# Post-Construction Monitoring Report Year 1, Antrim Wind Project, 2020

Antrim, New Hampshire

January 26, 2020

Prepared for:

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# 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, 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, 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. 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 during the first year of operation in 2020 represent the first year of required studies. In addition to post-construction monitoring, an acoustic bat monitoring study was completed, common nighthawk (*Chordeiles minor*) surveys were conducted, and operational control measures were applied to select turbines from July 15 to September 30, 2020.

Stantec conducted fatality searches from April 16 to October 12, 2020. Weather and site maintenance activities permitting, all nine turbines were searched once every five days. During the 2020 study period, 333 of 333 (100%) scheduled searches were completed. Fifty-one carcasses were found: 8 birds and 43 bats. Seven bird species were found, including five passerine species (*Passeriformes*), one woodpecker species (*Colaptes* sp.), and one raptor species (*Cathartes* sp.). Six bat species were found, including three tree-roosting species and three cave-dwelling species. Two *Myotis* species (n=4) were found: three little brown bats (*Myotis lucifugus*) and one eastern small-footed bat (*Myotis leibii*).

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) using the Huso fatality estimator. Searcher efficiency for birds and bats was 46% and 65%, respectively, and carcass persistence for birds and bats was 16.95 days and 10.46 days, respectively. Based on the Huso estimator, estimates of bird fatalities were 3.65 birds per turbine per year. During the survey period, fatality searches and a curtailment study occurred simultaneously from July 15 to September 30, 2020. The nine turbines were broken up into two groups, a control group and an experimental group, for the curtailment study. The cut-in wind speeds for the turbines in the experimental group were raised from 3.0 meters per second (m/s) to 5.0 m/s during this time, while the turbines in the control group were allowed to operate as usual. The estimates of fatalities for bats were analyzed separately for the two treatment groups. The estimates of fatality for bats were 14.07 bats (control treatment) and 5.21 bats (experimental treatment) per turbine per year. Estimates of bird and bat fatality by rated power were 1.14 birds per MW per year, and 4.40 bats (control treatment) and 1.63 bats (experimental treatment) per MW per year.

The 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 bat fatality estimate from turbines in the control curtailment group is higher than the three other New Hampshire wind facilities. The bat fatality estimates at the other New Hampshire projects ranged from 2.6 (Granite Reliable, 2012) to 7.13 (Lempster, 2010) bats per turbine per year. Other New Hampshire wind projects did not use curtailment treatments, so the bat fatality estimate from turbines in the experimental group at Antrim cannot be compared to the results from other New Hampshire wind facilities.

Operational control measures were applied to five turbines (T01, T02, T05, T07, and T08) from July 15 to September 30, 2020. The cut-in wind speed was raised at these five turbines from 3.0 m/s to 5.0 m/s. During this curtailment period, an average of 81.8% of possible periods were curtailed at experimental treatment turbines. Twenty-seven bat carcasses were found, three of which (11%) were found at turbines in the experimental treatment group, during the curtailment period. Based on data from the control group of turbines, the fatality estimate was 127 bats per year. Based on data from the experimental treatment group of turbines, the fatality estimate was 47 bats per year. There was an estimated 63% decrease of bat fatalities between the control and experimental treatment groups.

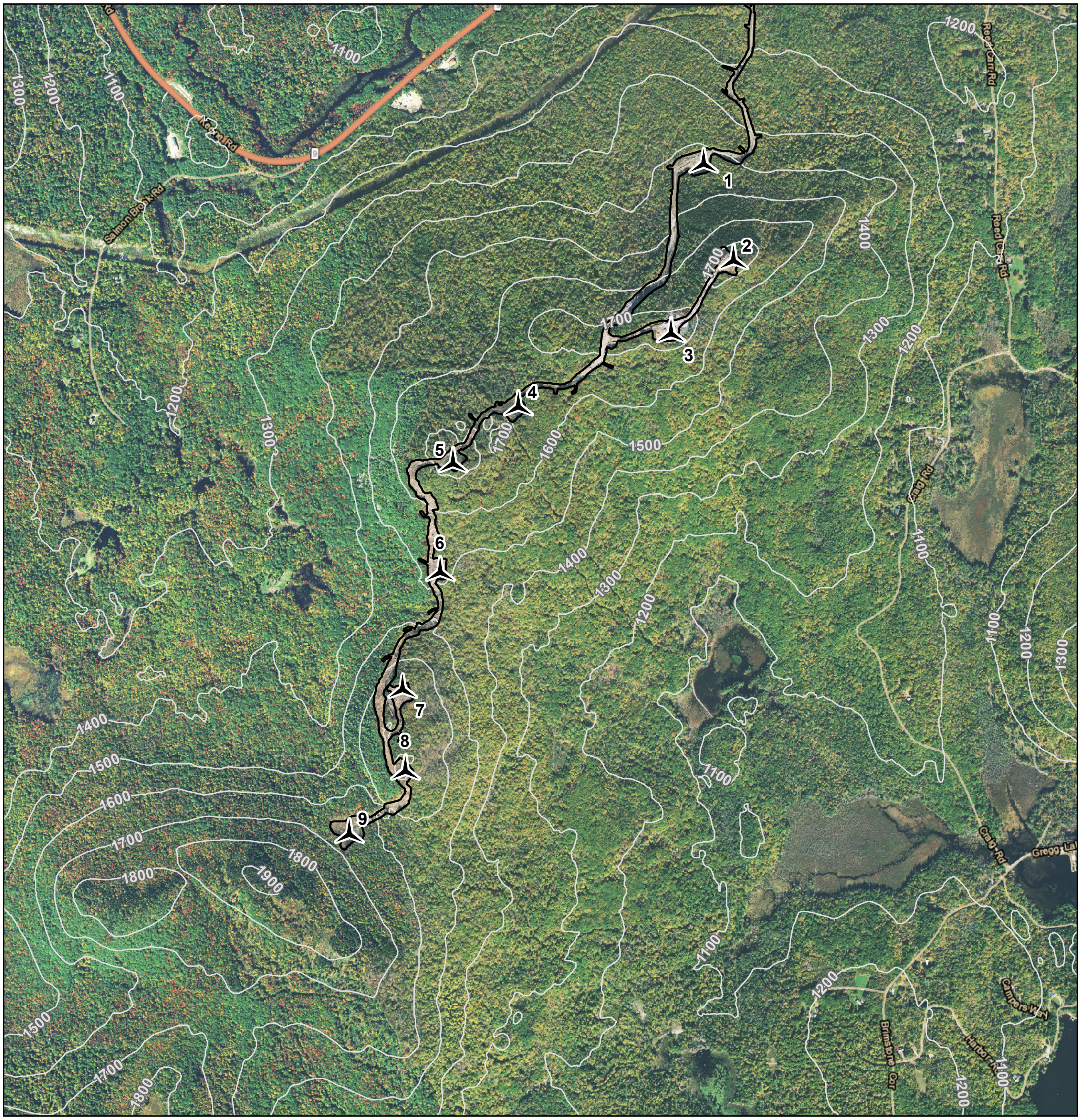
Wildlife Acoustics SM4 full-spectrum acoustic detectors were installed on four Siemens SWT-3.2-113 turbines. Two of the turbines (T01 and T08) were in the experimental treatment group of the curtailment study while the other two turbines (T03 and T06) were part of the control treatment group. Conducting nacelle-height acoustic monitoring allowed Stantec to test the ability of the curtailment operations to reduce the exposure of bats to turbine operation and reduce the corresponding risk of turbine-related fatality. The data collected from the acoustic detectors provided confirmation of what was observed during both the curtailment study and fatality searches/estimates. Detectors operated from May 1 to October 15, 2020, and recorded the number of bat passes each night. There was a total of 1,952 bat passes during this period. There were 948 bat passes recorded at the experimental turbines and 1,004 bat passes recorded at the control turbines (Table 3-17). Inside the curtailment period, there were 489 bat passes recorded at the control turbines with 395 passes (80.8%) exposed to turbine operation (Table 3-19). There were 366 bat passes recorded at experimental turbines inside the curtailment period with 55 passes (15.0%) exposed to turbine operation (Table 3-19). The data provided by the detectors showed that hoary bats (*Lasiurus cinereus*), silver-haired bats (*Lasionycteris noctivagans*), and big brown bats (*Eptisicus fuscus*) were the most active species. Bat activity peaked in mid-June and mid-August, increased when temperature increased and wind speed decreased, and there was a greater probability of finding a bat carcass at a turbine following intervals with high rates of exposed bat activity.

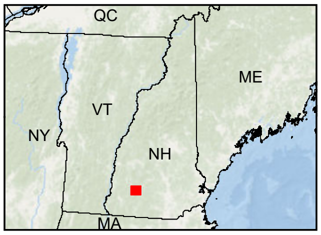
Common nighthawk surveys were conducted on three separate occasions at the Project during the summer months of June and July. The surveys covered all nine turbines and were located in open areas either near or between turbines. Surveys covered the crepuscular period when common nighthawk activity/detectability is greatest and occurred from 8:00 pm to 9:30 pm and 3:30 am to 5:00 am, when temperatures were above 18.3°C, 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 during the surveys.

# 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 are on 92.5-meter (m) towers and one turbine 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

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Feet
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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 2020-11-10

*Client/Project*
195601919
TransAlta Corporation
Antrim Wind Project

*Figure No.*
**1-1**

*Title*
**Project Layout**

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## 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 NH Audubon Society. 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 '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 (Stantec 2020). The components of the Study Plan are explained in further detail in the Methods section of this report.

# 2.0 METHODS

## 2.1 FATALITY SEARCHES

Surveys occurred between April 15 to October 15, 2020, 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
- Bald eagles (*Haliaeetus leucocephalus*) and golden eagles (*Aquila chrysaetos*)

Stantec conducted fatality searches at all nine turbines once every 5 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 was 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 condition and 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 5 m apart and oriented north-south. 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 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 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 its 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 for each carcass:

- Date and time discovered
- 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 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 the carcasses that were collected by the surveyor through pictures. 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. Stantec assisted AWE in immediately implementing a "root caused analysis" determining the likely cause of the event. The analysis was presented during a consultation with the NHFGD and USFWS, which occurred within the 14-day period following the reported incident. 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 types were observed throughout the survey period, and changes in dominant vegetation type, visibility class, or height were recorded. A GPS was used through the ArcGIS Collector™ app[1] once during the survey period to map the ground cover types at each turbine. The mapped search area plots are provided in Appendix B.

[1] 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 searchers ability to find a fatality) rates of birds and bats. The trials targeted the total placement of 25 bird and 25 bat carcasses. 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 heights. The same trial carcasses were re-used throughout the study period until they became too decomposed. Due to the limited number of carcasses found onsite, mice and quail were obtained from a feed supply lab and used in place of birds and bats when 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 carcasses found after all searches were completed. The project manager picked up carcasses that were not found 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 carcasses found onsite, mice and quail obtained from a feed supply lab were used in place of birds and bats when 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 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. Stantec assessed the effectiveness of the Project’s curtailment strategy to reduce impacts to bats during the first year (2020 – the evaluation phase) of the curtailment evaluation study.

During the 2020 survey period, five turbines (T01, T02, T05, T07, and T08) operated under a curtailment program designed to reduce impacts to bats (experimental treatment) and four turbines (T03, T04, T06, and T09) operated normally with cut-in speeds at approximately 3.0 meters per second (m/s) (control treatment). AWE applied curtailment operations between July 15 and September 30, from 30 minutes after sunset until sunrise, when wind speeds were less than 5.0 m/s. 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 1. Curtailment performance was evaluated as the percent of 10-minute periods meeting conditions in which minimum rpm was less than 1. 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 ACOUSTIC BAT SURVEY

Stantec conducted nacelle-height acoustic monitoring from May 1 to October 15, 2020, to document seasonal and temporal patterns in bat activity, and to characterize relationships between bat activity, temperature, and wind speed. Acoustic data also provided information on species composition of bat activity at nacelle height and was used to examine the relationship between experimental cut-in speed treatments with potential bat fatality risk.

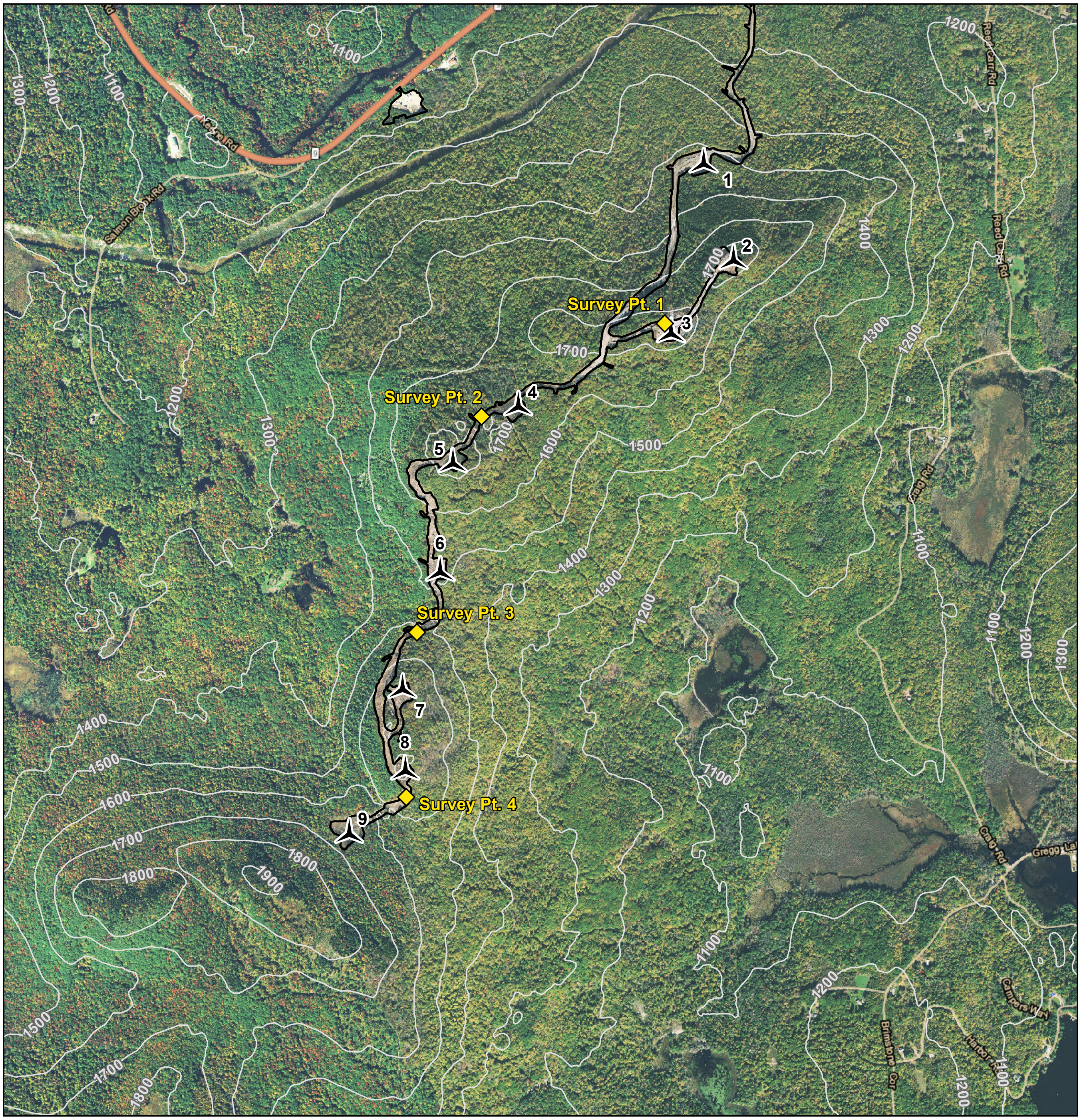
Stantec coordinated with AWE to install Wildlife Acoustics SM4 full-spectrum acoustic detectors on four Siemens SWT-3.2-113 turbines. While the BBCS required use of two acoustic detectors, a total of four acoustic detectors were utilized to provide capacity for additional data collection and redundancy in case of equipment failure. Acoustic monitors were placed on two turbines within the experimental curtailment treatment (5.0 m/s) group (T01 and T08) and two turbines within the control curtailment treatment (3.0 m/s) group (T03 and T06). The acoustic monitors were mounted at the back end of the nacelle (Figure 2-1) near the wind vanes and anemometers. The detector installation method did not require connection to turbine power or communications infrastructure (detectors used an external 12-volt solar panel to operate) and were attached without permanent modification to the turbine itself. Stantec programmed the detectors to record nightly bat activity from 30 minutes before sunset to 30 minutes after sunrise. Remote data transfer was unavailable so Stantec coordinated with AWE to change memory cards and batteries in the detectors at least twice during the survey period.

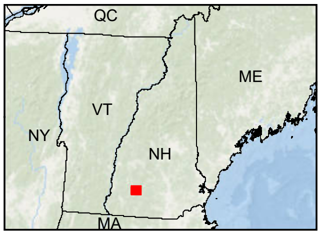
**Figure 2-1. Close-Up of a Wind Turbine with an Acoustic Bat Monitor Mounted at the Back End of the Nacelle**

## 2.7 COMMON NIGHTHAWK SURVEYS

Stantec conducted common nighthawk surveys for the first year of the Project per the New Hampshire Site Evaluation Committee conditions and the MOU with NH Audubon. Each survey was conducted over three consecutive days, usually on the days of scheduled fatality searches. 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 were chosen to cover 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 wind speeds were 10 miles per hour (mph) or less and there was no rain.

Four survey points were scouted and approved by the NH Audubon prior to initiation of surveys. 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

***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.*
**2-2**

*Title*
**Common Nighthawk Survey Points**

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**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.

## 2.8 STATISTICAL ANALYSIS

### 2.8.1 Temporal Distribution

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

### 2.8.2 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 were plotted on a scatterplot diagram (Figure 3-3) with 10-m concentric distance increments.

### 2.8.3 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 1 or more model inputs over a period of time. As such, the Huso estimator was used to estimate fatality at the Project for 2020. 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, $\tilde{i}$), with $\tilde{i}$ representing the length of time beyond which a the probability of a carcass persisting is ≤ 1% (i.e., $\tilde{i}$ is such that P[T > $\tilde{i}$] ≤ 0.01.
- $\tilde{i}$ can be estimated as $\tilde{i}$ = -log(0.01)x$\bar{t}$ (based on exponential distribution [e]).
- v is the effective search interval, where v = min (1, $\tilde{i}$ /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%.

### 2.8.4 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.

### 2.8.5 Curtailment and Fatality Events

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

- Determining if and when bat fatalities were documented during the curtailment period (July 15, 2020, through September 30, 2020);
- 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.

### 2.8.6 Acoustic Data Analysis

Stantec converted recorded acoustic files to a zero-crossing format and processed them using Kaleidoscope Pro software (Kaleidoscope; version 5.1.9g). Files were processed through an automated identifier within the software (classifier 5.1.0, set to the "0 Balanced" setting and configured for bat species expected to occur in the region). Kaleidoscope includes Indiana bat (*Myotis sodalis*) in the set of bat species potentially occurring within the region. The project occurs outside the known range of this species and we do not believe that this species occurs within the study area. Therefore, we did not include Indiana bat as a species designation within the automated identification process.

A Stantec biologist experienced in the analysis of acoustic bat signatures visually inspected files identified as a bat pass by Kaleidoscope to check accuracy of differentiation of bat activity from ultrasonic "static" or interference by the program. Files found to contain only static were removed from analysis. The biologist re-identified bat passes to the correct species or species group in files that contained a bat pass but was determined by the biologist to be misidentified as the incorrect species by the program. The biologist also reviewed files classified by the program as noise; files which were labeled as noise by the program but contained bat passes were re-identified to species or species group by the biologist to be included in the analysis.

Each bat pass identified by Kaleidoscope, or reidentified by the biologist, was manually assigned to a species group reflecting species with similar acoustic characteristics, as outlined below.

Species Group Codes

- BBSH = big brown bat (*Eptesicus fuscus*) and silver-haired bat (*Lasionycteris noctivagans*)
- Hoary bat (*Lasiurus cinereus*) = hoary bat[2]
- Myotis = little brown bat (*Myotis lucifugus*), northern long-eared bat (*M. septentrionalis*), and eastern small-footed bat (*M. leibii*)
- RBTB = eastern red bat (*Lasiurus borealis*) and tri-colored bat (*Pipistrellus subflavus*)
- Unknown = high frequency and low frequency unknown species passes

We obtained temperature and wind speed data collected by weather instruments on the nacelles of the acoustic survey turbines. We rounded timestamps of recorded bat passes and weather data to the nearest hour and averaged weather data within that hour for alignment with time-stamped bat passes.

Stantec calculated the total number of bat passes, bat passes per detector-night (a detector-night is equal to one detector successfully operating for at least a portion of one night), and species composition per turbine and for all turbines combined; the seasonal bat activity by species per turbine; timing of bat activity (relative to sunset) per turbine; and the relationships between bat activity and temperature and wind speed per turbine.

[2] Hoary bat passes are distinctive among the species occurring in the area and constitutes its own species group.

# 3.0 RESULTS

## 3.1 FATALITY SEARCHES

### 3.1.1 Fatalities Discovered

A total of 51 fatalities were found (Appendix A Table 1). Two of the 51 fatalities, a big brown bat and northern flicker (*Colaptes auratus*) (Table 3-1), were found incidentally (outside of the standard searches). Of the 51 fatalities, 8 were birds. Passerines (n=6) represented 75% of the birds found. There were five different species of passerines, one species of raptor (turkey vulture (*Cathartes aura*); n=1), and one species of woodpecker (northern flicker; n=1) found (Table 3-1).

The remaining 43 fatalities were bats. Six species of bats were found. Hoary bats (n=15) and big brown bats (n=12) represented 62.8% of the bats found. The other species included silver-haired bats (n=7), eastern red bats (n=5), little brown bats (n=3) and an eastern small-footed bat (n=1). The two latter *Myotis* species, little brown bat and eastern small-footed bat, are both listed as endangered species in New Hampshire. The Project's Immediate Alert Procedure was followed for each of the four *Myotis* carcasses found.

**Table 3-1. Total Number and Species Composition of Bird and Bat Fatalities Found at Antrim Wind Project, 2020.**

| Species | | Number of Carcasses | Percent of Carcasses |
|---|---|---|---|
| **Birds** | | | |
| red-breasted nuthatch | *Sitta canadensis* | 2 | 25.0% |
| red-eyed vireo | *Vireo olivaceus* | 1 | 12.5% |
| turkey vulture | *Cathartes aura* | 1 | 12.5% |
| northern flicker* | *Colaptes auratus* | 1 | 12.5% |
| northern parula | *Setophaga americana* | 1 | 12.5% |
| American redstart | *Setophaga ruticilla* | 1 | 12.5% |
| golden-crowned kinglet | *Regulus Satrapa* | 1 | 12.5% |
| | **Total Birds** | **8** | **100.0%** |
| **Bats** | | | |
| hoary bat | *Lasiurus cinereus* | 15 | 34.9% |
| big brown bat* | *Eptesicus fuscus* | 12 | 27.9% |
| silver-haired bat | *Lasionycteris noctivagans* | 7 | 16.3% |
| eastern red bat | *Lasiurus borealis* | 5 | 11.6% |
| little brown bat | *Myotis lucifugus* | 3 | 7.0% |
| eastern small-footed bat | *Myotis leibii* | 1 | 2.3% |
| | **Total Bats** | **43** | **100.0%** |

*includes one carcass found incidentally

Based on carcass condition, most of the birds found (n=4; 50.0%) were estimated to have died 2 to 3 days prior to discovery. Almost half of the bats found (n=21; 48.8%) were estimated to have died the night prior to discovery (Table 3-2).

**Table 3-2. Estimated Time of Death for Bird and Bat Carcasses Found at Antrim Wind Project, 2020.**

| Species Type | Estimated Time of Death | Number of Carcasses | Percent of Carcasses |
|---|---|---|---|
| Birds | Last night | 1 | 12.5% |
| | 2–3 days | 4 | 50.0% |
| | 4–7 days | 3 | 37.5% |
| Bats | Last night | 21 | 48.8% |
| | 2–3 days | 9 | 20.9% |
| | 4–7 days | 13 | 30.2% |

### 3.1.2 Temporal Distribution of Fatalities

All birds were found during the summer and fall migration months. The majority of the birds were found during September (n=3; 37.5%) followed by August (n=2; 25.0%). No birds were found during the spring migration months (Table 3-3; Figure 3-1).

**Table 3-3. Seasonal Timing of Bird Fatalities, Antrim Wind Project, 2020.**

| Month | Number of Birds | Percent Total |
|---|---|---|
| April | 0 | 0.0% |
| May | 0 | 0.0% |
| June | 1 | 12.5% |
| July | 1 | 12.5% |
| August | 2 | 25.0% |
| September | 3 | 37.5% |
| October | 1 | 12.5% |
| **Total** | **8** | **100.0%** |

Bats were found throughout the late spring, summer, and fall migration months. The first bat was found at the end of May (Appendix A Table 1). A majority of the bats were found during August (n=15; 34.9%) followed by July (n=10; 23.3%) (Table 3-4; Figure 3-1).

**Table 3-4. Seasonal Timing of Bat Fatalities, Antrim Wind Project, 2020.**

| Month | Number of Bats | Percent Total |
|---|---|---|
| April | 0 | 0.0% |
| May | 1 | 2.3% |
| June | 8 | 18.6% |
| July | 10 | 23.3% |
| August | 15 | 34.9% |
| September | 7 | 16.3% |
| October | 2 | 4.7% |
| **Total** | **43** | **100.0%** |

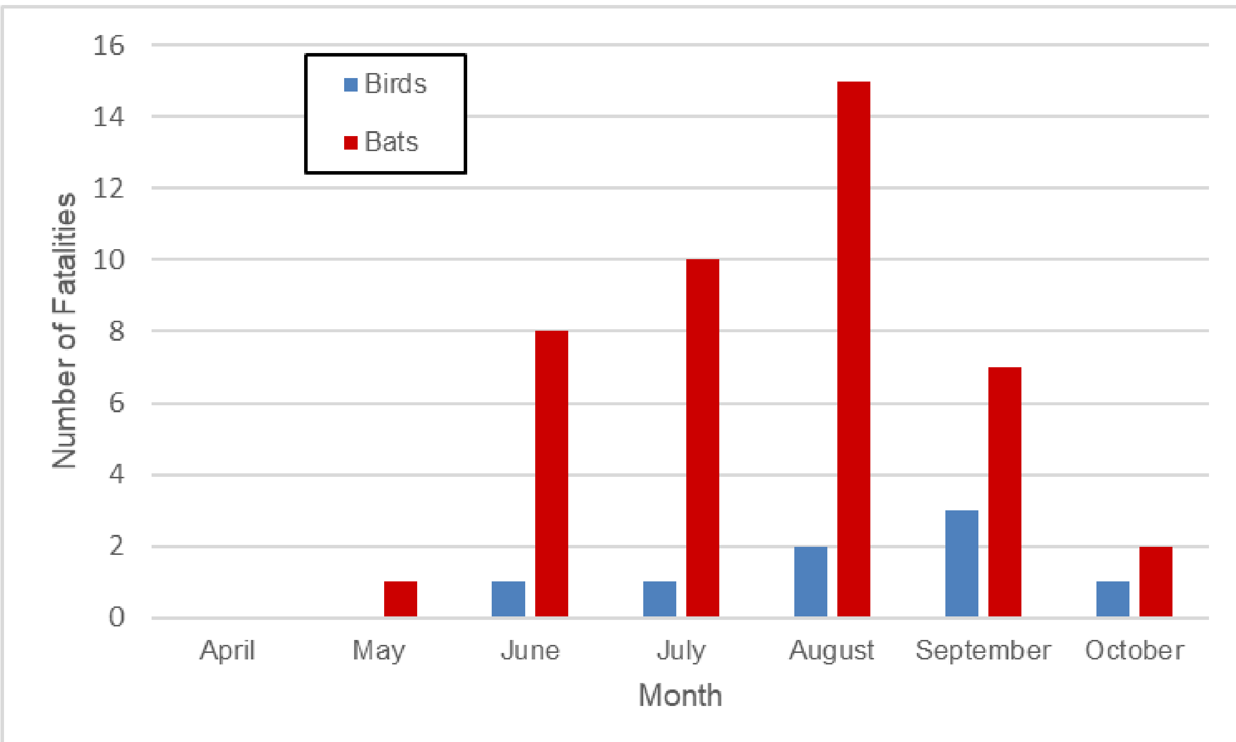


**Figure 3-1. Seasonal Timing of Bird and Bat Fatalities, Antrim Wind Project, 2020.**

### 3.1.3 Spatial Distribution of Fatalities

The number of birds found at individual turbines ranged from 0 birds (T01, T04, and T07) to 2 birds (T05 and T08). The number of bats found at individual turbines ranged from 1 bat (T02 and T08) to 12 bats (T09). The number of bird fatalities were relatively distributed across the nine turbines at the Project; however, most of the bat fatalities were found at T01 (n=6), T04 (n=6), T06 (n=9), and T09 (n=12). Almost half of the overall fatalities (birds and bats combined; n=23; 45.1%) were found at T09 (n=13; 25.5%) and T06 (n=10; 19.6%) (Table 3-5).

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

| Treatment | Turbine | Number of Bird Fatalities | Number of Bat Fatalities | Percent of Fatalities |
|---|---|---|---|---|
| Curtailed | T01 | 0 | 6 | 11.8% |
| | T02 | 1 | 1 | 3.9% |
| | T05 | 2 | 2 | 7.8% |
| | T07 | 0 | 3 | 5.9% |
| | T08 | 2 | 1 | 5.9% |
| Control | T03 | 1 | 3 | 7.8% |
| | T04 | 0 | 6 | 11.8% |
| | T06 | 1 | 9 | 19.6% |
| | T09 | 1 | 12 | 25.5% |
| **Total** | | **8** | **43** | **100.0%** |

The distance birds were found from turbine bases ranged from 5 m to 52 m (approximately 16 feet [ft] to 171 ft). The average distance a bird fatality was found from the base of a turbine was 31.7 m (104 ft). The distance bats were found from the turbine bases ranged from 6 m to 48 m (approximately 20 ft to 157 ft). The average distance a bat fatality was found from the base of a turbine was 22.7 m (74 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=27; 53%) of bird and bat fatalities were found between 0 m and 20 m (0 ft to 66 ft). A large number of bat fatalities (n=20) and a bird fatality (n=1) make up 41.2% of that 53.0% and were found in the 11 m to 20 m (36 ft to 66 ft) range (Figure 3-2).

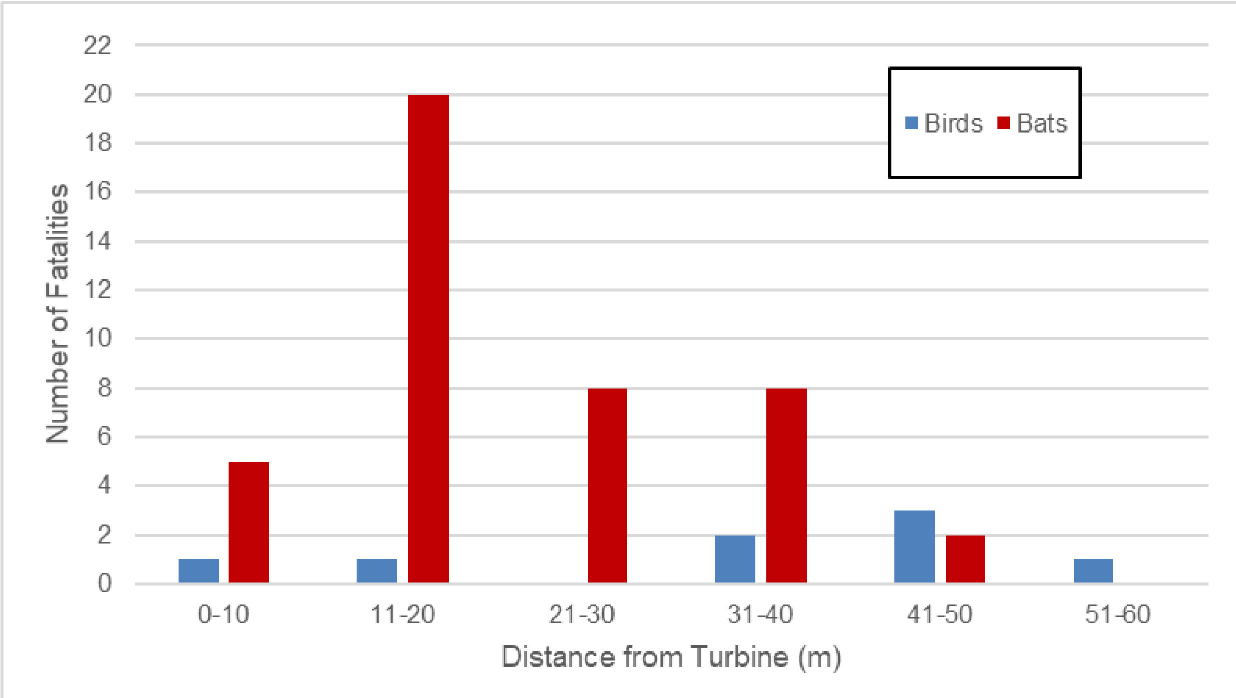


**Figure 3-2. Distribution of Bird and Bat Fatalities Found in 10-m Distance Increments from Turbines, Antrim Wind Project, 2020.**

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, northeast, and southwest quadrants of the search plots. Bat fatalities were found in all quadrants of the search plots. All fatalities were found less than 60 m from turbine bases (Figure 3-3).

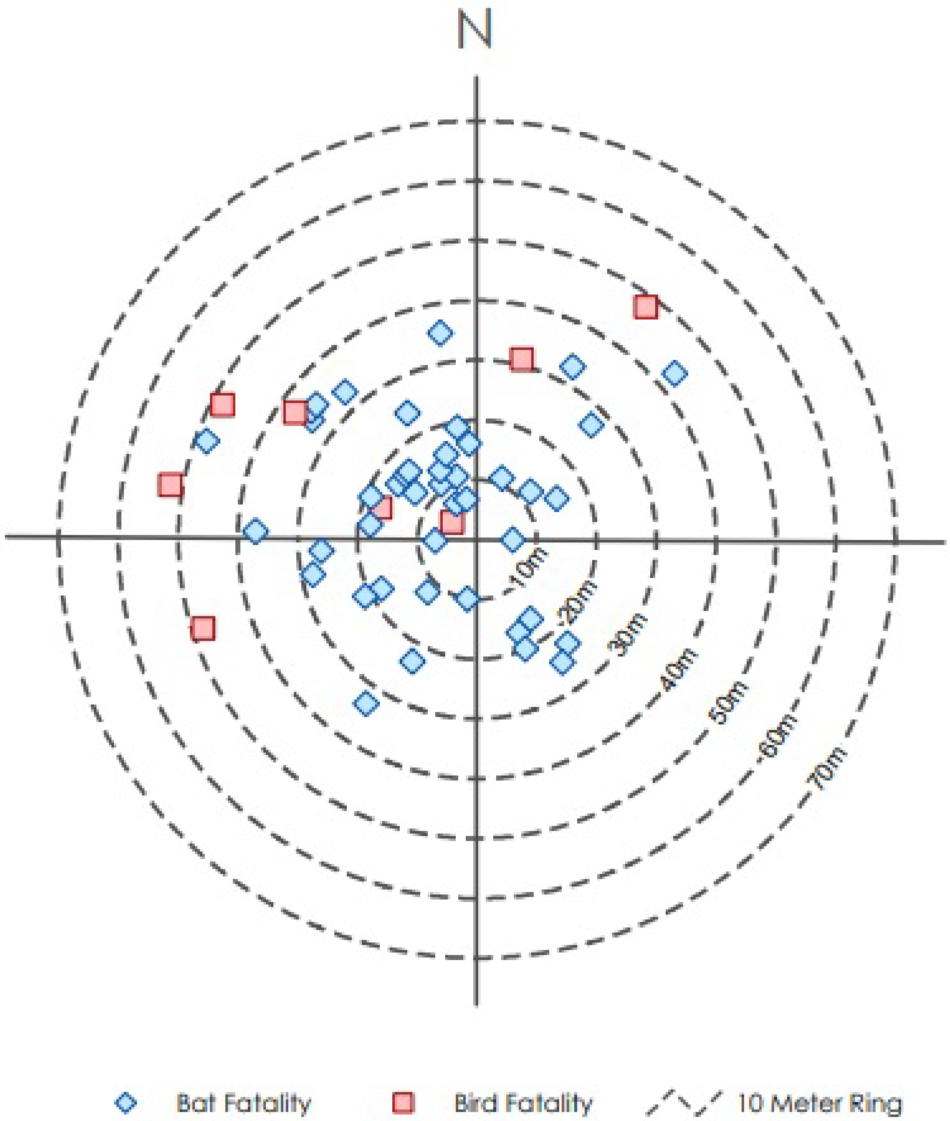


**Figure 3-3. Distribution of Bird and Bat Carcasses Found at Antrim Wind Project, 2020.**

### 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, 2020.**

| Distance Bin | Number birds found | Proportion all birds per bin | Distance bin | Number bats found | Proportion all bats per bin |
|---|---|---|---|---|---|
| 1–10 | 0 | 0.000 | 1–10 | 5 | 0.119 |
| 11–20 | 1 | 0.143 | 11–20 | 19 | 0.452 |
| 21–30 | 0 | 0.000 | 21–30 | 8 | 0.190 |
| 31–40 | 2 | 0.286 | 31–40 | 8 | 0.190 |
| 41–50 | 3 | 0.429 | 41–50 | 2 | 0.048 |
| 51–60 | 1 | 0.143 | 51–60 | 0 | 0.000 |
| **Total** | **7** | | **Total** | **42** | |

**Table 3-7. Density-Weighted Proportion (DWP) Area Searched Values for Birds and Bats, Antrim Wind Project, 2020.**

| Turbine Number | DWP Value | |
|---|---|---|
| | Birds | Bats |
| T01 | 0.615 | 0.918 |
| T02 | 0.486 | 0.807 |
| T03 | 0.559 | 0.878 |
| T04 | 0.471 | 0.817 |
| T05 | 0.485 | 0.794 |
| T06 | 0.493 | 0.797 |
| T07 | 0.397 | 0.726 |
| T08 | 0.514 | 0.866 |
| T09 | 0.715 | 0.942 |

### 3.1.5 Bird and Bat Fatality Estimates

Estimates for bird and bat fatality were generated with area corrections using the Huso estimator. The fatality estimate for birds was 3.65 birds/turbine/year, or 33 birds/year (Table 3-8)[3]. The fatality estimates for bats were 14.07 bats/turbine/year (control), or 127 bats/year(control), and 5.21 bats/turbine/year (experimental), or 47 bats/year (experimental) (Table 3-9).

**Table 3-8. Huso Estimates of Bird Fatality (All Turbines Combined) with Area Corrections, Antrim Wind Project, 2020.**

| Results | Birds, Area Corrected |
|---|---|
| **Number carcasses found** | 7 |
| **Adjusted fatality/turbine/year** | **3.65** |
| 95% CI lower | 2.33 |
| 95% CI upper | 6.37 |
| **Adjusted fatality/year** | **33** |
| 95% CI lower | 21 |
| 95% CI upper | 57 |
| **Adjusted fatality/MW/year** | **1.14** |

**Table 3-9. Huso Estimates of Bat Fatality (Control vs Experimental Curtailment) with Area Corrections, Antrim Wind Project, 2020.**

| Results | Bats, Area Corrected (Control) | Bats, Area Corrected (Experimental) |
|---|---|---|
| **Number carcasses found** | **42** | **42** |
| **Adjusted fatality/turbine/year** | **14.07** | **5.21** |
| 95% CI lower | 7.72 | 2.39 |
| 95% CI upper | 22.95 | 9.46 |
| **Adjusted fatality/year** | **127** | **47** |
| 95% CI lower | 69 | 22 |
| 95% CI upper | 207 | 85 |
| **Adjusted fatality/MW/year** | **4.40** | **1.63** |

### 3.1.6 Weather Conditions and Fatality Events

There was one night where a bird carcass was documented as 'fresh' (no signs of decomposition) upon discovery and was determined to have died the prior night. The wind speed for this night was 7.2 m/s and

[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.

the temperature was 29.8°C. The moon was a waning crescent, and the sky condition was partly cloudy (Table 3-10).

There were 15 cases where bat carcasses were documented as fresh upon discovery and were determined to have died the prior night. The mean nightly wind speed for these 15 nights was 5.0 m/s (median = 4.8 m/s) and the mean nightly temperature was 20.6°C. 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. The moon phase was variable among the 15 nights; however, for 7 of the 15 nights (46.7% of nights) the moon phase was a wanning crescent. The sky condition and weather also varied. It rained on 1 of the 15 nights (Table 3-10). 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, 2020.**

| 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/ Preceipitation[3] |
|---|---|---|---|---|---|---|
| 6/10/2020 | 6/9/2020 | 1 bat | 4.8 | 18.3 | Waning Gibbous | Clear |
| 6/15/2020 | 6/14/2020 | 2 bats | 4.2 | 14.6 | Waning Crescent | Mostly cloudy |
| 6/16/2020 | 6/15/2020 | 1 bat | 1.4 | 20.2 | Waning Crescent | Clear |
| 6/30/2020 | 6/29/2020 | 1 bat | 4.8 | 17.4 | Waxing Gibbous | Rain |
| 7/5/2020 | 7/4/2020 | 2 bats | 2.6 | 28.1 | Full Moon | Few clouds |
| 7/16/2020 | 7/15/2020 | 1 bat | 5.1 | 20.4 | Waning Crescent | Mostly cloudy |
| 7/20/2020 | 7/19/2020 | 1 bat; 1 bird | 7.2 | 29.8 | Waning Crescent | Partly cloudy |
| 8/14/2020 | 8/13/2020 | 2 bats | 3.8 | 27.5 | Waning Crescent | Partly cloudy |
| 8/15/2020 | 8/14/2020 | 2 bats | 4.6 | 25.3 | Waning Crescent | Few clouds |
| 8/19/2020 | 8/18/2020 | 2 bats | 7.0 | 20.6 | Waxing Crescent | Clear |
| 9/8/2020 | 9/7/2020 | 2 bats | 6.8 | 21.5 | Waning Gibbous | Overcast, low clouds |
| 9/12/2020 | 9/11/2020 | 1 bat | 5.3 | 15.3 | Waning Crescent | Clear |
| 9/26/2020 | 9/25/2020 | 1 bat | 4.1 | 21.7 | First Quarter | Partly cloudy |
| 10/6/2020 | 10/5/2020 | 1 bat | 5.9 | 13.9 | Waning Gibbous | Overcast, low clouds |
| 10/7/2020 | 10/6/2020 | 1 bat | 8.1 | 15.2 | Waning Gibbous | Partly cloudy |

[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.

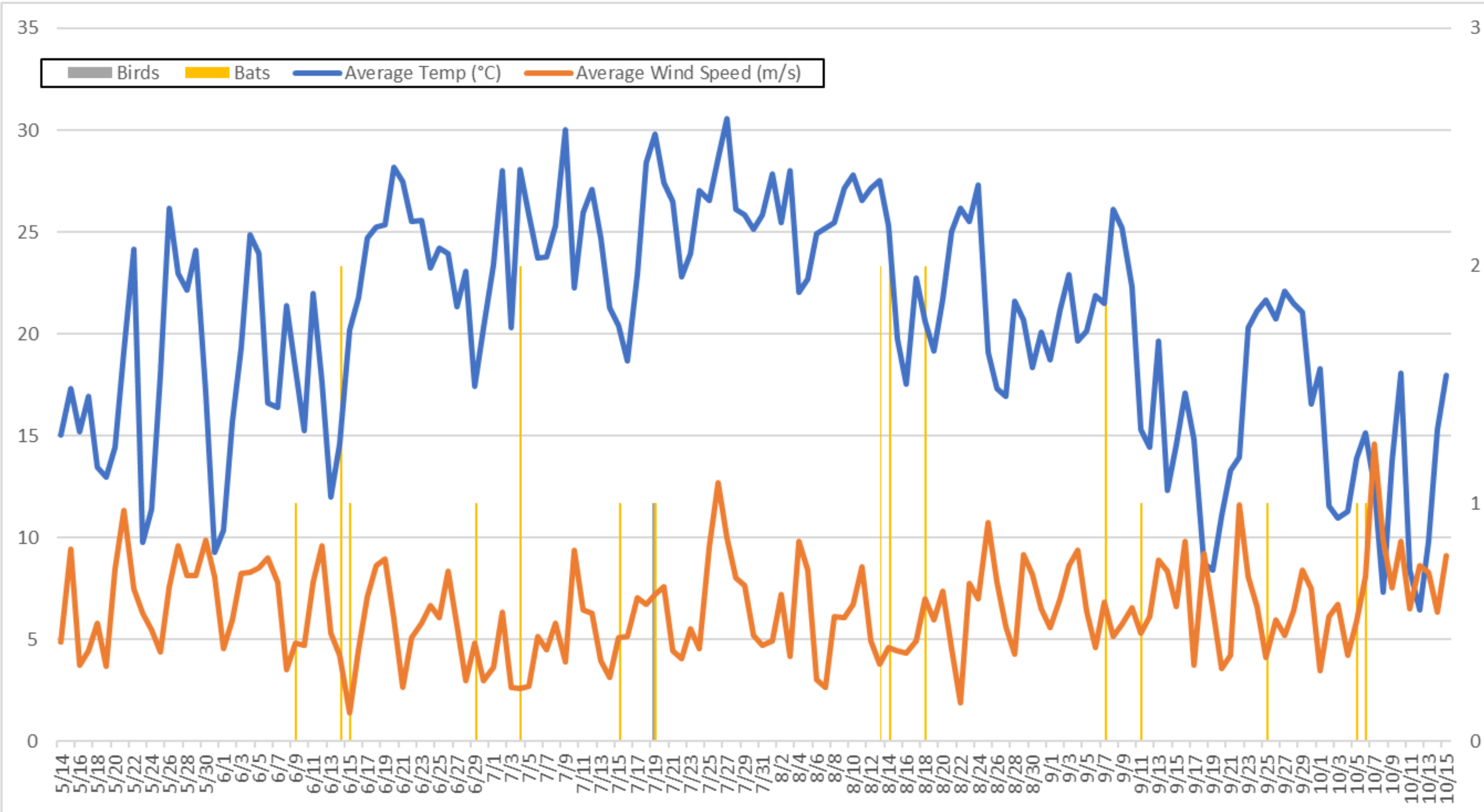


**Figure 3-4. Timing and Number of Bird and Bat Carcasses Found in Relation to Average Nightly Wind Speed and Air Temperature, Antrim Wind Project, 2020.**

## 3.2 SEARCHER EFFICIENCY TRIALS

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

- 5/26/2020
- 6/11/2020
- 7/1/2020
- 8/20/2020
- 9/17/2020
- 10/1/2020

A total of 29 native birds were placed for all searcher efficiency trials combined; however, 1 bird was not counted because it was scavenged prior to the search. Of the 28 birds available to be found, 13 were found. The mean searcher efficiency rate for birds was 46% (Table 3-11).

**Table 3-11. Searcher Efficiency Rate (SE) for Trial Birds, 95% Confidence Interval, Antrim Wind Project, 2020.**

| | |
|---|---|
| Number of trial birds placed | 28 |
| Number of trial birds found | 13 |
| Mean SE | 0.46 |
| Lower SE | 0.29 |
| Upper SE | 0.64 |

A total of 27 bats (20 bats and 7 mice surrogates) were placed for all searcher efficiency trials combined; however, 1 mouse was not counted because it was scavenged prior to the search. Of the 26 bats available to be found, 17 (bats and mice surrogates) were found. The mean searcher efficiency rate for bats was 65% (Table 3-12).

**Table 3-12. Searcher Efficiency Rate (SE) for Trial Bats, 95% Confidence Interval, Antrim Wind Project, 2020.**

| | |
|---|---|
| Number of trial bats placed | 26 |
| Number of trial bats found | 17 |
| Mean SE | 0.65 |
| Lower SE | 0.46 |
| Upper SE | 0.85 |

## 3.3 CARCASS PERSISTENCE TRIALS

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

- 5/26/2020
- 6/11/2020
- 7/20/2020
- 9/16/2020
- 10/1/2020

There was a total of 26 birds (6 native birds and 20 quail surrogates) placed for all carcass persistence trials combined. The mean number of days a trial bird carcass persisted was 16.95 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, 2020.**

| | |
|---|---|
| Number of trial birds placed | 26 |
| Mean number of days CP | 16.95 |
| Lower number of days CP | 11.23 |
| Upper number of days CP | 27.25 |
| Mean CP rate | 0.87 |
| Lower CP rate | 0.81 |
| Upper CP rate | 0.91 |

There was a total of 26 bats (10 bats and 16 mice surrogates) placed for all carcass persistence trials combined. The mean number of days a trial bat persisted was 10.46 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, 2020.**

| | |
|---|---|
| Number of trial bats placed | 26 |
| Mean number of days CP | 10.46 |
| Lower number of days CP | 7.02 |
| Upper number of days CP | 16.82 |
| Mean CP rate | 0.91 |
| Lower CP rate | 0.85 |
| Upper CP rate | 0.96 |

## 3.4 CURTAILMENT EVALUATION STUDY

Five turbines (T01, T02, T05, T07, and T08) were curtailed from 30 minutes after sunset to sunrise from July 15 to September 30, 2020, at wind speeds below 5.0 m/s per the Study Plan. Operational data were available between May 15 and October 15, representing 9,185–9,259 10-minute periods per turbine between sunset and sunrise. Curtailment conditions were met for 910–1,801 10-minute periods per turbine for the five curtailed turbines. Curtailment occurred during 85.8–86.9% of these periods (Table 3-15). Graphical comparison of median turbine rpm as a function of wind speed at day and night illustrates the operational difference between the curtailed and control turbines during the 2020 survey period (Figure 3-5).

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

| Turbine (treatment) | Number of 10-minute periods | Number of Periods meeting Curtailment Conditions | Number of Periods Curtailed (%)* |
|---|---|---|---|
| T01 (Curtailed) | 9,185 | 1,801 | 1,565 (86.9%) |
| T02 (Curtailed) | 9,256 | 942 | 819 (86.9%) |
| T03 (Control) | 9,256 | 0 | 0 |
| T04 (Control) | 9,257 | 0 | 0 |
| T05 (Curtailed) | 9,198 | 910 | 787 (86.5%) |
| T06 (Control) | 9,258 | 0 | 0 |
| T07 (Curtailed) | 9,258 | 1,076 | 924 (85.9%) |
| T08 (Curtailed) | 9,259 | 1,096 | 940 (85.8%) |
| T09 (Control) | 9,259 | 0 | 0 |
| **Total** | **83,186** | **5,825** | **5,035(86.4%)** |

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

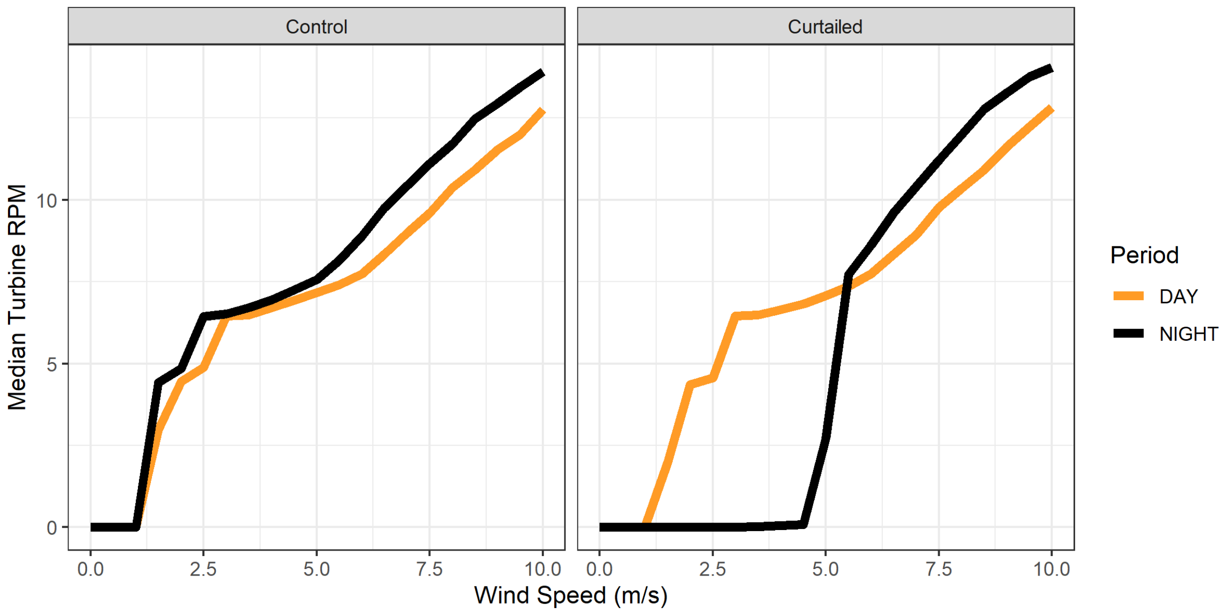


**Figure 3-5. Median Turbine RPM During the Day and Night as a Function of Wind Speed for Treatment Turbines During the Curtailment Period.**

The curtailment period took place during the peak period of bat collision risk. A majority of the bat carcasses were found during the curtailment period; however, bat carcasses were also found before and after the curtailment period. Two bat carcasses were found at the curtailed turbines during the curtailment period and were documented as being fresh with the estimated time of death believed to be the prior night. The previous night's curtailment activity is summarized in Table 3-16 for the turbine where the two fresh bat carcasses were found.

**Table 3-16. Summary of Fresh Bat Carcasses Found and Turbine Activity the Previous Night, Antrim Wind Project, 2020.**

| Turbine | Night of: | Species | Total Number of Periods | Periods Meeting Curtailment Conditions | Periods Curtailed | Percent Curtailed |
|---|---|---|---|---|---|---|
| T07 | 8/13/2020 | hoary bat | 60 | 45 | 37 | 82.20%[1] |
| T07 | 9/11/2020 | eastern red bat | 68 | 6 | 6 | 100.00% |

[1] As noted, there is a lag time associated with turbines ramping down once conditions for curtailment are met.

## 3.5 ACOUSTIC BAT SURVEY

Bat detectors operated for a total of 504 out of 667 (76%) available detector-nights between May 1 and October 15, 2020 (Table 3-17). Bat detectors recorded a total of 1,952 bat passes during this period, yielding an overall activity level of 3.9 passes per detector night (DN) (Table 3-17). The T03 detector recorded the lowest detection rate (2.1 passes per DN) and the T01 detector recorded the greatest detection rate (6.0 passes per DN).

**Table 3-17. Acoustic Survey Effort and Results, Antrim Wind Project, 2020.**

| Turbine | Survey Dates | Calendar Nights | Detector Nights (DN) | Bat Passes | Rate (passes per DN) | Maximum Passes per Night |
|---|---|---|---|---|---|---|
| T01 | May 1 – October 15 | 168 | 111 | 670 | 6.0 | 80 |
| T03 | May 1 – October 15 | 168 | 148 | 318 | 2.1 | 24 |
| T06 | May 3 – October 15 | 166 | 166 | 686 | 4.1 | 73 |
| T08 | May 4 – October 15 | 165 | 79 | 278 | 3.5 | 44 |
| | **Total** | **667** | **504** | **1,952** | **3.9** | **-** |

Of the 1,952 recorded bat passes, Stantec identified 1,716 (88%) to species or species group and categorized the remainder as high frequency or low frequency unknown passes. Hoary bats were the most commonly identified species at all detectors, besides T01 where silver-haired bats were the most commonly identified. Overall, hoary bats accounted for 57% of passes identified to species (Table 3-18). Silver-haired and eastern red bats accounted for 26% and 2% of identified passes, respectively. Together, these three long-distance migratory species accounted for 85% of passes identified to species or species group. Big brown bats accounted for 12% of identified species. Two percent of bat passes were identified as either big brown or silver-haired bat and less than 1% were identified as either eastern red or tri-colored bat. Only 6 passes were identified as *Myotis* species, most likely little brown bat, with activity occurring at only T01 and T06.

**Table 3-18. Species Composition of Recorded Bat Activity, Antrim Wind Project, 2020.**

| Turbine | Big brown/ silver-haired | | | Hoary bat | *Myotis* | Eastern Red/ Tri-colored Bat | | | Unknown | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Big Brown | Silver-haired | BBSH | | | Eastern Red | Tri-colored | RBTB | High Frequency | Low Frequency | |
| T01 | 67 | 224 | 28 | 170 | 4 | 11 | | 1 | 5 | 160 | 670 |
| T03 | 2 | 89 | | 201 | | 11 | | | | 15 | 318 |
| T06 | 92 | 109 | 2 | 438 | 2 | 14 | | | 6 | 23 | 686 |
| T08 | 52 | 29 | | 169 | | 1 | | | 1 | 26 | 278 |
| **Total** | **213** | **451** | **30** | **978** | **6** | **37** | | **1** | **12** | **224** | **1,952** |

Seasonal patterns in activity varied among turbines. A peak in activity occurred in mid-June at T06 and T08; however, the detectors at T01 and T03 were not operating during this period (Figure 3-6) due to equipment malfunction. As noted in Section 2.6, an additional two acoustic detectors were utilized to provide redundancy, increase the survey area, and maintain capacity for continuous data collection over the study period. Activity peaked in mid-August at T01 and T03. This peak in activity was not observed at T06 and the detector at T08 was not operating during this period (Figure 3-6) due to equipment malfunction. Overall timing of bat activity showed similar patterns among species groups but varied slightly among detectors, with activity generally decreasing the few hours before sunrise (Figure 3-7).

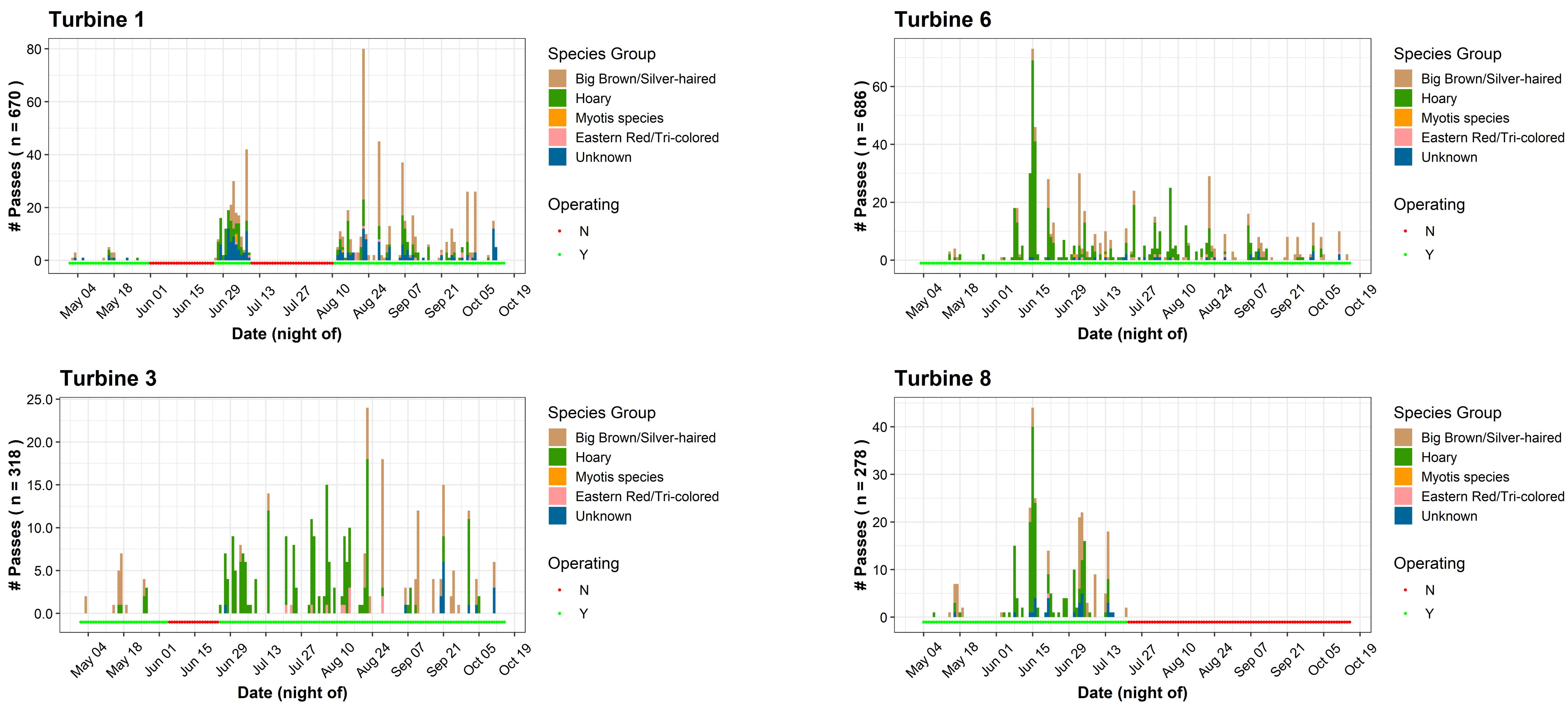


**Figure 3-6. Total Bat Passes Identified to Species Per Week, by Turbine, Antrim Wind Project, 2020.**

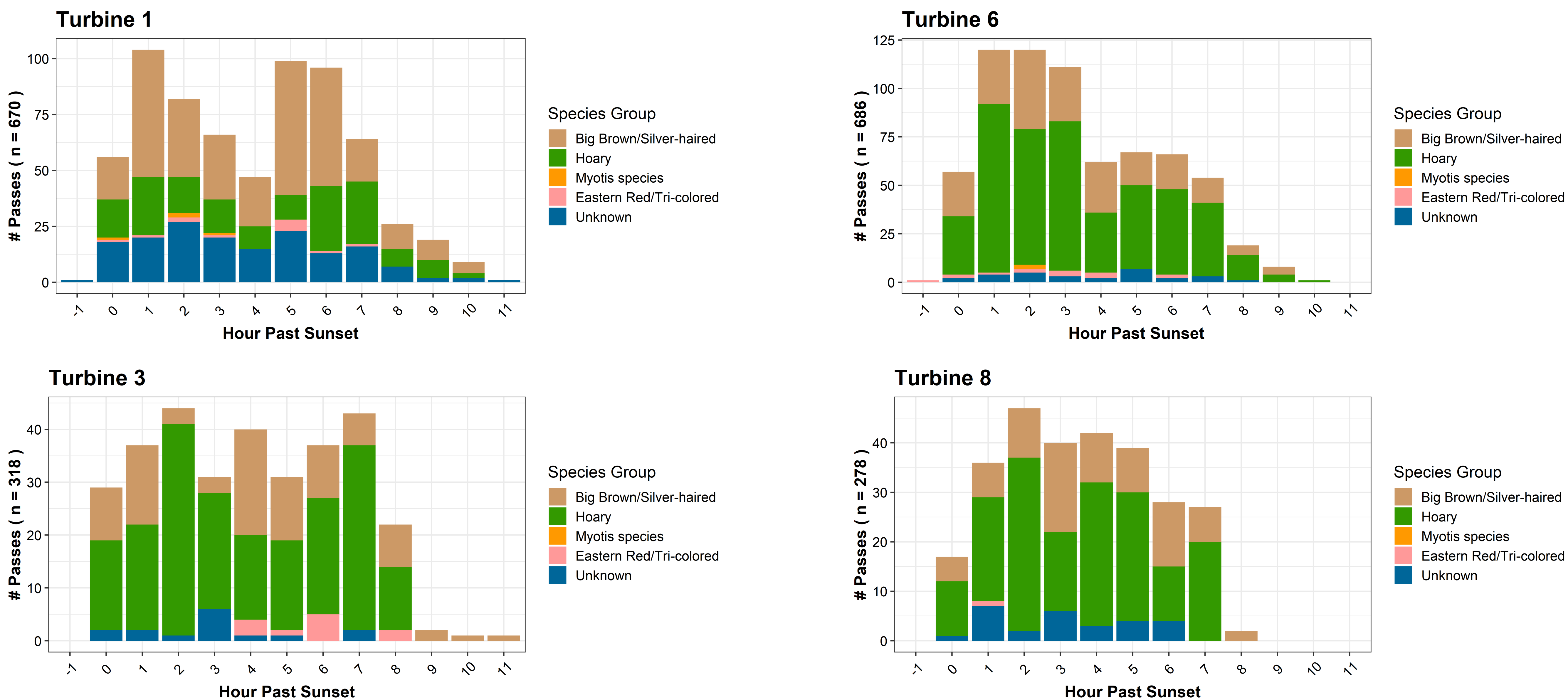


**Figure 3-7. Overall Timing of Bat Activity, by Turbine, Antrim Wind Project, 2020.**

### 3.5.1 Bat Activity and Weather

Bat activity showed clear relationships with temperature and wind speed measured at corresponding turbine nacelles, with 92% of passes for which weather data were available (n = 1,931) occurring when temperature was greater than 15°C and 85% of passes occurring at wind speeds less than 5 m/s (Figure 3-8, Figure 3-9). Considering temperature and wind speed together, bat activity occurred disproportionally during calm, warm conditions, and few bat passes were recorded during times with higher wind speeds or cooler temperatures (Figure 3-10).

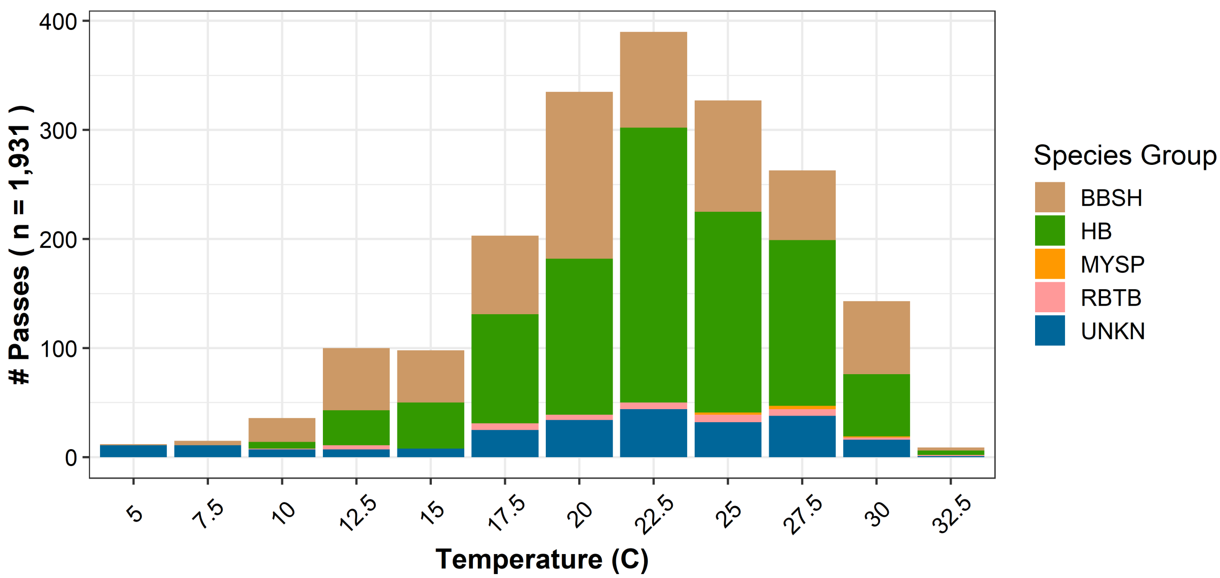


**Figure 3-8. Bat Activity by Temperature Bin (2.5 Degrees C) Recorded at Turbines 1, 3, 6, and 8 Combined, Antrim Wind Project, 2020.**

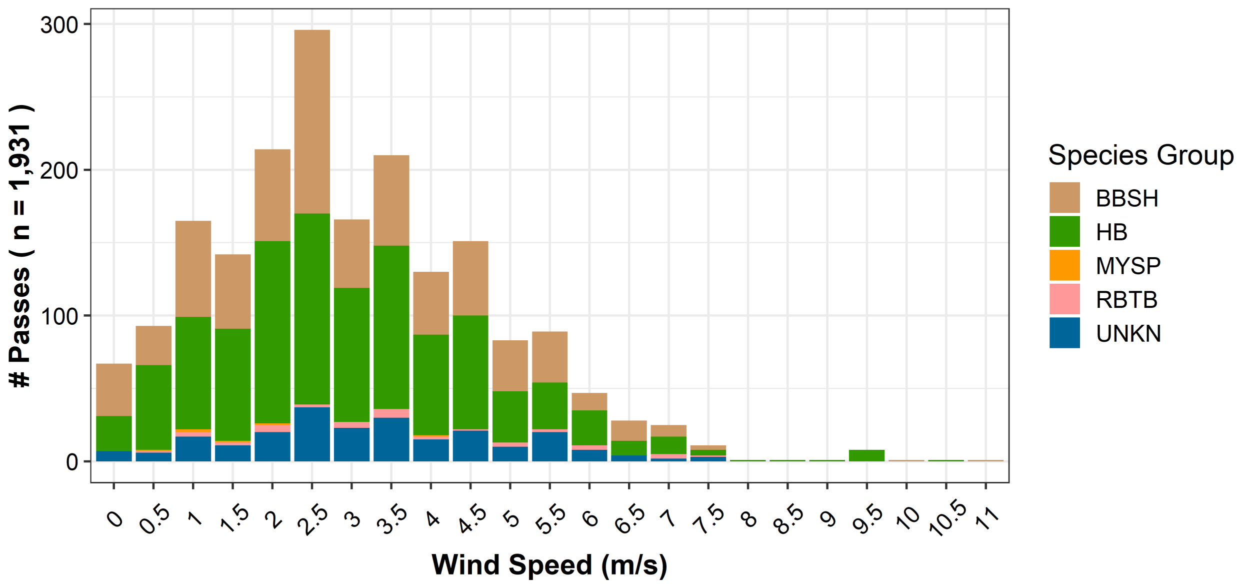


**Figure 3-9. Bat Activity by Wind Speed Bin (0.5 m/s) Recorded at Turbines 1, 3, 6, and 8 Combined, Antrim Wind Project, 2020.**

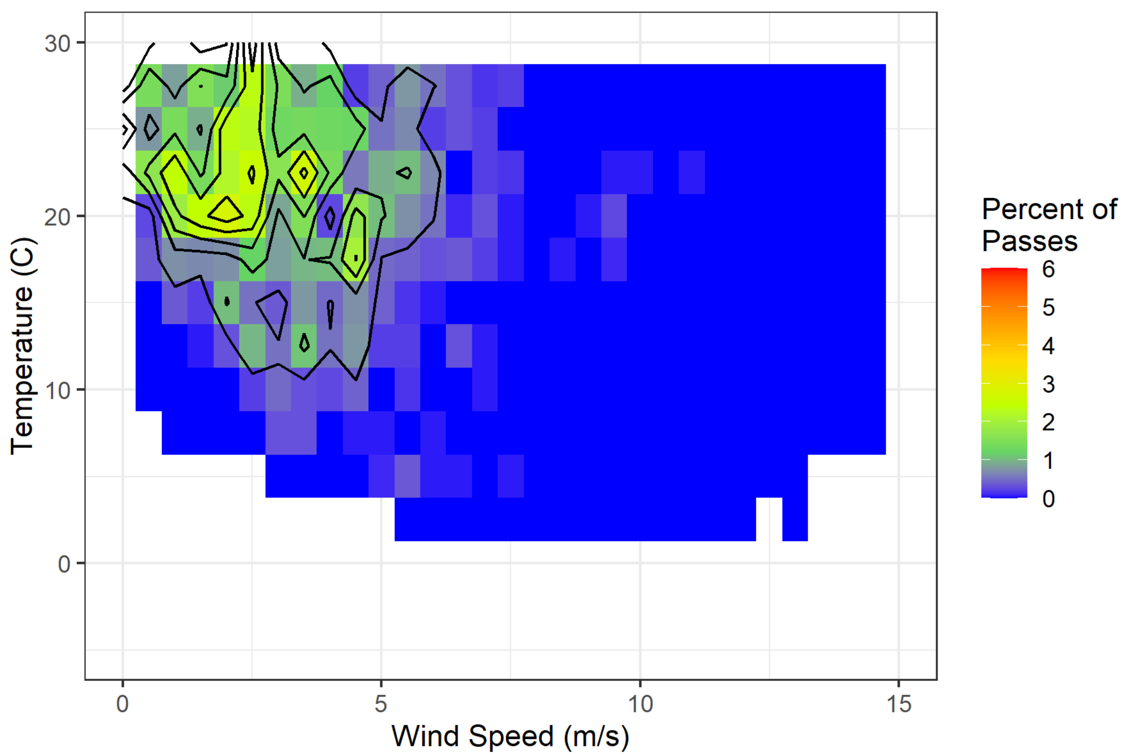


**Figure 3-10. Percent of Bat Passes as a Function of Wind Speed and Temperature Based on Nacelle-Mounted Acoustic Detectors, Antrim Wind Project, 2020.**

### 3.5.2 Bat Activity and Turbine Operation

Of the four turbines with bat detectors, two were curtailed and two were control, providing an opportunity to compare measured exposure of bat passes to turbine operation at experimental versus control turbines. Outside the curtailment period (i.e., before July 15 and after September 30), exposure of bat activity to turbine operation was similar at both groups of turbines (Table 3-19) whereas the percent of passes exposed to turbine operation was significantly lower at experimental turbines during the curtailment period when analyzed on a weekly basis ($F(1,44) = 238.56$, $p < 0.001$, $R^2 = 0.84$; Figure 3-11). In Figure 3-11, the boxes represent the upper and lower quartiles, the horizontal bar represents the median percentage, and the black dot represents an outlier.

**Table 3-19. Exposure of Bat Passes to Turbine Operation at Treatment and Control Turbines Inside and Outside the Curtailment Period, Antrim Wind Project, 2020.**

| Curtailment Period | Treatment | NPasses | Exposed | Percent |
|---|---|---|---|---|
| Outside | Control | 509 | 388 | 76.2 |
| | Experimental | 567 | 443 | 78.1 |
| Inside | Control | 489 | 395 | 80.8 |
| | Experimental | 366 | 55 | 15.0 |

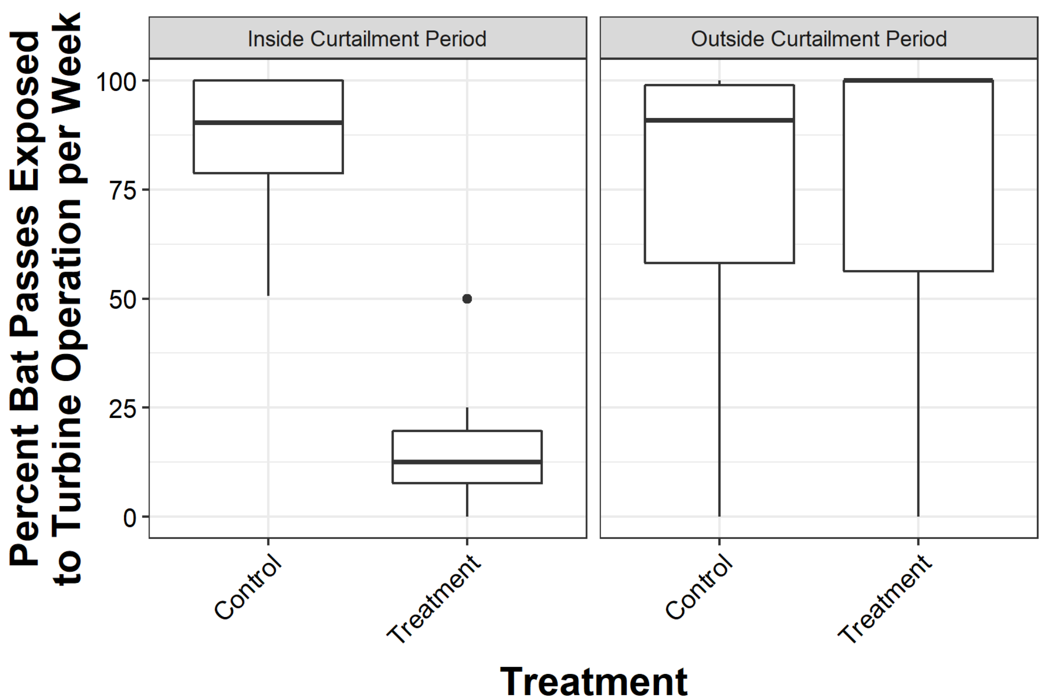


**Figure 3-11. Percent of Bat Passes Exposed to Turbine Operation on a Weekly Basis at Control Versus Treatment Turbines Inside and Outside the Curtailment Period, Antrim Wind Project, 2020.**

### 3.5.3 Bat Activity and Fatalities

Acoustic bat data were available for the interval preceding 104 turbines searched at T01, T03, T06, and T08, with bat carcasses found during 12 of these searches. The probability of finding a bat carcass was significantly greater following intervals with higher rates of exposed bat activity ($\chi^2 = 6.1$, $p = 0.014$), although total bat activity did not have the same effect on probability of carcass detection ($\chi^2 = 2.0$, $p = 0.16$; Figure 3-12).

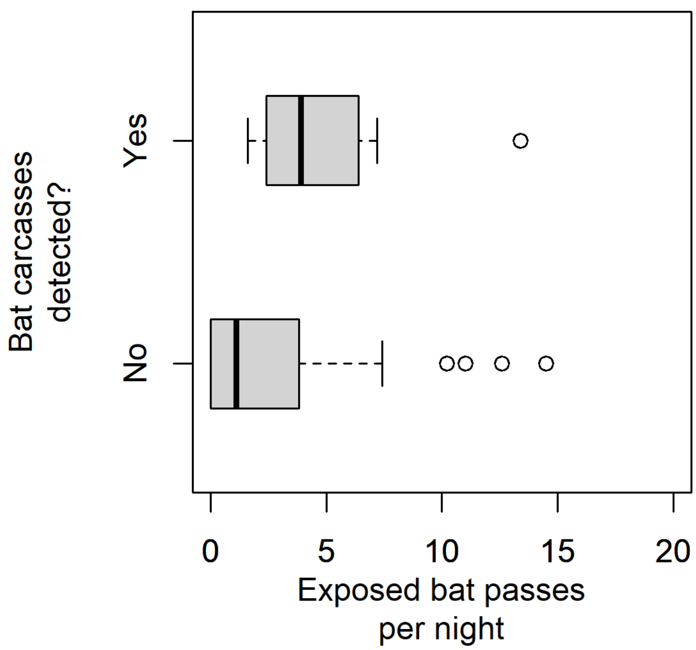


**Figure 3-12. Distribution of the Rate of Exposed Bat Passes Detected During Intervals Before Turbine Searches with and Without Bat Carcasses, Antrim Wind Project, 2020.**

## 3.6 COMMON NIGHTHAWK SURVEYS

Common nighthawk surveys were conducted on three separate occasions during the survey period (Table 3-20). The four survey points were in open areas (0% canopy cover), ranged from 15 m to 35 m from the forest edge, and all had the same vegetation characteristics (Table 3-21). All surveys were conducted during the required weather conditions except for one survey. On July 5, 2020, a thunderstorm moved in during the survey (Table 3-22). There were no nighthawks seen or heard during the surveys.

**Table 3-20. Common Nighthawk Survey Dates, Antrim Wind Project, 2020.**

| Survey Number | Dates |
|---|---|
| 1 | 6/4/20 – 6/6/20 |
| 2 | 7/2/20, 7/5/20 – 7/6/20 |
| 3 | 7/19/20 – 7/21/20 |

**Table 3-21. 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 3-22. Weather Conditions During Each Common Nighthawk Survey Conducted.**

| Survey Point | Date | Sky | Wind Speed (mph) | Temperature (°C) | Morning (M)/ Night (N) |
|---|---|---|---|---|---|
| 1 | 6/4/2020 | Scattered clouds/variable sky | 1–3 | 26.7 | N |
| 2 | 6/5/2020 | Scattered clouds/variable sky | 1–3 | 21.1 | M |
| 3 | 6/5/2020 | Scattered clouds/variable sky | 4–8 | 26.7 | N |
| 4 | 6/6/2020 | Scattered clouds/variable sky | 4–8 | 20.0 | M |
| 1 | 7/2/2020 | Partly cloudy/broken sky | 1–3 | 24.4 | N |
| 2 | 7/2/2020 | Partly cloudy/broken sky | 1–3 | 24.4 | N |
| 3 | 7/5/2020 | Thunderstorm* | 4–8 | 23.3 | N |
| 4 | 7/6/2020 | Partly cloudy/broken sky | 4–8 | 19.4 | M |
| 3 | 7/19/2020 | Partly cloudy/broken sky | 4–8 | 27.2 | N |
| 1 | 7/20/2020 | Scattered clouds/variable sky | 4–8 | 22.8 | M |
| 2 | 7/20/2020 | Clear | 1–3 | 25.0 | N |
| 4 | 7/21/2020 | Scattered clouds/variable sky | 1–3 | 19.4 | M |

* Survey conducted during inadequate weather conditions.

# 4.0 DISCUSSION

## 4.1 FATALITY SEARCHES

### 4.1.1 Fatalities Discovered and Fatality Estimates – Birds

Passerines made up the majority of the bird fatalities found at the Project. The migrant passerine group is the most diverse and abundant group of birds in the world. 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 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). Other wind facilities in the northeast have discovered the same findings. A total of 2,039 bird fatalities were reported by 44 northeast wind facilities, and 78% of those fatalities were passerines (Choi et al. 2020). Three of the most common species found were red-eyed vireo (*Vireo olivaceus*), golden-crowned kinglet (*Regulus satrapa*), and turkey vulture (*Cathartes aura*; Choi et al. 2020), all of which were found at the Project in 2020.

The estimated bird fatality rate at the Project is 3.65 birds/turbine/year, or 33 birds/year. Compared to other wind projects in New Hampshire, the estimated bird fatality at the Project is low. Estimated bird fatalities at the Lempster wind project were 81 birds/year and 63 birds/year in 2009 and 2010, respectively, and estimated bird fatalities at the Granite Reliable wind project were 66 to 92 birds/year in 2012 (Curry and Kerlinger 2013; Tidhar et al. 2010 and 2011). The estimated number of bird fatalities is small considering the population estimates of the species that were found at the Project (Table 3-1). The Partners in Flight (PIF) database[4] provides estimates of North American landbird populations. The PIF database estimates that there are 130 million red-eyed vireos, 8.4 million turkey vultures, 20 million red-breasted nuthatches, 11 million northern flickers, 18 million northern parulas, 42 million American redstarts, and 130 million golden-crowned kinglets in the U.S. (PIF 2020[4]). Relatively, impacts on bird populations from wind turbines are low compared to other anthropogenic causes including buildings, cats, automobiles, pesticides, and communication towers (Erickson et al. 2005).

### 4.1.2 Fatalities Discovered and Fatality Estimates – Bats

More bat fatalities were found than bird fatalities at the Project (Table 3-1), which is consistent with results of fatality monitoring studies at other wind projects in the U.S. (Thompson et al. 2017). Bat fatalities found at the Project consisted of three tree-roosting species (hoary bat, silver-haired bat, and eastern red bat) and three rock- or cave-dwelling species (big brown bat, little brown bat, and eastern small-footed bat), with hoary bats (n=15) and big brown bats (n=12) making up 62.8% of the total bat fatalities found. Most of the bat fatalities found were tree-roosting species (Table 3-1). Migratory tree-roosting species are most commonly found at wind projects during fatality studies in North America (Arnett et al. 2008) with hoary bats being the most frequently killed (Thompson et al. 2017). A total of 418 bat fatalities were reported by

[4] Available at http://pif.birdconservancy.org/

22 northeast wind facilities, and 90% of those fatalities were migratory tree-roosting bats (Choi et al. 2020). Almost as many big brown bat fatalities (n=12) were found as hoary bat fatalities (n=15) at the Project, which is inconsistent with results at other northeast wind projects.

The estimated bat fatality rate for turbines in the control treatment group at the Project is 14.07 bats/turbine/year [4.4 bats/MW/year], or 127 bats/year. The estimated bat fatality rate for turbines in the experimental treatment group is 5.21 bats/turbine/year [1.63 bats/MW/year], or 47 bats/year The control group fatality estimate is higher 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). The experimental curtailment group fatality estimate is lower than the Lempster, Granite Reliable, and Groton projects, but it is important to note that none of these projects are curtailing. There is limited information on bat population abundance and trends; however, many species are in decline (Thompson et al. 2017). The decline in bat populations, especially species that hibernate in large colonies in the northeast such as cave-dwelling species, including *Myotis* species, is linked to white-nose syndrome, an infectious disease spread between bats (USGS 2015).

Three little brown bats and one eastern small-footed bat were found at the Project. A higher number of *Myotis* species were taken from the Project compared to 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.

### 4.1.3 Temporal Distribution

During the 2020 study period, 75% of bird fatalities occurred during the fall migration period of August through October (Table 3-3). No bird fatalities were discovered during the spring migration months of April or May. When compared to other wind projects in the region, it is typical to document bird fatalities during fall migration. However, when compared to other wind projects in the region it is unusual that no bird fatalities were found in May during spring migration (Choi et al. 2020).

Bat fatalities were found at the Project from May to October, and none were found in April. Most bat fatalities were found from June to September, with fatalities peaking in August (n=15; 34.9%) (Table 3-4). These results are consistent with results at other U.S. wind projects and wind projects in the northeast, as most bat fatalities occur between July and October (Choi et al. 2010; Thompson et al. 2017).

### 4.1.4 Spatial Distribution

Most of the bird and bat carcasses (68.7%; Table 3-5) were found at turbines T01 (n=6), T04 (n=6), T06 (n=9), and T09 (n=12). The average distance a carcass was found from the base of a turbine was 22.7 m. Over half of the fatalities (53%; n=27; Figure 3-2) were found between 0 and 20 m from the base of a turbine. This is consistent with results documented at other U.S. wind projects. Kerns and Kerlinger (2004) reported birds falling an average of 20.8 m and bats falling an average of 18.87 m at the Mountaineer project in Tucker County, West Virginia. Most of the bird and bat fatalities at the Mountaineer project were found between 16 and 30 m (Kerns and Kerlinger 2004). Another example is the Meyersdale, Pennsylvania, project, where the majority of the bird and fatalities in 2004 were found within 30 m of turbine bases (Kerns et al. 2005). These results, as well as carcass distance distributions observed at the Project, suggest that few carcasses may have landed further than 60 m from turbines.

### 4.1.5 Weather Conditions and Fatality Events

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). This relationship was observed at the Project, as more fresh bat carcasses (75%; n=15) were found during the warmer months (June, July, and August) and on nights when wind speeds dropped below 5 m/s (Figure 3-4). Less than 1% of the nights prior to finding fresh bat carcasses was characterized by rain. Only one bird carcass discovered was documented as fresh and suspected to have died the prior night. The sample size of fresh bird carcasses is too small to observe a correlation between weather and bird fatalities.

## 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 (16.95 days for birds and 10.46 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. The estimates of fatality for the Project may be slightly overestimated by the Huso estimator due to the short search interval.

## 4.3 CURTAILMENT EVALUATION STUDY

Operational control is an effective method for reducing bat fatalities at wind facilities. Increased bat activity and bat fatalities are correlated with low wind speeds (Arnett et al. 2011). Arnett et al. (2011) documented a reduction in bat fatalities when cut-in speeds are altered, which is consistent with a similar study conducted by Baerwald et al. in 2009. These two studies differed in design, but both showed evidence that bat fatalities were reduced when cut-in speeds were raised. Specifically, Arnett et al. (2011) documented that bat fatalities were reduced by 44% when turbine cut-in speeds were raised to 5.0 m/s. Curtailment is most effective during the summer and fall months, as they are peak periods for bat activity and migration (Arnett et al. 2011).

Five turbines (T01, T02, T05, T07, and T08) were curtailed from 30 minutes after sunset to sunrise from July 15 to September 30, 2020 at wind speeds below 5.0 m/s at the Project. During the curtailment period, the number of periods meeting curtailment conditions were 6,174 and the number of periods actually curtailed were 5,050. The average rate of curtailment for all turbines in the experimental treatment group was 81.8%. A total of 27 bat fatalities were found during the curtailment period at all nine turbines combined. Three bat carcasses (11%) were found at the experimental turbines during the curtailment period, with two identified as fresh and believed to have died the night prior to discovery (Table 3-16). One *Myotis* species (a little brown bat) was found during the curtailment period at a control turbine (T09 in August). The other three myotis carcasses were found outside of the curtailment period in June and October.

Fatality estimates were run for bats using both the control and experimental treatment turbine data. The estimated bat fatality rate at control turbines is 14.07 bats/turbine/year, or 127 bats/year (Table 3-9). The estimated bat fatality at experimental turbines is 5.21 bats/turbine/year, or 47 bats/year (Table 3-9). Curtailment evaluation at the Project indicates a 63% decrease between the estimated number of fatalities at control turbines versus experimental turbines.

## 4.4 ACOUSTIC BAT SURVEY

Nacelle-height acoustic monitoring provided an opportunity to test the ability of the curtailment operations to reduce the exposure of bats to turbine operation and reduce the corresponding risk of turbine-related fatality. The data collected from the acoustic detectors provided confirmation of what was observed during the curtailment study and fatality searches/estimates.

The average number of bat passes per DN ranged from 2.1 to 6.0 among the four turbines. Hoary bats, silver-haired bats, and big brown bats were the most recorded species. These species of bats were also the most frequently found during fatality searches. The detectors showed two peaks of bat activity, one in mid-June (recorded at T06 and T08) and another in mid-August (recorded at T01 and T03). This seasonal trend was observed during the fatality searches, as a greater number of bat fatalities were found during these months. This confirms that bats are more active from June through August at the Project and is an appropriate period of time to implement a successful curtailment strategy.

The data from the bat detectors indicates that the probability of finding a bat carcass was greater at turbines following a night of intervals with higher rates of exposed bat activity (Figure 3-12). Bat activity is shown to be positively correlated with temperature and negatively correlated with wind speed (Figure 3-10). Acoustic detectors at the Project confirmed this, as bats were most active when the temperature was above 15°C and wind speeds were below 4.5 m/s. This, along with lower fatality estimates and lower bat exposure to turbine operation at experimental treatment turbines, suggests that a cut-in speed of 5.0 m/s could decrease bat fatalities at the Project in the future. Nacelle-height acoustic surveys are a reliable way to collect data that can be analyzed and used to create a curtailment program that is beneficial to the Project.

## 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, open pine-forests, prairies, and farmlands (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.

Common nighthawk surveys were conducted on three separate occasions (Table 3-20) at the Project. The surveys covered all nine turbines and took place from 8:00 pm to 9:30 pm and 3:30 am to 5:00 am. The survey points were located in open areas either near or between turbines, and the habitat surrounding the open areas was mixed forest. Surveys were conducted when temperatures were above 18.3°C, wind speeds were below 10 mph, and there was no rain, except for one survey period during which a thunderstorm moved through. Common nighthawks were not seen or heard during the surveys. A forested ridgeline with man-made clearings provides favorable habitat; however, it is likely common nighthawks were not nesting or foraging at the Project. Common nighthawks are known to be more active around dawn and dusk, but they are also active throughout the night and sometimes day. It is possible that if they were foraging or nesting near the Project, they were not near survey points or were not active during surveys. However, since common nighthawks were not seen or heard during surveys or found during fatality searches it is unlikely that they are nesting at the Project site.

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# APPENDICES

# APPENDIX A LIST OF FATALITIES

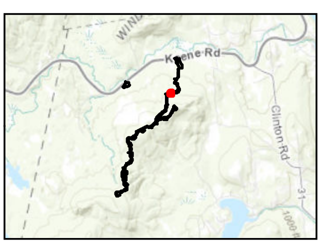
**Appendix A Table 1. List of Fatalities Found During the Survey Period, Antrim Wind Project, 2020**

| Date | Turbine | Common Name | Scientific Name | Subgroup | Age | Sex | Condition | Estimated Time Since Death | Position | Distance (m) | Azimuth |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5/22/2020 | T03 | Silver-haired Bat | *Lasionycteris noctivagans* | Tree-roosting Bat | Adult | Unknown | Decomposing – early | 4–7 days | Face Up | 25 | 145 |
| 6/5/2020 | T09 | Red-eyed Vireo | *Vireo olivaceus* | Passerine | Adult | Unknown | Decomposing – late | 4–7 days | Face Up | 48 | 36 |
| 6/10/2020 | T09 | Big Brown Bat | *Eptisicus fuscus* | Cave-dwelling Bat | Adult | Male | Fresh | 24–48 hours | Face Up | 7 | 345 |
| 6/15/2020 | T09 | Eastern Small-footed Bat | *Myotis leibii* | Cave-dwelling Bat | Adult | Male | Fresh | 24–48 hours | Face Up | 16 | 305 |
| 6/15/2020 | T09 | Hoary Bat | *Lasiurus cinereus* | Tree-roosting Bat | Adult | Unknown | Fresh | 25–48 hours | Face Up | 23 | 139 |
| 6/16/2020 | T01 | Big Brown Bat | *Eptisicus fuscus* | Cave-dwelling Bat | Adult | Male | Fresh | 24–48 hours | Face Down | 33 | 318 |
| 6/26/2020 | T01 | Hoary Bat | *Lasiurus cinereus* | Tree-roosting Bat | Adult | Unknown | Decomposing – early | 2–3 days | Face Down | 35 | 350 |
| 6/26/2020 | T01 | Little Brown Bat | *Myotis lucifugus* | Cave-dwelling Bat | Adult | Male | Fresh | 4–7 days | Face Down | 15 | 63 |
| 6/26/2020 | T04 | Big Brown Bat | *Eptisicus fuscus* | Cave-dwelling Bat | Adult | Unknown | Decomposing – late | 4–7 days | Face Up | 37 | 272 |
| 6/30/2020 | T07 | Hoary Bat | *Lasiurus cinereus* | Tree-roosting Bat | Adult | Male | Fresh | 24–48 hours | Face Down | 20 | 156 |
| 7/5/2020 | T03 | Hoary Bat | *Lasiurus cinereus* | Tree-roosting Bat | Adult | Male | Decomposing – late | 4–7 days | Face Up | 18 | 243 |
| 7/5/2020 | T05 | Big Brown Bat | *Eptisicus fuscus* | Cave-dwelling Bat | Adult | Male | Fresh | 24–48 hours | Face Up | 16 | 146 |
| 7/5/2020 | T05 | Big Brown Bat | *Eptisicus fuscus* | Cave-dwelling Bat | Adult | Female | Fresh | 24–48 hours | Face Up | 12 | 48 |
| 7/5/2020 | T09 | Big Brown Bat | *Eptisicus fuscus* | Cave-dwelling Bat | Adult | Unknown | Decomposing – late | 4–7 days | Face Up | 16 | 315 |
| 7/11/2020 | T01 | Big Brown Bat | *Eptisicus fuscus* | Cave-dwelling Bat | Adult | Male | Decomposing – early | 2–3 days | On Side | 7 | 269 |
| 7/16/2020 | T03 | Big Brown Bat | *Eptisicus fuscus* | Cave-dwelling Bat | Adult | Male | Fresh | 24–48 hours | Face Up | 11 | 22 |
| 7/20/2020 | T08 | Turkey Vulture | *Cathartes aura* | Raptor | Adult | Female | Fresh | 24–48 hours | Face Down | 17 | 288 |
| 7/20/2020 | T09 | Big Brown Bat | *Eptisicus fuscus* | Cave-dwelling Bat | Adult | Male | Fresh | 24–48 hours | Face Down | 16 | 312 |
| 7/25/2020 | T06 | Hoary Bat | *Lasiurus cinereus* | Tree-roosting Bat | Unknown | Unknown | Desiccated | 4–7 days | Face Down | 33 | 29 |
| 7/26/2020 | T01 | Hoary Bat | *Lasiurus cinereus* | Tree-roosting Bat | Adult | Male | Decomposing – early | 2–3 days | Face Up | 34 | 306 |
| 7/26/2020 | T02 | Eastern Red Bat | *Lasiurus borealis* | Tree-roosting Bat | Adult | Female | Fresh | 2–3 days | Face Up | 35 | 308 |
| 8/4/2020 | T06 | Big Brown Bat | *Eptisicus fuscus* | Cave-dwelling Bat | Adult | Unknown | Decomposing – late | 4–7 days | Face Down | 17 | 146 |
| 8/4/2020 | T09 | Little Brown Bat | *Myotis lucifugus* | Cave-dwelling Bat | Adult | Unknown | Decomposing – early | 2–3 days | Face Down | 6 | 91 |
| 8/10/2020 | T06 | Big Brown Bat* | *Eptisicus fuscus* | Cave-dwelling Bat | Unknown | Unknown | Decomposing – early | 2–3 days | Face Down | 12 | 223 |
| 8/14/2020 | T06 | Hoary Bat | *Lasiurus cinereus* | Tree-roosting Bat | Adult | Female | Fresh | 24–48 hours | Face Up | 28 | 258 |
| 8/14/2020 | T06 | Hoary Bat | *Lasiurus cinereus* | Tree-roosting Bat | Adult | Male | Decomposing – early | 2–3 days | Face Up | 27 | 45 |
| 8/14/2020 | T06 | Red-breasted Nuthatch | *Sitta canadensis* | Passerine | Adult | Unknown | Decomposing – early | 4–7 days | Face Down | 31 | 347 |
| 8/14/2020 | T07 | Hoary Bat | *Lasiurus cinereus* | Tree-roosting Bat | Adult | Male | Fresh | 24–48 hours | Face Up | 11 | 342 |
| 8/14/2020 | T09 | Big Brown Bat | *Eptisicus fuscus* | Cave-dwelling Bat | Adult | Female | Decomposing – late | 4–7 days | Face Up | 43 | 50 |
| 8/15/2020 | T03 | Red-breasted Nuthatch | *Sitta canadensis* | Passerine | Adult | Female | Fresh | 2–3 days | Face Up | 37 | 305 |
| 8/15/2020 | T04 | Hoary Bat | *Lasiurus cinereus* | Tree-roosting Bat | Adult | Female | Fresh | 24–48 hours | Face Down | 24 | 331 |
| 8/15/2020 | T04 | Hoary Bat | *Lasiurus cinereus* | Tree-roosting Bat | Adult | Female | Fresh | 24–48 hours | Face Down | 35 | 310 |

| Date | Turbine | Common Name | Scientific Name | Subgroup | Age | Sex | Condition | Estimated Time Since Death | Position | Distance (m) | Azimuth |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 8/19/2020 | T06 | Hoary Bat | *Lasiurus cinereus* | Tree-roosting Bat | Adult | Male | Fresh | 24–48 hours | Face Up | 15 | 340 |
| 8/19/2020 | T09 | Eastern Red Bat | *Lasiurus borealis* | Tree-roosting Bat | Adult | Female | Fresh | 24–48 hours | Face Up | 19 | 350 |
| 8/24/2020 | T06 | Eastern Red Bat | *Lasiurus borealis* | Tree-roosting Bat | Unknown | Female | Fresh | 2–3 days | Face Up | 10 | 189 |
| 8/25/2020 | T04 | Silver-haired Bat | *Lasionycteris noctivagans* | Tree-roosting Bat | Unknown | Unknown | Decomposing – early | 4–7 days | Face Down | 48 | 290 |
| 8/29/2020 | T09 | Eastern Red Bat | *Lasiurus borealis* | Tree-roosting Bat | Adult | Unknown | Decomposing – early | 4–7 days | Face Down | 7 | 330 |
| 8/30/2020 | T04 | Hoary Bat | *Lasiurus cinereus* | Tree-roosting Bat | Adult | Male | Fresh | 2–3 days | Face Up | 16 | 355 |
| 9/3/2020 | T09 | Silver-haired Bat | *Lasionycteris noctivagans* | Tree-roosting Bat | Unknown | Male | Decomposing – early | 4–7 days | Face Up | 13 | 332 |
| 9/8/2020 | T06 | Hoary Bat | *Lasiurus cinereus* | Tree-roosting Bat | Adult | Male | Fresh | 24–48 hours | Face Up | 23 | 208 |
| 9/8/2020 | T09 | Hoary Bat | *Lasiurus cinereus* | Tree-roosting Bat | Adult | Female | Fresh | 24–48 hours | Face Down | 21 | 243 |
| 9/12/2020 | T07 | Eastern Red Bat | *Lasiurus borealis* | Tree-roosting Bat | Unknown | Female | Fresh | 24–48 hours | Face Up | 11 | 327 |
| 9/12/2020 | T09 | Silver-haired Bat | *Lasionycteris noctivagans* | Tree-roosting Bat | Unknown | Unknown | Decomposing – early | 4–7 days | Face Up | 13 | 307 |
| 9/17/2020 | T04 | Silver-haired Bat | *Lasionycteris noctivagans* | Tree-roosting Bat | Adult | Unknown | Decomposing – early | 4–7 days | Face Up | 18 | 278 |
| 9/21/2020 | T05 | Northern Flicker* | *Colaptes auratus* | Woodpecker | Adult | Male | Fresh | 2–3 days | Face Up | 5 | 305 |
| 9/21/2020 | T08 | Northern Parula | *Setophaga americana* | Passerine | Adult | Female | Fresh | 2–3 days | Face Up | 52 | 280 |
| 9/26/2020 | T06 | Silver-haired Bat | *Lasionycteris noctivagans* | Tree-roosting Bat | Adult | Female | Fresh | 24–48 hours | Face Up | 26 | 266 |
| 9/27/2020 | T02 | American Redstart | *Setophaga ruticilla* | Passerine | Adult | Male | Decomposing – early | 4–7 days | On Side | 48 | 252 |
| 10/6/2020 | T08 | Silver-haired Bat | *Lasionycteris noctivagans* | Tree-roosting Bat | Adult | Male | Fresh | 24–48 hours | Face Up | 33 | 214 |
| 10/7/2020 | T01 | Little Brown Bat | *Myotis lucifugus* | Cave-dwelling Bat | Adult | Male | Fresh | 24–48 hours | Face Up | 19 | 292 |
| 10/12/2020 | T05 | Golden-crowned Kinglet | *Regulus Satrapa* | Passerine | Adult | Female | Fresh | 2–3 days | Face Up | 48 | 298 |

*Indicates carcass found incidentally.

# APPENDIX B TURBINE SEARCH PLOTS


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

Visibility Rating
1 = Easy
2 = Moderate
3 = Difficult

0 100 Feet
(At original document size of 8.5x11)
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N

Stantec

*Project Location*
Antrim,
New Hampshire

Prepared by HCT on 2020-12-08
TR by KWH on 2020-12-08
IR Review by LJ on 2020-12-08

*Client/Project*
TransAlta Corporation
Antrim Wind Project

195601919

*Figure No.*
**1 of 9**

*Title*
**Vegetation and Visibility Classification**
**Turbine 1**

***Notes***
**1.** Coordinate System: NAD 1983 UTM Zone 19N
**2.** Data Sources: TransAlta, Stantec
**3.** Background: 2018 National Agriculture Program (NAIP) aerial orthoimagery provided by USDA's Farm Service Agency

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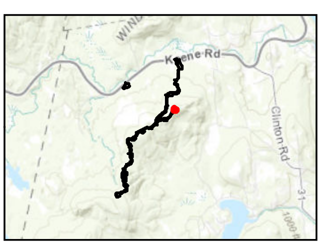


Legend
- Pad/Gravel
- Bare Ground
- Grass
- Boulders
- Search Plot

Visibility Rating
- 1 = Easy
- 2 = Moderate
- 3 = Difficult

0 100 Feet

(At original document size of 8.5x11)
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N

Stantec

Project Location
Antrim,
New Hampshire

Prepared by HCT on 2020-12-08
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Client/Project
195601919
TransAlta Corporation
Antrim Wind Project

Figure No.
**2 of 9**

Title
**Vegetation and Visibility Classification Turbine 2**

***Notes***
1. Coordinate System: NAD 1983 UTM Zone 19N
2. Data Sources: TransAlta, Stantec
3. Background: 2018 National Agriculture Program (NAIP) aerial orthoimagery provided by USDA's Farm Service Agency

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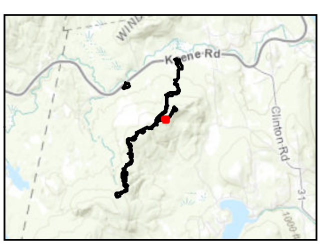


**Notes**
**1.** Coordinate System: NAD 1983 UTM Zone 19N
**2.** Data Sources: TransAlta, Stantec
**3.** Background: 2018 National Agriculture Program (NAIP) aerial orthoimagery provided by USDA's Farm Service Agency

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

Visibility Rating
- 1 = Easy
- 2 = Moderate
- 3 = Difficult

0 100 Feet
(At original document size of 8.5x11)
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N

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*Project Location*
Antrim,
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*Client/Project*
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Antrim Wind Project

195601919

*Figure No.*
**3 of 9**

*Title*
**Vegetation and Visibility Classification Turbine 3**

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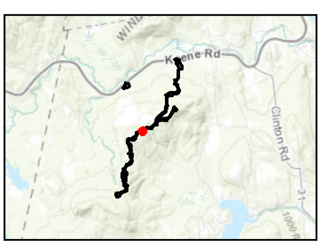


Legend
Pad/Gravel
Grass
Boulders
Search Plot

Visibility Rating
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2 = Moderate
3 = Difficult

0 100 Feet
(At original document size of 8.5x11)
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N

Stantec

Project Location
Antrim,
New Hampshire

Prepared by HCT on 2020-12-08
TR by KWH on 2020-12-08
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Client/Project
TransAlta Corporation
Antrim Wind Project

195601919

Figure No.
**4 of 9**

Title
**Vegetation and Visibility Classification Turbine 4**

***Notes***
**1.** Coordinate System: NAD 1983 UTM Zone 19N
**2.** Data Sources: TransAlta, Stantec
**3.** Background: 2018 National Agriculture Program (NAIP) aerial orthoimagery provided by USDA's Farm Service Agency

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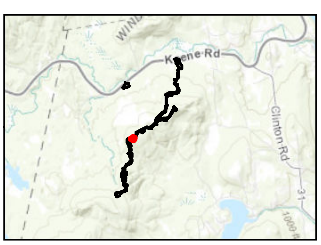


Legend
- Pad/Gravel
- Grass
- Boulders
- Rocks/Boulders
- Search Plot

Visibility Rating
- 1 = Easy
- 2 = Moderate
- 3 = Difficult

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(At original document size of 8.5x11)
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*Client/Project*
TransAlta Corporation
Antrim Wind Project

195601919

*Figure No.*
**5 of 9**

*Title*
**Vegetation and Visibility Classification**
**Turbine 5**

***Notes***
**1.** Coordinate System: NAD 1983 UTM Zone 19N
**2.** Data Sources: TransAlta, Stantec
**3.** Background: 2018 National Agriculture Program (NAIP) aerial orthoimagery provided by USDA's Farm Service Agency

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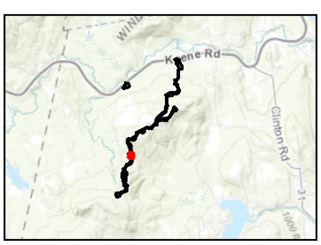


**Notes**
**1.** Coordinate System: NAD 1983 UTM Zone 19N
**2.** Data Sources: TransAlta, Stantec
**3.** Background: 2018 National Agriculture Program (NAIP) aerial orthoimagery provided by USDA's Farm Service Agency

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

Visibility Rating
1 = Easy
2 = Moderate
3 = Difficult

0 100 Feet
(At original document size of 8.5x11)
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N

Stantec

*Project Location*
Antrim,
New Hampshire

Prepared by HCT on 2020-12-08
TR by KWH on 2020-12-08
IR Review by LJ on 2020-12-08

*Client/Project*
195601919
TransAlta Corporation
Antrim Wind Project

*Figure No.*
**6 of 9**

*Title*
**Vegetation and Visibility Classification**
**Turbine 6**

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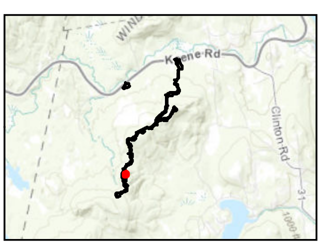


**Legend**

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

**Visibility Rating**

1 = Easy
2 = Moderate
3 = Difficult

0 100 Feet

(At original document size of 8.5x11)
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N

Stantec

*Project Location*
Antrim,
New Hampshire

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TR by KWH on 2020-12-08
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*Client/Project*
TransAlta Corporation
Antrim Wind Project

195601919

*Figure No.*
**7 of 9**

*Title*
**Vegetation and Visibility Classification**
**Turbine 7**

***Notes***

**1.** Coordinate System: NAD 1983 UTM Zone 19N
**2.** Data Sources: TransAlta, Stantec
**3.** Background: 2018 National Agriculture Program (NAIP) aerial orthoimagery provided by USDA's Farm Service Agency

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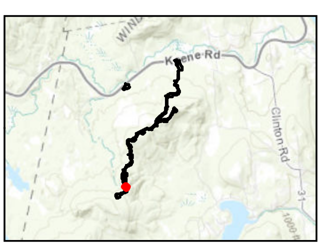


**Legend**

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

**Visibility Rating**

1 = Easy
2 = Moderate
3 = Difficult

0 100 Feet

(At original document size of 8.5x11)
1:200,000

N

Stantec

*Project Location*
Antrim,
New Hampshire

Prepared by HCT on 2020-12-08
TR by KWH on 2020-12-08
IR Review by LJ on 2020-12-08

*Client/Project*
TransAlta Corporation
Antrim Wind Project

195601919

*Figure No.*
**8 of 9**

*Title*
**Vegetation and Visibility Classification**
**Turbine 8**

***Notes***
**1.** Coordinate System: NAD 1983 UTM Zone 19N
**2.** Data Sources: TransAlta, Stantec
**3.** Background: 2018 National Agriculture Program (NAIP) aerial orthoimagery provided by USDA's Farm Service Agency

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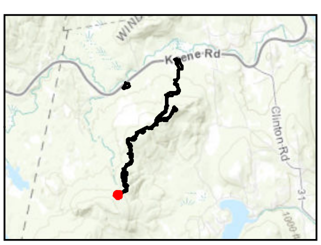


**Legend**

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

**Visibility Rating**

1 = Easy
2 = Moderate
3 = Difficult

0 100 Feet

(At original document size of 8.5x11)
1:200,000

N

Stantec

*Project Location*
Antrim,
New Hampshire

Prepared by HCT on 2020-12-08
TR by KWH on 2020-12-08
IR Review by LJ on 2020-12-08

*Client/Project*
TransAlta Corporation
Antrim Wind Project

195601919

*Figure No.*
**9 of 9**

*Title*
**Vegetation and Visibility Classification Turbine 9**

***Notes***

**1.** Coordinate System: NAD 1983 UTM Zone 19N
**2.** Data Sources: TransAlta, Stantec
**3.** Background: 2018 National Agriculture Program (NAIP) aerial orthoimagery provided by USDA's Farm Service Agency

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