Fall 2008 Radar Survey Report

for the Groton Wind Project
In Groton, New Hampshire

Prepared for

Groton Wind, LLC

Prepared by

Stantec Consulting
30 Park Drive
Topsham, ME 04086

FINAL

January 2009

Updated October 2009

Executive Summary

During fall 2008, Stantec Consulting (Stantec) conducted field surveys of bird and bat migration activity at the Groton Wind Project area in Groton, New Hampshire (Project). The surveys are part of the planning process by Groton Wind, LLC (Groton Wind) for a proposed wind Project, which will include the erection of up to 25 wind turbines and associated infrastructure (e.g., access roads, transmission lines, electrical substation, turbine lay-down/staging area, and operations and maintenance building. The turbines will likely be 2.0 Megawatt (MW) machines mounted on tubular steel towers with an approximate hub height of 78 meters (m; 256 feet [']) and a rotor diameter of 87 m (285'). The proposed turbines would have a maximum height of approximately 121 m (400'). These surveys represent the second season of investigation undertaken at this site.

The results of the spring and fall 2008 radar surveys provide information on seasonal migration activity and patterns during a full year of site-specific surveys. This data can then be used for general site-to-site comparisons with other radar studies conducted by Stantec, other consultants, and academic research.

Nocturnal Radar Survey

The fall field survey targeted a 45-night period between August 14 and October 10, 2008 within the 60 night period typically considered to be the period for fall migration (August 15 – October15). Overall, the targeted 45 nights of survey were successfully collected within this time period. Some nights were not sampled due to inclement weather conditions in which the radar could not adequately document bird movements (i.e. steady rain). However, some nights with suboptimal migration conditions including passing showers were sampled in order to characterize migration patterns during nights without optimal migration conditions. Surveys were conducted using X-band radar, sampling from sunset to sunrise. Each hour of sampling included the recording of radar video files during horizontal and vertical operation. The radar site provided good visibility of the airspace around it, except for a small 20 degree portion to the south where the ridge increased in elevation and tree height was slightly taller; however, this limitation did not dramatically impede the collection and analysis of radar data. Although targets were obstructed by ground clutter in this area, targets were still detected as they flew into or out of this portion of the radar detection range.

The overall passage rate for the survey period was 470 ± 17 targets per kilometer per hour (t/km/h). Nightly passage rates varied from 94 t/km/h on September 30 to 1174 t/km/h on September 29. Mean flight direction through the Project area was 260° ± 58°.

The seasonal average mean flight height of all targets was 342 ± 16 m (1122 ± 52') above the radar site. The average nightly flight height ranged from 237 m (778') on October 4 to 534 m (1752') on October 6. The percent of targets observed flying below 125m (410'), the anticipated height of the proposed turbines with blades, averaged 13 percent for the season and varied by night from 2 to 32 percent.

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 landscape movement, rather than a concentration or funneling of flight movements over or through a particular part of the Project area. Moreover, the flight height of targets is within the range of other studies and indicates that the vast majority of nocturnal migration in this area or region is not directed or impeded by topography and occurs well above the height of the proposed wind turbines. This type of broad front movement, particularly in conjunction with the high flight heights, indicates a limited nocturnal migrant mortality risk during fall.

Table of Contents

Figures

Appendices

PN195600299

1.0 Introduction

This report has been prepared to provide a summary of the findings documented during nocturnal radar surveys conducted during the fall 2008 migration season at Groton Wind, LLC's (Groton Wind) Groton Wind Project, in Groton New Hampshire (Project).

Following is a brief description of the Project, a review of the methods used to conduct scientific surveys, the results of those surveys, a discussion of those results, and the conclusions reached based on those results.

1.1 PROJECT CONTEXT

Groton Wind is considering construction of a wind Project located in Groton, New Hampshire (Figure 1-1). The Groton Wind Project (Project) will consist of up to 25 wind turbines and associated infrastructure (e.g., access roads, transmission lines, electrical substation, turbine lay-down/staging area, and an operations and maintenance building). The turbines will likely be 2.0 Megawatt (MW) machines mounted on tubular steel towers with an approximate hub height of 78 meters (m; 256 feet [']) and a rotor diameter of 87 m (285'). The proposed turbines would have a maximum height of 121 m (400').

In advance of permitting activities for the Project, Groton Wind contracted Stantec Consulting (Stantec) to conduct a second season of nocturnal radar migration surveys during fall 2008. The surveys will provide one full year of data to help assess the potential risk for the proposed Project to impact nocturnally migrating birds and bats. The scope of surveys was based on a combination of standard methods that are developing within the wind power industry for pre-construction surveys and is consistent with several other studies conducted recently in New Hampshire and throughout the Northeast region of the United States.

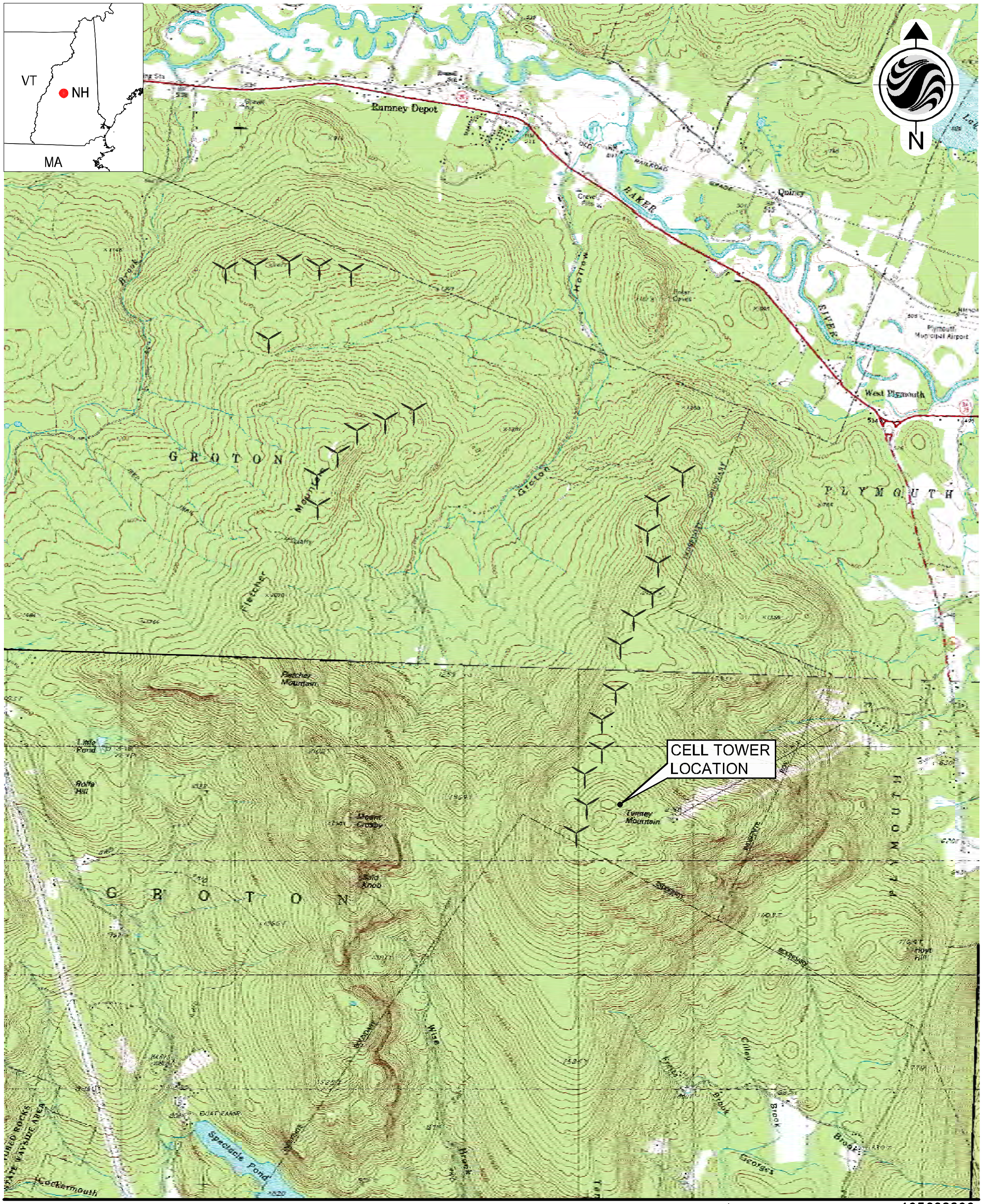
1.2 PROJECT AREA DESCRIPTION

The Project is located in Grafton County, New Hampshire within the Sunapee Uplands subsection as characterized by Sperduto and Nichols 2004 in *Natural Communities of New Hampshire*. This subsection of New Hampshire is classified by its moderate topography consisting of granite hills and peaks of shallow, nutrient poor soils interspersed with small lakes and narrow stream valleys (Sperduto and Nichols 2004).

More specifically, the Project is located on Tenney and Fletcher Mountains in Groton, New Hampshire. Both of these ridges are northeast/southwest oriented and range in elevation from 549 m (1801') to 701 m (2300'). Due to its moderate elevation, the most dominant tree species in the Project area include sugar maple (*Acer saccharum*), yellow birch (*Betula alleghaniensis)*, and American Beech (*Fagus grandifolia*), which are typical of northern hardwood – conifer forests. This forest community is the most common in the northern half of the state of New Hampshire. Some small pockets of red spruce (*Picea rubens*) and balsam fir (*Abie balsamea*) are present, but are limited to the summit of the ridges. Common understory species include; regenerating canopy species (e.g., sugar maple, yellow birch, and American beech), hobblebush (*Viburnum lantanoides*), striped maple (*Acer pensylvanicum*), and white birch (*Betula papyrifera*).

As currently planned, the majority of the Project site (the northern two-thirds of Tenney Mountain) is located on lands owned by Green Acres Woodlands and managed by FORECO, a local forest management company. The Fletcher Mountain portion of the Project area is owned and managed by Wagner Forest Management. Both companies actively manage these lands for commercial forestry products. Consequently, human disturbances are evident across the majority of the Project site. Historically and presently, the land within and surrounding this area, including the summits of the ridgeline, has been used for commercial timber production. This is evident by the recent and past cuts as well as the presence of a network of haul roads that extend through the site. These forest management operations have resulted in a variation of forest age classes. The Crosby Mountain State Park is located south of the Fletcher Mountain Project area. The Park includes 230 acres of state land, Jericho Lake, and Mount Crosby at an elevation of 676 m (2,218'). The Tenney Mountain downhill ski area is adjacent to the Project site and is located on the southeast side of the ridge and includes approximately 48 cleared ski trails. At this location, trails and maintenance roads provide access to the summit for servicing ski trails and chairlifts. A tall communication tower is also adjacent to the Project, on the summit of Tenney Mountain. The southern summit is the highest point of elevation within the Project area and is evident by a greater frequency of red spruce and balsam fir.

For the purposes of describing nocturnal migration within the Project area, the Project boundary or Project area refers to the proposed turbine areas as depicted in Figure 1-1.



Stantec

Stantec Consulting Services Inc.
30 Park Drive
Topsham ME U.S.A.
04086
Tel. 207.729.1199
Fax. 207.729.2715
www.stantec.com

LEGEND

Turbine

0 4000'

Client/Project

Groton Wind LLC
Groton Wind Project
Groton, New Hampshire

195600299

Figure No.

1-1

Title

Project Location Map

October 29, 2009

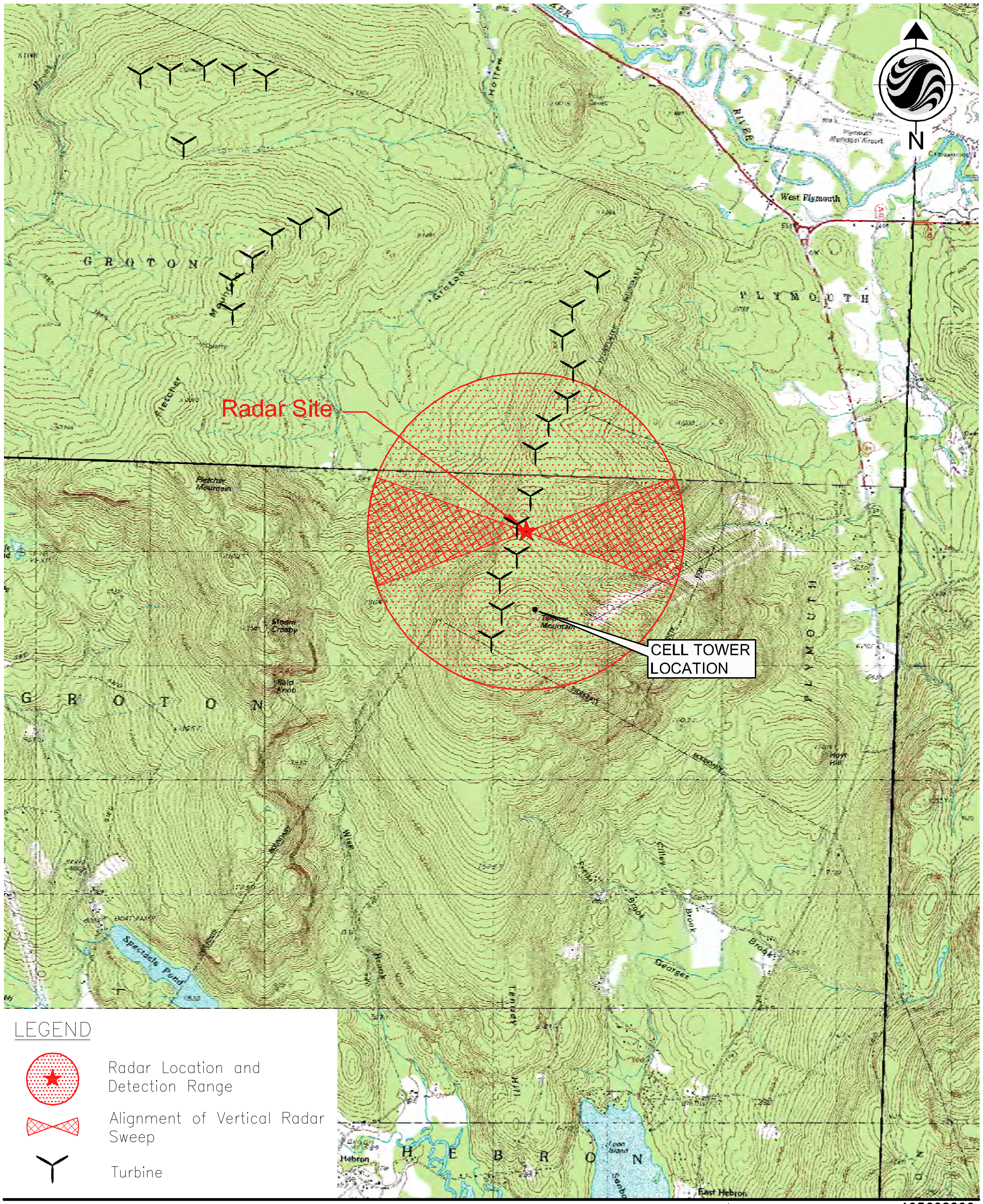
2.0 Nocturnal Radar Surveys

2.1 INTRODUCTION

The majority of North American passerines migrate at night. The strategy to migrate at night may have evolved to take advantage of more stable atmospheric conditions for flapping flight (Kerlinger 1995). Additionally, night migration may allow more efficient regulation of body temperature during active, flapping flight and could reduce the potential for predation while in flight (Alerstam 1990, Kerlinger 1995). Conversely, species such as raptors use soaring daytime flight during migration 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. Whereas raptor migration can be documented by visual daytime surveys, documenting the patterns of nocturnally migrating birds requires the use of radar or other non-visual technologies. Nocturnal radar surveys were conducted in the Project area to characterize spring nocturnal migration patterns. 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

The radar study was conducted from the same location as the spring 2008 survey, within the forest opening at the on-site meteorological measurement tower (met tower) at the summit of Tenney Mountain (Figure 2-1). In anticipation of Groton Wind potentially acquiring additional land for the Project on Fletcher Mountain, Stantec decided to situate the radar on the Tenney ridgeline, the higher of the two, so that it would document activity over a 2.8 km wide area that included views into the valley west of Tenney Mountain. Considering that nocturnal migration has been documented to occur in a broad front movement at most all radar studies conducted in the northeast, including three in New Hampshire, it is expected that the radar data collected from Tenney Mountain provided a representative sampling of the airspace to the west and, consequently, Fletcher Mountain. Therefore, results from the radar survey will still be valid if the Project does make that expansion. The radar antenna was elevated approximately 8 m (25’) above the ground to be even with the surrounding tree height to increase the amount of visible airspace detectable by the radar and to minimize ground clutter obstructions to the center of the radar screen. This site, at an elevation of 640 m (2100’) and centrally located within the Project area, provided a good view in most directions. A small 20 degree portion to the south was obstructed due to an elevation increase and taller tree heights, but targets were still detected flying into or out of this area; therefore resulting in nearly 100 percent coverage of targets flying through the view of the radar. Steep topography to the west allowed for detection of some targets flying below the horizon in the valley below. However, this was only true during the brief period in late fall when leaves were not present on the trees.



Stantec

Stantec Consulting Services Inc.
30 Park Drive
Topsham ME U.S.A.
04086
Tel. 207.729.1199
Fax. 207.729.2715
www.stantec.com

0 4000'

Client/Project 195600299

Groton Wind LLC
Groton Wind Project
Groton, New Hampshire

Figure No.

2-1

Title

Radar Location Map

October 29, 2009

Marine surveillance radar, similar to that described by Cooper *et al.* (1991), was used during field data collection. The radar has a peak power output of 12 kilowatts (kW) and has the ability to track small targets, including birds, bats, and even insects, based on settings selected for the radar functions. It cannot, however, readily distinguish between different types of targets being detected. The radar has an "echo trail" function which captures past echoes of flight trails, enabling determination of flight direction. During all operations, the radar's echo trail was set to 30 seconds. The radar was equipped with a 2 m (6.5') waveguide antenna. The antenna has a vertical beam height of 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 targets flying over those areas. However, vegetation, as mentioned above, 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 (Figure 2-2). The presence or reduction of potential clutter producing objects was carefully considered during site selection and radar station configuration.

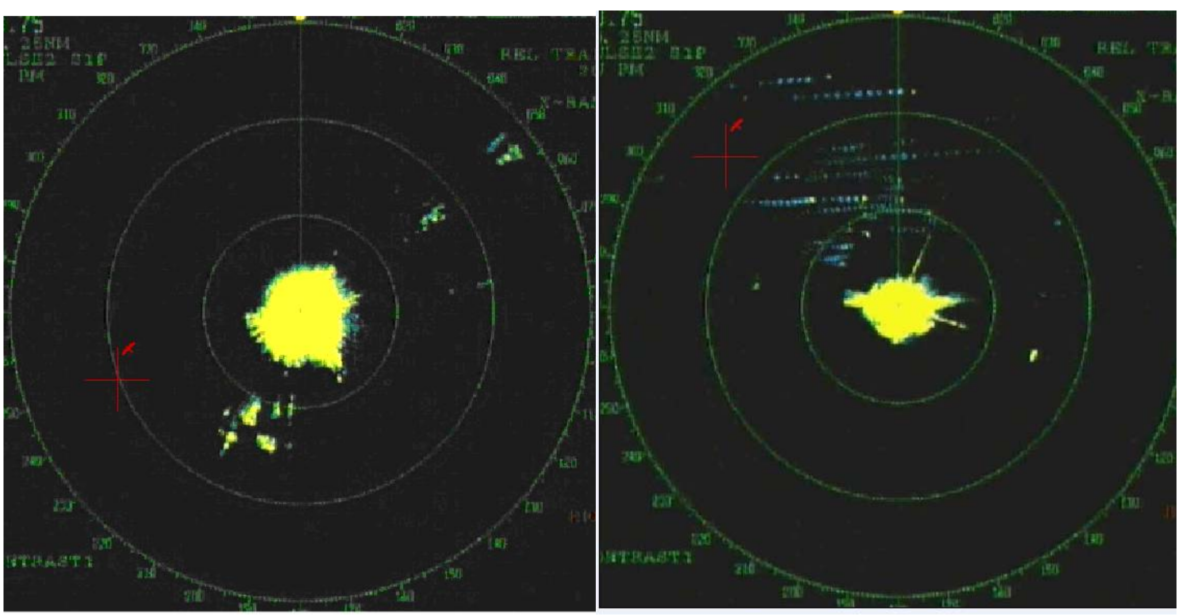


Figure 2-2. Horizontal (left) and Vertical (right) radar screen shots

Radar surveys were conducted from sunset to sunrise, targeting a 45 nights of survey during the 60 night period typically considered for fall migration (August 15 – October 15). Within this period 45 nights of data was successfully collected from August 14 to October 10, 2008. This level of survey effort was well above the 30 nights of radar surveys typically recommended in New Hampshire. Because the anti-rain function of the radar must be turned down to detect small songbirds and bats, surveys could not be conducted during some nights of inclement weather. Therefore, surveys were planned largely for nights without rain. However, in order to characterize migration patterns during nights without optimal conditions, some nights with weather forecasts including occasional showers were sampled.

The radar was operated in two modes throughout the night. In surveillance mode, 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 vertical mode, the radar unit is tilted 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 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, thus limiting the ability to observe the movement pattern of individual targets.

2.2.1 Data Collection

The radar display was connected to video recording software of a computer enabling digital archiving of the radar data for subsequent analysis. This software recorded and archived video samples continuously every hour from sunset to sunrise of each survey night. Alternating the radar antenna every ten minutes from vertical mode to horizontal mode, a total of 30 minutes of vertical samples and 30 minutes of horizontal samples were collected within each hour. Video recordings were subsequently analyzed based on a random schedule for each night. These included 15 one-minute horizontal samples and 10 one-minute vertical samples. This analysis schedule allowed for randomization of sample selection and prevented double-counting of targets due to the 30-second echo trail used to determine the flight path vector.

2.2.2 Weather Data

Temperature, relative humidity, wind speed, and wind direction were recorded for the duration of the survey period at 10-minute intervals by an onsite weather station (HOBO Pro v2 U23-001, Onset Computer Corporation) placed on the radar platform and extended just above tree canopy. While this weather station did not provide data from heights which most migrants fly, it did capture overall trends by hour and night. The mean, maximum, and minimum temperature, relative humidity, wind speed, and wind direction were calculated for each night. Hourly temperature and wind speed values were summarized using linear statistics. Hourly wind directions were summarized by the program Oriana (Oriana2© Kovach Computing Services) which generated nightly mean wind directions.

2.2.3 Data Analysis

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

Mean target flight directions (± 1 circular standard deviation) were summarized using software designed specifically to analyze directional data (Oriana2© Kovach Computing Services). The statistics used for this analysis are based on those used by Batschelet (1965), because they take into account the circular nature of the data. Weather data was collected from the nearest meteorological measurement tower (met tower) to the radar and nightly wind direction was summarized.

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

2.3 RESULTS

Forty-five nights of radar surveys were conducted from August 14 to October 10, 2008 during the 60 night period typically considered for fall migration (Appendix A, Table 1). The radar site provided good visibility of the surrounding airspace and targets were observed in most areas of the radar display unit. The radar was located at the edge of a small clearing with surrounding tree heights of approximately 10 m (33') being level with, or slightly higher than, the height of the radar antenna. Some trees were slightly higher than the radar antenna to the south/southwest where elevation increased, resulting in approximately a 20 degree "blind spot" in this area. Although targets could not be seen directly in that part of the radar screen, targets were observed flying through the area; therefore, resulting in nearly 100 percent coverage of targets flying through the radar viewshed. In vertical mode tree heights did not affect the radar view because the radar beam was directed vertically into the sky perpendicular (east to west) to the orientation of the ridge. Tree heights to the east and west were even with the height of the radar antenna allowing for the detection of targets flying at altitudes even with the tree-tops up to the range of the radar (4500') in vertical mode.

2.3.1 Passage Rates

The overall passage rate for the entire survey period was 470 ± 17 targets per kilometer per hour (t/km/h). Nightly passage rates varied from 94 t/km/h on September 30 to 1174 t/km/h on September 29 (Figure 2-3; also Appendix A, Table 1).

Individual hourly passage rates ranged from 0 to 1743 t/km/h (Appendix A, Table 2). Hourly passage rates varied between nights and within nights. For the entire season, passage rates were highest during the third hour after sunset and dropped off gradually through sunrise (Figure 2-4).

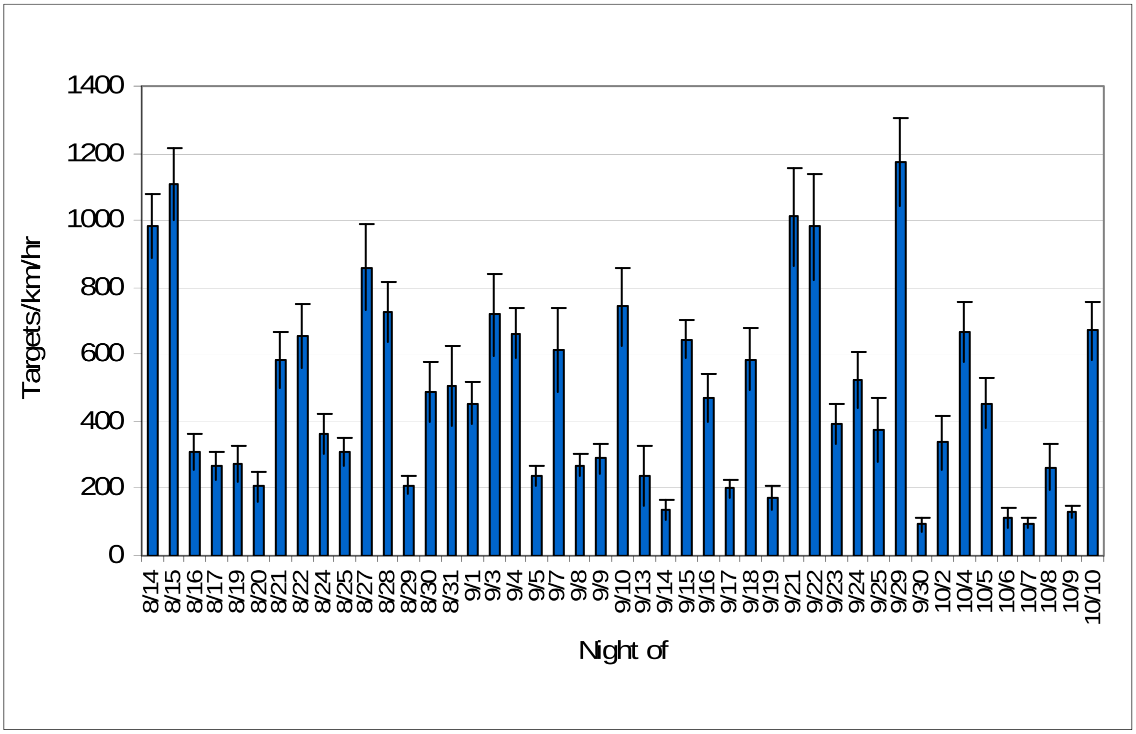


Figure 2-3. Nightly passage rates observed (error bars ± 1 SE)

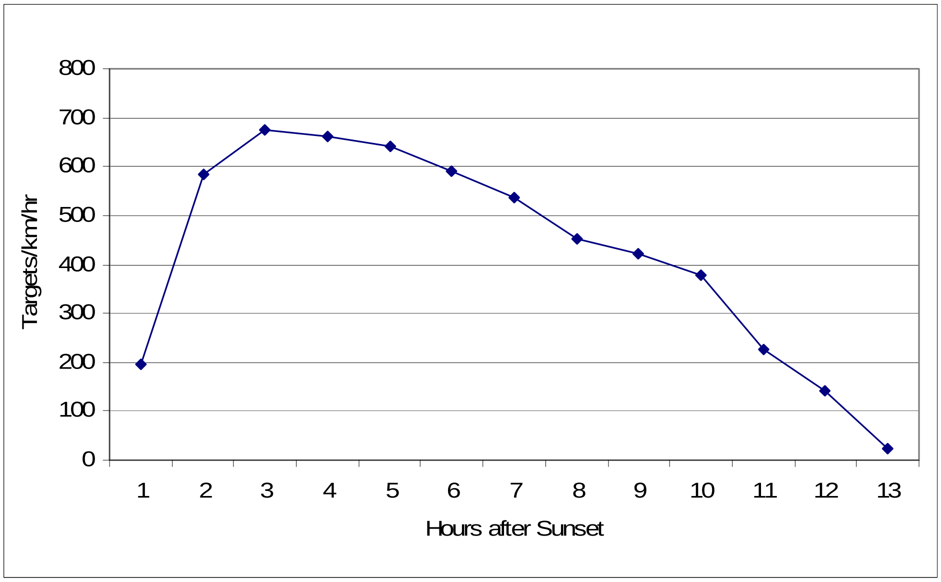


Figure 2-4. Hourly passage rates for entire season

2.3.2 Flight Direction

Mean flight direction through the Project area was 260° ± 58 (Figure 2-5). There was considerable variation between nights in mean flight direction, although most nights included flight directions generally to the in a southerly direction (53%) (Appendix A, Table 2). The remaining nights, flight directions were observed in northerly direction (31%) and a westerly direction (16%).

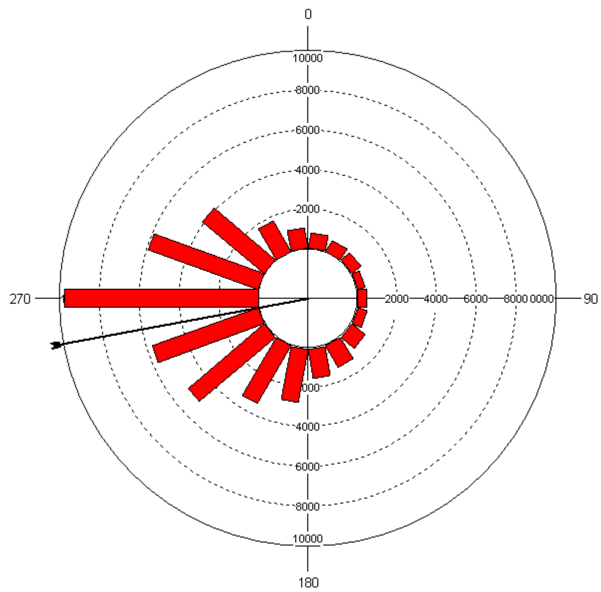


Figure 2-5. Mean flight direction for the entire season (the bracket along the margin of the histogram is the 95% confidence interval)

2.3.3 Flight Altitude

The seasonal average mean flight height of all targets was 342 ± 16 m (1122' ± 52') above the radar site. The average nightly flight height ranged from 237 m (778') on October 4 to 534 m (1752') on October 6 (Figure 2-6; Appendix A, Table 3). The percent of targets observed flying below 125 m (410') averaged 13 percent for the season and varied by night from 2 to 32 percent (Figure 2-7). The night with the highest percentage of birds flying below 125 m (October 8) had a fairly low passage rate relative to the other nights (Figure 2-7). On this night winds were from the southwest, which is not optimal for fall migration. The mean hourly flight height for the entire seasonal data was relatively constant throughout the first 10 hours, but dropped off to the 12th hour where it increased significantly to the 13th hour (Figure 2-8). The significant change in flight height from the 12th hour to the 13th hour is likely due to the small sample size for that hour because sampling during that hour was only achievable near the end of September and October when hours of daylight became shorter. The same was trueFlight height for eachmost individual nights was relatively constant throughout the night, though overalland all but one night with thirteen hours exhibited the increase in flight height in the last hour. Overall nightly flight heights did varyvaried between nights (Appendix A, Table 4) and is most likely attributed to varying weather conditions throughout the survey period.

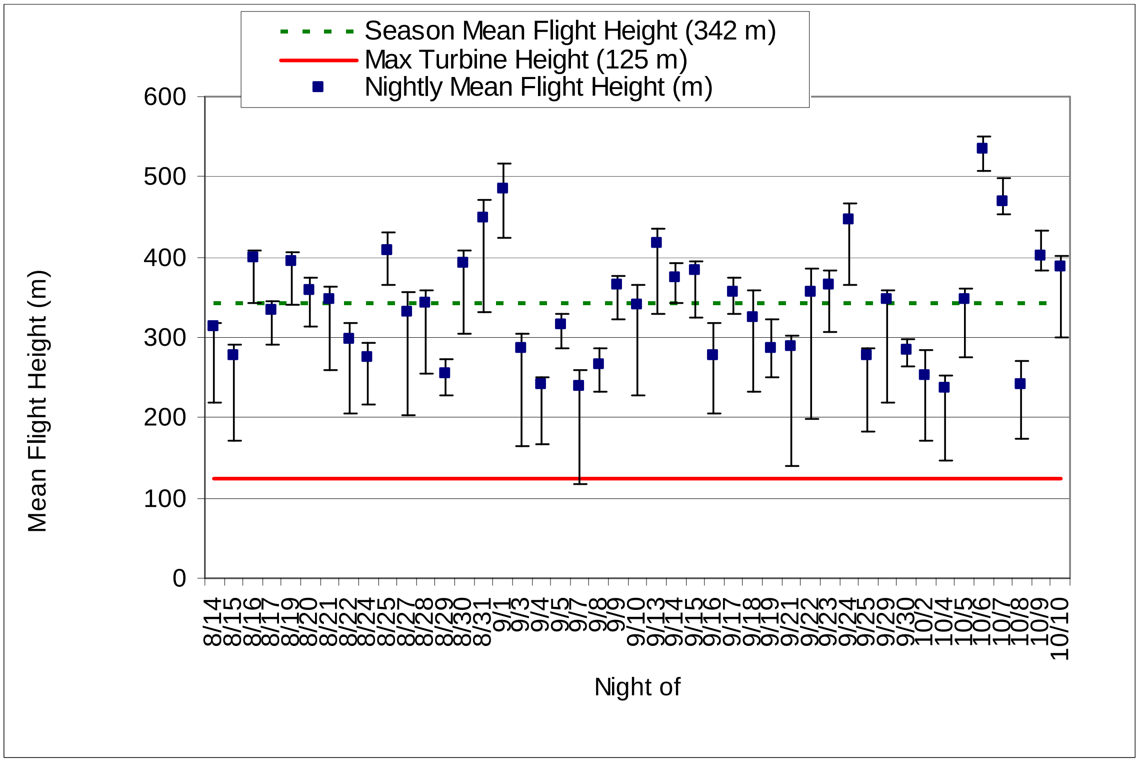


Figure 2-6. Mean nightly flight height of targets (error bars ± 1 SE)

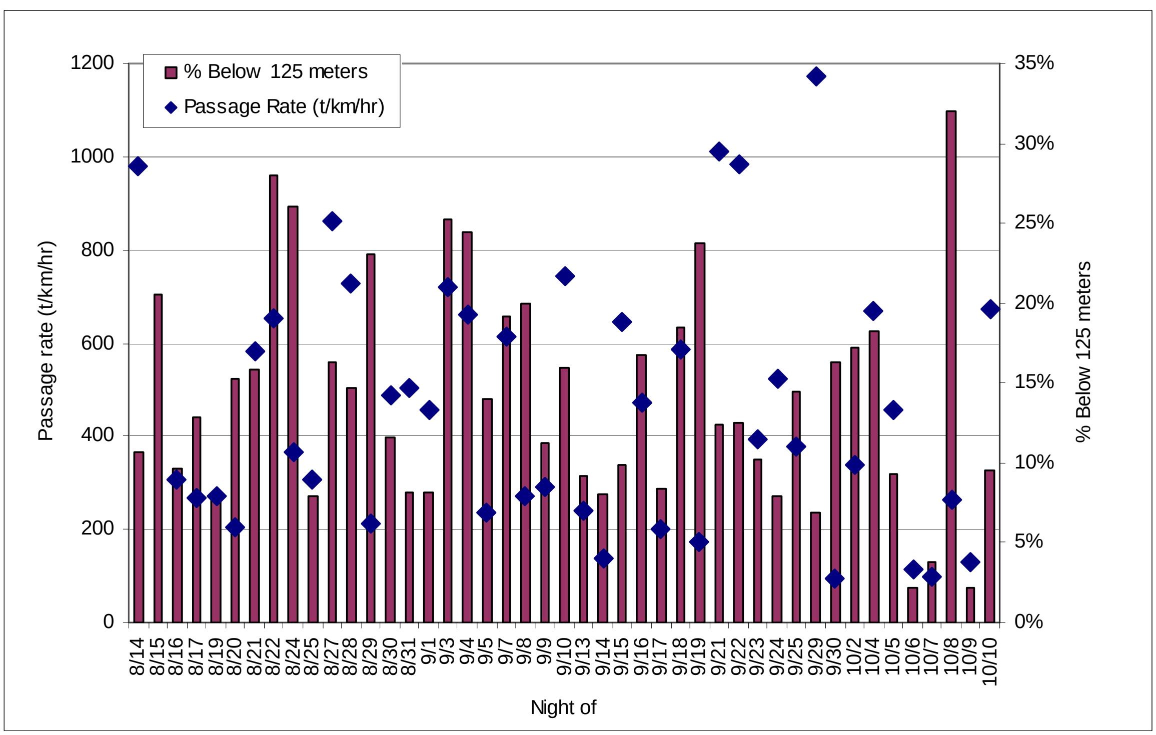


Figure 2-7. Percent of targets observed flying below a height of 125 m (410')

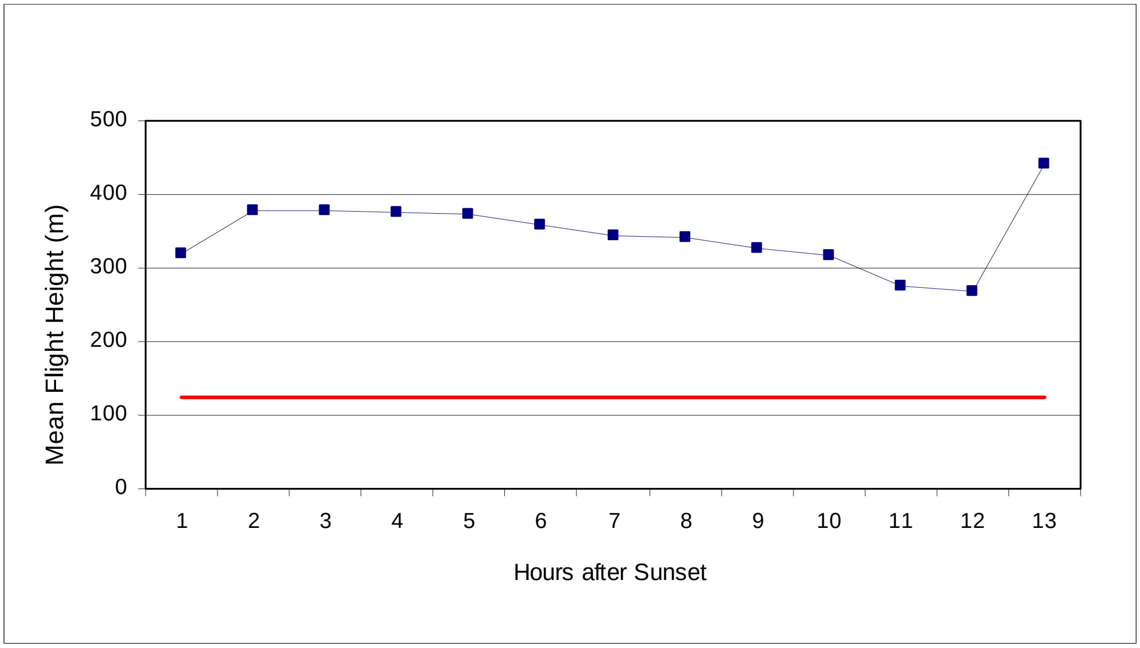


Figure 2-8. Hourly target flight height distribution

2.3.4 Weather Data

Wind speeds and temperature in the Project area were recorded by Stantec's weather station situated at a height of 20 m (65'). During the survey period, mean nightly wind speeds in the Project area during the survey period varied between 0 and 3 meters per second (m/s; Appendix A, Table 1). Mean nightly temperatures varied between 3 and 20 degrees Celcius. No attempt was made to correlate weather variables with passage rates, flight heights, and wind direction due to the inability to collect accurate weather data from heights at which the majority of migration was observed to occur. Furthermore, it is thought that migration may be influenced by a combination of weather variables rather any single variable alone. Additionally, some variables (i.e., cloud ceiling height) can not be accurately collected using current technologies or technologies that are economically feasible.

2.4 DISCUSSION

Within the last several years data from regional surveys using similar methods and equipment as those used at this Project are rapidly becoming available. These other studies provide an opportunity to compare the results from this Project with other projects in northern New England and the region. There are limitations in comparing data from previous years with data from 2008, as year-to-year variation in continental bird populations may influence how many birds migrate through an area. Additionally, differences in site characteristics, particularly the topography, local landscape conditions, and vegetation surrounding a radar survey location, can play a large role in any radar's ability to detect targets and the subsequent calculation of passage rate. These differences should be recognized as one of the more significant limiting factors in making direct site-to-site comparisons in passage rates.

Regardless of potential differences between radar survey locations, the results at the Project are within the typical range of results at projects in landscapes on forested ridges (see Appendix A, Table 5). There is currently no accurate quantitative method of directly correlating pre-construction passage rates at wind farms to operational impacts to nocturnal migrants.

However, direct comparisons may be made between seasons for a particular site since site characteristics were identical between spring and fall. Spring and fall survey periods for this site yielded similar results. Mean passage rates were higher in fall (470 t/km/hr) than spring (234 t/km/hr), but hourly passage rates were similar. Higher fall passage rates are to be expected as fall migrants usually include juveniles and weaker birds, a substantial proportion of which die either during migration or over winter and therefore are not included in overall spring passage rates (Stoddard 1962; Mizrahi *et al*. 2008). Fall hourly passage rates for the entire season also exhibited a similar pattern of dropping off during the later evening hours through sunrise. Seasonal mean flight height of all targets was relatively similar between seasons (13% in fall in comparison to 12% in spring). Flight direction in fall was almost exactly opposite that of spring, which is expected to occur during seasonal migration.

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, Gauthreaux 1991). High passage rates at the Project site occurred on nights with lower-than-average nightly wind speeds. Wind direction on high passage nights was in the westerly 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 1980; Bingman *et al*. 1982; Bruderer and Jenni 1990; Richardson 1998; Fortin *et al*. 1999; Williams *et al.* 2001; Diehl *et al*. 2003). Those studies that suggest night-migrating birds *are* influenced by topography have typically been conducted in areas of steep and abrupt topography, such as the most rugged areas of the northern Appalachians and the Alps. The moderate elevation of this Project's site in addition to the northeast/southwest orientation of the ridges did not seem to affect flight direction and flight height for night-migrating birds. This study did not document any bird concentration in a particular area during migration. On all nights of radar sampling, targets were evenly distributed within the range of the radar indicating a broad front type migration pattern rather than a channeling pattern near the ridges.

The emerging body of studies characterizing nocturnal bird movements shows a relatively consistent pattern in flight altitude, with most birds appearing to fly at altitudes of several hundred meters or more above the ground (Table 2-1). Emerging evidence, both from other Stantec studies as well as academic research, is beginning to indicate that flight height seems to be more important in determining potential collision risk than passage rate or flight direction (Cooper and Mabee 2000; Cooper *et al*. 2004b; Gauthreaux and Livingston 2006; Mizrahi *et al*. 2008). Comparison of flight height between survey sites as measured by the radar in a vertical position is generally less influenced by site characteristics as the main portion of the radar beam is directed skyward, and the potential effects of surrounding vegetation on the radar's view can be more easily controlled. The radar, centrally located on the summit of Tenney Mountain, allowed for unobstructed views in vertical mode, and targets were observed flying in all areas of the vertical detection range. Although a small 20 degree portion of ground clutter to the south obstructed some views in horizontal mode, targets were observed passing through that area resulting in nearly 100 percent coverage of targets flying within the radar viewshed, thus allowing a valid sampling to occur. The radar view in horizontal mode was comparable to other studies conducted by Stantec in the state.

2.5 CONCLUSIONS

Radar surveys during the spring 2008 migration period have provided important information on nocturnal bird migration patterns in the vicinity of the Project area. The results of the surveys indicate that bird migration patterns are generally similar to patterns observed at other forested ridge sites in the northeastern U.S. region. The mean passage rate is within the typical range of passage rates observed at other regional sites studied with similar methods and equipment. The combination of the flight height and flight direction data indicates that the majority of migrants are unimpeded by topography and flying at significantly high elevations (relative to the proposed turbines and blade heights). The emerging body of studies characterizing nocturnal bird movements shows a relatively consistent pattern in flight altitude, with most birds appearing to fly at altitudes of several hundred meters or more above the ground (Table Appendix A, Table 5). This pattern applies to this site, as birds appeared to fly at fairly consistent heights near 300 meters above the ground both nightly and throughout the survey period.

There is currently no accurate quantitative method of directly correlating pre-construction passage rates at wind farms to operational impacts to nocturnal migrants. This radar survey is designed to sample migration activity over a given point to provide baseline data pre-construction. However, general flight heights at the Project site are well above the proposed turbine height of 125 m, demonstrating a limited avian mortality risk during fall migration.

3.0 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.

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. 1980. Inland morning flight behavior of nocturnal passerine migrants in Eastern New York. Auk 97:465–72.

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.

Bruderer, B., and L. Jenni. 1990. Migration across the Alps. In Bird Migration: Physiology and Ecophysiology (E. Gwinner, Ed.). Springer Verlag, Berlin.

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.

Cooper, B.A., A.A. Stickney, Jand T.J. Mabee. 2000. Bird migration near proposed wind turbine sites at Wethersfield and Harrisburg, New York. Unpublished report prepared for Niagara–Mohawk Power Corporation, Syracuse, NY, by ABR, Inc., Forest Grove, OR. 46 pp.

Cooper, B.A., T.J. Mabee, and J.H. Plissner. 2004b. A Radar Study of Nocturnal Bird Migration at a Proposed Mount Storm wind power development, West Virginia, Fall 2003. Appendix in Avian baseline studies Mount Storm wind power project Grant County, West Virginia, final report 2004. Prepared for NedPower Mount Storm, LLC.

Cooper, B.A., A.A. Stickney, and T.J. Mabee. 2004c. A radar study of nocturnal bird migration at the proposed Chautauqua wind energy facility, New York .Final Report prepared by ABR Inc. Chautauqua Windpower LLC., Fall 2003.

Diehl, R., R. Larkin, and J. Black. 2003. Radar observations of bird migration over the Great Lakes. The Auk 120(2):278–290.

EchoTrack Inc. 2008. Pre-Construction Bat and Nocturnal Migrant Bird Monitoring Report – Wolfe Island Wind Project, Ontario, Canada, Fall 2007. Prepared for Canadian Renewable Energy Corporation.

Environmental Design and Research. 2006a Draft Environmental Impact Statement for the Dairy Hills Wind Farm Project. Towns of Perry, Warsaw and Covington, Wyoming County, New York. Prepared for Dairy Hills Wind Farm, LLC.

Fortin, D., F. Liechti, and B. Bruderer. 1999. Variation in the nocturnal flight behaviour of migratory birds along the northwest coast of the Mediterranean Sea. Ibis 141:480–488.

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

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

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.

Mabee, T.J., J.H. Plissner, and B.A. Cooper. 2005a. A Radar and Visuall study of nocturnal bird and bat migration at the proposed Prattsburg-Italy Wind Power Project, New York, Fall 2004. Unpublished report prepared for Ecogen LLC, West Seneca, NY, by ABR, Inc., Forest Grove, OR. 26 pp.

Mabee, T.J., J.H. Plissner, and B.A. Cooper. 2006a. A Radar and Visual Study of Nocturnal Bird and Bat Migration at the Proposed Clinton County Windparks, New York, Spring and fall 2005. Report prepared for Ecology and Environment, LLC and Noble Environmental Power, LLC. January 2006.

Mabee, T.J., J.H. Plissner, and B.A. Cooper. 2006c. A Radar and Visual Study of Nocturnal Bird and Bat Migration at the Proposed Centerville and Wethersfield Windparks, New York, Fall 2006. Report prepared for Ecology and Environment, LLC and Noble Environmental Power, LLC. December 2006.

Mizrahi, D.S., R. Fogg, K.A. Peters and P.A. Hodgetts. 2008. Assessing bird and bat migration patterns in the mid Atlantic Appalachian mountain region using marine radar. Report prepared for U.S. Geological Survey, U.S. Fish and Wildlife Service Maryland, Department of Natural Resources Virginia Department of Game and Inland Fisheries,and West Virginia Division of Natural Resources. June 2008.

Richardson, W.J. 1998. Bird migration and wind turbines: migration timing, flight behavior, and collision risk. Proceedings: National Avian-Wind Power Planning Meeting III, sponsored by Avian Workgroup of the National Wind Coordinating Committee, June 2000.

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

Sielman, M., L. Sheriff, and T. Williams. 1981. Nocturnal Migration at Hawk Mountain, Pennsylvania. American Birds 35(6):906–909.

Sperduto and Nichols. 2004. Natural Communities of New Hampshire. New Hampshire Natural Heritage Bureau and The Nature Conservancy.

Stantec Consulting Services, Inc. 2007b. Fall 2007 Radar, Visual, and Acoustic Survey of Bird and Bat Migration at the Proposed Windpark in Coos County, New Hampshire by Granite Reliable Power, LLC. Prepared for Granite Reliable Power, LLC.

Stoddard, H. L. Sr. 1962. Bird casualties at a Leon County, Florida TV Tower: 1955-1961. Bull. Tall Timbers Res. Stn. 1:1-94.

Western EcoSystems Technology, Inc. (WEST). 2007. Avian and Bat Studies for the Proposed Cape Vincent Wind Power Project, Jefferson County, NY. Prepared for BP Alternative Energy North America.

Williams T, J. Williams, G. Williams, and P. Stokstad. 2001. Bird Migration Through a Mountain Pass Studied with High Resolution Radar, Ceilometers, and Census. The Auk118(2):389–403.

Woodlot Alternatives, Inc. 2005a. A Visual and Acoustic Survey of Bird and Bat Migration at the Proposed Liberty Gap Wind Project in Franklin, West Virginia – Fall 2004. Prepared for US Wind Force, LLC.

_____. 2005c. A Fall 2004 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.

_____.2005c. Fall 2004 Avian Migration Surveys at the Proposed Deerfield Wind/Searsburg Expansion Project in Searsburg and Readsboro, Vermont. Prepared for Deerfield Wind, LLC and Vermont Environmental Research Associates.

_____. 2005l. A Fall 2005 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, LLC Corporation.

_____. 2005m. A Fall 2005 Radar, Visual, and Acoustic Survey of Bird and Bat Migration at the Proposed Clayton Wind Project in Clayton, New York. Prepared for PPM Atlantic Renewable.

_____. 2005g. Fall 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.

_____. 2005o. A Fall 2005 Survey of Bird and Bat Migration at the Proposed Howard Wind Power Project in Howard, New York. Prepared for Everpower Global.

_____. 2005p. A Fall 2005 Radar Survey of Bird and Bat Migration at the Proposed Top Notch Wind Project in Fairfield, New York. Prepared for PPM Atlantic Renewable.

_____. 2005q. A Fall 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.

_____. 2005r. Summer and Fall 2005 Bird and Bat Surveys at the Proposed Munnsville Wind Project in Munnsville, New York. Prepared for AES-EHN NY Wind, LLC.

_____. 2005s. A Fall 2005 Radar and Acoustic Survey of Bird and Bat Migration at the Proposed Deerfield Wind Project in Searsburg and Readsboro, Vermont. Prepared for Deerfield Wind LLC and Vermont Environmental Research Associates.

_____. 2005t. A Fall 2005 Radar, Visual, and Acoustic Survey of Bird and Bat Migration at the Proposed Mars Hill Wind Project in Mars Hill, Maine. Prepared for UPC Wind Management, LLC.

_____. 2006a. Avian and Bat Information Summary and Risk Assessment for the Proposed Sheffield Wind Power Project in Sheffield, Vermont. Prepared for UPC Wind Management, LLC.

_____. 2006f. Fall 2005 Radar Survey of Bird and Bat Migration at the Proposed Kibby Wind Power Project in Kibby and Skinner Townships, Maine. Prepared for TransCanada, Ltd.

_____. 2006j. A Fall 2006 Survey of Bird and Bat Migration at the Proposed Chateaugay Windpark in Chateaugay, New York. Prepared for Ecology and Environment, Inc. and Noble Power, LLC.

_____. 2007a. A Fall 2006 Survey of Bird and Bat Migration at the Proposed Lempster Mountain Wind Power Project in Lempster, New Hampshire. Prepared for Lempster Wind, LLC.

_____. 2007b. A Fall 2006 Survey of Bird and Bat Migration at the Proposed Stetson Mountain Wind Power Project in Washington County, Maine. Prepared for Evergreen WindpowerWind V, LLC.

_____. 2007f. A Fall 2007 Radar, Visual, and Acoustic Survey of Bird and Bat Migration at the Proposed Laurel Mountain Wind Energy Project near Elkins, West Virginia. Prepared for AES Laurel Mountain, LLC.

Young, D.P. 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.

Young, D.P., C.S. Nations, V.K. Poulton, J. Kerns, and L. Pavilonis, 2006. Avian and bat studies for the Proposed Dairy Hills wind project, Wyoming County, New York. Prepared for Horizon Wind Energy, April 2006, Cited in the Draft Environmental Impact Statement for the Noble Wethersfield Windpark, Wyoming County, New York. Prepared for Noble Wethersfield Windpark, LLC by Ecology and Environment.

Appendix A

Radar survey results

Appendix A Table 1. Survey dates, results, level of effort, and weather - Fall 2008								
Date	**Passage Rate (t/km/h)**	**Flight Direction (degrees)**	**Flight Height (m)**	**% below 125 (m)**	**Hours of Survey**	**Temperature (°C)**	**Wind Speed (m/s)**	**Wind Direction (degrees)**
8/14/2008	981	223	314	11%	10	13	1	339
8/15/2008	1108	242	278	21%	8	15	0	330
8/16/2008	308	162	399	10%	10	14	3	300
8/17/2008	267	159	333	13%	10	17	2	287
8/19/2008	273	219	396	8%	11	9	3	337
8/20/2008	206	212	358	15%	11	12	3	329
8/21/2008	584	253	347	16%	11	15	1	302
8/22/2008	655	302	298	28%	11	17	1	230
8/24/2008	365	298	276	26%	11	17	2	242
8/25/2008	307	210	408	8%	10	10	3	343
8/27/2008	861	265	332	16%	11	15	1	353
8/28/2008	728	293	342	15%	11	14	1	139
8/29/2008	211	141	254	23%	11	17	2	281
8/30/2008	488	214	393	12%	11	16	2	309
8/31/2008	505	251	450	8%	11	14	2	329
9/1/2008	455	253	486	8%	11	17	2	356
9/3/2008	718	300	285	25%	10	16	2	259
9/4/2008	663	277	242	24%	11	18	2	151
9/5/2008	237	354	317	14%	11	18	3	221
9/7/2008	614	224	240	19%	11	12	3	311
9/8/2008	270	297	265	20%	11	14	3	256
9/9/2008	290	212	366	11%	11	11	3	319
9/10/2008	742	271	341	16%	12	6	1	1
9/13/2008	240	336	416	9%	10	16	3	172
9/14/2008	138	47	374	8%	12	20	3	199
9/15/2008	646	238	384	10%	12	10	3	331
9/16/2008	472	277	278	17%	12	8	1	270
9/17/2008	200	189	356	8%	12	11	3	293
9/18/2008	586	276	325	18%	12	4	2	52
9/19/2008	172	336	286	24%	12	4	2	202
9/21/2008	1010	268	289	12%	10	10	1	320
9/22/2008	982	267	357	13%	12	5	1	53
9/23/2008	393	255	365	10%	12	9	2	322
9/24/2008	524	278	446	8%	11	11	1	213
9/25/2008	377	285	278	14%	12	10	3	133
9/29/2008	1174	280	348	7%	11	12	1	307
9/30/2008	94	11	284	16%	13	12	2	148
10/2/2008	337	208	253	17%	12	4	3	279
10/4/2008	667	249	237	18%	13	3	2	295
10/5/2008	455	255	348	9%	13	3	1	323
10/6/2008	114	238	534	2%	13	3	3	336
10/7/2008	98	223	470	4%	13	6	3	318
10/8/2008	265	338	242	32%	10	10	2	218
10/9/2008	130	188	402	2%	13	11	5	297
10/10/2008	671	257	388	10%	13	7	2	324
Entire Season	**470**	**260**	**342**	**13%**	**509**	**11**	**2**	**300**

Appendix A Table 2. Summary of passage rates by hour, night, and for entire season.

Night of	Passage Rate (targets/km/hr) by hour after sunset													Entire Night			
	1	2	3	4	5	6	7	8	9	10	11	12	13	Mean	Median	Stdev	SE
8/14/2008	514	1213	1291	1329	1127	1043	1018	990	820	463	NA	NA	NA	981	1030	300	95
8/15/2008	--	--	1432	1264	1430	1228	1087	1045	839	543	NA	NA	NA	1108	1157	303	107
8/16/2008	86	464	643	471	305	307	254	225	218	107	--	NA	NA	308	280	174	55
8/17/2008	--	386	370	389	375	371	220	242	209	83	21	NA	NA	267	306	134	43
8/19/2008	171	568	450	468	373	329	275	145	143	70	11	NA	NA	273	275	180	54
8/20/2008	125	488	471	214	193	198	182	93	171	113	21	NA	NA	206	182	146	44
8/21/2008	244	632	750	1029	894	585	493	686	686	402	21	NA	NA	584	632	286	86
8/22/2008	263	533	761	1016	879	954	964	737	591	464	43	NA	NA	655	737	311	94
8/24/2008	93	285	436	550	551	420	553	514	407	204	0	NA	NA	365	420	194	58
8/25/2008	270	486	394	429	263	471	300	156	114	189	--	NA	NA	307	285	133	42
8/27/2008	241	739	1014	909	1529	1271	1157	1079	839	583	107	NA	NA	861	909	427	129
8/28/2008	393	884	1082	959	839	843	934	638	507	840	86	NA	NA	728	840	294	89
8/29/2008	225	300	257	291	364	200	157	159	150	157	57	NA	NA	211	200	87	26
8/30/2008	134	546	857	1093	514	279	393	493	514	450	96	NA	NA	488	493	290	87
8/31/2008	257	766	1227	1016	743	573	400	204	164	171	39	NA	NA	505	400	390	118
9/1/2008	129	766	700	733	545	421	382	266	325	386	354	NA	NA	455	386	206	62
9/3/2008	407	1157	857	1191	1050	921	793	289	241	275	--	NA	NA	718	825	380	120
9/4/2008	273	611	800	979	973	825	871	596	616	436	311	NA	NA	663	616	249	75
9/5/2008	139	223	236	142	123	214	250	295	416	393	171	NA	NA	237	223	98	30
9/7/2008	373	1414	1146	640	664	493	836	691	141	243	113	--	NA	614	640	408	123
9/8/2008	136	193	219	314	214	317	359	375	246	486	114	--	NA	270	246	111	34
9/9/2008	236	507	593	311	253	279	264	214	279	198	57	--	NA	290	264	146	44
9/10/2008	183	257	879	936	986	1050	964	1214	1050	832	543	11	NA	742	907	394	114
9/13/2008	150	836	600	321	268	48	71	43	43	16	--	--	NA	240	111	277	88
9/14/2008	7	146	107	43	93	94	54	116	273	407	198	114	NA	138	111	110	32
9/15/2008	434	830	721	657	713	771	743	600	670	864	638	107	NA	646	691	203	59
9/16/2008	257	650	957	720	429	536	669	471	370	354	188	64	NA	472	450	251	72
9/17/2008	68	240	250	286	364	249	179	164	206	229	129	38	NA	200	217	92	26
9/18/2008	443	586	793	1264	879	611	600	546	679	418	219	0	NA	586	593	320	92
9/19/2008	129	407	264	161	279	300	229	94	86	34	64	14	NA	172	145	123	35
9/21/2008	200	1071	1204	1313	1532	1593	--	--	1107	789	1000	296	NA	1010	1089	468	148
9/22/2008	186	1248	1743	1610	1607	1269	1136	911	820	671	457	129	NA	982	1023	548	158
9/23/2008	116	614	807	643	466	439	264	284	321	286	263	207	NA	393	304	205	59
9/24/2008	150	--	546	775	671	896	818	664	514	350	243	134	NA	524	546	270	82
9/25/2008	193	493	1007	841	664	549	361	96	43	58	86	133	NA	377	277	331	96
9/29/2008	193	1025	986	761	1400	1257	1639	1179	1414	1733	1323	--	--	1174	1257	431	130
9/30/2008	118	132	193	129	129	21	102	110	14	26	0	225	21	94	110	72	20
10/2/2008	134	1014	789	439	329	193	271	204	230	198	132	111	--	337	217	283	82
10/4/2008	86	605	724	879	1029	1064	1029	699	714	714	659	471	0	667	714	329	91
10/5/2008	120	314	364	336	625	836	843	734	643	514	326	236	21	455	364	266	74
10/6/2008	34	225	86	239	268	257	107	129	29	21	24	43	14	114	86	99	28
10/7/2008	100	107	186	204	171	118	32	129	34	50	47	75	21	98	100	61	17
10/8/2008	141	305	359	402	500	569	364	--	--	--	0	5	0	265	332	213	68
10/9/2008	107	118	54	263	236	214	86	91	86	150	129	129	29	130	118	70	19
10/10/2008	146	660	786	883	1071	1136	954	793	643	600	507	454	93	671	660	319	88
Mean for Entire Season	**195**	**582**	**675**	**663**	**642**	**591**	**538**	**451**	**423**	**377**	**226**	**143**	**25**	**470**	**364**	**381**	**17**
Median for Entire Season	**150**	**546**	**721**	**643**	**545**	**493**	**388**	**295**	**323**	**352**	**114**	**114**	**21**				

Appendix A Table 3. Mean Nightly Flight Direction		
Night of	**Mean Flight Direction**	**Circular Stdev**
8/14/2008	223°	43°
8/15/2008	242°	52°
8/16/2008	162°	48°
8/17/2008	159°	63°
8/19/2008	219°	49°
8/20/2008	212°	61°
8/21/2008	253°	45°
8/22/2008	302°	64°
8/24/2008	298°	60°
8/25/2008	210°	40°
8/27/2008	265°	45°
8/28/2008	293°	46°
8/29/2008	141°	80°
8/30/2008	214°	53°
8/31/2008	251°	38°
9/1/2008	253°	36°
9/3/2008	300°	63°
9/4/2008	277°	48°
9/5/2008	354°	71°
9/7/2008	224°	47°
9/8/2008	297°	81°
9/9/2008	212°	44°
9/10/2008	271°	26°
9/13/2008	336°	44°
9/14/2008	47°	40°
9/15/2008	238°	42°
9/16/2008	277°	45°
9/17/2008	189°	70°
9/18/2008	276°	26°
9/19/2008	336°	54°
9/21/2008	268°	40°
9/22/2008	267°	31°
9/23/2008	255°	41°
9/24/2008	278°	38°
9/25/2008	285°	39°
9/29/2008	280°	54°
9/30/2008	11°	36°
10/2/2008	208°	77°
10/4/2008	249°	37°
10/5/2008	255°	30°
10/6/2008	238°	36°
10/7/2008	223°	44°
10/8/2008	338°	36°
10/9/2008	188°	62°
10/10/2008	257°	36°
Entire Season	**260°**	**58°**

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

Night of	Mean Flight Height (m) by hour after sunset													Entire Night				% of targets below 125 meters
	1	2	3	4	5	6	7	8	9	10	11	12	13	Mean	Median	STDV	SE	
8/14/2008	332	332	334	321	290	301	304	290	308	325	NA	NA	NA	314	315	17	5	11%
8/15/2008	--	--	225	232	275	262	291	324	301	312	NA	NA	NA	278	283	36	13	21%
8/16/2008	387	350	410	379	398	440	438	371	430	394	387	NA	NA	399	394	28	9	10%
8/17/2008	--	391	390	338	328	332	297	324	308	363	260	NA	NA	333	330	41	13	13%
8/19/2008	421	437	421	404	354	339	362	406	408	404	--	NA	NA	396	405	33	10	8%
8/20/2008	286	299	310	299	381	415	413	408	377	437	318	NA	NA	358	377	57	17	15%
8/21/2008	287	340	290	371	350	377	433	413	393	300	259	NA	NA	347	350	57	17	16%
8/22/2008	318	361	348	339	347	302	289	264	254	329	126	NA	NA	298	318	67	20	28%
8/24/2008	344	369	329	259	291	290	196	219	231	229	--	NA	NA	276	274	58	18	26%
8/25/2008	348	450	475	479	495	416	364	420	412	402	224	NA	NA	408	416	76	23	8%
8/27/2008	318	364	400	444	464	338	338	300	212	233	237	NA	NA	332	338	84	25	16%
8/28/2008	318	396	416	347	370	363	361	297	364	292	243	NA	NA	342	361	50	15	15%
8/29/2008	369	315	341	223	210	222	239	202	253	250	171	NA	NA	254	239	62	19	23%
8/30/2008	325	370	343	318	396	465	481	416	392	412	402	NA	NA	393	396	52	16	12%
8/31/2008	319	446	487	502	487	487	553	502	404	417	340	NA	NA	450	487	72	22	8%
9/1/2008	382	514	517	518	550	574	595	547	512	357	277	NA	NA	486	517	101	30	8%
9/3/2008	191	362	334	240	284	363	304	303	320	230	211	NA	NA	285	303	60	18	25%
9/4/2008	294	260	257	239	224	194	203	262	238	257	228	NA	NA	242	239	29	9	24%
9/5/2008	261	369	318	398	313	346	327	326	304	273	249	NA	NA	317	318	45	14	14%
9/7/2008	265	333	326	277	250	211	192	194	268	239	249	76	NA	240	249	68	20	19%
9/8/2008	210	346	369	315	299	259	220	--	254	185	193	--	NA	265	256	65	21	20%
9/9/2008	333	357	333	333	338	370	413	428	392	359	368	--	NA	366	359	33	10	11%
9/10/2008	338	394	380	472	421	341	370	293	294	251	196	--	NA	341	341	79	24	16%
9/13/2008	356	479	472	465	377	503	367	422	414	310	--	--	NA	416	418	63	20	9%
9/14/2008	381	351	436	486	449	345	365	376	337	336	399	231	NA	374	370	66	19	8%
9/15/2008	358	385	336	444	417	430	358	394	391	386	329	--	NA	384	386	37	11	10%
9/16/2008	468	459	382	322	368	217	211	213	188	--	200	32	NA	278	217	133	40	17%
9/17/2008	323	478	450	388	328	329	323	364	279	343	388	273	NA	356	336	62	18	8%
9/18/2008	350	402	402	466	490	458	333	240	191	189	167	206	NA	325	341	121	35	18%
9/19/2008	--	339	371	428	306	270	206	188	184	163	166	523	NA	286	270	119	36	24%
9/21/2008	331	343	320	331	344	323	255	244	230	245	244	256	NA	289	288	46	13	12%
9/22/2008	290	472	482	457	425	405	414	349	311	258	202	217	NA	357	377	100	29	13%
9/23/2008	364	431	426	434	445	433	335	349	334	267	266	299	NA	365	356	67	19	10%
9/24/2008	388	450	491	500	572	538	475	389	340	400	391	421	NA	446	436	70	20	8%
9/25/2008	--	322	319	263	284	250	255	275	287	289	270	246	NA	278	275	25	8	14%
9/29/2008	--	364	419	400	337	330	336	343	327	303	322	--	--	348	337	36	11	7%
9/30/2008	245	234	308	302	310	324	285	306	365	295	193	240	--	284	299	47	14	16%
10/2/2008	263	283	301	326	420	358	242	--	193	147	180	67	--	253	263	101	30	17%
10/4/2008	246	307	266	309	260	255	282	204	228	204	265	148	103	237	255	60	17	18%
10/5/2008	311	304	415	434	386	342	327	354	351	298	332	320	--	348	337	43	12	9%
10/6/2008	--	469	469	491	501	484	537	601	545	603	585	532	597	534	534	52	15	2%
10/7/2008	--	641	526	514	529	490	463	450	472	429	268	383	--	470	472	94	28	4%
10/8/2008	209	230	317	273	334	300	--	--	--	--	179	94	--	242	252	81	29	32%
10/9/2008	235	323	378	448	399	413	335	342	401	479	312	466	693	402	399	111	31	2%
10/10/2008	357	380	323	352	356	378	442	433	432	489	402	332	370	388	378	49	14	10%
Mean for Entire Season	**319**	**377**	**377**	**375**	**372**	**360**	**344**	**342**	**328**	**318**	**275**	**268**	**441**	**342**	**338**	**71**	**16**	**13%**
Median for Entire Season	**324**	**364**	**371**	**371**	**356**	**345**	**335**	**343**	**323**	**303**	**259**	**251**	**483**					

-- indicates no data for that hour

Appendix A Table 5. Summary of available fall avian radar survey results

Project Site	Number of Survey Nights	Number of Survey Hours	Landscape	Average Passage Rate (t/km/hr)	Range in Nightly Passage Rates	Avg. Flight Direction	Avg. Flight Height (m)	(Turbine Ht) % Targets Below Turbine Height	Citation
Fall 1998									
Harrisburg, NY	35	n/a	Great Lakes plain/ADK foothills	122	n/a	181	182	45	Cooper and Mabee 2000
Wethersfield, Wyoming Cty, NY	35	n/a	Agricultural plateau	168	n/a	179	154	57	Cooper and Mabee 2000
Fall 2003									
Westfield Chautauqua Cty, NY	30	180	Great Lakes shore	238	10-905	199	532	(125 m) 4 %	Cooper *et al.* 2004c
Mt. Storm, Grant Cty, WV	45	270	Forested ridge	241	8-852	184	410	n/a	Cooper *et al.* 2004b
Fall 2004									
Franklin, Pendleton Cty, WV	34	349	Forested ridge	229	18-643	175	583	(125 m) 8%	Woodlot 2005a
Prattsburgh, Steuben Cty, NY	30	315	Agricultural plateau	193	12-474	188	516	(125 m) 3%	Woodlot 2005b
Prattsburgh, Steuben Cty, NY	45	292.5	Agricultural plateau	200	18-863	177	365	(125 m) 9.2%	Mabee *et al.* 2005a
Martindale, Lancaster, Cty, PA	n/a	n/a	Reclaimed minelands	187	n/a	188	436	(n/a) 8%	Young 2006
Casselman, Somerset Cty, PA	n/a	n/a	Reclaimed minelands	174	n/a	219	448	(n/a) 7%	Young 2006
Deerfield, Bennington Cty, VT (Existing Facility)	28	300	Forested ridge	175	7-519	194	438	(100 m) <1%	Woodlot 2005c
Deerfield, Bennington Cty, VT (Western Expansion)	14	159	Forested ridge	193	8-1121	223	624	(100 m) 5%	Woodlot 2005c
Deerfield, Bennington Cty, VT (Valley Site)	13	136	Forested ridge	150	58-404	214	503	(100 m) < 1%	Woodlot 2005c
Deerfield, Bennington Cty, VT (3 sites combined)	28	595	Forested ridge	178	7-1121	212	611	(100 m) 3%	Woodlot 2005c
Sheffield, Caledonia Cty, VT	18	176	Forested ridge	114	19-320	200	566	(125 m) 1%	Woodlot 2006a
Fall 2005									
Churubusco, Clinton Cty, NY	38	414	Great Lakes plain/ADK foothills	152	9-429	193	438	(120 m) 5%	Woodlot 2005l
Ellenberg, Clinton Cty, NY	n/a	n/a	Great Lakes plain/ADK foothills	197	n/a	162	333	(n/a) 12%	Mabee *et al.* 2006a
Dairy Hills, Clinton Cty, NY	n/a	n/a	Agricultural plateau	94	n/a	180	466	(n/a) 10%	Young et al. 2006
Flat Rock, Lewis Cty, NY	n/a	n/a	Great Lakes plain/ADK foothills	158	n/a	184	415	(n/a) 8%	ED&R 2006a
Clayton, Jefferson Cty, NY	37	385	Agricultural plateau	418	83-877	168	475	(150 m) 10%	Woodlot 2005m
Bliss, Wyoming Cty, NY	8	n/a	Agricultural plateau	440	52-1392	n/a	411	(125 m) 13%	Young 2006
Perry, Wyoming Cty, NY	n/a	n/a	Agricultural plateau	64	n/a	180	466	(125 m) 10%	Young 2006
Sheldon, Wyoming Cty, NY	36	347	Agricultural plateau	197	43-529	213	422	(120 m) 3%	Woodlot 2005n
Howard, Steuben Cty, NY	39	405	Agricultural plateau	481	18-1434	185	491	(125 m) 5%	Woodlot 2005o
Fairfield, Herkimer Cty, NY	38	423	Agricultural plateau	691	116-1351	198	516	(125 m) 4%	Woodlot 2005p
Jordanville, Herkimer Cty, NY	38	404	Agricultural plateau	380	26-1019	208	440	(125 m) 6%	Woodlot 2005q
Munnsville, Madison Cty, NY	31	292	Agricultural plateau	732	15-1671	223	644	(118 m) 2%	Woodlot 2005r
Deerfield, Bennington Cty, VT	32	324	Forested ridge	559	3-1736	221	395	(100 m) 13%	Woodlot 2005s
Kibby, Franklin Cty, ME (Mountain)	12	115	Forested ridge	565	109-1107	167	370	(125 m) 16%	Woodlot 2006d
Kibby, Franklin Cty, ME (Range 1)	12	101	Forested ridge	201	12-783	196	352	(125 m) 12%	Woodlot 2006d
Kibby, Franklin Cty, ME (Valley Site)	5	13	Forested valley	452	52-995	193	391	(125 m) 16%	Woodlot 2006d
Mars Hill, Aroostook Cty, ME	18	117	Forested ridge	512	60-1092	228	424	(120 m) 8%	Woodlot 2005t
Fall 2006									
Chateaugay, Franklin Cty, NY	35	327	Agricultural plateau	643	38-1373	212	431	(120 m) 8%	Woodlot 2006j
Wethersfield, Wyoming Cty, NY	56	n/a	Agricultural plateau	256	31-701	208	344	(125 m) 11%	Mabee et al. 2006c
Centerville, Allegany Cty, NY	57	n/a	Agricultural plateau	259	12-877	208	350	(125 m) 12%	Mabee et al. 2006c
Lempster, Sullivan Cty, NH	32	290	Forested ridge	620	133-1609	206	387	(125 m) 8%	Woodlot 2007a
Stetson, Penobscot Cty, ME	12	77	Forested ridge	476	131-1192	227	378	(125 m) 13%	Woodlot 2007b
Cape Vincent, Jefferson Cty, NY	63	508	Great Lakes plain	346	n/a	209	490	(125 m) 8%	WEST 2007
Fall 2007									
Coos County, NH	29	232	Forested ridge	366	54 to 1234	223	343	(125 m) 15%	Stantec 2007b
Wolfe Island, Ontario, Canada*	n/a	n/a	Interior Lake Island	n/a	n/a	95	233	(125m) 23%	EchoTrack 2008
Laurel Mountain, VA	20	212	Forested ridge	321	76-513	209	533	(130 m) 6%	Woodlot 2007f

*Certain pieces of information are not available for comparison due to differences in survey methodology and design.