Spring 2006 Bird and Bat Migration Surveys at the Proposed Deerfield Wind Project in Searsburg and Readsboro, Vermont

Prepared For:

PPM Energy, Inc.
1500 Market Street, 12th Floor East Tower
Philadelphia, PA 19102

Prepared By:

Woodlot Alternatives, Inc.
30 Park Drive
Topsham, ME 04086

December 2006

WOODLOT
ALTERNATIVES, INC.
ENVIRONMENTAL CONSULTANTS

Executive Summary

During spring 2006, Woodlot Alternatives, Inc. (Woodlot) conducted field surveys of bird and bat migration activity at the Deerfield Wind Project areas in Searsburg and Readsboro, Vermont. The surveys are part of the planning process by PPM Energy Inc. (PPM) for a proposed wind project, which will include the erection of 15 to 24 wind turbines along two ridge lines. Field investigations included nighttime surveys of birds and bats using radar and bat echolocation detectors. These surveys represent the latest of the four (over three years) radar migration surveys undertaken at the Deerfield Wind Project area.

The overall goals of the investigations were to:

- document nocturnal migration activity in the vicinity of the project area, including the number of migrants, their flight direction, and their flight altitude; and
- document the presence of bats in the area, including the rate of occurrence and, when possible, species present during the spring and summer migration period.

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

Radar Survey

The spring field survey targeted 30 nights of radar surveys to collect and record video samples of the radar during horizontal operation, which documents the abundance, flight path, and speed of targets moving through the project area, and vertical operation, which documents the altitude of targets. While 30 nights of sampling were targeted, a total of 26 were sampled due to inclement weather creating conditions in which the radar could not adequately document bird movements or the available data was unsuitable for analysis.

Nightly passage rates varied from 5 ± 2 targets per kilometer per hour (t/km/hr) to 934 ± 120 t/km/hr, with the overall passage rate for the entire survey period at 263 ± 45 t/km/hr. Mean flight direction through the project area was 58º ± 54º. Seven percent of all radar targets were classified as insects.

Flight direction varied between nights and was probably due to variation in the weather (particularly wind direction and speed). The mean flight height of targets was 435 meters (m) ± 36 m (1,427’ ± 118’) above the radar site. The average nightly flight height ranged from 43 m ± 20 m (141’ ± 66’) to 913 m ± 92 m (2,995’ ± 302’). The percent of targets observed flying below 125 m (410’) also varied by night, from 0 percent to 94 percent. The seasonal average percentage of targets flying below 125 m was 11 percent. Nights with the lowest mean flight heights were typically associated with passage rates well below the seasonal mean.

The results from the spring 2006 surveys at the Deerfield Wind Power Project were generally similar to those documented during the 2004 and 2005 surveys, which were conducted at different locations within the proposed development. In general, most of the reported survey metrics (i.e., passage rate, flight height, and percentage of targets below turbine height) were within the range of those results from the three previous seasons of surveys.

The mean flight direction, qualitative analysis of the surrounding topography and landscape, and mean flight altitude of targets passing over the project area indicates that avian migration in this area involves a broad front type of movement over the landscape. Although migration paths through the project area would bring migrants across ridgelines of the proposed wind farm, the high flight height of targets indicates that the vast majority of bird migration in the area occurs well above the height of the proposed wind turbines. This is consistent with the three previous seasons of data.

Analysis of NEXRAD weather data was examined to identify the proportion of the migration season during which the radar survey at the Deerfield Wind Project occurred. In general, approximately 50 percent of the nights with regional migration activity were sampled with the on-site radar. Nights with light and heavy regional migration activity sampled with the on-site radar occurred in proportion to how they occurred throughout the full migration season. However, nights with moderate regional migration activity were sampled on-site in greater proportion to how they occurred throughout the migration season, while nights with no regional migration activity were under sampled.

Bat Activity – Spring 2006

Five bat detectors were deployed in the project area: two in the Eastern Project area and three in the Western Project Area. Detectors were deployed from April 14 to June 13[1].

A total of 194 detector-nights of data were recorded during the sampling period, during which only 15 call sequences were recorded. The overall detection rate was 0.1 call sequences per detector-night, which is nearly identical to spring 2005 surveys at this and other sites in the region.

Of the recorded call sequences, four were classified as unknown due to poor file quality or too few call pulses on which to make identifications. Five call sequences were identified as within the big brown bat guild—which includes the big brown bat (*Eptesicus fuscus*), silver-haired bat (*Lasionycteris noctivagans*), and hoary bat (*Lasiurus cinereus*)—and five were identified as myotids. One call was identified as either an eastern red bat (*L. borealis*) or eastern pipistrelle (*Pipistrellus subflavus*).

---

[1] Detectors were left in place in the project area until October 27, 2006. For the purposes of this spring study, however, only data recorded until June 13th is included this report.

Table of Contents

List of Appendices

Appendix A	Radar Survey Data Tables
Appendix B	Bat Survey Data Tables and Figures

List of Tables

List of Figures

1.0 Introduction

1.1 Project Context

PPM Energy, Inc. has proposed the construction of a wind project, located in the towns of Searsburg and Readsboro in Bennington County, Vermont (Figure 1-1). The development, the Deerfield Wind Project, would occur on approximately 80 acres of land in the Manchester District of the Green Mountain National Forest adjacent to the Green Mountain Power Corporation's (GMP) existing Searsburg Wind Facility. The proposed project would occur in two areas. The Eastern Project Area is located east of Vermont State Route 8, south of the existing 11 turbine, 6-megawatt (MW) facility. The Western Project Area is located on the west side of Route 8. The proposed project layout includes approximately 15 to 24 wind turbines, access roads to and along the ridgelines, and a power collection system.

Radar surveys of nighttime bird and bat migration and acoustic surveys of bats were conducted during the 2006 spring migration period. The radar survey represents the latest of four consecutive migration season studies (including two spring and two fall surveys) at the site. The bat detector survey represents the third consecutive seasonal survey (two spring surveys and one summer survey) for bats at the site. Bat detector surveys continued through the summer and fall migration period of 2006.

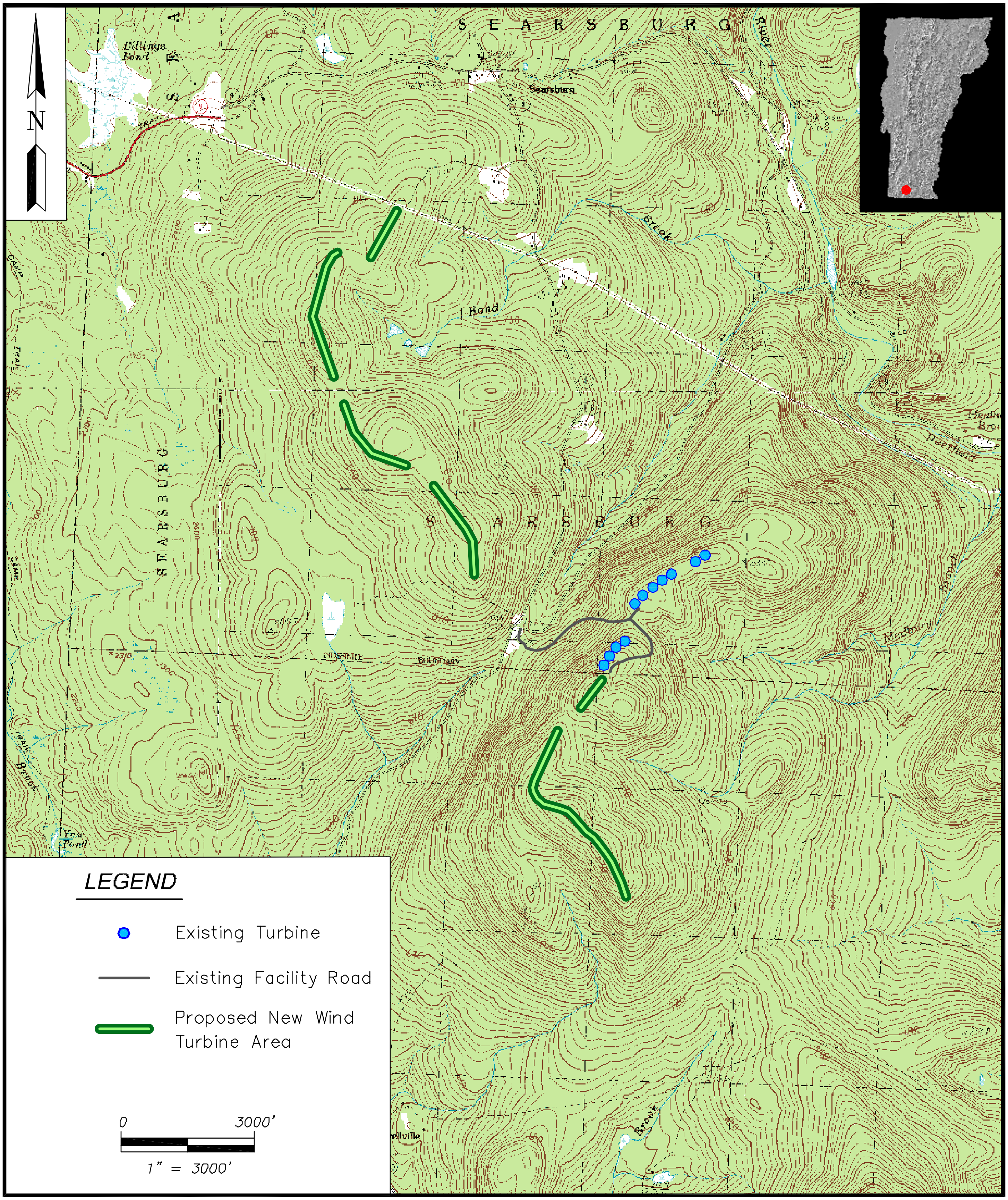
The surveys for this project were conducted to provide data that will be used to help assess the potential risk to birds and bats from this proposed project. In total, three years of pre-construction survey information will be available for this assessment.

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 parallel arrangement of the highlands of northern Vermont. The mountaintops are characterized by thin soils and abundant, exposed, acidic bedrock, while 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 lower elevation valleys, with average July temperatures in the mid-60 ºFs (15.5 ºC). The growing season is short, approximately 90 days, and the average winter temperature is around 17ºF (-8.3 ºC). Clouds and fog are common and the area receives relatively frequent 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 ecoregion. Higher elevations exhibit typical mountain forest zonation, with northern hardwood forests ascending into yellow birch (*Betula alleghaniensis*) and red spruce (*Picea rubens*) forests, grading then into higher elevation forests dominated by spruce and balsam fir (*Abies balsamea*). Valleys are predominantly forested with northern hardwoods and varying components of white pine (*Pinus strobus*) and hemlock (*Tsuga canadensis*). Low, south-facing slopes typically support a red oak (*Quercus rubra*) community.



PREPARED BY:

WOODLOT
ALTERNATIVES, INC.
ENVIRONMENTAL CONSULTANTS

106065-F101-Location.dwg

SHEET TITLE:

Study Area Location Map

PROJECT:

Deerfield Wind Project
Searsburg, Vermont

DATE: June 2006
SCALE: 1"=3000'
PROJ. NO.: 106065
FIGURE:

1-1

The Deerfield Wind Project area is located on two mountaintops and ridges, with elevations ranging from 850 m (2,790’) to 950 m (3,120’). The Eastern Project Area is on a higher ridgeline that is more steeply sided than the Western Project Area. Northern hardwood forests are dominant on the lower slopes of both mountains and along much of the ridgeline at the Western Project Area. Montane yellow birch-red spruce forests 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 spring of 2006. The overall goals of the investigations were to:

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

Radar surveys were conducted from the vicinity of a meteorological measurement tower (met tower), 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. NEXRAD weather radar images from the Albany, New York, radar station (the nearest station) were accessed for the full migration period (approximately May 16 to June 1, 2006). These radar images were used to determine the general proportion of the spring 2006 migration activity that was sampled with the on-site radar.

Bat surveys included the use of Anabat II (Titley Electronics Pty Ltd) bat detectors to record the location and timing of bat activity. The surveys consisted of deploying four bat detectors in two separate met towers: one in the Eastern Project area and one in the Western Project area. A fifth detector was deployed over a regenerating hardwood stand in the Western Project area.

While the survey used the same general techniques as the previous three seasons of avian and bat migration surveys at the site, the application, location, duration, and timing of the surveys was developed in coordination with State and Federal resource agencies. Included in the study design were the U.S. Forest Service (USFS), U.S. Fish and Wildlife Service (USFWS), and Vermont Agency of Natural Resource (VANR).

2.0 Nocturnal Radar Survey

2.1 Introduction

The vast majority of North American landbirds 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). Because wind turbines are tall structures and have moving parts, avian collisions with wind turbines have been identified as a potential concern at proposed wind projects.

Factors that could affect potential collision risk of night-migrating birds by wind turbines 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 Deerfield Wind Project area to characterize fall nocturnal migration patterns in the area. The goal of the surveys was to document the passage rates of nocturnal migrants in the vicinity of the project area, their flight direction, and their flight altitude.

2.2 Methods

Field Surveys

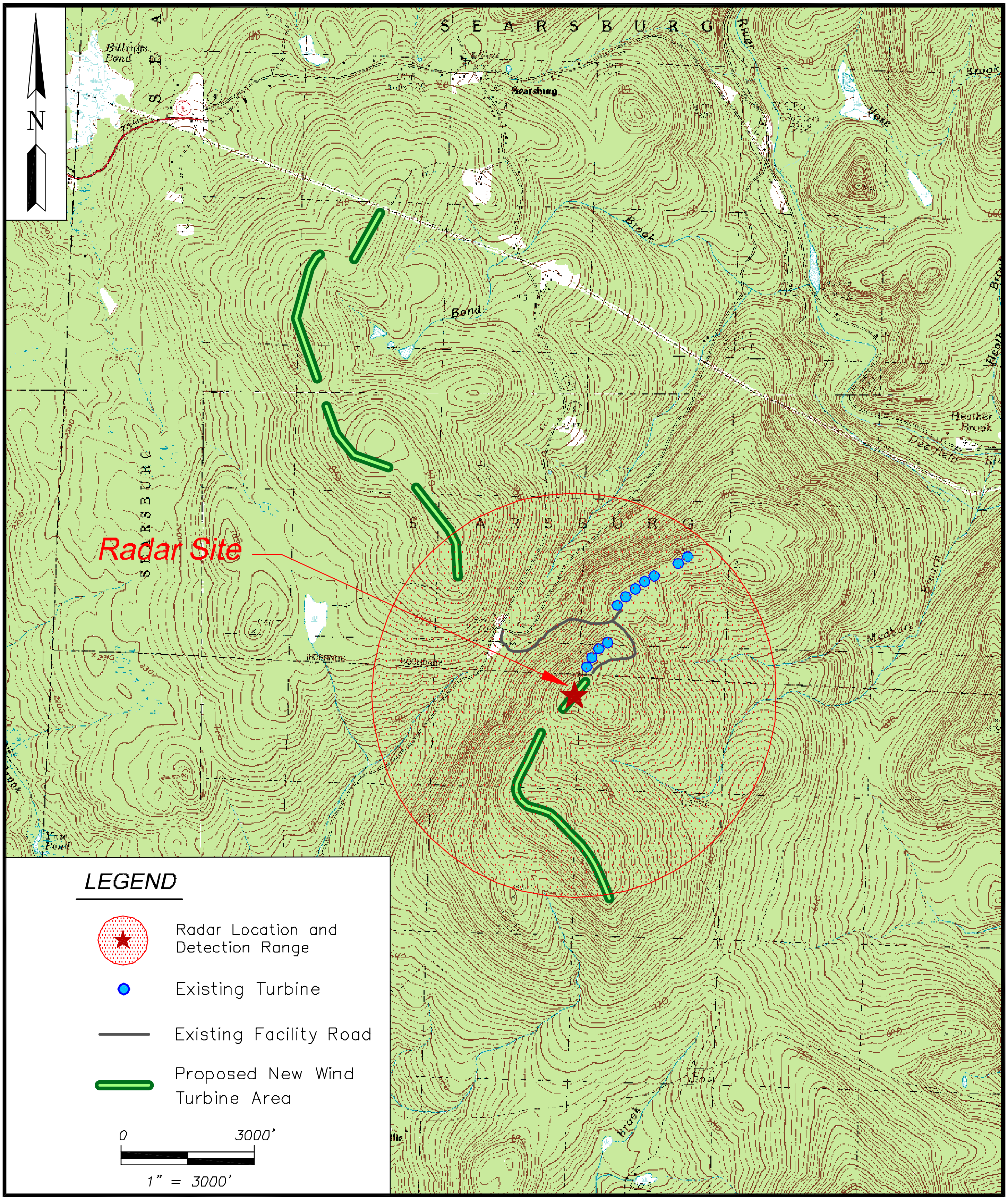
Radar surveys were conducted from a met tower clearing located just south of the existing Searsburg facility and at an elevation of approximately 884 m (2,900’) (Figure 2-1). A marine surveillance radar similar to that described by Cooper *et al.* (1991) was used during field data collection. The radar has a peak power output of 12 kW and has the ability to track small animals, including birds, bats, and even insects, based on the radar settings. 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 targets. 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 the antenna was inclined approximately 5º to increase the proportion of the beam directed into the sky.

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 near the radar can be used to reduce or eliminate ground clutter by ‘hiding’ clutter-causing objects from the radar although care is needed to ensure that the nearby vegetation does not block the radar’s view of the sky. Therefore, the radar antenna was placed on an approximately 8 m (26’) tower to raise it to the level of the surrounding tree canopy and maximize the radar’s view of the surrounding airspace while still suppressing ground clutter to the best extent possible (Figure 2-2).

Radar surveys were conducted from sunset to sunrise and were originally targeted for 20 nights in the month of May. At the request of the USFS and USFWS, the study was expanded to target thirty nights between April 15 and June 10, 2006. 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 targeted largely for nights without rain. However, to characterize migration patterns on nights without optimal migration conditions, some nights with weather forecasts including occasional showers were sampled.

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 and speed of targets can be determined. In the second mode



PREPARED BY:

WOODLOT ALTERNATIVES, INC.
ENVIRONMENTAL CONSULTANTS

106065–F201–radar.dwg

SHEET TITLE:

Radar Location Map

PROJECT:

Deerfield Wind Project
Searsburg, Vermont

DATE: July 2006
SCALE: 1"=3000'
PROJ. NO.: 106065
FIGURE:
2-1

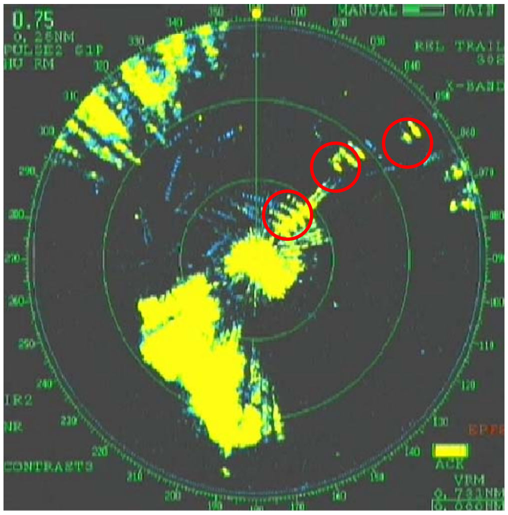


Figure 2-2. Ground clutter in project area – red circles indicate existing wind turbine blades

of operation, vertical, the antenna is rotated 90° 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 radar beam. Both modes of operation were used during each hour of sampling.

The radar was operated at a range of 1.4 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 and document the movement pattern of individual targets. The geographical limits of the range setting used are depicted in Figure 2-1.

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. This included 15 one-minute horizontal samples and 10 one-minute vertical samples.

During each hour, additional information was also recorded, including weather observations and ceilometer observations. Weather data recorded included wind speed and direction, cloud cover, temperature, and precipitation. Ceilometer observations involved directing a one million candlepower spotlight vertically into the sky in a manner similar to that described by Gauthreaux (1969). The ceilometer beam was observed by eye for 5 minutes to document and characterize low-flying (below 125 m [410']) targets. The ceilometer was held in-hand so that any birds, bats, or insects passing through it could be tracked for several seconds, if needed. Observations from each ceilometer period were recorded, including the number of birds, bats, and insects observed. This information was used during data analysis to help characterize activity of insects, birds, and bats.

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/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. Targets identified as insects, based on slow flight speeds, were also documented. 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 [km] 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 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 met tower at the radar.

Flight altitude data were summarized using linear statistics. Mean flight altitudes (± 1 standard error) were calculated by hour, night, and overall season. The percent of targets flying below 125 m (410’) (the approximate maximum height of proposed wind turbines) was also calculated hourly, for each night, and for the entire survey period.

NEXRAD Radar Data Analysis

NEXRAD weather radar images from the National Weather Service station in Albany, New York, were compiled for the full migration period (April 15 to June 10). NEXRAD radar provides a different type of data than the marine surveillance radar used at the project area. This long range Doppler radar produces reflectivity data on objects (and precipitation) in the sky, as well as velocity of those objects. It does not track individual birds but can be used to interpret large-scale bird migration patterns (Gauthreaux and Belser 1998).

Nightly samples of reflectivity and velocity images were obtained from the National Oceanic and Atmospheric Administration and visually assessed to determine the overall intensity of nightly migration. Each night was qualitatively categorized as: 1) no migration (nearly no activity or rainy nights); 2) light migration; 3) moderate migration; or 4) heavy migration. These determinations were based on the color-coded strength of the radar reflectance data (which indicate the magnitude [decibels] of the radar energy [Z] reflected back to the radar from airborne targets), velocity and direction, and winds aloft data (Figure 2-3). The images selected for this assessment were generally timed to be from 2 to 4 hours after sunset.

For data interpretation purposes, bird migration is easily discernable from most precipitation, unless the weather system is a large, slow moving front that remains over the weather observation station in excess of six to eight hours. However, bird activity can be detected on nights when scattered rain showers are also visible on the NEXRAD image.

Once the NEXRAD images were analyzed, the nights of on-site surveys at the Deerfield Wind Project area were compared with those same nights of NEXRAD data. Additionally, the remainder of the nightly NEXRAD data was summarized to identify the general proportion of nights in the spring 2006 migration season that were sampled with the on-site radar.

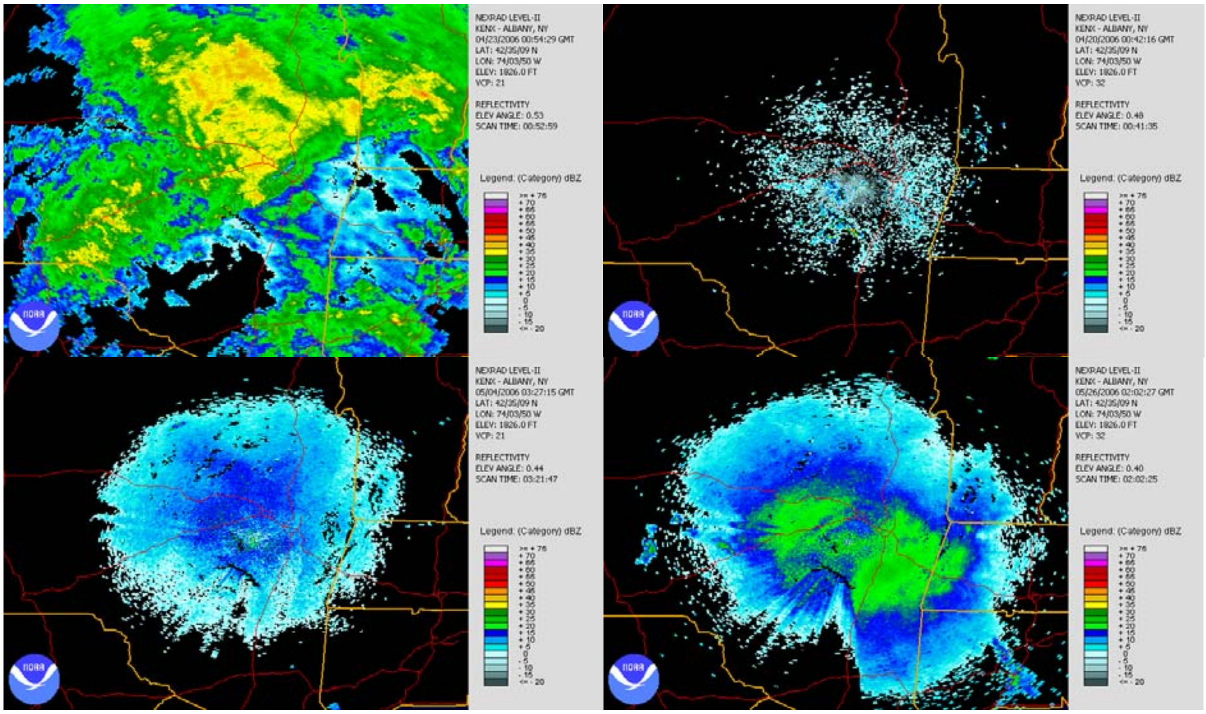


Figure 2-3. Examples of migration categories used to classify available NEXRAD data: upper left – rain; upper right – light migration; lower left – moderate migration; and lower right – heavy migration activity.

2.3 Results

Radar surveys were targeted for 30 nights of the migration period, in groups of 5 to10 nights. As mentioned above, the radar cannot readily detect night migrants in periods of consistent rain. Consequently, 4 of the targeted nights were too inclement to adequately characterize migration and a total 26 nights of data were recorded. The radar site provided excellent visibility of the surrounding airspace and targets were observed in most areas of the radar display unit. Interestingly, the placement of the radar antenna at the upper edge of the surrounding tree canopy afforded a view of the blades of several of the existing Searsburg facility turbines (Figure 2-4).

Figure 2-4. View from radar antenna towards existing turbines – trees in foreground blocked ground clutter from the land around each turbine but provided a clear view of the air around and above the turbine blades.

Passage Rates

Nightly passage rates varied from 5 ± 2 targets per km per hour (t/km/hr) (May 14) to 934 ± 120 t/km/hr (May 17), and the overall passage rate for the entire survey period was 263 ± 45 t/km/hr (Figure 2-5; Appendix A Table 1). The largest passage rates were documented on April 20, 29, 30 and May 15, 16, 17, 19, and 25. Generally, there were higher passage rates observed on nights with calm winds and clear skies. Passage rates were also high with strong winds blowing from the south. Passage rates tended to be lower in inclement weather such as heavy fog or strong wind. Seven percent of all radar targets were classified as insects while 93 percent were either birds or bats.

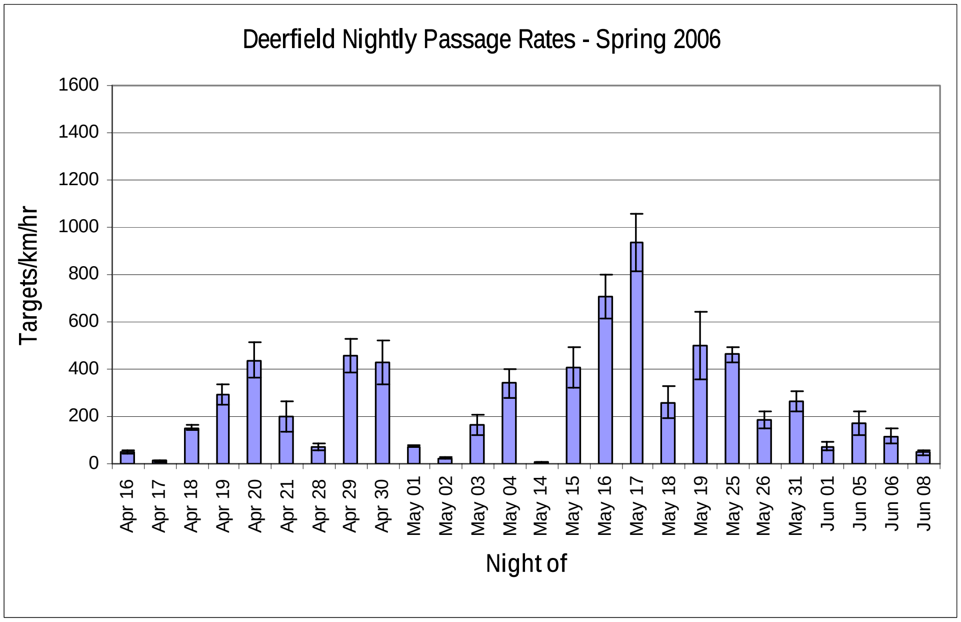


Figure 2-5. Nightly passage rates (error bars = ± 1 Standard Error [SE]) observed

Individual hourly passage rates throughout the entire season varied from 0 to 1,680 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 second through the fifth hour after sunset, though passage rate peaked at four hours after sunset. This was followed by a generally steady decline for the remainder of the night (Figure 2-6).

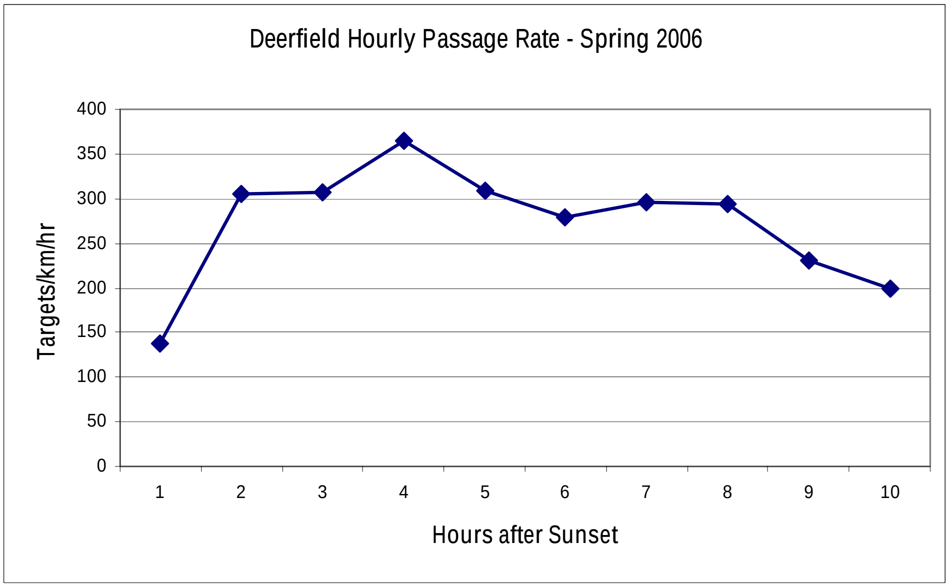


Figure 2-6. Hourly passage rates for entire season

Flight Direction

Mean flight direction through the project area was 58º ± 54º (Figure 2-7; Appendix A Table 2). There was night to night variation in mean flight direction, with several nights when the mean flight direction was westerly or southerly. However, the average on most nights was northeasterly.

In general, nights with flight directions to the south and west were with low passage rates and less then optimal migration weather. For example, on nights when the wind speeds were greatest, flight direction was downwind even when that direction was contrary to typical spring migration flight directions. Alternatively, on nights with light winds in any direction or strong winds were from the south, flight direction was typically northeastward.

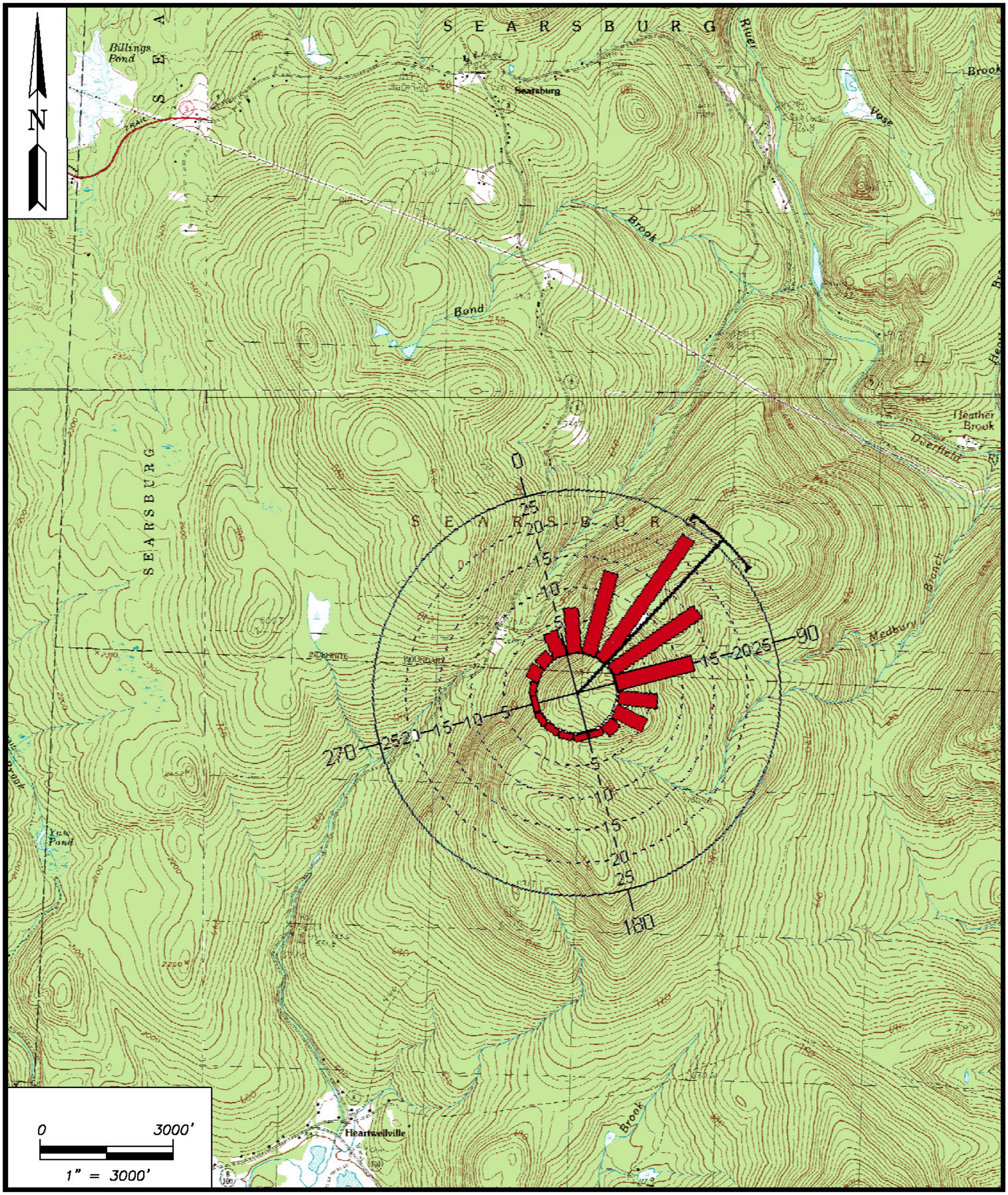
Flight Altitude

The mean flight height of targets was 435 m ± 36 m (1,427’ ± 118’) above the radar site. The average nightly flight height ranged from 43 m ± 20 m (141’ ± 66’) on April 17 to 913 m ± 92 m (2,995’ ± 302’) (Figure 2-8; Appendix A Table 3). The percent of targets observed flying below 125 m (410’) also varied by night, from 0 percent to 94 percent (Figure 2-9). The seasonal average percentage of targets flying below this height was 11 percent.

Hourly flight height peaked 6 hours after sunset and gradually decreased over the night (Figure 2-10), but was fairly consistent between the forth and eighth hours after sunset. Within 100 m (328’) height zones, the greatest percentage of targets (13%) was documented from 100 m to 200 m (328’ to 656’), 45 percent were observed from 200 m to 700 m (656’ to 2,297’), and 65 percent were observed from 100 m to 800 m (328’ to 2,625’) above the radar site (Figure 2-11).

Ceilometer Observations

Ceilometer data collected during the radar survey yielded a total of 171 five-minute observations. Those observations, however, resulted in few sightings. Only 1 bat was observed flying through the ceilometer beam out of all observations and no birds were observed at all.



PREPARED BY:

WOODLOT ALTERNATIVES, INC.
ENVIRONMENTAL CONSULTANTS
106065–F206–target.dwg

SHEET TITLE:
Spring 2006 Target Flight direction

PROJECT:
Deerfield Wind Project
Searsburg, Vermont

DATE: July 2006
SCALE: 1"=3000'
PROJ. NO.: 106065
FIGURE:
2-7

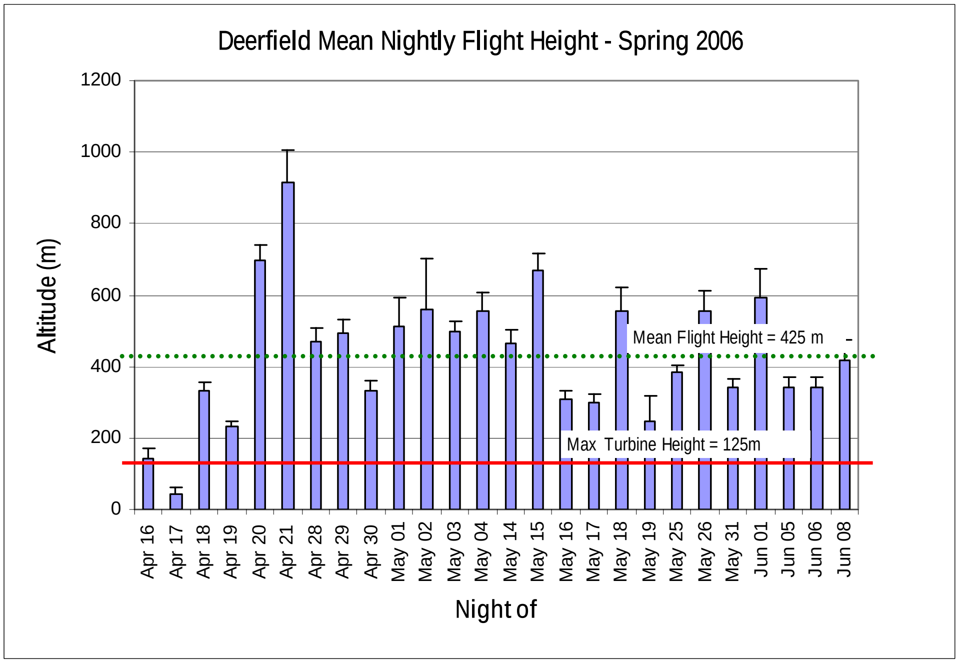


Figure 2-8. Mean nightly flight height of targets

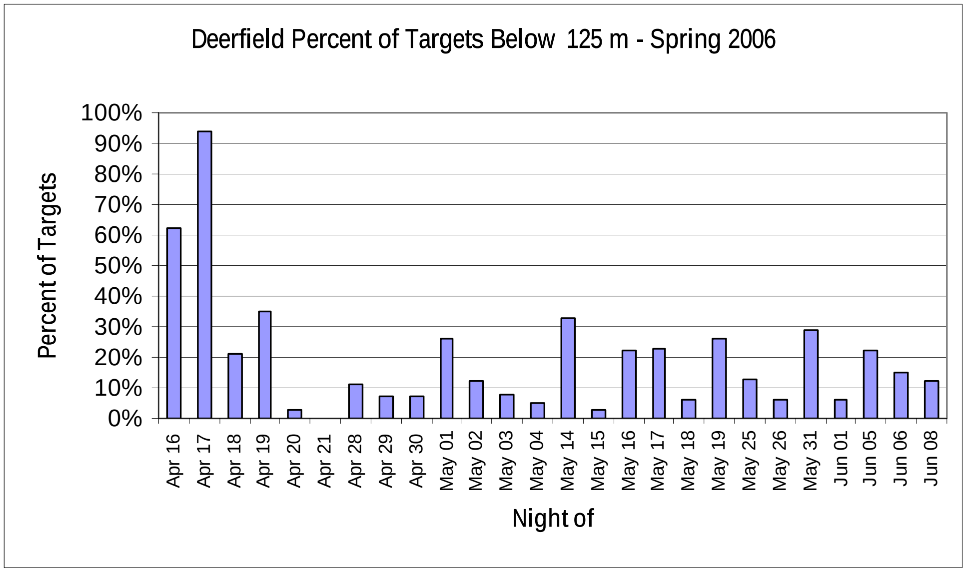


Figure 2-9. Percent of targets observed flying below a height of 125 m (410’)

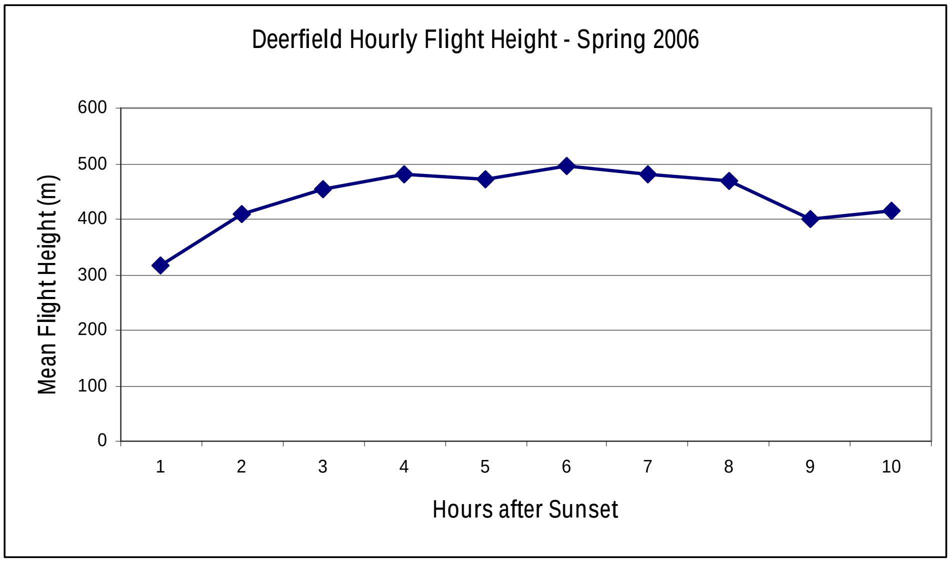


Figure 2-10. Hourly target flight height distribution

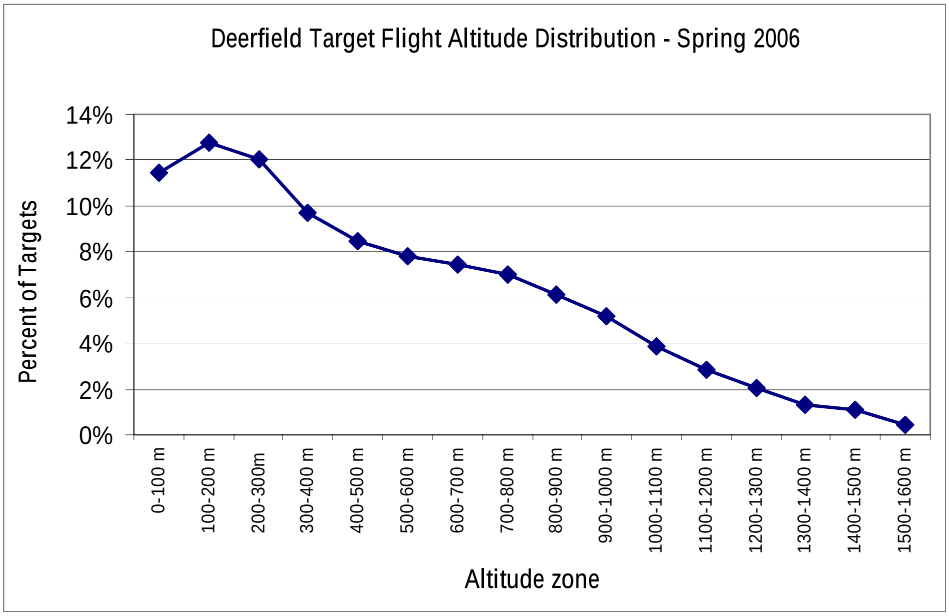


Figure 2-11. Target flight height distribution within 100 m altitude zones

NEXRAD Weather Radar Analysis

A total of 53 nights of NEXRAD weather data were available from April 16 to June 8, 2006. Table 2-1 provides a summary of the number of nights (and percent of the 53 nights) classified to the different migration categories using the NEXRAD images. The table also identifies the proportion of the on-site radar data set that was collected on each night classified with the NEXRAD data. In general, the on-site radar was operated on nights of light and heavy migration generally in proportion to the occurrence of these two categories within the migration season (i.e. nights with light migration according to NEXRAD represented 28% of all nights in the season and 27% of nights with on-site radar data). Nights of no migration activity, however, were under-sampled (21% of the entire migration season but only 8% of the on-site radar data) while nights of moderate migration activity were sampled at nearly twice their rate of occurrence (21% of the entire season but 38% of on-site data set).

Table 2-1. Summary of NEXRAD and on-site radar data collection

Migration Category	**NEXRAD**		**On-site Radar**	
	No. nights*	**% of nights**	**No. nights sampled**	**% of nights sampled****
No Migration	11	21%	2	8%
Little Migration	15	28%	7	27%
Moderate Migration	11	21%	10	38%
Heavy Migration	16	30%	7	27%
Total	53		26	

* Indicates the number of nights within each migration category

** Indicates the percent of the radar survey data within each migration category

2.4 Discussion

Spring 2006 radar surveys documented migration activity and patterns in the vicinity of the proposed Deerfield Wind Project. In general, migration activity and flight patterns varied between and within nights. Nightly variation in the magnitude and flight characteristics of nocturnally migrating songbirds 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, and Gauthreaux 1991).

Recent radar surveys using similar methods and equipment conducted within the past several years are provided in Table 2-2. While there are some limitations in comparing data between sites and years, passage rates documented at the Deerfield Wind Project during the spring 2006 migration were within the range of those other available studies. This is true not only for the mean passage rate for the entire season but also for the range in nightly passage rates.

Flight Direction

The mean flight direction at the project during the spring 2006 radar survey was 58º. This northeasterly flight direction is typical of nocturnal migration across the Northeast, as most recent radar surveys have documented seasonal flight directions between approximately 20º and 70º (Table 2-2).

Flight Altitude

The emerging body of studies characterizing nighttime bird movements shows a relatively consistent trend in regards to the altitude at which night migrants fly. In general, nighttime migration typically occurs several hundred meters or more above the ground and the range in mean documented flight heights is approximately 320 m (1,050’) to 600 m (2,000’) above the ground (Table 2-2). The percentage of targets documented at heights below that of typical modern wind turbines is variable, but is typically 10-20 percent. The results from the spring 2006 surveys at the Deerfield Wind Project are consistent within this range.

The percentage of targets flying below maximum turbine height was 11 percent, though it varied from 0 percent on April 21 (the night with the greatest mean flight height) to 94 percent on April 17. Four nights had percentages of targets below turbine height greater than 30 percent. The first two nights of the survey period, in particular, included high percentages of targets below turbine height (62% and 94%). These two nights, however, included the first and fifth lowest passage rates due to inclement weather that included periods of rain and snow.

Deerfield Wind Project Radar Data: 2004 – 2006

As mentioned previously, the spring 2006 radar surveys represent the fourth consecutive migration season of investigations at the proposed project. Table 2-3 provides a summary of the two years of fall and two years of spring migration survey results.

Table 2-2. Summary of available radar survey results

Project Site	Landscape	Season	Average Passage Rate (t/km/hr)	Range in Nightly Passage Rates	Average Flight Direction	Average Flight Height (m)	% Targets <Turbine Height	Reference
2003								
Chautauqua, NY	Great Lakes shore	Spring	395	15-1702	29	528	(125 m) 4%	Cooper *et al.* 2004
2005								
Top Notch, NY	Agric. plateau/ADK foothills	Spring	509	80-1175	44	419	(125 m) 20%	Woodlot 2005a
Jordanville, NY	Agric. plateau	Spring	409	26-1410	40	371	(125 m) 21%	Woodlot 2005b
Marble River, NY	Grt Lks plain/ADK foothills	Spring	254	3-728	40	422	(120 m) 11%	Woodlot 2005c
Clinton Co., NY	Grt Lks plain/ADK foothills	Spring	110	n/a	30	338	(n/a) 20%	Young 2006
Dairy Hills, NY	Great Lakes shore	Spring	117	n/a	14	397	(n/a) 15%	Young 2006
Cohocton, NY	Agric. plateau	Spring	371	133-773	28	609	(125 m) 12%	Woodlot 2006a
Prattsburgh, NY	Agric. plateau	Spring	277	70-621	22	370	(125 m) 16%	Woodlot 2005d
Prattsburgh, NY	Agric. plateau	Spring	170	3-844	18	319	(125 m) 18%	Mabee *et al.* 2005
Deerfield, VT	Forested ridge	Spring	404	74-973	69	523	(125 m) 6%†	Woodlot 2005e
Sheffield, VT	Forested ridge	Spring	208	11-439	40	522	(125 m) 6%	Woodlot 2006b
Liberty Gap, WV	Forested ridge	Spring	457	34-240	53	492	(125 m) 11%	Woodlot 2005f
2006								
Deerfield, VT	Forested ridge	Spring	271	13-934	58	433	(125 m) 11%	this report

†Percentage of targets below turbine height is for below 125 m. The previous report for this study included an analysis for 100 m.

Table 2-3. Summary of Deerfield radar survey results: 2004 – 2006

Location	**Season**	**Average Passage Rate**	**Range in Nightly Passage Rates**	**Average Flight Direction**	**Average Flight Height (m)**	**% Targets < Turbine Height†**
Existing Facility	*Fall 2004*	*175*	*7 - 519*	*194*	*438*	*1%*
Western Project Area	*Fall 2004*	*193*	*8 - 1121*	*223*	*624*	*7%*
Valley Location	*Fall 2004*	*150*	*58 - 404*	*214*	*503*	*1%*
All 3 sites combined	Fall 2004*	178	7 - 1121	212	611	4%
Existing Facility	Spring 2005**	404	74 - 973	69	523	6%
Western Project Area	Fall 2005***	559	3 - 1736	221	395	17%
Eastern Project Area	Spring 2006	263	5 - 934	58	435	11%

* Woodlot 2005g, ** Woodlot 2005e, ***Woodlot2005h

†Percentage of targets below turbine height for surveys in 2004 and 2006 is for below 125 m. Previous reports for those studies include an analysis for 100 m.

2.5 Conclusions

Radar surveys during the spring 2006 migration period have provided a fourth consecutive season of nighttime migration characteristics in the vicinity of the Deerfield Wind Project area. The results of the surveys indicate that bird migration patterns are generally similar to patterns observed at other sites in the region and to the previous three seasons of data collection at the site.

Migration activity varied throughout the season and is largely attributable to weather patterns. The mean passage rate (263 ± 45 t/km/hr) is comparable to those observed at similar recent studies in the Northeast. Migration activity throughout each night typically peaked four hours after sunset and gradually decreased over the hour periods toward sunset. Passage rates tended to be lower during those nights and hour periods with strong winds or inclement weather.

Flight direction for the entire season was 58º ± 54º. The topography of the project area does not appear to effect movement patterns of migrants through the site. Flight direction data indicate that nocturnal migrants are not avoiding the project area for any topographic-related reasons. The majority of targets had flight paths that would lead them across some of the ridges of the proposed wind farm. Flight heights, however, indicate that the majority of the migrants are flying at altitudes well above the turbine height.

The average flight altitude above the ground was 435 m ± 36 m (1,427’ ± 118’). Only 11 percent of the targets observed during vertical radar operation were flying below the height of modern turbines, indicating that risk of collision to night-migrating birds is limited to a small subset of those migrants. This was variable by night, but on those nights with the greatest percentages of low-flying targets the passage rate of those targets was very low (refer to Figures 2-5 and 2-9). This limits the overall number of night migrants exposed to 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). While concerns about the risk of bat collision mortality were initially focused on forested ridgelines in the eastern United States, 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 operating 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. The species most commonly found during mortality searches are the migratory tree bats: eastern red bat (*Lasiurus borealis*), hoary bat (*L. 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. 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, and that resident breeding bat populations are not currently impacted by wind plants.

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 (*M. sodalis*), 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 the silver-haired bat, eastern pipistrelle, and northern long-eared bat (northern myotis) are rare in Vermont.

To document bat activity in the vicinity of the proposed Deerfield Wind Project, Woodlot conducted acoustic monitoring surveys during spring 2006. Anabat II detectors were used for the duration of the survey. The survey was designed to document bat passages at several different heights above the ground.

3.2 Methods

Field Surveys

Anabat detectors are frequency division detectors, dividing the frequency of ultrasonic calls made by bats so that they are audible to humans. A factor of 16 was used in this study. Frequency division 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 Vermont. Data from the Anabat detectors were logged onto compact flash media using a CF ZCAIM (Titley Electronics Pty Ltd.) and downloaded to a computer for analysis.

Five detectors were deployed in the project area, two in each of two met towers in the project area and one along a treeline. These were passive surveys, as the detectors were placed at the site and left there for the duration of the study. The location of the bat detectors are provided in Figure 3-1. In the Eastern

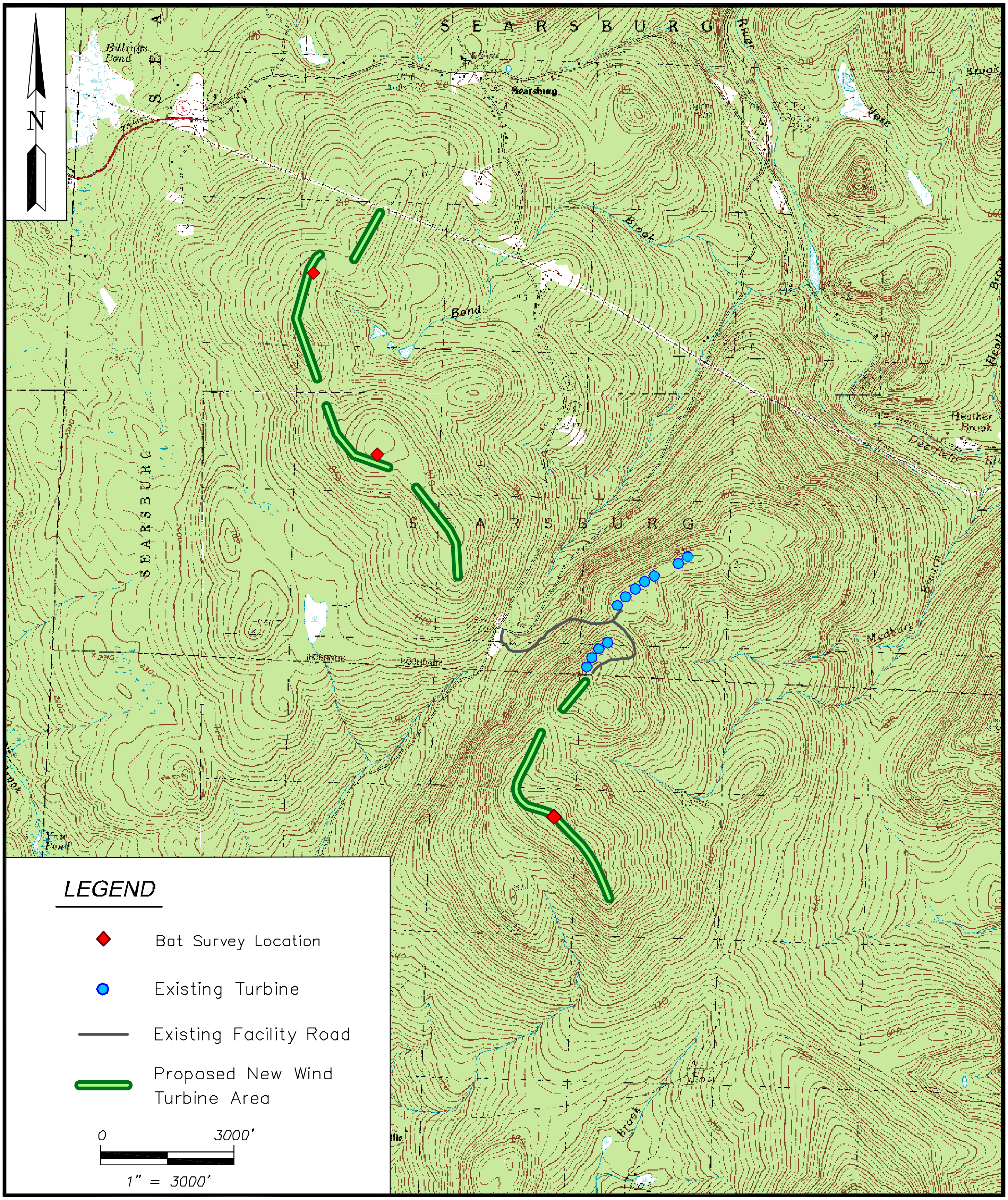
Project Area, the detectors were deployed at heights of approximately 10 m (33') and 20 m (67') at the southernmost of the two met towers. In the Western Project Area, the detectors were deployed at heights of approximately 15 m (50') and 35 m (115'). At the request of VANR, the fifth detector was deployed along a tree line in the northern third of the Western Project Area to obtain echolocation data from a broader geographic extent within the project area. The microphone was located at a height of approximately 7 m (23') and was above a low, dense canopy of regenerating saplings.

Detectors were deployed on April 14, 2006 and remained operational through the summer and fall until they were removed on October 27, 2006. The data presented in this report extends from April 14 to June 13, 2006. The detectors were programmed to record nightly from 7:00 pm to 7:00 am, and were periodically checked to download data and ensure operation.

Data Analysis

Potential call files were extracted from recorded 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 northeastern bats. This software screens all data recorded by the bat detector and extracts call files using a filter. The filter simply removes files created by noises other than bat calls based on the characteristics of the call file and the established characteristics of northeastern bat calls. Using the default settings for this initial screen also ensures comparability between data sets. Settings used by the filter include a max 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 noise files and poor quality call sequences are retained within the data set. A call is a single pulse of sound produced by a bat. A call sequences is a combination of two or more pulses recorded in a call file.

Following the initial screening, each file was visually inspected to ensure that files created by static or some other form of interference that were still within the frequency range of northeastern bats were not included in the data set. Call sequences were identified based on visual comparison of call sequences with reference libraries of known calls recorded by Woodlot during mist netting surveys in 2006 in New York and Pennsylvania. Supplemental reference calls that were also used were provided by nationally-recognized bat experts Lynn Robbins and Chris Corben, who is also the developer of the Anabat software. Bat calls typically include a series of pulses characteristic of normal flight or prey location and capture periods (feeding 'buzzes') and visually look very different than static, which typically forms a solid line at either a constant frequency or with great frequency variation. Using these characteristics, bat call files are easily distinguished from non-bat files.



PREPARED BY:

WOODLOT ALTERNATIVES, INC.
ENVIRONMENTAL CONSULTANTS

106065–F401–BatSurvey.dwg

SHEET TITLE:

Bat Survey Location Map

PROJECT:

Deerfield Wind Project
Searsburg, Vermont

DATE: June 2006
SCALE: 1"=3000'
PROJ. NO.: 106065
FIGURE:
3-1

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). A call sequence was considered of suitable quality and duration if the individual call pulses were 'clean' (i.e., consisting of sharp, distinct lines) and consisted of at least seven pulses if it was suspected of being a myotid or at least five pulses if non-myotid (all pulses less than 35-40 kHz). Call sequences were classified to species whenever possible, using the reference calls described above. However, due to similarity of call signatures between several species, all classified call sequences were then categorized into four guilds for presentation in this report. This classification scheme follows that of Gannon *et al.* (2003) and is as follows:

- Unknown (UNKN) – all call sequences with too few pulses (less than seven) or of poor quality (such as indistinct pulse characteristics or background static);
- Myotid. (MYSP) – All bats of the genus *Myotis*. While there are some general characteristics believed to be distinctive for several of the species in this genus, these characteristics do not occur consistently enough for any one species to be relied upon at all times when using Anabat recordings;
- Red bat/pipistrelle (RBEP) – Eastern red bats and eastern pipistrelles. Like so many of the other northeastern bats, these two species can produce calls distinctive only to each species. However, significant overlap in the call pulse shape, frequency range, and slope can also occur; and
- Big brown/silver-haired/hoary bat (BBSHHB) – This guild will also be referred to as the big brown bat guild. These species' call signatures commonly overlap and have therefore been included as one guild in this report.

This guilding represents a very conservative approach to bat call identification. However, since some species do 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. Tables and figures in the body of this report will reflect those guilds. However, 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 placed into the appropriate guilds, nightly tallies of detected calls were compiled. Mean detection rates (number of calls/detector-night) for the entire sampling period were calculated for each detector and for all detectors combined. It is important to note that detection rates indicate only the number of calls detected and do not necessarily reflect the number of individual bats in an area. For example, a single individual can produce one or many call files recorded by the bat detector, but the bat detector cannot differentiate between individuals of the same species producing those calls. Consequently, detections recorded by the bat detector system likely over-represent the actual number of animals that produced the recorded calls.

Ceilometer and Radar Data

Nocturnal radar surveys and hourly ceilometer surveys were also conducted concurrently with the acoustic bat monitoring on 31 nights of the sampling period. While conclusive differentiation between bats and birds is not possible using radar, work conducted by Woodlot using radar and thermal imaging cameras indicates that nocturnal targets that move erratically or in curving paths are typically bats while those with straight flight paths are birds. Additionally, while bats can create radar flight paths more similar to birds (i.e., straight flight path), no birds were observed creating the erratic radar flight paths observed to be created by some bats (Woodlot, unpublished observations).

During the analysis of the radar video data, radar targets with erratic flight paths, similar to those previously observed to be created by bats, were noted. Nightly tallies of these targets were then made[2]. Additionally, the ceilometer observations made during the radar survey were an opportunity to document birds and bats flying at low altitude over the radar site. Any bats observed during the ceilometer surveys were recorded.

Weather Data

Mean, maximum, and minimum wind speeds and temperatures between 7:00 pm and 7:00 am were calculated for each night of the survey period.

3.3 Results

Detector Survey

A total of 194 detector nights of data were collected between April 14 and June 13, 2006. Each detector worked fairly consistently, although periodic damage by wildlife and periods of severe weather caused some breaks in coverage during that time period. A total of only 15 calls were recorded during the survey period (Table 3-1). The number of call sequences recorded at each detector ranged from 0 at the eastern low detector and western high detector to 7 at the western low detector. The mean detection rate for all detectors was 0.1 calls/detector-night and the range in detection rates was from 0 to 0.3 calls/detector-night.

Table 3-1. Summary of bat detector field survey effort and results

Location	**Dates**	**# Detector-Nights***	**# Recorded sequences**	**Detection Rate ****	**Maximum # calls recorded *****
Eastern MET tower high	April 14 - June 13	60	4	0.1	1
Eastern MET tower low	April 14 - May 31	47	0	0.0	--
Western MET tower high	April 14 - May 2 and May 11 - May 20	29	0	0.0	--
Western MET tower low	April 14 - April 25 and May 8 - May 16	21	7	0.3	5
Western tree detector	April 14 - April 24 and May 17 - June 11	37	4	0.1	1
Overall Results	***April14 - June 13***	***194***	***15***	***0.1***	--

* Detector-night is a sampling unit during which a single detector is deployed overnight. On nights when two detectors are deployed, the sampling effort equals two detector-nights, etc.

** Number of bat passes recorded per detector-night.

*** Maximum number of bat passes recorded from any **single** detector for a 12-hour sampling period.

---

[2] While these targets were noted and tallied, they were included in the radar analysis data set for the calculation of passage rate, flight direction, and flight height.

Appendix B Table 1 provides more detailed information about the 15 call sequences recorded at the project during the spring migration period. Included is the actual file name, the time and date of the recorded call sequence, the detector location, and the weather during that night of recording. In general, calls were recorded infrequently during the spring migration period but uniformly throughout that period. The first calls were recorded in the middle of April, just two days after the deployment of the detectors, and the last were recorded in the beginning of June.

Table 3-2 provides a summary of the identification of the recorded calls. In general, nearly one-third of the calls are of unknown origin while the remainder was identified to guild.

Table 3-2. Summary of the composition of recorded bat call sequences

Detector	**Guild**				**Total**
	Big brown bat guild	**Red bat/ E. pipistrelle**	**Myotis**	**Unknown**	
Eastern MET tower high	--	1	2	1	4
Eastern MET tower low	--	--	--	--	0
Western MET tower high	--	--	--	--	0
Western MET tower low	5	--	1	1	7
Western tree detector	--	--	2	2	4
Total	***5***	***1***	***5***	***4***	***15***

Ceilometer and Radar Surveys

Only one bat was observed during the course of ceilometer observations conducted during the radar field data collection. During analysis of the radar survey video data, however, a total of 1,701 target trails were identified as potentially being created by bats. These observations were generally distributed throughout the sampling period. There appeared to be no obvious correlation between the total number of recorded bat call sequences and ceilometer, radar target, or radar passage rates.

Table 3-3. Summary of ceilometer and radar observations

Night of	Number of observed or suspected bats	
	Ceilometer	Radar
4/16/2006	0	17
4/17/2006	0	3
4/18/2006	0	43
4/19/2006	0	96
4/20/2006	0	28
4/21/2006	0	1
4/28/2006	0	54
4/29/2006	1	148
4/30/2006	0	60
5/1/2006	0	171
5/2/2006	0	0
5/3/2006	0	262
5/4/2006	0	79
5/14/2006	0	5
5/15/2006	0	4
5/16/2006	0	0
5/17/2006	0	70
5/18/2006	0	177
5/19/2006	0	12
5/25/2006	0	0
5/26/2006	0	338
5/31/2006	0	44
6/1/2006	--	58
6/5/2006	--	4
6/6/2006	--	3
6/8/2006	--	24
Total	**1**	**1701**

3.4 Discussion

Bat echolocation surveys in 2006 at the proposed Deerfield Wind Project provide some insight into activity patterns, possible species composition, and timing of movements of bats in the project area. The results are generally similar to previous seasons of data, particularly that of the spring 2005 surveys (Woodlot 2005e). These results are also similar to other studies conducted recently in the northeast (Table 3-4).

Table 3-4. Summary of other available bat detector survey results

Project	Location	Season	Calls per detector night	Reference
Sheffield	Sheffield, VT	Spring 2005	0.2	Woodlot 2006c
Deerfield	Searsburg, VT	Spring 2005	0.1	Woodlot 2005e
Marble River	Churubusco, NY	Spring 2005	0.3	Woodlot 2005c
Jordanville	Warren, NY	Spring 2005	0.5	Woodlot 2005b
Cohocton	Cohocton, NY	Spring 2005	0.7	Woodlot 2006b
Prattsburgh	Prattsburgh, NY	Spring 2005	0.3	Woodlot 2005d
Liberty Gap	Franklin, WV	Spring 2005	0.5	Woodlot 2005f
Deerfield	Searsburg, VT	Spring 2006	0.1	this report

Results of acoustic surveys must be interpreted with caution. Room for error exists in identification of bats based upon acoustic calls alone, especially if a site-specific or regionally specific library of recorded reference calls is not available. Also, detection rates are not necessarily correlated with the actual numbers of bats in an area, because it is not possible to differentiate between individual bats.

3.5 Conclusions

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 overall passage rate of all of the detection data is similar to past work at the site as well as some other sites in the northeast surveyed in spring 2005.

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., W.P. Erickson, J. Kerns, and J. Horn. 2005. Relationships between bats and wind turbines in Pennsylvania and West Virginia: an assessment of fatality search protocols, patterns of fatality, and behavioral interactions with wind turbines. Bats and Wind Energy Cooperative.

Avery, M.L., P.F. Spring, and J.F. Cassel. 1976. The effects of a tall tower on nocturnal bird migration – A portable ceilometer study. Auk. 93(2): 281-291.

_____. 1977. Weather influences on nocturnal bird mortality at a North Dakota tower. Wilson Bulletin. 89(2):291-299.

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 characteristics of birds: I. Radar measurements of speeds. Ibis. 143:178-204.

Cooper, B.A., A.A. Stickney, and T.J. Mabee. 2004. A radar study of nocturnal bird migration at the proposed Chautauqua wind energy facility, New York, Fall 2003.

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.

Crawford, R.L. 1981. Bird kills at a lighted man-made structure: often on nights close to a full moon. Amer. Birds. 35: 913-914.

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

Gauthreaux, S.A., Jr. 1969. A Portable ceilometer technique for studying low-level nocturnal migration. Bird-Banding 40(4):309-320.

_____. 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.

Gauthreaux, S.A., Jr. and C.G. Belser. 1998. Displays of Bird Movements on the WSR-88D: Patterns and Quantification. American Meteorological Society. 13:453-464.

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.

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

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

Lowery, G.H., Jr. 1951. A quantitative study of the nocturnal migration of birds. University of Kansas Publications, Museum of Natural History 3(2):361-472.

Mabee, T.J., J.H. Plissner, and B.A. Cooper. 2005. A Radar and Visual Study of Nocturnal Bird and Bat Migration at the Proposed Prattsburgh-Italy Wind Power Project, New York, Fall 2004. Final Report prepared for Ecogen LLC, March 2005.

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.

Ogden, L.J. 1996. Collision Course: The hazards of lighted structures and windows to migrating birds. A special report for the World Wildlife Fund Canada and the Fatal Lights Awareness Program. Published on the web at www.flap.org.

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

Thompson, E.H. and E.R. Sorenson. 2000. Wetland, Woodland, Wildland: A Guide to the Natural Communities of Vermont. University Press of New England, Hanover, NH.

Whitaker, J.O. and W.J. Hamilton. 1998. *Mammals of the Eastern United States*. Cornell University Press.

Woodlot Alternatives, Inc. 2005a. A Spring 2005 Radar Survey of Bird and Bat Migration at the Proposed Top Notch Wind Project in Fairfield, New York. Prepared for PPM Atlantic Renewable.

Woodlot Alternatives, Inc. 2005b. A Spring 2005 Radar and Acoustic Survey of Bird and Bat Migration at the Proposed Jordanville Wind Project in Jordanville, New York. Prepared for Community Energy, Inc.

Woodlot Alternatives, Inc. 2005c. A Spring Radar, Visual, and Acoustic Survey of Bird and Bat Migration at the Proposed Marble River Wind Project in Clinton and Ellenburg, New York. Prepared for AES Corporation.

Woodlot Alternatives, Inc. 2005d. A Spring 2005 Radar, Visual, and Acoustic Survey of Bird and Bat Migration at the Proposed Windfarm Prattsburgh Project in Prattsburgh, New York. Prepared for UPC Wind Management, LLC.

Woodlot Alternatives, Inc. 2005e. A Spring 2005 Radar, Visual, and Acoustic Survey of Bird and Bat Migration at the Proposed Deerfield Wind Project in Searsburg and Readsboro, Vermont. Prepared for PPM Energy/Deerfield Wind, LLC.

Woodlot Alternatives, Inc. 2005f. 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.

Woodlot Alternatives, Inc. 2005g. Fall 2004 Avian Migration Surveys at the Proposed Deerfield Wind/Searsburg Expansion Project in Searsburg and Readsboro, Vermont. Prepared for PPM Energy/Deerfield Wind, LLC.

Woodlot Alternatives, Inc. 2005h. Fall 2005 Radar and Acoustic Survey of Bird and Bat Migration at the Proposed Deerfield Wind Project in Searsburg and Readsboro, Vermont. Prepared for PPM Energy/Deerfield Wind, LLC.

Woodlot Alternatives, Inc. 2006a. Avian and Bat Information Summary and Risk Assessment for the Proposed Cohocton Wind Power Project in Cohocton, New York. Prepared for UPC Wind Management, LLC.

Woodlot Alternatives, Inc. 2006b. Avian and Bat Information Summary and Risk Assessment for the Proposed Sheffield Wind Power Project in Sheffield, Vermont. Prepared for UPC Wind Management, LLC.

Young, D. 2006. Wildlife Issue Solutions: What Have Marine Radar Surveys Taught Us About Wildlife Risk Assessment? Presented at Windpower 2006 Conference and Exhibition. June 4-7, 2006. Pittsburgh, PA.

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**	**Mean**	**SD**	**SE**
4/16/2006	32	29	76	87	63	87	44	49	38	26	**53**	24	7
4/17/2006	10	15	17	4	8	21	--	--	--	--	**13**	6	3
4/18/2006	134	219	160	197	153	151	150	148	112	104	**153**	35	11
4/19/2006	99	168	407	474	415	404	381	263	181	139	**293**	138	44
4/20/2006	161	242	281	934	591	580	482	499	366	255	**439**	229	73
4/21/2006	54	407	579	402	251	102	121	54	24	21	**201**	197	62
4/28/2006	29	49	64	182	114	80	50	47	49	43	**71**	46	14
4/29/2006	64	351	621	797	546	263	336	729	527	315	**455**	228	72
4/30/2006	373	714	719	790	537	315	193	120	95	--	**429**	271	90
5/1/2006	73	99	69	61	54	60	84	92	87	54	**73**	16	5
5/2/2006	11	21	21	21	24	29	35	--	--	--	**23**	7	3
5/3/2006	16	21	43	184	152	439	290	166	234	114	**166**	132	42
5/4/2006	402	673	489	432	273	315	464	43	236	94	**342**	190	60
5/14/2006	--	--	0	18	0	12	5	3	3	0	**5**	7	2
5/15/2006	52	63	147	446	724	480	704	687	513	250	**407**	263	83
5/16/2006	194	598	866	904	949	842	882	929	765	139	**707**	302	96
5/17/2006	496	1114	1251	1151	1147	859	1254	1210	734	123	**934**	380	120
5/18/2006	--	--	327	545	461	318	231	113	69	12	**260**	189	67
5/19/2006	50	300	401	389	360	746	483	407	193	1680	**501**	452	143
5/25/2006	478	469	478	543	551	476	436	503	227	--	**462**	95	32
5/26/2006	107	371	132	244	214	171	40	196	--	--	**184**	100	35
5/31/2006	64	414	291	211	220	273	445	335	127	--	**265**	125	42
6/1/2006	--	158	86	107	44	58	29	32	--	--	**73**	47	18
6/5/2006	114	485	220	168	77	113	124	64	--	--	**171**	136	48
6/6/2006	129	270	190	116	56	31	27	--	--	--	**117**	90	34
6/8/2006	12	64	50	77	34	53	94	74	24	0	**48**	30	10
Entire Season	**137**	**305**	**307**	**365**	**308**	**280**	**295**	**294**	**230**	**198**	**263**	**229**	**45**

-- indicates no data for that hour

Appendix A Table 2. Mean nightly flight direction

Night of	Mean Flight Direction	Circular SD
4/16/2006	192	70
4/17/2006	235	39
4/18/2006	204	57
4/19/2006	120	37
4/20/2006	5	44
4/21/2006	14	29
4/28/2006	213	87
4/29/2006	43	52
4/30/2006	2	47
5/1/2006	242	105
5/2/2006	278	50
5/3/2006	81	72
5/4/2006	80	32
5/14/2006	284	23
5/15/2006	35	41
5/16/2006	75	28
5/17/2006	63	30
5/18/2006	57	35
5/19/2006	71	26
5/25/2006	52	24
5/26/2006	70	49
5/31/2006	65	29
6/1/2006	68	62
6/5/2006	48	58
6/6/2006	337	58
6/8/2006	94	58
Entire Season	**58**	**54**

Appendix C 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 < 125 m
	1	2	3	4	5	6	7	8	9	10	Mean	SD	SE	
4/16/2006	26	101	150	197	243	200	325	86	43	37	141	99	31	62%
4/17/2006*	--	--	52	--	5	73	--	--	--	--	43	35	20	94%
4/18/2006	311	343	429	342	354	376	343	401	272	163	333	74	22	21%
4/19/2006	261	297	255	215	231	272	168	244	196	205	234	39	12	35%
4/20/2006	296	706	760	712	780	845	784	753	649	669	695	152	46	3%
4/21/2006	526	725	953	--	1216	1184	1071	1093	975	476	913	275	92	0%
4/28/2006	--	501	475	697	522	580	438	363	336	300	468	126	40	11%
4/29/2006	431	640	583	516	618	624	472	375	340	344	494	119	38	7%
4/30/2006	329	464	428	388	273	329	322	237	228	--	333	81	27	7%
5/1/2006	24	257	704	778	557	569	438	933	493	381	513	262	79	26%
5/2/2006	76	160	286	999	771	891	730	--	--	--	559	375	142	12%
5/3/2006	586	499	446	441	703	533	477	442	440	416	498	89	28	8%
5/4/2006	253	352	558	712	652	742	714	568	451	570	557	163	51	5%
5/14/2006	--	--	403	540	365	572	420	583	240	582	463	126	42	33%
5/15/2006	665	867	940	733	650	635	670	637	475	401	667	159	50	3%
5/16/2006	331	261	242	247	293	366	309	285	240	485	306	75	24	22%
5/17/2006	367	409	385	309	292	302	223	239	228	239	299	69	22	23%
5/18/2006	--	--	--	507	720	768	657	522	418	298	556	169	64	6%
5/19/2006	257	175	124	120	87	137	129	104	668	670	247	227	72	26%
5/25/2006	327	360	365	409	342	346	375	371	394	543	383	61	19	13%
5/26/2006	372	445	752	736	510	374	644	625	--	--	557	153	54	6%
5/31/2006	349	285	346	388	--	--	--	--	--	--	342	42	21	29%
6/1/2006	--	301	--	--	606	617	697	749	--	--	594	174	78	6%
6/5/2006	331	389	323	269	271	306	501	--	--	--	341	81	31	22%
6/6/2006	440	395	359	353	342	296	204	--	--	--	341	75	28	15%
6/8/2006	100	457	570	443	356	416	416	213	510	715	420	173	55	12%
Entire Season	**317**	**408**	**454**	**480**	**470**	**494**	**480**	**468**	**400**	**416**	**435**	**185**	**36**	**11%**

* Periods of heavy snow showers prevented suitable analysis of vertical radar samples, though horizontal samples could be analyzed.

Appendix B

Bat Survey Table

Appendix B Table 1. Summary of bat detector field survey effort and results

Night of	Time	Height	Species	Location	Wind Speed	Wind Direction	Temperature
					(m/s)	(degrees)	(degrees C)
5/27/2006	9:10 PM	20m	*Myotis* spp.	East Met High	13	46	13
5/29/2006	10:22 PM	20m	*Myotis* spp.	East Met High	5	67	15
6/2/2006	11:25 PM	20m	eastern red	East Met High	7	88	10
6/6/2006	11:06 PM	20m	unknown	East Met High	14	89	11
4/16/06	3:49 AM	15m	unknown	Western Met Low	18	70	0
4/18/06	10:26 PM	15m	*Myotis* spp.	Western Met Low	19	31	4
5/8/06	9:26 PM	15m	hoary	Western Met Low	11	105	7
5/8/06	12:40 AM	15m	hoary	Western Met Low	11	105	7
5/8/06	12:43 AM	15m	hoary	Western Met Low	11	105	7
5/8/06	1:08 AM	15m	silver-haired/big brown	Western Met Low	11	105	7
5/8/06	1:09 AM	15m	silver-haired/big brown	Western Met Low	11	105	7
4/19/06	5:23 AM	7 m	*Myotis* spp.	Western Tree	17	236	9
5/24/06	4:49 AM	7 m	*Myotis* spp.	Western Tree	14	286	12
5/25/06	8:42 PM	7 m	unknown	Western Tree	14	248	15
5/26/06	11:55 PM	7 m	unknown	Western Tree	9	270	17