A Fall 2005 Radar and Acoustic Survey of Bird and Bat Migration at the Proposed Deerfield Wind Project in Searsburg and Readsboro, Vermont

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Executive Summary

During Fall 2005, Woodlot Alternatives, Inc. (Woodlot) conducted field surveys of bird and bat migration activity at the Deerfield Wind Project in Searsburg and Readsboro, Vermont. The surveys are part of the planning process by Deerfield Wind, LLC for a proposed wind project, which will include the erection of up to 20 to 30 wind turbines on mountain tops and ridge lines within the Green Mountain National Forest. Surveys included nighttime surveys of birds and bats using radar and bat echolocation detectors. The studies represent the third season of migration surveys undertaken by Deerfield Wind, LLC at this site.

The results of the field surveys provide useful information about site-specific migration activity and patterns in the vicinity of the Deerfield Wind Project, especially when reviewed along with results of surveys conducted in Spring 2005 and Fall 2004 in the same vicinity. This analysis is a valuable tool for the assessment of risk to birds and bats during migration through the area.

Radar Survey

The fall field survey included 32 nights of radar surveys from September 2 to November 1, 2005, to collect and record radar data during horizontal, which documents the abundance, flight path and speed of targets moving through the project area, and vertical, which documents the altitude of targets, operation. Thirty nights of data collection were originally targeted. Some nights of inclement weather resulted in only 2 to 4 hours of data. While that data doesn't represent a full night of migration activity, it does provide information on migration activity during suboptimal weather and were included in the complete data set.

The radar study was conducted at a meteorological measurement tower (met tower) at the Western Expansion Area. This site was one of three surveyed during radar studies conducted in the fall of 2004.

Nightly passage rates varied from 3 ± 1 targets/kilometer/hour (t/km/hr) to 1,736 ± 295 t/km/hr, with the overall passage rate for the entire survey period at 559 ± 87 t/km/hr. This is notably higher than the fall 2004 results (193 ± 41 t/km/hr) at the same location. Mean flight direction through the project area was 221º ± 71º. Interestingly, this is nearly identical to the fall 2004 results at this location (223º ± 56º).

The mean flight height of targets was 395 meter (m) ± 21 m (1,296' ± 69') above the radar site, which was lower than that documented during the fall 2004 survey at this location (503 m ± 21 m or 1,650' ± 69'). The average nightly flight height ranged from 111 m ± 39 m (364' ± 128') on October 6 to 672 m ± 393 m (2,205' ± 1,289') on October 15. The percent of targets observed flying below 100 m (328'), the approximate height of the proposed turbines, also varied by night, from 1 percent to 54 percent. The seasonal average percentage of targets flying below this height was 13 percent.

Suboptimal weather conditions, which include rainy nights and nights with winds from the south, often resulted in lower migration height than nights with weather more conducive to fall migration. However, those nights were typically associated with less migration activity. For example, on October 6 more than 50 percent of all targets were observed flying below the height of the proposed turbines. However, that night had the lowest passage rate documented (only 3 t/km/hr).

Bat Surveys

Field surveys for bats included the deployment of bat detectors in the guy wire array of two met towers: one at the Eastern Expansion Area and one at the Western Expansion Area. Detectors were deployed either singly or in pairs in the met towers. On nights when two detectors were used, they were deployed at heights of 15 m and 30 m (50' and 100'); otherwise, one detector was deployed at 30 m (100'). Additionally, deployment at the Western Expansion Area included two time periods (late September and late October) when one detector was located high in the met tower and the second was located along the treeline of the met tower opening. In total, 34 detector-nights of data were recorded at the Eastern Expansion Area from July 7 to September 9 and 119 detector-nights were recorded at the Western Expansion Area from July 4 to November 1, 2005.

A total of 79 bat call sequences were recorded: 39 at the Eastern Expansion Area and 40 at the Western Expansion Area. Detection rates at any given detector ranged from 0.0 calls/detector-night (low detector at the Eastern Expansion Area) to 1.6 calls/detector-night (high detector at the Eastern Expansion Area). The mean detection rates were 1.1 calls/detector-night at the Eastern Expansion Area and 0.3 calls/detector-night at the Western Expansion Area. The detection rates at the high, low, and treeline detectors at the Western Expansion Area were 0.2, 0.5, and 0.6 calls/detector-night, respectively. The distribution of detection rates (lowest up high and greatest near the treeline) is typically expected during bat detector surveys. However, that relationship was reversed at the Eastern Expansion Area, where no bats were detected at the low detector and the high detector had the greatest detection rate recorded during the survey. Survey effort may be the biggest factor in the latter relationship, as the low detector operated correctly on less than a dozen of the nights it was deployed.

Pulses of increased detections were documented during the survey, though limited survey effort due to occasional detector failures resulted in an inconsistent look at bat activity. The largest peak at both expansion areas occurred in late August. Lesser peaks in activity were documented in early September (at the Eastern Expansion Area) and in the end of September (at the Western Expansion Area). No bat calls were recorded after the October 2, 2005.

When possible, recorded bat calls were identified to species, genus (in the case of *Myotis*), or as "unknown," based upon the shape of the call sequence, the slope, and the maximum and minimum frequencies. Of the 79 calls recorded, 54 were identified to species or genus group. Twenty-five calls were too short or of too poor a quality to identify. Big brown bats (*Eptesicus fuscus*) were the most common calls recorded (20), followed by those of the *myotids* (17). Calls of the eastern red bat (*Lasiurus borealis*), hoary bat (*L. cinereus*), and silver-haired bat (*Lasionycteris noctivagans*) were only documented 5 or 6 times, each. No eastern pipistrelles (*Pipistrellus subflavus*) were recorded by the detectors.

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1.0 Introduction

1.1 Project Context

Deerfield Wind, LLC has proposed to develop the Deerfield Wind Project, a wind power facility located on Federal land in Searsburg and Readsboro, Vermont, (Figure 1-1). The project would be constructed on approximately 80 acres of land in the Manchester District of the Green Mountain National Forest, adjacent to Green Mountain Power Corporation's (GMP) existing Searsburg Wind Facility, which was constructed in the mid 1990s. The expansion project will occur in two areas. The Eastern Expansion Area is located east of State Route 8, immediately south of the existing 11-turbine, 6-megawatt (MW) facility, and the Western Expansion Area is located on the west side of Route 8. The proposed expansion project consists of adding 20 to 30 wind turbines, capable of producing approximately 30 to 45 MW. The proposed turbines would be up to 113 meters (m) (370') tall.

These surveys represent the third migration season of surveys conducted at the site. In the fall of 2004 radar and raptor migration surveys were conducted. Radar surveys were conducted at three locations, the existing facility, the Western Expansion Area, and a valley to the west of the Western Expansion Area. Raptor surveys that year were conducted at the existing facility and the Western Expansion Area. In the spring of 2005 radar and raptor surveys were again conducted, along with bat detector surveys. The radar was operated at only one location, the existing facility. Raptor surveys were conducted at the same two sites as in the fall of 2004. Bat surveys consisted of deploying bat detectors in the guy wire array of a meteorological measurement tower (met tower) for automated recordings of bat calls. The fall 2005 surveys provided in this report include radar and bat detector surveys. For this work, the radar site at the Western Expansion Area was again surveyed. Bat detectors surveys included the deployment of bat detectors in two met towers, one at the Eastern Expansion Area and one at the Western Expansion Area.

1.2 Project Area Description

The project area is located in Searsburg and Readsboro, Vermont, approximately 15 miles north of the Massachusetts border. It is in the Southern Green Mountains Biophysical Region of Vermont. This region is an area of varied topography, with high peaks, plateaus, steep sided valleys, and foothills. Mountaintops in this region are somewhat randomly located, in sharp contrast to the long, linear arrangements of the highlands of northern Vermont. The mountaintops are characterized by thin soils and abundant, exposed, acidic bedrock but the lower slopes and valleys in this region contain deep glacial till soils.

The climate of the region is generally cool. Higher elevations are typically colder than low valleys, with average July temperatures in the mid 60ºFs. The growing season is short, approximately 90 days, and the average winter temperature is around 17ºF. Clouds and fog are common and the area receives a relatively large amount of precipitation. Combined, 127 to 178 centimeters (50" to 70") of rain and snow fall in the region annually (Thompson and Sorenson 2000).

Northern hardwoods and boreal woodland species dominate the forests of the region. The higher elevations exhibit typical mountain forest zonation, with northern hardwood forests ascending into yellow birch and red spruce forests, which then grade into higher elevation forests dominated by spruce and fir. Valleys are predominantly forested with northern hardwoods and various amounts of white pine (*Pinus strobus*) and hemlock (*Tsuga canadensis*). Low, south-facing slopes typically contain red oak (*Quercus rubra*).

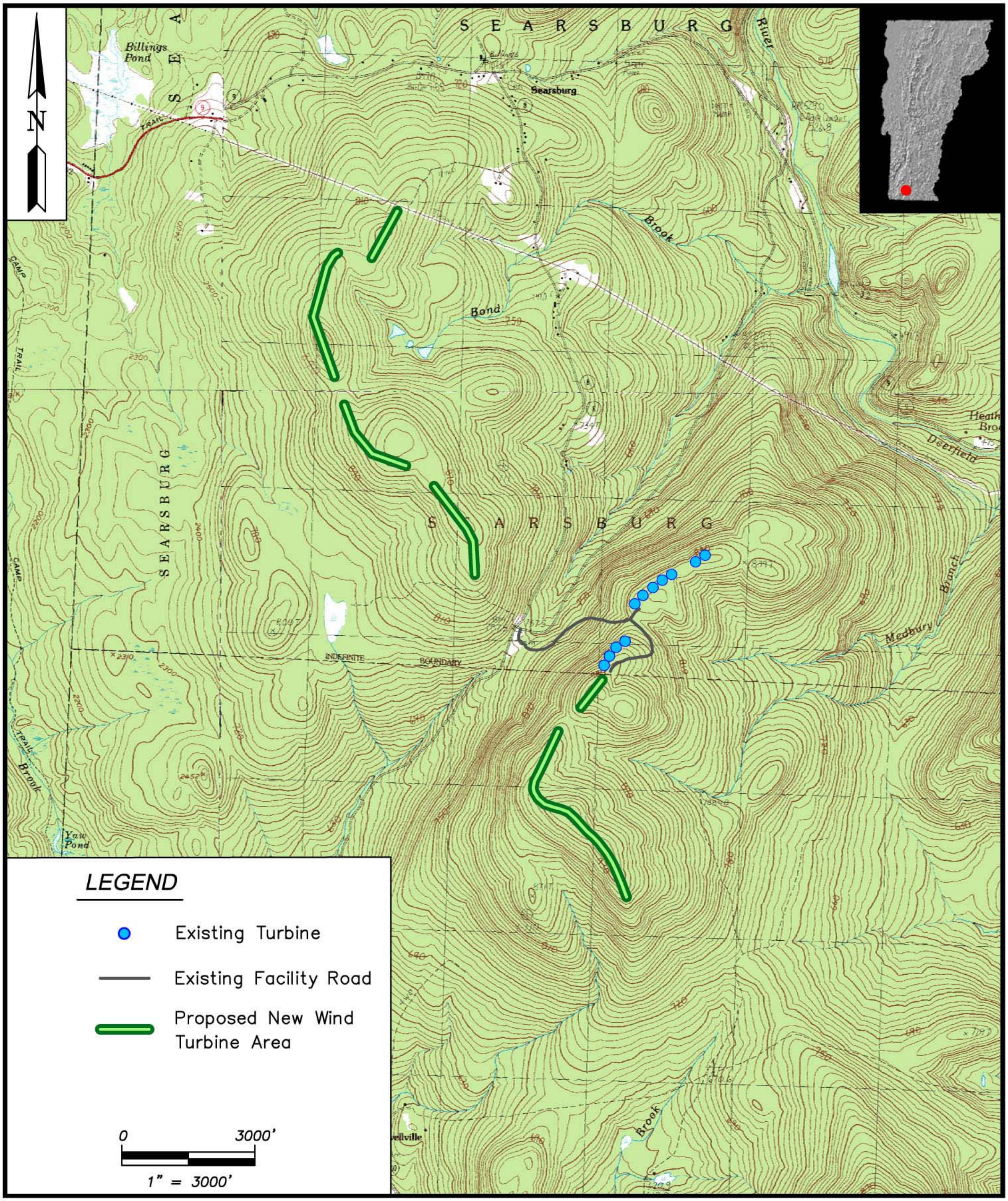

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Figure 1-1
Study Area Location Map
Deerfield Wind Project
Searsburg, Vermont

REV.

The Deerfield Wind Project area is located on two mountaintops, with elevations ranging from 850 m (2,790') to 950 m (3,120'). The Eastern Expansion Area is on a higher ridgeline that is more steeply sided than the Western Expansion Area. Northern hardwood forests are dominant on the lower slopes of both mountains and along much of the ridgeline at the Western Expansion Area. Montane yellow birch – red spruce forest and red spruce – northern hardwood forests are more common at higher elevations.

1.3 Survey Overview

Woodlot Alternatives, Inc. (Woodlot) conducted field investigations for bird and bat migration during the fall of 2005. The overall goals of the investigations were to:

- document nocturnal migration in the vicinity of the Western Expansion Area, including the number of migrants, their flight direction, and their flight altitude; and
- document the presence of bats in the Eastern Expansion Area and Western Expansion Area, including the rate of occurrence and, when possible, species present during the late summer and fall migration period.

The field surveys included a radar study of bird and bat migration activity, and recordings of bat echolocation calls in several landscape settings and heights. Surveys were conducted from September 2 to November 1, 2005, although effort for the different aspects of the work varied within this time period. A total of 32 nights of radar surveys, and 153 detector-nights of bat recordings were completed.

Radar surveys were conducted from the met tower on the ridgeline of the Western Expansion Area, which provided wind data for the time period of sampling. Radar data provide insight on the flight patterns of birds (and bats) migrating over the project area, including abundance, flight direction, and flight altitude.

Bat surveys included the use of Anabat II (Titley Electronics Pty Ltd) bat detectors to record the location and timing of bat activity. During the late summer and fall, passive surveys consisted of deploying a bat detector approximately 30 m (100') above the ground from the guy wire array of the on-site met tower and another at 15 m (50') or in a tree on the edge of the met tower opening. The detectors were deployed prior to sunset and retrieved after sunrise.

In an attempt to determine if calls of the Indiana bat (*Myotis sodalis*) had been recorded, calls of the genus *Myotis* were examined using call characteristics identified by a national expert as suitable for identifying Indiana bats from other *myotids* from recorded call sequences.

This report is divided into two primary sections that discuss the methods and results for each field survey. Each section includes summary graphs of the survey results. In addition, supporting data tables are provided in a separate appendix for each chapter.

2.0 Nocturnal Radar Survey

2.1 Introduction

The vast majority of North American land birds migrate at night. The strategy to migrate at night may be to take advantage of more stable atmospheric conditions for flapping flight (Kerlinger 1995). Conversely, species using soaring flight, such as raptors, migrate during the day to take advantage of warm rising air in thermals and laminar flow of air over the landscape, which can create updrafts along hillsides and ridgelines. Additionally, night migration may provide a more efficient medium to regulate body temperature during active, flapping flight and could reduce the potential for predation while in flight (Alerstam 1990, Kerlinger 1995).

Collision with unseen obstacles is a potential hazard to night-migrating birds. Additionally, some lighted structures may actually attract birds to them under certain weather conditions, which can be associated with collision or exhaustion of birds, both of which often result in mortality (Ogden 1996). For example, birds have been documented colliding with tall structures, such as buildings and communication towers, particularly when weather conditions are foggy (Crawford 1981; Avery *et al.* 1976, 1977). Wind turbines can also pose a potential threat to migrating birds as they are relatively tall structures, have moving parts, and may be lit, depending on their height and location.

Factors that could affect potential collision risk with wind turbines by nocturnally-migrating birds can include weather, magnitude of migration, height of flight, and movement patterns in the vicinity of a wind project, along with the height of turbines and other site-specific characteristics of a wind project. Radar surveys were conducted at the Western Expansion Area of the Deerfield Wind project to characterize fall nocturnal migration patterns in the area. The goal of the surveys was to document the overall passage rates for nocturnal migration in the vicinity of the project area, including the number of migrants, their flight direction, and their flight altitude.

2.2 Methods

Field Methods

The radar study was conducted from the met tower opening on the Western Expansion Area ridgeline (Figure 2-1). A 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 kW and has the ability to track small animals, including birds, bats, and even insects, based on settings selected for the radar functions. It cannot, however, readily distinguish between different types of animals being detected. Consequently, all animals observed on the radar screen are called targets. The radar has an echo trail function that maintains past echoes of trails. 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 20º (10º above and below horizontal) and the front end of it was inclined approximately 5º to increase the proportion of the beam directed into the sky.

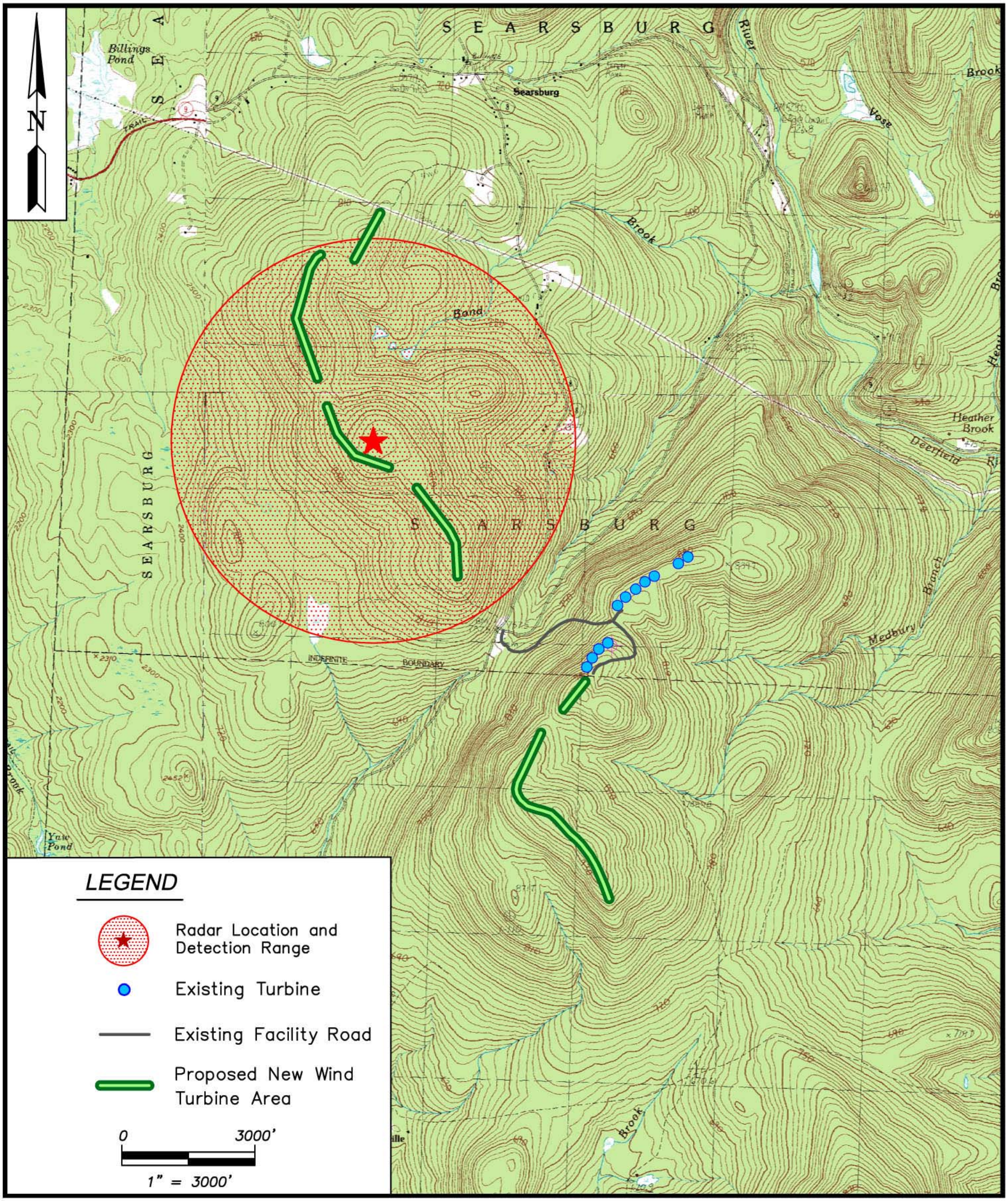

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Figure 2-1
Radar Location Map
Deerfield Wind Project
Searsburg, Vermont

REV.

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 birds and bats flying over those areas. However, vegetation and hilltops near the radar can be used to reduce or eliminate ground clutter by 'hiding' clutter-causing objects from the radar. 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. The presence of ground clutter and other objects that could reduce clutter were important factors considered during the site selection process.

The met tower opening provided an excellent view of the surrounding airspace. Forest harvesting has occurred in the area and the trees along the edge of the opening were level with the top of the radar antenna tower and, consequently, ground clutter was limited to the very center of the screen (Figure 2-2) and targets were observed in all parts of the radar display. From the top of the tower, the existing Searsburg wind facility could be seen.

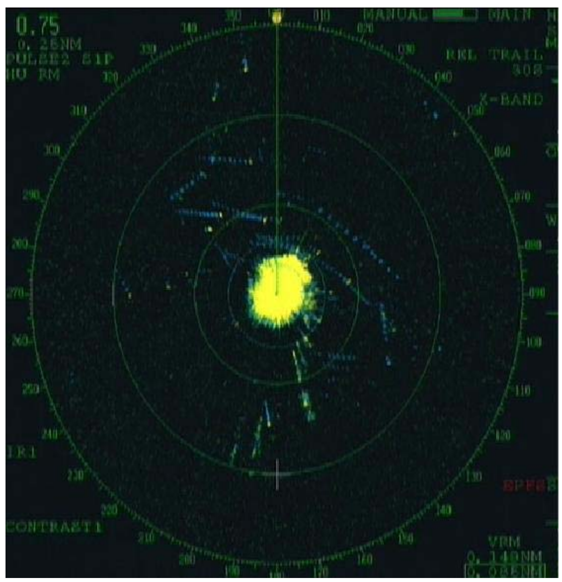

Figure 2-2. Ground clutter in project area

Radar surveys were conducted from sunset to sunrise. Thirty nights of surveys were targeted from sampling between September 1 and October 20, 2005. Because the anti-rain function of the radar must be turned down to detect small songbirds and bats, surveys could not be conducted during periods of inclement weather. Therefore, surveys were extended due to periods of rain resulting in a total of 32 radar nights between September 2 and November 1, 2005. However, in order to characterize migration patterns during nights without optimal conditions, nights with weather forecasts including occasional showers were sampled. The operation of the radar for each survey night is presented in Table 2-1.

The radar was operated in two modes throughout the night. In the first mode, surveillance, the antenna spins horizontally to survey the airspace around the radar and detects targets moving through the area. By analyzing the echo trail, the flight direction of targets can be determined. In the second mode of operation, vertical, the antenna is rotated 90º to vertically 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, 20º radar beam. Both modes of operation were used during each hour of sampling.

The radar was operated at a range of 1.4 kilometers (km) (0.75 nautical miles). At this range, the echoes of small birds can be easily detected, observed, and tracked. At greater ranges, larger birds can be detected but the echoes of small birds are reduced in size and restricted to a smaller portion of the radar screen, reducing the ability to observe the movement pattern of individual targets. The geographical limits of the range setting used are depicted in Figure 2-1.

Table 2-1. Survey dates, level of effort, and weather – Deerfield Wind Project, Fall 2005

Night of	Sunset	Sunrise	Hours of Survey	Weather	Wind Direction (from)
Sept 2	19:24	6:19	11	clear, light winds	W
Sept 3	19:23	6:20	11	clear, calm	E
Sept 4	19:21	6:21	11	partly cloudy, calm	n/a
Sept 5	19:19	6:22	12	clear and calm	n/a
Sept 6	19:17	6:23	11	clear and calm	n/a
Sept 7	19:16	6:24	12	clear and calm	n/a
Sept 8	19:14	6:25	11	mostly cloudy, slight breeze	variable
Sept 9	19:12	6:26	11	partly cloudy, calm	n/a
Sept 10	19:10	6:27	12	clear and calm	n/a
Sept 17	18:58	6:35	11	overcast, fog, light winds	SW
Sept 18	18:56	6:36	12	partly cloudy, calm	variable
Sept 21	18:51	6:39	12	clear, light winds	W
Sept 22	18:49	6:40	10	partly cloudy, light winds	SW
Sept 27	18:40	6:46	13	clear, light winds	N
Sept 28	18:38	6:47	12	mostly cloudy, strong winds	SW
Sept 29	18:36	6:48	12	partly cloudy, moderate winds	NW
Oct 5	18:26	6:55	10	clear, light winds	W
Oct 6	18:24	6:56	13	mostly cloudy, fog, light winds	SW
Oct 12	18:14	7:03	9	overcast, moderate winds, rain	E
Oct 13	18:13	7:04	8	overcast, strong winds	ESE
Oct 15	18:09	7:06	3	mostly cloudy, moderate winds	W
Oct 19	18:03	7:11	2	mostly cloudy, moderate winds	W
Oct 20	18:02	7:13	8	mostly clear, light winds to calm	W
Oct 21	18:00	7:14	9	clear and calm	W
Oct 23	17:57	7:16	9	overcast, calm	W
Oct 24	17:56	7:17	3	overcast, rain, light winds	E
Oct 26	17:53	7:20	9	overcast, light winds	W
Oct 27	17:52	7:21	12	overcast, slight breeze	NNW
Oct 28	17:50	7:22	13	clear changing to overcast, strong winds	SW
Oct 30	16:47	6:24	11	clear, light winds to calm	WSW
Oct 31	16:46	6:26	13	overcast, clearing late, calm	n/a
Nov 1	16:45	6:27	8	overcast, light winds	W

Note: Additional nights of survey were attempted but foul weather prevented the initiation of surveys.

Data Collection

The radar display was connected to video recording software of a computer. Based on a random sequence for each night approximately 25 minutes of video samples were recorded during each hour of operation. These included 15 one-minute horizontal samples and 10 one-minute vertical samples.

Data Analysis

The video samples were analyzed using a digital video analysis software tool developed by Woodlot. For horizontal samples, targets were identified as birds and bats rather than insects based on their speed. The speed of targets was corrected for wind speed and direction; targets traveling faster than approximately 6 m per second were identified as a bird or bat target. The software tool recorded the time, location, and flight vector for each target traveling fast enough to be a bird or bat. The results for each sample 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. The results for each sample were output 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 SD) were summarized using software designed specifically to analyze directional data (Oriana2© Kovach Computing Services). The statistics used for this are based on Batschelet (1965), which take into account the circular nature of the data. Nightly wind direction was also summarized using similar methods and data collected from the nearest met tower to the radar.

Flight altitude data were summarized using linear statistics. Mean flight altitudes (± 1 SE) were calculated by hour, night, and overall season. The percent of targets flying below 100 m (328'), the approximate maximum height of proposed wind turbines, was also calculated hourly, for each night, and for the entire survey period.

2.3 Results

Radar surveys were conducted on 32 nights between September 2 and November 1, 2005 (Table 2-1). The radar site provided excellent visibility of the surrounding airspace and targets were observed in most areas of the radar display unit. Trees in the vicinity of the radar site were used to limit ground clutter to the center of the radar screen. During data analysis, the ground clutter appeared to have little effect on overall target visibility due to the radar location at a high elevation peak in the Western Expansion Area.

Passage Rates

Nightly passage rates varied from 3 ± 1 targets/km/hour (t/km/hr) (October 6) to 1,736 ± 295 t/km/hr (October 20), and the overall passage rate for the entire survey period was 559 ± 87 t/km/hr (Figure 2-3; Appendix B Table 1).

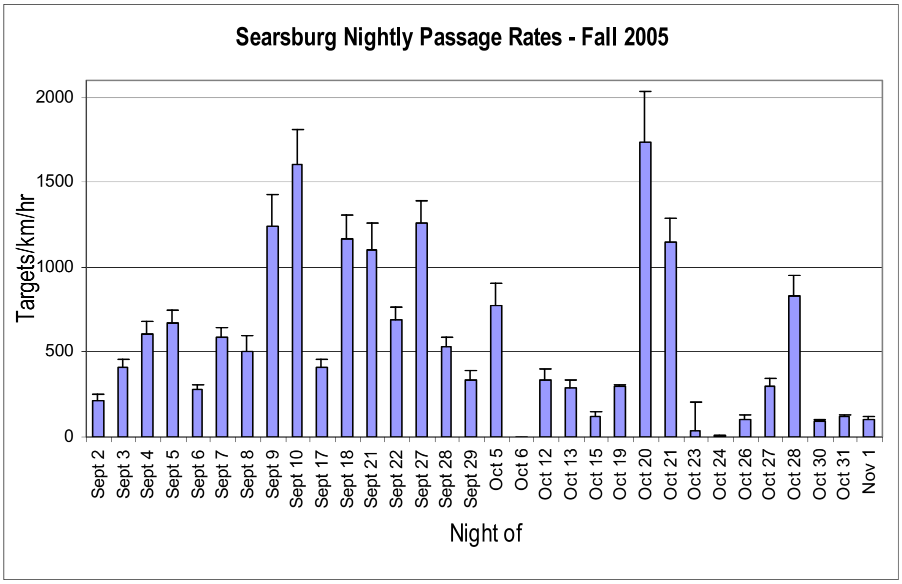

Figure 2-3. Nightly passage rates (error bars = 1 SE) observed

Individual hourly passage rates throughout the entire season varied from 0 to 2,454 t/km/hr. Hourly passage rates varied throughout each night and for the season overall. For the entire season, passage rates were highest during the fourth hour after sunset, followed by a relatively steady decline for the remainder of the night (Figure 2-4).

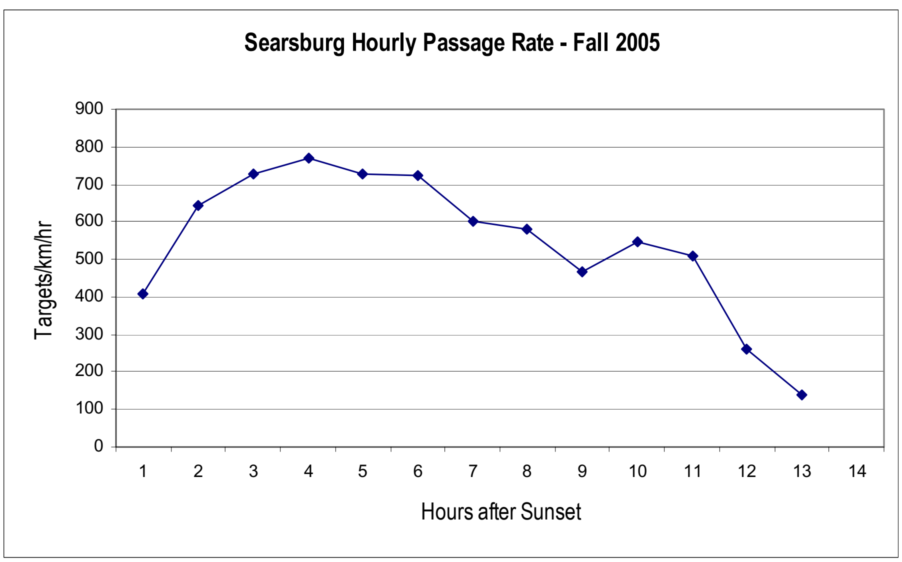

Figure 2-4. Hourly passage rates for entire season

Flight Direction

Mean flight direction through the project area was 221º ± 71º (Figure 2-5; Appendix A Table 2). There was considerable night to night variation in mean direction, although within each night there was less variation. The average nightly flight direction was typically south to southwest on more than half of the nights sampled.

On nights when the wind speeds were greatest, flight direction was generally downwind even when that direction was contrary to typical fall migration flight directions. Alternatively, on nights with light winds flight direction was typically southward, regardless of the wind direction, as migrants could easily fly into light headwinds.

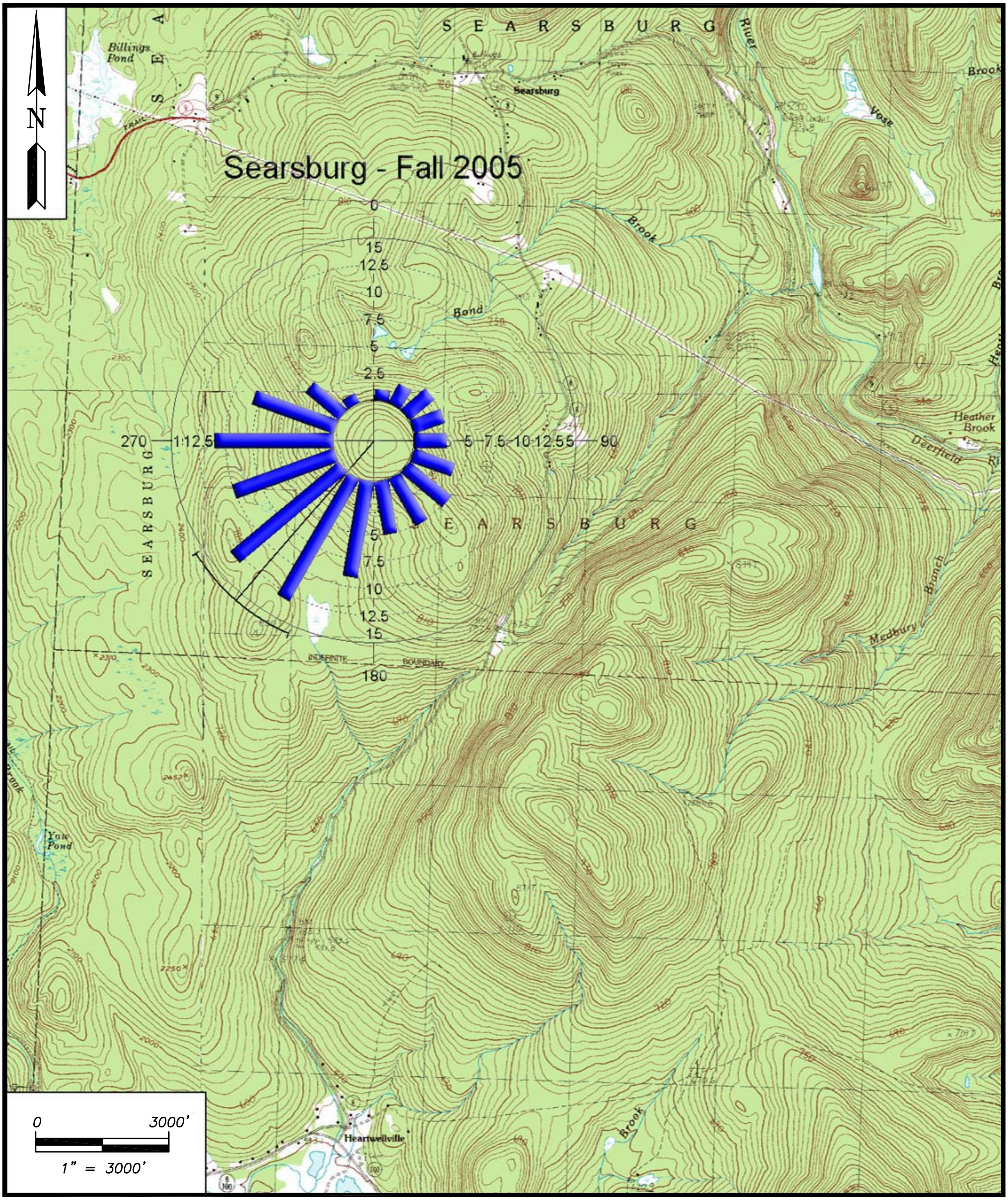

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Figure 2-5
Fall 2005 Target Flight Direction
Deerfield Wind Project
Searsburg, Vermont

REV.

Flight Altitude

The mean flight height of all targets was 395 m ± 21 m (1296' ± 69') above the radar site. The average nightly flight height ranged from 111 m ± 39 m (364' ± 128') to 672 m ± 393 m (2205' ± 1289') (Figure 2-6; Appendix B Table 3). The percent of targets observed flying below 100 m (328') also varied by night, from 1 percent to 54 percent (Figure 2-7). The seasonal average percentage of targets flying below 100 m was 13 percent.

Hourly flight height peaked from about 2 to 4 hours after sunset (Figure 2-8) and stayed fairly constant throughout the night. Within 100 m (328') height zones, the greatest percentage of targets (17%) was documented from 200 m to 300 m (656' to 984'), 68 percent were observed from 100 m to 600 m (328' to 1969') (Figure 2-9).

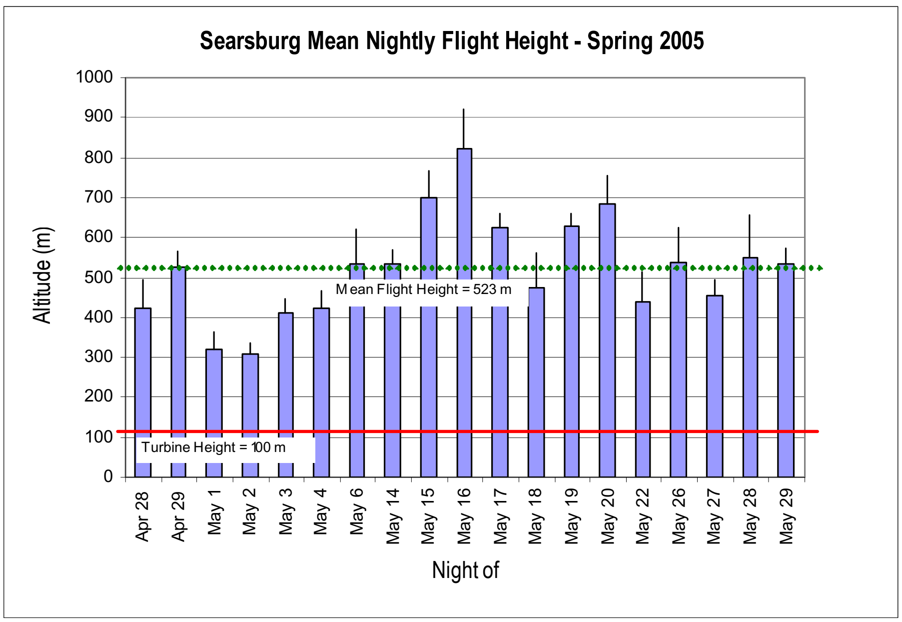


Figure 2-6. Mean nightly flight height of targets

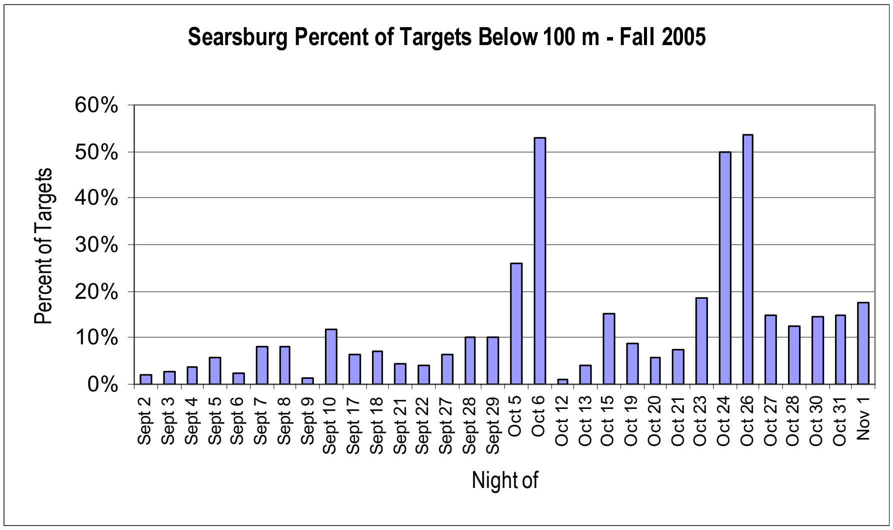


Figure 2-7. Percent of targets observed flying below a height of 100 m (328')

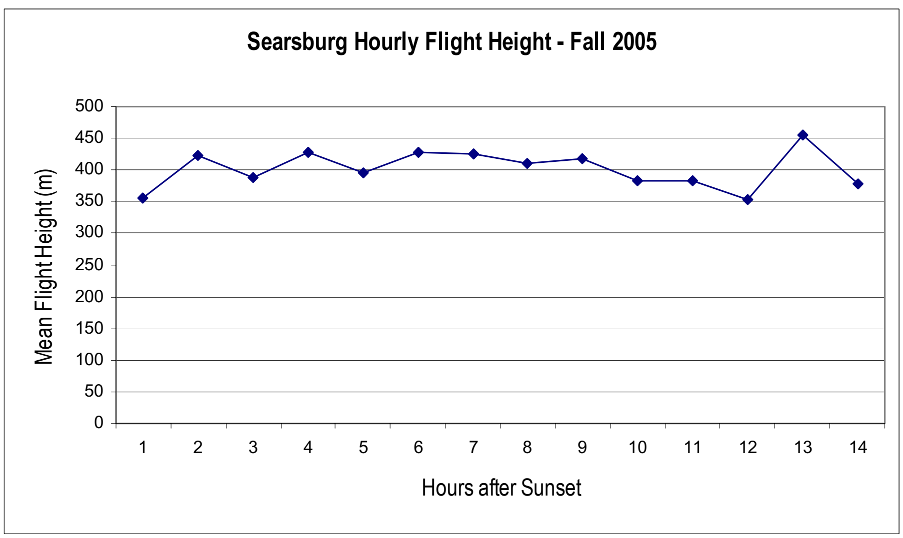


Figure 2-8. Hourly target flight height distribution

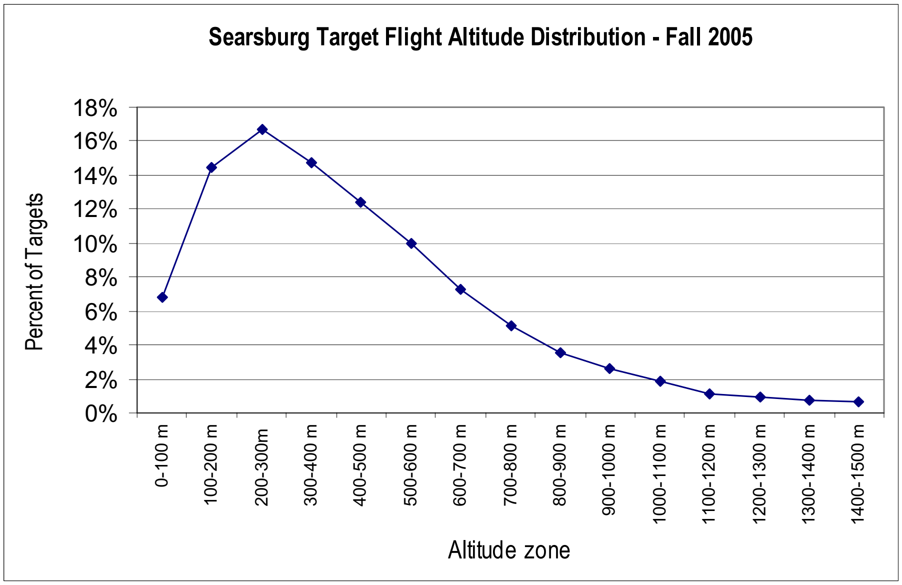


Figure 2-9. Target flight height distribution within 100 m height zones

2.4 Discussion

Fall 2005 radar surveys documented migration activity and patterns in the Western Expansion Area of the proposed Deerfield Wind Project. In general, migration activity and flight patterns varied between and within nights. The results of fall 2005 sampling were generally similar to sampling conducted at the same location in the fall of 2004.

Passage Rates

Nightly passage rates varied from 3 ± 1 to 1,736 ± 295 t/km/hr, with an overall mean of 559 ± 87 t/km/hr. Passage rates often peaked 4 hours after sunset, which is typical of nighttime migration activity (Able 1970; Richardson 1972). Few surveys using the same methods and equipment and conducted during the same time period are available for comparison, although this is slowly changing as more surveys are becoming available (Table 2-2). There are limitations in comparing that data with data from previous years, as year-to-year variation in continental bird populations invariably affects how many birds migrate through an area. However, passage rates observed at the Deerfield Wind Project during fall 2005 were within the range of those studies.

Table 2-2. Summary of passage rates from other fall radar studies

Year	Location	Passage Rate (t/km/hr)	Reference
1994	Western Maine	551	ND&T 1995
1994	Copenhagen, NY	341	Cooper *et al*. 1995
1994	Martinsburg, NY	661	Cooper *et al*. 1995
1998	Harrisburg, NY	336	Cooper and Mabee 1999
1998	Wethersfield, NY	466	Cooper and Mabee 1999
2003	Chautauqua, NY	235	Cooper *et al*. 2004a
2003	Mt. Storm, WV	241	Cooper *et al*. 2004b
2004	Searsburgh, VT	193	Roy and Pelletier 2005

Differences in the overall passage rates could be due to several factors. Surveys conducted during different years can yield different results, as the size of continental bird populations likely changes year-to-year. Weather patterns may differ from year to year and could affect the timing of migration. Different surveys may be timed at different points within those varying migration seasons. Also, as explained above, the selection of a radar sampling site is an important determinant of how effectively radars can detect birds in the surrounding airspace. Due to this important, but highly variable factor, radar studies at different locations are not always equally comparable.

Flight Direction

Some research suggests that bird migration may be affected by landscape features, such as coastlines, large river valleys, and mountain ranges. This has been documented for diurnally-migrating birds, such as raptors, but is not as well established for nocturnally migrating birds (Sielman *et al*. 1981; Bingman *et al*. 1982; Bruderer and Jenni 1990; Richardson 1998; Fortin *et al*. 1999; Williams *et al.* 2001; Diehl *et al*. 2003; Woodlot Alternatives, Inc. unpublished data).

Evidence suggesting topographic effects to night-migrating birds has typically included areas of varied topography, such as the most rugged areas of the northern Appalachians and the Alps. The landscape around the Deerfield Wind Project area consists of valleys and peaks with elevation differentials of less than 300 m (985'). This is considerably less than in those other areas where potential topographic effects on flight direction have been suggested so it is unlikely that topography would affect migration in this area.

Interestingly, the mean flight direction of 221º ± 71º was nearly identical to the fall 2004 sampling that occurred at the same site (223º ± 56º). This flight direction takes migrants at a variety of angles across the project area ridgelines and indicates that topography in the project area is not altering the movement of migrants in the area. This is further corroborated by the fall 2004 surveys. During that study, three radar sites were used to characterize migration: two along ridgelines and one in a nearby valley. The flight heights documented at all three of these sampling locations indicated that the majority of migrants were flying well above the proposed development areas and above the influence of the surrounding ridges and mountaintops (Roy and Pelletier 2005).

Flight Altitude

The high mean flight altitude of targets documented during this study (395 m ± 21 m or 1,296’ ± 69’) further supports the presumption that topographic features are not affecting migration patterns, particularly flight direction. The mean flight altitude being so high above the radar indicates that most birds are flying high enough that their flight is unimpeded by topographic features, such as hillsides or mountaintops, as they pass over valleys, ridges, and mountaintops. Figure 2-10 depicts a 3-dimensional view of the project area and the seasonal target flight direction histogram. This figure provides additional, though qualitative evidence that the project area does not contain significant topographic features that could affect nighttime bird migration activity, particularly towards any of the proposed wind turbines.

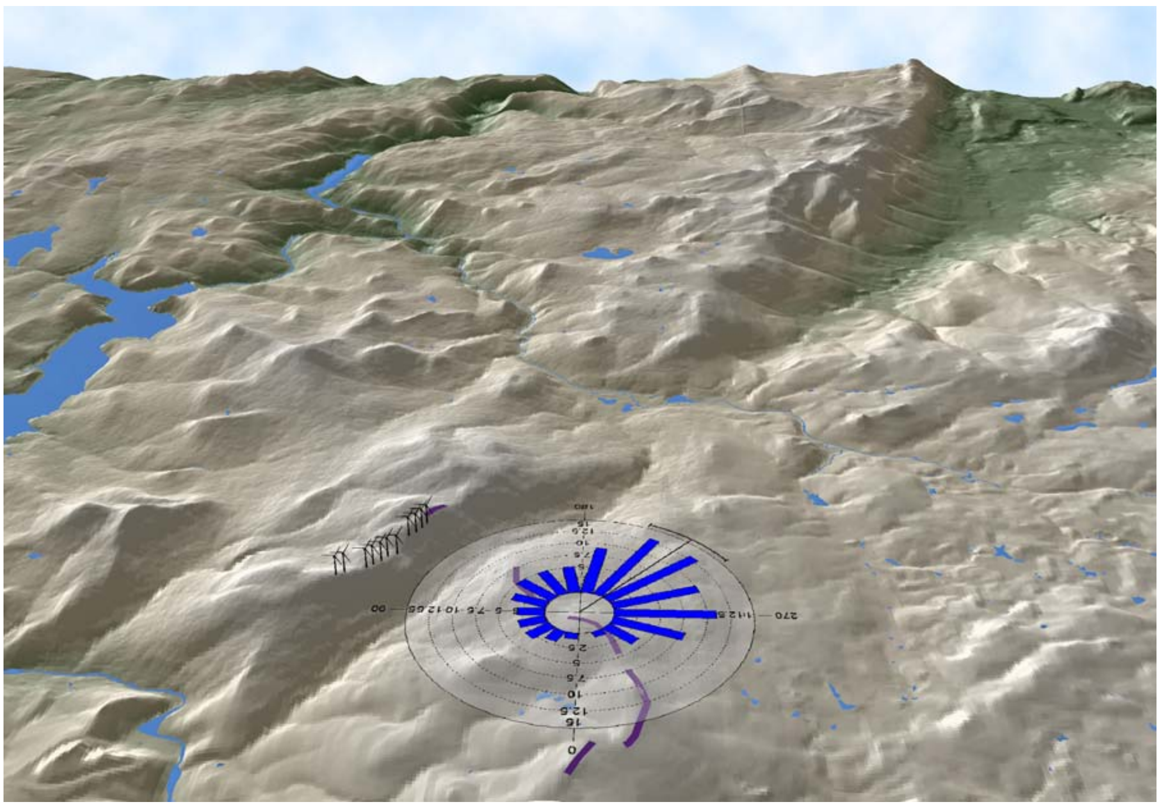


Figure 2-10. Three-dimensional view of project area showing mean target flight direction, existing turbines, and the proposed expansion areas (view from the north)

2.5 Conclusions

Radar surveys during the fall 2005 migration period have provided important information on nocturnal bird migration patterns in the vicinity of the Deerfield Wind Project. The results of the surveys indicate that bird migration patterns are generally similar to patterns observed at other sites in the Northeast. The fall 2005 surveys also complete a three-season, 1.5 year survey of bird and bat migration over the project area.

When all three seasons of data are reviewed, it is apparent that bird migration in the vicinity of the project is largely broad front, and no obvious areas of concentrated migration activity appeared. Flight height was generally higher than the proposed turbines although certain weather conditions can cause migrants to fly at heights that would make them susceptible to collisions with the turbines.

3.0 Bat Survey

3.1 Introduction

Wind projects have emerged as a potentially significant source of mortality for migrating bats following results of post-construction mortality surveys conducted at several operational wind farms in the southeastern United States (Arnett *et al*. 2005). Concerns about the risk of bat collision mortality were initially focused on forested ridgelines in the eastern United States. However, recent evidence from one facility on the prairies of Alberta indicate that bat mortality in those open habitats can be comparable to that observed along the forested ridgelines of the central Appalachian mountains (Robert Barclay, unpublished data).

Two consistent patterns have emerged from mortality studies of bats at operational wind farms: the timing of mortality and the species most commonly found. The majority of bat collisions appear to occur consistently during the month of August, which is thought to be linked to fall migration patterns, and the species most commonly found during mortality searches are the migratory species and tree bats: eastern red bat (*Lasiurus borealis*), hoary bat (*Lasiurus cinereus*), eastern pipistrelle (*Pipistrellus subflavus*), and silver-haired bat (*Lasionycteris noctivagans*) (Arnett *et al.* 2005). Bat collision mortality during the breeding season has been virtually non-existent, despite the fact that relatively large populations of some bat species have been documented in close proximity to some wind facilities that have been investigated. These data suggest that wind plants do not currently impact resident breeding bat populations in the United States. All available evidence indicates that most of the bat mortality at wind plants in the United States involves migrant or dispersing bats in the late summer and fall.

A number of plausible hypotheses explaining the high rates of bat mortality, as well as these patterns in timing and species vulnerability, have been presented by bat researchers, but none have been adequately tested. The most likely mechanisms explaining bat collision center on the possibility that bats are unable to detect rotating turbine blades by echolocation, that bats are visually or acoustically attracted to wind turbines as potential roost habitat or due to curiosity, or that ridgelines act as corridors for migrating bats (Arnett *et al.* 2005). Additionally, bats may rely on navigational cues other than echolocation while migrating, making them less able to detect the rotating blades of a wind turbine. Although evidence is highly preliminary, the rotation of turbines appears to be linked to mortality estimates, as no dead bats were found beneath the single non-operational turbine at the West Virginia site surveyed for fatalities (Arnett *et al.* 2005).

Nine species of bats occur in Vermont, based upon their normal geographic range. These are the little brown bat (*Myotis lucifugus*), northern long-eared bat, (*M. septentrionalis*), Indiana bat, eastern small-footed bat (*M. leibii*), silver-haired bat, eastern pipistrelle, big brown bat (*Eptesicus fuscus*), eastern red bat, and hoary bat (Whitaker and Hamilton 1998). The Indiana bat is an Endangered species in Vermont, the eastern small-footed bat is considered threatened and both the silver-haired bat and the eastern pipistrelle are rare in Vermont.

Results of winter population surveys in 23 known bat hibernacula have revealed declines in Vermont's Indiana bat wintering population, an increase in the little brown bat wintering population, and few changes in the small winter populations of all other species known to overwinter in the state (i.e., small-footed bats, northern long-eared bat, big brown bat, and eastern pipistrelle [Trombulak *et al*. 2001]). The largest known Indiana bat hibernaculum in Vermont is located in the Town of Manchester in the southern part of the state. The Deerfield Wind Project is located in southern Vermont, within the published normal range and known dispersal distance of the Indiana bat (Whitaker and Hamilton 1998).

To document bat activity in the area of the proposed Deerfield Wind Project, acoustic monitoring surveys were conducted during summer and fall 2005. Anabat II detectors were used for the duration of the surveys and were designed to document bat passages near the rotor zone of the proposed turbines, at an intermediate height, and near the ground. The results of these surveys are presented below.

3.2 Methods

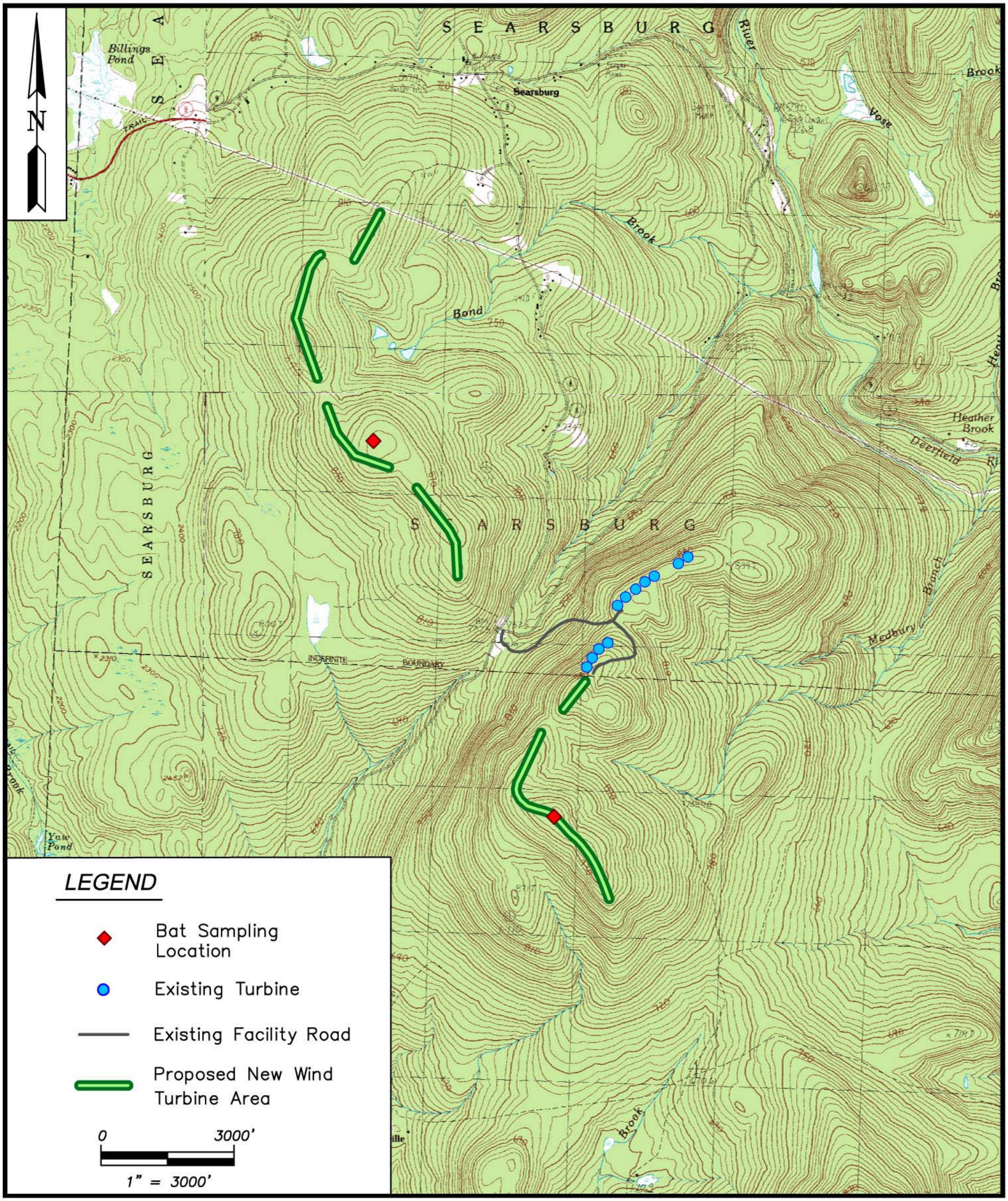
Field Surveys

Anabat II detectors were used for the duration of this study. Anabat detectors are frequency-division detectors, dividing the frequency of ultrasonic calls made by bats (a factor of 16 was used in this study[1]) so that they are audible to humans. These detectors are able to detect all bat species known to occur in New England using this setting. Data from the Anabat detectors were logged onto compact flash media using a CF Storage ZCAIM (Titley Electronics Pty Ltd), and downloaded to a computer for analysis.

The acoustic surveys were designed primarily to document the occurrence and detection rates of bats near the rotor height of the proposed turbines and at heights nearer the ground. To do this, one to two detectors were suspended from the guy wires of the met towers located at the southern end of the Eastern And Western Expansion areas (Figure 3-1). Detectors were programmed to begin recording at 7:00 pm each night and cease recording at 7:00 am each morning.

Detectors were deployed either singly or in pairs in the met towers. On nights when two detectors were used, they were deployed at heights of 15 m and 30 m (50' and 100'); otherwise, one detector was deployed at 30 m (100'). Additionally, deployment at the Western Expansion Area included two time periods around late September and late October when one detector was located high in the met tower and the second was located along the treeline of the met tower opening.

[1] The frequency division setting literally divides ultrasonic calls detected by the detector by the division setting in order to produce signals at frequencies audible to the human ear.



PREPARED BY:
WOODLOT ALTERNATIVES, INC.
ENVIRONMENTAL CONSULTANTS

DATE:	November 2005
SCALE:	1" = 3000'
JOB NO.	105028
FILE:	105028-00-Location.dwg

Figure 3-1
Fall 2005 Bat Detector Survey Locations
Deerfield Wind Project
Searsburg, Vermont

REV.

Data Analysis

Potential call files were extracted from data files using CFCread© software, with default settings in place. This software screens all data recorded by the bat detector and extracts call files based on the number of pulses recorded within a certain time period. Every potential call file was visually inspected, with any distinct grouping of recognizable calls or call fragments being considered a bat call sequence. Call sequences were identified based on visual comparison of call sequences with reference libraries of known calls collected by Chris Corben, Lynn Robbins, and the University of Maine Mammalogy Department using the Anabat system.

Qualitative visual comparison of recorded call sequences of sufficient length to reference libraries of bat calls allows for relatively accurate identification of bat species (O'Farrell *et al*. 1999, O'Farrell and Gannon 1999). However, the accuracy of this method depends upon experience and the relevance of reference call files used. Poor quality recordings or brief fragments were labeled as unknown, except in cases where we were reasonably sure that the fragment was exclusively within the *myotid* frequency range. *Myotids* were not identified to species, due to the similarity of calls between species within this genus. Appendix B contains representative examples of call files included in this report.

Once all of the call files were identified, nightly tallies of detected calls by species were compiled for each detector. Mean detection rates (calls/detector-night) were calculated for each detector and each site. Detection rate indicates only the number of calls detected and does not necessarily reflect the number of individual bats in an area.

3.3 Results

Of the total deployment period, a total of 153 detector-nights were sampled: 34 at the Eastern Expansion Area from July 7 to September 9, 2005, and 119 at the Western Expansion Area from July 4 to November 1, 2005. Table 3-1 summarizes the survey effort performed by the detectors as well as the number of calls and species composition of the calls recorded by each detector. Also provided are the results from the entire data set, combined. Appendix B Tables 1 and 2 provided detailed nightly summaries of the detectors operating during each night of deployment and the number of calls detected by that detector.

The remote deployment of the detectors resulted in periods when detectors were not operating, not operating correctly, or receiving some form of interference. The interference was in the form of static that was recorded into 15-second files by the detectors. The static occurred in an inconsistent manner between the two met towers used and between the detectors at each of the two towers. It was unclear what was causing the static. Several thousand static files were recorded during the survey. Because of this each night of downloaded data was carefully reviewed to determine when each detector was operating correctly in order to include it as a detector-night of sampling. This effort resulted in the identification of bat calls even on nights with many static files. This assessment indicated that despite the static interference that occurred on some nights the detectors were still capable of detecting nearby bats.

A total of 79 bat call sequences were recorded; 39 at the Eastern Expansion Area and 40 at the Western Expansion Area (Table 3-1). Detection rates at any given detector ranged from 0 calls/detector-night (low detector at the Eastern Expansion Area) to 1.6 calls/detector-night (high detector at the Eastern Expansion Area). The mean detection rates were 1.1 calls/detector-night at the Eastern Expansion Area and 0.3 calls/detector-night at the Western Expansion Area.

The detection rates at the individual high, low, and treeline detectors at the Western Expansion Area were 0.2, 0.5, and 0.6 calls/detector-night, respectively. The distribution of detection rates (the least number of calls up high and the greatest near the treeline) is typically what is expected during bat detector surveys. However, that relationship was reversed at the Eastern Expansion Area, where no bats were detected at the low detector and the high detector had the largest detection rate recorded during the survey. Survey effort may be the biggest factor in the latter relationship, as the low detector operated correctly on less than a dozen of the nights it was deployed.

Pulses of increased detections were documented during the survey, though limited survey effort due to occasional detector failures resulted in an inconsistent look at bat activity (Appendix B Tables 1 and 2). The largest peak was in late August, when 10 calls were recorded by the high detector at the Eastern Expansion Area. Activity was increased at the Western Expansion Area at this same time. Other peaks in activity occurred in early September (at the Eastern Expansion Area) and in the end of September (at the Western Expansion Area). No bat calls were recorded after October 2, 2005.

Table 3-1. Summary of bat detector surveys at the Deerfield Wind Project - Summer and Fall 2005

Site/Detector	Operational Survey Period	# Detector-nights	Number of Calls/Species						Total
			Big brown bat	Eastern red bat	Hoary bat	Silver-haired bat	Myotis spp.	Unknown	
Eastern - High	7/7 - 9/9	24	13	1	1	0	10	14	**39**
Eastern - Low	7/7 - 7/16	10	0	0	0	0	0	0	**0**
Western - High	7/4 - 11/1	73	1	0	2	6	3	4	**16**
Western - Low	7/4 - 10/13	29	3	0	3	0	3	5	**14**
Western - Treeline	9/21 -11/1	17	3	4	0	0	1	2	**10**
Total		***153***	***20***	***5***	***6***	***6***	***17***	***25***	***79***
			Detection Rate*						
Eastern - High	7/7 - 9/9	24	0.5	0.04	0.04	0.0	0.4	0.6	**1.6**
Eastern - Low	7/7 - 7/16	10	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Western - High	7/4 - 11/1	73	0.01	0.0	0.03	0.1	0.04	0.1	**0.2**
Western - Low	7/4 - 10/13	29	0.1	0.0	0.1	0.0	0.1	0.2	**0.5**
Western - Treeline	9/21 -11/1	17	0.2	0.2	0.0	0.0	0.1	0.1	**0.6**
Total		***153***	***0.1***	***0.03***	***0.04***	***0.04***	***0.1***	***0.2***	***0.5***

* Calls per detector-night

Of the 79 calls recorded, 54 were identified to species or genus (*Myotis*). Twenty-five calls were too short or of too poor a quality to identify. Big brown bats were the most common calls recorded (20) followed by those of the *myotids*. Calls of the eastern red bat, hoary bat, and silver-haired bat were only documented 5 or 6 times, each. No eastern pipistrelles were recorded by the detectors during the entire survey. The species composition of the calls recorded at each expansion area is provided in Figures 3-2 and 3-3.

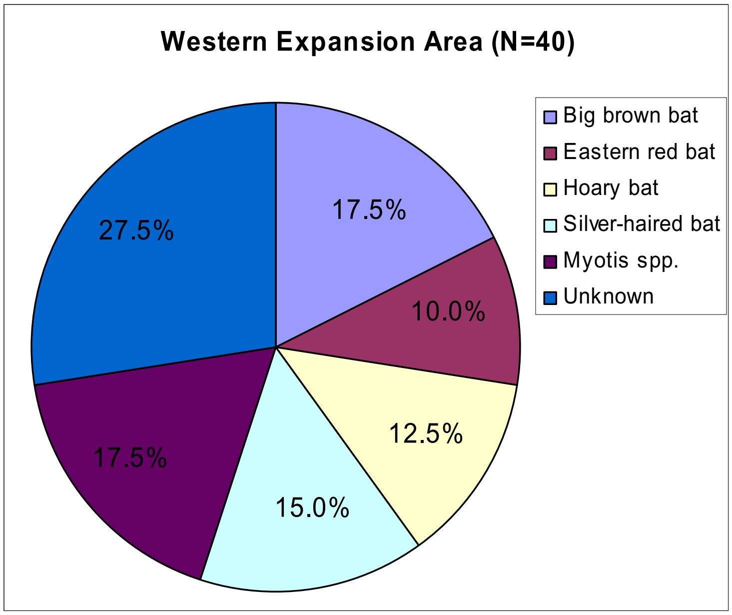


Figure 3-2. Species composition of calls recorded at the Western Expansion Area

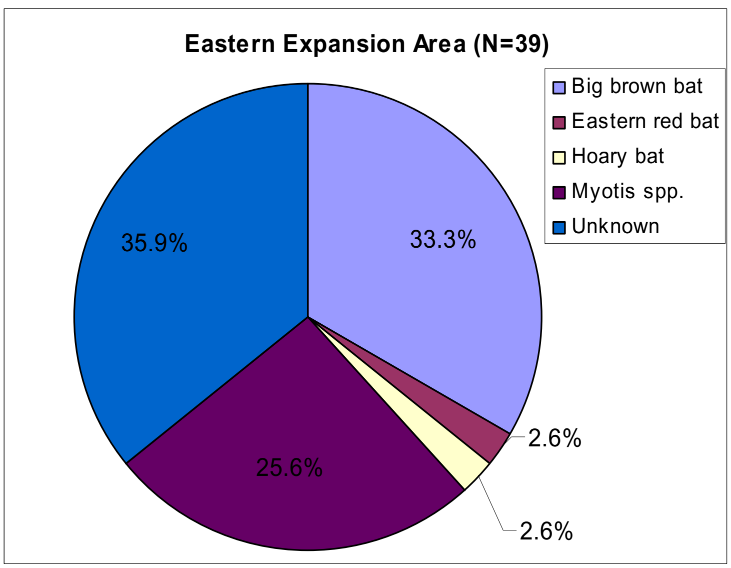


Figure 3-3. Species composition of calls recorded at the Eastern Expansion Area

In an attempt to determine if calls of the Indiana bat had been recorded, calls of the genus *Myotis* were examined using call characteristics described by Eric Britzke (a national expert researching the ability to identify this species from recorded call sequences) as suitable for identifying Indiana bats. Additionally, the *myotid* calls that were recorded were sent to Mr. Britzke for review using his filters based on known Indiana bat calls[2]. This examination revealed that no calls of Indiana bats were likely included in the calls recorded during these surveys. Mr. Britzke had not provided the results of his review prior to the completion of this report.

[2] At this time, Mr. Britzke has not made his filter publicly available.

While the number of calls detected overall was somewhat pulsed during the survey period, no obvious trends in species' presence were observed. Big brown bats and *myotids* were observed throughout the sampling period. Of the remaining species; eastern red bats were recorded in late August at the Eastern Expansion Area and in late September/early October at the Western Expansion Area (only by the treeline detector), hoary bats were recorded in mid-July and mid-August at the Western Expansion Area and in early September at the Eastern Expansion Area, and silver-haired bats were recorded in mid-August and early September only at the Western Expansion Area. Appendix B Table 3 provides a nightly summary of the number of each species recorded during each night of the survey. Also included in the table are weather conditions for those nights.

3.4 Discussion

Bat mortality at wind projects in the eastern United States has recently been identified as a potential risk to certain bat populations (Williams 2003). The study of this issue, however, poses difficulties, including insufficient scientific understanding of bat migration patterns and navigation systems, inadequate amounts of data on mortality rates and interactions between bats and turbines at existing wind farms, a lack of accurate population estimates for many bat species, and limited monitoring methods available that provide credible, comprehensive, and reliable data on bat movements.

This study aimed to document bats in and near the blade-swept zone of the proposed wind farm. The overall low numbers of bats detected during this survey could indicate a small bat population in the region, avoidance of the area by bats, poor conditions for bats, or limited survey timing and level of effort.

The project area is located in a mountainous region of Vermont. Generally, climate conditions are expected to be harsher along ridgelines than at valley bottoms and cooler temperatures and windier conditions may lower the suitability of these areas for bats. This could correspond with limited bat activity along ridgelines than at lower elevations. However, the knowledge base of bat habitat use at varying elevations is very limited and it is not possible to deduce that the results obtained are typical of low levels of use along ridgelines.

The daily timing of each recorded bat call, by species, is provided in Appendix B Table 3, along with daily weather information. No obvious relationships in weather conditions and bat detections were observed. This is largely due to the limited number of observations with which to make those relationships. In general, bats were detected on nights with varying winds, including nights with mean wind speeds above 6 m/s (13.4 mph) and on nights with and without rain showers.

The location of just two sets of detectors along the project area ridgelines also limits the total volume of airspace over the project area that was sampled for bats. Differences in the total number, detection rate, and species presence were observed between these two sites. These differences were likely due to total sampling effort (more effort occurred at the Western Expansion Area), sampling timing (sampling at the Eastern Expansion Area was predominantly in summer and not during the migration period), and sampling duration and not necessarily due to large differences in the bat community at each site.

The detector surveys at the existing facility included the entire month of October, which included only 1 call recorded on the second day of the month. Two detectors were operating during most of that month for a total of 50 detector-nights during which no calls were recorded. This decreases the overall detection rate due to the preponderance of no detections on these late-season nights. In fact, if the survey period available from the Eastern Expansion Area (July 7 to September 9) is applied to the data set from the Western Expansion Area during that time (29 calls), the detection rate at the Western Expansion Area doubles, from 0.3 to 0.6 calls/detector-night. This is still lower than, but certainly much closer to, that of the Eastern Expansion Area (1.1 calls/detector-night).

The species composition was fairly similar was fairly similar between the two sites. Only one species, silver-haired bat, was observed at one site (Western Expansion Area) and not the other. These occurred in late August, a time period when detectors were operating correctly at both sites. The fact that silver-haired bats were not documented by the detectors at the Eastern Expansion Area is likely due to simple variation in the distribution of the species (either during the summer months or during migration) across the landscape and random chance that an individual bat will enter the detection cone of a detector. That short increase in the number of silver-haired bats recorded could be due to the initiation of migration by that species at that time.

The greatest number of eastern red bats occurred near the end of September and into early October. This species is known to be migratory and believed to be one of the later migrants in the region. This increase at the end of September could also indicate the initiation of migration or a pulse of migrant red bats through the project area. Interestingly, calls of this species at the Western Expansion Area, which account for 5 of the 6 calls recorded, were only from the detector located along the treeline of met tower opening.

Emerging information on the potential susceptibility of bats to wind turbine-induced mortality indicates that some species may be particularly vulnerable to collisions with turbines. The tree roosting bats (i.e., hoary and eastern red bats), along with the eastern pipistrelle, appear to have a higher risk of collision with wind turbines based on mortality data collected at existing facilities. Although these species are generally believed to be uncommon relative to some of the *myotids* and big brown bats, they have constituted disproportionably large percentages of bat fatalities at existing facilities. These species were documented during the fall 2005 surveys, except for the eastern pipistrelle. They also represented a small proportion of the calls (17 of 54, or 32%) recorded.

3.5 Conclusions

Detector surveys during the summer and fall 2005 migration period have provided important information on bat activity in the vicinity of the Deerfield Wind Project. The surveys documented the species that would be expected in the area based on the species' range and abundance, as well as the habitats in the project area. The generally low level of activity could be caused by many biological factors, by simple chance, by survey effort, and the difficulties and limitations of studying bat populations. A peak in detections of silver-haired and eastern red bats likely occurred near the end of August and the end of September, respectively.

Although myotids were not identified to species, the majority of recorded calls most closely resembled the calls of the little brown bat, a very common species in Vermont, and none appeared to be of the Indiana bat. This does not mean that the species is not present, though due to its overall rarity, it is fairly unlikely.

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Appendix A

Radar Survey Data Tables

Appendix A Table 1. 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**	**11**	**12**	**13**	**14**	**Mean**	**SE**
Sept 2	54	139	163	229	221	300	418	286	273	171	150	--	--	--	219	30
Sept 3	207	279	436	357	286	264	600	570	550	621	334	--	--	--	409	46
Sept 4	696	776	1029	779	536	521	543	571	579	600	0	--	--	--	603	76
Sept 5	600	693	788	743	807	843	830	804	793	766	377	43	--	--	674	69
Sept 6	150	266	271	284	380	450	350	236	264	223	171	--	--	--	277	27
Sept 7	520	557	621	714	793	714	564	553	509	525	857	86	--	--	584	56
Sept 8	493	625	386	429	371	293	407	230	314	604	1350	--	--	--	500	93
Sept 9	434	938	1886	2213	--	1479	1461	1564	1379	1313	891	107	--	--	1242	184
Sept 10	279	1791	2148	2229	2139	2154	2006	1714	1564	1581	1614	32	--	--	1604	208
Sept 17	364	536	482	429	607	300	600	--	257	264	471	188	--	--	409	52
Sept 18	814	1195	2264	1939	1382	1136	964	1061	936	1104	723	450	--	--	1164	145
Sept 21	450	1532	1714	1440	1918	1071	1036	1637	1033	686	609	64	--	--	1099	164
Sept 22	604	686	--	793	818	757	664	750	664	654	557		--	--	695	68
Sept 27	1843	1639	1784	1821	1607	1166	1393	1264	1082	950	964	525	300	--	1257	136
Sept 28	586	777	895	654	530	621	536	348	371	268	429	407		--	535	53
Sept 29	268	557	729	571	521	386	321	246	134	94	81	75	--	--	332	64
Oct 5	--	11	34	46	--	--	0	0	11	29	27	14	11	--	772	129
Oct 6	0	11	5	0	13	0	0	0	0	0	0	5	0	--	3	1
Oct 12	188	391	514	621	441	466	167	134	64	--	--	--	--	--	332	66
Oct 13	--	--	520	359	332	314	241	343	163	21	--	--	--	--	287	52
Oct 15	--	--	--	--	--	--	--	--	--	--	82	121	171	--	125	26
Oct 19	--	--	--	--	295	309	--	--	--	--	--	--	--	--	302	7
Oct 20	814	2183	2088	2454	2079	2200	--	--	--	1146	921	--	--	--	1736	295
Oct 21	447	874	1045	1371	1431	1414	--	--	--	1452	1645	1789	--	--	1147	139
Oct 23	4	0	25	21	--	--	--	171	29	0	15	--	107	--	41	163
Oct 24	18	0	0	--	--	--	--	--	--	--	--	--	--	--	6	6
Oct 26	86	171	286	124	123	86	0	11	11	--	--	--	--	--	100	31
Oct 27	--	79	141	268	364	455	421	493	439	386	296	143	107	--	299	43
Oct 28	177	484	643	954	1232	1521	1286	1264	--	1071	943	675	407	150	831	123
Oct 30	--	--	64	159	190	129	114	107	43	86	21	43	30	--	90	17
Oct 31	64	139	107	121	71	161	75	150	171	150	179	120	86	--	123	11
Nov 1	--	--	43	201	136	--	--	--	--	17	34	99	162	129	103	23
Entire Season	406	642	728	770	727	723	600	580	465	547	509	262	138		**559**	**84**
-- indicates no data for that hour																

Appendix A Table 2. Mean Nightly Flight Direction		
Night of	**Mean Flight Direction**	**Circular Stdev**
Sept 2	164	47
Sept 3	219	46
Sept 4	251	21
Sept 5	311	75
Sept 6	95	55
Sept 7	139	63
Sept 8	194	57
Sept 9	232	30
Sept 10	262	29
Sept 17	131	26
Sept 18	201	39
Sept 21	139	46
Sept 22	73	32
Sept 27	221	37
Sept 28	26	32
Sept 29	181	36
Oct 5	224	107
Oct 6	20	80
Oct 12	294	18
Oct 13	298	15
Oct 15	129	16
Oct 19	155	22
Oct 20	198	21
Oct 21	261	33
Oct 23	248	86
Oct 24	293	8
Oct 26	184	44
Oct 27	245	42
Oct 28	264	36
Oct 30	144	30
Oct 31	73	108
Nov 1	146	46
Entire Season	**221**	**71°**

Appendix A Table 3. Summary of mean flight heights by hour, night, and for entire season																	
Night of	**Mean Flight Height (altitude in meters) by hour after sunset**													**Entire Night**		**% of targets below 100 m**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**Mean**	**SE**	
Sept 2	423	296	343	502	429	465	386	434	405	378	467	--	--	--	412	18	2%
Sept 3	447	452	373	391	355	412	438	463	456	416	370	--	--	--	416	12	3%
Sept 4	456	463	455	351	323	381	446	410	351	379	540	--	--	--	414	19	4%
Sept 5	--	422	434	471	454	451	516	404	449	455	467	--	--	--	452	10	6%
Sept 6	471	579	532	529	533	451	484	414	375	--	--	--	--	--	485	22	2%
Sept 7	317	354	364	369	319	348	421	452	344	430	352	--	--	--	370	14	8%
Sept 8	288	305	266	267	330	340	403	528	542	413	383	--	--	--	370	29	8%
Sept 9	505	634	496	449	422	447	486	484	444	487	408	--	--	--	478	18	1%
Sept 10	382	408	332	339	315	330	321	252	235	320	477	--	--	--	337	20	12%
Sept 17	291	419	426	492	586	585	613	669	593	441	516	514	--	--	512	30	6%
Sept 18	450	497	515	449	478	532	548	433	454	533	564	641	--	--	508	17	7%
Sept 21	323	668	743	770	610	599	541	412	415	382	374	301	--	--	512	47	5%
Sept 22	397	416	439	337	347	409	378	388	411	340	--	--	--	--	386	11	4%
Sept 27	461	662	679	642	591	600	538	474	505	485	453	412	556	--	543	24	6%
Sept 28	265	300	278	--	311	374	370	348	343	353	363	245	--	--	323	14	10%
Sept 29	276	306	346	353	338	362	383	312	306	231	261	461	--	--	328	18	10%
Oct 5	200	166	206	331	--	--	209	122	--	119	186	188	--	--	192	21	26%
Oct 6	--	124	66	37	215	--	--	--	--	--	--	--	--	--	111	39	53%
Oct 12	502	538	588	569	547	504	441	458	--	--	--	--	--	--	518	18	1%
Oct 13	--	--	482	469	301	441	344	333	372	501	--	--	--	--	405	27	4%
Oct 15	--	--	--	--	--	--	--	--	--	--	197	366	1452	--	672	393	15%
Oct 19	--	--	--	--	241	303	402	410	339	--	--	--	--	--	339	31	9%
Oct 20	360	809	447	707		579	--	--	--	338		264	258	488	472	65	6%
Oct 21	390	643	625	608	530	449	--	--	392	409	396	346	--	--	479	36	8%
Oct 23	--	464	222	646	--	437	--	594	--	--	--	94	231	--	384	78	18%
Oct 24	--	240	--	--	--	--	--	--	--	--	--	--	--	--	240	n/a	50%
Oct 26	193	328	96	--	524	--	--	--	874	--	--	--	--	--	403	138	54%
Oct 27	--	269	227	258	237	239	239	246	309	346	339	434	357	222	286	18	15%
Oct 28	98	344	331	357	339	350	323	400	345	366	366	259	440	300	330	21	13%
Oct 30	--	--	--	331	316	430	534	381	370	422	218	234	222	305	342	30	14%
Oct 31	--	294	220	240	293	326	--	432	390	235	143	201	221	655	304	40	15%
Nov 1	--	--	336	270	--	--	--	--	--	392	576	675	371	300	417	57	17%
Entire Season	357	422	388	427	396	429	425	410	417	382	383	352	456	378	**395**	**21**	**13%**
-- indicates no data for that hour																	

Appendix B

Bat Survey Data Tables and Figures

Appendix B Table 1. Summary of fall bat surveys at the eastern expansion area

Date (night of)	# Detectors	Detector Location(s)	Number of Calls		
			High Detector	Low Detector	Total
7/7/05	2	High, Low	0	0	0
7/8/05	2	High, Low	0	0	0
7/9/05	2	High, Low	0	0	0
7/10/05	2	High, Low	0	0	0
7/11/05	2	High, Low	0	0	0
7/12/05	2	High, Low	0	0	0
7/13/05	1	Low	--	0	0
7/14/05	1	Low	--	0	0
7/15/05	1	Low	--	0	0
7/16/05	1	Low	--	0	0
7/17/05	1	High	0	--	0
7/18/05	1	High	0	--	0
8/25/05	1	High	2	--	2
8/26/05	1	High	10	--	10
8/27/05	1	High	4	--	4
8/28/05	1	High	0	--	0
8/29/05	1	High	0	--	0
8/30/05	1	High	1	--	1
8/31/05	1	High	2	--	2
9/1/05	1	High	0	--	0
9/2/05	1	High	1	--	1
9/3/05	1	High	4	--	4
9/4/05	1	High	2	--	2
9/5/05	1	High	8	--	8
9/6/05	1	High	2	--	2
9/7/05	1	High	2	--	2
9/8/05	1	High	1	--	1
9/9/05	1	High	0	--	0
Total	34	N/A	39	0	39
Detection Rate:			1.6	0.0	1.1

Appendix B Table 2. Summary of fall bat surveys at the western expansion area						
Date (night of)	**# Detectors**	**Detector Location**	**Number of calls**			
			High Detector	**Low Detector**	**Treeline**	**Total**
7/4/05	2	High, Low				0
7/5/05	2	High, Low				0
7/6/05	2	High, Low				0
7/7/05	2	High, Low				0
7/8/05	2	High, Low				0
7/9/05	2	High, Low				0
7/10/05	2	High, Low				0
7/11/05	2	High, Low		1		1
7/12/05	2	High, Low				0
7/13/05	1	Low				0
7/14/05	1	Low				0
7/15/05	1	Low				0
7/17/05	1	Low				0
7/18/05	1	Low		2		2
7/19/05	1	Low		2		2
7/20/05	1	Low		0		0
7/21/05	1	Low		2		2
7/22/05	1	Low		3		3
7/23/05	1	Low		1		1
7/24/05	1	Low		3		3
7/25/05	1	Low				0
7/26/05	1	High				0
7/27/05	1	High				0
7/28/05	1	High				0
7/29/05	1	High				0
7/30/05	1	High				0
7/31/05	1	High				0
8/1/05	1	High				0
8/2/05	1	High				0
8/3/05	1	High				0
8/24/05	1	High				0
8/25/05	1	High	4			4
8/26/05	1	High	4			4
8/27/05	1	High	2			2
8/28/05	1	High	0			0
8/29/05	1	High	1			1
8/30/05	1	High	0			0
9/2/05	1	High				0
9/3/05	1	High				0
9/4/05	1	High	1			1
9/5/05	1	High	3			3
9/6/05	1	High				0
(continued)						

Appendix B Table 2. Summary of fall bat surveys at the western expansion area (continued)						
Date (night of)	**# Detectors**	**Detector Location**	**Number of calls**			
			High Detector	**Low Detector**	**Treeline**	**Total**
9/7/05	1	High				0
9/8/05	1	High				0
9/9/05	1	High				0
9/10/05	1	High	1			1
9/21/05	2	High, Treeline				0
9/22/05	2	High, Treeline				0
9/23/05	1	Treeline			1	1
9/24/05	1	Treeline			5	5
9/25/05	1	Treeline			0	0
9/26/05	1	Treeline			0	0
9/27/05	1	Treeline			0	0
9/28/05	1	Treeline			1	1
9/29/05	1	Treeline			1	1
9/30/05	1	Treeline			1	1
10/1/05	1	Treeline			0	0
10/2/05	1	Treeline			1	1
10/3/05	1	Treeline				0
10/4/05	1	Treeline				0
10/5/05	1	Treeline				0
10/6/05	2	High, Low				0
10/7/05	2	High, Low				0
10/8/05	2	High, Low				0
10/9/05	2	High, Low				0
10/10/05	2	High, Low				0
10/11/05	2	High, Low				0
10/12/05	2	High, Low				0
10/13/05	2	High, Low				0
10/14/05	1	High				0
10/15/05	1	High				0
10/18/05	1	Treeline				0
10/19/05	2	High, Treeline				0
10/20/05	2	High, Treeline				0
10/21/05	2	High, Treeline				0
10/22/05	2	High, Treeline				0
10/23/05	2	High, Treeline				0
10/24/05	2	High, Treeline				0
10/25/05	2	High, Treeline				0
10/26/05	2	High, Treeline				0
10/27/05	2	High, Treeline				0
10/28/05	2	High, Treeline				0
10/29/05	2	High, Treeline				0
10/30/05	2	High, Treeline				0
(continued)						

Appendix B Table 2. Summary of fall bat surveys at the western expansion area (continued)

Date (night of)	# Detectors	Detector Location	Number of calls			
			High Detector	Low Detector	Treeline	Total
10/31/05	2	High, Treeline				0
11/1/05	2	High, Treeline				0
Total	119	N/A	16	14	10	40
Detection Rate:			0.2	0.5	0.6	0.3

Appendix B Table 3. Summary of species recorded and weather during each night of the survey period*

Date	Big brown bat	Eastern red bat	Hoary bat	Silver-haired bat	*Myotis* spp.	Unknown	Total	Wind Speed (m/s)	Wind Direction	Temperature (F)
7/4/2005	0	0	0	0	0	0	**0**	6.2	224.239°	59.7
7/5/2005	0	0	0	0	0	0	**0**	4.1	261.886°	63.6
7/6/2005	0	0	0	0	0	0	**0**	7.7	85.23°	55.2
7/7/2005	0	0	0	0	0	0	**0**	5.9	98.44°	53.7
7/8/2005	0	0	0	0	0	0	**0**	5.7	40.86°	51.3
7/9/2005	0	0	0	0	0	0	**0**	7.7	301.218°	54.3
7/10/2005	0	0	0	0	0	0	**0**	8.2	292.96°	61.9
7/11/2005	0	0	0	0	0	1	**1**	4.0	49.337°	66.7
7/12/2005	0	0	0	0	0	0	**0**	5.7	205.714°	60.9
7/13/2005	0	0	0	0	0	0	**0**	5.2	240.88°	62.0
7/14/2005	0	0	0	0	0	0	**0**	5.1	288.618°	63.0
7/15/2005	0	0	0	0	0	0	**0**	3.9	181.953°	65.5
7/16/2005	0	0	0	0	0	0	**0**	5.6	207.678°	64.4
7/17/2005	0	0	0	0	0	0	**0**	6.5	214.492°	66.8
7/18/2005	2	0	0	0	0	0	**2**	5.9	246.316°	67.2
7/19/2005	0	0	1	0	0	1	**2**	6.3	303.515°	63.0
7/20/2005	0	0	0	0	0	0	**0**	3.6	281.712°	60.0
7/21/2005	0	0	0	0	1	1	**2**	5.9	286.1°	62.4
7/22/2005	0	0	0	0	2	1	**3**	8.1	351.37°	58.0
7/23/2005	0	0	1	0	0	0	**1**	6.7	344.705°	56.0
7/24/2005	1	0	1	0	0	1	**3**	8.1	225.843°	59.8
7/25/2005	0	0	0	0	0	0	**0**	4.9	268.237°	63.8
7/26/2005	0	0	0	0	0	0	**0**	10.7	232.63°	68.4
7/27/2005	0	0	0	0	0	0	**0**	8.9	SSW	71
7/28/2005	0	0	0	0	0	0	**0**	5.3	NNW	55
7/29/2005	0	0	0	0	0	0	**0**	5.8	WSW	55
7/30/2005	0	0	0	0	0	0	**0**	3.1	NW	55
7/31/2005	0	0	0	0	0	0	**0**	3.6	SSW	59
8/1/2005	0	0	0	0	0	0	**0**	5.8	SSW	64
8/2/2005	0	0	0	0	0	0	**0**	4.4	NW	66
8/3/2005	0	0	0	0	0	0	**0**	5.3	NNW	60
8/4/2005	0	0	0	0	0	0	**0**	4.4	SSW	62
8/5/2005	0	0	0	0	0	0	**0**	6.7	SW	66
8/6/2005	0	0	0	0	0	0	**0**	5.3	NNW	55
8/7/2005	0	0	0	0	0	0	**0**	6.4	SSW	53
8/8/2005	0	0	0	0	0	0	**0**	3.1	SW	60
8/9/2005	0	0	0	0	0	0	**0**	6.6	248.733°	61.2
8/10/2005	0	0	0	0	0	0	**0**	6.5	251.016°	63.7
8/11/2005	0	0	0	0	0	0	**0**	3.7	88.598°	63.7
8/12/2005	0	0	0	0	0	0	**0**	9.3	251.525°	65.1
8/13/2005	0	0	0	0	0	0	**0**	4.8	290.191°	65.1
8/14/2005	0	0	0	0	0	0	**0**	3.8	81.922°	60.6

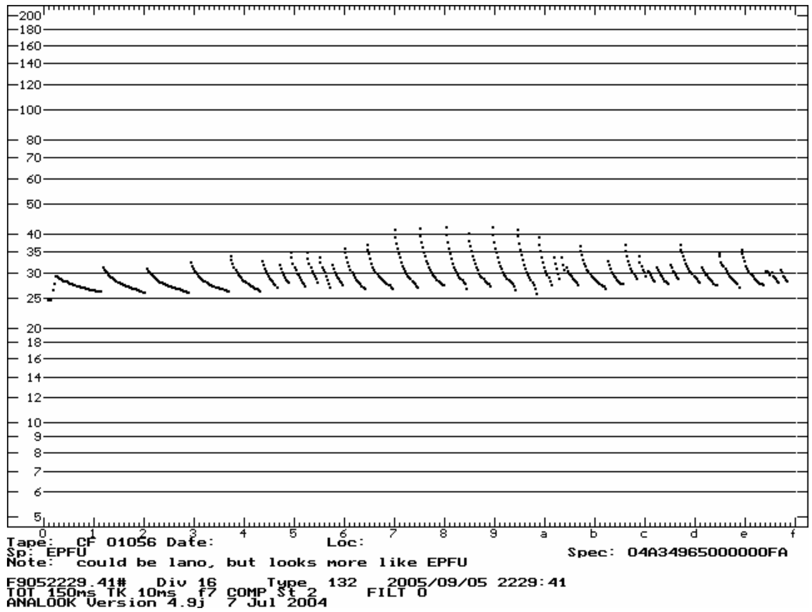
(continued)

Appendix B Table 3. Summary of species recorded and weather during each night of the survey period* (continued)

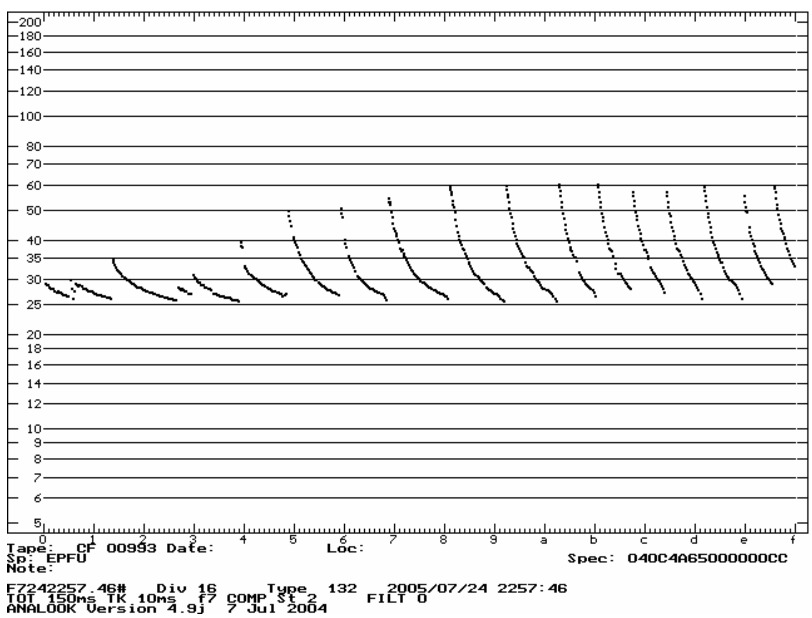
Date	Big brown bat	Eastern red bat	Hoary bat	Silver-haired bat	*Myotis* spp.	Unknown	Total	Wind Speed (m/s)	Wind Direction	Temperature (F)
8/15/2005	0	0	0	0	0	0	**0**	1.7	169.229°	57.6
8/16/2005	0	0	0	0	0	0	**0**	5.8	282.68°	55.9
8/17/2005	0	0	0	0	0	0	**0**	5.6	20.207°	51.4
8/18/2005	0	0	0	0	0	0	**0**	3.4	194.993°	55.8
8/19/2005	0	0	0	0	0	0	**0**	6.5	187.752°	55.3
8/20/2005	0	0	0	0	0	0	**0**	7.4	223.695°	63.7
8/21/2005	0	0	0	0	0	0	**0**	7.8	297.605°	58.1
8/22/2005	0	0	0	0	0	0	**0**	5.2	311.106°	50.3
8/23/2005	0	0	0	0	0	0	**0**	3.9	0.627°	51.1
8/24/2005	0	0	0	0	0	0	**0**	7.5	15.066°	49.9
8/25/2005	0	0	0	3	2	1	**6**	3.1	2.957°	57.8
8/26/2005	3	1	1	2	1	6	**14**	4.9	235.141°	58.4
8/27/2005	2	0	1	0	1	2	**6**	8.0	204.704°	57.5
8/28/2005	0	0	0	0	0	0	**0**	4.4	210.875°	61.8
8/29/2005	0	0	0	0	1	0	**1**	4.6	212.954°	61.7
8/30/2005	0	0	0	0	1	0	**1**	7.8	188°	63.7
8/31/2005	0	0	0	0	0	2	**2**	9.7	311.772°	57.7
9/1/2005	0	0	0	0	0	0	**0**	6.0	311.869°	54.9
9/2/2005	0	0	0	0	1	0	**1**	6.6	300.836°	52.8
9/3/2005	0	0	0	0	1	3	**4**	4.8	325.059°	52.9
9/4/2005	0	0	0	0	2	1	**3**	6.3	40.217°	49.9
9/5/2005	6	0	0	1	2	2	**11**	2.4	160.694°	54.7
9/6/2005	2	0	0	0	0	0	**2**	4.6	266.389°	55.6
9/7/2005	1	0	0	0	1	0	**2**	5.3	281.49°	57.9
9/8/2005	0	0	1	0	0	0	**1**	6.2	329.751°	54.1
9/9/2005	0	0	0	0	0	0	**0**	5.1	3.023°	48.5
9/10/2005	0	0	0	0	0	1	**1**	4.2	56.253°	45.9
9/11/2005	0	0	0	0	0	0	**0**	9.7	273.173°	55.0
9/12/2005	0	0	0	0	0	0	**0**	5.4	305.488°	63.0
9/13/2005	0	0	0	0	0	0	**0**	6.2	219.986°	63.9
9/14/2005	0	0	0	0	0	0	**0**	6.8	234.789°	62.6
9/15/2005	0	0	0	0	0	0	**0**	4.7	96.46°	59.8
9/16/2005	0	0	0	0	0	0	**0**	3.5	106.994°	57.5
9/17/2005	0	0	0	0	0	0	**0**	6.1	291.152°	53.9
9/18/2005	0	0	0	0	0	0	**0**	5.6	318.287°	52.3
9/19/2005	0	0	0	0	0	0	**0**	8.4	223.319°	56.6
9/20/2005	0	0	0	0	0	0	**0**	8.4	298.039°	51.5
9/21/2005	0	0	0	0	0	0	**0**	7.5	273.76°	56.1
9/22/2005	0	0	0	0	0	0	**0**	10.3	245.691°	57.6
9/23/2005	0	0	0	0	0	1	**1**	8.9	26.89°	43.2
9/24/2005	2	2	0	0	0	1	**5**	7.3	218.498°	45.2
9/25/2005	0	0	0	0	0	0	**0**	11.0	235.38°	54.2

(continued)

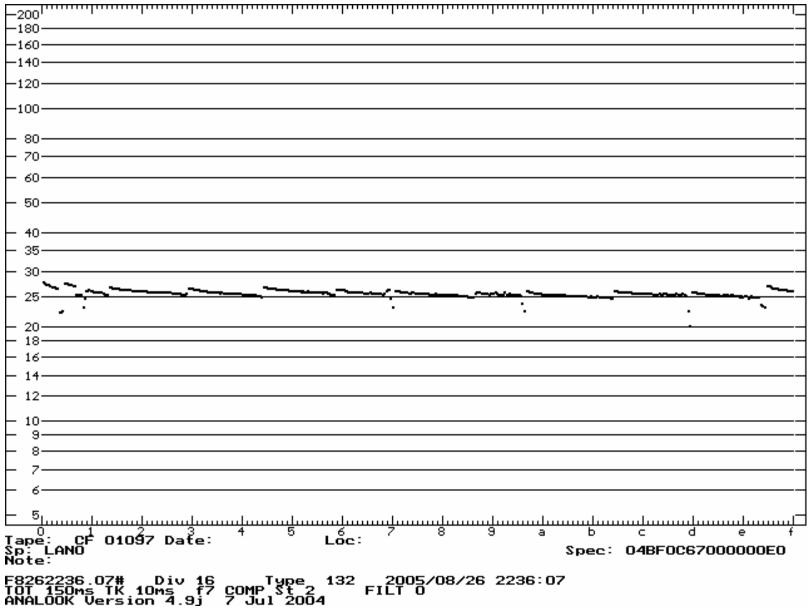
Appendix B Table 3. Summary of species recorded and weather during each night of the survey period* (continued)										
Date	**Big brown bat**	**Eastern red bat**	**Hoary bat**	**Silver-haired bat**	***Myotis* spp.**	**Unknown**	**Total**	**Wind Speed (m/s)**	**Wind Direction**	**Temperature (F)**
9/26/2005	0	0	0	0	0	0	**0**	10.0	303.562°	54.7
9/27/2005	0	0	0	0	0	0	**0**	4.0	334.915°	46.3
9/28/2005	1	0	0	0	0	0	**1**	11.9	198.076°	49.5
9/29/2005	0	1	0	0	0	0	**1**	7.4	306.807°	33.8
9/30/2005	0	1	0	0	0	0	**1**	5.8	261.549°	44.0
10/1/2005	0	0	0	0	0	0	**0**	6.7	298.421°	52.6
10/2/2005	0	0	0	0	1	0	**1**	4.0	193.618°	56.0
10/3/2005	0	0	0	0	0	0	**0**	4.2	258.169°	54.1
10/4/2005	0	0	0	0	0	0	**0**	4.3	256.591°	55.8
10/5/2005	0	0	0	0	0	0	**0**	6.2	243.091°	55.9
10/6/2005	0	0	0	0	0	0	**0**	8.9	224.435°	58.3
10/7/2005	0	0	0	0	0	0	**0**	10.5	205.76°	59.8
10/8/2005	0	0	0	0	0	0	**0**	9.7	77.497°	45.0
10/9/2005	0	0	0	0	0	0	**0**	7.4	90.308°	44.9
10/10/2005	0	0	0	0	0	0	**0**	3.1	45.019°	48.1
10/11/2005	0	0	0	0	0	0	**0**	13.4	85.309°	42.3
10/12/2005	0	0	0	0	0	0	**0**	14.3	95.616°	39.8
10/13/2005	0	0	0	0	0	0	**0**	10.3	96.23°	44.2
10/14/2005	0	0	0	0	0	0	**0**	8.1	84.542°	49.0
10/15/2005	0	0	0	0	0	0	**0**	14.3	293.15°	37.8
10/16/2005	0	0	0	0	0	0	**0**	12.8	299.765°	35.8
10/17/2005	0	0	0	0	0	0	**0**	9.2	274.688°	37.1
10/18/2005	0	0	0	0	0	0	**0**	10.2	292.316°	39.0
10/19/2005	0	0	0	0	0	0	**0**	11.0	304.411°	35.0
10/20/2005	0	0	0	0	0	0	**0**	6.1	299.495°	31.7
10/21/2005	0	0	0	0	0	0	**0**	4.0	83.057°	33.0
10/22/2005	0	0	0	0	0	0	**0**	2.3	89.231°	30.5
10/23/2005	0	0	0	0	0	0	**0**	0.4	4.087°	31.0
10/24/2005	0	0	0	0	0	0	**0**	13.1	86.462°	32.7
10/25/2005	0	0	0	0	0	0	**0**	3.7	49.615°	26.0
10/26/2005	0	0	0	0	0	0	**0**	3.9	49.231°	27.6
10/27/2005	0	0	0	0	0	0	**0**	0.4	49.308°	23.1
10/28/2005	0	0	0	0	0	0	**0**	1.7	49.231°	23.9
10/29/2005	0	0	0	0	0	0	**0**	10.7	331.229°	29.8
10/30/2005	0	0	0	0	0	0	**0**	8.5	285.137°	39.5
10/31/2005	0	0	0	0	0	0	**0**	7.7	246.716°	45.8
11/1/2005	0	0	0	0	0	0	**0**	9.1	273.341°	41.8
Total	20	5	6	6	17	25	**79**			
* Data is pooled between the two expansion areas. Weather data comes from the met tower at the western expansion area, with the exception of July 27 to Aug 8, which comes from the Keene, NH airport										



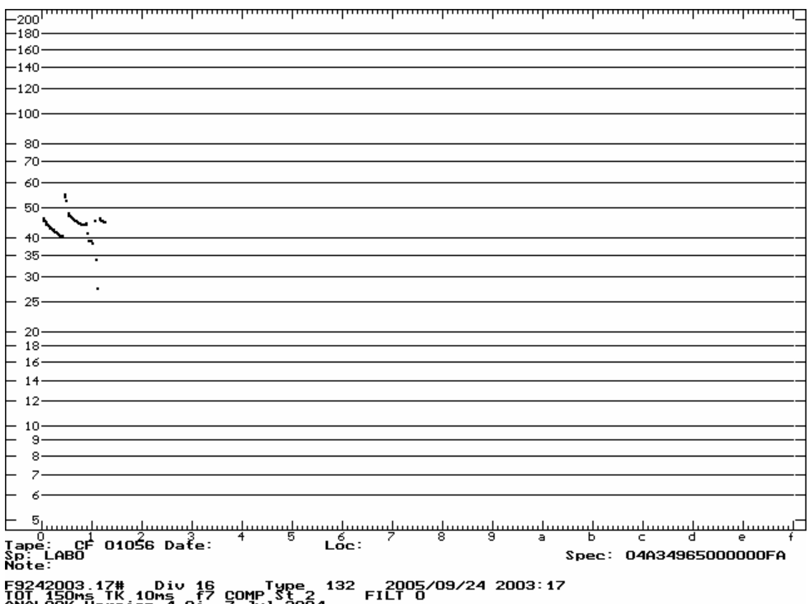
Appendix B Figure 1. Big brown bat call recorded at the Eastern Expansion Area high detector at 10:29 pm on September 5, 2005.



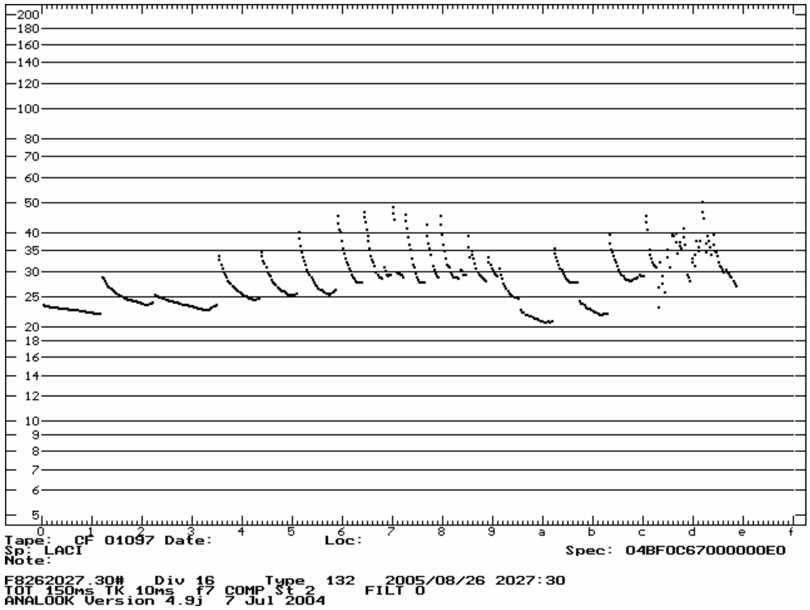
Appendix B Figure 2. Big brown bat call recorded at the Western Expansion Area low detector at 10:57 pm on July 24, 2005.



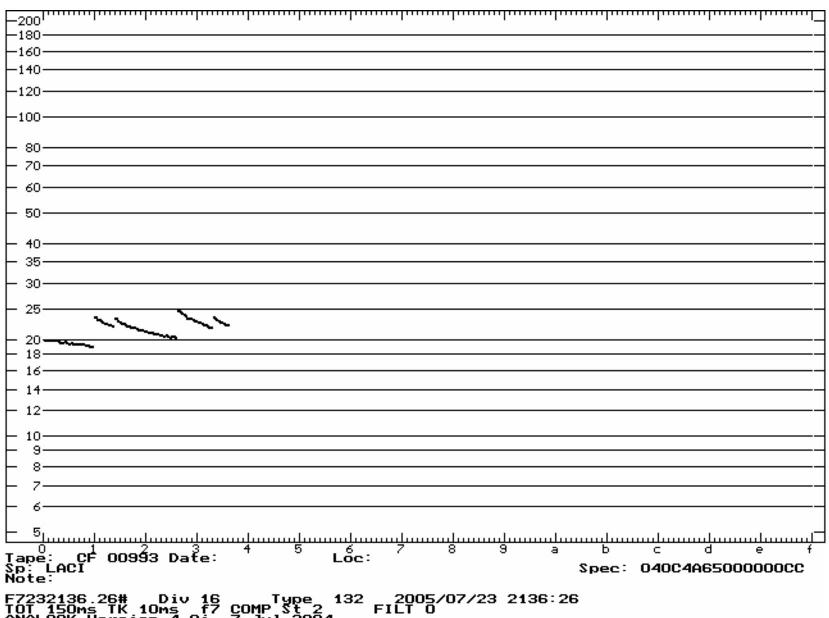
Appendix B Figure 3. Silver-haired bat call recorded at the Western Expansion Area high detector at 10:36 pm on August 26, 2005.



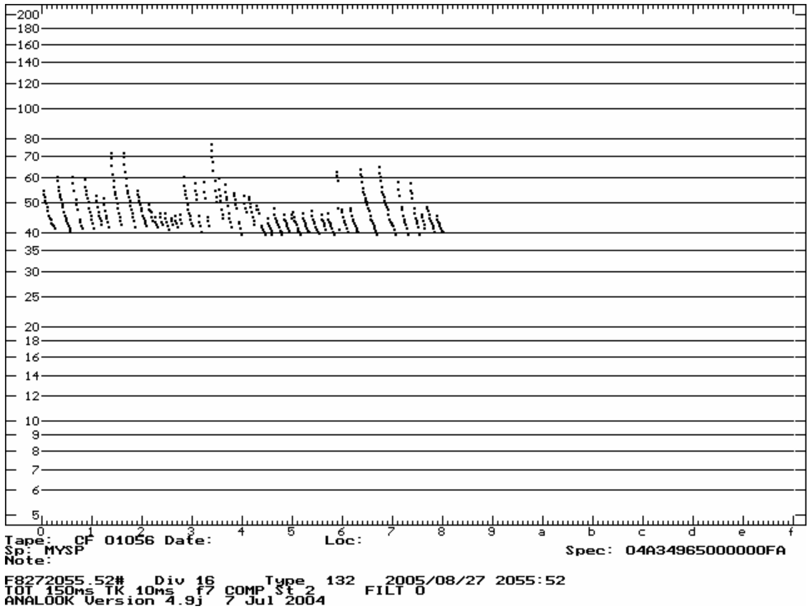
Appendix B Figure 4. Eastern red bat call recorded at the Western Expansion Area treeline detector at 12:03 am on September 24, 2005.



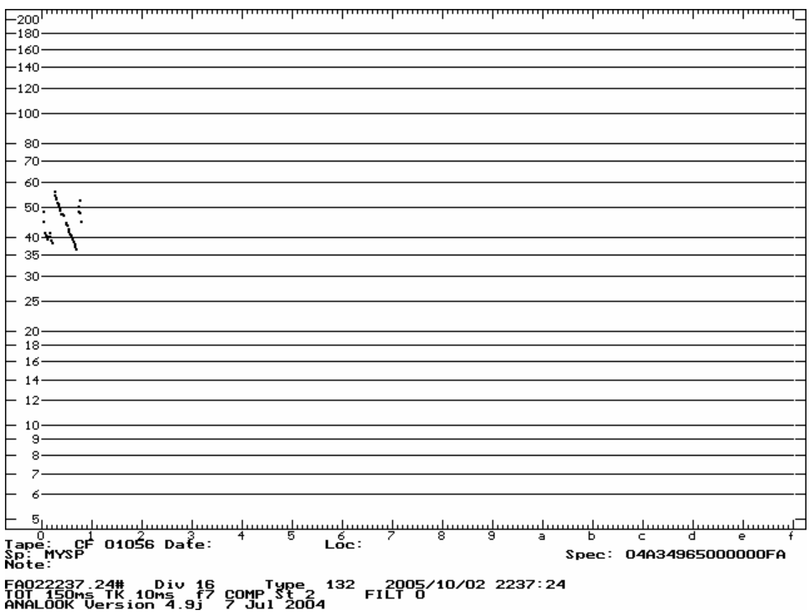
Appendix B Figure 5. Hoary bat call recorded at the Western Expansion Area high detector at 8:27 pm on August 26, 2005.



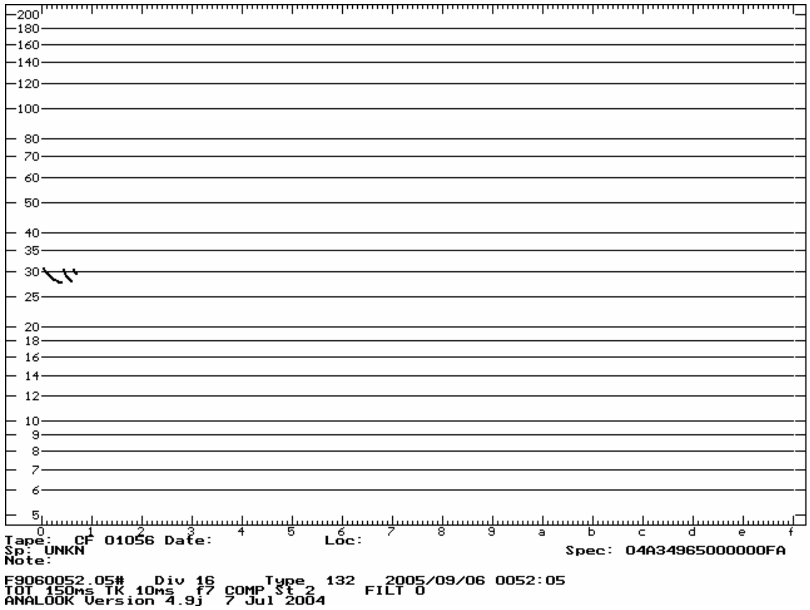
Appendix B Figure 6. Hoary bat call recorded at the Western Expansion Area low detector at 9:36 pm on July 23, 2005.



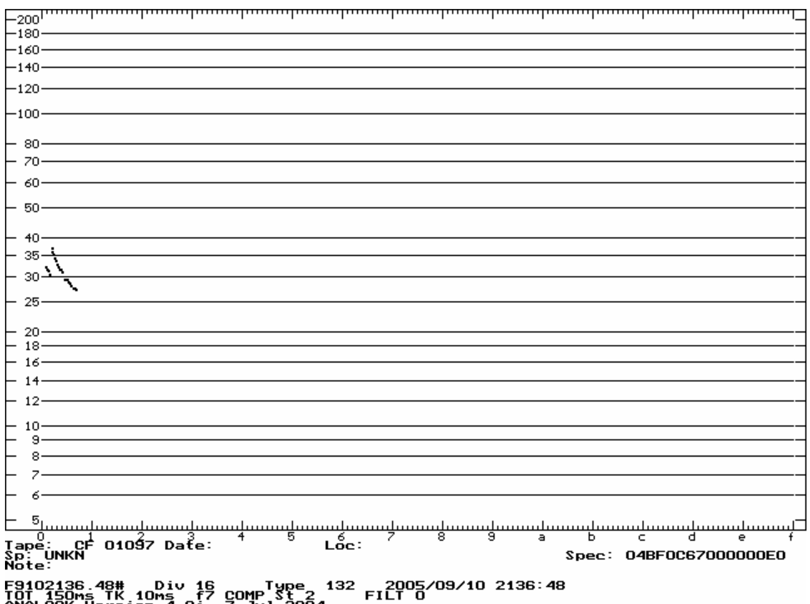
Appendix B Figure 7. *Myotid* bat call recorded at the Eastern Expansion Area high detector at 8:55 pm on August 27, 2005.



Appendix B Figure 8. *Myotid* bat call recorded at the Western Expansion Area treeline detector at 10:37 pm on October 2, 2005.



Appendix B Figure 9. Unknown bat call recorded at the Eastern Expansion Area high detector at 12:52 am on September 6, 2005.



Appendix B Figure 10. Unknown bat call recorded at the Western Expansion Area high detector at 9:36 pm on September 10, 2005.