A Spring 2005 Radar, Visual, and Acoustic Survey of Bird and Bat Migration at the Proposed Clayton Wind Project in Clayton, New York

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Executive Summary

During Spring 2005, Woodlot Alternatives, Inc. (Woodlot) conducted field surveys of bird and bat migration activity in Clayton, New York. The surveys are part of the planning process by PPM Atlantic Renewable for a proposed wind project. Surveys included daytime surveys of migrating raptors, visual observations of waterfowl and other bird movements at dusk and dawn, and nighttime surveys of birds and bats using radar and bat echolocation detectors.

The results of the field surveys provide useful information about site-specific migration activity and patterns in the vicinity of the Clayton project area. This analysis is a valuable tool for the assessment of risk to birds and bats during migration through the area.

Raptor Migration – Spring 2005

The spring field surveys included 10 days of visual observation between March 30 and May 7, 2005. A total of 700 raptors, representing 14 species, were observed during the surveys. Approximately 61 percent of the raptors observed were flying less than 150 meters (m) (492') above the ground.

Bird Migration – Spring 2005

The spring field survey included 36 nights of radar surveys to collect 1-minute video samples in horizontal operation, which documents the abundance, flight path and speed of avian targets moving through the project area, and 10-minute samples in vertical operation, which documents the altitude of targets.

A total of 2,778 one-minute horizontal radar video samples, including 53,134 targets, were analyzed to determine passage rate and flight direction. Nightly passage rates varied from 71 ± 14 t/km/hr to 1,769 ± 87 t/km/hr, with the overall passage rate for the entire survey period at 450 ± 62 t/km/hr.

Mean flight direction through the project area was 30º ± 53º.

A total of 226 ten-minute radar video samples, including 12,727 targets, were analyzed to determine flight altitude. The mean flight height of all targets was 443 m ± 38 m (1,453' ± 125') above the radar site. The average nightly flight height ranged from 199 m ± 8 m (653' ± 26') to 753 m ± 36 m (2,470' ± 118'). The percent of targets observed flying below 150 m (492') also varied by night, from 2 to 42 percent. The seasonal average percentage of targets flying below 150 m was 14 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. This type of broad front movement, particularly in conjunction with the high-elevation passage levels, demonstrates a limited avian mortality risk during spring migration. Additionally, the 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.

Bat Migration – Spring 2005

The fall field survey included deployment of 1 to 2 Anabat II detectors on 42 separate nights, yielding a total of 78 detector-nights. Sampling occurred from April 20 to May 30. On nights when only one detector was operated, the detector was deployed at a height of approximately 20 m (66') in a meteorological measurement tower (met tower). On nights when two detectors were operating simultaneously, the second detector was deployed at a height of approximately 15 m (49') from the same tower.

The detectors were set to collect data from 7:00 p.m. to 7:00 a.m., which meant that sampling occurred from before sunset to after sunrise on each night of sampling.

A total of 67 bat call sequences were recorded during the spring survey period. Calls were detected throughout the sampling period, with the greatest number of calls per night (15 calls) occurring on May 6. Due to the relatively low numbers of calls detected, hourly passage rates were not calculated. In general, most bat call sequences were detected between sunset and midnight.

When possible, recorded bat calls were identified to species, genus (in the case of *Myotis*), or as "unknown," based upon the shape of the call sequence, the slope, and the maximum and minimum frequencies. Recorded calls were compared to reference libraries of known calls created using the same equipment. Of the 67 calls recorded at Clayton, 27 were identified as big brown bats (*Eptesicus fuscus*), 18 as silver-haired bats (*Lasiurus noctivagans*), 12 as *Myotis* sp., and 1 as a hoary bat (*Lasiurus cinereus*). Nine were classified as unknown, due to lack of sufficient material on which to base an identification.

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1.0 Introduction

1.1 Project Context

PPM Atlantic Renewable has proposed the construction of a wind project to be located in Clayton, Orleans, and Brownville, New York (Figure 1-1). The project would include up to approximately 54 2.75-megawatt (MW) wind turbines that could generate up to 150 MW of power annually. Turbines would have a maximum height of approximately 150 meters (m) (492') and would be located predominantly in active agricultural fields being used for hay and crop production, as well as for pasturing.

Birds and bats are known to collide with tall structures during the migration season, such as buildings and communication towers, particularly when weather conditions are suboptimal for migration (Crawford 1981; Avery *et al.* 1976, 1977). Depending on their height and location, wind turbines can also pose a potential threat to migrating birds because they are relatively tall structures, have moving parts, and may be lit. The mortality of migrating and resident birds and bats has been documented at wind farms as a result of collisions with turbines, meteorological measurement towers (met towers), and guy wires (Anderson *et al.* 2004; Erickson *et al.* 2000, 2003; Johnson *et al.* 2003; Thelander and Rugge 2000).

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. The scope of the surveys was based on some standard methods that are developing within the wind power industry and consultation with the NY Department of Environmental Conservation (NYDEC).

1.2 Project Area Description

The project area is located within the Eastern Ontario Plain ecozone of NY (Andrle and Carroll 1988). This is a relatively flat region, with elevation ranging from approximately 76 m to 152 m (250' to 500'). Forest communities in the area are dominated by American elm (*Ulmus americana*), red maple (*Acer rubrum*), and northern hardwoods on soils of lake sediments that overlie limestone bedrock. Lake Ontario moderates the local climate, which has resulted in the widespread development of agricultural land uses, predominantly dairying.

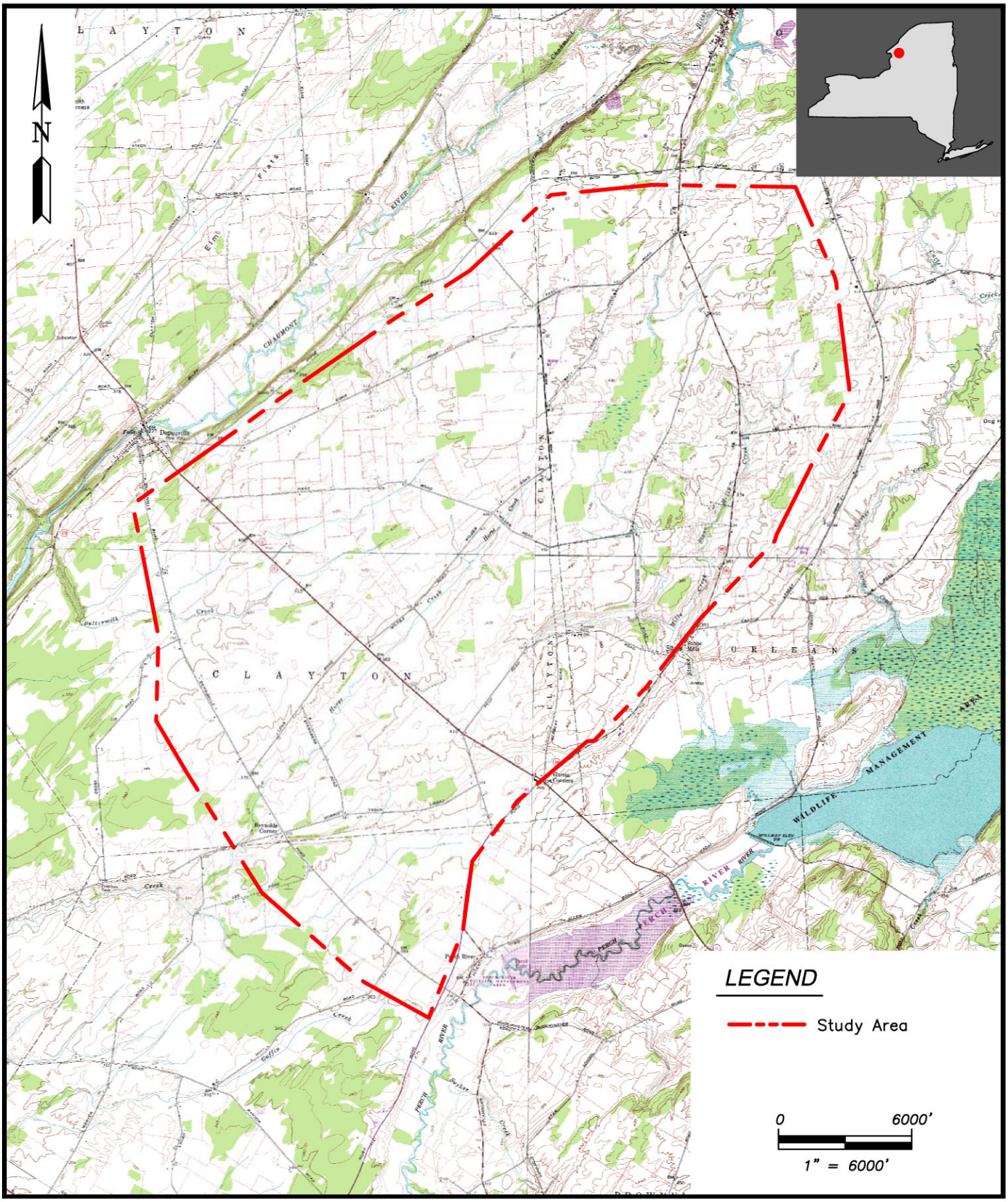

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Figure 1-1
Study Area Location Map
Clayton Wind Project
Clayton, New York

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1.3 Survey Overview

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

- document the occurrence and flight patterns of diurnally-migrating raptors (hawks, falcons, harriers, and eagles) in the project area, including number and species, general flight direction, and approximate flight height;
- 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; and
- document the presence of bats in the area, including the rate of occurrence and, when possible, species presence.

The field surveys included day-time raptor migration surveys, a radar study of bird and bat migration activity, and recordings of bat echolocation calls in several landscape settings and heights. Surveys were conducted from April 15 to May 30, 2005, although effort for the different aspects of the work varied within this time period. A total of 10 days of raptor surveys, 36 nights of radar surveys, and 78 nights of bat detector recordings were completed.

Raptor surveys were conducted near a meteorological met tower off of Lowe Road in Clayton. Methods employed were the same as those used by the Hawk Migration Association of North America (HMANA).

Radar surveys were targeted for 45 nights from April 15 to May 30, 2005. Radar surveys were conducted from the vicinity of the same met tower as raptor surveys, which provided wind data for the time period of sampling. Radar data provide insight on the flight patterns of birds (and bats) migrating over the project area, including abundance, flight direction, and flight altitude.

Bat surveys included the use of Anabat II (Titley Electronics Pty Ltd) bat detectors to record the location and timing of bat activity. One or 2 detectors were used during the survey, resulting in a total of 78 detector-nights that were recorded over the course of the 45 nights when the detectors were deployed. The detectors were deployed within the guy wire system of the met tower at heights of 15 m and 20 m (49’ and 66’) or, if one detector was used, at 20 m (66’) above the ground. Deployment in this fashion provided information on the bat community in the project area.

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

2.0 Diurnal Raptor Surveys

2.1 Introduction

The Clayton project site is located in the northeast portion of the Central Continental Hawk Flyway. The Great Lakes, specifically Lake Ontario, play a central role in shaping migration dynamics near and in the project area. Rather than crossing these large water bodies, migrating hawks will typically circumvent them by traveling along the shoreline until they can again proceed in their desired direction. During northbound migration each spring, hawks generally bypass the Lakes by moving east along the southern lake shorelines they encounter, while typically moving west along the northern lake shorelines they encounter to circumvent the Lakes during southbound movements each fall. Given these observed trends, the eastern portion of the Central Flyway and specifically, the southern and eastern shores of Lakes Erie and Ontario, could be expected to concentrate large numbers of northbound raptors during spring migration.

Woodlot conducted raptor surveys to determine if significant movement occurred in the vicinity of the proposed project location. The survey was conducted on 10 days spanning late March to early May, 2005, with the intent of documenting the dynamics of raptor migration in the project area, including species, abundance, approximate flight height, general direction and flight path, and other notable behaviors.

2.2 Methods

Field Surveys

Raptor surveys were conducted from a flat hayfield approximately 8 miles southeast of Clayton, NY. The survey site was adjacent to a 60 m (200') met tower located off of Lowe Road (Figure 2-1). This site, at an elevation of 122 m (400'), is surrounded by flat agricultural fields interspersed with small woodland fragments and wetlands. It afforded unobstructed views in all directions, except for perhaps very low-flying birds beyond nearby low treelines.

Raptor surveys occurred on 10 days from March 30 to May 7, 2005, and were generally conducted from 9 a.m. to 3 p.m. to include the time of day when the strongest thermal lift is produced and the majority of raptor migration occurs. Surveys were usually, but not always, conducted on days with favorable flight conditions produced by low-pressure systems bringing southerly winds and/or days following the passage of a weather front. Survey days were typically coordinated with strong migration flight forecasts made by the nearby Derby Hill Bird Observatory, which has been documenting spring raptor migrations for decades.

Surveys were based on methods used by the HMANA. Observers scanned the surrounding airspace for raptors flying into the survey area and recorded detailed notes on each bird's location, flight path, approximate flight height, and behavior onto HMANA data sheets. Objects with known heights, such as the met towers and surrounding trees, were used to estimate flight height. Additionally, on some occasions, the nearby radar was used to verify estimated flight heights. Flight heights were categorized as less than or greater than 150 m (492') above the ground, which is the maximum height of the proposed wind turbine blades.

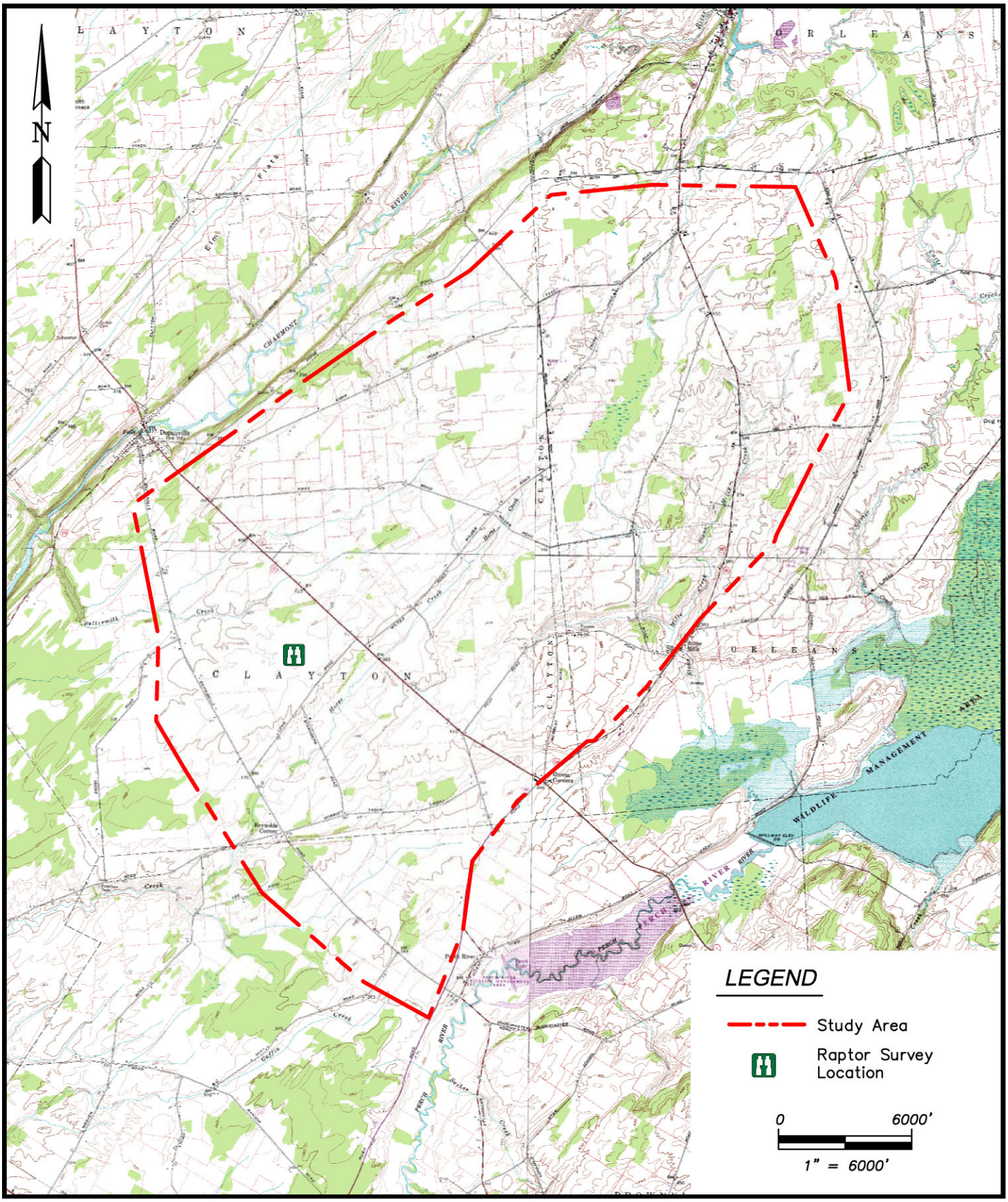

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Figure 2-1
Raptor Survey Location Map
Clayton Wind Project
Clayton, New York

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Information regarding an individual's behavior; such as known breeding range and habitat preferences, mating and breeding displays, and specific location within the project site; was incorporated to differentiate between migrant and resident birds. For most observations, flight paths of individuals were plotted on topographic maps of the project area.

Hourly weather observations, including wind speed and direction, temperature, percent cloud cover, and precipitation, were recorded on HMANA data sheets. Birds that flew too rapidly or were too distant to accurately identify were recorded to their genus or, if identification to genus was impossible, as unidentified raptor.

Data Analysis

Field observations were summarized for each survey day and for the entire survey period. This included totaling the number of individuals for each species, height class (above or below 150 m), and hour of observation. In addition, the observation rate (birds per hour) was calculated and the overall abundance and identity of resident birds was estimated. Finally, the mapped flight paths of individuals were reviewed to identify if any patterns in migration activity over the project area occurred.

Observations from the project area were compared to data obtained from local or regional HMANA hawk watch sites available from www.hmana.org. The HMANA watch site used for direct comparisons with the project site included Derby Hill in Mexico, NY; Braddock Bay in Greece, NY; and Hamburg, NY. The former two sites are located on the southern shoreline of Lake Ontario and the latter is located at the eastern end of Lake Erie.

2.3 Results

A majority of the 10 surveys were conducted on clear days with light or moderate southerly winds. Throughout the survey period, most observations were made under clear skies, while three days experienced partly or mostly cloudy conditions. However, cloud cover did not seem to influence migratory movements as much as passing weather fronts. In fact, the largest count (N=271 birds), made on April 28, followed the passing of overnight rain and early morning drizzle. In general, visibility on most survey days was excellent and only twice was limited because of heavy cloud cover. Further, four surveys were conducted on days with light to moderate north or northeasterly winds, which is suboptimal for northbound raptor migration but did not appear to greatly affect overall totals. On these days, which account for 40 percent of all survey days, nearly one-third of the season's birds were observed.

Surveys were conducted for a total of 58 hours during the 10 survey days. A total of 700 raptors, representing 14[1] species, were observed during that time, yielding an observation rate of 12.1 birds/hour (Appendix A Table 1; Figure 2-2). Broad-winged hawks (*Buteo platypterus*) N=252) and turkey vultures (*Cathartes aura*) (N=260) were the most commonly observed species and together accounted for 73.1 percent of the season's total birds. In decreasing order of abundance were red-tailed hawks (*Buteo jamaicensis*) (N=73; 10.4% of total), sharp-shinned hawks (*Accipiter striatus*) (N=25; 3.6% of total), and northern harrier (*Circus cyaneus*) (N=14; 2.0% of total).

The remainder of observed species each comprised less than 1.5 percent of the total (each with ≤ 10 individuals) and include osprey (*Pandion haliaetus*), American kestrel (*Falco sparverius*), rough-legged hawk (*Buteo lagopus*), red-shouldered hawk (*Buteo lineatus*), Merlin (*Falco columbarius*), peregrine

[1] Additional individuals that were not definitively identified were observed during the survey. While these were likely of the same species documented during the surveys, they have not been used in the calculation of the total number of species observed.

falcon (*Falco peregrinus*), bald eagle (*Haliaeetus leucocephalus*), golden eagle (*Aquila chrysaetos*), and Cooper's hawk (*Accipiter cooperii*). Some individuals remained unidentified (N=44) attributable to long distances or very brief looks. These were mostly from the genus *Buteo* (N=26), although several unidentified *Accipiter* (N=4) individuals were also observed. Of the aforementioned species, the golden eagle and peregrine falcon are listed as Endangered in NY, while the northern harrier and bald eagle are listed as Threatened. Species listed by the State as Species of Special Concern include osprey, red-shouldered hawk, sharp-shinned hawk, and Cooper's hawk. Only one federally listed species was observed: the bald eagle, which is listed as Threatened.

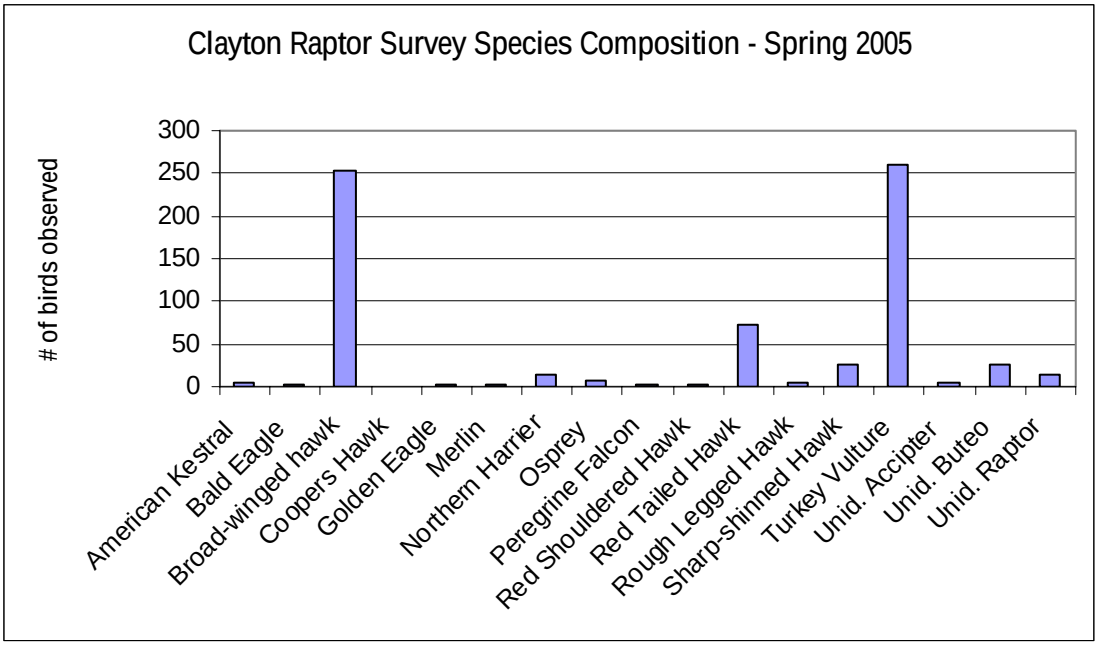


Figure 2-2. Species composition of raptors observed during raptor surveys.

Some observations of sharp-shinned hawks, American kestrels, and northern harriers were determined to be repeated sightings of the same individuals. In these cases, a particular bird may have been observed flying back and forth across the site or perching in an area repeatedly throughout one day or on multiple days. However, the vast majority of observed raptors were believed to be actively migrating and all observations are included in the count data reported. In general, those species with the highest seasonal totals (≥ 10 birds) were consistently observed throughout the season. An exception to this was the broad-winged hawk; of the 252 individuals observed, 242 (96%) were seen over a consecutive 2-day period in late April.

In addition to some seasonal variation, the timing of raptor movement varied within each survey day. Typically, relatively few birds were observed during the first and last 2 hours of each day. The majority of birds (60.1%) were seen at mid-day from 11:00 a.m. to 1:00 p.m. (Figure 2-3) and this pattern remained consistent for all frequently observed species.

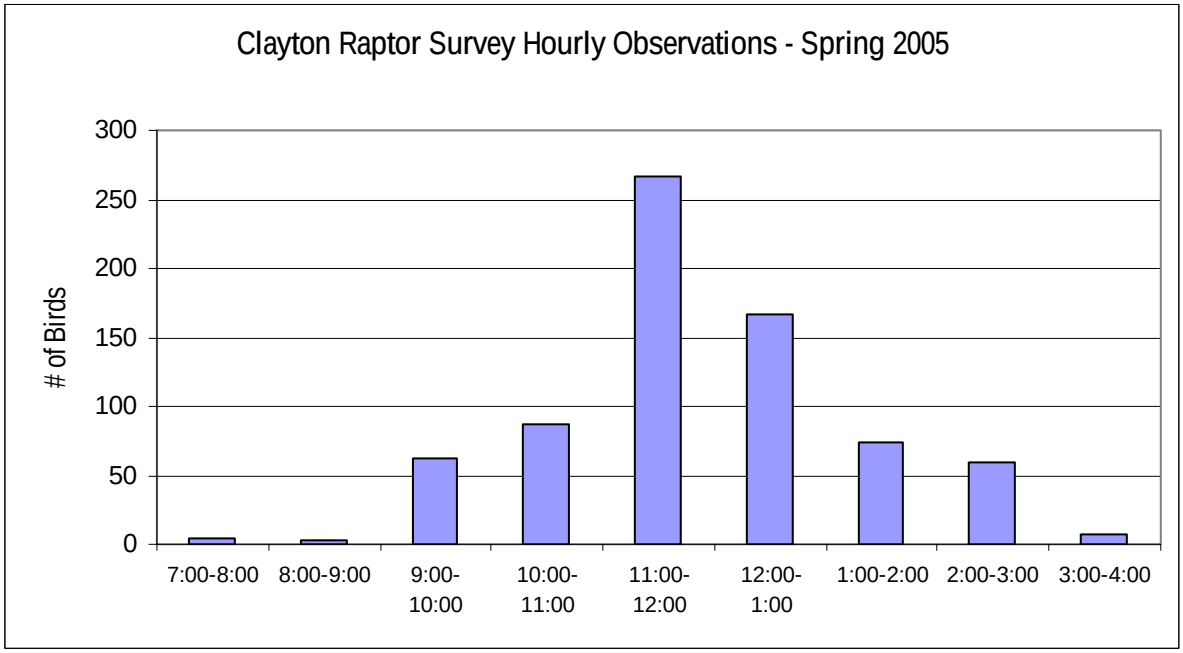


Figure 2-3. Hourly observation rates

Flight heights were categorized as below or above 150 m (492'), or the approximate maximum height of the proposed turbine blades. Overall, 61 percent of the observed raptors were estimated to be flying lower than 150 m.

Differences in flight altitudes between species were also observed (Figure 2-4; Appendix A Table 3). Some species assemblages, such as the accipiters, vultures, and falcons, were consistently observed flying lower than 150 m (492'). In fact, all of the falcons observed were flying below this height. Exceptions to this low-flying trend included broad-winged and red-tailed hawks, of which 58 percent and 41 percent, respectively, were flying less than 150 m above the ground. Overall, no species flew predominately above the 150 m threshold, while several species concentrated below 150 m. We acknowledge that issues of detectability may influence the counts of high-flying raptors.

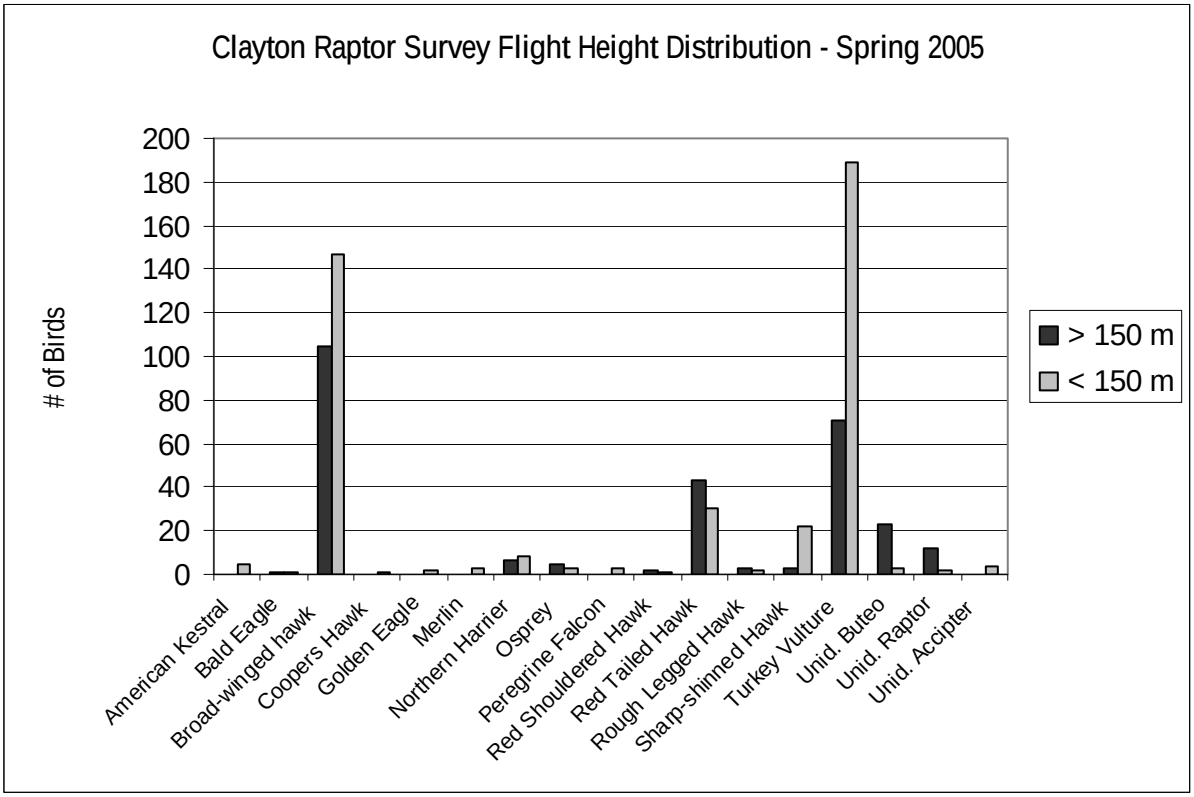


Figure 2-4. Raptor flight height distribution

2.4 Discussion

Raptor migration is a dynamic process responsive to both biotic and abiotic factors, migratory fitness, post-breeding dispersal, individual preferences, weather, and local and regional landscape characteristics. Migration varies by species both temporally and spatially, such that raptors are on the move almost every month of the year in some part of North America. In western NY, raptors moving north each spring become concentrated along the southern and eastern shores of Lake Erie and Lake Ontario because raptors generally prefer to not cross large bodies of water. In fact, raptor migration is so concentrated along these shores that popular hawk-watching sites have been established in Mexico (Derby Hill) and Hilton (Braddock Bay), NY; both along the southeastern shoreline of Lake Ontario. Hawk counts at these sites documented over 23,000 and 30,000 raptors, respectively, in spring 2005. Many of these raptors are presumed to continue flying along the eastern shoreline as they continue their annual migration northward. The Clayton project site is located along this flyway, slightly inland from the northeastern shore of Lake Ontario.

Regional location can affect the intensity of raptor migration at a particular site. Two well-known examples include the coastal observatory at Cape May, New Jersey, and a ridgeline site at Hawk Mountain, Pennsylvania. The location of these sites relative to large, landscape-scale features (coasts, mountain ridges) results in large concentrations of migrating raptors. This likely happens at smaller scales as well, as river valleys and smaller ridgelines may result in more suitable migration conditions (i.e., strong thermal development, crosswinds, and updrafts) with the effect of concentrating raptors along organized pathways. Established hawk survey locations target these areas of known, concentrated raptor migration activity.

At the Clayton project site, the absence of proximate landscape-scale features such as river corridors or mountain ridges played a significant role in the migratory patterns through the project area. This lack of major topography served to distribute migrants fairly evenly across the project area, rather than in a concentrated flight corridor. Also, because of the lack of features to concentrate migrating raptors, relatively few were observed at Clayton than at other lake-side sites. More than 20,000 migrating raptors were observed at each of the two Lake Ontario hawk watch locations (Braddock Bay and Derby Hill). At the Lake Erie site in Hamburg, NY, more than 13,000 raptors were observed. By comparison, only 700 raptors were observed at Clayton. To correct for sampling effort (those sites included counts during nearly every day of the migration period) the passage rate, birds/observation hour, can be observed. The overall passage rate over Clayton was 12.1 birds/hour. Passage rates at Braddock Bay and Derby Hill were 68.8 birds/hour and 61.1 birds/hour, respectively, and the passage rate in Hamburg, NY was 33.2 birds/hour (Appendix A Table 4).

The temporal and spatial flight dynamics of migrating raptors in the project area were variable and were often affected by temperature and wind patterns. Flight paths varied between survey dates and were most influenced by wind direction and speed. The lack of landscape-scale features suitable for creating updrafts meant that most migration movement occurred either via powered flight or after the ground had sufficiently heated to produce thermals (i.e., after 11:00 a.m. on most days). The most abundant species had a protracted migration pattern spanning most survey days, except for broad-winged hawks, the majority of which migrated through the area in a relatively brief, intense push in late April.

Temperatures influenced the daily timing of flights, with the effect of delaying early morning flights and concentrating observations at mid-day. Both wind direction and speed affected specific flight paths and directional trends on any given day were usually dependent on prevailing winds but still always oriented northward. Separating migrants from resident birds was fairly straightforward at this site, given that migratory individuals nearly always flew higher, more purposeful routes in a general northward direction and birds suspected as residents were repeatedly observed flying at lower elevations, hunting, courting, or perching.

The majority of raptors (61%) flew below the 150 m (492') height of the proposed turbine blades. Birds flying below this height should be considered more at risk of possible collision with the turbines, than those flying above the turbine blade height. Generally, it's still largely unknown what avoidance behavior migrating raptors possess when flying near wind turbines. Unpublished observations of hawk migration activity at an existing facility in New England (Woodlot, unpublished data) often included the passage of small raptors (such as sharp-shinned hawks) below the blade-swept area of turbines and the passage of larger raptors well above the turbines. Some observations have also included birds rising above one turbine and then decreasing altitude between turbines. It is unclear, however, if this type of presumed avoidance behavior would be observed at other wind turbine facilities in the East.

2.5 Conclusions

Spring raptor migration surveys indicated that large numbers of raptors utilize the airspace directly over and surrounding the project site. However, passage rates were low at the Clayton site compared to observations from the Derby Hill observatory and other regionally well-known hawk migration survey sites. Observation rates (birds observed per hour of observation) were three to five times lower than these other sites, indicating that the project area may not represent a concentration area for migrating raptors.

Resident birds comprised only a small fraction of the total raptors observed but always flew at relatively low elevations while traveling around the project area. As such, residents were observed flying almost exclusively below the maximum height of the proposed turbines and usually below the blade-swept area.

One of these more commonly observed resident species was the northern harrier, which is currently listed as Threatened in NY. Repeated observations of hunting and courtship activities indicate that this species is nesting in the project area. Another species listed by the State as a Species of Special Concern, the sharp-shinned hawk, is suspected to be nesting within the project area. Observations of this species included one to two individuals undertaking low flights while carrying food, indicative of nesting and chick-rearing activity. Other species listed as rare in the State or regionally were also observed. However, the individuals of those species were suspected to only be migrating through the project area and not nesting within it.

3.0 Nocturnal Radar Survey

3.1 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). Wind turbines can also pose a potential threat to migrating birds as they are relatively tall structures, have moving parts, and may be lit, depending on their height and location (Erickson *et al.* 2000).

Factors that could affect potential collision risk of nocturnally-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 Clayton project area to characterize spring nocturnal migration patterns in the area. The goal of the surveys was to document the overall passage rates for nocturnal migration in the vicinity of the project area, including the number of migrants, their flight direction, and their flight altitude.

3.2 Methods

Field Methods

A single marine surveillance radar similar to that described by Cooper *et al.* (1991) was used to document the night-time movement of migrating birds and bats over the study area. The radar was located in a small field largely surrounded by low trees near the met tower off of Lowe Road in Clayton (Figure 3-1). The radar had a peak power output of 25 kW and the ability to track small animals, including birds, bats, and even insects out to distances of up to 1.2 kilometer (km) (3,937'). The radar cannot, however, readily distinguish between different types of animals being detected. Consequently, all animals observed on the radar screen are called targets.

The radar was equipped with a 2-m (6.5') waveguide antenna. The antenna has a vertical beam height of 20º (10º above and below horizontal) and the front end of it was inclined approximately 5º to increase the proportion of the beam directed into the sky. 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. By utilizing the tree lines around the radar location, ground clutter was reduced as much as possible.

The radar was operated in two modes during each survey hour. In the first (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 number, flight direction, and speed of targets can be determined. In the second (vertical) mode of operation, the antenna is rotated 90º to vertically survey the airspace above the radar (Harmata *et al.* 1999). In vertical mode, target echoes do not provide directional data but do provide information on the altitude of targets passing through the vertical, 20º radar beam.

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 the movement pattern of individual targets. The geographical limits of the range setting used are depicted in Figure 3-1.

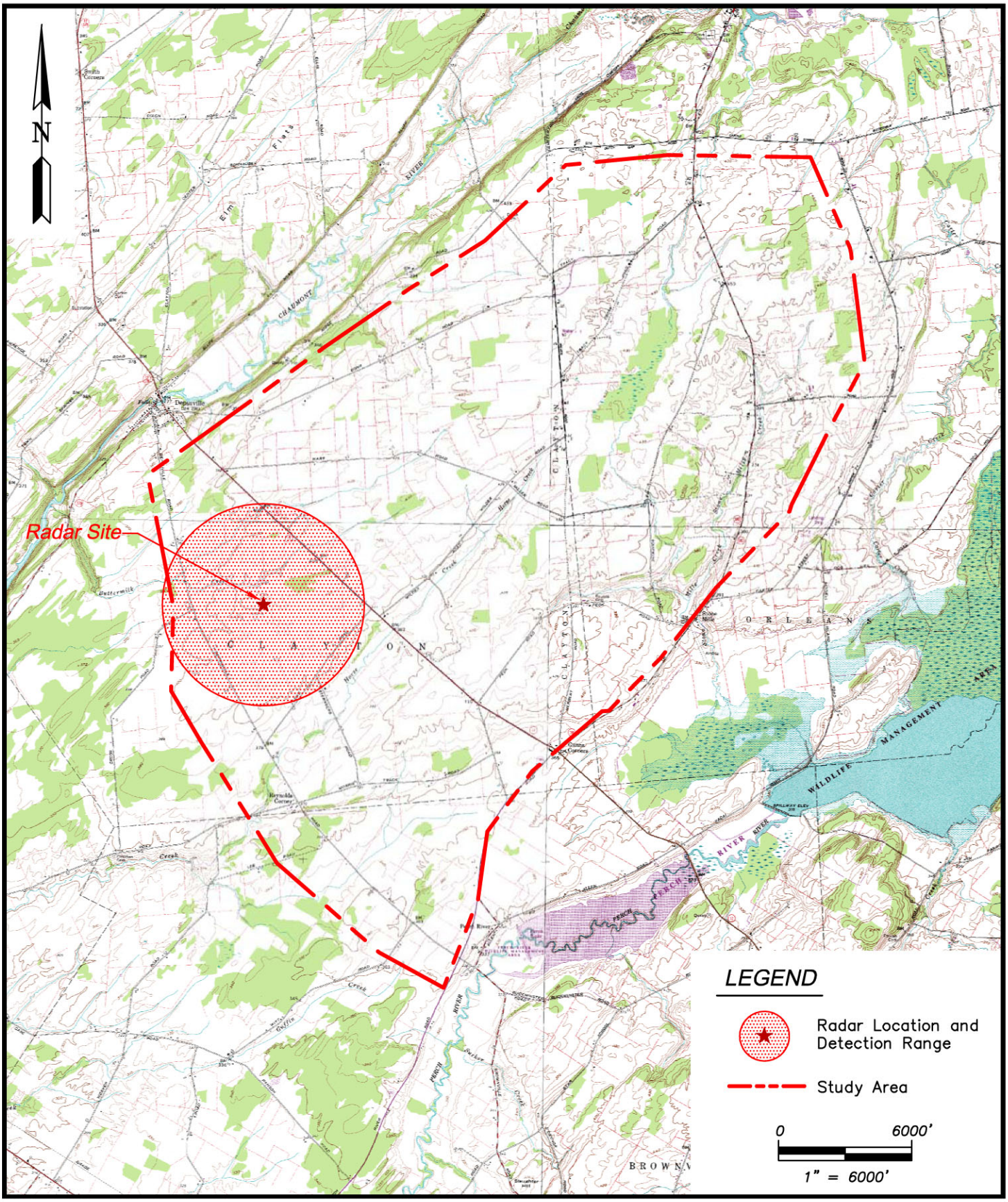
Radar surveys were conducted from sunset to sunrise. Forty-five nights of sampling were targeted between April 15 and May 30, 2005. Because the anti-rain function of the radar must be turned down to detect small songbirds and bats, surveys could not be conducted during periods of inclement weather. Therefore, surveys were targeted 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. In total, 36 nights of sampling were conducted over the 45 targeted nights due to poor performance of the radar because of weather.

Data Collection

The radar display was connected to video recording software of a computer. During surveillance mode, 15 one-minute samples of the radar display were recorded for each survey hour. During vertical mode, a single 10-minute video sample was recorded for each survey hour. The video samples were recorded on the following schedule for each 1-hour period after sunset:

- Seven 1-minute samples during the first 15 minutes after sunset;
- One 10-minute vertical sample during the next 30 minutes; and
- Eight 1-minute samples during the last 15 minutes of the hour.

During the 30-minute period when vertical data were recorded, additional information was also recorded, including weather observations and ceilometer observations. Weather data that was 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 150 m) 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. On nights with a full moon and clear skies, the ceilometer beam was too diffuse to readily detect birds and bats. On those nights, moonwatching (Lowery 1951) was used, which involved watching the face of the moon with binoculars for 5 minutes and recording any observations of birds or bats flying in front of the moon. Observations from each ceilometer or moonwatching period were recorded by hand, including the number of birds, bats and insects observed. This information was used during data analysis to help distinguish between insects from bird and bat targets.



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DATE:	September 2005
SCALE:	1" = 6000'
JOB NO.	105030
FILE:	105030-00-Location.dwg

Figure 3-1
Radar Location Map
Clayton Wind Project
Clayton, New York

REV.

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 compared with wind speed and direction; targets traveling faster than approximately 7 m per second were identified as a bird or bat target. The software tool recorded the time, location, and flight vector for each target traveling fast enough to be a bird or bat. The results for each sample were output to a spreadsheet. For vertical samples, the software tools 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, flight direction, and flight altitude of targets.

Hourly passage rates (in 1-hour increments post sunset) were calculated by tallying the total number of targets in the 1-minute samples for each hour and correcting for the number of samples collected in that hour. That estimate was then corrected for the radar range setting that was used in the field and was expressed as targets/km/hour (t/km/hr) ± 1 SE. The hourly rates were used to calculate passage rates for each night and the entire season.

Mean target flight directions (± 1 circular SD) were summarized in a similar manner: by hour, night, and for the entire season. Flight direction analysis and statistical analyses were conducted 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 calculated using similar methods and data collected from the central met tower, near the radar site. Mean wind speed was calculated using linear statistics (Zar 1999).

Flight altitude data were summarized using linear statistics. Mean flight altitudes (± 1 SE) were calculated by hour, night, and overall season. The percent of targets flying below 125 m (492'), the approximate maximum height of proposed wind turbines, was also calculated hourly, for each night, and for the entire survey period.

3.3 Results

Radar surveys were conducted during approximately 303 hours on 36 nights between April 15 and May 30, 2005 (Table 3-1). The radar site provided generally good visibility of the surrounding airspace and targets were observed in most areas of the radar display unit.

Passage Rates

A total of 2,778 one-minute radar video samples were analyzed during the passage rate and flight direction analysis and included a total of 53,134 targets. Nightly mean passage rates varied from 71 ± 14 t/km/hr (May 22) to 1,769 ± 87 t/km/hr (April 19), and the mean passage rate for the entire survey period was 460 ± 63 t/km/hr (Figure 3-2; Appendix B Table 1).

Table 3-1. Survey dates, level of effort, and weather – Clayton, Spring 2005

Night of	Sunset	Sunrise	Hours of Survey	Weather	Wind Direction (coming from)
Apr 15	7:48 PM	6:18 AM	3	calm and clear	
Apr 16	7:50 PM	6:16 AM	7	calm and clear	
Apr 17	7:51 PM	6:15 AM	11	calm, cloudy then clear	
Apr 18	7:52 PM	6:13 AM	11	calm and clear	
Apr 19	7:53 PM	6:12 AM	3	not available	
Apr 21	7:56 PM	6:08 AM	11	calm and clear	
Apr 24	7:59 PM	6:04 AM	11	light breeze, partly cloudy	SSE
Apr 26	8:01 PM	6:01 AM	6	light breeze, partly cloudy	SE
Apr 27	8:03 PM	5:59 AM	9	calm and mostly clear	SE
Apr 28	8:04 PM	5:58 AM	8	breezy, partly cloudy	SW
Apr 29	8:05 PM	5:56 AM	10	cloudy, mostly calm, light showers early	S
May 1	8:07 PM	5:53 AM	10	calm, partly cloudy, hazy with some rain	SSE
May 2	8:09 PM	5:52 AM	10	light breeze, partly cloudy	WSW
May 4	8:11 PM	5:49 AM	6	calm and clear	
May 5	8:12 PM	5:48 AM	10	calm and clear	E
May 6	8:13 PM	5:47 AM	10	calm and clear	SSE
May 7	8:14 PM	5:46 AM	7	calm and clear	NE
May 8	8:16 PM	5:44 AM	10	calm, partly cloudy then clear	ENE to NE
May 9	8:17 PM	5:43 AM	8	light breeze, partly cloudy then calm and clear	NNE
May 10	8:18 PM	5:42 AM	8	partly cloudy, light breeze, passing showers	NW
May 11	8:19 PM	5:41 AM	7	light breeze, cloudy	SW
May 12	8:20 PM	5:40 AM	10	calm and clear, cold	
May 15	8:24 PM	5:36 AM	6	light breeze, partly cloudy	SW
May 16	8:25 PM	5:35 AM	10	breezy, partly cloudy	SW
May 17	8:26 PM	5:34 AM	10	calm and cloudy	SW
May 18	8:27 PM	5:33 AM	10	calm and cloudy, cold	
May 19	8:28 PM	5:32 AM	10	light breeze, clear	N
May 20	8:29 PM	5:31 AM	8	calm and clear	NE
May 22	8:31 PM	5:30 AM	9	calm and cloudy, light rain	NE
May 23	8:32 PM	5:29 AM	9	light breeze, mostly cloudy, some rain showers	NE
May 24	8:33 PM	5:28 AM	7	light breeze, partly cloudy	NNE
May 25	8:34 PM	5:27 AM	9	light breeze, clear	NE
May 27	8:36 PM	5:26 AM	7	calm and partly cloudy, rain late	NE
May 28	8:37 PM	5:25 AM	9	light breeze, cloudy	NE
May 29	8:38 PM	5:25 AM	8	calm and clear	WSW
May 30	8:38 PM	5:24 AM	5	calm and cloudy	WSW

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

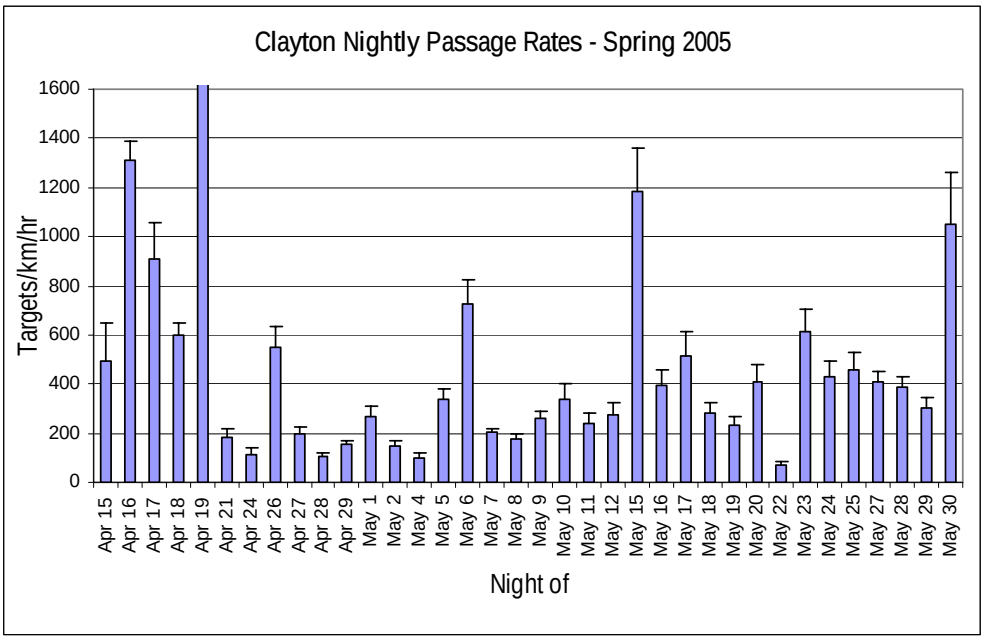


Figure 3-2. Nightly passage rates (error bars = 1 SE) observed.

Individual hourly passage rates throughout the entire season varied from 19 to 1,944 t/km/hr. Hourly passage rates varied throughout each night and for the season overall. In general, passage rates were highest during the third through sixth hours after sunset, followed by a relatively steady decline for the remainder of the night until a sudden rise in activity during the eleventh hour just before dawn (Figure 3-3).

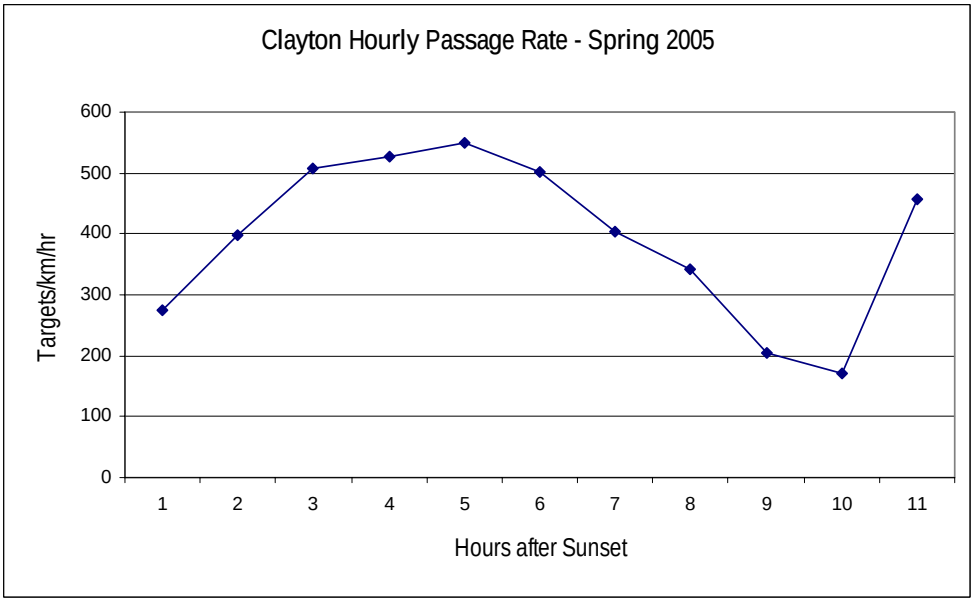


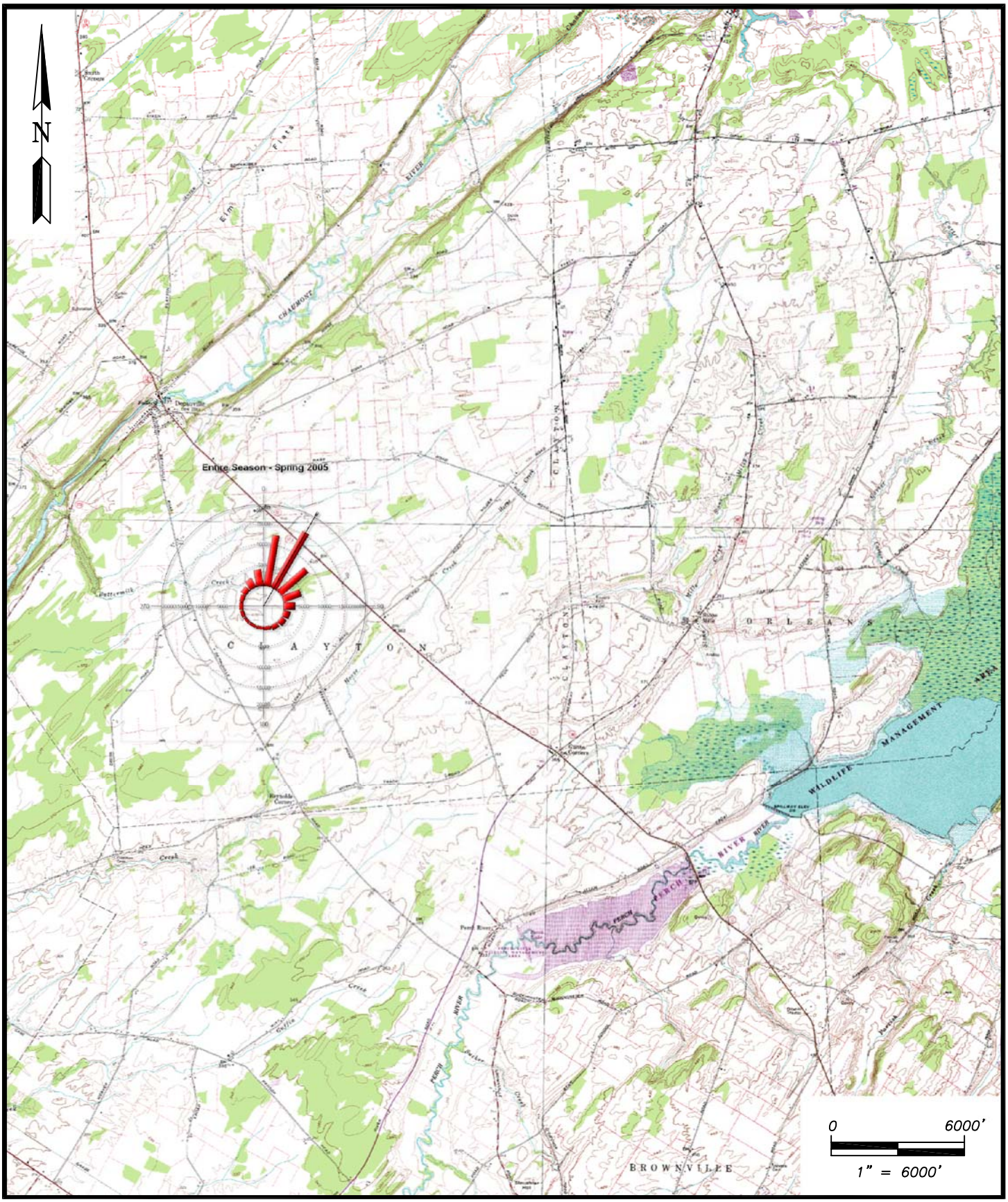
Figure 3-3. Hourly passage rates for entire season.

Flight Direction

Mean flight direction over the radar was 30º ± 53º (Figure 3-4; Appendix B Table 2). There was considerable night to night variation in mean direction, although within each night there was less variation (Figure 3-5). The average nightly flight direction was typically north to northeast on more than three quarters of the nights sampled.

Flight Altitude

The mean flight height of all targets was 443 m ± 38 m (1,453' ± 125') above the radar site. The average nightly flight height ranged from 199 m ± 8 m (653' ± 26') to 753 ± 36 (2,470' ± 118') (Figure 3-6, Appendix B Table 3). The percent of targets observed flying below 150 m (492') also varied by night, from 2 percent to 42 percent (Figure 3-7). The seasonal average percentage of targets flying below 150 m was 14 percent.



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DATE:	September 2005
SCALE:	1" = 6000'
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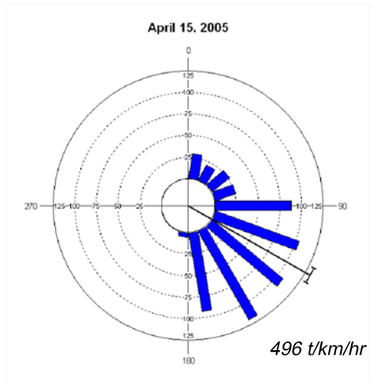
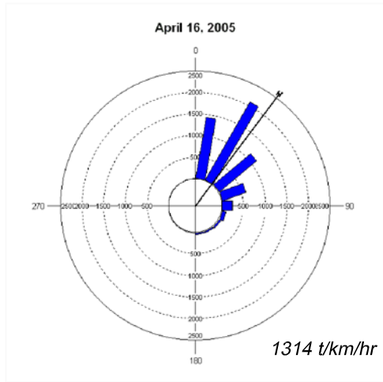
Figure 3-4
Spring 2005 Target Flight Direction
Clayton Wind Project
Clayton, New York

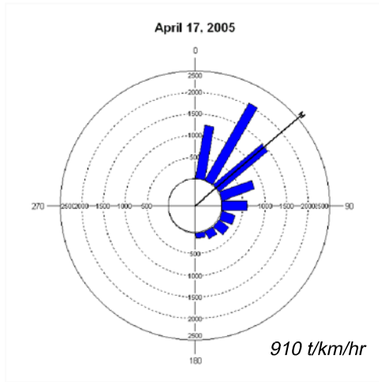
REV.



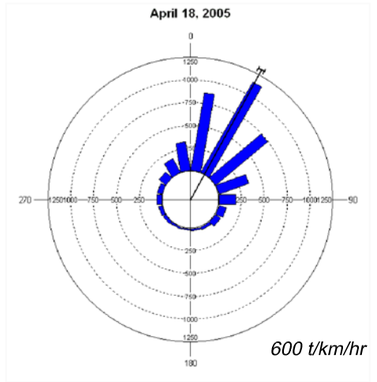
496 t/km/hr



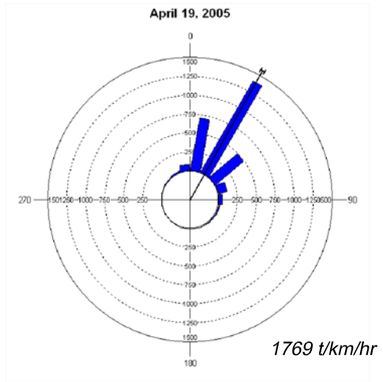
1314 t/km/hr



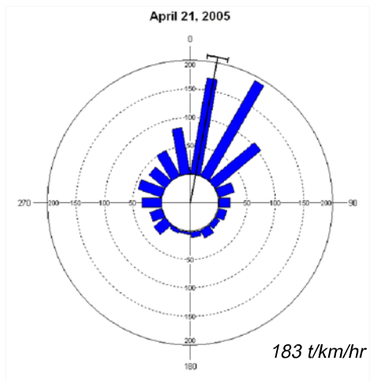
910 t/km/hr



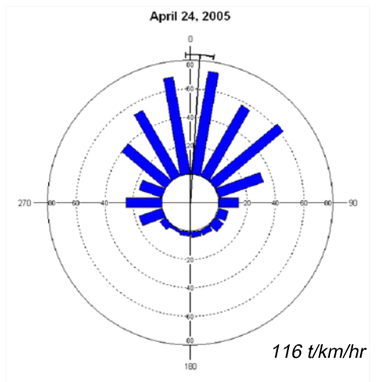
600 t/km/hr



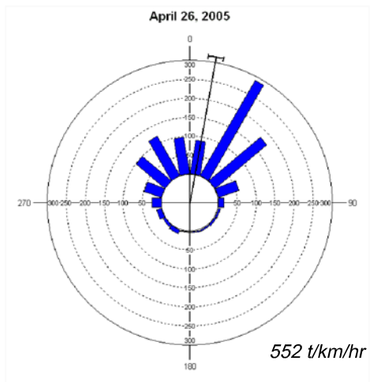
1769 t/km/hr



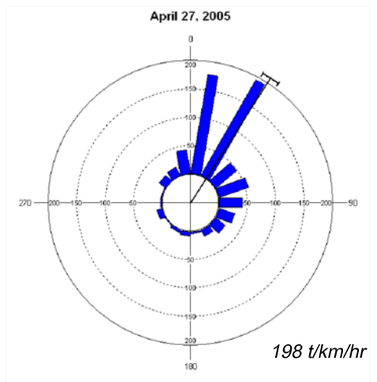
183 t/km/hr



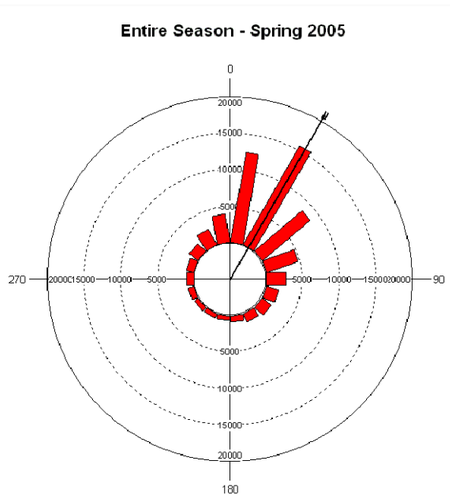
116 t/km/hr



552 t/km/hr



198 t/km/hr



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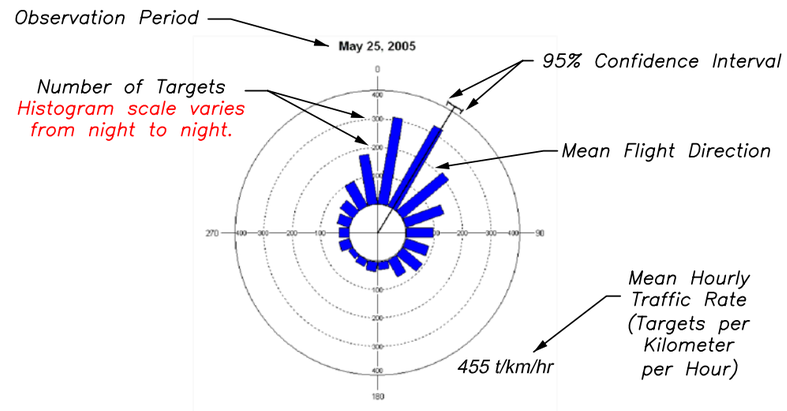


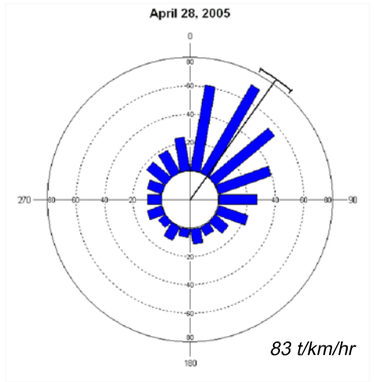
Data rose shows bird targets in directions of 20° increments.

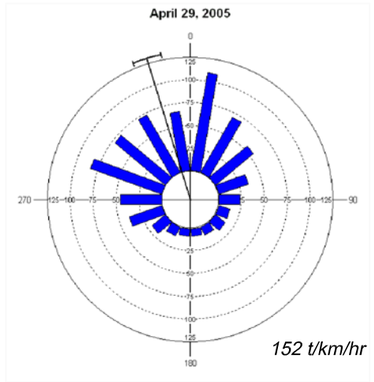
SHEET TITLE: Nightly Mean Flight Direction
SCALE: n/a
DATE: September 2005
NO. | REVISIONS | DATE

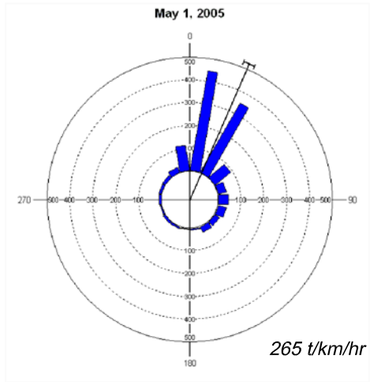
PROJECT: Clayton Wind Project
ADDRESS: Clayton, New York

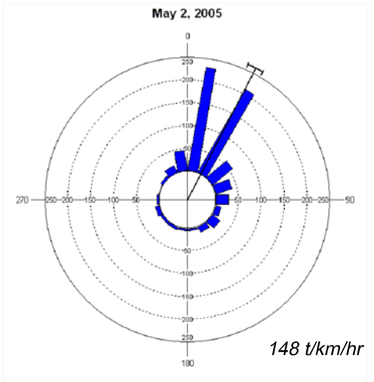
PREPARED BY: WOODLOT ALTERNATIVES, INC. ENVIRONMENTAL CONSULTANTS
105030-00-traffic.dwg

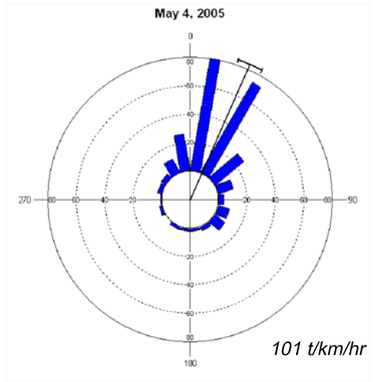
PROJ. NO. 105030
FIGURE NO. 3-5

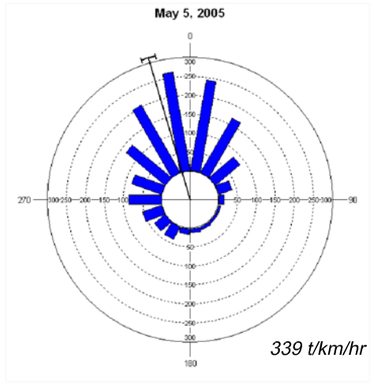


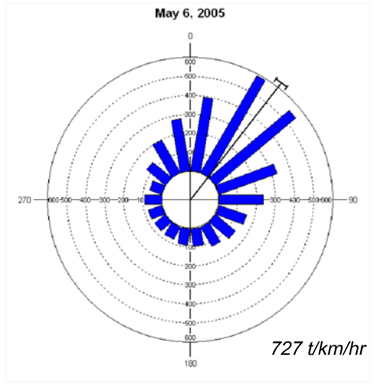


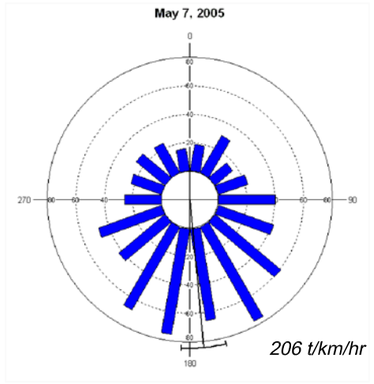


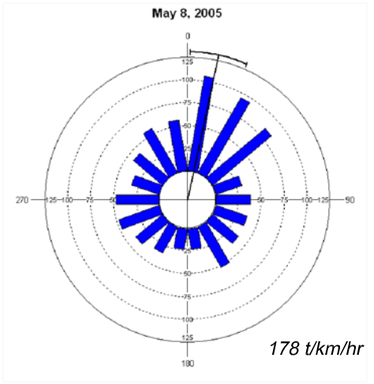


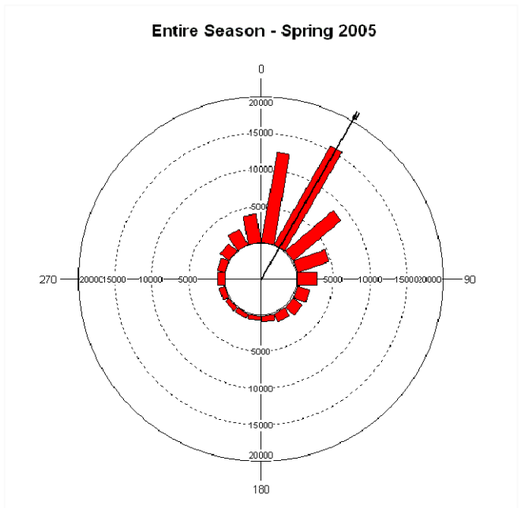












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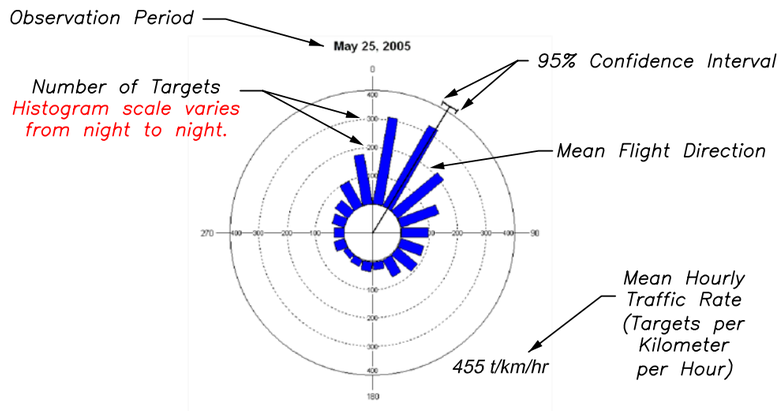
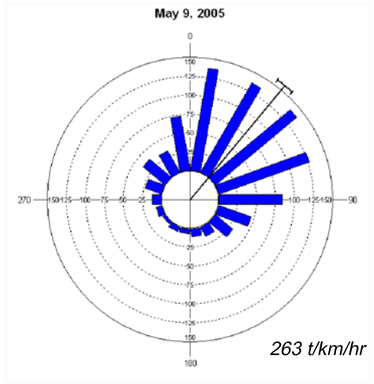
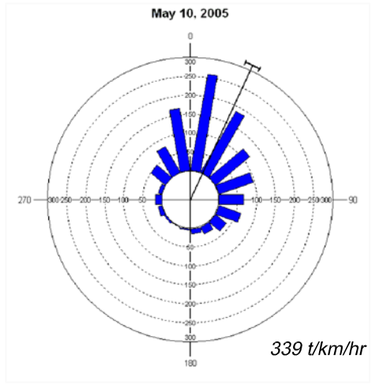


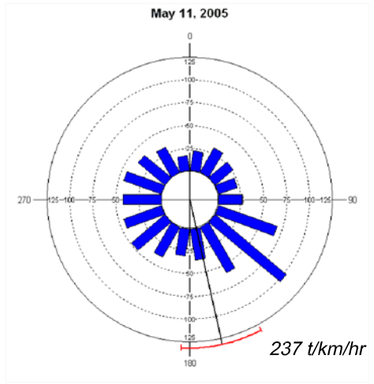
Data rose shows bird targets in directions of 20° increments.

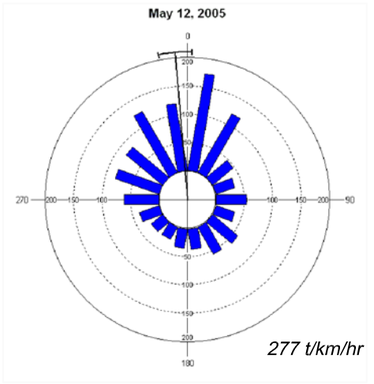
SHEET TITLE:	Nightly Mean Flight Direction
SCALE:	n/a
DATE:	September 2005
PROJECT:	Clayton Wind Project
ADDRESS:	Clayton, New York
PREPARED BY:	WOODLOT ALTERNATIVES, INC. ENVIRONMENTAL CONSULTANTS
	105030-00-traffic.dwg
PROJ. NO.	105030
FIGURE NO.	3-5

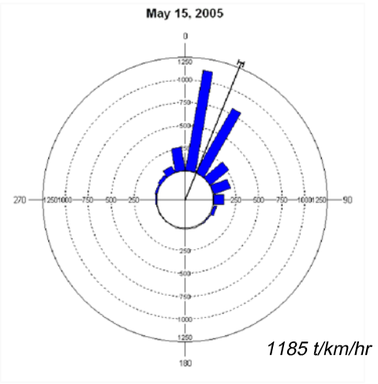
NO.	REVISIONS	DATE

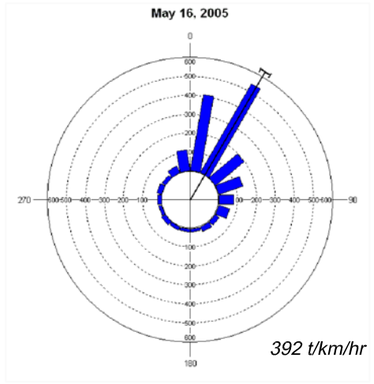


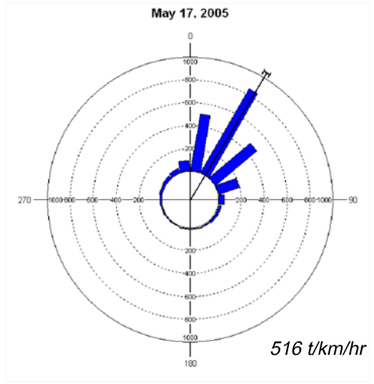


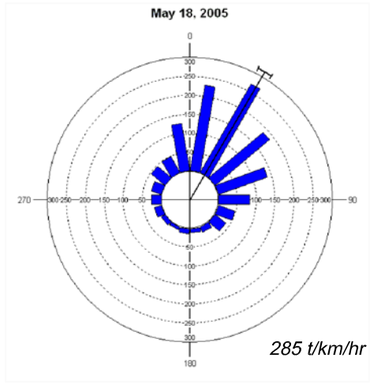


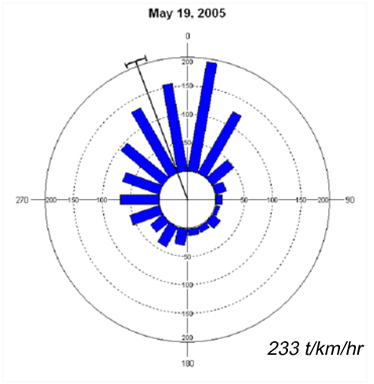


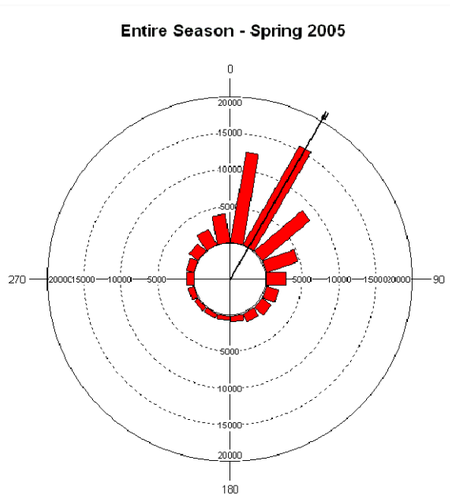












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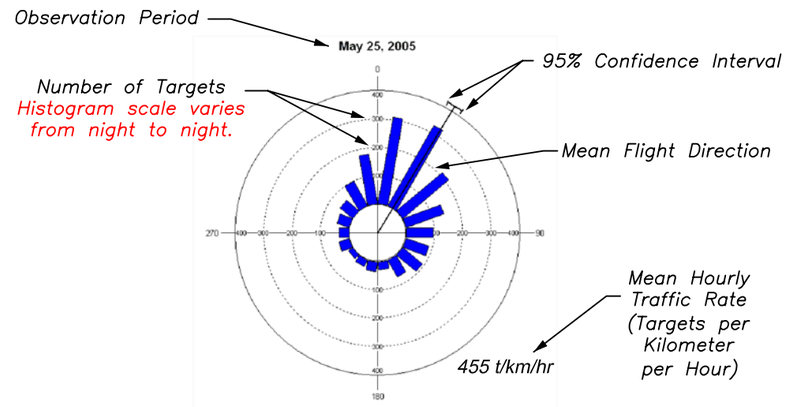


Data rose shows bird targets in directions of 20° increments.

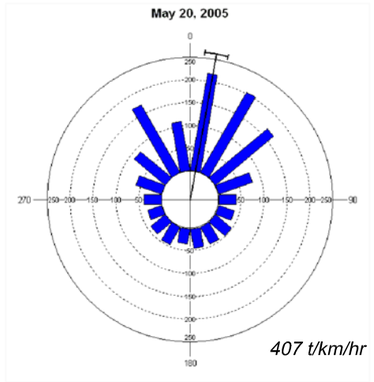
DATE | REVISIONS | NO.

SHEET TITLE: Nightly Mean Flight Direction
SCALE: n/a
DATE: September 2005

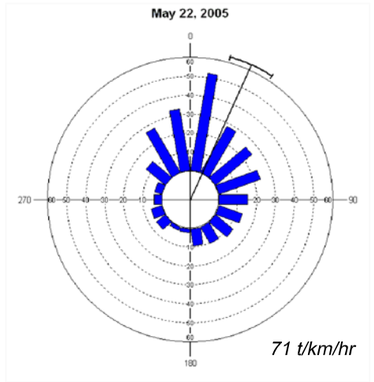
PROJECT: Clayton Wind Project
ADDRESS: Clayton, New York

PREPARED BY: WOODLOT ALTERNATIVES, INC. ENVIRONMENTAL CONSULTANTS
105030-00-traffic.dwg

PROJ. NO. 105030
FIGURE NO. 3-5



407 t/km/hr



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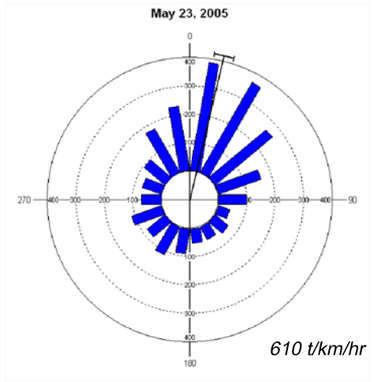

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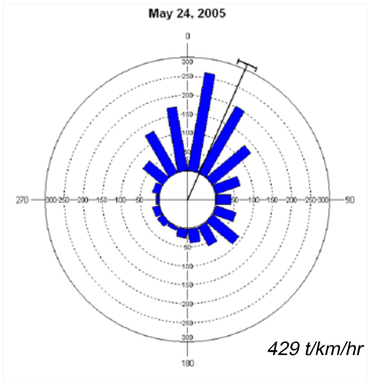

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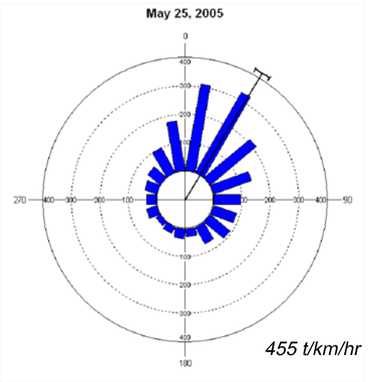
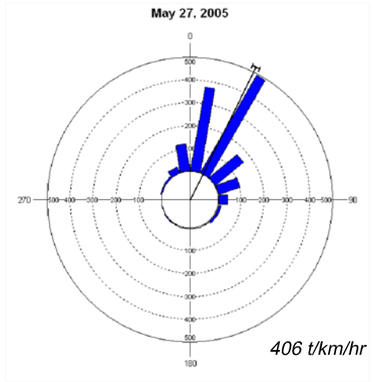


455 t/km/hr



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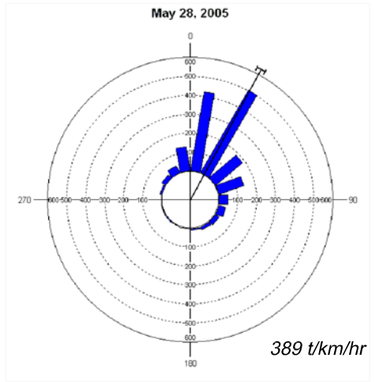
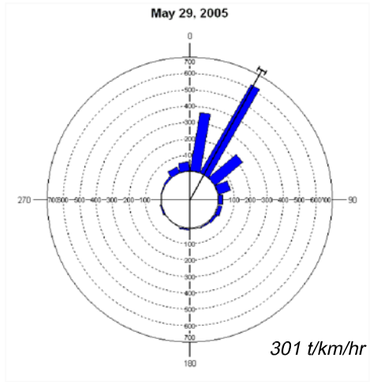


389 t/km/hr



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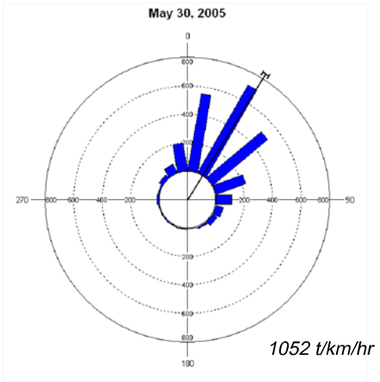
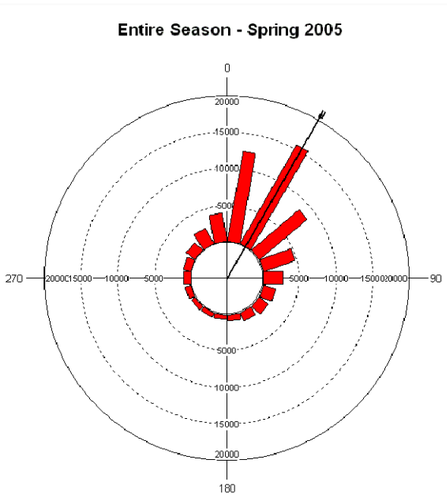
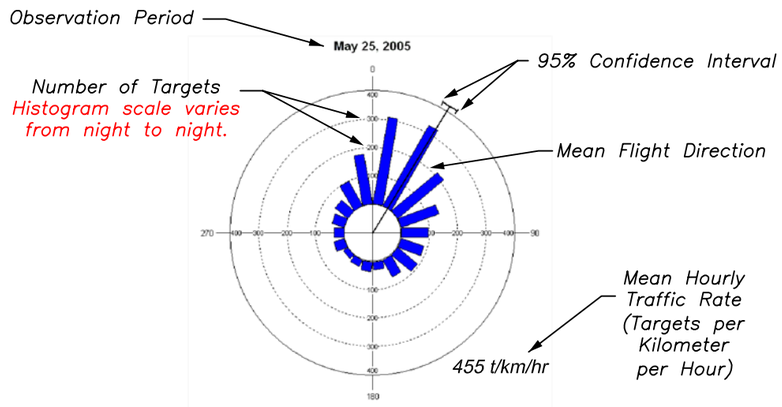


1052 t/km/hr



RADAR DATA ROSE LEGEND



Data rose shows bird targets in directions of 20° increments.

SHEET TITLE:	Nightly Mean Flight Direction
SCALE:	n/a
DATE:	September 2005
PROJECT:	Clayton Wind Project
ADDRESS:	Clayton, New York
PREPARED BY:	WOODLOT ALTERNATIVES, INC. ENVIRONMENTAL CONSULTANTS
	105030-00-traffic.dwg
PROJ. NO.	105030
FIGURE NO.	3-5

NO.	REVISIONS	DATE

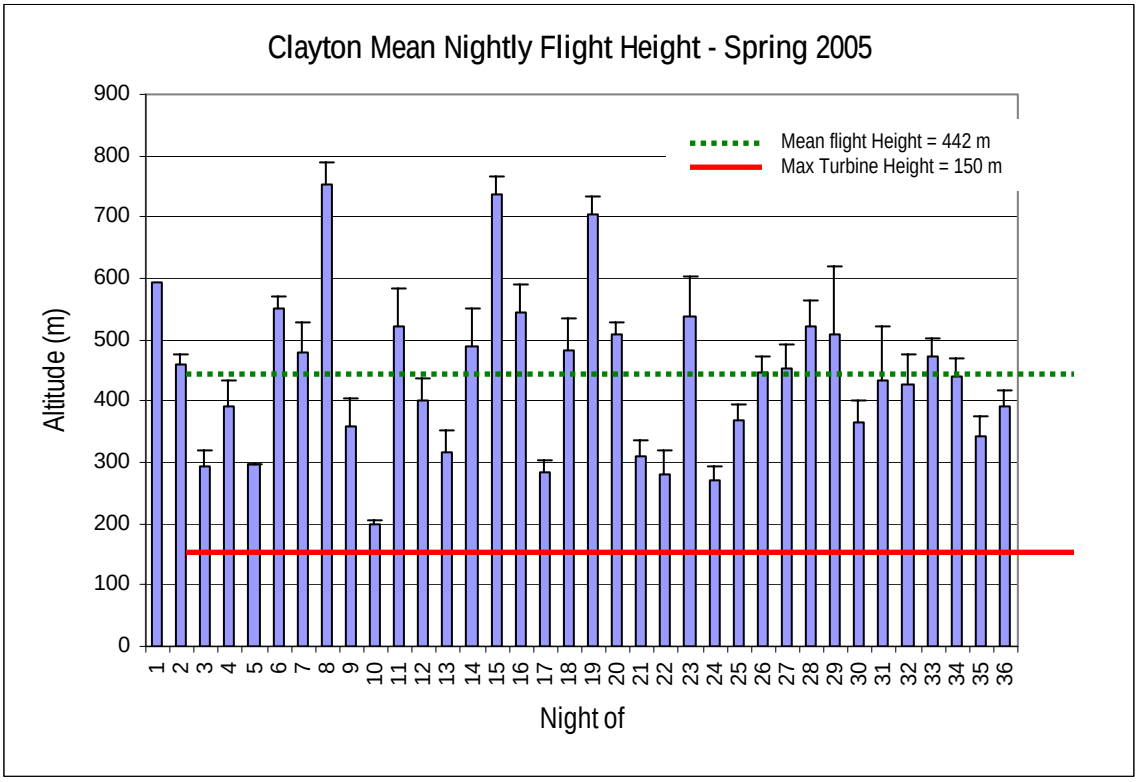


Figure 3-6. Mean nightly flight height of targets

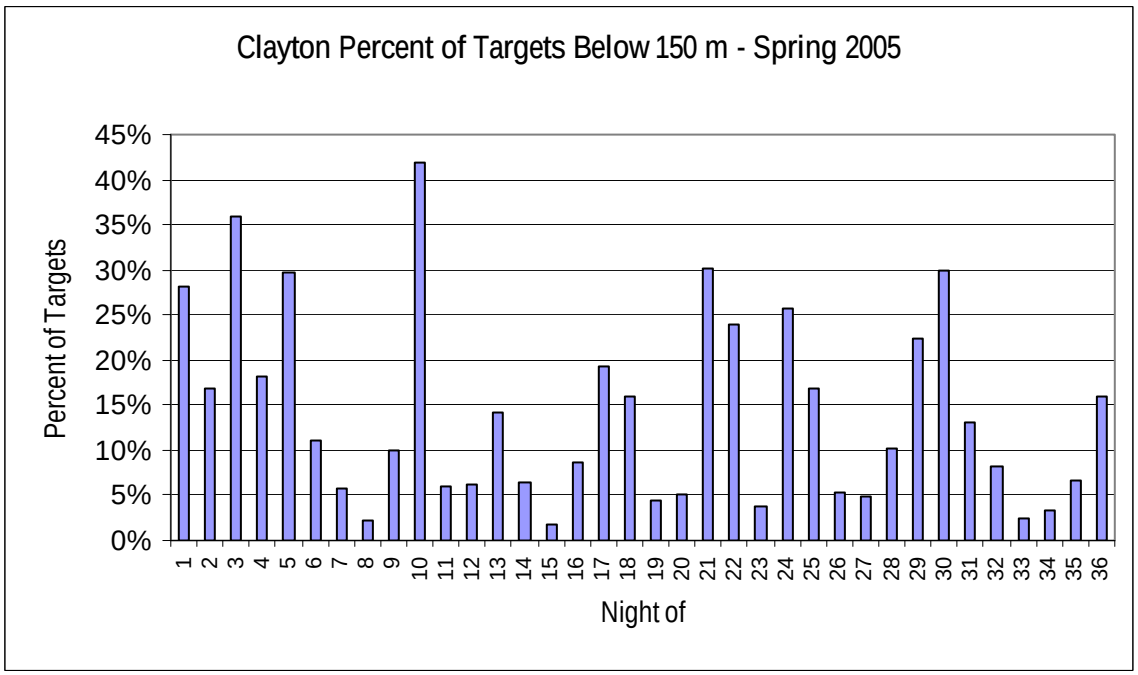


Figure 3-7. Percent of targets observed flying below a height of 150 m (492'')

Hourly flight height was generally consistent throughout the night, except during the first and eleventh hours after sunset when heights were lower (Figure 3-8). This is presumably the time during which migrants are ascending to or descending from their nightly flight height.

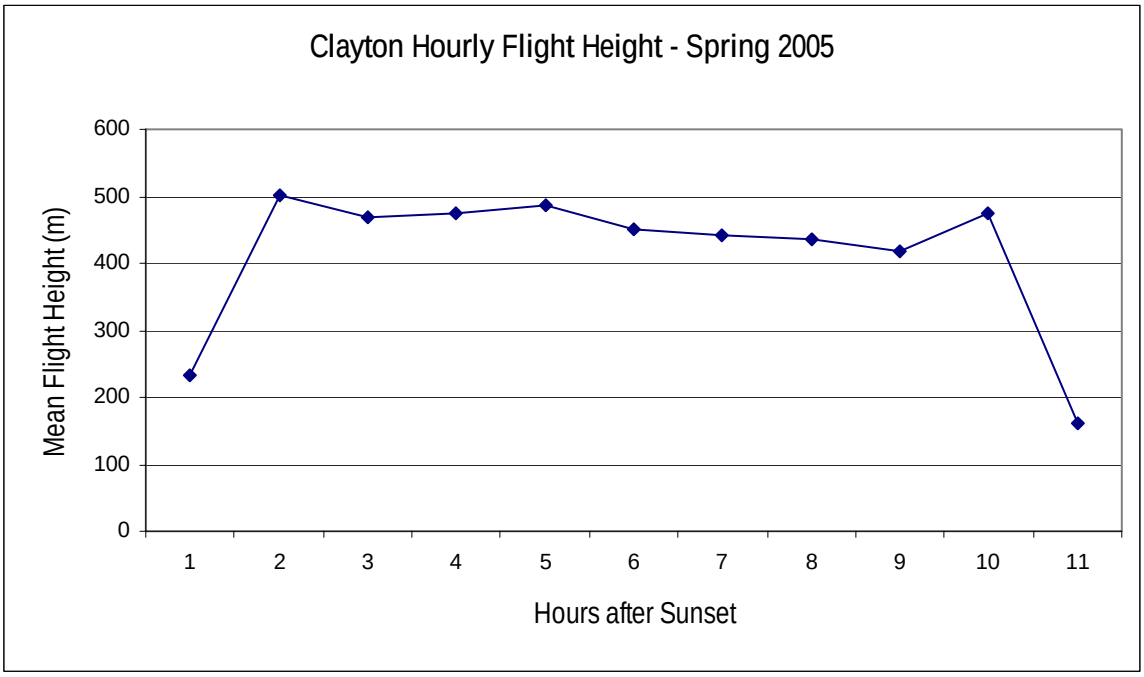


Figure 3-8. Hourly target flight height distribution

Ceilometer Observations

Ceilometer data collected during the radar survey yielded a total of 265 observations. Those observations, however, resulted in relatively few bird observations and relatively light insect activity. Eight birds were observed flying through the ceilometer beam.

3.4 Discussion

Spring 2005 radar surveys documented migration activity and patterns in the vicinity of the proposed Clayton wind project area. 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, Gauthreaux 1971, Richardson 1972, Able 1973, Bingman *et al.* 1982, and Gauthreaux 1991).

Passage Rates

As indicated above, weather patterns are probably the largest factor affecting the magnitude of bird migration, particularly at inland sites. In the spring, an approaching low pressure system typically produces light southerly winds from the west or southwest. Bird migration is often more abundant during these periods because of favorable wind direction for spring migration until the system passes (Richardson 1972). Consequently, nightly migration traffic rates can be expected to be variable and to

peak when the best migration weather occurs. The variable nightly passage rates documented at Clayton are consistent with this. Passage rates were variable on cloudy nights and generally low on nights with fog and passing showers, indicative of the role that weather can play in bird migration activity.

Nightly passage rates varied from 71 ± 14 to 1,769 ± 87 t/km/hr, with an overall mean of 450 ± 62 t/km/hr. Passage rates often peaked 3 to 6 hours after sunset, which is typical of nighttime migration activity (Able 1970; Gauthreaux 1971; Richardson 1971, 1972). However, average hourly flight heights for the entire season were consistent between 2 and 10 hours after sunset.

Few surveys using the same methods and equipment and conducted during the same time period are available for comparison (Table 3-2). In a similar study overlooking Lake Erie in western NY, Cooper *et al.* (2004a) documented spring 2003 passage rates between 15 and 1,702 t/km/hr with an overall passage rate of 395 t/km/hr. Previous studies by the same researchers found lower passage rates both in this general area of NY (Wethersfield) as well as in an upstate area (Carthage).

Table 3-2 Summary of regional spring migration studies using radar (Cooper *et al.* 2004a).

Location	Passage Rate
Chautauqua, NY	395
Carthage, NY	159
Wethersfield, NY	41

There are limitations in comparing that data with data from 2005, as year-to-year variation in continental bird populations invariably affects how many birds migrate through an area. However, nightly mean passage rates observed at Clayton were within the range of those studies.

Flight Direction

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

Evidence suggesting topographic effects to night-migrating birds has typically included areas of varied topography, such as the Alps and most rugged areas of the northern Appalachians. The landscape around the Clayton project area is very flat, with low hills. This is considerably less than in those other areas where potential topographic effects on flight direction have been observed. The mean flight direction was 30º ± 53º and there are no indications that the topography is altering the movement of migrants through the area.

Flight Height

The altitude at which nocturnal migrants fly has been one of the least understood aspects of bird migration. Bellrose (1971) flew a small plane at night along altitudinal transects to visually document the occurrence and altitude of migrating songbirds. He found the majority of birds observed were between 150 m and 450 m (492’ to 1,476’) above the ground level, but on some nights the majority of birds observed were from 450 m to 762 m (1,476’ to 2,500’) above the ground. Radar studies have largely confirmed those visual observations, with the majority of nocturnal bird migration appearing to occur less

than 500 m to 700 m (1,640' to 2,297') above the ground (Able 1970, Alerstam 1990, Gauthreaux 1991, Cooper and Ritchie 1995).

Recent studies at other proposed wind facilities in the Northeast and Mid-Atlantic states are consistent with this as well. Cooper *et al*. (2004a) documented a mean overall flight altitude of 528 m ± 3 m during a spring migration survey in Chautauqua, NY. The highest percentage (36%) of migrants was documented 300 m to 600 m above the ground and the smallest percentage (0.1%) above 1,401 m. In western NY, Cooper *et al*. (2004a) documented a mean flight altitude of 532 m with a small percentage (4%) of targets flying less 125 m above the ground. Results from Clayton are similar to those of Cooper *et al*. (2004a,b), with nightly flight altitudes varying from 199 m ± 8 m to 753 m ± 118 m and a mean of 443 m ± 38 m. The percentage of targets flying less than 150 m above the ground was low (14%), also similar to that found by Cooper *et al*. (2004a).

3.5 Conclusions

Radar surveys during the spring 2005 migration period have provided important information on nocturnal bird migration patterns in the vicinity of the Clayton project area. The results of the surveys indicate that bird migration patterns are generally similar to patterns observed at other sites in the region.

Migration activity varied throughout the season, which is probably largely attributable to weather patterns. The mean passage rate (460 ± 63 t/km/hr) is higher than that observed at similar studies, although the range in nightly passage rate (71 ± 14 to 1,769 ± 87 t/km/hr) is similar to those other studies during the previous fall. Migration activity throughout each night typically peaked 5 hours after sunset with a sudden rise in activity just before dawn. Flight direction for the entire season was 19° ± 83°. Flight direction data indicate that nocturnal migrants are not avoiding the project area for any topographic-related reasons.
The average flight altitude above the ground was 443 m ± 38 m. Only 14 percent of the targets observed during vertical radar operation were flying below an altitude of 150 m (492'), the height of the proposed turbines, indicating that risk of collision to night-migrating birds is limited to a very small subset of those birds.

Risk to nocturnally-migrating birds is known to occur, particularly during periods of inclement weather that can force birds to fly at lower heights and decrease night-time visibility. No consistent trend between flight height and weather patterns was observed. However, nights with inclement weather, which could be associated with increased risk, typically had low passage rates. While increased risk potential could develop due to inclement weather, the prediction of those events cannot be reliably made because night to night variation in flight characteristics occur, even on nights with similarly unsuitable migration weather.

4.0 Bat Survey

4.1 Introduction

Wind projects have been cited as a potential threat to migrating bats for a number of years, especially since a study at the Mountaineer Wind Energy Facility in Tucker County, West Virginia, documented 475 dead bats between April 20 and November 9, 2003 (Johnson and Strickland 2004). Subsequent fieldwork in 2004 at the Mountaineer site and nearby Meyersdale Wind Facility has revealed even higher rates of bat collision mortality with operating wind turbines (Arnett *et al.* 2005). These studies have raised numerous concerns regarding the potential for collision mortality associated with wind turbines to impact bat populations (Williams 2003). The concerns lie primarily with wind farms in the eastern United States, where documented bat fatality rates have been considerably higher (bats per turbine per year) than at western wind farms (Williams 2003, Arnett *et al.* 2005).

Researchers currently have limited understanding of the specific factors influencing rates of bat collision mortality, although evidence from the timing of fatalities documented at existing wind facilities and other structures suggests that migrating bats are at the highest risk (Johnson and Strickland 2004, Johnson *et al.* 2003, Whitaker and Hamilton 1998). A number of plausible hypotheses explaining the high rates of bat mortality have been presented by bat researchers, but none of these have been adequately tested. The most likely mechanisms explaining bat collision center on the possibility that ridges act as corridors for migrating or feeding bats, that bats are unable to detect turbines visually or by echolocation, or that bats may be attracted to wind turbines due to artificially high insect concentrations, light attraction, or acoustic attraction (Arnett *et al.* 2005).

Nine species of bats occur in NY, based upon their normal geographic range. These are the little brown myotis (*Myotis lucifugus*), northern myotis, (*Myotis septentrionalis*), Indiana myotis (*Myotis sodalis*), Eastern small-footed myotis (*Myotis leibii*), silver-haired bat (*Lasionycteris noctivagans*), Eastern pipistrelle (*Pipistrellus subflavus*), big brown bat (*Eptesicus fuscus*), Eastern red bat (*Lasiurus borealis*), and hoary bat (*Lasiurus cinereus*) (Whitaker and Hamilton 1998). Of these, the Indiana myotis is listed as federally endangered, and the small-footed bat is listed as a special concern species by the State. According to the NYDEC, eight Indiana myotis hibernacula are present in NY, located in Albany, Essex, Jefferson, Onondaga, Ulster, and Warren counties (NYDEC website, accessed 8/4/05). Clayton is located near the center of Jefferson County, in north central NY. Due to the proximity of the Clayton site to known Indiana myotis hibernacula, it is highly likely that the species is present in the study area. This was confirmed by the NYDEC in the spring of 2005 during a radio telemetry study (pers. comm. Al Hicks, NYDEC).

To document bat occurrence in the area of the proposed wind project, Woodlot conducted acoustic monitoring surveys from April 20 to May 30, 2005. Visual ceilometer observations were also made between April 15 and May 30, 2005, concurrent with a nocturnal radar study. Acoustic surveys were the primary survey type used in this study, and were designed to document bat passage rates in different habitat types and from ground level to heights of 20 m (66').

A primary goal of these surveys was to attempt to document the presence of bats migrating and foraging in and near the rotor zone of the proposed wind project. The majority of bats found in the eastern United States migrate, gather together near hibernacula, or enter hibernation between late July and early November (Whitaker and Hamilton 1998). Because recent research indicates that migrating bats appear to have a higher risk of collision with wind turbines than birds, most mortality at a wind farm would be

expected to occur during the fall and spring bat migrations, the timing of which depends upon the bat species and the location.

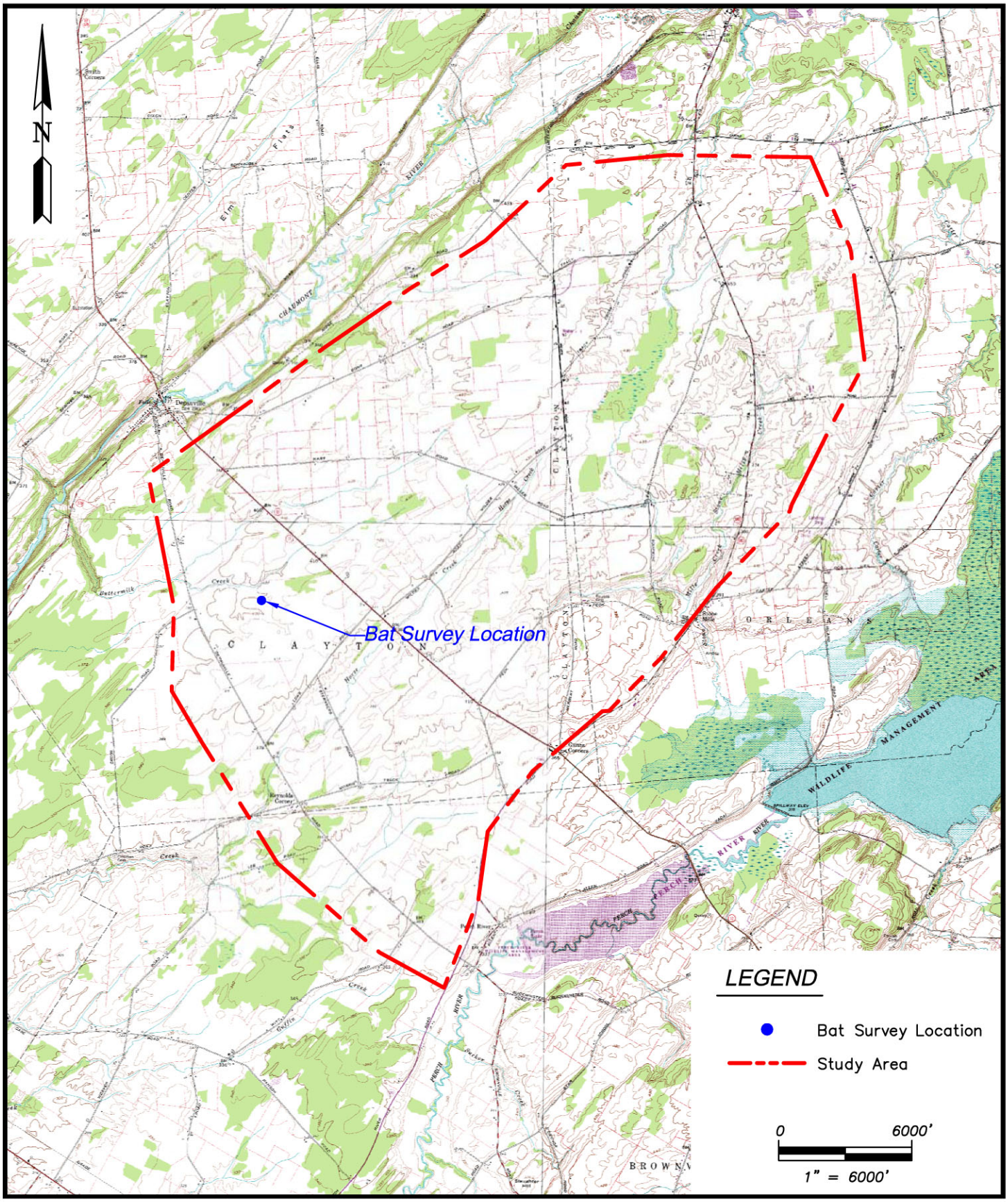
4.2 Methods

Field Surveys

Anabat II detectors were used for the duration of this study. Anabat detectors are frequency-division detectors, dividing the frequency of ultrasonic calls made by bats (a factor of 16 was used in this study[2]) so that they are audible to humans. These detectors are able to detect all bat species known to occur in New England using this setting. Data from the Anabat detectors were logged onto compact flash media using a CF ZCAIM (Titley Electronics Pty Ltd) and downloaded to a computer for analysis.

The acoustic surveys were designed primarily to document the occurrence and detection rates of bats near the ground and at heights near the low end of the blade-swept area of the proposed turbines. To do this, one to two detectors were suspended from the guy wires of the met tower near Lowe Road in Clayton (Figure 4-1). The two detectors were suspended at heights of 15 m and 20 m (49' and 66') from the met tower guy wires. Detectors were programmed to record data from 7:00 p.m. to 7:00 a.m. nightly, resulting in 12 hours of sampling per detector per night.

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



PREPARED BY:

WOODLOT ALTERNATIVES, INC.
ENVIRONMENTAL CONSULTANTS

DATE:	September 2005
SCALE:	1" = 6000'
JOB NO.	105030
FILE:	105030-00-Location.dwg

Figure 4-1
Bat Survey Location Map
Clayton Wind Project
Clayton, New York

REV.

Data Analysis

Call files were extracted from data files using CFCread© software, with default settings in place. Nightly tallies of detected calls were compiled for each detector. Mean detection rates (calls/hour and calls/night) were calculated for each night. These were summarized by time period within the migration season and detector location (15 m or 20 m high in the met tower). Detection rates indicate only the number of calls detected, and do not necessarily reflect the number of individual bats in an area.

Ultrasonic calls of bats are attenuated quickly by the atmosphere, and are only able to travel limited distances, depending upon their frequency (Griffin 1970, 1971). Also, Anabat detectors have a limited range of roughly 10 m to 15 m (33' to 49'). This was confirmed at the beginning of the survey period using an artificial "bat chirp" device and field tests with flying bats. Consequently, the height of bat calls recorded by the detectors deployed in the met tower was assumed to be roughly that of the detector that recorded the bat.

In addition to documenting passage rates, acoustic surveys with Anabat II detectors allow for limited species identification (O'Farrell and Gannon 1999). Because bat calls vary widely within species, and are influenced by habitat and region, definitive species identification based upon acoustic monitoring alone is not always possible. However, several of the species that are present in this area have calls that appear distinct when recorded with the Anabat system.

Qualitative visual comparison of recorded call sequences of sufficient length to reference libraries of bat calls allows for relatively accurate identification of bat species (O'Farrell *et al*. 1999a). Calls recorded during the survey were compared to reference calls compiled by Chris Corben, the designer of the Anabat II software used in this study, and data from the University of Maine Mammalogy Department. These reference calls were of western and northeastern origin and served as a basis for differentiating the calls that were recorded. Recorded calls were classified based upon the shape of the call sequence, the slope, and the maximum and minimum frequencies. Calls with insufficient material upon which to determine the species were classified as unknown. Because calls within the *Myotis* genus are so similar, they were not identified to the species level.

Ceilometer Surveys

As noted in Section 3.2, ceilometer surveys took place for 5 minutes during each hour of radar sampling. While species identification was not possible, targets were classified as either bats or birds and helped provide insight into the composition of the migrant animal population that occurred at low altitudes. The ceilometers were held in-hand so that animals passing through the light beam were followed for several seconds.

4.3 Results

Acoustic Monitoring

During the sampling period, a total of 67 bat call sequences were detected and recorded (Table 4-1). Of the total bat passages detected while high and low bat detectors were operating simultaneously, 55 (83%) were detected by the high bat detector, operating at a height of roughly 20 m (66'). This results in detection rates of 1.6 calls/night of survey and 0.9 calls/detector-night. Bats were detected between May 5 and May 28, with the peak passage rates occurring on May 6, when 15 call sequences were detected.

Table 4-1. Summary of bat calls detected at Clayton, NY, during spring 2005 surveys.			
Species	**High**	**Low**	**Total**
Big brown Bat	21	6	27
Hoary Bat	0	1	1
Silver-haired Bat	18	0	18
Myotis sp.	8	4	12
Unknown	8	1	9
Entire Season	**22**	**12**	**34**

Recorded calls were classified by species based upon the shape of the call sequence, the slope, and the maximum and minimum frequencies. Visual comparisons were made to libraries of known reference calls. Of the 67 recorded calls, 27 were identified as big brown bats, 18 as silver-haired bats, 12 as *Myotis* sp., and one as a hoary bat. Nine calls were classified as "unknown," due to insufficient material on which to base an identification. Because calls within the genus *Myotis* are so similar, we did not attempt to differentiate between species.

Ceilometer Data

Ceilometer data collected during the radar survey yielded a total of 265 observations. Those observations, as is typical, resulted in no bat observations.

4.4 Discussion

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

This study aimed to document passage rates of bats in and near the blade-swept zone of the proposed wind farm. Spring sampling at Clayton revealed very low levels of bat activity in late April, and moderate levels of bat activity during the month of May. Bats were recorded 21 of the 42 nights sampled. The majority (72%) of call sequences was detected during the first 4 hours of the night (between 8:00 p.m. and midnight). Detection rates were 1.6 calls/night for the 42 nights, but were 0.9 calls/detector-night when corrected for the number of detectors deployed and operating.

Of the 67 recorded calls, the majority were identified as big brown bat (27), silver-haired bat (18), and *Myotis* sp. (12). We did not attempt to differentiate between species within the genus *Myotis*, which includes the federally endangered Indiana myotis. However, most of the *Myotis* calls that were detected at Clayton were between 40 and 60 kHz, which is somewhat lower than the frequency of Indiana myotis calls, and most closely resembled the call shape of little brown bats. Clayton is located in Jefferson County, which is one of six counties in NY known to contain at least one Indiana myotis hibernacula. The nearest of which is located near Brownville, 16 to 32 km (10 to 20 miles) south of Clayton.

The ability to identify bats by acoustic methods requires significant amounts of practice and the accuracy of this method has been debated (O'Farrell *et al.* 1999b). The quality and length of recorded calls also influences the degree to which identification is possible (O'Farrell and Gannon 1999). The species identifications presented in this report are based on call analysis alone, and therefore are subject to error. The greatest potential for false identification would be in differentiating between big brown and silver-haired bats, due to the similarity of their call structure.

Data from spring bat surveys at Clayton revealed higher levels of bat activity at 20 m (66') than at 15 m (49'). Eighty-three percent of bat passages were detected by the high detector. The high and low detectors both functioned properly throughout the survey period, and were configured in exactly the same manner, although slight differences in sensitivity may have existed between the two detectors. Species detected by the high and low detectors were similar, although no silver-haired bats were detected by the low detector.

Emerging information on the potential susceptibility of bats to wind turbine-induced mortality indicates that some species may be particularly vulnerable to collisions with turbines. The tree roosting bats, (hoary and eastern red bats), along with the silver-haired bat, appear to have a higher risk of collision with wind turbines, based on mortality data collected at existing facilities. Although these species are all relatively common, they have constituted disproportionably large percentages of bat fatalities at existing facilities.

Ultrasonic calls of bats are attenuated quickly by the atmosphere and are only able to travel limited distances, depending upon their frequency (Griffin 1970, 1971). Anabat detectors have a limited range, roughly 10 m to 15 m (33' to 49'), based upon trials with an artificial "bat chirp" and field tests with flying bats. Due to these factors, a single Anabat II detector samples a cone of airspace approximately 45º wide and 9 m to 15 m (30' to 49') deep. Therefore, the detection distance of the upper detector, at 30 m (98'), would extend only 3 m to 5 m (10' to 16') into the bottom of a wind turbine's blade-swept area, representing only roughly 1 to 3 percent of that area.

Detectors were unable to sample bat passage rates in the central and upper regions of the rotor zone, which are at heights of approximately 80m (262') and 110 m (361'). It is not known whether or not certain bat species migrate at these higher altitudes. Because our detectors sampled only to roughly 20 m (66'), our methods would not have detected bats that may have been flying at higher altitudes. Additionally, our methods only allow the detection of bats that are producing ultrasonic signals. One possible explanation for why migrating bats may collide with turbines is that they do not use their echolocation system while migrating. This would either mean that bats do not monitor reflected echolocation signals, or that they do not produce ultrasonic signals when migrating, in which case they would be invisible to acoustic bat detectors. This possibility must be taken into account when interpreting data from acoustic monitoring surveys.

4.5 Conclusions

Acoustic bat surveys revealed very relatively low numbers of bats in the Clayton site during spring 2005. Bats were detected between April 24 and May 28, although the greatest number of bats detected in one night was two bats on the night of May 6. More bat passages were detected at the high detector than at the low detector at the Clayton site.

No definitive determination of the presence or absence of any rare bats from the project area can be made. Although 12 calls were identified as belonging to the genus *Myotis*, these calls could not be positively

identified to species. The Clayton site is known to be used by Indiana bats and calls recorded during the spring survey could be those of this species.

The many factors that may influence bat collision rates with wind turbines are largely unknown, it is impossible to accurately predict whether or not a wind facility will cause significant bat mortality before it is operational. Many of the theories explaining bat collisions, such as acoustic attraction and insect concentration, suggest that the operation of the turbines may actually attract bats. Because acoustic monitoring surveys detect only those bats that are producing ultrasonic signals, and because this survey technique samples a very small air space relative to the rotor zone of a single wind turbine, let alone an entire wind facility, results from these surveys must be interpreted with caution. Acoustic sampling reveals activity patterns, species distributions, and can document bats' presence in the air space near the rotor zone of wind turbines, but cannot monitor the entire rotor zone of a turbine, and cannot predict how bats might interact with an operational turbine.

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Appendix A

Appendix A Table 1. Summary of Daily Raptor Migration Surveys

Species	3/30/2005	3/31/2005	4/11/2005	4/12/2005	4/20/2005	4/24/2005	4/28/2005	4/29/2005	5/6/2005	5/7/2005	Entire Season
American Kestrel		1	1	1			2				5
Bald Eagle							1		1		2
Broad-winged hawk					4	3	205	37	3		252
Coopers Hawk							1				1
Golden Eagle						1	1				2
Merlin	1			1						1	3
Northern Harrier	3	1	3			1			4	2	14
Osprey					1	2	1		4		8
Peregrine Falcon						1	2				3
Red Shouldered Hawk	1	1							1		3
Red Tailed Hawk	9	34	11		1	4	5	5	2	2	73
Rough Legged Hawk	1	3	1								5
Sharp-shinned Hawk			4	1	1		15	1	1	2	25
Turkey Vulture	8	42	88	50	9	11	19	11	11	11	260
Unid. Accipter							3		1		4
Unid. Buteo	8	3				2	7	2	2	2	26
Unid. Raptor	2	2				1	7	1	1		14
Entire Season	**33**	**87**	**108**	**53**	**16**	**26**	**269**	**57**	**31**	**20**	**700**

Appendix A Table 2. Summary of Hourly Raptor Observations

Species	9:00-10:00	10:00-11:00	11:00-12:00	12:00-1:00	1:00-2:00	2:00-3:00	7:00-8:00	8:00-9:00	3:00-4:00	Entire Season
American Kestrel	1		2		1	1				5
Bald Eagle				1	1					2
Broad-winged hawk	13	19	126	80	13	1				252
Coopers Hawk				1						1
Golden Eagle			1	1						2
Merlin	2	1								3
Northern Harrier	1	3	1	5	3		1			14
Osprey	1	2	2	2	1					8
Peregrine Falcon			2	1						3
Red Shouldered Hawk		1	2							3
Red Tailed Hawk	6	12	25	14	6	7	3			73
Rough Legged Hawk		3		2						5
Sharp-shinned Hawk	2	3	12	4	4					25
Turkey Vulture	26	37	67	43	35	45			7	260
Unid. Accipter	1			1	2					4
Unid. Buteo		2	13	6	2			3		26
Unid. Raptor	1		5	2	6					14
Entire Season	**54**	**83**	**258**	**163**	**74**	**54**	**4**	**3**	**7**	**700**

Appendix A Table 3. Species distribution below turbine height			
Species	> 150 m	< 150 m	Entire Season
American Kestrel		5	5
Bald Eagle	1	1	2
Broad-winged hawk	105	147	252
Coopers Hawk		1	1
Golden Eagle		2	2
Merlin		3	3
Northern Harrier	6	8	14
Osprey	5	3	8
Peregrine Falcon		3	3
Red Shouldered Hawk	2	1	3
Red Tailed Hawk	43	30	73
Rough Legged Hawk	3	2	5
Sharp-shinned Hawk	3	22	25
Turkey Vulture	71	189	260
Unid. Buteo	23	3	26
Unid. Raptor	12	2	14
Unid. Accipter		4	4
Entire Season	**274**	**426**	**700**

Appendix A Table 4. Summary of Regional Spring (March - May) Migration Surveys*

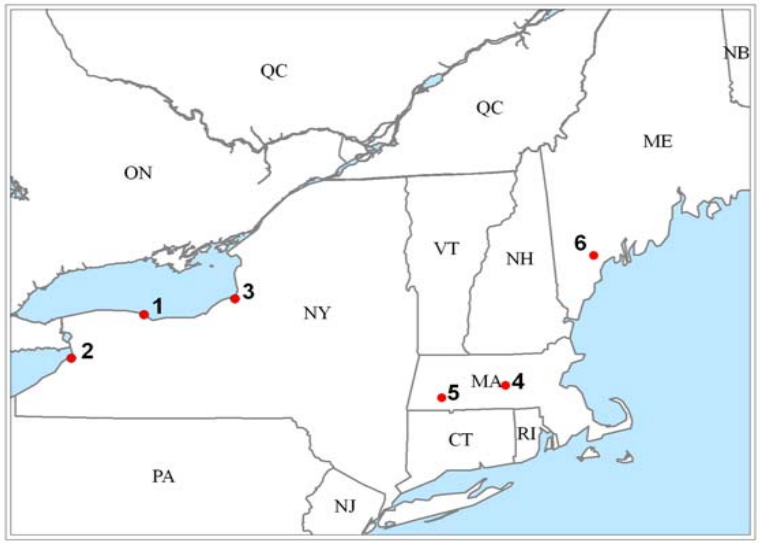
Site Number**	Year	Location	Observation Hours	BV	TV	OS	BE	NH	SS	CH	NG	RS	BW	RT	RL	GE	AK	ML	PG	SW	UR	UB	UA	UF	UE	TOTAL	BIRDS/ HOUR
1	**2005**	**Braddock Bay, NY**	447.75	1	8993	100	113	700	1382	392	46	200	16294	1999	318	31	188	21	12	3	0	0	0	0	0	30,793	68.8
2	**2005**	**Hamburg, NY**	396.25	0	7838	109	42	76	525	124	2	299	2503	1368	42	3	95	3	6	0	106	0	0	0	0	13,141	33.2
3	**2005**	**Derby Hill, NY**	386.75	1	6834	278	137	423	1510	330	26	501	8928	4022	369	49	158	29	4	0	24	0	0	0	0	23,626	61.1
4	**2004**	**Barre Falls, MA**	169	1	92	203	13	23	234	19	0	18	536	132	0	1	132	12	1	0	21	0	0	0	0	1,438	8.5
5	**2004**	**Blueberry Hill, MA**	121	1	98	125	13	24	128	18	0	18	515	132	0	3	81	0	1	0	10	0	0	0	0	1,167	9.6
6	**2004**	**Bradbury Mountain, ME**	66	0	0	168	8	16	364	14	0	1	668	24	0	0	182	14	2	0	0	0	0	0	0	1,488	22.5

* Data obtained from HMANA website.

** See map to right for site location.

Abbreviation Key:

BV - Black Vulture
TV - Turkey Vulture
OS - Osprey
BE - Bald Eagle
NH - Northern Harrier
SS - Sharp-shinned Hawk
CH - Cooper's Hawk
NG - Northern Goshawk
RS - Red-shouldered Hawk
BW - Broad-winged Hawk
RT - Red-tailed Hawk
RL - Rough-legged Hawk
GE - Golden Eagle
AK - American Kestrel
ML - Merlin
PG - Peregrine Falcon
SW - Swainson's Hawk
UR - unidentified Raptor
UB - unidentified Buteo
UA - unidentified Accipiter
UF - unidentified Falcon
UE - unidentified Eagle



Appendix B

Appendix B Table 1. Summary of passage rates by hour, night, and for entire season.

Night of	Passage Rate (targets/km/hr) by hour after sunset											Entire Night	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Mean**	**SE**
Apr 15	788	405	295	--	--	--	--	--	--	--	--	496	149
Apr 16	1074	1152	1189	1231	1417	1631	1504	--	--	--	--	1314	78
Apr 17	881	1292	1396	1591	1531	1121	691	481	329	284	418	910	150
Apr 18	491	449	549	544	625	847	796	717	647	313	625	600	47
Apr 19	1944	1676	1687	--	--	--	--	--	--	--	--	1769	87
Apr 21	56	136	130	152	159	188	182	242	156	139	477	183	32
Apr 24	55	43	75	110	142	155	111	67	84	126	311	116	22
Apr 26	252	426	439	725	702	767	--	--	--	--	--	552	85
Apr 27	135	157	--	321	307	245	212	187	79	136	--	198	31
Apr 28	83	64	84	114	--	--	159	94	62	173	--	104	18
Apr 29	67	62	109	126	223	189	146	156	184	259	--	152	20
May 1	83	115	384	459	493	261	270	296	178	107	--	265	46
May 2	136	140	155	208	236	217	147	114	88	43	--	148	19
May 4	36	81	107	150	137	93	--	--	--	--	--	101	17
May 5	279	173	248	274	327	432	390	585	446	241	--	339	39
May 6	484	550	844	1093	1258	928	660	771	496	184	--	727	101
May 7	136	169	231	247	229	233	196	--	--	--	--	206	15
May 8	117	184	229	227	190	274	225	200	66	68	--	178	23
May 9	279	257	246	246	306	405	238	129	--	--	--	263	27
May 10	242	436	474	--	--	429	470	394	173	96	--	339	61
May 11	91	251	210	467	270	231	139	--	--	--	--	237	45
May 12	118	259	435	482	471	329	206	176	93	199	--	277	46
May 15	399	986	1380	1493	1465	1386	--	--	--	--	--	1185	174
May 16	121	330	576	703	587	572	349	290	120	270	--	392	65
May 17	104	439	754	536	596	791	816	853	94	171	--	516	95
May 18	141	259	304	354	343	431	424	332	122	136	--	285	37
May 19	94	160	199	231	287	333	384	386	129	129	--	233	34
May 20	75	300	238	368	441	555	617	661	--	--	--	407	71
May 22	19	24	41	54	62	76	109	120	136	--	--	71	14
May 23	247	529	981	800	995	765	568	335	271	--	--	610	97
May 24	63	396	471	634	526	446	465	--	--	--	--	429	67
May 25	129	467	765	705	636	465	437	259	232		--	455	73
May 27	139	379	519	497	446	407	454	--	--	--	--	406	48
May 28	158	321	339	527	420	444	441	529	318	--	--	389	39
May 29	98	271	413	376	404	388	287	171	--	--	--	301	41
May 30	256	982	1269	1370	1386	--	--	--	--	--	--	1052	212
Entire Season	274	398	508	528	551	501	403	342	205	171	458	**450**	**62**

-- indicates no data for that hour

Appendix B Table 2. Mean Nightly Flight Direction		
Night of	**Mean Flight Direction**	**Circular Stdev**
Apr 15	119.769°	42.959°
Apr 16	36.788°	26.627°
Apr 17	49.537°	38.245°
Apr 18	28.603°	43.942°
Apr 19	29.329°	22.329°
Apr 21	10.655°	58.711°
Apr 24	3.587°	59.184°
Apr 26	10.134°	49.47°
Apr 27	32.71°	48°
Apr 28	35.431°	67.768°
Apr 29	342.944°	69.042°
May 1	23.468°	41.607°
May 2	27.274°	43.972°
May 4	23.903°	42.302°
May 5	343.596°	55.499°
May 6	37.862°	70.38°
May 7	174.739°	85.336°
May 8	12.204°	97.753°
May 9	39.669°	56.053°
May 10	24.736°	52.923°
May 11	167.464°	105.602°
May 12	355.07°	84.347°
May 15	22.177°	30.698°
May 16	30.364°	48.478°
May 17	30.942°	33.103°
May 18	30.269°	54.149°
May 19	339.448°	64.307°
May 20	10.176°	74.538°
May 22	24.384°	67.832°
May 23	13.3°	77.993°
May 24	23.825°	66.087°
May 25	31.404°	65.573°
May 27	26.325°	28.653°
May 28	28.389°	36.9°
May 29	28.984°	30.985°
May 30	31.88°	36.505°
Entire Season	**30°**	**53°**

Appendix B Table 3. Summary of mean flight heights by hour, night, and for entire season

Night of	Mean Flight Height (altitude in meters) by hour after sunset											Entire Night		% of targets below 150 meters
	1	2	3	4	5	6	7	8	9	10	11	Mean	SE	
Apr 15	--	595	--	--	--	--	--	--	--	--	--	595		28%
Apr 16	--	405	518	472	447	487	424	--	--	--	--	459	17	17%
Apr 17	183	253	304	309	357	331	314	341	394	348	90	293	26	36%
Apr 18	121	461	--	434	472	486	427	471	422	--	231	392	42	18%
Apr 19	--	--	--	--	297	297	--	--	--	--	--	297	0	30%
Apr 21	--	595	496	--	574	548	489	509	635	--	--	550	21	11%
Apr 24	114	632	623	546	517	522	548	515	455	328	--	480	49	6%
Apr 26	--	832	--	770	753	658	--	--	--	--	--	753	36	2%
Apr 27	183	428	296	--	503	354	--	397	--	--	--	360	45	10%
Apr 28	--	210	174	--	--	--	185	203	195	228	--	199	8	42%
Apr 29	66	330	548	561	683	628	629	682	549	555	--	523	60	6%
May 1	161	478	361	414	520	468	429	415	376	--	--	402	35	6%
May 2	108	397	264	266	314	387	460	386	277	--	--	317	35	14%
May 4	181	564	550	521	519	597	--	--	--	--	--	489	63	6%
May 5	--	837	869	737	719	--	758	716	634	620	--	736	31	2%
May 6	263	665	745	689	614	475	541	547	462	447	--	545	45	9%
May 7	210	316	357	--	288	257	277	--	--	--	--	284	20	19%
May 8	273	699	566	--	557	395	297	523	553		--	483	52	16%
May 9	--	--	--	603	618	813	739	742	641	764	--	703	31	5%
May 10	574	550	519	--	--	--	473	525	412	513	--	509	20	5%
May 11	--	233	308	358	398	272	299	--	--	--	--	311	24	30%
May 12	132	376	359	328	450	226	--	155	207	--	--	279	41	24%
May 15	298	540	683	596	574	--	--	--	--	--	--	538	65	4%
May 16	181	396	284	324	186	264	285	273	255	--	--	272	22	26%
May 17	239	426	463	404	434	378	326	300	353	--	--	369	24	17%
May 18	284	449	414	421	473	488	516	484	505	--	--	448	24	5%
May 19	255	618	--	384	555	448	425	507	425	--	--	452	39	5%
May 20	300	640	656	522	524	592	453	494	--	--	--	522	40	10%
May 22	--	227	236	--	--	910	731	462	488	--	--	509	111	23%
May 23	410	474	403	--	--	346	433	230	255	--	--	365	35	30%
May 24	20	690	669	518	489	333	306	--	--	--	--	432	88	13%
May 25	286	684	576	421	--	358	403	373	327	--	--	429	48	8%
May 27	369	627	497	436	449	460	479	--	--	--	--	474	30	3%
May 28	266	516	453	537	501	491	457	380	351	--	--	439	30	3%
May 29	241	491	--	357	337	296	293	274	462	--	--	344	32	7%
May 30	307	413	438	401	--	--	--	--	--	--	--	390	29	16%
Entire Season	232	501	470	474	487	452	443	436	419	475	161	*443*	*38*	*14%*

-- indicates no data for that hour

Appendix C

Appendix C Table 1. Bat calls detected at Clayton, NY, during spring 2005 surveys

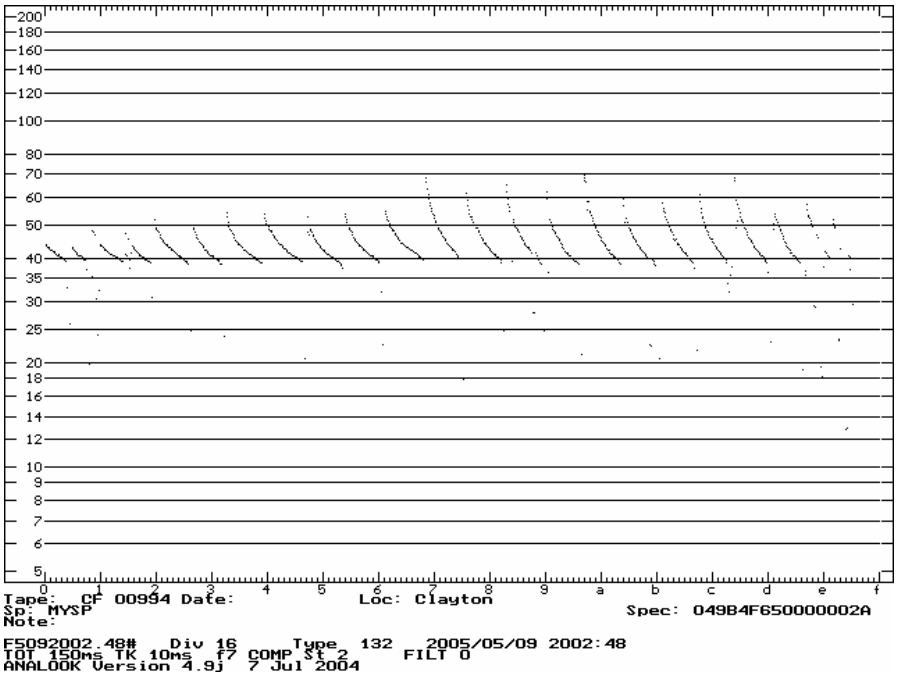
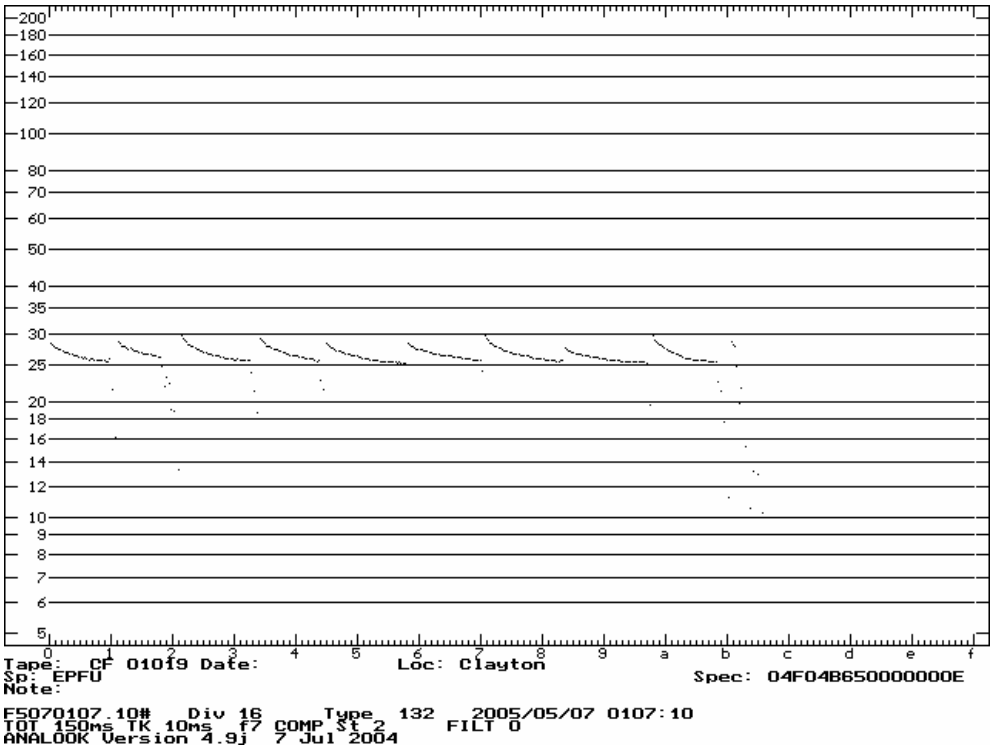
Night of	Time	Detector	Species
24-Apr	22:07	High	MYSP
26-Apr	20:57	High	UNKN
5-May	21:13	High	LANO
5-May	21:13	High	LANO
5-May	21:41	High	LANO
6-May	19:42	Low	MYSP
6-May	21:15	High	LANO
6-May	21:22	High	LANO
6-May	21:52	High	EPFU
6-May	21:58	High	EPFU
6-May	22:14	High	LANO
6-May	22:18	High	LANO
6-May	22:21	High	LANO
6-May	22:24	High	LANO
6-May	22:31	High	LANO
6-May	22:36	High	LANO
6-May	22:36	High	EPFU
6-May	22:36	High	MYSP
6-May	22:41	High	LANO
6-May	1:07	High	EPFU
7-May	23:09	High	EPFU
8-May	21:32	High	EPFU
8-May	0:07	High	EPFU
8-May	0:22	High	EPFU
9-May	20:02	Low	MYSP
9-May	21:36	High	LANO
9-May	21:50	High	UNKN
9-May	22:00	High	EPFU
9-May	22:08	High	UNKN
9-May	22:16	High	LANO
9-May	22:18	High	LANO
9-May	22:57	High	EPFU
9-May	0:56	High	UNKN
9-May	1:11	High	EPFU
9-May	2:12	Low	LACI
10-May	2:54	Low	EPFU
10-May	3:06	High	EPFU
12-May	21:52	High	MYSP
12-May	22:42	High	MYSP
12-May	23:26	High	MYSP
13-May	23:16	Low	MYSP
15-May	0:49	High	LANO
15-May	1:16	High	LANO
17-May	1:50	Low	EPFU
17-May	2:48	High	UNKN
18-May	23:50	High	LANO
19-May	20:22	Low	MYSP
19-May	21:20	High	MYSP

Appendix C Table 1. Bat calls detected at Clayton, NY, during spring 2005 surveys			
Night of	**Time**	**Detector**	**Species**
19-May	21:28	High	EPFU
19-May	0:12	High	EPFU
19-May	2:01	High	EPFU
20-May	21:21	Low	UNKN
20-May	22:20	High	UNKN
20-May	2:55	High	MYSP
21-May	23:17	High	EPFU
23-May	20:52	Low	EPFU
24-May	21:40	High	UNKN
24-May	22:11	Low	EPFU
24-May	23:09	High	EPFU
25-May	23:27	High	MYSP
25-May	1:40	High	UNKN
26-May	23:57	Low	EPFU
26-May	0:31	High	EPFU
26-May	0:55	High	EPFU
28-May	22:51	Low	EPFU
28-May	23:49	High	EPFU
28-May	1:13	High	EPFU

EPFU = big brown bat, LACI = hoary bat, LANO = silver-haired bat, MYSP = *Myotis* sp., UNKN = unknown

Appendix C Figure 1. Representative samples of calls detected during Spring 2005. Figure 1a is identified as *Myotis* spp, and 1b is identified as big brown bat (*Eptesicus fuscus*).

1a



1b