 By: hturner



Legend
- Grass
- Pad/Gravel
- Rock
- Rocks/Boulders
- Search Plot

Visibility Rating
1 = Easy
2 = Moderate
3 = Difficult

0 100 Feet
(At original document size of 8.5x11)
1:1,200

N

Stantec

Project Location
Antrim, New Hampshire

Prepared by HCT on 2021-12-07
IR Review by AP on 2021-12-07

Client/Project
Antrim Wind Project
Post Construction Monitoring

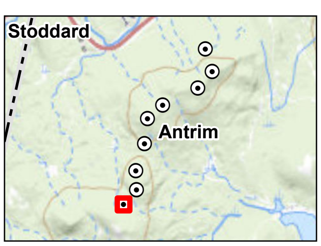
195601919

Figure No.
8 of 9

Title
2021 Vegetation Mapping
T8

Notes
1. Coordinate System: NAD 1983 UTM Zone 19N
2. Data Sources: Stantec
3. Background: National Agriculture imagery Program (NAIP) New Hampshire 2018

V:\1956\active\195601919\03_data\gis_cad\GIS\mxd\PCM\2021\PCMVegMapping2021\PCMVegMapping2021.aprx Revised: 2022-01-28 By: hturner



Legend
- Grass
- Pad/Gravel
- Rock
- Search Plot

Visibility Rating
1 = Easy
2 = Moderate
3 = Difficult

0 100 Feet
(At original document size of 8.5x11)
1:1,200

N

Stantec

Project Location
Antrim, New Hampshire

Prepared by HCT on 2021-12-07
IR Review by AP on 2021-12-07

Client/Project
195601919
Antrim Wind Project
Post Construction Monitoring

Figure No.
9 of 9

Title
2021 Vegetation Mapping
T9

Notes
1. Coordinate System: NAD 1983 UTM Zone 19N
2. Data Sources: Stantec
3. Background: National Agriculture imagery Program (NAIP) New Hampshire 2018

V:\1956\active\195601919\03_data\gis_cad\GIS\mxd\PCM\2021\PCMVegMapping2021\PCMVegMapping2021.aprx Revised: 2022-01-28 By: hturner