Spring 2011 Radar and Acoustic Bat Survey Report

for the Antrim Wind Energy Project
In Antrim, New Hampshire

Prepared for

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

Prepared by

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

October 2011

Executive Summary

Antrim Wind Energy, LLC is considering development of the Antrim Wind Energy Project (Project) located in Antrim, New Hampshire. The proposed Project would include wind turbines located on a series of ridgelines associated with Tuttle Hill (Figure 1). Stantec Consulting Services Inc. performed nocturnal radar surveys and acoustic bat surveys at the Project to characterize seasonal nocturnal migration and bat activity patterns at the Project. This report discusses the methods and results of the spring 2011 radar and acoustic bat surveys.

Nocturnal Radar Survey

To characterize spring nocturnal migration activity over the Project area, radar surveys were conducted on 30 nights between April 18 and May 26, 2011. Surveys were conducted from sunset to sunrise using X-band radar. Each hour of sampling included the recording of radar video files during horizontal and vertical operation. The radar was placed within a clearing for the meteorological (met) tower, Met Tower 1, located at the northeastern end of Tuttle Hill. This site provided adequate visibility of the surrounding airspace.

The overall mean passage rate for the entire spring survey period was 223 ± 23 targets per kilometer per hour (t/km/hr), and nightly passage rates varied from 6 ± 3 t/km/hr on May 17 to 1215 ± 299 t/km/hr on May 20. The seasonal mean flight height of targets was 305 ± 1 meters (m; 1000 ft [']) above the radar site, and nightly flight heights ranged from 135 ± 31 m to 486 ± 85 m. Mean flight direction through the Project area for the season was northeasterly at 44° ± 49°. Flight heights, when analyzed for the anticipated 150 m (492') height of the proposed turbines; indicate that the percentage of targets flying below turbine height ranged from 7 to 63 percent with a seasonal average of 30 percent.

In summary, results at the Project are within the range of results recorded at other radar studies conducted in the East, and provide a sample of baseline migration activity over the Project area during spring 2011.

Acoustic Bat Survey

Stantec conducted spring acoustic bat surveys between April 7 and June 1, 2011 to sample bat activity patterns and species composition within the Project area. Six Anabat® detectors were deployed during this period, collecting data for a total of 304 detector-nights over a period of 323 available calendar nights. Two detectors were deployed in the guy wires of an existing 60 m meteorological tower and the remaining four detectors were suspended from trees along forested corridors and adjacent to wetlands where bats would likely travel or forage.

The six detectors recorded a total of 1,483 bat call sequences yielding an overall detection rate of 4.9 bat call sequences per detector-night. Among sampling locations, detection rates ranged from 0.1 to 14.1 bat call sequences per detector-night. Typical of this type of survey, activity levels varied considerably among nights within the survey period and among detectors.

Although bats within the *Myotis* genus comprised the greatest overall percentage of detected call sequences (32 %), most of these sequences were recorded at a single detector over only a few nights. Other species, such as hoary bats (*Lasiurus cinereus*) were detected at all six detectors, though in smaller numbers. Spring 2011 acoustic bat surveys documented variable activity levels within the Project area, although results suggest that activity increased in May relative to April.

Table of Contents

Figures

Tables

Appendices

PN195600689*

* *This report was prepared by Stantec Consulting Services Inc. for TRC and Eolian Renewable Energy. The material in it reflects Stantec's judgment in light of the information available to it at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibility of such third parties. Stantec accepts no responsibility for damages, if any suffered by any third party as a result of decisions made or actions based on this report.*

1.0 Introduction

1.1 PROJECT BACKGROUND

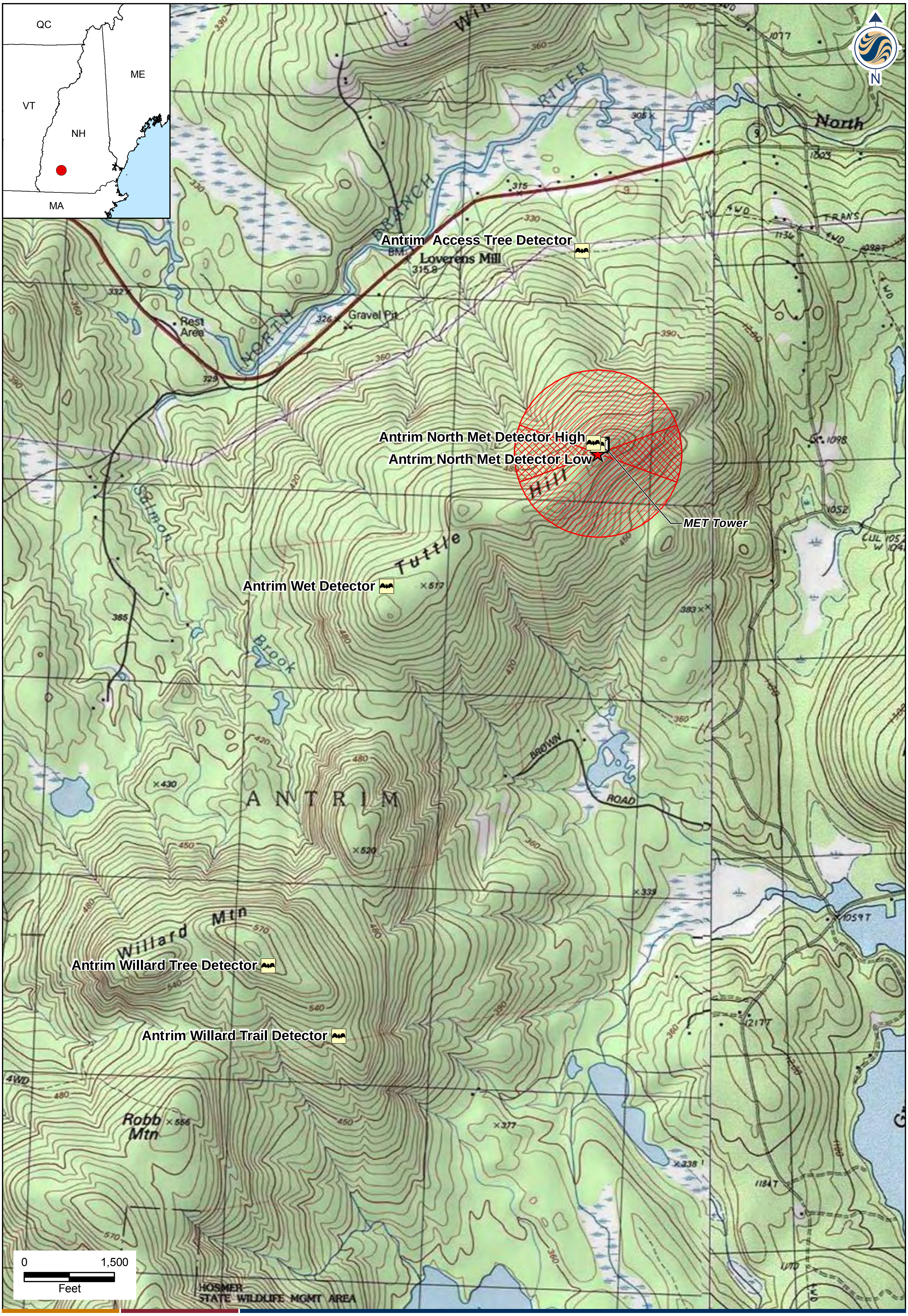
Eolian Renewable Energy (Eolian) is considering development of the Antrim Wind Energy Project (Project) located in Antrim, New Hampshire (Project; Figure 1-1). The Project is in the preliminary stages of design and the layout of Project infrastructure, including turbines and access roads, has not been determined at this time. The proposed turbines are expected to have a maximum height of 150 meters (m) (492 feet [']).

As part of Project planning, Eolian contracted Stantec Consulting Services Inc. (Stantec) to conduct spring 2011 nocturnal radar surveys, and acoustic bat surveys. Stantec developed a work plan for the Project that described survey scopes and methodologies and presented it to the New Hampshire Department of Fish and Game and the U.S. Fish and Wildlife Service at an introductory project meeting on June 21, 2011. The scope and methodology of these surveys are consistent with several other studies conducted recently at proposed wind projects in New Hampshire and the Northeast U.S. Mist nest surveys for bats also were conducted for the Project, and the results of these surveys are presented in a separate report.

1.2 PROJECT AREA DESCRIPTION

The Project is located along the edge of the Sunapee Uplands and Worcester/Monadnock Plateau ecogregions of New England (Griffith *et al*. 2009). The Sunapee Uplands is a transition zone from the Worcester/Monadnock Plateau and the typically cooler ecoregions to the north. The mountains within the Sunapee Uplands are generally of lower elevations than those mountains to the north, but higher in elevation than those found in the Worcester/Monadnock Plateau (Griffith *et al*. 2009). The mountains and hills of the Sunapee Uplands are mostly between 305 to 610 m (1000 to 2000') in elevation, but range from 152 m (500') to more than 914 m (3000'). This ecoregion includes many streams and small lakes. Northern hardwood forests dominated by sugar maple (*Acer saccharum*), American beech (*Fagus grandifolia*) and yellow birch (*Betula alleghaniensis*) are common. Also present, but less common are eastern hemlock dominated (*Tsuga canadensis*) forests, oak (*Quercus* spp.) dominated forests, and forests dominated by spruce (*Picea* sp.) and balsam fir (*Abies balsamea*) (Griffith *et al*. 2009). The Worcester/Monadnock Plateau includes the north-central portion of Massachusetts and the south-central portion of New Hampshire. In many basic characteristics including elevation and climate this ecoregion is similar to colder and more mountainous ecoregions to the north. Elevations within this ecoregion range from 152 to 427 m (500 to 1400') with some peaks exceeding 610 m (2000'). Forested uplands include transition hardwoods such as maple-beech-birch-oak-hickory forests and northern hardwoods such as the maple-beech-birch forests (Griffith *et al*. 2009). Forested wetlands are common within the Worcester/Monadnock Plateau.

The Project area is associated with Tuttle Hill, which has an elevation of approximately 423 m (1,390'). The Project area is dominated by mixed forests with coniferous species more common along the ridge tops and deciduous species dominant along the slopes. Common tree species present include paper birch (*Betula papyrifera*), red spruce (*Picea rubens*), eastern hemlock (*Tsuga canadensis*), northern red oak (*Quercus rubra*), American beech (*Fagus grandifolia*), maple (*Acer* spp.), and eastern white pine (*Pinus strobus*). Forest management activities have occurred throughout the area in the recent past and are still ongoing. Evidence of these activities includes numerous skidder trails and stumps throughout the Project area.



195600689

Stantec Consulting Services Inc.
30 Park Drive
Topsham, ME USA
04086
Phone (207) 729-1199
Fax: (207) 729-2715
www.stantec.com

Legend

- Met Tower
- Radar Survey Location
- Bat Detector Location
- Alignment Vertical Radar Sweep
- Horizontal Radar Detection Range

Client/Project
TRC Companies, Inc.
Antrim Wind Energy Project
Antrim, New Hampshire

Figure No.
1-1

Title
Survey Location Map
7/19/2011

00689_1-1_SurveyLocation.mxd

2.0 Nocturnal Radar Survey

2.1 INTRODUCTION

Nocturnal radar surveys were conducted in the Project area to sample and characterize nocturnal migration patterns in spring 2011. The majority of North American passerines (songbirds) migrate at night. This migratory strategy may have evolved to take advantage of more stable atmospheric conditions for flapping flight (Kerlinger 1995); additionally, cooler nighttime temperatures may help regulate body temperature during more active, flapping flight and reduce predation risk while in flight (Alerstam 1990, Kerlinger 1995). Documenting the patterns of nocturnal migrants requires the use of radar or other non-visual technologies. The goal of the surveys was to sample and characterize nocturnal migration at the Project area including passage rate, flight direction, and flight altitude.

2.2 DATA COLLECTION METHODS

Spring radar surveys were conducted from sunset to sunrise on 30 nights between April 18 and May 26, 2011. The radar was placed within clearing for the meteorological (met) tower, Met Tower 1, located at the northeastern end of Tuttle Hill (Figures 1-1, 2-1). This site has an elevation of approximately 423 m (1,390’).

Efforts were made to maximize the airspace sampled by elevating the radar antenna approximately 6 m (20’) above ground level. Elevating the antenna helps to reduce the amount of the radar beam reflected back by surrounding vegetation and topography, which can cause ground clutter interference on the radar screen. The elevated radar limited ground clutter obstructions and resulted in an adequate view of the surrounding airspace.

Figure 2-1. Photo of the radar on the ridgeline of Tuttle Hill.

2.2.1 Radar Data

Marine surveillance radar, similar to that described by Cooper *et al.* (1991), was used during field data collection. The radar has a peak power output of 12 kilowatts (kW) and has the ability to track small animals, including birds, bats, and insects, based on settings selected for the radar functions. It cannot, however, readily distinguish between different types of animals. Consequently, all animals, excluding insects, observed on the radar screen were identified as "targets." The radar has an "echo trail" function that captures past echoes of flight trails, enabling determination of flight direction. During all operations, the radar's echo trail was set to 30 seconds. The radar was equipped with a 2 m (6.5') waveguide antenna. The antenna has a vertical beam height of 20° (10° above and below horizontal).

Objects on the ground detected by the radar cause returns on the radar screen (echoes) that appear as blotches called ground clutter. Large amounts of ground clutter reduce the ability of the radar to track targets flying over (Figure 2-2).

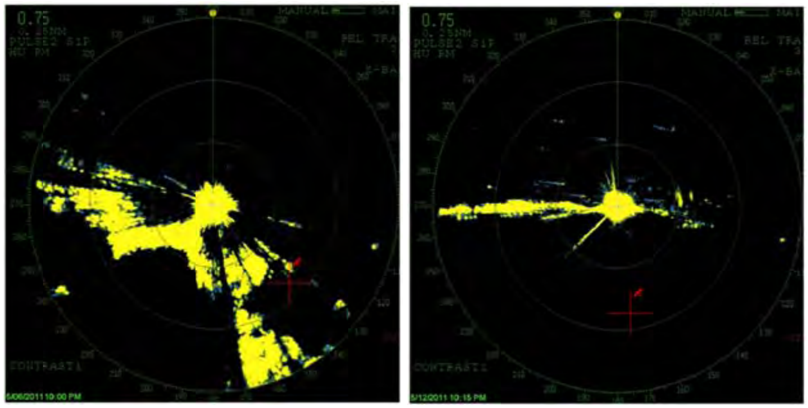


Figure 2-2. Screenshots from actual radar files showing ground clutter in horizontal mode (left) and vertical mode (right). Although the radar records three-dimensional space, it is translated by the radar screen as a two dimensional representation, which can cause targets to be obscured from view.

However, vegetation and hilltops near the radar can be used to reduce or eliminate ground clutter by "hiding" clutter-causing objects from the radar (Figure 2-3). These nearby features also cause ground clutter, but their proximity to the radar antenna generally limits the ground clutter to the center of the radar screen. Targets traveling into and out of the ground clutter areas can be tracked. The presence or reduction of potential clutter producing objects was carefully considered during site selection and radar station configuration.

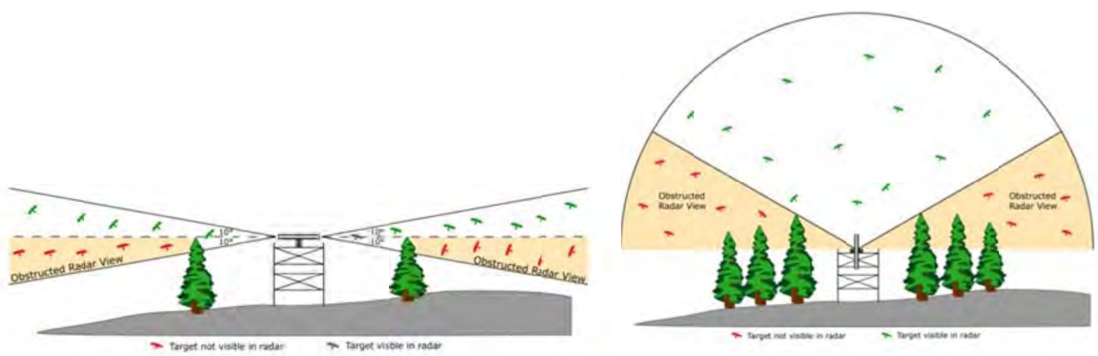


Figure 2-3. An example of a tree of a specific height that causes ground clutter, but "masks" a section of the radar beam, allowing adequate detection of targets beyond it (left). The effect of ground clutter on target detection in vertical mode is also shown (right).

The anti-rain function of the radar must be turned down to detect small songbirds and bats. Since radar surveys cannot be conducted during active rainfall, survey nights targeted nights without steady rain. To characterize migration patterns during nights without optimal conditions, some nights with weather forecasts including occasional showers, mist, or fog were sampled.

The radar was operated in two modes throughout the course of each night and both modes of operation were used during each hour of sampling. In surveillance mode, the antenna spins horizontally to survey the airspace around the radar and detects the number of targets and their flight direction as they pass through the project site (Figure 2-3). By analyzing the echo trail, the flight direction and flight speed of targets can be determined.

In vertical mode, the radar unit is tilted 90° to survey the airspace above the radar (Harmata *et al.* 1999). In vertical mode, target echoes do not provide directional data, but do provide information on the altitude of targets passing through the vertical, 20° radar beam (Figure 2-4). .

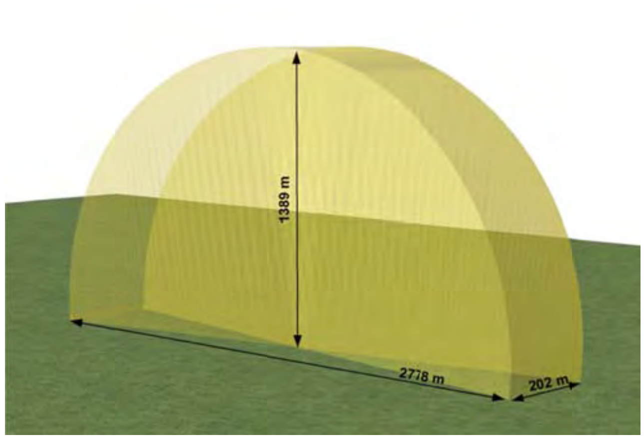


Figure 2-4. Detection range of the radar in vertical mode.

The radar was operated at a range of 1.4 km (0.75 nautical miles) to ensure detection of small targets. When radar is operated at ranges greater than 1.4 km, the echoes of small birds are reduced in size and restricted to a smaller portion of the radar screen, which limits the detection and observable movement pattern of individual targets. Consequently, 1.4 km is the appropriate detection range for this type of study.

The radar display was connected to a computer with video recording software enabling digital archiving of the radar data for subsequent analysis. This software recorded and archived video samples continuously every hour from sunset to sunrise of each survey night. By alternating the radar antenna every ten minutes from vertical mode to horizontal mode, a total of 30 minutes of vertical samples and 30 minutes of horizontal samples were collected within each hour. A stratified random sample set was developed for analysis by randomly selecting 6 horizontal samples and 6 vertical samples per hour of survey. This sampling schedule allowed for randomization of sample selection and prevented double-counting of targets due to the 30-second echo trail used to determine the flight path vector.

2.2.2 Weather Data

Temperature, wind speed and direction were recorded by the on-site met tower. Additionally, to consider the atmospheric influences on migration, regional surface weather map images were interpreted to determine the dates that pressure systems (high, low, or none) moved through the region. Surface weather maps, prepared by the National Centers for Environmental Prediction, the Hydro-meteorological Prediction Center, and the National Weather Service, were downloaded daily during the survey window.

2.3 DATA ANALYSIS METHODS

2.3.1 Radar Data

Video samples were analyzed using a digital analysis software tool developed by Stantec. For horizontal samples, targets (either birds or bats) were differentiated from insects based on their flight speed. Following adjustment for wind speed and direction, targets traveling faster than approximately 6 m (20') per second were identified as a bird or bat target (Larkin 1991, Bruderer and Boldt 2001). The software tool recorded the time, location, and flight vector for each target traveling fast enough to be a bird or bat within each horizontal sample, and these results were output to a spreadsheet. For vertical samples, the software tool recorded the entry point of targets passing through the vertical radar beam, the time, and flight altitude above the radar location, and then subsequently outputs the data to a spreadsheet. These datasets were then used to calculate passage rate (reported as targets per kilometer of migratory front per hour), flight direction, and flight altitude of targets.

Mean target flight directions (± 1 circular standard deviation) were summarized using software designed specifically to analyze directional data (Oriana2© Kovach Computing Services). The statistics used for this analysis are based on those used by Batschelet (1965) which take into account the circular nature of the data.

Flight altitude data were summarized using linear statistics. Mean flight altitudes (± 1 standard error [SE]) were calculated by hour, night, and overall season. The percent of targets flying below 150 m (492'), the approximate maximum height of the proposed wind turbines with blades, was also calculated nightly and for the entire survey period.

2.3.2 Weather Data

The mean, maximum, and minimum temperature, hourly wind speed, and hourly wind direction were calculated from the onsite met tower for each night of survey.

2.4 RESULTS

Radar surveys were conducted during 30 nights between April 18 and May 26, 2011 (Appendix A Table 1) resulting in 284 total hours surveyed.

2.4.1 Passage Rates

Nightly passage rates varied from 6 ± 3 targets per kilometer per hour (t/km/hr) on May 17 to 1215 ± 299 t/km/h on May 20, and the overall passage rate for the entire survey period was 223 ± 23 t/km/hr (Figure 2-5; also Appendix A Table 1). Individual hourly passage rates varied between nights and throughout the season, and ranged from 0 t/km/hr during various hours of various nights to 2279 t/km/hr during the 7th hour of May 20 (Appendix A Table 2). For the entire season, mean passage rates increased rapidly between hours one and two after sunset, then gradually increased to the 6th hour after sunset before steadily declining until sunrise (Figure 2-6).

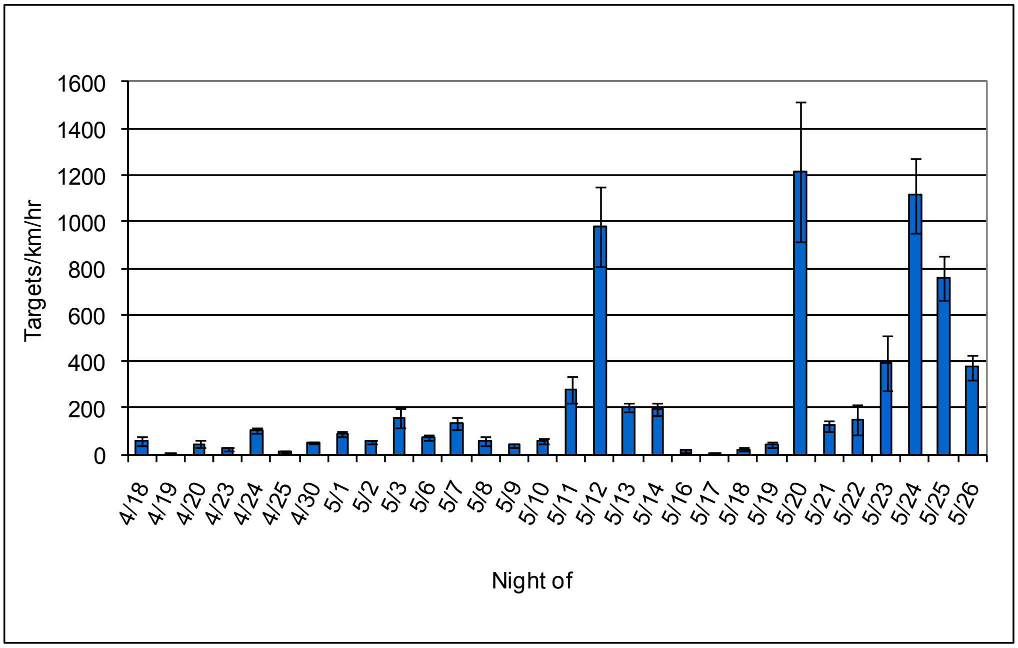


Figure 2-5. Nightly passage rates observed during spring 2011 at the Antrim Wind Project (error bars ± 1 SE).

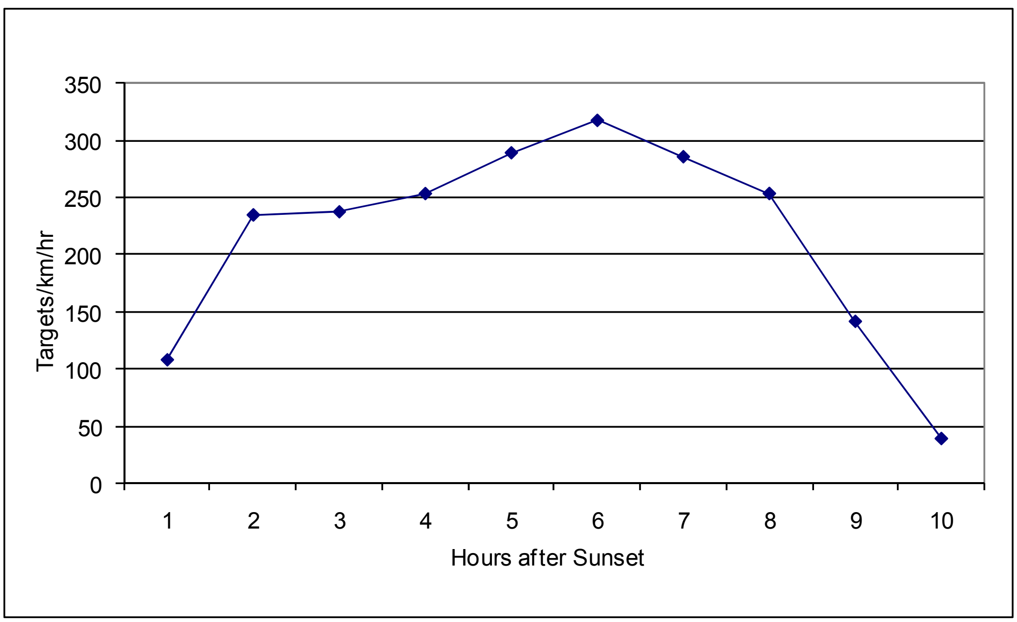


Figure 2-6. Hourly passage rates for entire season during spring 2011 at the Antrim Wind Project.

2.4.2 Flight Direction

Mean flight direction through the Project area was 44° ± 49° (Figure 2-7). Overall, the mean flight direction was northeast, but varied between nights (Appendix A Table 3).

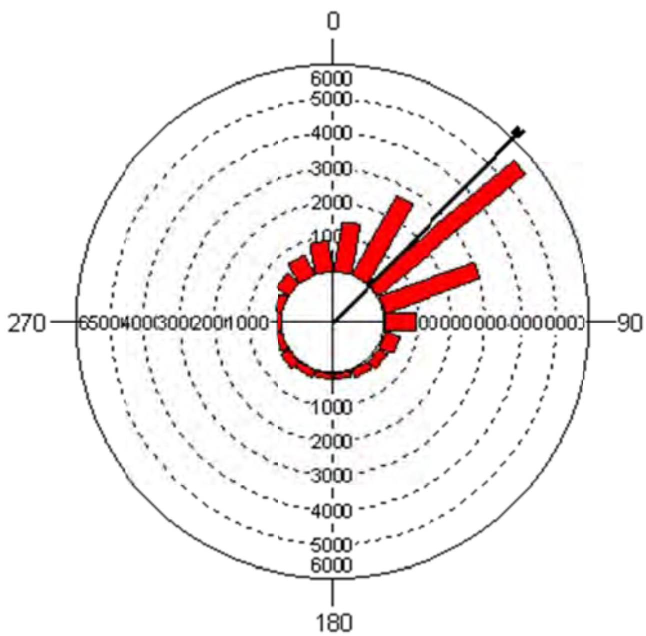


Figure 2-7. Mean flight direction for the entire season during spring 2011 at the Antrim Wind Project (the bracket along the margin of the histogram is the 95% confidence interval).

2.4.3 Flight Altitude

The seasonal mean flight height of targets was 305 ± 1 m (1000‘) above the radar site. The average nightly flight height ranged from 135 ± 31 m on May 9 to 486 ± 85 m on May 19 (Figure 2-8; Appendix A Table 4). The percent of targets observed flying below 150 m was 30 percent for the season and varied nightly from 7 percent (51 targets) on May 22 to 64 percent (253 targets) on May 7 (Figure 2-9). Figure 2-10 below shows the distribution of individual nightly flight heights of all targets recorded relative to the proposed turbine height. The yellow boxes seen in Figure 2-10 depict the middle 50 percent of targets. The error bars depict the statistical outliers, or 25 percent of targets above and below the middle 50 percent of targets. The horizontal line within each box represents the median flight height value for that night. For the entire season, the mean hourly flight heights did not vary greatly between the hours after sunset but were lowest during first and last hour after sunset (Figure 2-11).

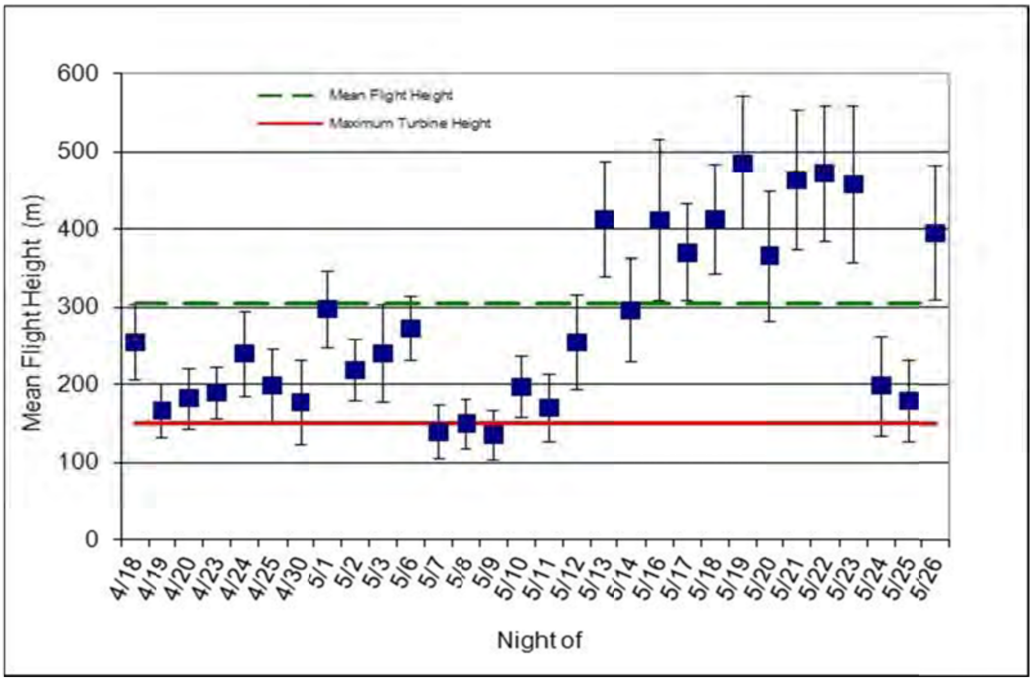


Figure 2-8. Mean nightly flight height of targets during spring 2011 at the Antrim Wind Project (error bars ± 1 SE).

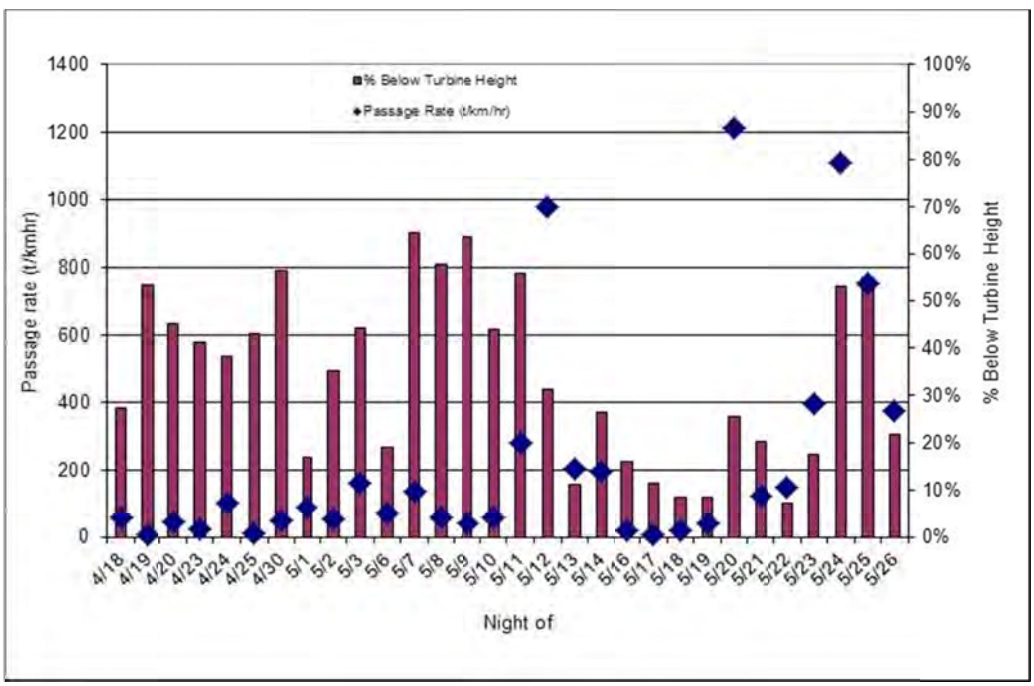


Figure 2-9. Percent of targets observed flying below a height of 150 m (492') during spring 2011 at the Antrim Wind Project.

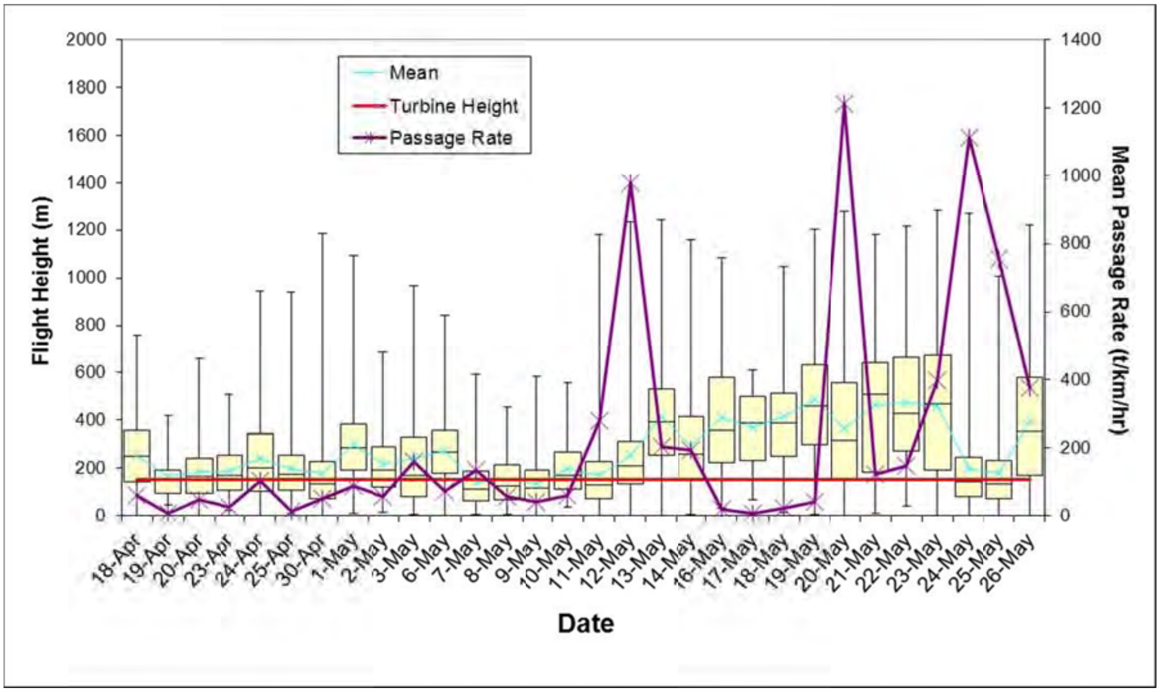


Figure 2-10. Flight height whisker plot depicting the vertical distribution of targets for each survey night during spring 2011 at the Antrim Wind Project.

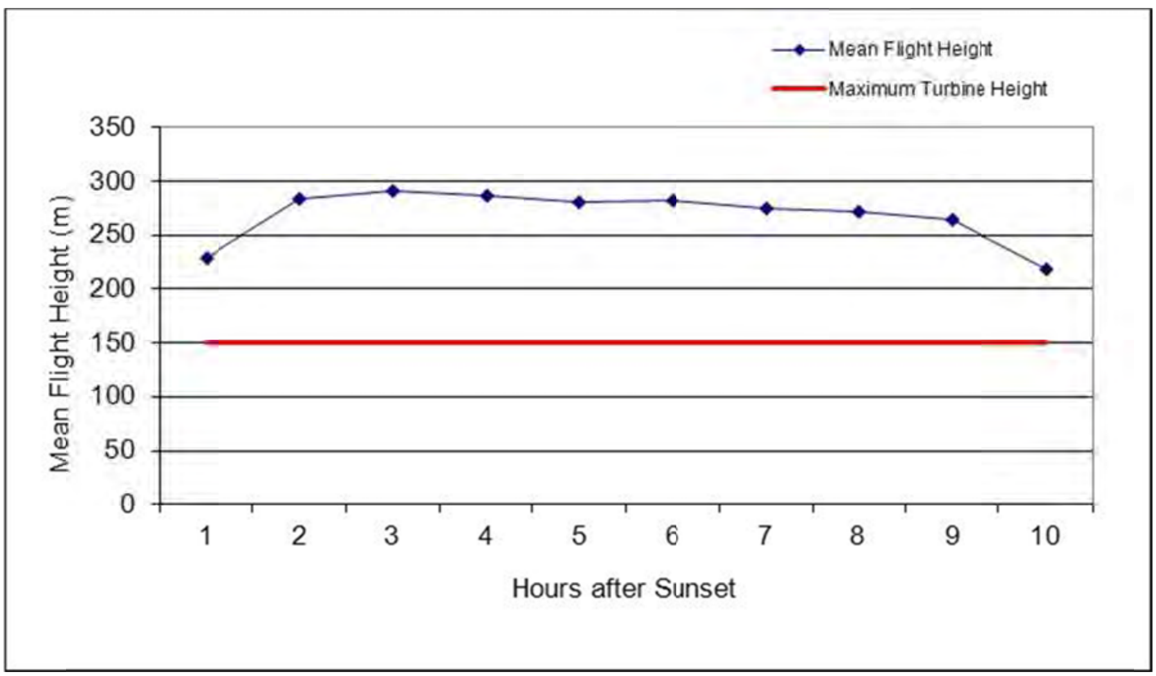


Figure 2-11. Hourly target flight height distribution during spring 2011 at the Antrim Wind Project.

2.4.4 Weather Data

Regional surface weather maps indicated that spring 2011 included many low pressure systems. During the nights surveyed from April 18 to May 26, average nightly wind speed varied between 1 and 10 meters per second (m/s), with an overall mean of 6 m/s (Figure 2-11). Mean nightly temperatures gradually increased throughout the survey period, and varied between 2 °C and 18 °C, with an overall mean of 9 °C (Figure 2-12).

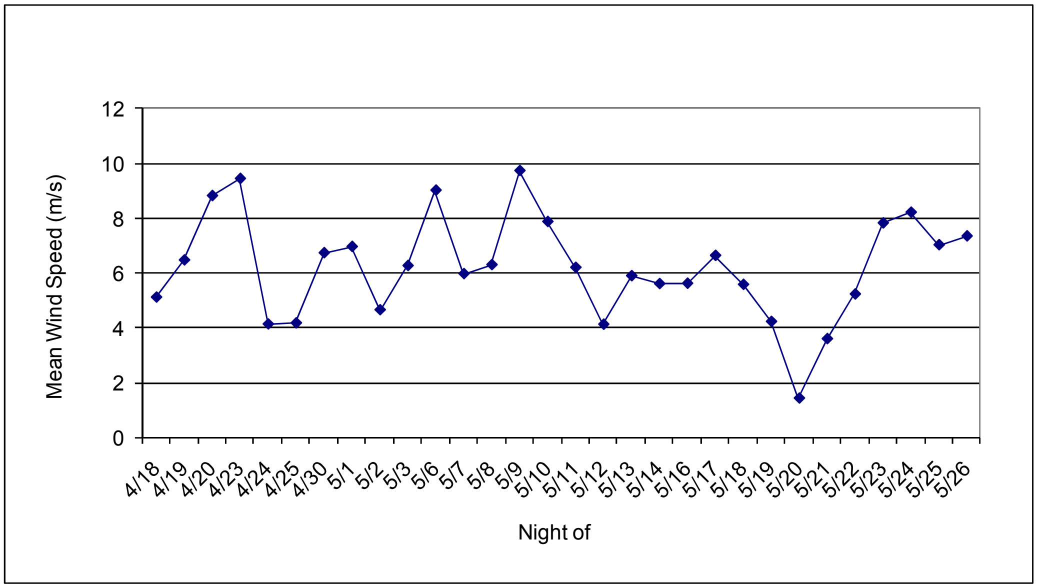


Figure 2-12. Nightly mean wind speed (m/s) during spring 2011 at the Antrim Wind Project. (nightly maximum and minimum temperatures not available)

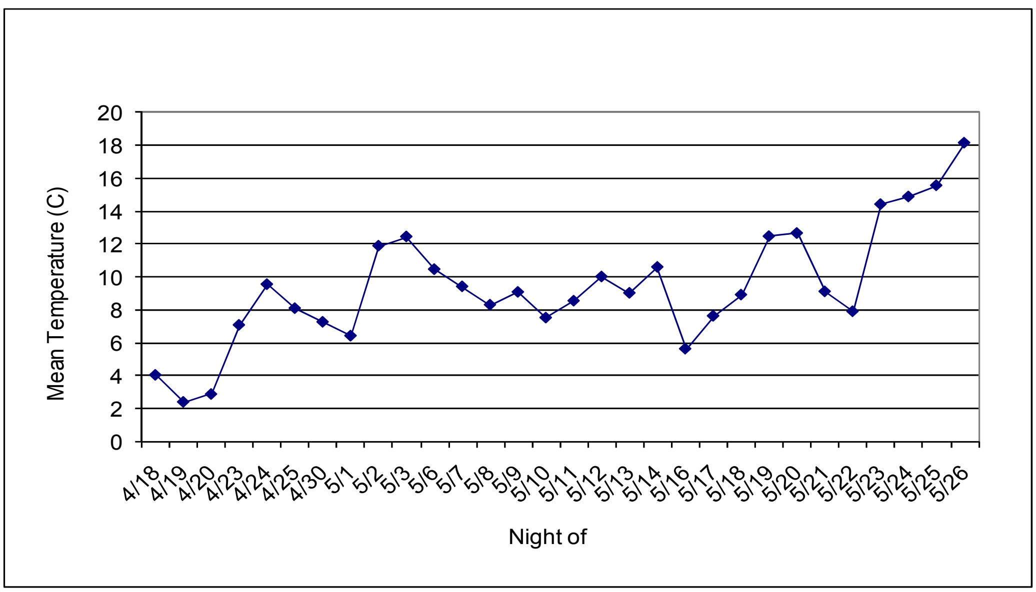


Figure 2-13. Nightly mean temperature (Celsius) during spring 2011 at the Antrim Wind Project.

2.5 DISCUSSION

Radar surveys are designed and implemented to sample migration activity over a specific location in the Project area to provide baseline pre-construction site data. The results of this nocturnal radar survey provide a snapshot of avian migration in space and time; in this case, over the Project area during dates typical for spring migration in New Hampshire. Spring radar surveys in the Project area documented patterns in nocturnal migration similar to those documented at recent radar surveys conducted at other locations in New Hampshire and the Eastern US (Appendix A Table 5). These include highly variable passage rates between nights, a generally northward flight direction, and flight heights typically averaging over 200 m.

The radar site was located within an existing met tower clearing at one of the highest points on Tuttle Hill. The radar had somewhat limited visibility of the airspace west and south of the radar site, but was still capable of detecting targets within the majority of its range. Nightly mean passage rates were highly variable, ranging from 6 ± 3 to 1215 ± 299 t/km/hr. This indicates that nocturnal migration was pulsed, presumably related to seasonal timing and regional weather conditions. Results also showed a general increase in mean nightly passage rates as well as mean nightly flight height during the course of the survey period. The average passage rate at the Project (223 ± 23 t/km/hr) is at the low end of the range of results of other radar studies conducted in the East (147 t/km/hr to 1020 t/km/hr; Appendix A Table 5). Comparison of passage rates between radar surveys at the Project and similar surveys conducted at other sites must be done with caution, as differences in passage rates are due in large part to differences in radar view between sites and varying weather patterns between years, and not necessarily the amount of migration above a radar site.

The average flight height (305 ± 1 m) is near the mid-range of average flight heights recorded at other radar studies conducted in the East (210 m to 552 m) and is well above the proposed turbine height (150 m). The nightly average flight heights were below the proposed turbine height on two nights (May 7 and 9) and at the proposed turbine height on one night (May 8). Passage rates on these three nights were relatively low, ranging from 40 to 134 t/km/hr. The emerging body of studies characterizing nocturnal migrant movements shows a relatively consistent pattern in flight altitude, with most targets appearing to fly at altitudes of several hundred meters or more above the ground (Figure 2-8; Appendix A Table 5). Comparison of flight height between survey sites as measured by radar is generally less influenced by site characteristics as the main portion of the radar beam is directed skyward, and the potential effects of surrounding vegetation on the radar's view can be more easily controlled.

Nightly variation in the magnitude and flight characteristics of nocturnal migrants is not uncommon and is often attributed to weather patterns, such as cold fronts and winds aloft (Hassler *et al.* 1963, Gauthreaux and Able 1970, Richardson 1972, Able 1973, Bingman *et al.* 1982, Gauthreaux 1991). Overall, the spring 2011 migration season consisted of many low pressure systems resulting in many nights with rain. Between April 18 and May 26 the weather station located at Hillsborough, New Hampshire, approximately 9 miles northeast of the Project area, recorded 24 days with precipitation (Weather Underground 2011). The nights with the lowest passage rates (April 19 and May 17) were characterized by low pressure systems and rain. On the nights with the highest passage rates (1215 ± 299 t/km/hr on May 20 and 1139 ± 176 t/km/hr on May 24), a low pressure system was present on May 20 and no pressure system was evident on May 24. It is likely that migrants were forced to move on nights with less than optimal conditions because of the numerous low pressure systems that occurred during the traditional migration window. Wind speeds were low to moderate and from the southwest on those nights with the highest passage rates apparently providing more suitable conditions for migration than other nights. It is worth noting that a radar site located in western mountains of Maine and one located in Downeast Maine also recorded peak or near peak passage for the spring 2011 migration period on May 24 suggesting similar migration conditions for the region.

In summary, results at the Project are within the range of results recorded at other radar studies conducted in New Hampshire and the East, and provide a sample of baseline migration activity over the Project area during spring 2011 that is typical of data from other proposed projects on Northeastern forested ridges.

3.0 Acoustic Bat Survey

3.1 INTRODUCTION

Acoustic sampling of bat activity has become a standard pre-construction survey for proposed wind-energy development (Kunz *et al.* 2007). Although acoustic surveys are associated with several major assumptions (Hayes 2000) and results cannot be used to determine the number of bats inhabiting an area or determine the number of bats which will be killed post-construction, acoustic surveys can provide insight into seasonal patterns in activity levels and examine how weather conditions influence bat activity. While these data may be useful in predicting trends in post-construction mortality rates, the current lack of data on this topic precludes quantitative prediction of risk. The object of spring acoustic surveys at the Project were (1) to document bat activity patterns from mid-April through the end of May in airspace near the rotor zone of the proposed turbines, at an intermediate height, and near the ground; and (2) to document bat activity patterns in relation to weather factors including wind speed, temperature, and relative humidity.

Eight species of bats occur in New Hampshire, based upon their normal geographical range. These are the little brown bat (*Myotis lucifugus*), northern long-eared bat, (*M. septentrionalis*), eastern small-footed bat (*M. leibii*), silver-haired bat (*Lasionycteris noctivagans*), tri-colored bat (*Perimyotis subflavus*), big brown bat (*Eptesicus fuscus*), eastern red bat (*Lasiurus borealis*), and hoary bat (*L. cinereus*) (BCI 2001). Of these eight species, the eastern small-footed bat is state-listed as endangered with a rank of S1 ("Critically Imperiled"[2]), and five species (tri-colored bat, eastern red bat, silver-haired bat, hoary bat, and northern long-eared bat) are state-listed as Species of Special Concern. All six state-listed species are also listed as Species of Greatest

[2] A state ranking of S1 is assigned to species characterized as critically imperiled because of extreme rarity (generally one to five occurrences) or because some factor of its biology makes it particularly vulnerable to extinction.

Conservation Need under New Hampshire's Wildlife Action Plan (New Hampshire Fish and Game Department 2005).

3.2 DATA COLLECTION METHODS

3.2.1 Acoustic Detector Site Selection

Anabat SDI and SD2 detectors (Titley Electronics Pty Ltd.) were used for the duration of the spring 2011 acoustic bat survey. Anabat detectors were selected based upon their widespread use for this type of survey, their ability to be deployed for long periods of time, and their ability to detect a broad frequency range, which allows detection of all species of bats that could occur in the Project area. Anabat detectors were programmed to turn on and off on a daily basis to sample at least the period between sunset and sunrise, and stored recorded bat call sequences on removable 1 gigabyte (GB) compact flash cards. Anabat detectors are frequency division detectors, dividing the frequency of echolocation sounds made by bats by a factor of 16, then recording these sounds for subsequent analysis. The audio sensitivity setting of each Anabat system was set between six and seven (on a logarithmic scale of one to ten) to maximize sensitivity while limiting ambient background noise and interference. The sensitivity of individual detectors was then tested using an ultrasonic Bat Chirp (Reno, NV) to ensure that the detectors would be able to detect bats up to a distance of at least 10 m (33').

Each Anabat detector was powered by a 12-volt gel battery charged by a solar panel. Each solar-powered Anabat system was deployed in waterproof housing enabling the detector to record while unattended for the duration of the survey. The housing suspends the Anabat microphone downward to give maximum protection from precipitation. To compensate for the downward position, the microphone was positioned within a 90 degree PVC elbow on the bottom of the waterproof enclosure, allowing the microphone to record the airspace horizontally surrounding the detector while minimizing acoustic signal loss.

The six Anabat detectors were deployed in the Project area between April 7 and April 16, and collected data through the end of May. Two detectors were deployed in the guy wires of the existing 60 m (197') met tower at heights of approximately 15 and 30 m (49 and 98') above ground level, and the remaining four detectors were deployed in trees throughout the Project area at heights of approximately 5 to 10 m (16 and 33') above ground level (agl) (Figures 3-1 to 3-3). Table 3-1 provides information on location and placement of detectors as well as surrounding habitat. Maintenance visits were conducted approximately every two weeks to check the condition of the detectors and to download data to a computer for archiving and subsequent analysis.

Table 3-1. Habitat descriptions of locations sampled during spring 2011 acoustic bat surveys at the Antrim Wind Project.

Detector Name	Elevation (m)	Height (m agl)	Habitat Notes
Willard Tree	563	5	Detector located 10 m from the edge of a 50 m diameter opening in an even-aged spruce/red maple forest with open understory, 15 m surrounding canopy height. Herbaceous vegetation and scattered trees in opening.
Willard Trail	522	5	Detector located 15 m from the edge of a 50 m clearing in an even-aged oak/maple forest with open understory.
Acces Tree	355	10	Detector suspended above intersection of forested trails 30 m from a transmission line corridor. Surrounding canopy (beech, birch, maple) 20 m tall with dense shrub understory.
Wetland	525	5	Detector located within a small wetland opening surrounded by uneven aged red maple/conifer forest.
N Met High	536	30	Detector deployed as high as possible in the guy wires of the met tower. Tower clearing surrounded by conifer-dominated forest.
N Met Low	536	15	Detector deployed in the guy wires of the met tower. Tower clearing surrounded by conifer-dominated forest.

Figure 3-1. Photos of the Willard Tree (left) and Willard Trail (right) bat detectors.

Figure 3-2. Photos of the Access Tree (left) and Wetland (right) bat detectors.

Figure 3-3. Photos of the North Met High (left) and Low (right) bat detectors.

3.3 DATA ANALYSIS METHODS

Ultrasound recordings of bat echolocation may be broken into recordings of a single bat call or recordings of bat call sequences. A call is a single pulse of sound produced by a bat, while a call sequence is a combination of two or more pulses recorded in an Anabat file. Recordings containing less than two calls were eliminated from analysis as has been done in similar studies (Arnett *et al*. 2006). Call sequences typically include a series of calls characteristic of normal flight or prey location ("search phase") and capture periods (feeding "buzzes").

Potential call files were extracted from data files using CFCread© software. The default settings for CFCread© were used during this file extraction process, as these settings are recommended for the calls that are characteristic of bats in New Hampshire. This software screens all data recorded by the bat detector and extracts call files using a filter. Using the default settings for this initial screening also ensures comparability between data sets. Settings used by the filter include a maximum TBC (time between calls) of 5 seconds, a minimum line length of 5 milliseconds, and a smoothing factor of 50. The smoothing factor refers to whether or not adjacent pixels can be connected with a smooth line. The higher the smoothing factor, the less restrictive the filter is and the more non-bat noise files and poor quality call sequences are retained within the data set.

Following extraction of call files, each file was visually inspected for species identification and to check that only bat calls were included in the data set. Insect activity, wind, and interference can also sometimes produce Anabat files that pass through the initial filter and need to be visually inspected and removed from the data set. Call sequences are easily differentiated from other recordings, which typically form a diffuse band of dots at either a constant frequency or widely varying frequency.

Because bat activity levels are highly variable among individual nights and individual hours (Hayes 1997, Arnett *et al*. 2006), detection rates are summarized on both of these temporal scales. Nightly detection rates were summarized by month as well as for the entire sampling period. Hourly detection rates were summarized by hour after sunset, as recommended by Kunz *et al*. (2007). Quantitative comparisons among these temporal periods were not attempted because the high amount of variability associated with bat detection would require much larger sample sizes (Arnett *et al*. 2006, Hayes 1997).

Bat call sequences were individually marked and categorized by species group, or "guild" based on visual comparison to reference calls. Relatively accurate identification of bat species can be attained by visually comparing recorded call sequences of sufficient length to bat call reference libraries (O'Farrell *et al*. 1999, O'Farrell and Gannon 1999). Call sequences were classified to species whenever possible, based on criteria developed from review of reference calls collected by Chris Corben, the developer of the Anabat system, as well as other bat researchers. However, due to the similar call signatures of several species, classified calls were categorized into five guilds[3] that reflect the bat community in the region of the Project area:

- **Unknown (UNKN)** – All call sequences with less than five calls, or poor quality sequences (those with indistinct call characteristics or background static). These sequences were further identified as either "high frequency unknown" (HFUN) for sequences with a minimum frequency above 30 to 35 kHz, or "low frequency unknown" (LFUN) for sequences with a minimum frequency below 30 to 35 kHz.

- **Myotis (MYSP)** – All bats of the genus *Myotis*. While there are some general characteristics believed to be distinctive for several species in this genus, these characteristics are not sufficiently consistent to be relied upon for species identification at all times when using Anabat recordings.

- **Eastern red bat/tri-colored bat[4] (RBTB)** – Eastern red bats and tri-colored bats. These two species can produce distinctive calls; however, significant overlap in the call pulse shape, frequency range, and slope can also occur.

- **Big brown/silver-haired bat (BBSH)** – Big brown and silver-haired bats. The call signatures of these species commonly overlap and are included as one guild in this report.

- **Hoary bat (HB)** – Hoary bats. Calls of hoary bats can usually be distinguished from those of big brown and silver-haired bats by minimum frequency extending below 20 kHz or by calls varying widely in minimum frequency across a sequence.

This method of guild identification represents a conservative approach to bat call identification. Since some species sometimes produce calls unique only to that species, all calls were identified to the lowest possible taxonomic level before being grouped into the listed guilds.

---

[3] Gannon *et al.* 2003 categorized bats into guilds based upon similar minimum frequency and call shape. These guilds were: Unidentified, Myotis, LABO-PISU and EPFU-LANO-LACI. To report the activity of the migratory hoary bat, it was placed into a separate guild.
[4] The scientific and common name of the eastern pipistrelle (*Pipistrellus subflavus*) has been changed to the tri-colored bat (*Perimyotis subflavus*).

Tables and figures in the body of this report will reflect those guilds. In addition, since species-specific identification did occur in some cases, each guild will also be briefly discussed with respect to potential species composition of recorded call sequences.

Once all of the call files were identified and categorized in appropriate guilds, nightly tallies of detected calls were compiled. Mean detection rates (number of recordings/detector-night) for the entire sampling period were calculated for each detector and for all detectors combined.

3.3.1 Weather Data

Temperature, wind speed and direction were recorded by the on-site met tower. Data at the met tower was recorded at 10-minute intervals for the survey period between April 10 and June 1, 2011. Weather data were summarized on a nightly basis during the survey period and compared to nightly bat activity levels using a scatterplot and linear correlation analysis. In addition to the met tower data, 24-hour precipitation, relative humidity, and barometric pressure data were obtained from a weather station located in Hillsborough, New Hampshire approximately nine miles northeast of the Project (Weather Underground 2011).

3.4 RESULTS

3.4.1 Timing of Activity

During the 56-night survey period (April 7 and June 1), individual detectors recorded between 38 and 56 nights of data with a total 304 detector-nights surveyed out 323 available calendar-nights (94 percent; Table 3-2). The only detector to malfunction for greater than one night was the North Met High detector, which malfunctioned on May 15 through the end of the spring survey period due to an improperly formatted memory card. This problem was corrected during a June 1 site visit.

Combined, detectors recorded a total of 1,483 bat call sequences during the spring survey period (Table 3-2). Individual detectors recorded between 5 sequences (North Met High) and 760 sequences (Access Tree) with corresponding detection rates ranging from 0.1 sequences per detector-night to 14.1 sequences per detector-night. The overall detection rate was 4.9 sequences per detector-night during the spring 2011 survey period (Table 3-2).

Table 3-2. Summary of bat detector field survey effort and results at the Antrim Wind Project, spring 2011.						
Location	**Dates Deployed**	**Calendar Nights**	**Detector-Nights***	**Recorded Sequences**	**Detection Rate ** **	**Maximum Sequences recorded *** **
Access Tree	4/7 - 5/31	55	54	760	14.1	331
N Met High	4/7 - 5/31	55	38	5	0.1	2
N Met Low	4/7 - 5/31	55	55	95	1.7	61
Wetland Tree	4/16 - 5/31	46	45	49	1.1	24
Willard Trail	4/7 - 6/1	56	56	211	3.8	60
Willard Tree	4/7 - 6/1	56	56	363	6.5	130
Overall Results		***323***	***304***	***1,483***	***4.9***	--
* One detector-night is equal to a one detector successfully operating throughout the night.						
** Number of bat echolocation sequences recorded per detector-night.						
*** Maximum number of bat passes recorded from any single detector for a detector-night.						

Acoustic bat activity was sporadic throughout the survey period, but the number of nights with recorded bat activity increased at each detector between April and May, indicating more consistent bat activity in late versus early spring (Table 3-3). By detector, acoustic activity was detected on the greatest percentage of nights at the Access Tree detector (54 percent of nights surveyed). In addition to more consistent bat activity, the total number of calls detected also increased from April through May (Table 3-4). The two met tower detectors recorded acoustic bat activity on the lowest percentage of nights sampled during April and May. The Access Tree detector recorded both the highest activity rate and detected bats on the highest percentage of nights surveyed. Nightly timing of acoustic activity varied among nights and detectors, although overall timing peaked during the hour of sunset and the first hour past sunset and declined steadily thereafter (Figure 3-4).

Table 3-3. Percent of nights with acoustic activity by month and overall during spring 2011 acoustic surveys*			
Detector	**April**	**May**	**Overall**
Access Tree	30% (7/23)	71% (22/31)	54% (29/54)
N Met High	0% (0/24)	29% (4/14)	11% (4/38)
N Met Low	0% (0/24)	45% (14/31)	25% (14/55)
Wetland Tree	27% (4/15)	43% (13/30)	38% (17/45)
Willard Trail	21% (5/24)	61% (19/31)	45% (25/56)
Willard Tree	4% (1/24)	52% (16/31)	32% (18/56)
*% Nights with activity (# nights with activity/# nights surveyed)			

Table 3-4. Monthly summary of spring 2011 acoustic survey results at the Antrim Wind Project .

Detector / Month	Dates	Calendar Nights	Detector-Nights*	Recorded Sequences	Detection Rate **	Maximum Sequences recorded ***
Access Tree						
April	01 April–30 April	30	23	541	23.5	331
May	01 May–31 May	31	31	219	7.1	39
N Met High						
April	01 April–30 April	30	24	0	0.0	0
May	01 May–31 May	31	14	5	0.4	2
N Met Low						
April	01 April–30 April	30	24	0	0.0	0
May	01 May–31 May	31	31	95	3.1	61
Wetland Tree						
April	01 April–30 April	30	15	7	0.5	4
May	01 May–31 May	31	30	42	1.4	24
Willard Trail						
April	01 April–30 April	30	24	6	0.3	2
May	01 May–31 May	31	31	162	5.2	60
June	01 June–30 June	30	1	43	43.0	43
Willard Tree						
April	01 April–30 April	30	24	1	0.0	1
May	01 May–31 May	31	31	319	10.3	130
June	01 June–30 June	30	1	43	43.0	43
Overall Results		**426**	**304**	**1483**	**4.9**	--

* One detector-night is equal to a one detector successfully operating throughout the night.
** Number of bat echolocation sequences recorded per detector-night.
*** Maximum number of bat passes recorded from any single detector for a detector-night.

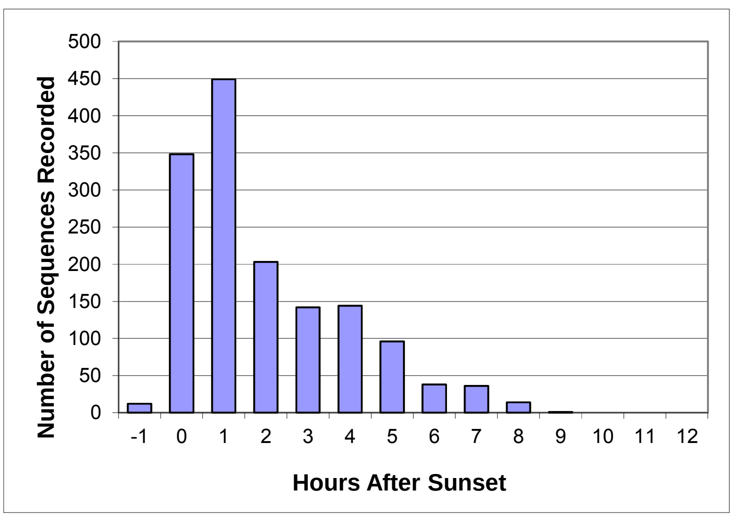


Figure 3-4. Hourly bat call sequence detections during spring 2011 surveys at the Antrim Wind Project.

3.4.2 Species Composition

Bats were identified within each of the defined guilds during analysis. Calls of species in the *Myotis* guild were the most common, comprising 32 percent of the total (Table 3-5). The BBSH guild was the next most commonly identified guild, comprising 31 percent of the total. Most call sequences within the BBSH guild were identified as big brown bats or big brown/silver-haired bats, and only a small fraction were classified as silver-haired bats. Twenty-four percent of call sequences were classified as "unknown" due to their relatively short length or quality. Hoary bats comprised 12 percent of bat call sequences recorded and were detected at all detectors. The RBTB guild was the least commonly detected guild and comprising only 1 percent of the recorded call sequences (Table 3-5).

Species composition differed among detectors. *Myotis* species were most common at the Access Tree detector where they comprised the majority of bats detected. Although the *Myotis* species were the most commonly recorded guild and represented a majority of calls at the Access Tree detector, they were recorded at relatively low numbers at three of the detectors and they were not recorded at the North Met High or Wetland Tree detectors. Unknown bats comprised between 16 and 67 percent of recorded call sequences by detector. The highest percentage of unknown call sequences was recorded at the Wetland Tree detector, where several sequences lacked a sufficient number of pulses to be classified. Hoary bats were detected most frequently at the Willard Tree detector, and three of the five bats recorded at the North Met High detector were hoary bats (Figure 3-5).

Table3-5. Distribution of detections by guild for detectors at Antrim Wind Project, spring 2011.

Detector	Guild					Total
	BBSH	HB	MYSP	RBTB	UNKN	
Access Tree	128	5	438	13	176	760
N Met High	0	3	0	1	1	5
N Met Low	41	5	24	0	25	95
Wetland Tree	8	8	0	0	33	49
Willard Trail	108	24	7	2	70	211
Willard Tree	167	132	5	1	58	363
Total	**452**	**177**	**474**	**17**	**363**	**1,483**
Guild Compositior	**30.5%**	**11.9%**	**32.0%**	**1.1%**	**24.5%**	

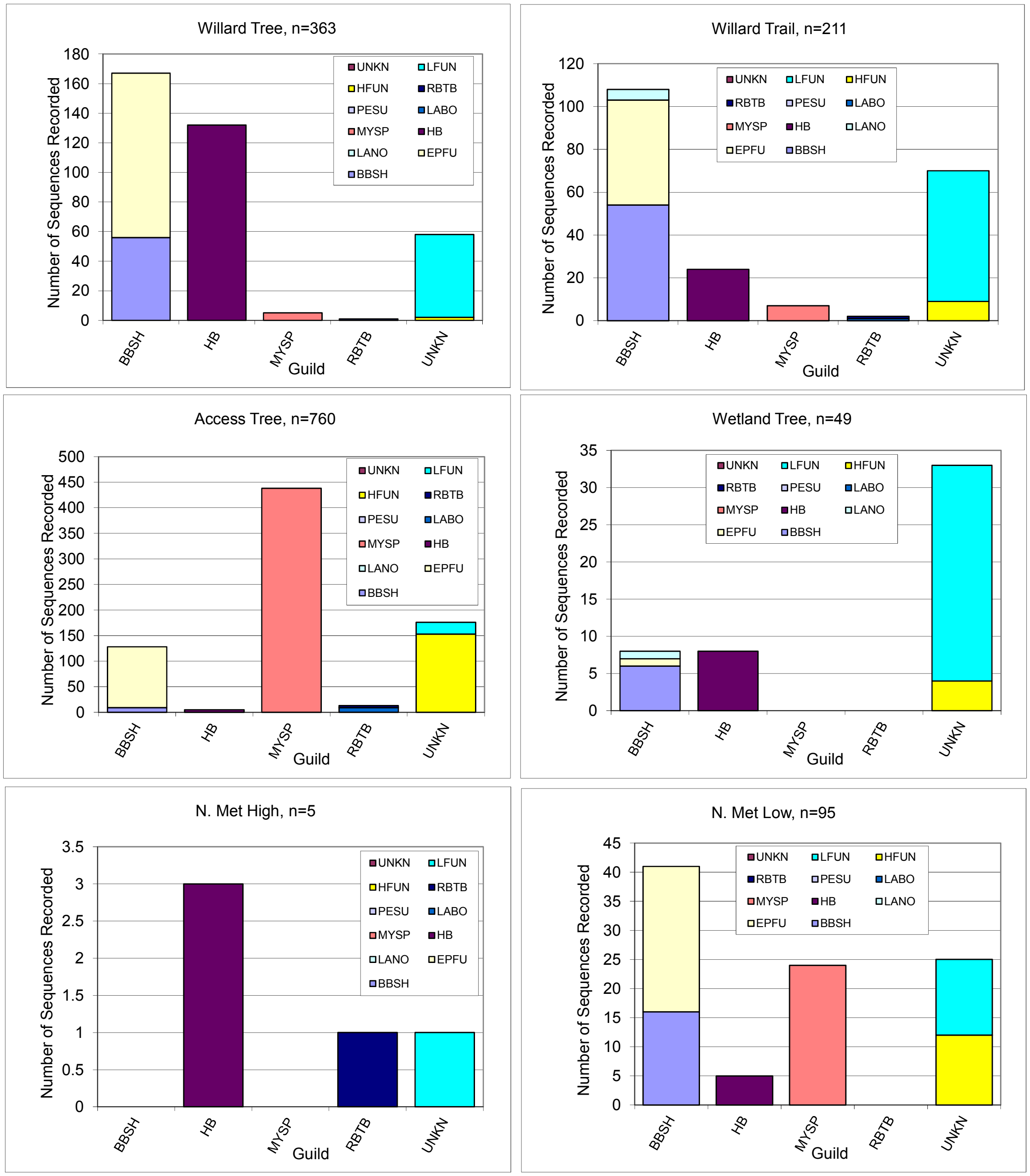


Figure 3-5. Histograms showing species composition of recorded bat call sequences. Note the differing scales on the y-axes. BBSH = big brown/silver-haired, HB = hoary bat, MYSP = Myotis species, RBTB = red bat/tri-colored bat, UNKN = unknown, LFUN = low frequency unknown, HFUN = high frequency unknown, PESU = tri-colored bat, LABO = red bat, LANO = silver-haired bat, EPFU = big brown bat.

Appendix B provides a series of tables with more specific information on the nightly timing, number, and species composition of recorded bat call sequences. Specifically, Appendix B Tables 1 through 6 provide information on the number of call sequences by guild and suspected species recorded at each detector and the weather conditions for that night. An electronic copy of all acoustic data files can be provided upon request.

3.4.3 Activity and Weather

Mean nightly wind speeds in the Project area from April 7 through June 1 varied between 1.4 and 12.5 m/s, with an overall mean of 7.3 m/s (Figure 3-6). Mean nightly temperatures varied between -1.8 °C and 20.2 °C, with an overall mean of 9.1 °C (Figure 3-7). Figure 3-9 displays scatterplots of overall acoustic activity versus nightly temperature and wind speed. Combined bat activity levels showed a weak negative correlation with increasing nightly wind speed and a weak positive correlation with increasing nightly temperature (Figure 3-8).

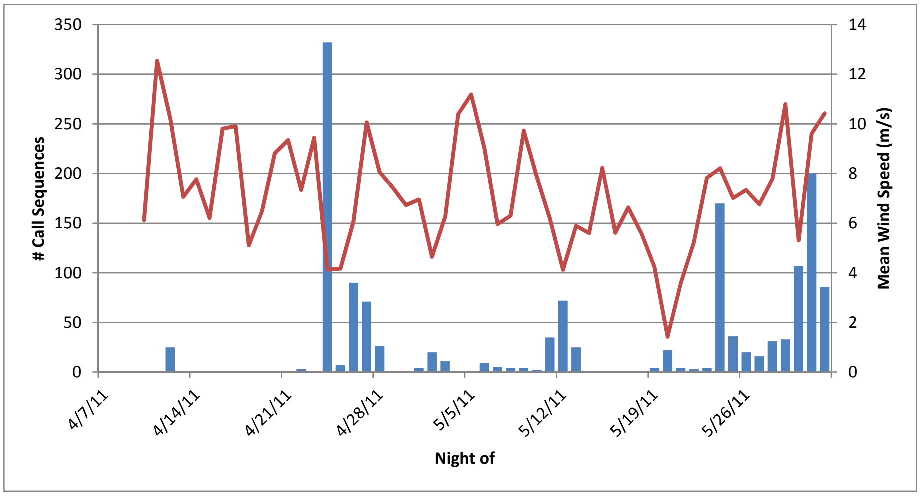


Figure 3-6. Nightly mean wind speed (m/s) (red line) and combined bat call detections during spring 2011 surveys at the Antrim Wind Project.

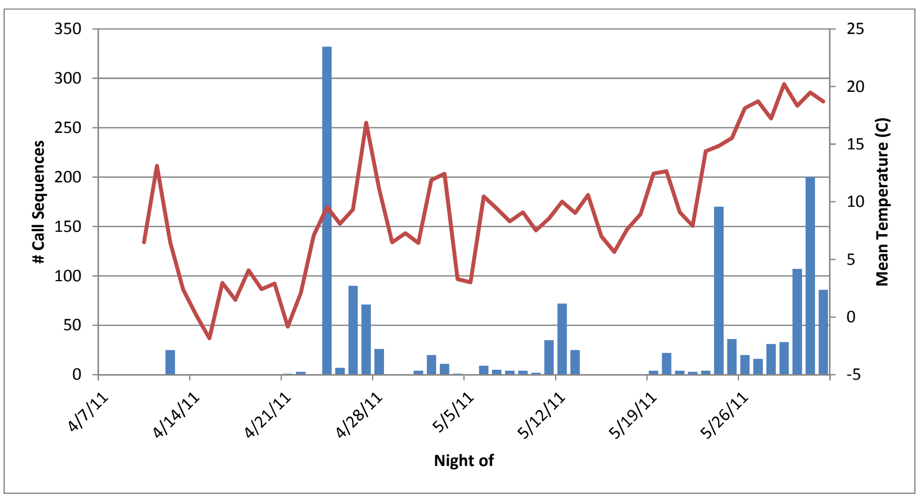


Figure 3-7. Nightly mean temperature (Celsius) (red line) and combined bat detections during spring 2011 bat surveys at the Antrim Wind Project.

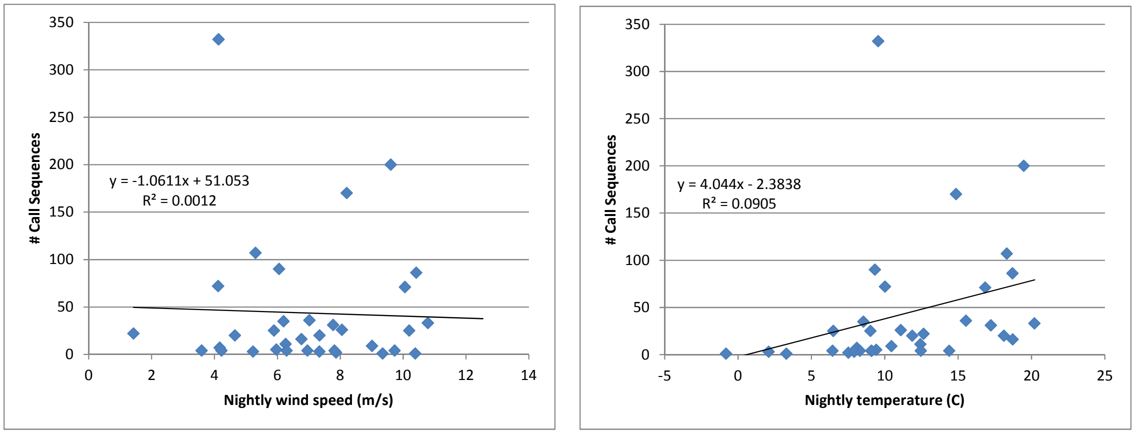


Figure 3-8. Nightly mean wind speed (left), and mean temperature (right) versus combined bat detections during spring 2011 bat surveys at the Antrim Wind Project

3.5 DISCUSSION

Spring 2011 acoustic surveys at the Antrim Wind Project documented variable levels of bat activity among the six detectors deployed in the Project area. Activity levels were also highly variable among nights during the April 7 to June 1 study period. However, some general trends were also observed, including more consistent acoustic activity in May than April (as indicated by the percentage of nights with detected activity), and overall increases in the number of call files in the second half of May as temperatures increased. In a subsequent report, the spring acoustic data will be considered together with data recorded for the remainder of summer and fall to discuss overall seasonal trends in activity.

Inter-night and inter-detector variability is common in acoustic bat surveys, where microhabitat surrounding detectors can influence the number of calls recorded as well as the quality of call files. Although Stantec made an effort to deploy acoustic detectors in similar configurations (along habitat edges and corridors that may concentrate bat activity), slight differences in deployment lead to inevitable differences in detection rates that do not necessarily correspond to the number of bats in the vicinity of the detectors.

The Access Tree detector recorded substantially more bat calls than the other detectors deployed in the Project area, and recorded the majority of the total *Myotis* species call sequences. The Access Tree detector also detected activity on the greatest percentage of nights surveyed. Although deployed in a similar configuration to other detectors, this detector was located approximately 170 m lower in elevation than the other five detectors. The lower elevation may have resulted in milder conditions, potentially increasing the amount of acoustic activity at this location. Nearly half of the bat call sequences and the majority of Myotis sequences recorded at this detector occurred on the night of April 24, highlighting the variability of acoustic detection rates among nights.

Comparison of acoustic bat activity documented at the North Met High and North Met Low detectors with the other Project detectors may help clarify activity patterns of bats in the air space above tree canopy and within the rotor zone of proposed wind turbines. The North Met

High detector recorded substantially less acoustic activity than any other detector, and recorded activity on the smallest percentage of nights sampled. However, it is also important to note that this detector malfunctioned for the final two weeks of the spring monitoring period, which corresponds to the period when higher activity levels were documented at the other detectors. The North Met Low detector recorded an activity rate slightly higher than the Wetland Tree detector, but recorded activity on a smaller percentage of sampled nights than all detectors except the North Met High detector. Despite the malfunctioning high detector, the met tower detectors recorded lower acoustic activity rates and less frequent activity than detectors suspended from trees along forested corridors, suggesting that bats were less active in open air spaces and above the forest canopy, which aligns with their foraging behavior.

Bat call sequences were identified to guild, although calls were provisionally categorized by species when possible during analysis. Certain species, such as the eastern red and hoary bat, have easily identifiable calls, whereas other species, such as the big brown bat and silver-haired bat, are difficult to distinguish acoustically. Similarly, species within the *Myotis* genus have very similar calls and Stantec did not make an attempt to differentiate call sequences within this genus. *Myotis* species have been particularly affected by the white-nose syndrome (WNS) that has become widespread in the Northeast. While the large number of *Myotis* sequences recorded at the Access Tree detector is notable, the majority of these calls were recorded on one night, and do not necessarily reflect a large number of these bats in the Project area. The high variability activity levels of *Myotis* species at the Project may actually suggest that a small number of *Myotis* are present within the Project area. Prior to WNS, *Myotis* call sequences often tended to dominate acoustic data collected from detectors deployed in trees (Peterson *et al.* unpublished data). Exclusive of the Access Tree detector, the Project area detectors recorded fewer than 40 *Myotis* call sequences during spring 2011 surveys suggesting relatively few *Myotis* species within the surveyed area.

Recent studies have found that bat activity patterns are influenced by weather conditions (Arnett *et al*. 2006, Arnett *et al*. 2008, Reynolds 2006). Acoustic surveys have documented a decrease in bat activity rates as wind speed increase and temperatures decrease, and bat activity has been shown to correlate negatively to low nightly mean temperatures (Hayes 1997, Reynolds 2006). Similarly, weather factors appeared to be related to bat collision mortality rates documented at two wind energy facilities in the southeastern United States, with mortality rates negatively correlated with both wind speed and relative humidity, and positively correlated to barometric pressure (Arnett 2005). These patterns suggest that bats are more likely to migrate on nights with low wind speeds (less than 4 to 6 m/s) and generally warm temperatures. Thus, several weather variables can individually affect bat activity, as does the interaction among variables (*i.e*., warm nights with low wind speeds). Spring 2011 acoustic sampling at the Project documented weak correlations between acoustic activity and wind speed and temperature. Raw acoustic data of the type analyzed in this study are prone to substantial variability and it is not surprising that acoustic activity was still documented on nights with higher wind speeds and colder temperatures.

When considering the level of activity documented at the Project during the spring 2011 acoustic survey, it is important to acknowledge that numbers of recorded bat call sequences cannot be correlated with the number of bats in an area because acoustic detectors do not allow for differentiation between individuals. While these data may be useful in predicting trends in post-construction mortality rates, the current lack of data on this topic precludes quantitative prediction of risk.

4.0 Literature Cited

Able, K.P. 1973. The role of weather variables and flight direction in determining the magnitude of nocturnal migration. Ecology 54(5):1031–1041.

Alerstam, T. 1990. Bird Migration. Cambridge University Press, Cambridge, United Kingdom.

Arnett, E.B., technical editor. 2005. Relationships between bats and wind turbines in Pennsylvania and West Virginia: an assessment of bat fatality search protocols, patterns of fatality, and behavioral interactions with wind turbines. A final report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, Texas, USA.

Arnett, E. B., J. P. Hayes, and M. M. P. Huso. 2006. An evaluation of the use of acoustic monitoring to predict bat fatality at a proposed wind facility in south central Batschelet, E. 1965. Statistical Methods for the Analysis of Problems in Animal Orientation and Certain Biological Rhythms. AIBS Monograph. American Institute of Biological Sciences. Washington, DC.

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

(BCI) Bat Conservation International. 2001. Bats in Eastern Woodlands. http://www.batcon.org/nabcp/newsite/forrep.pdf. Accessed on November 2007.

Batschelet, E. 1965. Statistical Methods for the Analysis of Problems in Animal Orientation and Certain Biological Rhythms. AIBS Monograph. American Institute of Biological Sciences. Washington, DC.

Bingman, V.P., K.P. Able, and P. Kerlinger. 1982. Wind drift, compensation, and the use of landmarks by nocturnal bird migrants. Animal Behavior 30:49–53.

Bruderer, B. and A. Boldt. 2001. Flight characterstics of birds: I. Radar measurements of speeds. Ibis. 143:178-204.

Cooper, B.A., R.H. Day, R.J. Ritchie, and C.L. Cranor. 1991. An improved marine radar system for studies of bird migration. Journal of Field Ornithology 62:367–377.

Gannon, W.L., R.E. Sherwin, and S. Haywood. 2003. On the importance of articulating assumptions when conducting acoustic studies of habitat use by bats. Wild. Soc. Bull. 31 (1):45–61.

Gauthreaux, S.A., Jr. 1991. The flight behavior of migrating birds in changing wind fields: radar and visual analyses. American Zoologist 31:187–204.

Gauthreaux, S.A., Jr., and K.P. Able. 1970. Wind and the direction of nocturnal songbird migration. Nature 228:476–477.

Griffith, G.E., Omernik, J.M., Bryce, S.A., Royte, J., Hoar, W.D., Homer, J.W., Keirstead, D., Metzler, K.J., and Hellyer, G., 2009, Ecoregions of New England (color poster with map, descriptive text, summary tables, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:1,325,000).

Harmata, A., K. Podruzny, J. Zelenak, and M. Morrison. 1999. Using marine surveillance radar to study bird movements and impact assessment. Wildlife Society Bulletin 27(1):44–52.

Hassler, S.S., R.R. Graber, and F.C. Bellrose. 1963. Fall migration and weather, a radar study. The Wilson Bulletin 75(1):56–77.

Hayes J. P. 1997. Temporal variation in activity of bats and the design of echolocation-monitoring studies. Journal of Mammalogy 78:514–24.

Hayes, J.P. 2000. Assumptions and practical considerations in the design and interpretation of echolocation-monitoring studies. Acta Chiropterologica 2(2):225-236.

Kerlinger, P. 1995. How Birds Migrate. Stackpole Books. Mechanicsburg, PA.

Kunz, T.H., E.B. Arnett, B.P. Cooper, W.P. Erickson, R.P. Larkin, T. Mabee, M.L. Morrison, M.D. Strickland, and J.M. Szewczak. 2007. Assessing impacts of wind-energy development on nocturnally active birds and bats: A guidance document. Journal of Wildlife Management 71:2449-2486.

Larkin, R.P. 1991. Flight speeds observed with radar, a correction; slow “birds” are insects. Behavioral Ecology and Sociobiology. 29:221-224.

New Hampshire Fish and Game Department. 2005. New Hampshire Wildlife Action Plan. Concord, NH.

O’Farrell, M.J., and W.L. Gannon. 1999. A comparison of acoustic versus capture techniques for the inventory of bats. Journal of Mammalogy 80(1):24–30.

O’Farrell, M.J., B.W. Miller, and W.L. Gannon. 1999. Qualitative identification of free-flying bats using the anabat detector. Journal of Mammalogy 80(1):11–23.

Peterson, T., K. Watrous, A. Gravel and S. Pelletier. 2011. Acoustic detection rates of Myotis at proposed wind development sites in Maine, unpublished data. Stantec Consulting Services Inc.

Reynolds, D. S. 2006. Monitoring the potential impacts of a wind development site on bats in the Northeast. Journal of Wildlife Management 70(5):1219 – 1227.

Richardson, W.J. 1972. Autumn migration and weather in eastern Canada: a radar study. American Birds 26(1):10–16.

Weather Underground. 2011. http://www.wunderground.com/. Last Accessed September 2, 2011.

Appendix A

Radar survey results

Appendix A Table 1. Survey dates, results, level of effort, and weather - Spring 2011

Date	Sunset	Sunrise	# of Hours Analyzed	Passage rate	Flight Direction	Flight Height (m)	% below 150 m	Temperature (C)	Wind Speed (m/s)	Wind Direction (degrees)
4/18	19:32	6:02	10	59	46	254	27%	4	5	297
4/19	19:34	6:01	10	7	209	166	54%	2	6	127
4/20	19:35	5:59	10	45	46	181	45%	3	9	255
4/23	19:38	5:54	10	25	48	189	41%	7	9	234
4/24	19:39	5:53	10	102	61	239	38%	10	4	232
4/25	19:41	5:51	10	13	309	198	43%	8	4	121
4/30	19:46	5:44	10	50	151	177	56%	7	7	160
5/1	19:47	5:43	10	88	25	297	17%	6	7	189
5/2	19:49	5:41	10	56	36	218	35%	12	5	230
5/3	19:50	5:40	10	160	29	240	44%	12	6	154
5/6	19:53	5:36	10	73	26	272	19%	10	9	229
5/7	19:54	5:35	10	134	66	139	64%	9	6	178
5/8	19:55	5:33	10	58	78	150	58%	8	6	154
5/9	19:56	5:32	10	40	89	135	63%	9	10	220
5/10	19:58	5:31	10	60	226	197	44%	8	8	36
5/11	19:59	5:30	10	279	46	169	56%	9	6	50
5/12	20:00	5:29	10	979	40	254	31%	10	4	191
5/13	20:01	5:27	10	203	4	412	11%	9	6	159
5/14	20:02	5:26	9	194	28	296	26%	11	6	202
5/16	20:04	5:24	9	19	271	412	16%	6	6	82
5/17	20:05	5:23	8	6	242	370	11%	8	7	71
5/18	20:06	5:22	9	22	253	413	8%	9	6	72
5/19	20:07	5:21	9	42	264	486	8%	12	4	74
5/20	20:08	5:20	9	1215	49	366	26%	13	1	187
5/21	20:09	5:19	9	123	335	464	20%	9	4	112
5/22	20:10	5:19	7	147	28	472	7%	8	5	163
5/23	20:11	5:18	8	395	32	458	18%	14	8	198
5/24	20:12	5:17	9	1113	55	198	53%	15	8	297
5/25	20:13	5:16	9	755	57	178	55%	16	7	191
5/26	20:14	5:15	9	375	30	395	22%	18	7	217
Entire Season			**284**	**223**	**44**	**305**	**30%**	**9**	**6**	**169**

Appendix A Table 2. Summary of passage rates by hour, night, and for entire season.														
Night of	**Passage Rate (targets/km/hr) by hour after sunset**										**Entire Night**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Mean**	**Median**	**Stdev**	**SE**
4/18	0	4	11	46	32	29	111	129	154	71	59	39	55	17
4/19	21	14	7	7	0	7	0	0	0	11	7	7	7	2
4/20	0	0	0	14	118	125	100	64	21	11	45	18	51	16
4/23	0	4	4	0	29	4	64	57	25	64	25	14	27	9
4/24	43	46	114	143	168	114	121	100	75	96	102	107	39	12
4/25	18	14	4	18	11	4	4	0	0	57	13	7	17	5
4/30	68	32	71	71	50	57	54	43	39	18	50	52	18	6
5/1	75	121	136	75	61	71	89	96	104	54	88	82	26	8
5/2	18	61	64	54	86	50	57	64	79	30	56	59	20	6
5/3	61	57	64	93	136	464	318	175	96	136	160	116	132	42
5/6	36	64	79	64	104	93	111	96	75	7	73	77	32	10
5/7	14	193	157	214	261	225	157	61	57	4	134	157	93	29
5/8	46	175	104	82	25	43	46	21	25	7	58	45	50	16
5/9	21	39	75	68	57	54	46	11	32	0	40	43	24	8
5/10	46	118	114	39	36	21	75	71	79	4	60	59	38	12
5/11	182	336	250	164	229	339	268	293	693	32	279	259	172	54
5/12	254	1282	1375	1718	1375	1179	1039	996	514	57	979	1109	536	170
5/13	218	286	236	254	161	236	246	154	200	39	203	227	70	22
5/14	104	239	229	261	304	236	146	137	93	N/A	194	229	75	25
5/16	61	57	11	21	7	11	0	0	0	N/A	19	11	24	8
5/17	7	11	0	25	Rain	0	4	0	0	N/A	6	2	9	3
5/18	89	11	25	14	18	7	21	0	11	N/A	22	14	26	9
5/19	104	25	25	25	68	75	32	21	0	N/A	42	25	33	11
5/20	171	254	429	768	2246	2125	2279	1857	807	N/A	1215	807	897	299
5/21	289	182	100	50	132	136	111	68	36	N/A	123	111	78	26
5/22	189	468	261	Rain	14	Rain	21	36	43	N/A	147	43	170	64
5/23	214	329	118	107	100	832	911	550	N/A	N/A	395	271	331	117
5/24	425	1282	1568	1489	1432	1514	1029	975	304	N/A	1113	1282	474	158
5/25	225	961	1004	1000	846	889	686	836	346	N/A	755	846	285	95
5/26	232	371	486	457	275	261	418	686	193	N/A	375	371	156	52
Entire Season	**108**	**235**	**237**	**253**	**289**	**317**	**285**	**253**	**141**	**39**	**223**	**73**	**393**	**23**
0 indicates no targets counted for that hour								N/A indicates no or only partial data for that hour						

Appendix A Table 3. Mean Nightly Flight Direction		
Night of	**Mean Flight Direction**	**Circular Stdev**
4/18	46	51
4/19	209	92
4/20	46	59
4/23	48	27
4/24	61	63
4/25	309	70
4/30	151	99
5/1	25	45
5/2	36	51
5/3	29	76
5/6	26	37
5/7	66	47
5/8	78	70
5/9	89	69
5/10	226	47
5/11	46	85
5/12	40	31
5/13	4	54
5/14	28	51
5/16	271	40
5/17	242	29
5/18	253	29
5/19	264	41
5/20	49	36
5/21	335	63
5/22	28	43
5/23	32	50
5/24	55	32
5/25	57	30
5/26	30	46
Entire Season	**44**	**49**

Appendix A Table 4. Summary of mean flight heights by hour, night, and for entire season.

Night of	Mean Flight Height (m) by hour after sunset										Entire Night				Number of targets below 150 meters	% of targets below 150 meters
	1	2	3	4	5	6	7	8	9	10	Mean	Median	STDV	SE		
4/18	--	166	205	254	289	275	285	231	218	258	254	248	148	49	238	27%
4/19	279	158	215	190	111	135	93	--	--	124	166	147	97	34	15	54%
4/20	--	254	222	232	196	158	191	155	151	188	181	164	118	39	209	45%
4/23	--	290	180	210	247	238	194	183	158	157	189	171	98	33	136	41%
4/24	179	226	191	203	227	201	287	295	266	239	239	200	173	55	223	38%
4/25	129	181	137	215	221	206	--	313	201	286	198	175	143	48	47	43%
4/30	125	202	168	245	158	134	119	162	209	319	177	135	170	54	118	56%
5/1	208	289	322	314	299	282	293	279	293	304	297	285	155	49	217	17%
5/2	179	242	220	222	273	216	196	211	173	175	218	193	126	40	136	35%
5/3	152	264	366	325	300	136	162	112	162	194	240	171	201	64	275	44%
5/6	242	305	290	274	269	281	262	256	234	226	272	266	133	42	346	19%
5/7	207	186	126	142	96	136	111	127	158	272	139	113	108	34	253	64%
5/8	130	127	118	181	180	202	183	152	145	170	150	127	100	32	135	58%
5/9	102	138	90	125	171	132	167	199	152	--	135	114	94	31	99	63%
5/10	169	226	197	Rain	Rain	250	155	164	218	164	197	168	114	40	72	44%
5/11	175	209	226	157	148	93	88	116	104	101	169	131	139	44	320	56%
5/12	282	273	224	228	273	254	265	233	251	315	254	208	194	61	1388	31%
5/13	231	496	503	417	387	380	313	311	315	N/A	412	390	222	74	277	11%
5/14	258	297	296	273	304	317	326	302	277	N/A	296	257	201	67	269	26%
5/16	238	368	523	332	654	845	406	--	--	N/A	412	355	274	104	10	16%
5/17	353	--	444	Rain	Rain	511	439	536	174	N/A	370	386	152	62	4	11%
5/18	349	507	398	440	400	405	341	410	601	N/A	413	386	208	69	14	8%
5/19	292	417	362	425	526	519	438	482	677	N/A	486	460	256	85	23	8%
5/20	428	528	586	506	271	272	198	182	208	N/A	366	317	251	84	1328	26%
5/21	188	254	541	566	454	519	520	493	496	N/A	464	506	271	90	176	20%
5/22	342	376	498	465	528	Rain	680	601	561	N/A	472	429	247	87	51	7%
5/23	223	364	273	294	294	444	575	500	N/A	N/A	458	466	287	102	286	18%
5/24	222	266	212	195	157	125	125	121	212	N/A	198	142	191	64	1454	53%
5/25	232	225	182	167	142	117	104	96	197	N/A	178	134	157	52	1003	55%
5/26	281	406	437	438	307	415	476	385	319	N/A	395	353	261	87	471	22%
Entire Season	**229**	**284**	**292**	**287**	**281**	**283**	**276**	**272**	**264**	**218**	**305**	**244**	**230**	**1**	**9593**	**30%**

-- indicates no targets counted for that hour   N/A indicates no or only partial data for that hour

Appendix A Table 5. Summary of available avian spring radar survey results conducted at proposed (pre-construction) US wind power facilities in eastern US, using X-band mobile radar systems (2004-present)

Year	Project Site	Number of Survey Nights	Number of Survey Hours	Landscape	Average Passage Rate (t/km/hr)	Range in Nightly Passage Rates	Average Flight Direction	Average Flight Height (m)	(Turbine Ht) % Targets Below Turbine Height	Reference
Spring 2005										
2005	Sheffield, Caledonia Cty, VT	20	180	Forested ridge	166	12-440	40	552	(125 m) 6%	Woodlot Alternatives, Inc. 2006. Avian and Bat Information Summary and Risk Assessment for the Proposed Sheffield Wind Power Project in Sheffield, Vermont. Prepared for UPC Wind Management, LLC.
2005	Stamford, Delaware Cty, NY	35	301	Forested ridge	210	10-785	46	431	(110 m) 8%	Woodlot Alternatives, Inc. 2007. A Spring and Fall 2005 Radar and Acoustic Survey of Bird Migration at the Proposed Moresville Energy Center in Stamford and Roxbury, New York. Prepared for Invenergy, LLC. Rockville, MD.
2005	Deerfield, Bennington Cty, VT	20	183	Forested ridge	404	74-973	69	523	(100 m) 4%	Woodlot Alternatives, Inc. 2005. Spring 2005 Bird and Bat Migration Surveys at the Proposed Deerfield Wind Project in Searsburg and Readsboro, Vermont. Prepared for PPM Energy, Inc.
2005	Franklin, Pendleton Cty, NY	21	204	Forested ridge	457	34-1240	53	492	(125 m) 11%	Woodlot Alternatives, Inc. 2005. A Spring 2005 Radar and Acoustic Survey of Bird and Bat Migration at the Proposed Liberty Gap Wind Project in Franklin, West Virginia. Prepared for US Wind Force, LLC.
2005	Dans Mountain, Allegany Cty, MD	23	189	Forested ridge	493	63-1388	38	541	(125 m) 15%	Woodlot Alternatives, Inc. 2005. A Spring 2005 Radar, Visual, and Acoustic Survey of Bird and Bat Migration at the Proposed Dan's Mountain Wind Project in Frostburg, Maryland. Prepared for US Wind Force.
Spring 2006										
2006	Kibby, Franklin Cty, ME (Range 1)	10	80	Forested ridge	197	6-471	50	412	(120 m) 22%	Woodlot Alternatives, Inc. 2006. A Spring 2006 Survey of Bird and Bat Migration at the Proposed Kibby Wind Power Project in Kibby and Skinner Townships, Maine. Prepared for TransCanada Maine.
2006	Deerfield, Bennington Cty, VT	26	236	Forested ridge	263	5-934	58	435	(100 m) 11%	Woodlot Alternatives, Inc. 2006. Spring 2006 Bird and Bat Migration Surveys at the Proposed Deerfield Wind Project in Searsburg and Readsboro, Vermont. Prepared for PPM Energy, Inc.
2006	Mars Hill, Aroostook Cty, ME	15	85	Forested ridge	338	76-674	58	384	(120 m) 14%	Woodlot Alternatives, Inc. 2006. A Spring 2006 Radar, Visual, and Acoustic Survey of Bird Migration at the Mars Hill Wind Farm in Mars Hill, Maine. Prepared for Evergreen Windpower, LLC.
2006	Kibby, Franklin Cty, ME (Valley)	2	14	Forested ridge	443	45-1242	61	334	(120 m) n/a	Woodlot Alternatives, Inc. 2006. A Spring 2006 Survey of Bird and Bat Migration at the Proposed Kibby Wind Power Project in Kibby and Skinner Townships, Maine. Prepared for TransCanada Maine.
2006	Kibby, Franklin Cty, ME (Mountain)	6	33	Forested ridge	456	88-1500	67	368	(120 m) 14%	Woodlot Alternatives, Inc. 2006. A Spring 2006 Survey of Bird and Bat Migration at the Proposed Kibby Wind Power Project in Kibby and Skinner Townships, Maine. Prepared for TransCanada Maine.
2006	Kibby, Franklin Cty, ME (Range 2)	7	57	Forested ridge	512	18-757	86	378	(120 m) 25%	Woodlot Alternatives, Inc. 2006. A Spring 2006 Survey of Bird and Bat Migration at the Proposed Kibby Wind Power Project in Kibby and Skinner Townships, Maine. Prepared for TransCanada Maine.
Spring 2007										
2007	Stetson, Washington Cty, ME	21	138	Forested ridge	147	3-434	55	210	(120 m) 22%	Woodlot Alternatives, Inc. 2007. A Spring 2007 Survey of Bird and Bat Migration at the Stetson Wind Project, Washington County, Maine. Prepared for Evergreen Wind V, LLC.
2007	Laurel Mountain, Barbour Cty, WV	20	197	Forested ridge	277	13-646	27	533	(130 m) 3%	Stantec Consulting Services Inc. 2007. A Spring 2007 Radar, Visual, and Acoustic Survey of Bird and Bat Migration at the Proposed Laurel Mountain Wind Energy Project near Elkins, West Virginia. Prepared for AES Laurel Mountain, LLC.
2007	Errol, Coos County, NH	30	212	Forested ridge	342	2 to 870	76	332	(125 m) 14%	Stantec Consulting Inc. 2007. Spring 2007 Radar, Visual, and Acoustic Survey of Bird and Bat Migration at the Proposed Windpark in Coos County, New Hampshire by Granite Reliable Power, LLC. Prepared for Granite Reliable Power, LLC.
2007	Roxbury, Oxford Cty, ME	20	n/a	Forested ridge	539	137-1256	52	312	(130 m) 18%	Woodlot Alternatives, Inc. 2007. A Spring 2007 Survey of Bird and Bat Migration at the Record Hill Wind Project, Roxbury, Maine. Prepared for Roxbury Hill Wind LLC.
2007	Lempster, Sullivan Cty, NH	30	277	Forested ridge	542	49-1094	49	358	(125 m) 18%	Woodlot Alternatives, Inc. 2007.A Spring 2007 Survey of Nocturnal Bird Migration, Breeding Birds, and Bicknell's Thrush at the Proposed Lempster Mountain Wind Power Project Lempster, New Hampshire. Prepared for Lempster Wind, LLC.
Spring 2008										
2008	Allegany, Cattaraugus Cty, NY	30	275	Forested ridge	268	53-755	18	316	(150 m) 19%	New York Department of Conservation [Internet]. c2008. Publicly Available Radar Results for Proposed Wind Sites in New York. Albany, NY: NYDEC; [updated May 2008; cited June 2009]. Available at http://www.dec.ny.gov/docs/wildlife_pdf/radarwindsum.pdf
2008	Oakfield, Penobscot Cty, ME	20	194	Forested ridge	498	132-899	33	276	(120 m) 21%	Stantec Consulting Services Inc. 2008.A Spring 2008 Survey of Bird and Bat Migration at the Oakfield Wind Project, Washington County, Maine. Prepared for Evergreen Wind, LLC.
2008	New Creek, Grant Cty, WV	20	n/a	Forested ridge	1020	289-2610	30	354	(130 m) 13%	Stantec Consulting Services Inc. 2008. A Spring 2008 Survey of Bird Migration at the New Creek Wind Project, West Virginia. Prepared for AES New Creek, LLC.
2008	Tenney, Grafton Cty, NH	40	373	Forested ridge	234	35-549	77	321	(125 m) 12%	Stantec Consulting Services Inc. 2008. Spring 2008 Radar Survey Report for the Groton Wind Project. Prepared for Groton Wind, LLC.
2008	Rollins, Penobscot Cty, ME	20	189	Forested ridge	247	40 - 766	75	316	(120 m) 13%	Stantec Consulting. 2008. Spring 2008 Bird and Bat Migration Survey Report: Visual, Radar and Acoustic Bat Surveys for the Rollins Wind Project. Prepared for First Wind, LLC.
Spring 2009										
2009	Sisk (Kibby Expansion), Franklin Cty, ME	21	193	Forested ridge	207	50-452	28	293	(125 m) 18%	Stantec Consulting Services Inc. 2009. Spring 2009 Nocturnal Migration Survey Report for the Kibby Expansion Wind Project. Prepared for TRC Engineers LLC.
2009	Vermont Community Wind Farm, Orleans Cty, VT	15	90	Forested ridge	435	49-771	48	320	(130 m) 22%	Stantec Consulting Services Inc. 2009. Spring and Summer 2009 Bird and Bat Survey Report. Prepared for Vermont Community Wind Farm, LLC.
2009	Moresville, Delaware Cty, NY	30	275	Forested ridge	230	30-575	53	314	(125 m)12%	Stantec Consulting Services Inc. 2009. 2009 Spring Nocturnal Radar Survey Report for the Moresville Energy Center. Prepared for Moresville Energy LLC.
2009	Highland, Somerset Cty, ME (location 1)	21	192	Forested ridge	496	10-1262	47	287	(130.5m) 26%	Stantec Consulting Services Inc. 2009. Spring 2009 Ecological Surveys for the Highland Wind Project. Prepared for Highland Wind LLC
2009	Highland, Somerset Cty, ME (location 2)	19	161	Forested ridge	511	8-1735	53	314	(130.5m) 23%	Stantec Consulting Services Inc. 2009. Spring 2009 Ecological Surveys for the Highland Wind Project. Prepared for Highland Wind LLC
Spring 2010										
2010	Bowers, Carroll Plantation, ME	20	188	Forested ridge	289	20-589	56	243	(131 m) 26%	Stantec Consulting Services Inc. 2010. Draft 2010 Spring Avian and Spring/Summer Bat Surveys for the Bowers Wind Project. Prepared for Champlain Wind Energy LLC.
2010	Bull Hill, T16 MD, ME	20	184	Forested ridge	387	43-879	48	217	(145 m) 38%	Stantec Consulting Services Inc. 2010. Spring 2010 Avian and Bat Survey Report for the Bull Hill Wind Project. Prepared for Blue Sky East Wind LLC.
Spring 2011										
2011	Antrim, Antrim, NH	30	284	Forested ridge	223	6-1215	44	305	(150 m) 30%	Stantec Consulting Services Inc. 2011. Spring 2011 Radar and Acoustic Survey Report for the Antrim Wind Energy Project. Prepared for Eolian Renewable Energy.

Note:

[1] The percent targets below turbine height can be found in the addendum to the report "Effect of Top Notch (now Hardscrabble) Wind Project revision to turbine layout and model changes on the spring and fall 2005 nocturnal radar survey reports." Prepared August 26, 2009, by Stantec Consulting Services Inc.

Appendix B

Bat survey results

Stantec

Appendix B Table 1. Summary of acoustic bat data and weather during each survey night at the Access Tree detector – 2011.

		BBSH			HB	MYSP	RBTB			UNKN							
Night of	Operational?	BBSH	Big brown	Silver-haired	Hoary	MYSP	Eastern red	Tri-colored	RBTB	HFUN	LFUN	UNKN	Total	Wind Speed (m/s)	Temperature (celsius)	Barometric Pressure	Relative Humidity (%)
04/07/11	0												**0**			1022	50
04/08/11	1												**0**			1025	38
04/09/11	1												**0**			1022	44
04/10/11	1												**0**	6	6	1021	57
04/11/11	1												**0**	13	13	1013	82
04/12/11	1		1			10				13			**24**	10	6	1021	50
04/13/11	1												**0**	7	2	1022	86
04/14/11	1												**0**	8	0	1024	74
04/15/11	1												**0**	6	-2	1033	46
04/16/11	1												**0**	10	3	1033	75
04/17/11	1												**0**	10	1	1012	74
04/18/11	1												**0**	5	4	1017	61
04/19/11	1												**0**	6	2	1022	80
04/20/11	1												**0**	9	3	1021	92
04/21/11	1												**0**	9	-1	1026	63
04/22/11	1									1			**1**	7	2	1032	46
04/23/11	1												**0**	9	7	1029	83
04/24/11	1					232				99			**331**	4	10	1016	72
04/25/11	1					7							**7**	4	8	1020	83
04/26/11	1		1		3	81				1	3		**89**	6	9	1018	96
04/27/11	1		1			54				9	3		**67**	10	17	1016	88
04/28/11	1		2			14				4	2		**22**	8	11	1010	90
04/29/11	1												**0**	7	6	1010	63
04/30/11	1												**0**	7	7	1024	61
05/01/11	1												**0**	7	6	1027	45
05/02/11	1										1		**1**	5	12	1026	60
05/03/11	1				1	1				1	1		**4**	6	12	1021	69
05/04/11	1												**0**	10	3	1015	93
05/05/11	1												**0**	11	3	1012	77
05/06/11	1	1								2			**3**	9	10	1012	53
05/07/11	1	1								2			**3**	6	9	1011	65
05/08/11	1												**0**	6	8	1014	63
05/09/11	1										1		**1**	10	9	1016	46
05/10/11	1	1							1				**2**	8	8	1019	60
05/11/11	1		18			2				10	1		**31**	6	9	1021	74
05/12/11	1		35				1			1	2		**39**	4	10	1020	65
05/13/11	1		22										**22**	6	9	1016	70
05/14/11	1												**0**	6	11	1012	85
05/15/11	1												**0**	8	7	1009	96
05/16/11	1												**0**	6	6	1016	96
05/17/11	1												**0**	7	8	1022	96
05/18/11	1												**0**	6	9	1023	97
05/19/11	1					3							**3**	4	12	1021	98
05/20/11	1		12			1					1		**14**	1	13	1017	98
05/21/11	1		2										**2**	4	9	1019	92
05/22/11	1					1	1			1			**3**	5	8	1022	94
05/23/11	1	1	2										**3**	8	14	1021	97
05/24/11	1		6			7	4		3	2	3		**25**	8	15	1009	88
05/25/11	1	1	1			15				3			**20**	7	16	1013	67
05/26/11	1		2			2				1	2		**7**	7	18	1014	76
05/27/11	1		3			2				1			**6**	7	19	1015	65
05/28/11	1		2			2	1				1		**6**	8	17	1019	92
05/29/11	1	2	3		1								**6**	11	20	1019	81
05/30/11	1	1	4			2	1			1	1		**10**	5	18	1020	67
05/31/11	1	1	2			2	1			1	1		**8**	10	19	1023	56
06/01/11													**0**	10	19	1020	76
By Species		**9**	**119**	**0**	**5**	**438**	**9**	**0**	**4**	**153**	**23**	**0**	**760**				
By Guild		**128**			**5**	**438**	**13**			**176**							
		BBSH			**HB**	**MYSP**	**RBTB**			**UNKN**			**Total**				

* 1 = Detector functioned for the entire night; 0 = Non-operational for all or part of the night

Appendix B Table 2. Summary of acoustic bat data and weather during each survey night at the N. Met High detector – 2011.

		BBSH			HB	MYSP	RBTB			UNKN							
Night of	**Operational?**	**BBSH**	**Big brown**	**Silver-haired**	**Hoary**	**MYSP**	**Eastern red**	**Tri-colored**	**RBTB**	**HFUN**	**LFUN**	**UNKN**	**Total**	**Wind Speed (m/s)**	**Temperature (celsius)**	**Barometric Pressure (mb)**	**Relative Humidity (%)**
04/07/11	1												**0**			1022	50
04/08/11	1												**0**			1025	38
04/09/11	1												**0**			1022	44
04/10/11	1												**0**	6	6	1021	57
04/11/11	1												**0**	13	13	1013	82
04/12/11	1												**0**	10	6	1021	50
04/13/11	1												**0**	7	2	1022	86
04/14/11	1												**0**	8	0	1024	74
04/15/11	1												**0**	6	-2	1033	46
04/16/11	1												**0**	10	3	1033	75
04/17/11	1												**0**	10	1	1012	74
04/18/11	1												**0**	5	4	1017	61
04/19/11	1												**0**	6	2	1022	80
04/20/11	1												**0**	9	3	1021	92
04/21/11	1												**0**	9	-1	1026	63
04/22/11	1												**0**	7	2	1032	46
04/23/11	1												**0**	9	7	1029	83
04/24/11	1												**0**	4	10	1016	72
04/25/11	1												**0**	4	8	1020	83
04/26/11	1												**0**	6	9	1018	96
04/27/11	1												**0**	10	17	1016	88
04/28/11	1												**0**	8	11	1010	90
04/29/11	1												**0**	7	6	1010	63
04/30/11	1												**0**	7	7	1024	61
05/01/11	1												**0**	7	6	1027	45
05/02/11	1												**0**	5	12	1026	60
05/03/11	1				1								**1**	6	12	1021	69
05/04/11	1				1								**1**	10	3	1015	93
05/05/11	1												**0**	11	3	1012	77
05/06/11	1												**0**	9	10	1012	53
05/07/11	1												**0**	6	9	1011	65
05/08/11	1												**0**	6	8	1014	63
05/09/11	1												**0**	10	9	1016	46
05/10/11	1												**0**	8	8	1019	60
05/11/11	1										1		**1**	6	9	1021	74
05/12/11	1												**0**	4	10	1020	65
05/13/11	1				1				1				**2**	6	9	1016	70
05/14/11	1												**0**	6	11	1012	85
05/15/11	0												**0**	8	7	1009	96
05/16/11	0												**0**	6	6	1016	96
05/17/11	0												**0**	7	8	1022	96
05/18/11	0												**0**	6	9	1023	97
05/19/11	0												**0**	4	12	1021	98
05/20/11	0												**0**	1	13	1017	98
05/21/11	0												**0**	4	9	1019	92
05/22/11	0												**0**	5	8	1022	94
05/23/11	0												**0**	8	14	1021	97
05/24/11	0												**0**	8	15	1009	88
05/25/11	0												**0**	7	16	1013	67
05/26/11	0												**0**	7	18	1014	76
05/27/11	0												**0**	7	19	1015	65
05/28/11	0												**0**	8	17	1019	92
05/29/11	0												**0**	11	20	1019	81
05/30/11	0												**0**	5	18	1020	67
05/31/11	0												**0**	10	19	1023	56
By Species		**0**	**0**	**0**	**3**	**0**	**0**	**0**	**1**	**0**	**1**	**0**	**5**				
By Guild		**0**			**3**	**0**	**1**			**1**							
		BBSH			**HB**	**MYSP**	**RBTB**			**UNKN**			**Total**				

* 1 = Detector functioned for the entire night; 0 = Non-operational for all or part of the night

Appendix B Table 3. Summary of acoustic bat data and weather during each survey night at the N. Met Low detector – 2011.

		BBSH			HB	MYSP	RBTB			UNKN							
Night of	**Operational?**	**BBSH**	**Big brown**	**Silver-haired**	**Hoary**	**MYSP**	**Eastern red**	**Tri-colored**	**RBTB**	**HFUN**	**LFUN**	**UNKN**	**Total**	**Wind Speed (m/s)**	**Temperature (celsius)**	**Barometric Pressure**	**Relative Humidity (%)**
04/07/11	1												**0**			1022	50
04/08/11	1												**0**			1025	38
04/09/11	1												**0**			1022	44
04/10/11	1												**0**	6	6	1021	57
04/11/11	1												**0**	13	13	1013	82
04/12/11	1												**0**	10	6	1021	50
04/13/11	1												**0**	7	2	1022	86
04/14/11	1												**0**	8	0	1024	74
04/15/11	1												**0**	6	-2	1033	46
04/16/11	1												**0**	10	3	1033	75
04/17/11	1												**0**	10	1	1012	74
04/18/11	1												**0**	5	4	1017	61
04/19/11	1												**0**	6	2	1022	80
04/20/11	1												**0**	9	3	1021	92
04/21/11	1												**0**	9	-1	1026	63
04/22/11	1												**0**	7	2	1032	46
04/23/11	1												**0**	9	7	1029	83
04/24/11	1												**0**	4	10	1016	72
04/25/11	1												**0**	4	8	1020	83
04/26/11	1												**0**	6	9	1018	96
04/27/11	1												**0**	10	17	1016	88
04/28/11	1												**0**	8	11	1010	90
04/29/11	1												**0**	7	6	1010	63
04/30/11	1												**0**	7	7	1024	61
05/01/11	1												**0**	7	6	1027	45
05/02/11	1				1								**1**	5	12	1026	60
05/03/11	1				1						2		**3**	6	12	1021	69
05/04/11	1												**0**	10	3	1015	93
05/05/11	1												**0**	11	3	1012	77
05/06/11	1												**0**	9	10	1012	53
05/07/11	1												**0**	6	9	1011	65
05/08/11	1				1						1		**2**	6	8	1014	63
05/09/11	1				1								**1**	10	9	1016	46
05/10/11	1												**0**	8	8	1019	60
05/11/11	1												**0**	6	9	1021	74
05/12/11	1					7				1			**8**	4	10	1020	65
05/13/11	1												**0**	6	9	1016	70
05/14/11	1												**0**	6	11	1012	85
05/15/11	1												**0**	8	7	1009	96
05/16/11	1												**0**	6	6	1016	96
05/17/11	1												**0**	7	8	1022	96
05/18/11	1												**0**	6	9	1023	97
05/19/11	1												**0**	4	12	1021	98
05/20/11	1	1											**1**	1	13	1017	98
05/21/11	1												**0**	4	9	1019	92
05/22/11	1												**0**	5	8	1022	94
05/23/11	1		1										**1**	8	14	1021	97
05/24/11	1		6								2		**8**	8	15	1009	88
05/25/11	1												**0**	7	16	1013	67
05/26/11	1		1										**1**	7	18	1014	76
05/27/11	1	1	1							1			**3**	7	19	1015	65
05/28/11	1										1		**1**	8	17	1019	92
05/29/11	1	1			1								**2**	11	20	1019	81
05/30/11	1	13	16			17				10	5		**61**	5	18	1020	67
05/31/11	1										2		**2**	10	19	1023	56
By Species		**16**	**25**	**0**	**5**	**24**	**0**	**0**	**0**	**12**	**13**	**0**	**95**				
By Guild		**41**			**5**	**24**	**0**			**25**							
		BBSH			**HB**	**MYSP**	**RBTB**			**UNKN**			**Total**				

* 1 = Detector functioned for the entire night; 0 = Non-operational for all or part of the night

Appendix B Table 4. Summary of acoustic bat data and weather during each survey night at the Wetland Tree detector – 2011.

		BBSH			HB	MYSP	RBTB			UNKN							
Night of	**Operational?**	**BBSH**	**Big brown**	**Silver-haired**	**Hoary**	**MYSP**	**Eastern red**	**Tri-colored**	**RBTB**	**HFUN**	**LFUN**	**UNKN**	**Total**	**Wind Speed (m/s)**	**Temperature (celsius)**	**Barometric Pressure**	**Relative Humidity (%)**
04/16/11	1												**0**	10	3	1033	75
04/17/11	1												**0**	10	1	1012	74
04/18/11	1												**0**	5	4	1017	61
04/19/11	1												**0**	6	2	1022	80
04/20/11	1												**0**	9	3	1021	92
04/21/11	1												**0**	9	-1	1026	63
04/22/11	1									1			**1**	7	2	1032	46
04/23/11	1												**0**	9	7	1029	83
04/24/11	1										1		**1**	4	10	1016	72
04/25/11	1												**0**	4	8	1020	83
04/26/11	1												**0**	6	9	1018	96
04/27/11	1	1	1								2		**4**	10	17	1016	88
04/28/11	1			1									**1**	8	11	1010	90
04/29/11	1												**0**	7	6	1010	63
04/30/11	1												**0**	7	7	1024	61
05/01/11	1												**0**	7	6	1027	45
05/02/11	1									1			**1**	5	12	1026	60
05/03/11	1	1									1		**2**	6	12	1021	69
05/04/11	1												**0**	10	3	1015	93
05/05/11	1												**0**	11	3	1012	77
05/06/11	1									1	1		**2**	9	10	1012	53
05/07/11	1										1		**1**	6	9	1011	65
05/08/11	1												**0**	6	8	1014	63
05/09/11	1												**0**	10	9	1016	46
05/10/11	1												**0**	8	8	1019	60
05/11/11	1												**0**	6	9	1021	74
05/12/11	1				7						17		**24**	4	10	1020	65
05/13/11	1												**0**	6	9	1016	70
05/14/11	1												**0**	6	11	1012	85
05/15/11	1												**0**	8	7	1009	96
05/16/11	1												**0**	6	6	1016	96
05/17/11	1												**0**	7	8	1022	96
05/18/11	1												**0**	6	9	1023	97
05/19/11	1												**0**	4	12	1021	98
05/20/11	1										1		**1**	1	13	1017	98
05/21/11	1												**0**	4	9	1019	92
05/22/11	1												**0**	5	8	1022	94
05/23/11	1												**0**	8	14	1021	97
05/24/11	1	1											**1**	8	15	1009	88
05/25/11	1	1											**1**	7	16	1013	67
05/26/11	1	1									2		**3**	7	18	1014	76
05/27/11	1				1						1		**2**	7	19	1015	65
05/28/11	1										2		**2**	8	17	1019	92
05/29/11	1									1			**1**	11	20	1019	81
05/30/11	1	1											**1**	5	18	1020	67
05/31/11	0												**0**	10	19	1023	56
By Species		**6**	**1**	**1**	**8**	**0**	**0**	**0**	**0**	**4**	**29**	**0**	**49**				
By Guild		**8**			**8**	**0**	**0**			**33**							
		BBSH			**HB**	**MYSP**	**RBTB**			**UNKN**			**Total**				

* 1 = Detector functioned for the entire night; 0 = Non-operational for all or part of the night

Appendix B Table 5. Summary of acoustic bat data and weather during each survey night at the Willard Trail detector – 2011.

		BBSH			**HB**	**MYSP**	**RBTB**			**UNKN**							
Night of	**Operational?**	**BBSH**	**Big brown**	**Silver-haired**	**Hoary**	**MYSP**	**Eastern red**	**Tri-colored**	**RBTB**	**HFUN**	**LFUN**	**UNKN**	**Total**	**Wind Speed (m/s)**	**Temperature (celsius)**	**Barometric Pressure**	**Relative Humidity (%)**
04/07/11	1												**0**			1022	50
04/08/11	1												**0**			1025	38
04/09/11	1												**0**			1022	44
04/10/11	1												**0**	6	6	1021	57
04/11/11	1												**0**	13	13	1013	82
04/12/11	1					1							**1**	10	6	1021	50
04/13/11	1												**0**	7	2	1022	86
04/14/11	1												**0**	8	0	1024	74
04/15/11	1												**0**	6	-2	1033	46
04/16/11	1												**0**	10	3	1033	75
04/17/11	1												**0**	10	1	1012	74
04/18/11	1												**0**	5	4	1017	61
04/19/11	1												**0**	6	2	1022	80
04/20/11	1												**0**	9	3	1021	92
04/21/11	1									1			**1**	9	-1	1026	63
04/22/11	1				1								**1**	7	2	1032	46
04/23/11	1												**0**	9	7	1029	83
04/24/11	1												**0**	4	10	1016	72
04/25/11	1												**0**	4	8	1020	83
04/26/11	1					1							**1**	6	9	1018	96
04/27/11	1												**0**	10	17	1016	88
04/28/11	1			1							1		**2**	8	11	1010	90
04/29/11	1												**0**	7	6	1010	63
04/30/11	1												**0**	7	7	1024	61
05/01/11	1			1							3		**4**	7	6	1027	45
05/02/11	1				1								**1**	5	12	1026	60
05/03/11	1										1		**1**	6	12	1021	69
05/04/11	1												**0**	10	3	1015	93
05/05/11	1												**0**	11	3	1012	77
05/06/11	1								1	1	1		**3**	9	10	1012	53
05/07/11	1												**0**	6	9	1011	65
05/08/11	1									1			**1**	6	8	1014	63
05/09/11	1					1							**1**	10	9	1016	46
05/10/11	1												**0**	8	8	1019	60
05/11/11	1										1		**1**	6	9	1021	74
05/12/11	1				1								**1**	4	10	1020	65
05/13/11	1									1			**1**	6	9	1016	70
05/14/11	1												**0**	6	11	1012	85
05/15/11	1												**0**	8	7	1009	96
05/16/11	1												**0**	6	6	1016	96
05/17/11	1												**0**	7	8	1022	96
05/18/11	1												**0**	6	9	1023	97
05/19/11	1												**0**	4	12	1021	98
05/20/11	1			3	1	1				1			**6**	1	13	1017	98
05/21/11	1	1											**1**	4	9	1019	92
05/22/11	1												**0**	5	8	1022	94
05/23/11	1												**0**	8	14	1021	97
05/24/11	1	1	6							1	2		**10**	8	15	1009	88
05/25/11	1	8	2								4		**14**	7	16	1013	67
05/26/11	1	1			2						4		**7**	7	18	1014	76
05/27/11	1						1				3		**4**	7	19	1015	65
05/28/11	1	2	2		3						6		**13**	8	17	1019	92
05/29/11	1	4	5							1	2		**12**	11	20	1019	81
05/30/11	1	9	4		1	2					5		**21**	5	18	1020	67
05/31/11	1	22	23		1	1				2	11		**60**	10	19	1023	56
06/01/11	1	6	7		13						17		**43**	10	19	1020	76
By Species		**54**	**49**	**5**	**24**	**7**	**1**	**0**	**1**	**9**	**61**	**0**	**211**				
By Guild		**108**			**24**	**7**	**2**			**70**							
		BBSH			HB	MYSP	RBTB			UNKN			Total				

* 1 = Detector functioned for the entire night; 0 = Non-operational for all or part of the night

Appendix B Table 6. Summary of acoustic bat data and weather during each survey night at the Willard Tree detector – 2011.

		BBSH			HB	MYSP	RBTB			UNKN							
Night of	**Operational?**	**BBSH**	**Big brown**	**Silver-haired**	**Hoary**	**MYSP**	**Eastern red**	**Tri-colored**	**RBTB**	**HFUN**	**LFUN**	**UNKN**	**Total**	**Wind Speed (m/s)**	**Temperature (celsius)**	**Barometric Pressure**	**Relative Humidity (%)**
04/07/11	1												**0**			1022	50
04/08/11	1												**0**			1025	38
04/09/11	1												**0**			1022	44
04/10/11	1												**0**	6	6	1021	57
04/11/11	1												**0**	13	13	1013	82
04/12/11	1												**0**	10	6	1021	50
04/13/11	1												**0**	7	2	1022	86
04/14/11	1												**0**	8	0	1024	74
04/15/11	1												**0**	6	-2	1033	46
04/16/11	1												**0**	10	3	1033	75
04/17/11	1												**0**	10	1	1012	74
04/18/11	1												**0**	5	4	1017	61
04/19/11	1												**0**	6	2	1022	80
04/20/11	1												**0**	9	3	1021	92
04/21/11	1												**0**	9	-1	1026	63
04/22/11	1												**0**	7	2	1032	46
04/23/11	1												**0**	9	7	1029	83
04/24/11	1												**0**	4	10	1016	72
04/25/11	1												**0**	4	8	1020	83
04/26/11	1												**0**	6	9	1018	96
04/27/11	1												**0**	10	17	1016	88
04/28/11	1										1		**1**	8	11	1010	90
04/29/11	1												**0**	7	6	1010	63
04/30/11	1												**0**	7	7	1024	61
05/01/11	1												**0**	7	6	1027	45
05/02/11	1				9						7		**16**	5	12	1026	60
05/03/11	1												**0**	6	12	1021	69
05/04/11	1												**0**	10	3	1015	93
05/05/11	1												**0**	11	3	1012	77
05/06/11	1		1										**1**	9	10	1012	53
05/07/11	1					1							**1**	6	9	1011	65
05/08/11	1										1		**1**	6	8	1014	63
05/09/11	1									1			**1**	10	9	1016	46
05/10/11	1												**0**	8	8	1019	60
05/11/11	1					2							**2**	6	9	1021	74
05/12/11	1												**0**	4	10	1020	65
05/13/11	1												**0**	6	9	1016	70
05/14/11	1												**0**	6	11	1012	85
05/15/11	1												**0**	8	7	1009	96
05/16/11	1												**0**	6	6	1016	96
05/17/11	1												**0**	7	8	1022	96
05/18/11	1												**0**	6	9	1023	97
05/19/11	1				1								**1**	4	12	1021	98
05/20/11	1												**0**	1	13	1017	98
05/21/11	1				1								**1**	4	9	1019	92
05/22/11	1												**0**	5	8	1022	94
05/23/11	1												**0**	8	14	1021	97
05/24/11	1		1		95						30		**126**	8	15	1009	88
05/25/11	1				1								**1**	7	16	1013	67
05/26/11	1		1				1						**2**	7	18	1014	76
05/27/11	1					1							**1**	7	19	1015	65
05/28/11	1				7						2		**9**	8	17	1019	92
05/29/11	1	3	5		2						2		**12**	11	20	1019	81
05/30/11	1	1	3			1				1	8		**14**	5	18	1020	67
05/31/11	1	31	80		15						4		**130**	10	19	1023	56
06/01/11	1	21	20		1						1		**43**	10	19	1020	76
By Species		**56**	**111**	**0**	**132**	**5**	**1**	**0**	**0**	**2**	**56**	**0**	**363**				
By Guild		**167**			**132**	**5**	**1**			**58**							
		BBSH			**HB**	**MYSP**	**RBTB**			**UNKN**			**Total**				

* 1 = Detector functioned for the entire night; 0 = Non-operational for all or part of the night