PATRIOT RENEWABLES
Canton Mountain Wind, LLC

Attachment 7-3
Summer/Fall 2010 Bird and Bat Biological Survey Report

TETRA TECH

Summer/Fall 2010 – Bird and Bat Biological Survey Report

Canton Mountain Wind Project

Canton, Maine

Prepared for:

PATRIOT RENEWABLES

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EXECUTIVE SUMMARY

During summer and fall 2010, Tetra Tech, Inc. (Tetra Tech) conducted field surveys to document avian and bat activity at the Canton Mountain Wind Project (Project) in Canton, Maine. The surveys were initiated by Patriot Renewables, LLC (Patriot) as part of the planning and permitting process for a wind energy generation facility proposed on Canton Mountain (Project Area). These surveys were the second of two migratory seasons sampled during the 2010 study period. Summer and fall surveys included an avian radar survey, visual raptor migration survey, migrant stopover survey, bat acoustic survey, and an eagle survey.

The results of these surveys provide data on temporal and spatial use of the Project Area by birds and bats that can be used to evaluate the potential risk to these species posed by the Project. Both spring and fall 2010 avian and bat surveys will help to create a baseline dataset for comparison with post-construction surveys at the Project Area.

<u>Avian Radar Study</u>

An on-site avian radar survey was conducted as part of this study to provide comprehensive data on avian counts/passage rates, flight heights, and flight direction in the Project Area. Radar data were collected using a MERLIN avian radar system during a 31-day/night period from September 3 to October 4, 2010. Based upon standard radar survey protocols, nights were defined as 45 minutes before sunset to 45 minutes after sunrise, and days consisted of the remaining time period. The MERLIN avian radar system simultaneously uses horizontal and vertical radars to automatically and continuously record bird and bat activity in the vicinity of the proposed Project. The Vertical Surveillance Radar (VSR) output provides both count and altitude information on biological targets, whereas the Horizontal Surveillance Radar (HSR) provides target directions. Biological targets include birds, as well as bats and large insects. It should be noted that this continuously monitoring radar has the potential to count individual targets more than once if they fly in and out of the radar beam.

During the fall 2010 sampling period, nightly target passage rates were variable, ranging from 2.4 to 1,220 targets/kilometer/hour, with a nightly average of 292 targets/kilometer/hour. This was greater than the average target passage rates (14 targets/kilometer/hour) during days. The greatest amount of nocturnal migration occurred on September 29th and the greatest amount of diurnal migration occurred on September 11th. The magnitude of migration (passage rates) reported for the fall period was less than other MERLIN radar studies in Maine (Saddleback Ridge and Spruce Mountain). Analysis of hourly activity verified that target passage rates were greatest during the early night (8 –11 pm) time period, and that activity was very low throughout the daylight hours.

As would be expected during fall migration, the majority of nights (54.2 percent) averaged target movements to the southwest or south. Radar data from the horizontal radar also indicated an average target direction of southwest during both nights (231 compass degrees) and days (233 compass degrees). The concentration of target movements, however, was greater during nights (concentration coefficient (r) = 0.47) than days (average r = 0.28) indicating nocturnal migration and local movements during the day, respectively. For reporting and analysis purposes, Tetra Tech assumed an elevation range representing the potential rotor swept zone (RSZ) of proposed turbines of 36–130 m [188–427 feet (ft)] above ground level (AGL).

The mean target height was greater during nights (157.9 m~518.0 ft) than days (129.4 m~424.5 ft) adjusted AGL as was the median target height for nights (134.4 m ~440.9 ft) when compared to days (75.3 m~247.0 ft)] adjusted AGL. More targets were also detected above the RSZ during fall sampling period nights (51.5 percent) than days (27.0 percent). In general, target heights were low during the survey period when compared to data for other MERLIN radar studies in the region, with 38.2 percent and 50.8 percent of targets occurring within the RSZ heights during nights and days, respectively, and 10.3 percent and 22.1 percent below the RSZ during nights and days, respectively.

Approximately 60 percent of both night and day targets had mean heights within the RSZ and approximately 80 percent of median target heights occurred within the RSZ heights during both nights and days in the fall 2010 sampling period. Most targets within the RSZ heights did not fly over the ridgeline.

Seasonal differences may be a relevant factor explaining both the lower target heights and lower passage rates in fall when compared to the spring 2010 radar results. The data suggest that there was less migration activity and lower flight heights during the fall survey period when compared to the spring. Other MERLIN studies in Maine have shown similar variations between spring and fall migration rates. At the Saddleback Ridge wind project located west of Canton Mountain, fall passage rates were less than spring. However, at the Spruce Mountain wind project, fall passage rates were greater than spring. It is also possible that some fall migration events occurred outside the September 3 – October 4 sampling period.

Raptor Migration Study

On-site raptor surveys were completed to identify the species composition and behavioral characteristics of raptors using the Project Area. Fall 2010 raptor surveys were conducted on 13 days between September 2 and October 13 for a total of 66.5 hours of survey effort. A total of 144 raptors representing 13 species were observed and recorded. This produced an overall observation rate of 2.17 birds/hour (hr.) Fifty-five (55) percent of the observed raptors flew within the airspace over the Project Area. The Project's airspace is defined as the airspace immediately above the ridge where turbines are proposed. Daily totals ranged from 0 to 31 birds observed. The highest count of raptors (31 observations) was recorded on September 11, 2010; temperatures were between 10° Celsius (C) and 18°C (50° Fahrenheit (F) and 64°F) with moderate north-northeast winds throughout the day. The lowest count (0 observations) occurred on September 2, 2010, with winds mostly from the southwest and temperatures between 27°C and 33°C (80°F and 91°F). The Project Area had relatively low numbers of migrating raptors when compared to data from Cadillac Mountain in Acadia National Park. Across the same survey dates, 1,677 raptors were observed at Cadillac Mountain compared to 144 raptors at Canton Mountain.

Broad-winged hawks (*Buteo platypterus*) (*n* = 57) and sharp-shinned hawks (*Accipiter striatus*) (*n* = 24) were the most commonly observed species. Turkey vultures (*Cathartes aura*) (*n* = 20) and Cooper's hawks (*Accipiter cooperii*) (*n* = 9) were the next most abundant species. The remaining nine species were observed seven or fewer times, per species. No federally endangered or federally threatened raptors were observed. One state-endangered peregrine falcon (*Falco peregrinus*) (*n* = 1) and two state-listed species of special concern were observed during raptor surveys: the bald eagle (*Haliaeetus leucocephalus*) (*n* = 5) and northern harrier (*Circus cyaneus*) (*n* = 2).

Raptor flight paths were generally southbound but varied in location from survey to survey, with observations of raptors moving south along the western and eastern side slopes and nearby valleys (outside the proposed turbine area) and other movements directly along the spine of the ridge (within the proposed turbine area). Most of the initial and ending flight heights of raptors were above 130 m (427 ft). In addition, only one species of special concern was found within the RSZ.

Migrant Stopover Study

During fall 2010, Tetra Tech biologists conducted standardized point count surveys along a single transect in the Project Area to sample the number and species of migrant birds. Each point was sampled on 11 different mornings during the fall migration season. Points were selected to be representative of all habitat types across the elevation gradient in the Project Area. Specific habitats surveyed included the two major habitat types identified in the Project Area: mixed deciduous hardwood and mixed spruce and fir forest. All birds visually or audibly detected during 10-minute sampling periods at each survey point were recorded.

A total of 717 individual birds representing 50 species were documented. Overall relative abundance was 65.18 birds/survey. Four avian state species of special concern were documented: American redstart (*Setophaga ruticilla*), black-and-white warbler (*Mniotilta varia*), chestnut-sided warbler (*Dendroica pensylvanica*), and white-throated sparrow (*Zonotrichia albicollis*). White-throated sparrow was one of the most abundant birds observed during the surveys. No federally listed threatened or endangered species were documented.

Bat Acoustic Study

The 2010 bat acoustic monitoring survey started on April 14 and ended on October 31. Tetra Tech surveyed the spring migration (April 14 to May 31), summer residency period (June 1 to August 15), and fall migration period (August 16 to October 31). During the 201-night survey period, seven different detectors operated for 619 detector-nights (number of detectors multiplied by the number of nights that detectors were operational). A total of 2,585 bat call sequences and 2,010 minutes of bat activity were recorded during this period.

The highest Index of Activity (IA) rate (number of minutes of bat activity/detector-nights * 100) was recorded by the Ridge Pond detector (IA = 3,311.1), which sampled the fewest number of nights (n = 9). This detector recorded 412 call sequences during 298 minutes of bat activity. The lowest IA rate (42.6) was recorded by the met tower Low Detector, which recorded 54 call sequences. The met tower High Detector recorded 56 call sequences with an IA rate of 47.0. Five species were definitively identified within the recorded call sequences. A total of 232 calls (9 percent), were attributed to long-distance migratory bats, including the hoary bat (*Lasiurus cinereus)*, silver-haired bat (*Lasionycteris noctivagans*), and Eastern red bat (*Lasiurus borealis)*. The remaining two identified were the big brown bat (*Eptesicus fuscus*) and Northern myotis (*Myotis septentrionalis*). The majority (79 percent) of recorded call sequences (n = 2,030) were identified as Northern myotis. All three long-distance migratory bats identified in the Project Area are listed as species of special concern in Maine.

Bald Eagle Survey

Tetra Tech conducted an initial site reconnaissance and visual survey of the two known nest locations during summer 2010. On June 30, 2010, a Tetra Tech biologist spent two hours observing the two nest locations. In addition, on July 15, 2010, two Tetra Tech biologists conducted a bald eagle survey by boat on the portion of the Androscoggin River south of the Project Area where the two documented nests occur. Four eagles were observed during the boat survey on July 15th including two adults, one first year juvenile, and one second year bird.

As observed during the June 30th survey, the first nest (Nest #1) was in disrepair and did not appear to be active. During the July 15th survey the second nest was active and well maintained, containing one adult bird with the juvenile perched alongside on a branch.

Bald eagles were not observed during the 10 migrant stopover surveys, three breeding bird surveys, or 10 raptor migration surveys during the spring 2010 season within the Project Area. During fall 2010 standardized raptor migration surveys a total of five bald eagles were observed on four survey dates (Sept. 11, Sept. 15, Sept. 20, and Oct. 5). Of the five bald eagles observed, four (three adults, one juvenile) flew through the Project Area, but only one adult bald eagle flew within the RSZ heights.

1.0 INTRODUCTION

1.1 Project Overview

Patriot Renewables, LLC (Patriot) proposes to develop the Canton Mountain Wind Project (Project) in northern Oxford County, Maine (Figure 1-0). The location of the proposed Project would be along the ridge of Canton Mountain in the Town of Canton, Maine. To date, Patriot has conducted several site evaluation and planning surveys including an assessment of existing habitat types, geology, physical constraints, wetland and waterbody and significant wildlife habitat surveys and evaluations of engineering and land ownership constraints. This report presents baseline bird and bat data collected during the summer and fall 2010 migration season. Specific data collection efforts during the fall season included an avian radar study, raptor migration survey, migrant stopover surveys, bat acoustic survey, and a bald eagle survey.

1.2 Project Area Description

The Canton Mountain Wind Project area (Project Area) is located in Oxford County in the western mountains of Maine. The Project Area is situated atop Canton Mountain, and the proposed access road originates in the valley west of the mountain. Canton Mountain has an elevation of 470 meters (m) (1,542 feet [ft]) and consists of mostly private, forested lands. There are several lakes and ponds in the region with six bodies of water located within 8 kilometers (km) (5 miles [mi]) of Canton Mountain: Wilson Pond to the northeast; Forest Pond, Round Pond, and Long Lake to the southeast; Lake Anasagunticook to the south; and Worthley Pond to the southwest. The mountains surrounding the Project Area are Fish Hill to the south, Paine Hill to the northeast, and Pinnacle Mountain to the northwest. These mountains range in elevation from 288 m to 410 m (945 ft to 1,345 ft). The topography of the Project Area ranges from relatively level on the valley floor, to steeply sloping along some of the side slopes with elevations ranging from approximately 182 m to 547 m (600 ft to 1,500 ft) above sea level.

1.3 Goals and Objectives

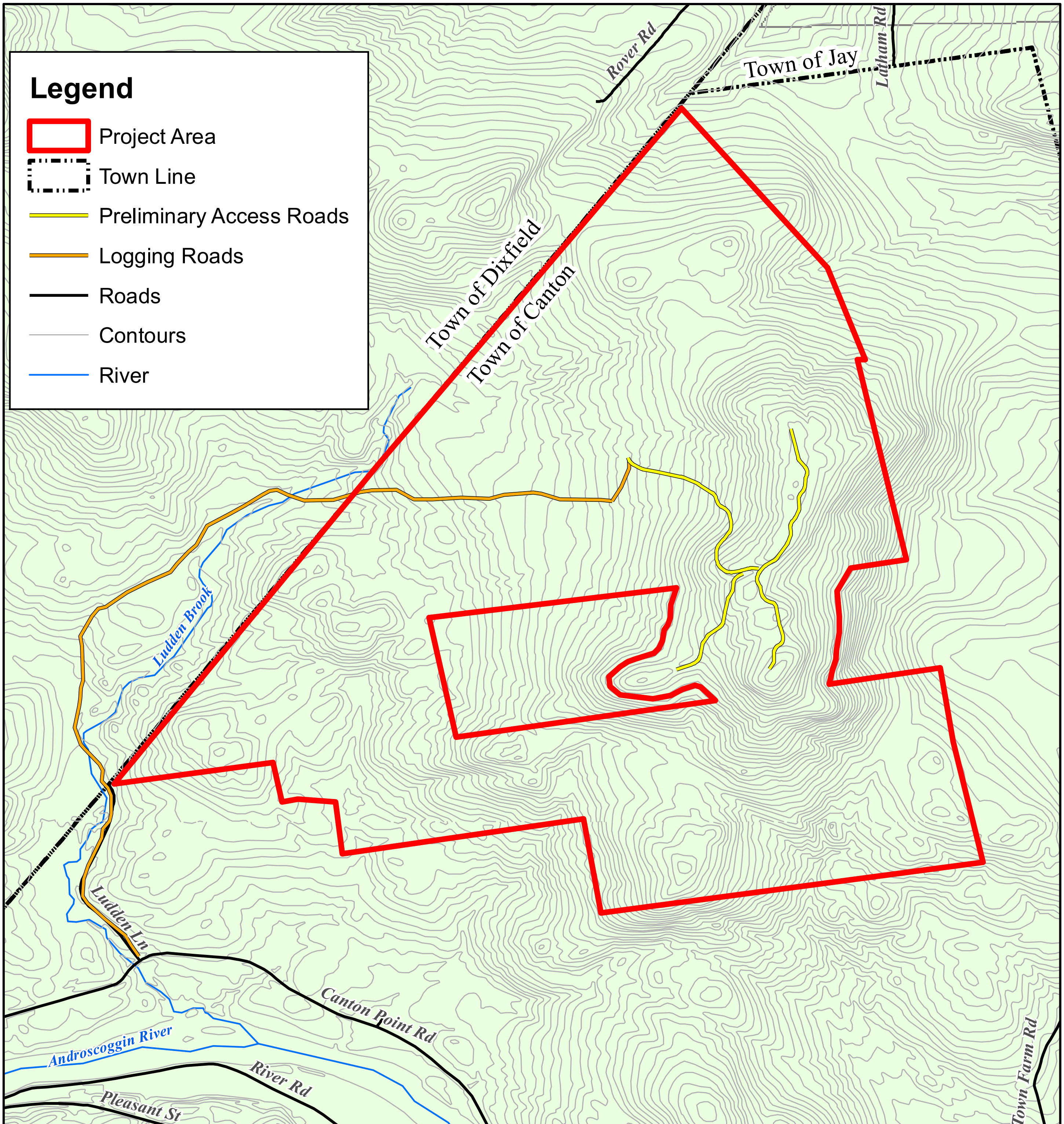
The goals of the bird and bat studies were to identify the spatial and temporal use of the Project Area by birds and bats during fall 2010. Objectives for the avian survey were to:

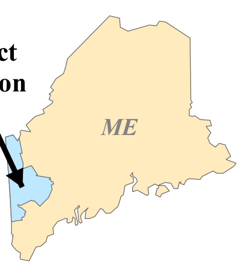
1) identify the average and peak passage rates for biological targets;
2) identify the average and range of flight heights for biological targets;
3) identify the percentage of targets above, within, and below the RSZ of 36–130 m (118-427 ft);
4) determine areas of greatest avian passage/use within the Project Area;
5) identify the species composition of migratory birds and raptors, including any special status species;
6) determine the relative abundance of migrant stopover birds among habitat types;
7) determine the peak periods of migratory activity; and,
8) identify movements of bald eagles within and immediately surrounding the Project Area.

Objectives for the bat survey were to:

1) identify the average level of bat activity within the Project Area,
2) determine the relative level of bat activity between detector sites, and,
3) identify peak periods of bat activity.

For the purposes of reporting, Tetra Tech assumed an approximate a RSZ of 36–130 m (118-427 ft). As of October 2011, Patriot plans to use GE 2.75 turbines with RSZ heights of 33.5–136.5m.





0 1,200 2,400 4,800 Feet

0 325 650 1,300 Meters

Source: Maine Office of Geographic Information Systems (MEGIS), Roads 2008, Countours, 2000. Additional data provided by client Patriot Renewables, spring 2010.

Figure 1.0 Canton Mountain Wind Project, Canton, Maine

Prepared For: PATRIOT RENEWABLES

Prepared By: TETRA TECH

Date: 11/2010

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2.0 AVIAN RADAR STUDY

2.1 Introduction

Tetra Tech conducted a fall avian radar migration survey for 31 days and nights of near continuous operation from September 3 to October 4, 2010. A DeTect MERLIN Avian Radar System (a combination of x-band and s-band marine radar, Figure 2-0) was used to document abundance and flight patterns of both diurnal and nocturnal migrants. The radar unit was situated on the western side slope below the Canton Mountain ridge proper. This location provided radar coverage over most of the Project Area. The radar system operated 24 hours a day, seven days a week, and provided real-time information on biological targets. The system classified targets into size classes (small, medium, large, and flock) but did not provide species-specific information.

Detailed results of the avian radar study are provided in Appendix A. Specific details provided in Appendix A include: total number of biological targets above ground level (AGL, radar unit elevation) under good and poor visibility conditions; total number of biological targets/km by hour of the day; passage rate of targets by period (day, night, or transition [dusk/dawn]); mean flight altitude; and nightly and seasonal flight direction. Based on the RSZ of 36–130 m (118-427 ft), the percentage of targets flying below, within, and above the RSZ heights was calculated. Qualitative descriptions of the general flight characteristics of radar targets were summarized. The results from the avian radar survey are provided in Appendix A.

Figure 2-0. Canton Mountain Wind Project avian radar unit, fall 2010.

3.0 RAPTOR MIGRATION STUDY

3.1 Introduction

A second set of raptor migration surveys were conducted during the fall 2010 season to document the presence of migrating raptors as well as local resident raptors. The survey protocol followed the methodology used by the Hawk Migration Association of North America (HMANA) (HMANA 2005). This protocol includes collecting data on multiple aspects of each observed raptor in flight.

The following sections summarize methods, observations and results of the raptor migration survey at Canton Mountain during the fall 2010 raptor migration season. Specific methods for the survey are presented in Section 3.2, while results of the data collection effort are found in Section 3.3. A discussion of the results including a discussion on seasonal timing, species, flight height, flight location, and flight type is presented in Section 3.4.

3.2 Methods

Tetra Tech biologists conducted standardized visual counts of migrating raptors from a single survey location (Figure 3-0) on the northern section of Canton Mountain. This location provided expansive views to the north, east, and west (Figure 3-1). The view to the south was limited and was obscured by a heavily wooded ridge. The elevation of the raptor observation point was approximately 457 m (1,500 ft). Surveys were conducted on 13 days from approximately 0900 hours to 1500 hours Eastern Daylight Time (EDT) within the recommended sampling window of early September to mid-October 2010. This time period was targeted to sample the time of year when strong thermals occur and when the majority of raptor migration activity is likely to occur in this region of Maine. One survey extended to the 1600 hour.

During observational surveys, the following data were recorded on standardized data forms:

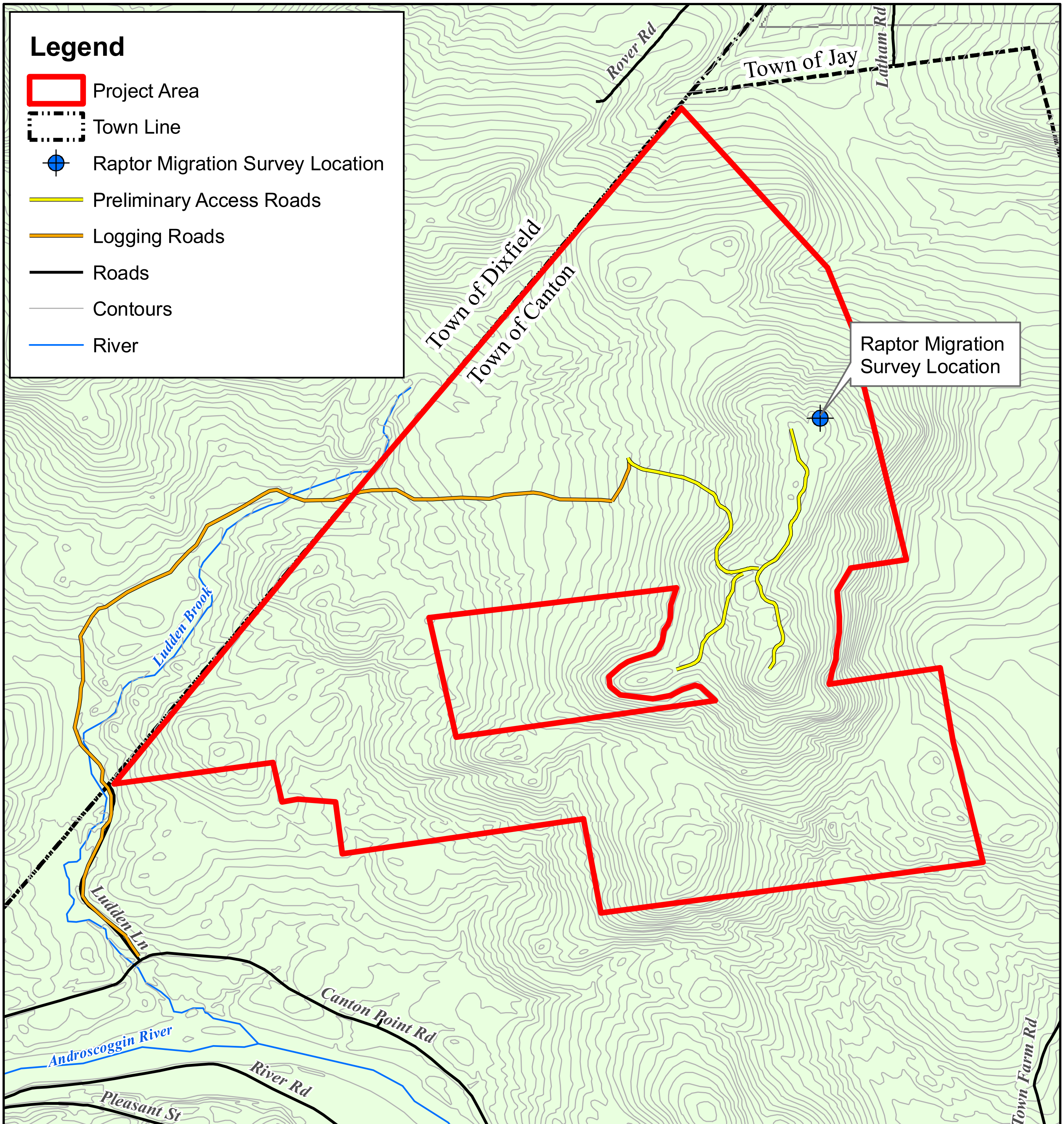
1) Species and number of birds. Age and sex were recorded when determination was possible.

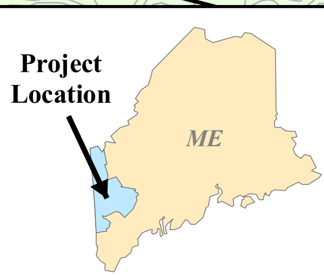
2) Exact time of each observation (in EDT).

3) Weather data for each hour of observation, including wind speed and direction, air temperature, percent cloud cover, precipitation, and visibility.

4) Flight direction, flight height at the start and end of each observation, flight type, and flight location for each raptor observed. Flight paths also were recorded on topographic maps of the Project Area.

5) Survey start and stop times and total minutes of observation.





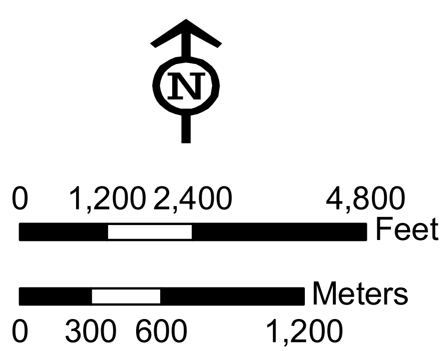


Figure 3.0 Raptor Migration Survey Location at Canton Mountain Wind Project-Fall 2010

Prepared For: PATRIOT RENEWABLES

Prepared By: TETRA TECH

Date: 11/2010

Source: Maine Office of Geographic Information Systems (MEGIS), Roads 2008, Countours, 2000. Additional data provided by client Patriot Renewables, spring 2010.

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Figure 3-1. View looking north from the raptor survey location at Canton Mountain Wind Project, fall 2010.

High quality optics (10 x 42 mm binoculars and 15–45 x 60 mm scopes) were used in sighting and identifying raptors. Field identification references included Wheeler and Clark (1995), Dunne et al. (1988), Clark and Wheeler (2001), and Liguori (2005). Surveys targeted optimal days (i.e., days with northerly winds) for raptor migration.

Weather data measurements were collected using HMANA protocols. All weather variables were recorded on-site at the time of survey.

Flight heights were visually estimated in meters above ground level at the beginning and end of each observation. Laser rangefinders were used to aid observers in correct estimation of flight heights. Flight heights were also classified using the following categories:

0 = below eye level;

1 = eye level to approximately 30 m (98 ft);

2 = birds easily seen with unaided eye;

3 = at limit of unaided vision;

4 = beyond limit of unaided eye but visible with binoculars up to 10x;

5 = at limit of binoculars;

6 = beyond limit of binoculars 10x or less but can detect with scope of greater power; and,

7 = no predominant height.

Flight type was recorded as the following:

- direct - direct flight with few changes in direction, all less than 30 degrees;
- indirect - indirect flight during which more than one circle was recorded, but more than 50 percent of flight is without such turns;
- soaring - soaring flight during which more than 50 percent of time is circling;
- hunting flight that appeared to be for hunting; or,
- perched - for birds that perched.

Migrant raptors are known to fly in a direct flight pattern, and all individuals observed in direct flight with a southerly heading were recorded as migrants. Raptors that were observed perching or hunting were recorded as possible residents but were excluded from the final migration tally.

Flight location was recorded as either valley, along ridge, on side slope, or crossed ridge. Any combination of these categories was possible based on individual raptor flight. Notes were also taken on behavior, vocalizations, and flight direction.

Flight heights at the start and end of each observation were categorized as 0−35 m (0–115 ft) (below wind turbine RSZ), 36−130 m (118–427 ft) (within RSZ), and greater than 130 m (427 ft) (above RSZ). Flight heights were visually estimated after training with a laser range finder.

Survey results, including the total counts and passage rates from the 2010 fall raptor migration surveys at Canton Mountain, were compared with results from surveys conducted on the same days at Cadillac Mountain in Acadia National Park, Maine, approximately 169 km (105 mi) east of Canton Mountain. Cadillac Mountain is a coastal mountain that rises from the coastal plain to an elevation of 148 m (485 ft) above sea level. Organized fall migration raptor counts have been conducted at Cadillac Mountain for the last eight years (2003−2010). The purpose of this comparison was to evaluate the level of raptor activity at the project site with the level of activity at a site in Maine that is known to have large migration numbers. This way, a rough estimation of the regional significance of the project site regarding raptor migration can be made.

3.3 Results

The total raptor survey effort resulted in 66.5 hours of direct, visual observation during 13 days between September 1 and October 13, 2010. A total of 144 migrating raptors, representing 13 species, were observed and recorded (Table 3-0). This produced an overall observation rate of 2.17 birds/hr. Daily count totals ranged from 0 to 31 birds. The highest count of raptors (31 observations) was recorded on September 11, 2010; temperatures were between 10°C and 18°C (50°F and 64°F) with moderate north-northeast winds throughout the day. The lowest count (0 observations) occurred on September 2, 2010, with winds mostly from the southwest and temperatures ranging between 27°C and 33°C (80°F and 91°F). The following tables summarize the results of the fall raptor survey. Raw data collected during the survey can be found in Appendix B.

Table 3-0. Daily summary of migrating raptors at Canton Mountain Wind Project, fall 2010.

Species	9/1/10	9/2/10	9/9/10	9/10/10	9/11/10	9/15/10	9/17/10	9/20/10	9/21/10	9/29/10	9/30/10	10/5/10	10/13/10	Grand Total
American kestrel								2				1		3
Bald eagle					1	1		2				1		5
Broad-winged hawk				2	21	11	15	6	2					57
Cooper's hawk			2		1	1		1				4		9
Merlin						1		1				1		3
Northern goshawk						1		1						2
Northern harrier								1				1		2
Osprey			2		1			1						4
Peregrine falcon					1									1
Red-shouldered hawk								1						1
Red-tailed hawk			1				2	1	1			1	1	7
Sharp-shinned hawk				1	5	2	2	7			2	3	2	24
Turkey Vulture	1		3			1	3		2	3	3	4		20
Unidentified buteo						1								1
Unidentified raptor					1	1						3		5
Daily Total	1	0	8	3	31	20	22	24	5	3	5	19	3	144
Survey Effort (hrs)	5	6	6	1	6	6	5	6	2	5.5	6.5	6	5.5	**66.5**
Raptors/Hour	0.20	0.00	1.33	3.00	5.17	3.33	4.40	4.00	2.50	0.55	0.77	3.17	0.55	**2.17**

Broad-winged hawks (*Buteo platypterus*) (*n* = 57) and sharp-shinned hawks (*Accipiter striatus*) (*n* = 24) were the most commonly observed species. Turkey vultures (*Cathartes aura*) (*n* = 20) and Cooper's hawks (*Accipiter cooperii*) (*n* = 9) were the next most abundant species. The remaining nine species were observed seven or fewer times, per species. No federally endangered or federally threatened raptors were observed. One state endangered peregrine falcon (*Falco peregrinus*) (n = 1) and two species of special concern were observed during raptor surveys: the bald eagle (*Haliaeetus leucocephalus*) (*n* = 5) and northern harrier (*Circus cyaneus*) (*n* = 2).

The frequency of raptor observations varied depending on the time of day (Table 3-1). Observations generally started slowly during the first hour of observation (0900 to 1000), then increased until 1200 when a lull of activity was recorded. Observations increased again after 1400. The majority of migrating raptors (*n* = 30) were observed between the hours of 1000-1100 and 1400–1500. The morning time frame coincides with the time of day when thermals begin in the morning, and the afternoon time frame is when stronger thermals, which provide optimal flight conditions for migrating raptors, are likely to occur.

Table 3-1. Hourly summary of migrating raptors at Canton Mountain Wind Project, fall 2010.

Species	0900–1000	1000–1100	1100–1200	1200–1300	1300–1400	1400–1500	1500–1600	Grand Total
American kestrel			1		1	1		3
Bald eagle			1	4				5
Broad-winged hawk	10	15	7	5	6	14		57
Cooper's hawk	3	1		1	2	2		9
Merlin		2			1			3
Northern goshawk	1			1				2
Northern harrier					2			2
Osprey	1		2	1				4
Peregrine falcon	1							1
Red-shouldered hawk		1						1
Red-tailed hawk		2	3		1	1		7
Sharp-shinned hawk	3	5	3	2	4	5	2	24
Turkey Vulture		2	4	2	5	6	1	20
Unidentified buteo				1				1
Unidentified raptor		2	2			1		5
Grand Total	19	30	23	17	22	30	3	144
Survey Effort (hrs)	8.5	11	12.5	11	11	11	1.5	66.5

The weather during the fall 2010 survey season was generally dry with high pressure systems prevailing. Temperatures ranged from 7°C to 33°C (45°F to 91°F). Winds were very optimal during the survey period, often from the north.

Flight locations varied between observations, but the majority (52%) of observations recorded were of migrants flying along the ridge, side slopes, and valley (*n* = 75) (Table 3-2). The second most common observation was raptor flights in the valleys (*n* = 25). Some of the observed raptors flew across different locations, for example from valley to ridge to side slope, while others were initially observed on the ridge, then moved over the side slopes, and then into the valley. These individuals were recorded under the category “valley, ridge, and sideslope”. These location changes were also documented with detailed notes. In addition, flight paths were hand drawn on topographic maps (see Appendix B).

Table 3-2. Flight locations of migrating raptors at Canton Mountain Wind Project, fall 2010.

Species	Valley	Ridge	Side slope	Valley, ridge, side slope	Valley, side slope	Ridge, side slope	Grand Total
American kestrel				1		2	3
Bald eagle				5			5
Broad-winged hawk	12	3		33	8	1	57
Cooper's hawk	2			5	1	1	9
Merlin				3			3
Northern goshawk				2			2
Northern harrier	1			1			2
Osprey	2			1		1	4
Peregrine falcon				1			1
Red-shouldered hawk					1		1
Red-tailed hawk	1	2		2	2		7
Sharp-shinned hawk		2	5	13	3	1	24
Turkey Vulture	7	1	1	3	1	7	20
Unidentified buteo				1			1
Unidentified raptor				4	1		5
Grand Total	25	8	6	75	17	13	144

Of the 144 raptors observed within the Project Area during the fall migration season, 79 raptors flew at some height within the Project Area’s airspace. The project’s airspace is defined as the airspace immediately above the ridge where turbines are proposed. This accounts for approximately 55 percent of the migrating raptors observed within the raptor observation viewshed (Table 3-3). Eleven (11) species of raptors were observed within the Project Area, and 10 species were observed outside the Project Area.

Table 3-3. Distribution of raptors within and outside the Project Area, fall 2010.

Species	Outside Project Area	Within Project Area	Grand Total
American kestrel		3	3
Bald eagle	1	4	5
Broad-winged hawk	28	29	57
Cooper's hawk	2	7	9
Merlin	1	2	3
Northern goshawk		2	2
Northern harrier	2		2
Osprey	2	2	4
Peregrine falcon		1	1
Red-shouldered hawk	1		1
Red-tailed hawk	3	4	7
Sharp-shinned hawk	10	14	24
Turkey Vulture	10	10	20
Unidentified buteo	1		1
Unidentified raptor	4	1	5
Grand Total	**65**	**79**	**144**

Tables 3-4 and 3-5 provide a breakdown of minimum and maximum flight heights of raptors within and outside of the Project Area. Most minimum and maximum flight heights of raptors observed migrating through or near Canton Mountain were not within the RSZ.

As can be seen in Table 3-4, 38 percent of the 79 raptors that flew within the Project Area's airspace had a minimum flight height within the RSZ (36–130 m [118–427 ft]), followed by 33 percent with a minimum flight height above 130 m (427 ft), and the remaining 29 percent with a minimum flight height below the RSZ (Table 3-4). The majority of raptors outside the Project Area's airspace (71 percent) had minimum flight heights above 130 m (427 ft).

Table 3-4. Minimum flight heights of migrating raptors at Canton Mountain Wind Project, fall 2010.

Species	Outside Project Area Minimum Flight Height				Within Project Area Minimum Flight Height			
	0-35m	36 to 130m	> 130m	Grand Total	0-35m	36 to 130m	> 130m	Grand Total
American kestrel					2	1		3
Bald eagle	1			1	3	1		4
Broad-winged hawk	3		25	28	1	8	20	29
Cooper's hawk			2	2	2	4	1	7
Merlin		1		1	1	1		2
Northern goshawk						2		2
Northern harrier			2	2				
Osprey		1	1	2		1	1	2
Peregrine falcon						1		1
Red-shouldered hawk			1	1				
Red-tailed hawk	1	1	1	3	1	1	2	4
Sharp-shinned hawk	4	1	5	10	5	8	1	14
Turkey Vulture	3	3	4	10	7	2	1	10
Unidentified buteo			1	1				
Unidentified raptor			4	4	1			1
Grand Total	12	7	46	65	23	30	26	79

Fifty four (54) percent of the 79 raptors that flew within the Project Area's airspace had a maximum flight height above 130 m (427 ft), 38 percent within the RSZ (36–130 m [118–427 ft]), and the remaining 8 percent below the RSZ (Table 3-5). Seventy one (71) percent of the raptors observed outside the Project Area had maximum flight heights above 130 m (427 ft).

There was not a consistent pattern amongst species with regards to minimum and maximum flight heights (Table 3-4 and Table 3-5). However, some species, including northern goshawk and peregrine falcon were exclusively found within the RSZ, while other species were observed across a range of flight heights.

Table 3-5. Maximum flight heights of migrating raptors at Canton Mountain Wind Project, fall 2010.

Species	Outside Project Area Maximum Flight Height				Within Project Area Maximum Flight Height			
	0-35m	36 to 130m	> 130m	Grand Total	0-35m	36 to 130m	> 130m	Grand Total
American kestrel					2	1		3
Bald eagle			1	1			4	4
Broad-winged hawk	2	1	25	28		5	24	29
Cooper's hawk			2	2	1	4	2	7
Merlin		1		1		1	1	2
Northern goshawk						2		2
Northern harrier			2	2				
Osprey		2		2		1	1	2
Peregrine falcon						1		1
Red-shouldered hawk			1	1				
Red-tailed hawk	1	1	1	3		1	3	4
Sharp-shinned hawk	4	1	5	10	3	4	7	14
Turkey Vulture	1	5	4	10		9	1	10
Unidentified buteo			1	1				
Unidentified raptor			4	4		1		1
Grand Total	8	11	46	65	6	30	43	79

Fall raptor data from Canton Mountain were compared to hawkwatch count data for the same survey dates from Cadillac Mountain in Acadia National Park, Maine (Appendix B, Table 1). The Cadillac Mountain hawkwatch followed the same standardized HMANA data collection methods used by Tetra Tech at Canton Mountain. Over the course of the same 13 days surveyed, a total of 1,677 raptors were recorded at Cadillac Mountain compared with 144 raptors observed at Canton Mountain. Hourly passage rates averaged 23.96 birds/hr at Cadillac Mountain, compared with 2.17 birds/hr at Canton Mountain. Cadillac Mountain logged 70 survey hours while Canton Mountain logged 66.5 survey hours. Thirteen (13) species of raptors were recorded at both Cadillac Mountain and Canton Mountain during the 13 days of comparison.

3.4 Discussion

Based on the above results it appears that most of the raptor species observed during the fall 2010 survey are species commonly found in Maine. A few state-listed species including northern harrier, peregrine falcon, and bald eagle (discussed in Section 6.0) were observed during the survey; however, sightings of these species were uncommon when compared with the total number of birds identified. Observations of these species accounted for only 2% of the total number of raptors observed. Therefore, use of the Project Area during the fall 2010 period by sensitive raptor species appeared to be low.

Overall raptor abundance (number of observations) and passage rates were found to be low in comparison with the hawkwatch site at Cadillac Mountain, a site known for abundant raptor movements. While it is possible that this could be due to yearly variation or other factors, given the large difference in both total raptor numbers and passage rates the data suggest that the project site may be less important to raptors as a migratory corridor than other high-value pathways in the state.

Migrants that fly within and below the RSZ are at higher risk of collision with the turbines than migrants that fly above the RSZ. While over a third of the raptors observed had flight heights that either started or ended within the RSZ the majority (remainder) of observations were either above or below the RSZ. However, the percentage of raptors with an end flight height above the RSZ is considerably greater than the number with a start flight height above the RSZ. It was apparent that raptors were using the local topography of the larger and sometimes smaller mountains to the north of the Project Area to gain lift. This indicates that in addition to the static percentage of individuals observed in the RSZ certain raptors are also crossing through the RSZ during their flight path through the Project Area.

Although broad-winged hawks were the most abundant species within the Project Area, most of their movements through the Project Area were above 130 m (427 ft), the top of the RSZ. In contrast, most sharp-shinned hawks flew within or below the RSZ during their flights though the Project Area. The overall dynamics of *buteo* migration and *accipiter* migration are very different (Liguori 2005). Sharp-shinned hawks migrate individually and tend to hug side-slopes and ridges as they attempt to hunt during migration (Dunne et al. 1988). Broad-winged hawks meanwhile migrate in groups and appear to work together to find lift.

4.0 MIGRANT STOPOVER STUDY

4.1 Introduction

The northeastern United States is known to support a diverse group of avian species during spring and fall migration periods. Diurnal migrants (birds that fly during the day), such as raptors, some shorebirds, and waterfowl, can be visually documented during migration, whereas nocturnal migrants (bird that fly at night) can be more difficult to assess and quantify. Many neo-tropical passerine species are nocturnal migrants that stop over en route during the day to rest and refuel before resuming migration. Weather, time of day, and habitat availability all influence when, where, and how birds migrate and where they choose to stopover (Sibley 2001). Field surveys were designed to target migrant stopover and staging with the aim of understanding how and when species use particular locations. Migrant stopover surveys were conducted at Canton Mountain during fall 2010 to document use of the Project Area, including temporal and spatial trends.

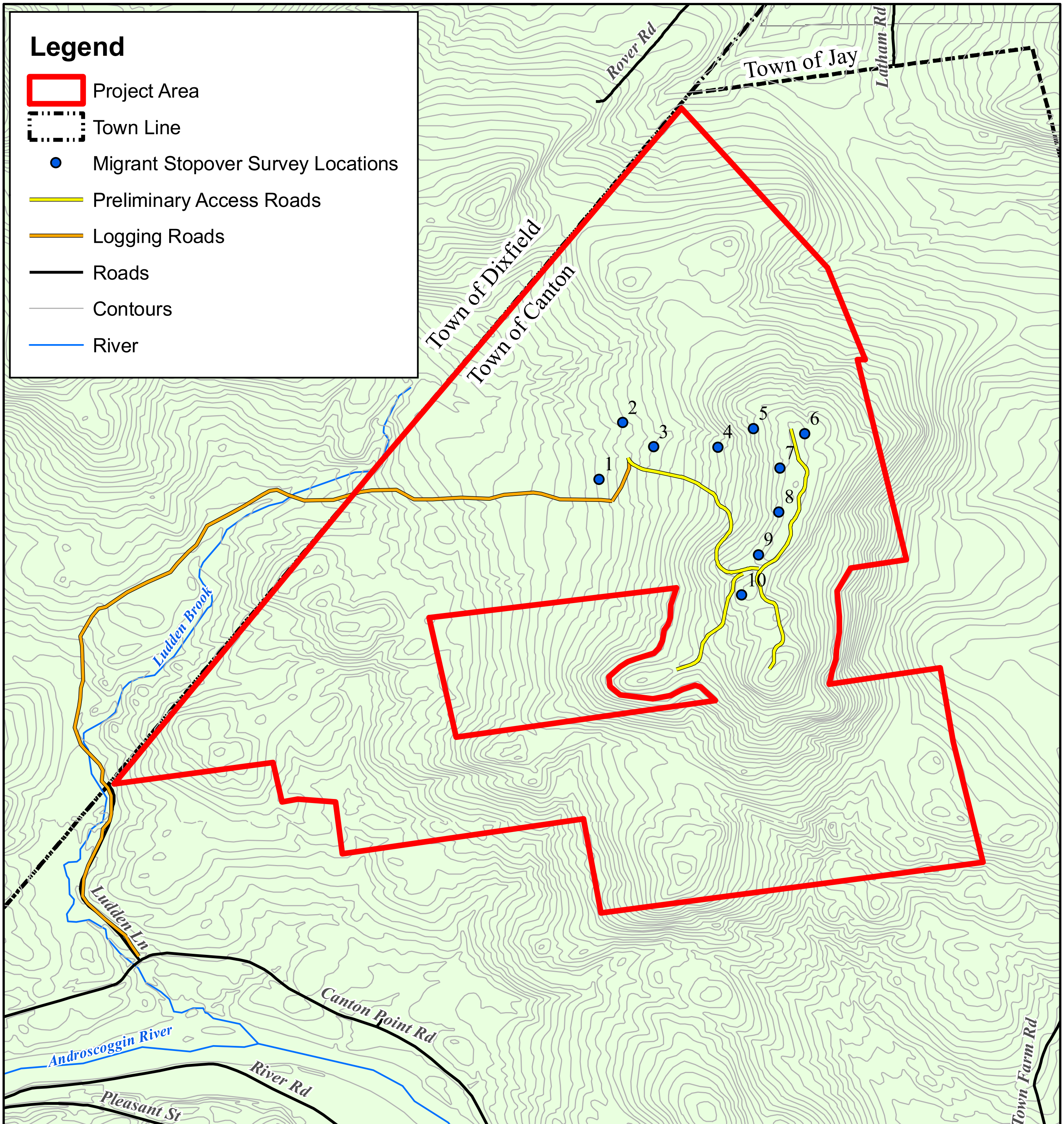
The following sections describe observations made at Canton Mountain during the fall 2010 migrant stopover surveys. Data on species composition, diversity, abundance, and location within the Project Area are presented and discussed.

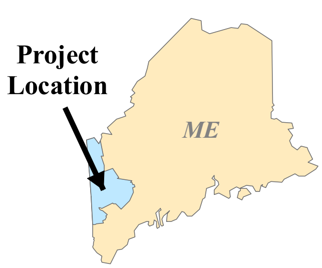
4.2 Methods

Tetra Tech biologists conducted standardized surveys along a single transect with 10 survey points (Figure 4-0). During the fall migration season, each point was sampled on 11 different days. Points were chosen to sample across elevation gradients and to include representative habitat types and were spaced approximately 0.18 km (0.11 mi) apart using a handheld Global Positioning System (GPS) unit to ensure individual birds were not counted twice. The length of the point-count transect was 2.3 km (1.4 mi). Standardized survey protocols were established by Tetra Tech biologists and reviewed by Maine Department of Inland Fisheries and Wildlife (MDIFW) prior to conducting the surveys.

Surveys targeted optimal weather conditions with light winds, warm temperatures, and no precipitation. Surveys began around sunrise and were completed within 4 hours. Each point was surveyed for 10 minutes. Every bird that was detected either audibly or visually was identified by species and recorded on standardized Tetra Tech data sheets. The behavior of migrant birds was also noted.

Survey point elevations along the point-count transect ranged from approximately 327 m (1,075 ft) to 465 m (1,525 ft). The habitat at the lower elevation points mainly consisted of mixed-deciduous northern hardwoods, with beech (*Fagus grandifolia*), maple (*Acer* spp.), and birch (*Betula* spp.) species present. The habitat changed as elevation increased, and the forest transitioned to spruce (*Picea* spp.) and balsam fir (*Abies balsamea*) species along the ridge.





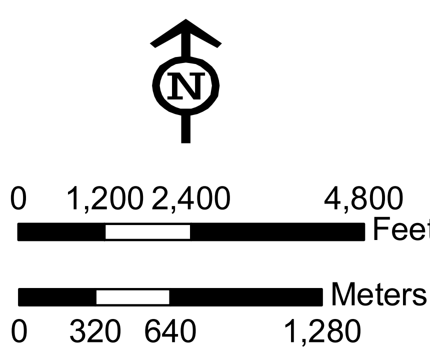


Figure 4.0 Migrant Stopover Survey Locations at Canton Mountain Wind Project - Fall 2010

Source: Maine Office of Geographic Information Systems (MEGIS), Roads 2008, Countours, 2000. Additional data provided by client Patriot Renewables, spring 2010.

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Date: 11/2010

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4.3 Results

A total of 717 birds, representing 50 species, were observed and recorded during the fall 2010 Canton Mountain Wind avian migrant stopover surveys (Table 4-0; Appendix C). All birds detected during surveys were assumed to be migrants. However, it is likely that some of these species are year-round residents of the Project Area. The number of different bird species detected (species richness) at each point ranged from 18 to 29 and total individuals observed ranged from 61 to 91 per point (Table 4-0).

Table 4-0. Summary of migrant stopover surveys by point at Canton Mountain Wind Project, fall 2010.

Point	Elevation (ft)	Species Richness/ Point	Total Number of Individuals/ Point
1	1,075	29	91
2	1,120	28	73
3	1,160	22	61
4	1,325	23	71
5	1,475	21	63
6	1,499	21	83
7	1,525	19	62
8	1,525	21	62
9	1,525	23	72
10	1,491	18	79
All Points		50	717

The number of different bird species detected (species richness) for each survey date ranged from 6 to 28 species, and total individuals observed ranged from 23 to 146 per day (Table 4-0). The highest observed counts of species richness and total number of individuals occurred on September 17, whereas the lowest counts occurred on October 13.

Table 4-1. Summary of migrant stopover surveys by date at Canton Mountain Wind Project, fall 2010.

Date	Species Richness/ Date	Total Number of Individuals/ Date
9/1/10	19	39
9/2/10	24	42
9/10/10	17	37
9/17/10	28	146
9/19/10	19	90
9/21/10	19	53
9/23/10	18	51
9/29/10	18	75
9/30/10	16	79
10/4/10	18	82
10/13/10	6	23
Grand Total	50	717

The average abundance (mean number of birds detected per survey) was 65.18 birds/survey day (Appendix C, Tables 1 and 2). The five most abundant bird species were black-capped chickadee (*Poecile atricapilla*) (9.00 birds/survey), white-throated sparrow (*Zonotrichia albicollis*) (7.36 birds/survey), blue jay (*Cyanocitta cristata)* (6.45 birds/survey), dark-eyed junco (*Junco hyemalis*) (6.82 birds/survey), and golden-crowned kinglet (*Regulus satrapa*) (3.00 birds/survey). Species richness and the total number of individuals observed generally declined with increasing elevation (Table 4-0 and Figure 4-1).

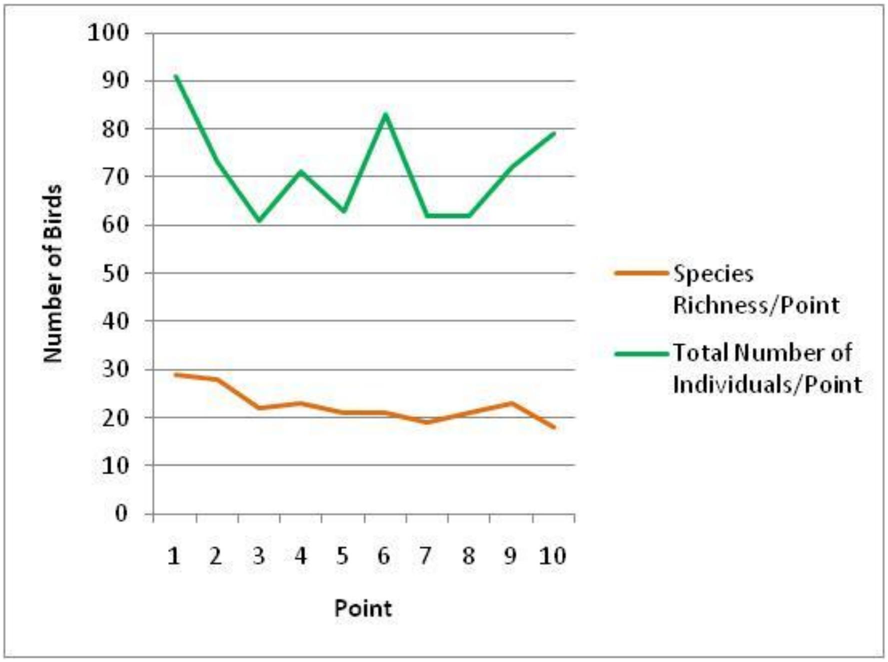


Figure 4-1. Species richness and total number of individuals detected by point-count location during migrant stopover surveys at Canton Mountain Wind Project, fall 2010.

Species richness slowly decreased over the survey period; however, the total number of individuals observed fluctuated across the survey period (Table 4-0 and Figure 4-2). The greatest species richness (28) and the greatest number of birds (146) detected occurred on September 17, 2010. Species richness and numbers of birds detected dropped during the last survey on October 13, 2010 where only 6 species and 23 individuals were observed. The most frequently observed species by survey date were black-capped chickadee (100 percent), blue jay (100 percent), golden-crowned kinglet (100 percent), white-throated sparrow (82 percent), red-breasted nuthatch (*Sitta canadensis)*(73 percent), common raven (*Corvus corax*) (73 percent), and dark-eyed junco (73 percent). The species composition observed is typical for this region of Maine. The remaining birds had frequencies below 70 percent and can be referenced in Appendix C, Table 2.

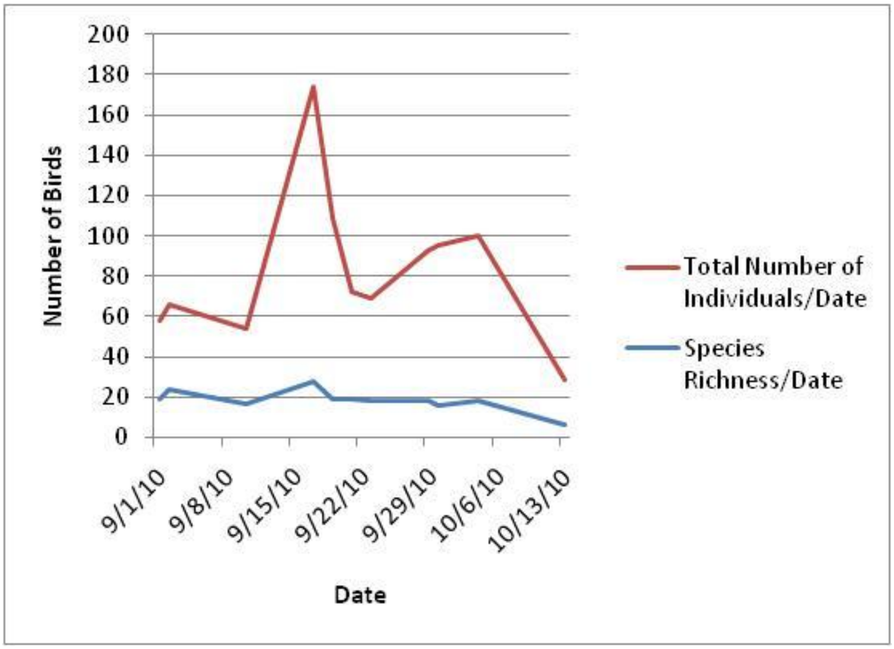


Figure 4-2. Species richness and total number of individuals detected by date-count location during migrant stopover surveys at Canton Mountain Wind Project, fall 2010.

4.4 Discussion

The species composition and abundance of the migrant population of passerine songbirds utilizing the Project Area is typical of the region as a whole (DeGraaf and Yamasaki 2001). The majority of these species are common throughout the region, although four of the documented species at Canton Mountain are considered species of special concern by MDIFW (MDIFW 2010). MDIFW considers these species to be vulnerable due to a variety of factors and could become endangered or threatened over time. Species of special concern are not protected under endangered species statutes nor do they receive any special legislative protection. These include the American redstart (*Setophaga ruticilla*), black-and-white warbler (*Mniotilta varia*), chestnut-sided warbler (*Dendroica pensylvanica*), and white-throated sparrow. All of these species of special concern are considered long-distance migrants; therefore, these individuals would be expected to fly in and out of the Project Area.

Many of the most abundant birds observed at the Project Area, including black-capped chickadee, blue jay, and dark-eyed junco, may be resident birds. These birds typically fly within or close to the forest canopy and therefore would have a reduced likelihood of occurring within the RSZ.

The data show that both species richness and numbers of birds drops precipitously on or around October 13th. This suggests that beyond this date the overall abundance of birds and presence of sensitive species is low.

5.0 BAT ACOUSTIC SURVEY

5.1 Introduction

Tetra Tech conducted bat acoustic surveys at the Project in the spring, summer, and fall of 2010. The goals of the study were to assess and quantify bat use of the Project Area. Bat activity was monitored using ultrasonic acoustic recorders (Anabat SD-1, Titley Scientific, Inc.) at seven different monitoring stations throughout the Project Area. This section presents the cumulative results of nearly 5 months of bat activity recorded during the spring migration, summer residency period, and fall migration.

5.2 Methods

Four acoustic bat detectors were deployed at seven monitoring stations at different times and elevations and within different habitat types in the Project Area. The duration of the deployment period for the seven detector stations varied. Initially, two detectors were deployed on April 14 (Table 5-0).

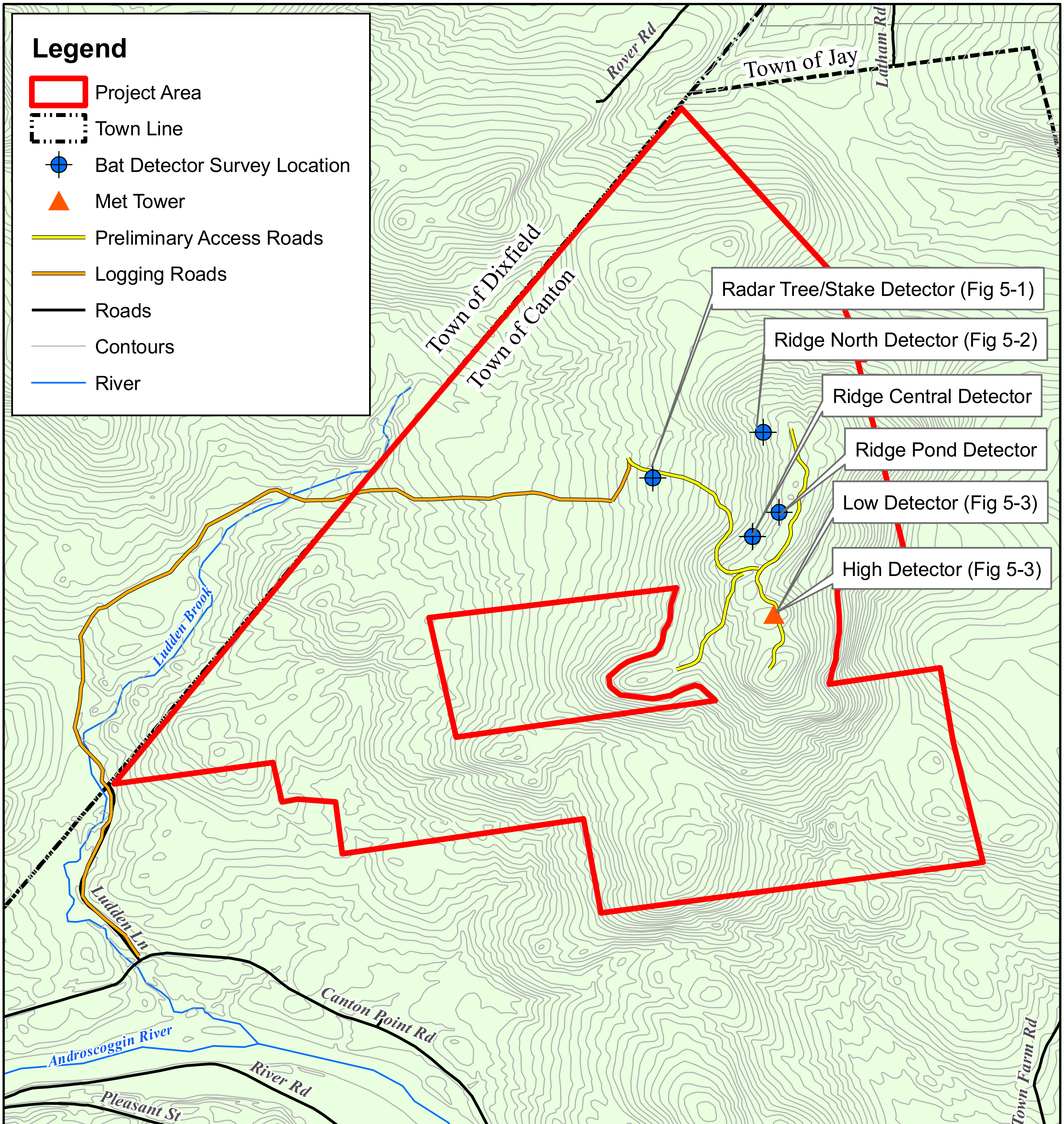
Table 5-0. Summary of acoustic monitoring survey effort by detector at Project Area, 2010.

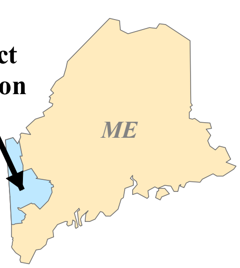
Detector Location		Period of Operation	Detector-Nights
Met Tower	High	June 30 - Oct. 31	117
	Low	June 30 - Oct. 31	122
Radar Site	Tree	April 14 - Aug. 23	101
	Stake	Aug. 23 - Oct. 31	65
Ridge	North	April 14 - Oct 31	183
	Central	June 8 - June 29	22
	Pond	June 21 - June 29	9
Total			619

One detector was placed in a tree near at the avian radar (Radar Tree detector) at a height of 5 m (15 ft) and at an elevation of 356 m (1,167 ft) (Figure 5-0). The second detector deployed on April 14 was placed higher up on the ridge (449 m [1,473 ft]) and north of the radar location (Ridge North detector). The Ridge North detector was located in a small clearing at a height of 2 m (6 ft) (Figures 5-0 and 5-2). On August 23, the Radar Tree detector was moved to maximize solar exposure on August 23 from the tree to a nearby stake at a height of 2 m (6 ft) near the avian radar system (Figure 5-1).

Four additional detector stations (using a total of two detectors) were established during June in the Project Area (Table 5-0). Two of these detector stations were placed for short durations in potential bat habitat, and two detectors were deployed for the duration of the summer and fall monitoring period at the met tower (Table 5-0, Figures 5-1 and 5-2). On June 8 the Ridge Central detector was deployed in a clear cut along the ridgeline (Figure 5-0). The Ridge Central detector was attached to a tree at a height of 4 m (12 ft) in a regenerating clear cut near the ridgeline at an elevation of approximately 457 m (1,500 ft). The Ridge Central detector operated until June 29. On June 21 a detector was placed 2 m (6 ft) above a small pond on the ridge top (Ridge Pond). The Ridge Pond detector operated until June 29 (Table 5-0 and Figure 5-0). After installation of the met tower on June 30, the Ridge Pond and Ridge Central Detectors were moved into the met tower at heights below and within the rotor-swept zone of the proposed turbines. The two met tower detectors sampled bat activity within the airspace of the proposed Project Area considered to be of highest risk to migratory bats. The 'High Detector' and 'Low Detector' (Figure 5-0) were deployed on the guy wires of the on-site met tower at an elevation of 457 m (1,500 ft). The 'High Detector' and 'Low Detector' were suspended at heights of 30 m (98 ft) and 15 m (49 ft), respectively.

To ensure that the greatest period of bat activity was surveyed, each detector was programmed to begin recording 45 minutes before sunset and stop recording 45 minutes after sunrise each day. This nightly monitoring period was consistent with MDIFW's recommended bat monitoring guidelines and was reviewed by MDIFW prior to commencement of the survey.





Source: Maine Office of Geographic Information Systems (MEGIS), Roads 2008, Countours, 2000. Additional data provided by client Patriot Renewables, spring 2010.

Figure 5.0 Bat Detector Survey Locations at Canton Mountain Wind Project - Fall 2010

Prepared For: PATRIOT RENEWABLES

Prepared By: TETRA TECH

Date: 11/2010

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Figure 5-1. Location of the Radar Stake detector at the Project Area, fall 2010.

Figure 5-2. Location of the Ridge North detector at the Project Area, fall 2010.

Figure 5-3. Location of the High and Low Met Tower Detectors at the Project Area, fall 2010.

Each detector station consisted of an Anabat SD-1 bat acoustic detector powered by a 5-watt solar panel and a 12-volt battery encased in a waterproof housing. The housing suspended the Anabat microphone downward. A plastic deflector shield angled at 45 degrees below the microphone facilitated recording of the airspace above and adjacent to the detector. Each detector was manually checked by Tetra Tech staff every 2 weeks during the survey period.

5.3 Data Analysis

Potential bat call files were extracted from data files using CFCread© software. CFCread© software screens all data recorded by the bat detector and extracts call files using a filter. The default settings for the CFCread© software were used during the file extraction process to ensure comparability between data sets. These settings include a maximum time between calls (TBC) of 5 seconds, a minimum pulse fragment line length of 5 milliseconds, and a smoothing factor of 50. The smoothing factor refers to whether or not adjacent pixels can be connected with a smooth line. The higher the smoothing factor, the less restrictive the filter, resulting in more noise files and poor quality call sequences retained within the data set. A call is defined as a single pulse of sound produced by a bat. A call sequence is defined as a combination of two or more pulses recorded in a single call file. However, a single bat can be responsible for a number of call sequences.

A qualitative visual comparison was made between recorded bat call sequences and established reference libraries of bat calls. This technique allows for relatively accurate identification of bat species (O'Farrell et al. 1999, O'Farrell and Gannon 1999). All call sequences were also run through a series of conservative filters based on call sequence characteristics outlined in Szewczak et al. (2008) and from known species call sequences (hand released and zip-line individuals) from a regional call library. A call sequence was considered of suitable quality and duration to be included in data analysis if the individual call pulse(s) exhibited the full spectrum of frequency modulation produced by a bat (i.e., consisting of sharp, distinct lines) with a minimum of 5 pulses.

Relative abundance, or the magnitude of each species' contribution to recorded bat activity levels, was obtained by calculating an Index of Activity (IA) modified from Miller (2001). The method is based on the presence/absence of bat vocalizations within 1-minute time increments. IA was calculated as the sum of minute-increments with a species presence divided by the unit effort (IA = # of minutes/detector-nights * 100). The IA calculation allows for samples with different levels of effort (i.e., different total number of detector-nights) to be accurately compared, thereby reducing the potential bias associated with comparing results from detectors with different study efforts.

5.4 Results

The 2010 bat acoustic monitoring survey started on April 14 and ended on October 31 (Table 5-1). During the 201-night survey period detectors operated for 619 detector-nights (number of detectors multiplied by the number of nights that detectors were operational). A total of 2,585 bat call sequences, and 2,010 minutes of bat activity (number of minutes with bat vocalizations present) were recorded during this period (Table 5-1 and 5-2).

The number of detector-nights recorded by each detector was variable (Table 5-1). The longest duration of monitoring was at the Ridge North stake detector (operating for 183 detector nights, *n* = 183). The Low Detector and High Detectors operated for nearly as long, 122 and 177 detector-nights, respectively. The detector located at the radar site operated from a tree (Radar Tree) for the first 101 detector-nights, and was then moved to a stake for the remaining 65 detector-nights (Radar Stake)
(Table 5-1). The Ridge Central and Ridge Pond detectors operated for shorter durations than the Ridge North; Ridge Central operated for 22 detector-nights and Ridge Pond operated for 9 detector-nights (Table 5-1). These detectors were deployed to record bat activity at selected habitat areas that were not being sampled by the other long-term bat monitoring stations.

The highest IA rate (# of minutes of bat activity/detector-nights * 100) was recorded by the Ridge Pond detector (IA = 3,311.1), which sampled the fewest number of nights (*n* = 9). This detector was deployed as an additional detector to evaluate a landscape feature that may attract bats. This detector recorded 412 call sequences during 298 minutes of bat activity. This pond is the largest source of water on the ride. The lowest IA rate (42.6) was recorded by the met tower Low Detector, which recorded 54 call sequences. The met tower High Detector recorded 56 call sequences with an IA rate of 47.0 (Table 5-1).

IA values were calculated for each of the detector groups: met tower, radar site, and ridge. IA values were calculated for the two met tower detectors (Low Detector and High Detector) pooled, the radar site detectors (Radar Tree and Radar Stake) pooled, and the ridge detectors pooled (North, Central, and Pond). The IA value for the met tower detectors was 46, substantially lower than the IA for the radar site (492.7). The IA value for the three ridge detectors was 774.3.

The total duration of recorded bat activity was variable across detector locations. The greatest duration of bat activity was recorded at the Ridge North detector (*n* = 776 minutes). This detector operated the longest (183 detector-nights) and recorded the greatest number of call sequences (*n* = 1,169). The next greatest duration of bat activity was recorded by the radar site detectors (Radar Tree and Radar Stake), which recorded 757 minutes of activity, combined. The radar site detectors operated for a combined 166 detector-nights and recorded a combined total of 818 call sequences. The least amount of activity was recorded by the Low Detector (*n* = 52 minutes) and High Detector (*n* = 55 minutes), which both operated for approximately 4 months (Table 5-1).

Table 5-1. Summary results of acoustic monitoring survey effort by detector at Project Area, 2010.

Detector Location		Period of Operation	Detector-Nights	Number of Minutes with Activity	Total Number of Call Sequences	Overall Index of Activity (# of Mins Activity/ Detector-Nights)*100	Pooled Index of Activity
Met Tower	High	June 30 - Oct. 31	117	55	56	*47.0*	46.0
	Low	June 30 - Oct. 31	122	52	54	*42.6*	
Radar Site	Tree	April 14 - Aug. 23	101	626	683	*619.8*	492.8
	Stake	Aug. 23 - Oct. 31	65	131	135	*201.5*	
Ridge	North	April 14 - Oct 31	183	776	1169	*424.0*	774.3
	Central	June 8 - June 29	22	72	76	*327.3*	
	Pond	June 21 - June 29	9	298	412	*3311.1*	
Total			**619**	**2010**	**2585**	***324.7***	**--**

Bat call sequences were identified to the lowest possible taxonomic level (Tables 5-2 and 5-3). Eighty-nine (89) percent of recorded calls were identified to species level (*n* = 2,301). Calls were then combined into four 'Known Species Groups' based on similarities in call sequence structure: Low Frequency Species, Middle Frequency Species, *Myotis* Species, and Eastern red bat (*Lasiurus borealis*) (Table 5-2). Call sequences that did not meet the parameters required for genus level identification could not be classified to species level (*n* = 284) and were grouped into 'Unknown Species Groups.' These Unknown Species Groups consisted of bat call sequences with insufficient quality to identify to species or 'Known Species Group' level (Table 5-2).

Five species were definitively identified within the recorded call sequences from the 2010 passive monitoring effort. A total of 232 calls (9 percent), were attributed to long-distance migratory bats including the hoary bat (*Lasiurus cinereus)*, silver-haired bat (*Lasionycteris noctivagans*), and Eastern red bat. The majority (79 percent) of recorded call sequences (*n* = 2,030) were identified as Northern myotis (*Myotis septentrionalis*). Northern *myotis* produce call sequences with relatively unique characteristics that can generally be accurately identified to species level. These calls were identified by steep slope, high mean maximum frequency, high characteristic frequency, and amplitude concentration in the higher frequency range of the call pulses. A small number of calls (*n* = 13) were identified as unknown species *Myotis*. It is possible, but unlikely, that a portion of the unknown *Myotis* species call sequences were from eastern small-footed myotis (*M. leibii*). None of these calls exhibited attributes consistent with reference calls from *M. leibii*. The remaining call sequences (*n* = 39) identified to species level were classified as big brown bat (*Eptesicus fuscus*). Overall, big brown bat calls comprised 1.5 percent of recorded call sequences. Big browns will migrate short distances to find an appropriate locations for hibernation.

Three Maine state-listed species of special concern were documented during the survey period: Eastern red bat, silver-haired bat, and hoary bat (MDIFW 2009). No calls of federally listed bat species were identified during the survey.

Table 5-2. Summary of bat call sequences and species recorded at Project Area, 2010.

Group	Characteristic Frequencies*	Species	Total Call Sequences
Low Frequency	12 kHz–24 kHz	Hoary bat	101
		Unknown low frequency call seq.	10
Middle Frequency	24 kHz–38 kHz	Big brown bat	39
		Silver-haired bat	68
		Silver-haired bat/ Big brown bat	0
		Unknown middle frequency call seq.	66
Eastern red bat	44–45 kHz	Eastern red bat	63
High Frequency (*Myotis* species)	46–52 kHz	Northern myotis	2,030
		Eastern small-footed myotis	0
		Little brown myotis	0
		Unknown *Myotis* species	13
		Unknown high frequency call seq.	195

*** Characteristic frequency (Fc) is generally defined as the frequency of the call pulse at the lowest slope, or the lowest frequency of the consistent frequency modulation sweeps. Fc represents the single most useful parameter for species identification.**

Table 5-3. Summary of Index of Activity by species recorded at Project Area, 2010.

Detector Location		Species									Total
		Hoary bat	Silver-haired bat	Big brown bat	Eastern red bat	Nothern myotis	*Myotis* species	Low Frequency	Middle Frequency	High Frequency	
Met Tower	High	22.2	5.1	1.7	11.1	0.9	0.0	1.7	1.7	2.6	47.0
	Low	22.1	0.8	0.0	16.4	0.0	0.0	0.0	0.0	3.3	42.6
Radar Site	Tree	10.9	25.7	22.8	6.9	496.0	8.9	0.0	48.5	0.0	619.8
	Stake	1.5	4.6	13.8	10.8	80.0	0.0	3.1	9.2	78.5	201.5
Ridge	North	16.9	16.4	0.0	8.7	348.6	1.6	3.3	3.8	24.6	424.0
	Central	9.1	0.0	0.0	0.0	254.5	0.0	0.0	0.0	63.6	327.3
	Pond	0.0	0.0	0.0	0.0	2544.4	0.0	0.0	0.0	766.7	3311.1
Total		15.8	10.7	5.5	10.2	238.6	1.9	1.6	10.3	30.0	324.7

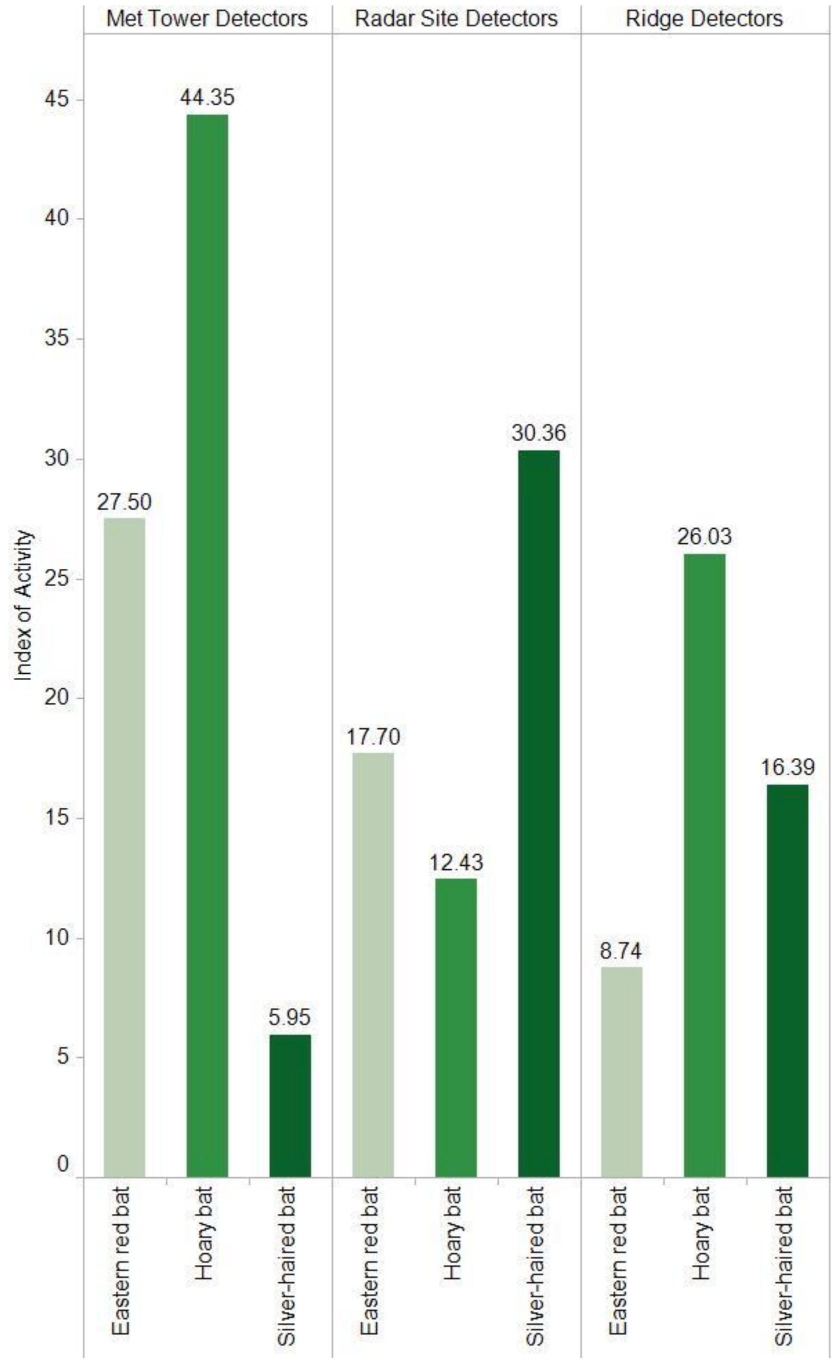


Figure 5-4. Index of Activity of migratory bat species by detector site group, 2010.

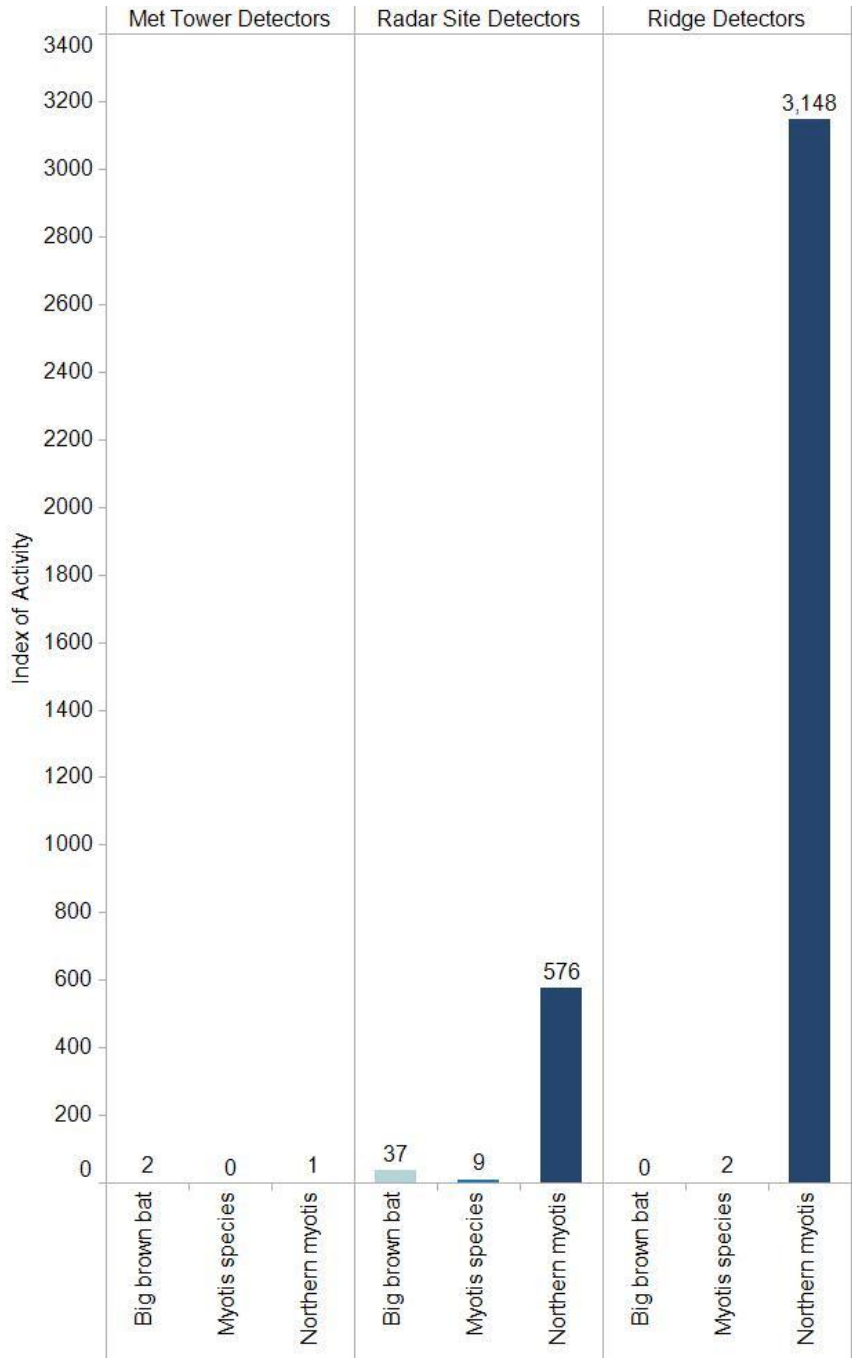


Figure 5-5. Index of Activity of non-migratory bats by detector site group, 2010.

Relative activity levels for each species and species group across sampling locations were calculated (Table 5-3). Northern myotis was the most active species, as represented by IA, at the radar site detectors and ridge detectors (Table 5-3). Hoary bat was the most active species at the met tower detectors, followed by Eastern red bat, and silver-haired bat. Northern myotis was the least active species at the High Detector and was not recorded by the Low Detector.

Bat activity varied between nights and between detector locations (Figures 5-6, 5-7, 5-8, 5-9). Overall, there was no bat activity recorded before April 20, 2010. Activity increased slightly after April 20 but declined again in late April. Activity began to increase in early May until peak activity was recorded on June 21. Activity declined after June, although bats were active and present at relatively consistent levels through July, August, and early September. Activity rates declined through September and there was no activity recorded between September 29 and October 14, when the last minutes of activity were recorded.

Seasonal variability in the combined activity rates recorded by the radar site detectors was similar to the combined activity rates of all the detectors (Figures 5-6 and 5-7). At the radar site, activity was first recorded on April 20, and increased thereafter until peak activity was recorded on June 9. After June 9 activity was lower, but consistent, until a secondary peak of activity was recorded on July 2. Activity declined from early July's peak through the end of July and into late August. In early September activity increased slightly, but declined thereafter until October 14, the last date bat activity was recorded.

The combined activity rate of the two met tower detectors was dissimilar to the overall trend of seasonal activity patterns for all the detectors combined (Figures 5-6 and 5-8). Activity at the met tower detectors was low and relatively consistent through August and early September; however, activity was greatest during late September. None of the other detector sites exhibited this seasonal distribution of bat activity. Majority of bat calls from the met tower detectors were from long-distance migrants. The other detector locations (ridge and radar) recorded peak activity during the summer months (resident bats); however, peak activity (minutes of activity) at the met tower detectors was recorded on September 21 (migratory bats).

At the three ridge detectors there was minimal activity recorded during the month of April, and activity rates did not begin to increase until late May and early June. Activity was greatest during the month of June (Figure 5-9) with peak activity at the ridge detectors recorded on June 21. The last call sequences were recorded on September 29.

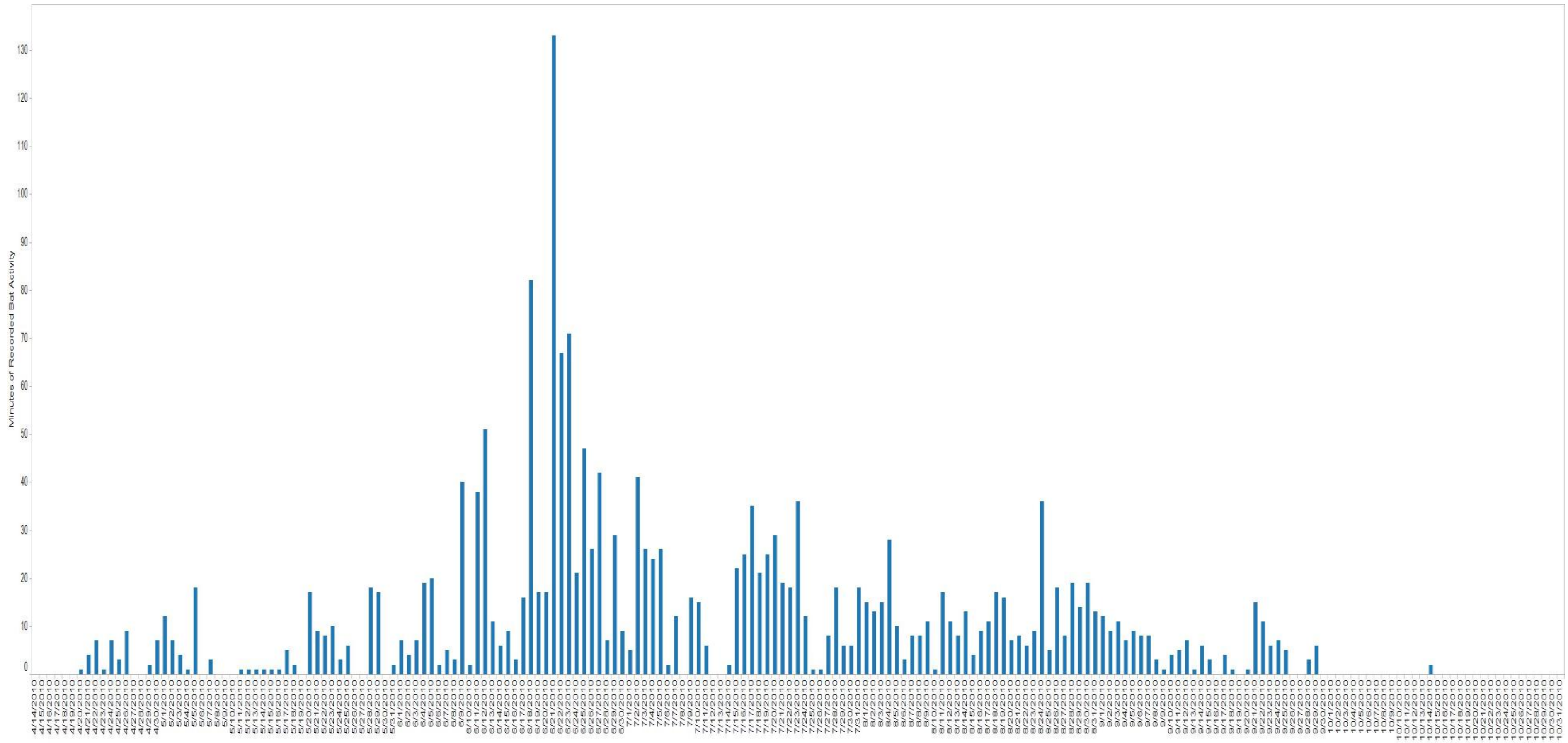


Figure 5-6. Minutes of activity per night for all detectors pooled, 2010.

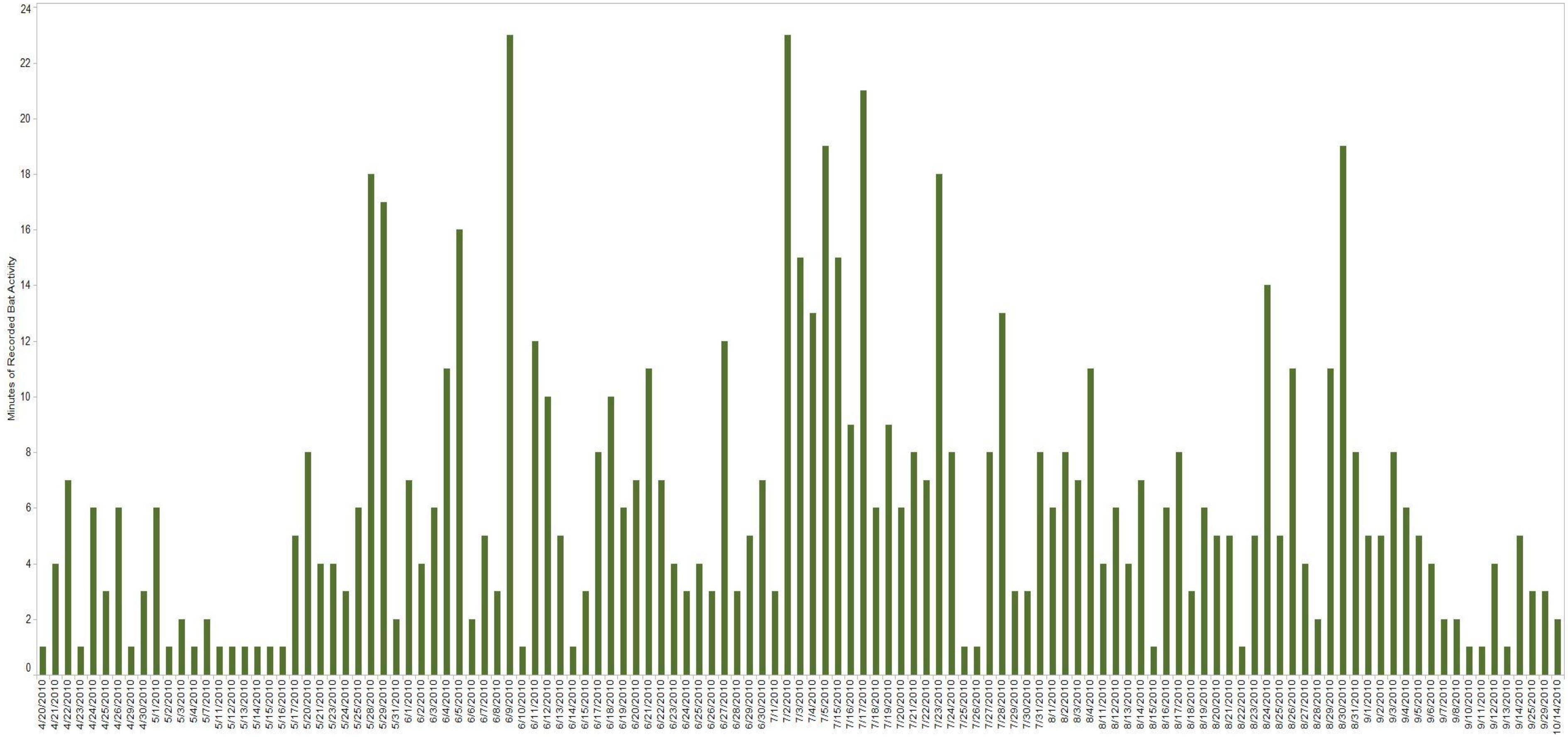


Figure 5-7. Minutes of activity per night for radar site detectors pooled, 2010.

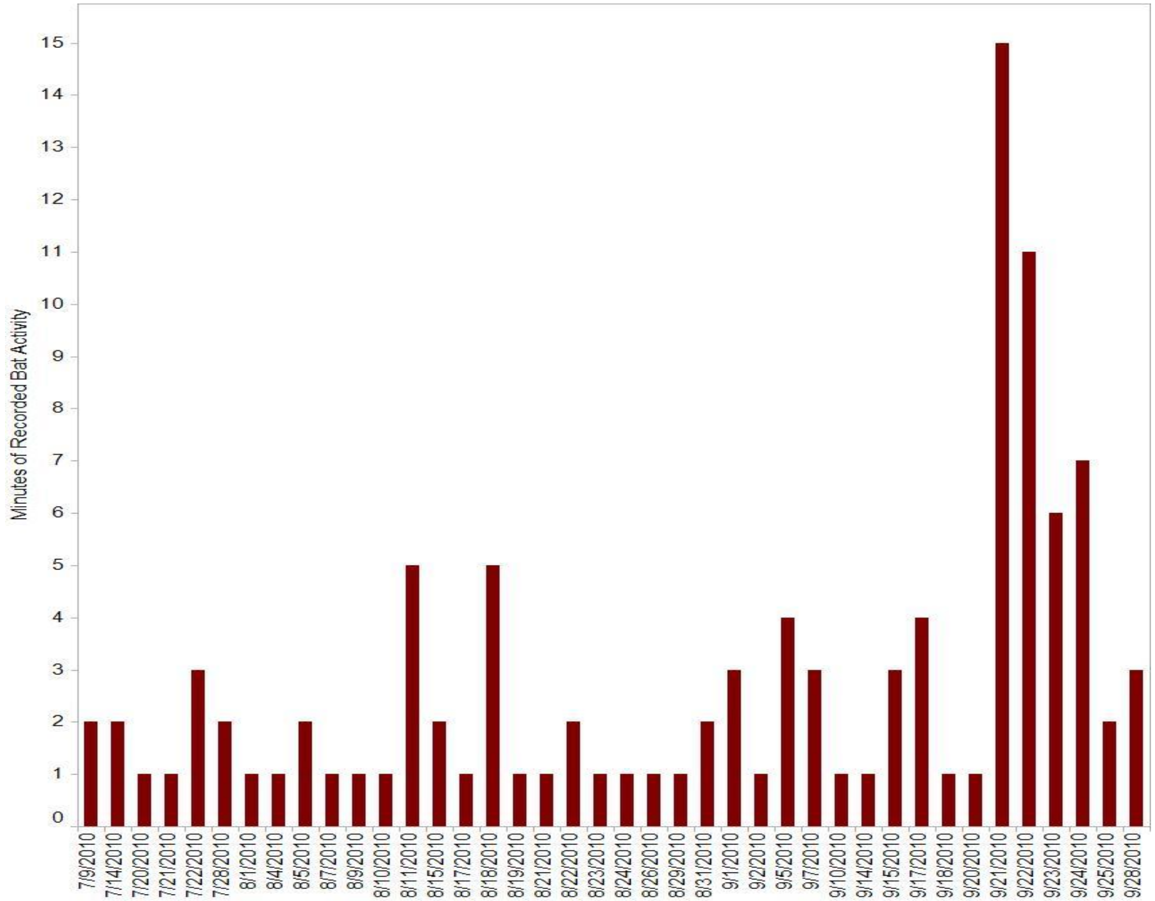


Figure 5-8. Minutes of activity per night for met tower detectors pooled, 2010.

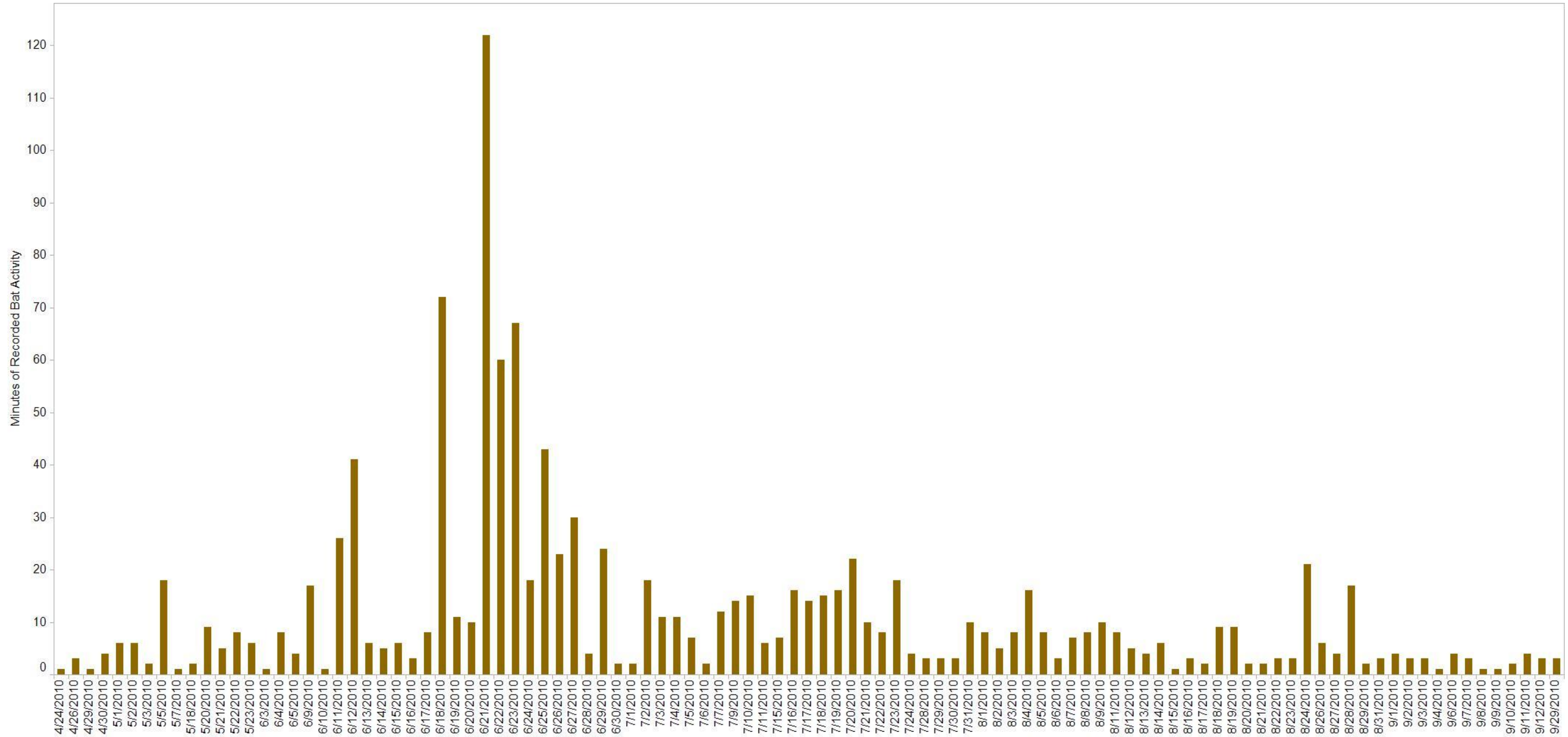


Figure 5-9. Minutes of activity per night for ridge detectors pooled, 2010.

5.5 Discussion

Recent research has demonstrated that tree-roosting migratory bat species have been the predominant species found during post-construction mortality studies at operational wind farms in North America (Arnett et al. 2008). Results from these mortality studies show the three bat species most commonly encountered during ground searches are long-distance migratory bats: Eastern red bat, hoary bat, and silver-haired bat (Kunz et. al 2007, Arnett et al. 2008). Silver-haired bat, Eastern red bat, and hoary bat were positively identified from recordings during the 2010 survey period; however, these species were recorded less frequently than non-migratory *Myotis* species. Overall, there was more *Myotis* species activity than migratory bat activity in the Project Area. This demonstrates that the bat community of the Project Area likely consists of summer resident *Myotis* species and occasional migratory bats during the migration periods.

Spatial distribution patterns of bat activity in the Project Area may be a function of the amount of open airspace available adjacent to the detector locations. Migratory bat activity was greatest at the met tower detectors and lowest at the ridge detectors. The three migratory species (hoary bat, Eastern red bat, and silver-haired bat) all have relatively higher wing aspect ratios than *Myotis* species; they are therefore more likely to occur in open habitat (Swartz 2003). The largest open habitat areas were at the met tower and radar site. The highest IA values for two of the three migratory species were recorded at the met tower. The met tower site was a completely cleared area of at least 30 m^2 (90 ft^2). Silver-haired bat IA rates were highest at the radar site detectors. The radar site was a moderate sized regenerating timber landing, which provided substantially more open habitat than adjacent forested areas. None of the other detector locations had similar types or amounts of adjacent open habitat.

Water resource availability is also known to be a driving factor of bat spatial distribution patterns (McCain 2007). The size of a body of water and the type of surrounding habitat may affect access by bats with different wing aspect ratios (size of wing in relation to body size). The Ridge Pond detector was located at the only permanent water source on the ridgeline. The small pond was a depression no greater than 5 m (16 ft) across, surrounded by a dense grove of eastern hemlock (*Tsuga canadensis*), spruce (*Picea* sp.), and fir (*Abies balsamea*). IA values were highest at the Ridge Pond detector, despite the limited duration of monitoring at this location (9 detector-nights). The detector only recorded call sequences from Northern myotis, and some High Frequency Unknown call sequences. Northern myotis prefer to forage in dense vegetation (Brooks and Ford 2005). Furthermore, Northern myotis have a low wing aspect ratio, whereas the long-distance migratory species occurring in the Project Area have high wing aspect ratios. In general species with low wing aspect ratios are able to fly through smaller forest openings (Swartz 2003). Therefore, it seems that the ridge pond acted as a water source for Northern myotis, but likely not for migratory species (Eastern red bat, hoary bat, or silver-haired bat). The habitat adjacent to the ridge pond likely made it an undesirable place for longer winged, less maneuverable migratory bats to access water or forage. Additionally, it is possible that the absence of a suitable body of water on the ridgeline discouraged the occurrence of migratory species during the summer residency period on the ridge. There were few recorded call sequences of migratory species outside of the migration period during the 2010 study.

Documented patterns of the spatial distribution of bats in the Project Area do not suggest the presence of a large bat migration corridor along the ridgeline. If a substantial migration corridor did exist over the Project Area, the data should show a higher ratio of minutes of bat activity to detector nights. The sporadic and low-level occurrence of long-distance migratory species at the sampling locations indicates that few individuals use the ridgeline in the vicinity of the detectors during migration. There did not appear to be an episode of dramatic fluctuation in recorded activity that could be definitively attributed to large-scale migration. There was an observable increase in migratory bat activity during the spring and fall migration periods at the met tower detectors; however this increase was minimal and was not indicative of a large number of bats moving through the Project Area (Cryan and Veilleux 2007).

Weather conditions, including mean nightly temperature and wind speed, probably contributed to the patterns of activity recorded by the acoustic detector sets. Overall, the increase in bat call sequences recorded in June may have resulted from the following: (1) increased foraging activity near the detectors due to a rise in mean nightly temperatures (Racey and Swift 1985, O'Donnell 2000, Kusch et al. 2004); (2) increases in food resource concentrations near the detectors; or, (3) bats leaving a roost and transiting to an established area of concentrated food resource. The increase in activity of hoary bat, Eastern red bat, and silver-haired bat at the met tower detectors during September was almost certainly attributable to migration (Cryan and Veilleux 2007).

There is inherent difficulty in attempting to interpret the number of recorded call sequences as an indication of activity levels; however, detection rates, recorded minutes of activity and IA values do provide a relative measure of bat activity near sampling locations. The limited maximum range of a single Anabat detector (approximately 30 m [100 ft]) makes the characterization of landscape-scale movements, such as migration, difficult to assess. However, a comparative assessment of the results from detectors arrayed along a ridgeline and at different elevations, such as at the Project Area, facilitates the characterization of spatial distribution and phenology of bats within the Project Area.

The total number of bat call sequences and minutes of activity recorded each night by a given detector may or may not reflect the absolute level of bat activity present in the Project Area, although some studies have suggested that there may be a relationship between the numbers of calls recorded and bat activity levels (Gorresen et al*.* 2008). The bias in passive acoustic surveys of this type stems from the unknowns associated with recorded call sequences. For example, a single foraging individual may produce a large number of call sequences that are within the range of a given detector set. Conversely, a large number of individual bats may pass the detector set and produce an equally large number of call sequences. It is important to note that the survey results are a sample of bat activity in the airspace surrounding the detectors and are not necessarily indicative of bat activity throughout the entire Project Area. In addition, the variability in sampling effort at the Project Area may have skewed the results between sampling locations. However, by calculating an Index of Activity coefficient, a comparison between sampling locations with different levels of effort becomes more valid.

At the Project Area in 2010, activity was greatest at the ridge detectors (IA = 774.3), followed by the radar site (IA = 492.7) and the met tower site (IA = 46). This variability in IA rates across detector sites is likely a function of habitat differences and variability of the height of the detectors. The ridge detectors were placed in forested or regenerating forest habitat. These detectors were located close to ground level, and in the case of the Ridge Pond and Ridge Central detectors, were focused on areas of expected high bat activity. The radar site detectors were located in habitat that was not necessarily optimal for bat foraging activity and was not near a water source. The met tower detectors were located well above ground level and in a large, recently cleared, forest opening at a high elevation on the ridge. The recorded IA values for each of these detector groupings shows that bat activity within the Project Area is greatest near ground level, near permanent water sources, and contiguously forested habitat interspersed with early successional forest openings (Brooks and Ford 2005).

6.0 BALD EAGLE SURVEYS

6.1 Introduction

MDIFW de-listed the bald eagle in 2009 and it is now considered a species of special concern in Maine. The bald eagle is no longer protected under the Endangered Species Act but it continues to receive protection from the Migratory Bird Treaty Act, the Bald and Golden Eagle Protection Act, and the Lacey Act. Each of these acts prohibits the 'take' of bald eagles. As part of the de-listing criteria, monitoring of bald eagles is still a requirement for MDIFW.

Patriot consulted with the U.S. Fish and Wildlife Service (USFWS) and the MDIFW regarding the possible presence of bald eagles in or near the Project Area. In early 2010, MDIFW provided Patriot with a map depicting all known eagle nest locations within 4 miles of the Project Area (Figure 6-0). Two nest structures were depicted on the map approximately 2.5 miles south of the Project Area on the Androscoggin River. These two nests are located in close proximity (within 0.5 mi) to each another.

The objective of eagle surveys was to support both state regulatory permitting for the Project and to address USFWS concerns regarding bald eagles nesting in the vicinity of the Project. The survey design and methodology were selected based on USFWS recommendations to address Bald and Golden Eagle Protection Act (BGEPA) concerns, and also to conform to bald eagle nest search protocols used historically by MDIFW.

6.2 Methods

Tetra Tech conducted an initial site reconnaissance and visual survey of the two known nest locations identified by MDIFW during summer 2010. On June 30, 2010, a Tetra Tech biologist spent two hours observing the two nest locations. In addition, on July 15, 2010, two Tetra Tech biologists conducted a bald eagle survey by boat on the portion of the Androscoggin River south of the Project Area where the two documented nests occur (Figure 6-1). The July 15 boat survey started at the Dixfield River Access boat launch, and all eagle activity was recorded as the boat floated downstream. The survey lasted 2.3 hours and ended just after the Route 140 Canton Bridge.

During eagle surveys the following data were collected:

- Condition of each nest
- Nest occupancy (active/inactive)
- Characteristics and behavior of any bald eagles observed
- Number of eagles in area

Other bald eagle surveys included observations of bald eagles made during other phases of the avian and bat study as well as during the spring 2010 and fall 2010 raptor surveys. In addition, a spring 2011 aerial flight was conducted to document nesting locations along the Androscoggin River, as well to evaluate the area within 10 miles of the Project Area (Figure 6-2). The survey design and methodology were selected based on USFWS recommendations to address Bald and Golden Eagle Protection Act (BGEPA) concerns, and also to conform to bald eagle nest search protocols used historically by MDIFW. In addition, based on consultations with USFWS and MDIFW prior to surveys, the nest-search flight radius around the Canton Mountain Wind

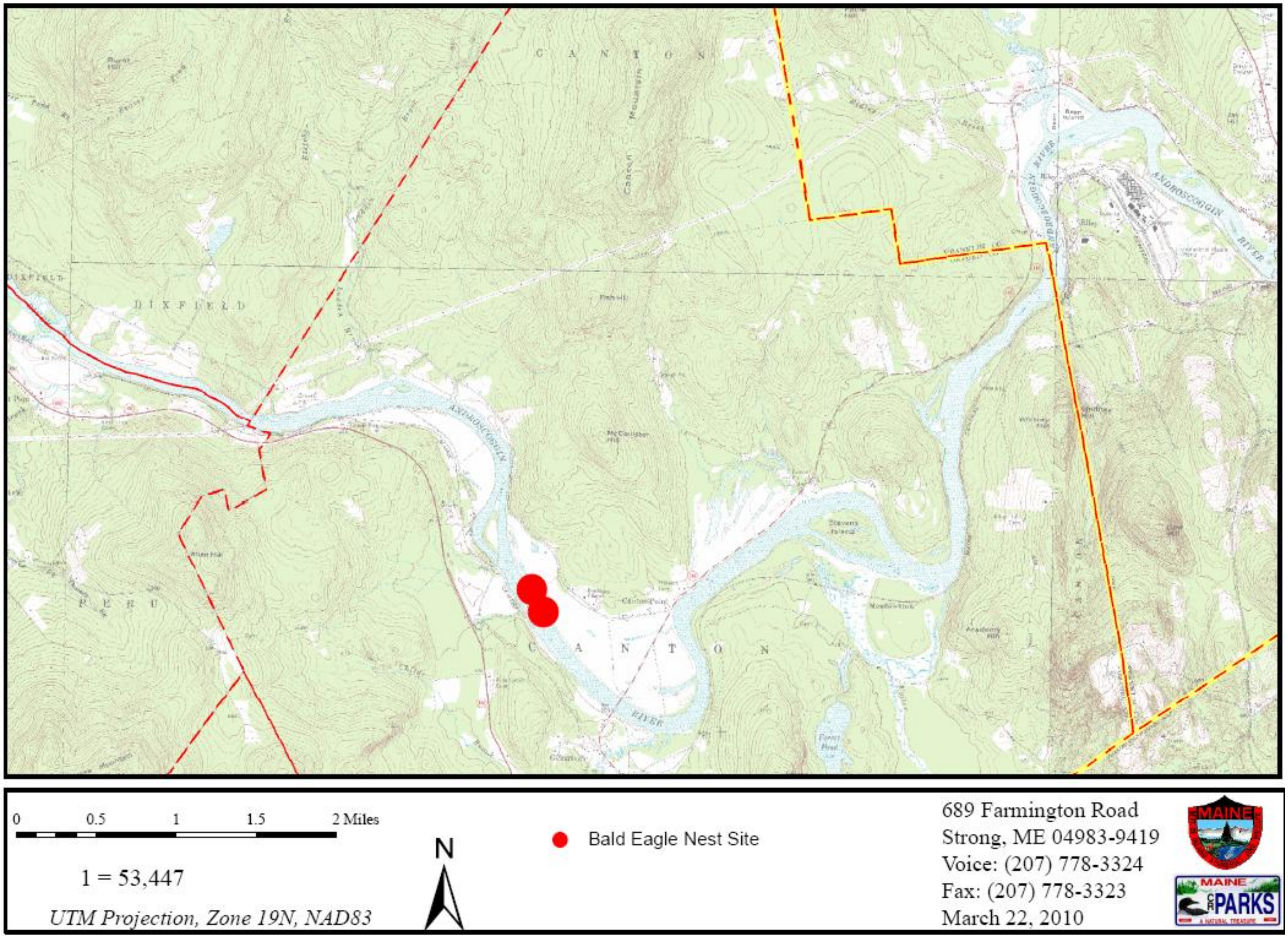
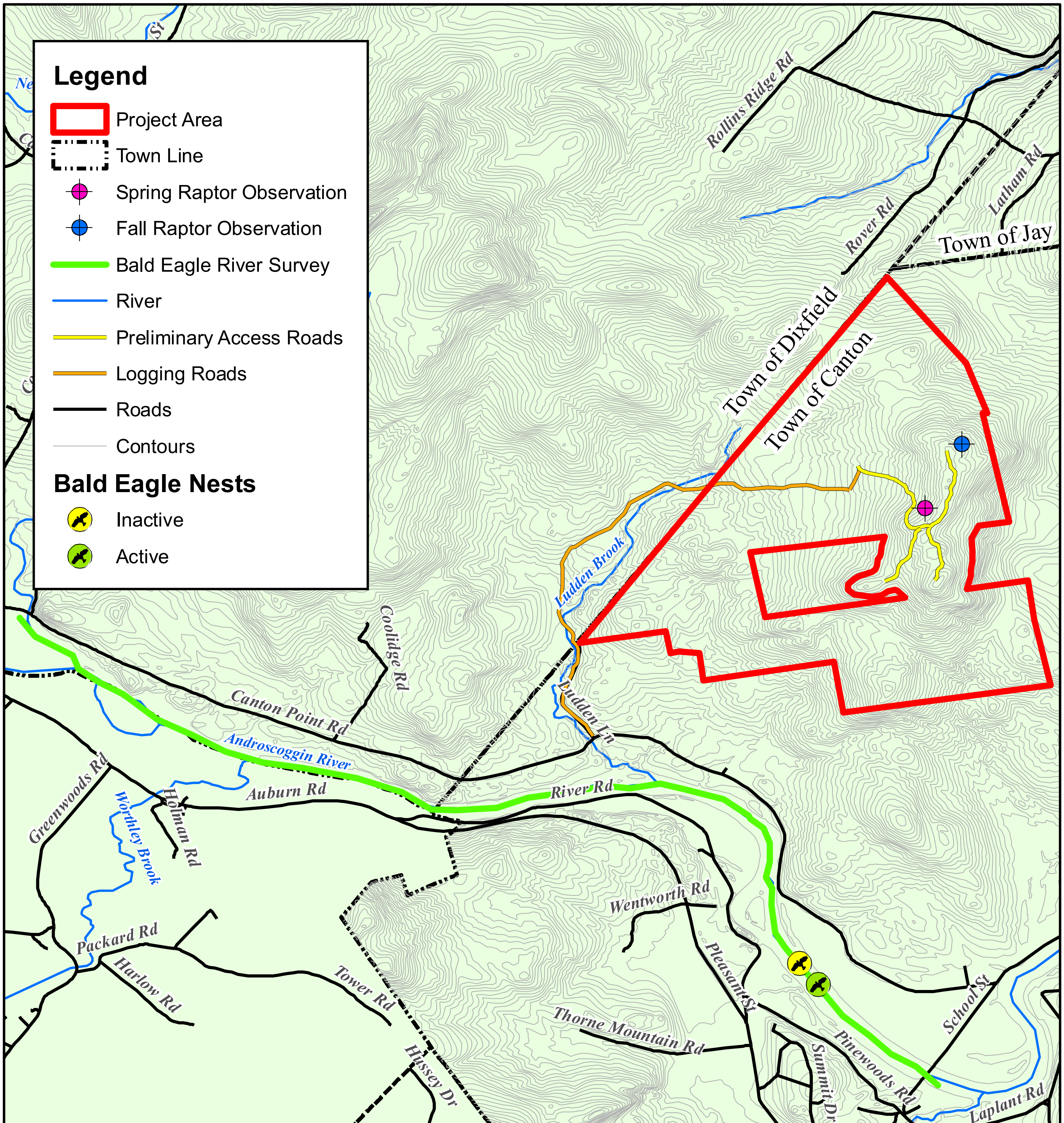
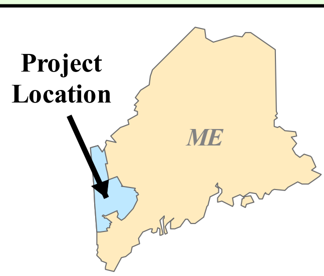


Figure 6-0. Bald Eagle Nest Location Map within 4 miles of Canton Mountain Wind Project, provided by MDIFW.





0 2,550 5,100 10,200 Feet

0 650 1,300 2,600 Meters

Figure 6.1 Bald Eagle Survey Locations at Canton Mountain Wind Project- Spring - Fall 2010

Prepared For: PATRIOT RENEWABLES

Prepared By: TETRA TECH

Date: 11/2010

Source: Maine Office of Geographic Information Systems (MEGIS), Roads 2008, Countours, 2000. Additional data provided by client Patriot Renewables, spring 2010.

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Project site was extended from 4 miles (the initial area of concern for eagles at inception of the Project) to 10 miles.

Aerial surveys were performed by Tetra Tech avian biologist, Derek Hengstenberg, and MDIFW biologist, Charlie Todd, from a Bell Ranger Helicopter contracted from Maine Helicopters, Inc. In addition, the helicopter pilot possessed previous bald eagle nest survey experience and was capable of identifying bald eagle nests from the air. The helicopter survey was completed in approximately five hours and covered all potential bald eagle habitats within the 10-mile radius of concern for the Project. Nest locations and the helicopter flight path were mapped using Global Positioning System (GPS) equipment and are shown in Figure 6-2.

Results of both the formal bald eagle site survey conducted during summer 2010 as well as observations of bald eagles during the raptor surveys and aerial survey are provided below.

6.3 Results

Bald Eagle Site Reconnaissance Survey

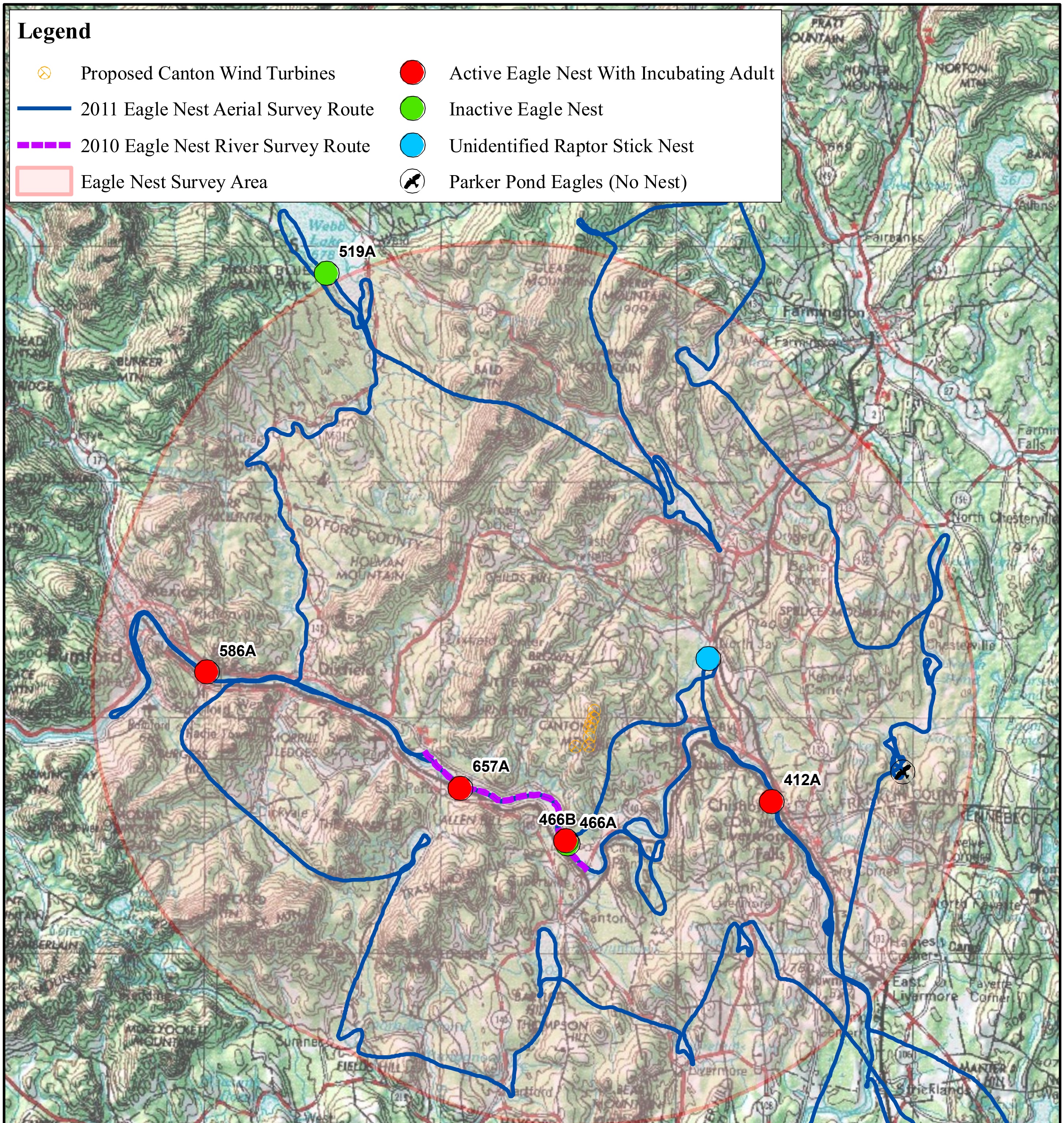
The site visit on foot on June 30th 2010 found that Nest #1 (Figure 6-1) appeared to be in disrepair and inactive. The second nest appeared to be potentially active; however, no eagles were observed during the June 30th survey.

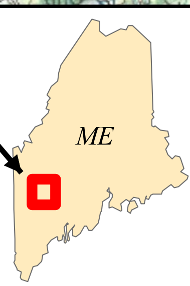
Four eagles were observed during the boat survey on July 15th including two adults, one first year juvenile, and one second year bird. Age confirmations were made from close-range plumage identification. All eagles observed remained within a few hundred meters of the river and appeared to spend considerable time perched in trees along the riverbank. As observed during the June 30th survey, the first nest (Nest #1) was still in disrepair and did not appear to be active. During the July 15th survey the second nest was active and well maintained, containing one adult bird with the juvenile perched alongside on a branch. One adult was observed circling up to 500 m (1,640 ft) above the river. An additional 23 incidental avian species were noted during the survey.

Additional observations of the active nest were made for 1 hour from across the river after the boat survey ended. The adults were not present; the second year bird was observed on the nest with the juvenile sitting on the riverbank below. The lack of territorial behavior from the adults suggests that the second year bird was the progeny of last year's nesting effort. During the active nest observation a number of potential human disturbances were noted. A train, vehicle traffic, and an agriculture pump engine being started near the nest did not appear to affect the birds and were largely ignored by both the juvenile and the second year bird. Further observation was made from the Route 140 Canton Bridge, which yielded no additional eagle sightings.

Spring 2010 Raptor Surveys

Bald eagles were not observed within the Project Area during the 10 migrant stopover surveys, three breeding bird surveys, or 10 raptor migration surveys during the spring 2010 season. Incidental observations of eagles in the vicinity of the Project Area occurred on multiple days while driving to and from the site during the spring. On April 12, one adult eagle was observed soaring above the Androscoggin River due east of the bridge on Route 140 in Canton, Maine. One adult eagle was also observed on April 13 flying above the Androscoggin River and farm fields near the Route 140 Canton Bridge, which is about 2 miles south of the Project Area.





N

0 1.5 3 6 Miles

0 2.5 5 10 Kilometers

Figure 6.2. Bald Eagle Nest Survey, Canton Wind Project

Source:ESRI Online Topographic Maps, 2010. Additional data provided by client Patriot Renewables, spring 2011.

Prepared For: PATRIOT RENEWABLES

Prepared By: TETRA TECH

Date: 06/2011

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Fall 2010 Raptor Surveys

During fall 2010, standardized raptor migration surveys were conducted from an observation platform on the north end of Canton Mountain. During the 13 days (66.5 hours of survey effort) a total of five bald eagles were observed on four survey dates (Sept. 11, Sept. 15, Sept. 20, and Oct. 5). Of the five bald eagles observed, four (three adults, one juvenile) flew through the Project Area, but only one adult bald eagle flew within the RSZ. On this occasion, the adult bald eagle spent 15 minutes circling and soaring at heights of 50–150 m (164–492 ft) over the northern end of the Project Area. It is very likely that the two adults and one juvenile bald eagle observed within the Project Area are from the nearby nesting site on the Androscoggin River, as documented during the summer 2010 survey. The one adult bald eagle observed outside the Project Area flew south along the eastern side-slopes of Saddleback Mountain, five miles away at a flight height greater than 130 m (427 ft).

Spring 2011 Eagle Nest Aerial Survey

Tetra Tech identified five bald eagle nests during aerial surveys within the 10-mile survey area encompassing the two projects. Four of these sites (nest 412 A, nest 466 B, nest 657 A, and nest 586 A) were active, with an adult bald eagle incubating the nest during the flyover. Nest 657 A is a bald eagle nest new to MDIFW as of spring 2011 and was found during the aerial survey. In terms of nesting habitat, all four nests were located in large, dominant Eastern white pine trees (*Pinus strobus*) along the banks of the Androscoggin River.

Bald eagle nest number 519 A (Webb Lake nest) was not active and no bald eagles were observed in the vicinity (Figure 6-2). In addition, two adult bald eagles were observed flying in the vicinity of Parker Pond. Although no nest was observed after repeated flyovers of the seven mile (7) mile Parker Pond wetland complex, an empty, apparently inactive unidentified raptor stick nest was observed in an Eastern white pine tree in the wetland complex (Figure 1).

Two of the four active nests (nest 466 B and nest 657 A) are located within four (4) miles of the Canton Wind Project, with nest 466 B located approximately two (2) miles south-southeast and nest 657 A approximately 3.5 miles southeast of the Canton Mountain Wind Project.

6.4 Discussion

As noted in the results of the 2010 and 2011 surveys, bald eagle activity near and within the Project Area appears to be mostly associated with birds from the two active nests on the Androscoggin River (within 4 miles of Project Area). No other bald eagle activity was observed that would suggest that the Project Area is important for migrating eagles. However, it does appear that the eagles currently occupying the two active nests on the Androscoggin River occasionally use the Project Area during over flights and foraging.

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APPENDIX A

Avian Radar Survey Data and Report

Draft MERLIN^{TM} Avian Radar Survey for the proposed Canton Mountain Wind Project

Data Report for September 3–October 4, 2010

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February 2011

Notice

This report was prepared by DeTect, Inc. in the course of performing work for Tetra Tech under DeTect's contract. The data and information developed as a result of this study and presented in this report are the property of Tetra Tech and are not to be disclosed to third parties without the express written consent of Tetra Tech.

Summary

This report presents radar data recorded September 3 through October 4, 2010 at the proposed Canton Mountain Wind Project site during fall migration. The MERLIN Avian Radar System simultaneously uses horizontal and vertical radars to automatically and continuously record bird and bat activity in the vicinity of the proposed project. The Vertical Surveillance Radar (VSR) data provide both count and altitude information on targets, while the Horizontal Surveillance Radar (HSR) provides target directions.

During the fall 2010 sampling period nightly target passage rates were variable, ranging from 2.4 to 1,220.2 targets/km/hr, with a nightly average of 292.0 targets/km/hr. This was much greater than the average target passage rates during days (13.9 targets/km/hr). Analysis of hourly activity verified that target passage rates were greatest at night, particularly early night (8–11 pm), and that activity was very low throughout the daylight hours.

As would be expected during fall migration, for the majority of nights (54.2%) target movements averaged to the southwest or south. Radar data from the horizontal radar also indicated an average target direction of southwest during both nights (231°) and days (233°). The concentration of target movements, however, was greater during nights (average r = 0.47) than days (average r = 0.28), indicating nocturnal migration and local movements during the day, respectively.

Target passage rates were greatest on nights when target movements averaged southwest, but also when winds were from the southwest. Although the prominent southwest movement is not surprising during fall migration, the frequency of southwest headwinds, along with a correlation between target passage rates and wind speeds, is somewhat surprising. Very few other associations occurred between weather parameters and target rates, target directions, or directional concentration of targets.

The mean target height was greater during nights than days (157.9 and 129.4 m adjusted above ground level [AGL], respectively); as was the median target height (134.4 m and 75.3 m adjusted AGL, respectively). More targets

were also detected above the rotor swept zone (RSZ) of the proposed wind turbines (83 m tower, 94 m rotor diameter, RSZ 36–130 m AGL) during nights of the fall sampling period (51.5%) than days (27.0%). However, target heights in general were low during all times, with 38.2% and 50.8% of targets occurring within the RSZ during nights and days, respectively, and 10.3% and 22.1% below the RSZ during nights and days, respectively. Approximately 60% of both night and day targets had mean heights within the RSZ, and more than 80% of median target heights occurred within the RSZ during both nights and days during the fall 2010 sampling period. These low target heights may be partially explained by the target height adjustment required to compensate for a 118 m (387 ft) ridge near the radar, location of the radar unit on the western side-slope just downhill from the ridge, use of a 10 kw X band radar (as opposed to a 25 kw X band radar in spring) during the fall period or a just a function of a low magnitude migration period in which lower flights are typically observed.

Seasonal differences may be a significant, or at least a partial, factor explaining both the lower target heights and passage rates compared to the spring 2010 radar results at this site. The data suggest that there was less migration activity and lower flight heights during the fall than the spring at the project site. It is also possible that some fall migration events occurred outside the September 3–October 4 sampling period.

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MERLIN™ Avian Radar Survey
Data Report for September 3 – October 4, 2010

INTRODUCTION

DeTect Inc. (DeTect) was contracted by Tetra Tech, Inc to conduct an Avian Radar Survey at the proposed Canton Mountain Wind Project site to determine use of the site by migrating birds and bats. The MERLIN Avian Radar System collected data on bird and bat movements and migration using both vertical and horizontal marine surveillance radar. This report presents data collected during the fall migration season (September 3–October 4, 2010).

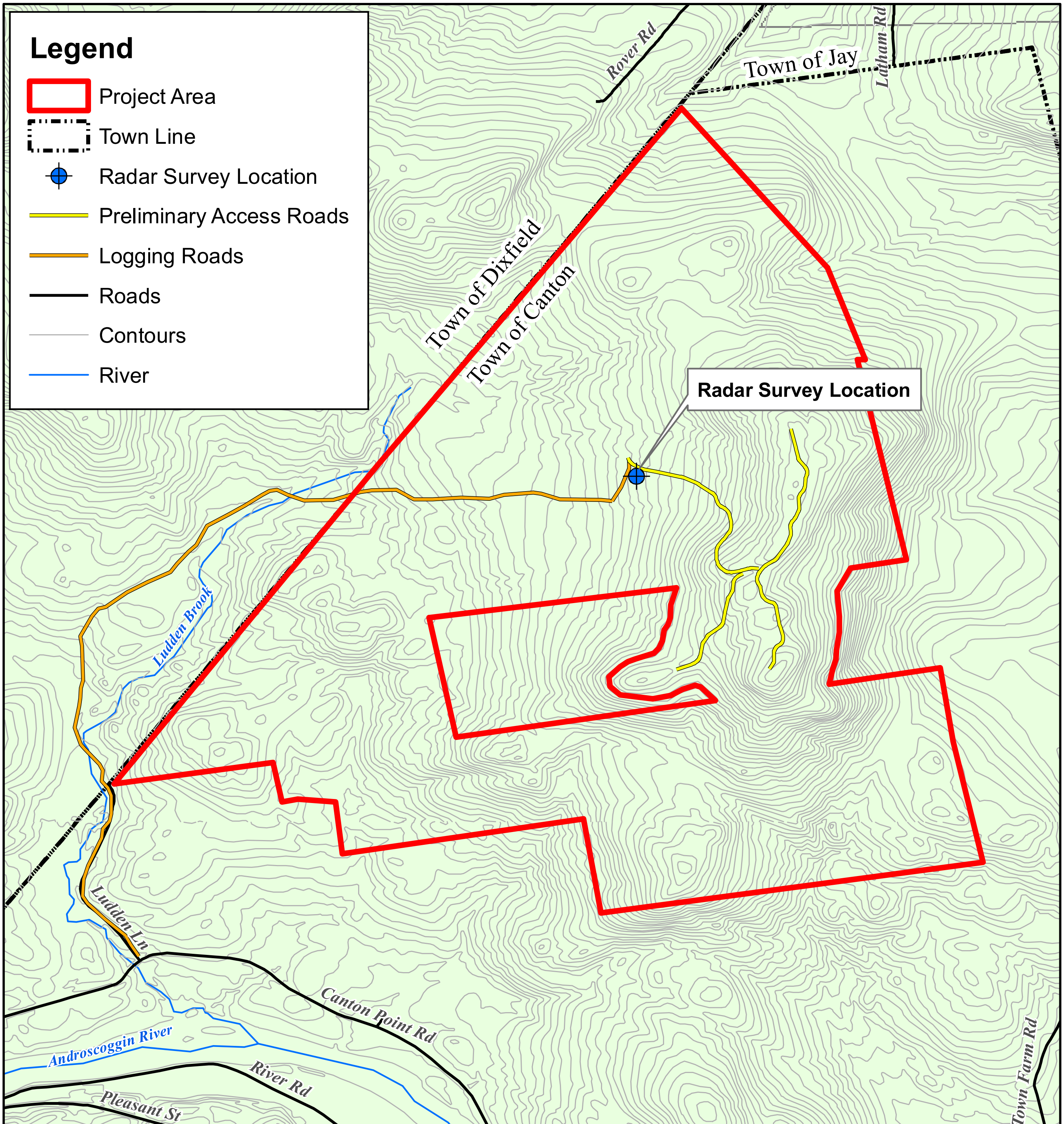
Objectives

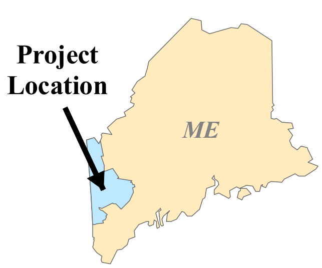
The objective of this radar survey was to collect near-continuous radar data on bird and bat activity and movements at the proposed project site, with a specific focus on assessing potential mortality risks to birds and bats from the proposed wind project.

STUDY AREA

The Canton Mountain Wind Project is located in Oxford County in the western mountains of Maine (Project Area) (Figure 1). The Project Area is situated on Canton Mountain, and the proposed access road originates in the valley southwest of the mountain. Canton Mountain has an elevation of 470 meters (m) and is surrounded by mostly private, forested lands. There are numerous lakes and ponds in the region with six bodies of water located within 8 kilometers (km) of Canton Mountain: Wilson Pond to the northeast; Forest Pond, Round Pond, and Long Lake to the southeast; Lake Anasagunticook to the south; and Worthley Pond to the southwest. The mountains surrounding the Project Area are Fish Hill to the south, Paine Hill to the northeast, and Pinnacle Mountain to the northwest. These mountains range in elevation from 288 to 410 m. The topography of the Project Area ranges from relatively level on the valley floor, to steep slopes with elevations from approximately 182–547 m above sea level.

The radar unit was located within the proposed Project Area, and was situated on the western side slope, about 118 m downslope from the Canton Mountain ridge for which turbine locations are proposed (Figure 1). This was a location that provided an elevated view of the surrounding area and was relatively unobstructed by trees, buildings, or other obstacles (Figure 2); the site also allowed for a clear line of sight for birds and bats in the area. The horizontal radar beam had a radius of 2.0 nautical miles (nm), and the vertical radar beam was orientated east-west with a radius of 0.75 nm. This orientation was approximately perpendicular to the expected flight direction of migrating birds, thus the majority of migrating birds would be crossing the vertical beam. The eastern half of the vertical beam was scanning uphill; this difference in ground level was adjusted for in the vertical radar data. Ground level was set to the ridgeline elevation (118 m above the radar elevation) for all targets (see a more detailed explanation on page 13).





Source: Maine Office of Geographic Information Systems (MEGIS), Roads 2008, Countours, 2000. Additional data provided by client Patriot Renewables, spring 2010.

N

0 1,250 2,500 5,000 Feet

0 320 640 1,280 Meters

Figure 1.0 Radar Survey Location at Canton Mountain Wind Project, Fall 2010

Prepared For: PATRIOT RENEWABLES

Prepared By: TETRA TECH

Date: 11/2010

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Figure 2. MERLIN Avian Radar unit at the Canton Mountain Wind Project site.

METHODS

Radar Equipment and Data Collection

MERLIN Avian Radar System

The MERLIN Avian Radar System is an advanced, automated radar system originally developed for and currently used by the U.S. Air Force and NASA for remote detection and tracking of hazardous bird activity on and around airfields and launch facilities, in support of aviation and flight safety (bird-aircraft strike avoidance). The MERLIN system is a fully self-contained, trailer-mounted, ornithological radar system developed and manufactured by DeTect of Panama City, Florida, specifically for bird detection and tracking. Since 2003, the MERLIN technology has also been extensively used for the collection of pre-construction survey data, risk modeling, and post-construction monitoring at proposed wind project sites in the United States, England, Scotland, The Netherlands, Poland, Norway, and New Zealand. Agency and research users of MERLIN include the U.S. Fish & Wildlife Service, U.S. Environmental Protection Agency, U.S. Geological Survey, various state natural resource agencies, the United Kingdom Central Science Lab (CSL, the UK environmental agency), and various U.S. and international universities.

A model XS1030e MERLIN Avian Radar System was used to survey the proposed Canton Mountain Wind Project site during fall 2010; this rental system differed from the Tetra Tech owned XS2530e system that was used during spring 2010. The XS1030e used a 10-kW radar instead of a 25-kW radar for the X-band radar. Although this power difference may decrease target detection at a long range, it should not affect target detection within the 0.75 NM radius used for this study. Of note, most avian radar studies to date have typically used a 10-kW X-band radar unit to detect biological targets at a short range (Harmata et. al 1999, Williams et al 2001, Gauthreaux and Belsar 2003, Desholm et. al 2006).

The MERLIN radar system precisely tracks targets within avian size ranges, displays the data in real-time (both at the radar and remotely via the Internet), and records all data on targets, tracks, and system parameters to internal databases. For environmental applications, the recorded databases are queried and used to develop statistical data as well as to model bird movements in the study area.

The MERLIN system used for this project has dual marine radar sensors: a 10-kW power, X-band frequency (3 cm wavelength), vertical-scanning radar (VSR) sensor, and a 30-kW power, S-band (10 cm wavelength), horizontally-scanning radar (HSR) sensor. A remote data uplink (cell phone based wireless internet) allowed remote system monitoring through the internet (remote data viewing in real time), access to recorded data, and system administration. A Tetra Tech biologist performed the initial set-up, after which the system was remotely monitored via the data uplink/internet connections for the remaining data collection period.

The radar unit was located within the proposed Project Area and was situated on the western side slope, about 118 m below the elevation of the Canton Mountain ridge for which turbine locations are proposed; this is the same location used during the spring 2010 survey. This location was chosen based on access and line-of-sight within the proposed site. Once in place, the HSR was positioned to minimize ground clutter, and the VSR was oriented along an east-west axis perpendicular to the expected direction of migration. The HSR processed data at a range of 2.0 NM and the VSR at 0.75 NM. These range settings allowed for optimal detection of bird-sized targets (Cooper et al. 1991). The MERLIN system collected radar data continuously (24 hours a day, 7 days a week), with the exception of limited periods of system maintenance and service downtime, and periods of moderate to heavy precipitation.

Vertical Scanning Radar (VSR) Operation

The VSR, or X-band radar, operates in the vertical (y-z) plane transmitting a wedge-shaped beam from horizon-to-horizon using the vertical scanning technique (Harmata et al. 1999). In this configuration the radar is turned on its side so it scans a vertical slice through the atmosphere. The MERLIN software detects and tracks targets that pass through or along the vertical beam, recording target size, speed, and altitude attributes, as well as other characteristics. This radar transmits a 22°, fan-shaped beam (Figure 3) at a scan rate of ~2.5 seconds/scan, and can reliably detect small, bird-sized targets up to 0.75 NM to either side and above the radar. The VSR in this configuration outputs the lowest power density, but it provides high spatial resolution data with low side lobe returns to provide optimal detection of bird targets as they pass through the study site. Because the X-band is a short wavelength radar (3 cm), it is susceptible to interference from precipitation, and data collection is suspended during rain events. VSR data are used to determine target altitudes and is the primary dataset used to determine target passage rates through the rotor swept zones for mortality risk assessments. Vertical radar images representing both high and low target passage rates are shown in Figures 4 and 5, respectively.

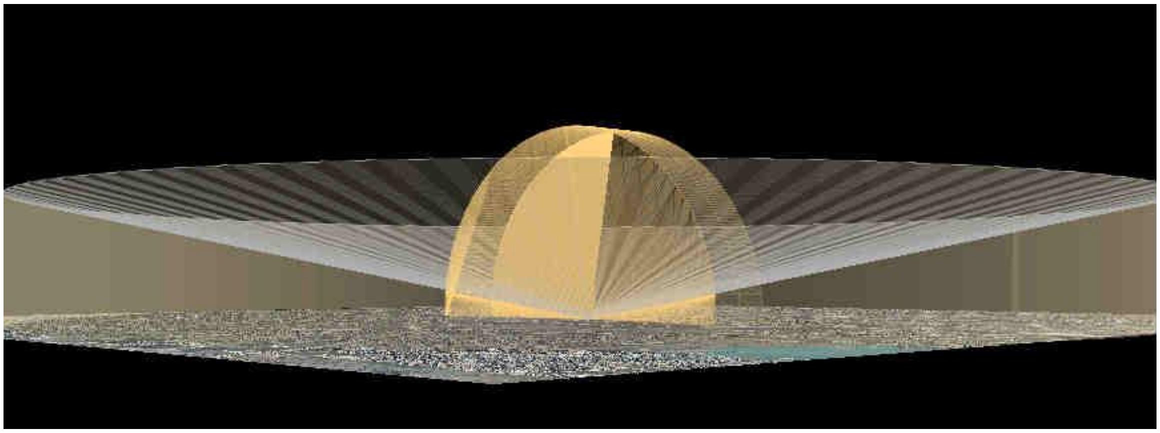

Figure 3. Illustration of beam coverage of the horizontal scanning radar (HSR) and the vertical scanning radar (VSR).

Figure 4. Vertical radar image from the proposed Canton Mountain Project radar site (triangle) showing a high target passage rate during a 15 minute interval on the night of September 17, 2010. Target direction is color-coded to correspond with the compass rose in the upper right corner.

Figure 5. Vertical radar image from the proposed Canton Mountain Wind Project radar site showing a low target passage rate during a 15 minute interval on the night of September 18, 2010. Target direction is color-coded to correspond with the compass rose in the upper right corner.

Horizontal Scanning Radar (HSR) Operation

The HSR, or S-band radar, operates in the horizontal (x-y) plane transmitting a 25°, wedge-shaped beam relatively perpendicular to the VSR (Figure 3). The HSR for this survey was configured to operate with a short pulse (0.08 microseconds or μs) but transmits at a longer wavelength (10 cm) of energy than the VSR. The S-band has the advantage of greater detection range and less signal attenuation (interference) from surrounding vegetation (typically referred to as ground clutter) and weather. It is also less sensitive to insect contamination. Ground clutter interference is additionally reduced by applying the MERLIN software clutter suppression algorithms that improve detection of small (bird-sized) targets in high clutter environments. The HSR scans 360° in the horizontal plane at a scan rate of ~2.5 seconds/scan and a range setting of 2.0 NM radius (for this survey), detecting and tracking targets moving around the survey site. The HSR in this configuration outputs the lowest power density available to the radar, but it provides the highest possible spatial (range) resolution data with low side lobe returns to enable optimal detection of bird targets as they move across the study site. HSR data are used to determine directional movement of targets over or through the Project Area. Horizontal radar images representing both high and low target passage rates are shown in Figures 6 and 7, respectively.

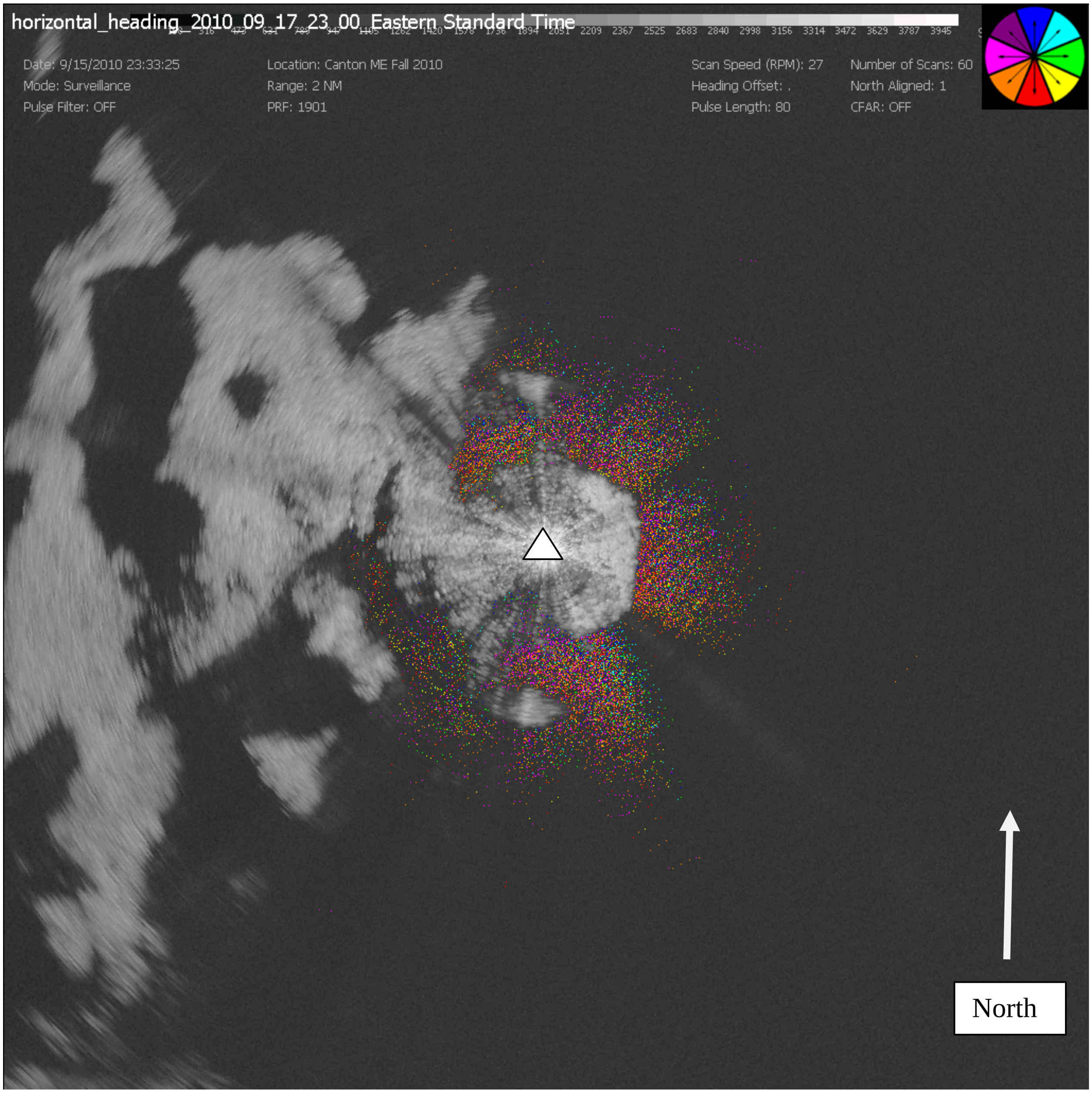

Figure 6. Horizontal radar image from the proposed Canton Mountain Wind Project site radar (triangle) showing a high target passage rate during a 15 minute interval on the night of September 17, 2010. Target direction is color-coded to correspond with the compass rose in the upper right corner. Gray areas are ground clutter.

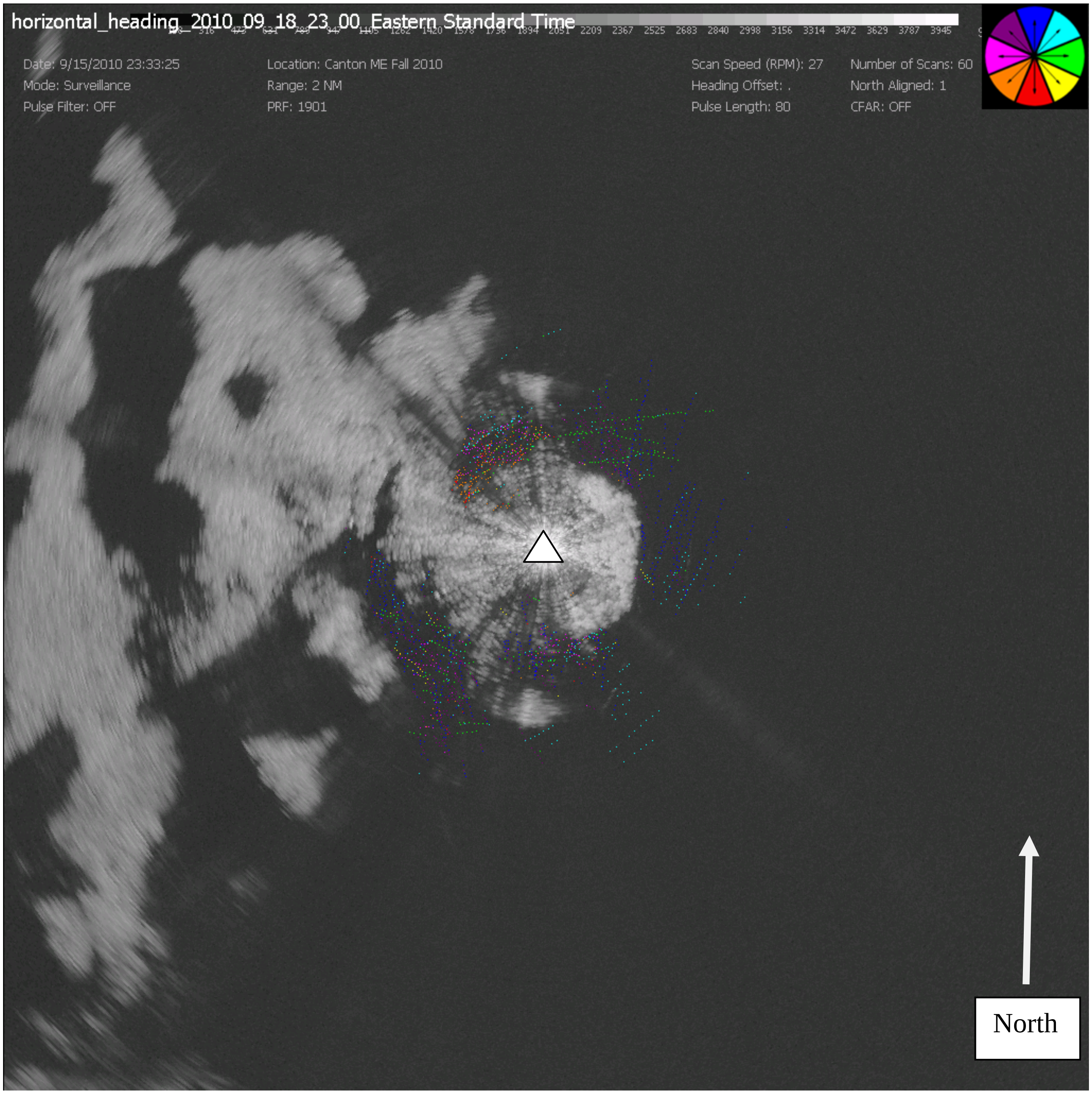

Figure 7. Horizontal radar image from the proposed Canton Mountain Project site radar (triangle) showing a low target passage rate during a 15 minute interval on the night of September 18, 2010. Target direction is color-coded to correspond with the compass rose in the upper right corner. Gray areas are ground clutter.

Radar Data Collection, Processing and Analysis

The MERLIN Avian Radar System uses modern, marine-grade radar signal processing technology to collect, process, and store 12-bit digitized radar data from both the VSR and HSR. Target data from both radars are processed in real-time by the MERLIN software at the radar, with all data recorded to compact, internal system databases for target and track processing, analysis, and reporting. All VSR and HSR target data and system metadata were written to internal system databases, and all radar data were processed at the radar in real-time by MERLIN system software. Database analysis of the radar data was conducted in DeTect's Data Lab in Panama City, Florida. The Data Lab uses Microsoft Windows® based computer systems, networks, and SQL (structured query language) servers for database processing and analysis. This database query development and analysis is conducted by DeTect staff programmers, radar ornithologists, and biologists.

MERLIN Avian Radar Processing Software

The MERLIN Avian Radar processing software uses automated clutter suppression in conjunction with biological target detection, tracking, and data recording to identify and track bird targets in the survey area. The software also identifies noise (undesired signals such as ground clutter and interference) within a given radar environment and applies a statistical approach to suppressing the noise while still allowing targets within the noise to be detected, tracked, and recorded. This maximizes the probability of detecting moving targets in high clutter environments (such as over vegetation). The application of CFAR (constant false alarm rate) algorithms and ground clutter mapping techniques are also included in the MERLIN software and provide automated, high resolution data while minimizing the amount of display lost to ground clutter.

The software allows the user to select settings specific to the conditions and objectives of each project. These settings include minimum and maximum target size (based on target pixel area), minimum and maximum target speed, and minimum reflectivity (a measure of target intensity). By using techniques common in image processing, the MERLIN software also extracts values other than the area or number of pixels. As an example, the length, width, roundness, and elongation of a target are extracted and recorded. These are the same parameters an expert observer of a radar display would use to separate a fast moving aircraft from a large skein of geese. In this way parameters are available to classify targets in the same manner a human radar ornithologist interprets the screen data, but the MERLIN software accomplishes this with the precision and consistency of a computer program.

The detection and tracking algorithms in the MERLIN software locate sequences of biological targets in the raw radar data that fit together into a linear sequence over time as the radar scans (each radar scan updates approximately every 2.5

seconds). When a target meeting the target definition of a bird is tracked for a minimum of three sequential scans, it is verified as a bird/bat target by the system, enumerated, and recorded to the system database. Targets continue to track as long as they are detected within three of the last four scans. The system can also detect and track other types of biological targets such as insects, but through optimization of the operational settings in the software, visual ground-truthing, and application of custom database queries, the inclusion of non-bird/bat targets in the survey counts was minimized.

It must also be noted that an individual radar echo does not necessarily represent an individual bird or bat, as individuals moving in and out of the radar beam (e.g., circling) would be "counted" by the radar system multiple times. Similarly, a target that is tracked but drops out of the radar line-of-sight (e.g., drops below a tree or brush line) is recorded as a "new" target once it "reappears" and is tracked again (within the MERLIN system, each target is assigned a unique, 64-digit identification number, which facilitates analysis of extended surveys). Therefore, an individual radar echo is referred to as a biological "target" in this study, and when counted together they represent an index of bird/bat activity or exposure level for any given period of time, and not necessarily a count of individuals.

Data Analysis

Radar Data

Radar data were analyzed for the fall sampling period of 2010 (September 3–October 4). A Tetra Tech biologist set up the MERLIN Avian Radar System, after which the system ran automatically and was remotely monitored daily for the remaining data collection period. Data were processed using standard and custom database queries developed by DeTect on a SQL server data network in DeTect's Radar Lab located in Panama City, Florida. In order to filter out false tracks in both the horizontal and vertical data (e.g., insects, ground clutter, interference), targets with only one entry in the database were eliminated from the database. The MERLIN software also dictated a minimum target-tracking area of 8 pixels to reduce tracking of possible insects. A custom-designed MERLIN mask was also used during post-processing to eliminate plots in areas near the radar that consistently generated false tracks (tracking a non-biological target) (Figure 8).

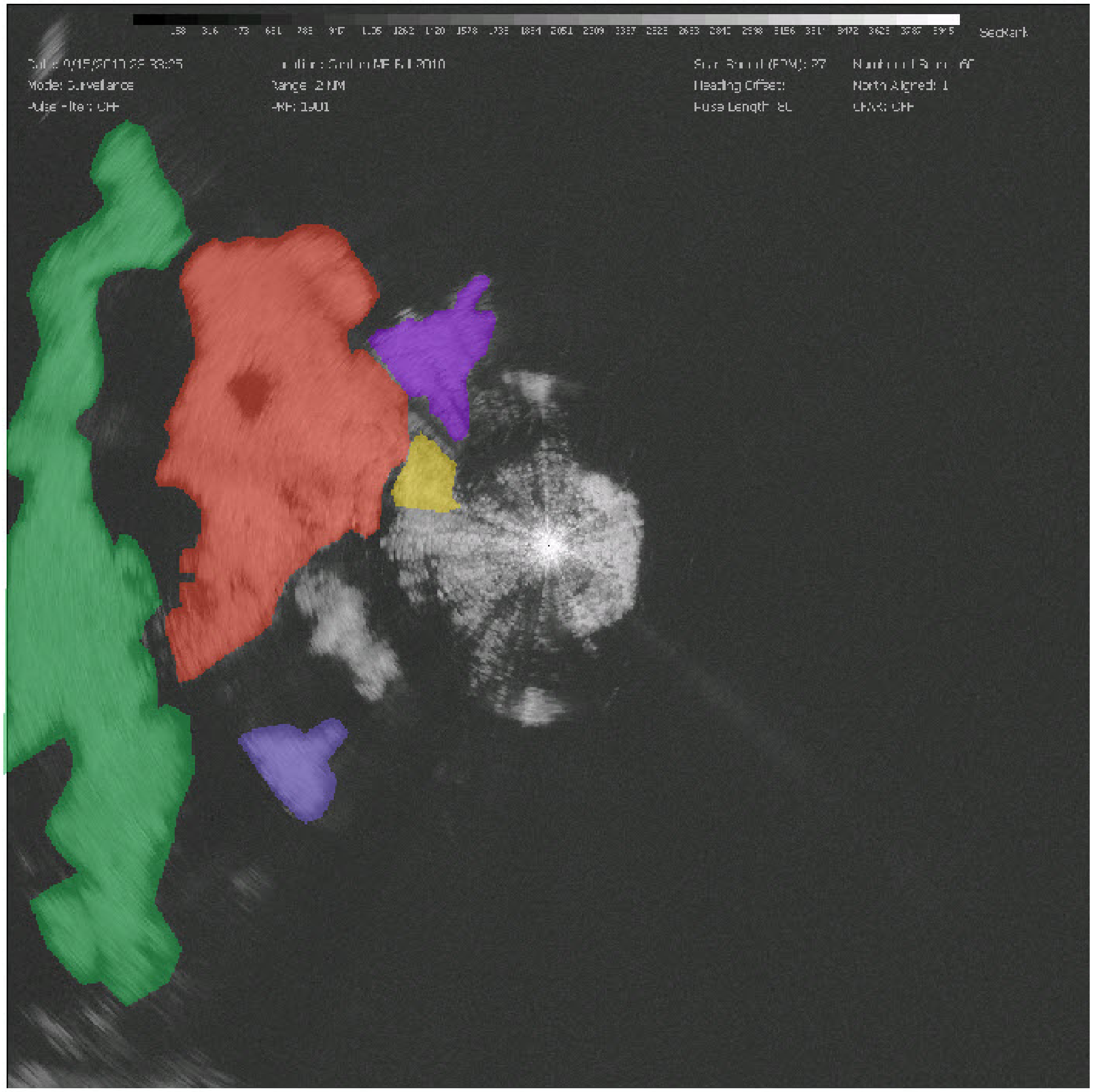

Figure 8. Illustration of horizontal area covered by a custom designed MERLIN mask (colored areas), in which plots were eliminated due to consistent false tracking.

Vertical Radar Data – Target Counts and Altitudes

As targets passed along or through the vertical scanning radar (VSR) beam, the altitude of the target was recorded with each scan (rotation) of the radar (approximately every 2.5 seconds), and the average altitude of each target above the ridgeline was generated. The topography at the radar location was not flat; the landscape under the eastern portion of the vertical beam sloped uphill creating a difference of 118 m between ground level at the radar unit and the height of the ridge. In order to standardize target heights so they would be comparable (as if the radar unit was directly on ridge), 118 m was subtracted from all target heights, after which all targets with negative target heights (i.e., below the ridge) were eliminated from the data. Adjusting target heights based on their location over the topography, and the elevation at that location, would have prevented the elimination of these targets but would not have accounted for biases from differences in detection probabilities. It would have also distorted the area sampled, invalidating the 1-km front used for target passage rate measurements.

These adjusted target heights were used to derive mean and median target heights, and group targets into one of three height categories: below rotor swept zone (RSZ heights), within RSZ heights, or above RSZ heights to a maximum height of 1,271 m (0.75 nm or 1,389 m minus 118 m) adjusted AGL (above ground level). Some migrating birds fly even higher than this altitude, but these were not detected in this radar study. The turbine dimensions used for the altitude analyses included a rotor swept height zone of 36–130 m AGL.

The VSR data queries were standardized to a 1-km front per hour, generally the industry standard for most migratory and wind energy avian studies and risk analyses. For this report, target passage rates are further defined as the number of targets detected within 0.5 km to either side of the radar and up to 1,271 m (1,389 - 118 m) adjusted AGL, for a total frontal width of 1 km during a 1-hour period. Passage rates were standardized using the number of minutes with radar data within a given time period (minus any time with rain) and collated for each night (45 minutes before sunset to 45 minutes after sunrise) and day (remaining time period), as well as the entire season. The average target passage rates (below, within, and above the RSZ, as well as total) and mean and median target heights were calculated for both days and nights during this survey. Target passage rates and average target heights were also calculated hourly. Target passage rates in 50-meter increments of altitude up to 1,271 m are also displayed.

Horizontal Radar Data – Target Directions

The horizontal radar data collected were used to develop information on the movement of targets throughout the Project Area. As targets were detected on the HSR, their bearings were recorded on each scan (rotation) of the radar (approximately every 2.5 seconds). The average bearing of each target was then generated as the target passed through the HSR beam. The horizontal radar data were queried and the average target directions were generated for each night (45 minutes before sunset to 45 minutes after sunrise) and day (remaining time period). The overall distribution was plotted for all nights and days using Microsoft Excel by averaging the bearing of each target to develop a frequency table of target numbers occurring in 45° increments (eight groups centered on north, northeast, east, southeast, south, southwest, west, and northwest). This provided a directional assessment of the target movements throughout the survey area.

Calculations of mean direction and angular concentration (*r*) for these time periods were calculated using SQL and formulas based on Zar (1999). The value of *r* is a measure of concentration; it has no units and varies from 0 (no concentration, all values very dispersed) to 1.0 (all data concentrated in the same direction), while 1-*r* is a measure of angular dispersion (Zar 1999).

Weather Data

Weather data were collected from a meteorological tower on site. Recordings of wind speed (m/s) at 60 m, wind direction at 58 m, and temperature (°C) were recorded every 10 minutes and used to derive nightly and daily averages. The mean angle and angular concentration (*r*) of wind directions were calculated using Zar (1999). Precipitation data were derived from the recorded vertical radar data.

RESULTS

The MERLIN Avian Radar System operated continuously (24 hours a day) during the fall 2010 sampling period, from September 3–October 4, 2010. Of the 768.0 hours available during this sampling period, 718.8 hours of vertical radar (93.6% of available time) and 563.1 hours of horizontal radar (73.3% of available time) were collected (Table 1). Most of the downtime for the horizontal radar was due to a malfunctioning radar computer interface (RCI) card during the first week that had to be replaced.

Additional down-time occurred because rain blocks the smaller wavelength of the X-band radar, few if any biological targets are discernable during rain. However, the longer wavelength of the horizontal (s-band) radar allows almost all targets to be detected in rain with the aid of digital processing. Therefore, of the 718.8 hours of vertical radar data, an additional 14.2 hours were removed because rain prevented the collection of radar data (2.0% of radar time, 1.8% of the sampling period). This left 704.6 hours (approximately 30 days/nights) of useable vertical radar data (98.0% of radar time, 91.7% of the sampling period; Table 1). Only 9.3 hours of horizontal radar data were removed because of rain (1.6% of radar time, 1.2% of the sampling period), leaving 553.8 hours (approximately 23 dayys/nights)w of useable horizontal radar data (98.4% of radar time, 72.1% of the sampling period; Table 1).

Table 1. Effort of radar monitoring during the fall sampling period at the proposed Canton Mountain Wind Project site.

	Available Time in Fall 2010 Samping Period	Time radar collected data	Radar downtime	Radar data with rain	Useable radar data
Vertical Radar (hrs)	768.0	718.8	49.2	14.2	704.6
Horizontal Radar (hrs)	768.0	563.1	204.9	9.3	553.8

Vertical Radar

Data collected from the VSR were used to quantify target movements through the 0.75 NM arc of the VSR beam located near the Project Area. Data are presented as total number of targets/km/hr. This rate is also used when quantifying targets above (up to 1,271 m adjusted AGL), below, and within the RSZ heights for the fall 2010 sampling period (Appendix D).

Targets Passage Rates Over Time

Nightly target passage rates varied throughout the fall 2010 sampling period (Figure 9), and the average nightly target passage rate was more than 20 times the daily passage rate (Figure 10). Target passage rate is defined as the number of specified targets passing through a 1-km wide front during 1 hour. This rate is standardized for effort, or the proportion of minutes radar data were recorded during a given time period. Nightly target passage rates ranged from 2.4 targets/km/hr to 1,220.2 targets/km/hr and averaged 292.0 targets/km/hr. The greatest amount of nighttime migration was recorded on September 29. Daily target passage rates were much lower (average 13.9 targets/km/hr), and only ranged from 0.1 targets/km/hr to 54.0 targets/km/hr. The greatest amount of diurnal migration was recorded on September 11.

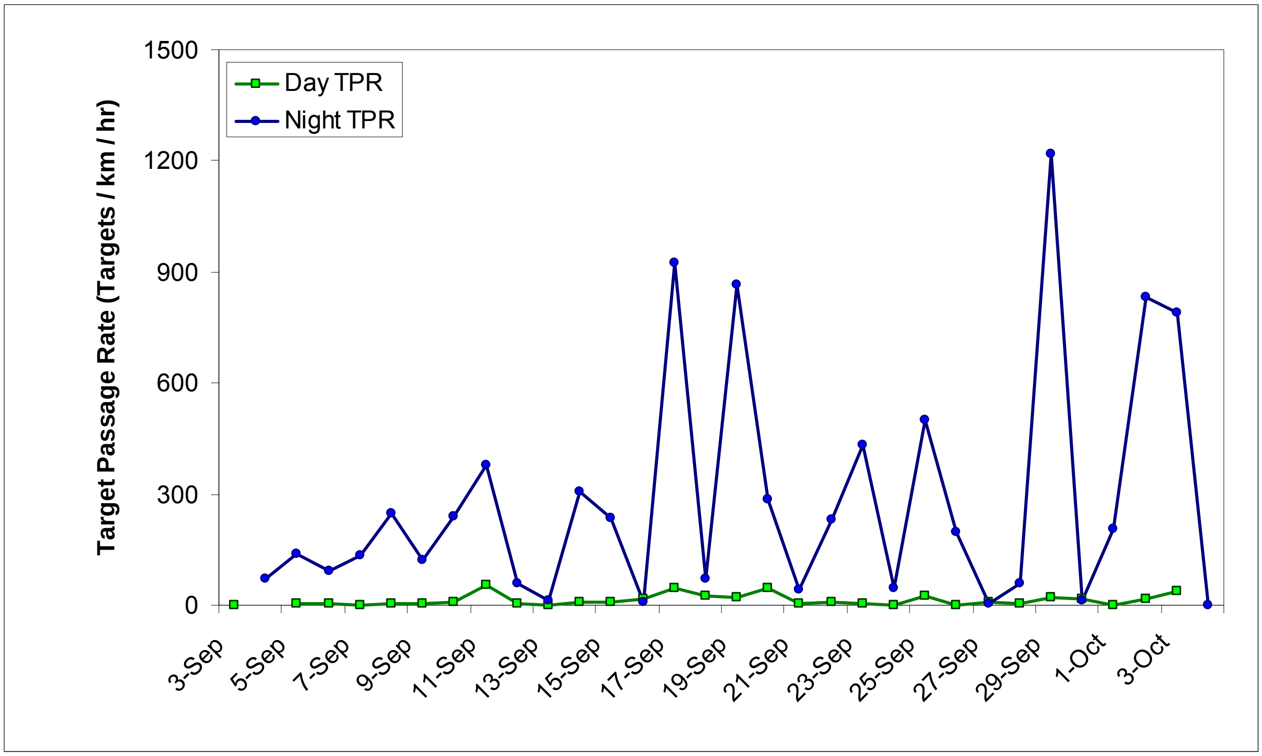

Figure 9. Target passage rates at the proposed Canton Mountain Wind Project site during days and nights of the fall 2010 sampling period.

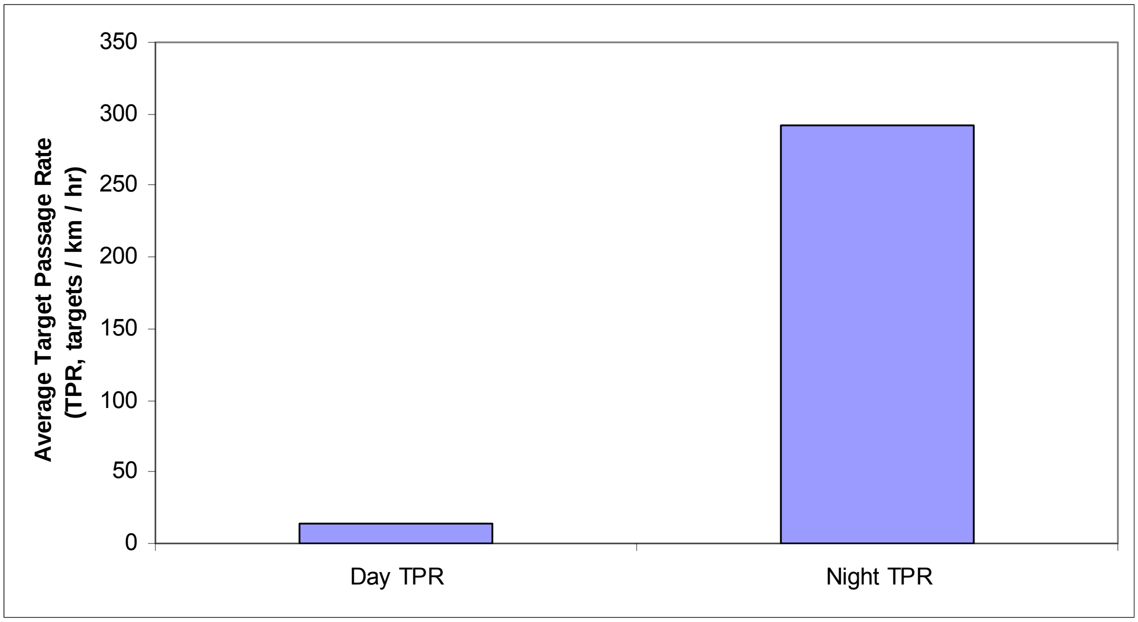

Figure 10. Average target passage rates at the proposed Canton Mountain Wind Project site during days and nights of the fall 2010 sampling period.

Average target passage rates also differed hourly throughout the fall 2010 sampling period (Figure 11) and were greatest during the early hours of night (hours 20–22, 8–11 pm), peaking during hour 22 at 609.2 targets/km/hour.

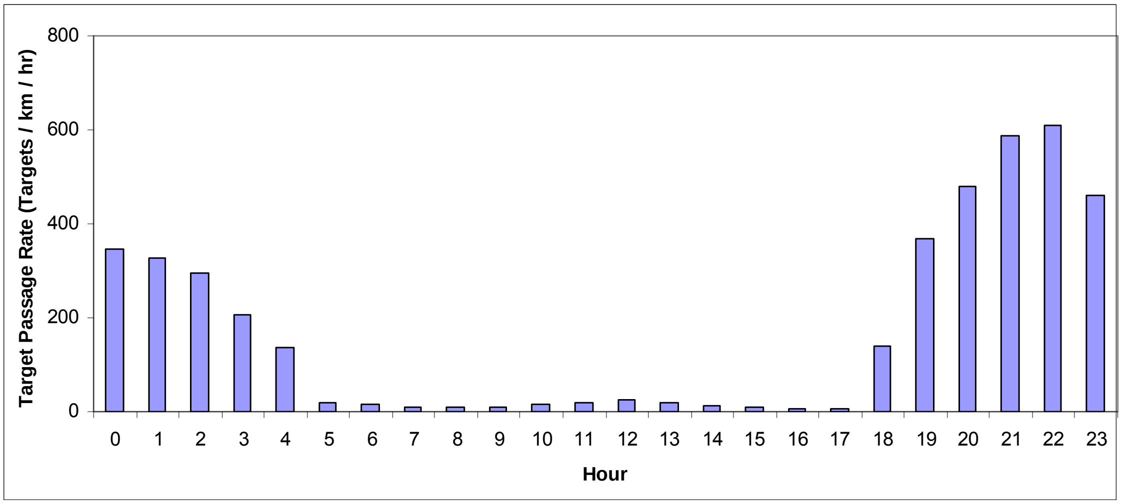

Figure 11. Hourly activity (average target passage rates) at the proposed Canton Mountain Wind Project site during the fall 2010 sampling period.

Altitudinal Distribution of Targets

Average hourly target heights varied, ranging between 86.0 m during hour 6 and 170.2 m during hour 1 (Figure 12). Hours 5–8 and 14–17 averaged within RSZ heights.

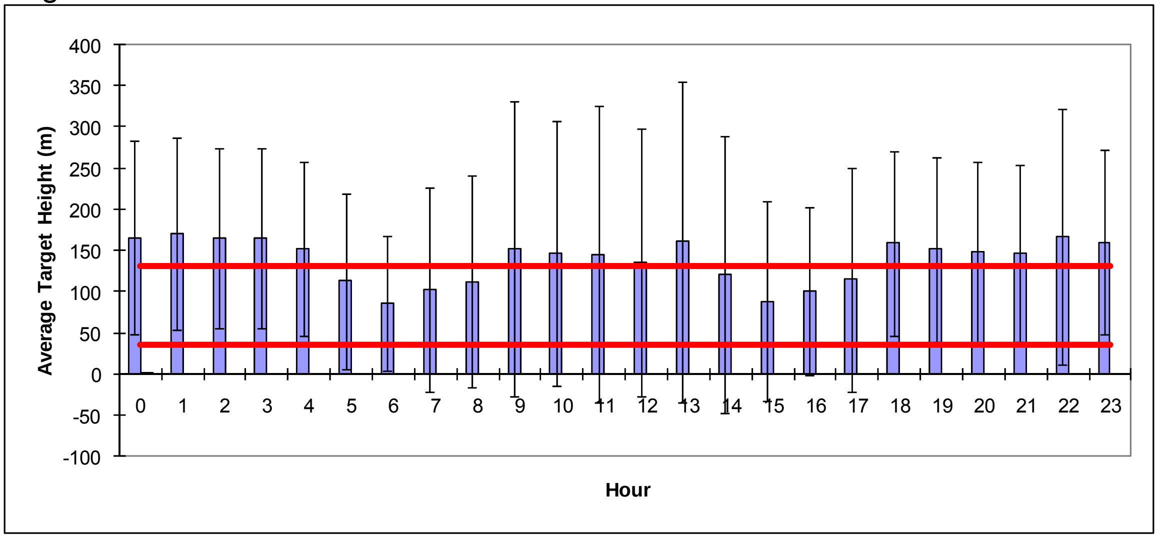

Figure 12. Average hourly target heights (adjusted AGL) at the proposed Canton Mountain Wind Project site during the fall 2010 sampling period. Whisker lines represent one standard deviation for each hour and red lines represent the rotor swept zone heights (36 - 130 m AGL). O m is the elevation of the ridge of Canton Mountain, the radar was located at -118 m adjusted AGL.

More targets were detected below than above the RSZ during the fall 2010 sampling period (Figure 13); 56% occurred under 150 m adjusted AGL.

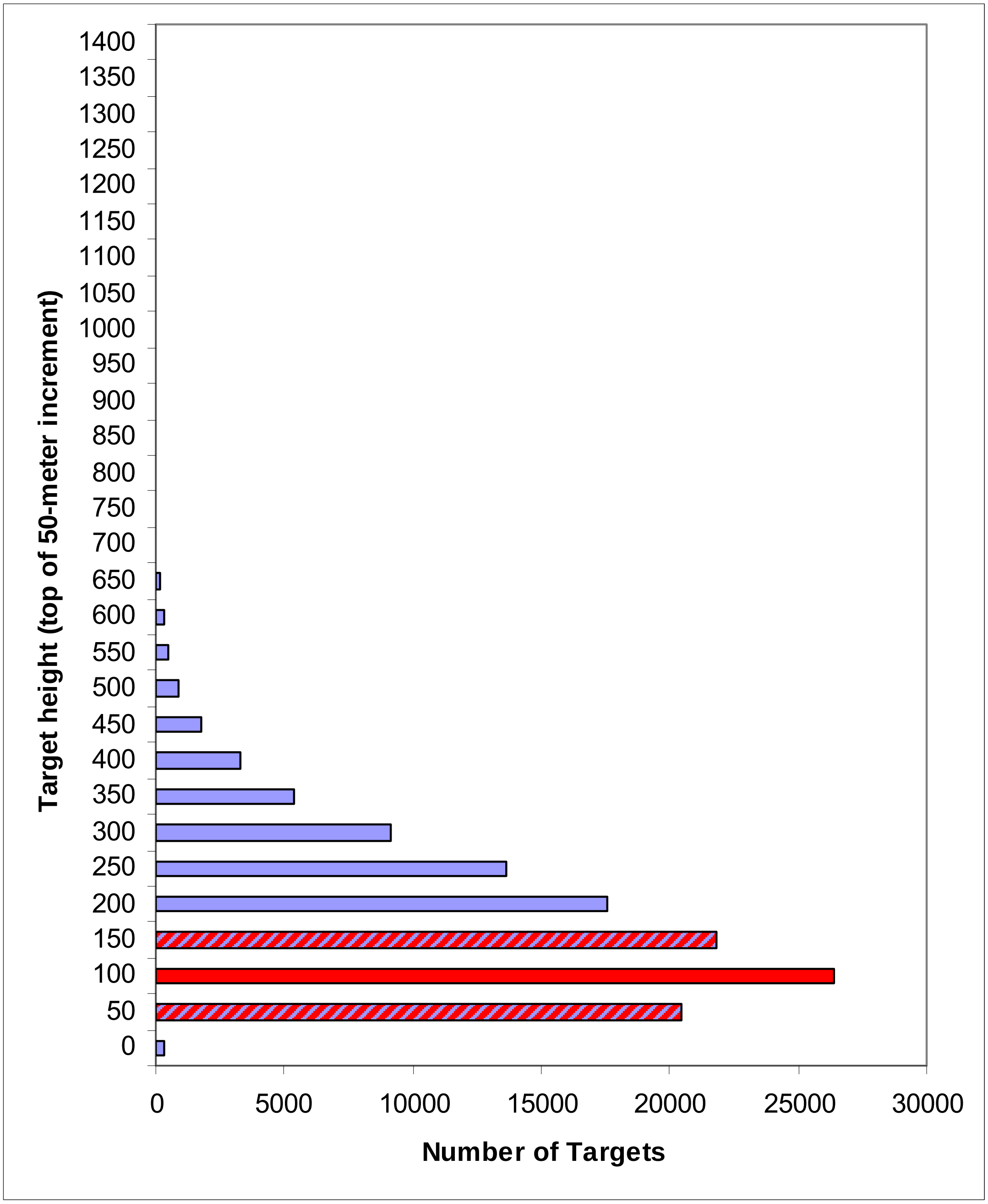

Figure 13. Number of targets occurring in each 50-meter increments adjusted AGL at the proposed Canton Mountain Wind Project site during the fall 2010 sampling period. Red indicates rotor swept heights, and red hashed indicates altitudes partially within rotor swept heights. Note: the height of the radar unit on this figure is -118 m. The target height adjustment for uneven topography subtracted 118 m from all target heights and then eliminated targets with negative heights.

Nights – Targets were detected up to 1,271 m adjusted AGL; target rates below, within, and above the RSZ heights of 36–130 m AGL are presented in Figure 14. Of all the targets that were detected by the vertical radar during nights of the fall 2010 sampling period, 51.5% were above the RSZ upper height limit, 38.2% were within the RSZ, and 10.3% below the RSZ. Nightly percentages of targets within the RSZ heights ranged from a minimum of 16.0% to a maximum of 61.0%, with an average of 45.7%. Nightly target passage rates averaged 149.4 targets/km/hr above the RSZ upper height limit, 112.1 targets/km/hr within the RSZ heights, and 30.5 targets/km/hr below the RSZ lower height limit. (All nightly counts, passage rates, and percents in RSZ can be found in Appendix D.)

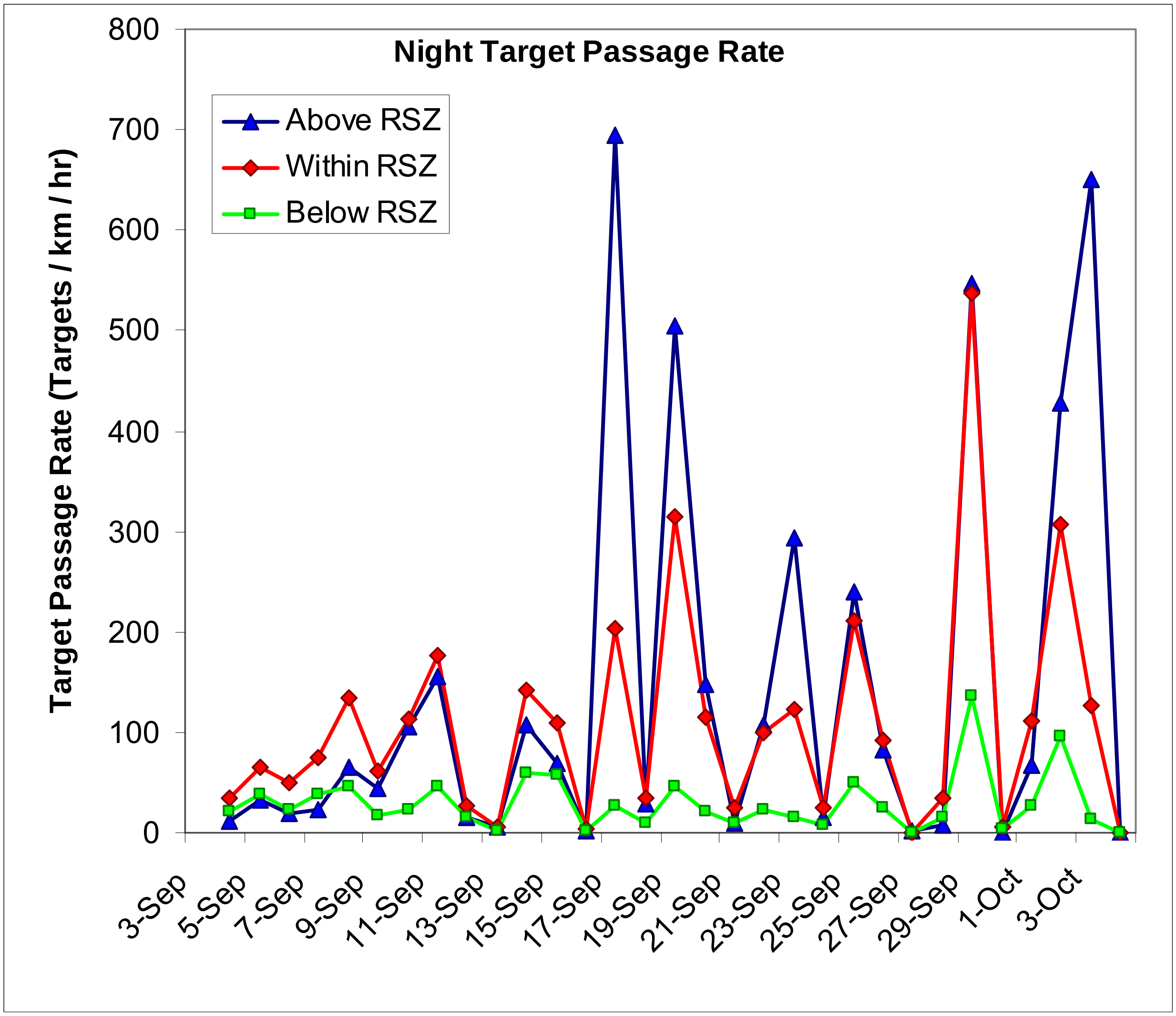

Figure 14. Target passage rates below, within, and above the rotor swept zone (RSZ) heights at the proposed Canton Mountain Wind Project site during nights of the fall 2010 sampling period.

Days – Targets were detected up to 1,271 m adjusted AGL; target rates below, within, and above the RSZ of 36–130 m AGL are presented in Figure 15. Of all the targets that were detected by the vertical radar during days of the fall 2010 sampling period, 27.0% were above the RSZ upper height limit, 50.8% were within the RSZ heights, and 22.1% were below the RSZ lower height limit. Daily percentages of targets within the RSZ heights ranged from a minimum of 0.0% to a maximum of 65.7%, with an average of 43.5%. Daily target passage rates averaged 3.8 targets/km/hr above the RSZ upper height limit, 7.1 targets/km/hr within the RSZ heights, and 3.1 targets/km/hr below the RSZ lower height limit. (All daily counts, passage rates, and percents in RSZ can be found in Appendix D.)

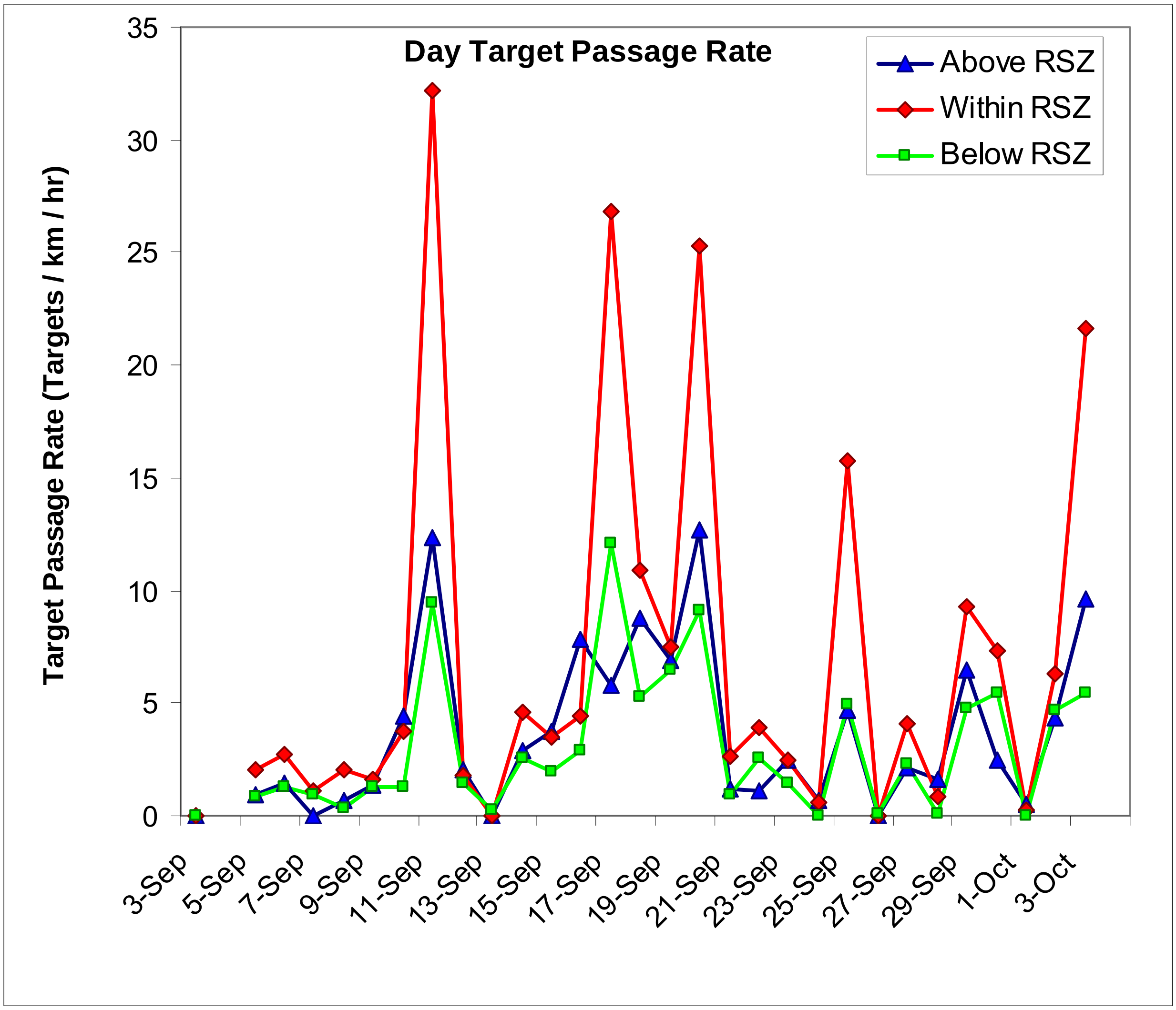

Figure 15. Target passage rates below, within, and above the rotor swept zone (RSZ) heights at the proposed Canton Mountain Wind Project site during days of the fall 2010 sampling period.

Nights – Mean target heights detected during the fall 2010 sampling period were slightly greater than the median target heights, and more than half of the nights had mean and median target heights that occurred within the RSZ heights of 36–130 m AGL (Figure 16). The average mean target height over all nights of the sampling period was 131.1 m AGL (range 60.7–229.2 m), while the average median height was 106.4 m AGL (range 51.1–217.0 m). All mean and median target height values can be found in Appendix D. When all targets of the sampling period were grouped by night, the mean target height was 157.9 m and the median target height was 134.4 (Figure 18).

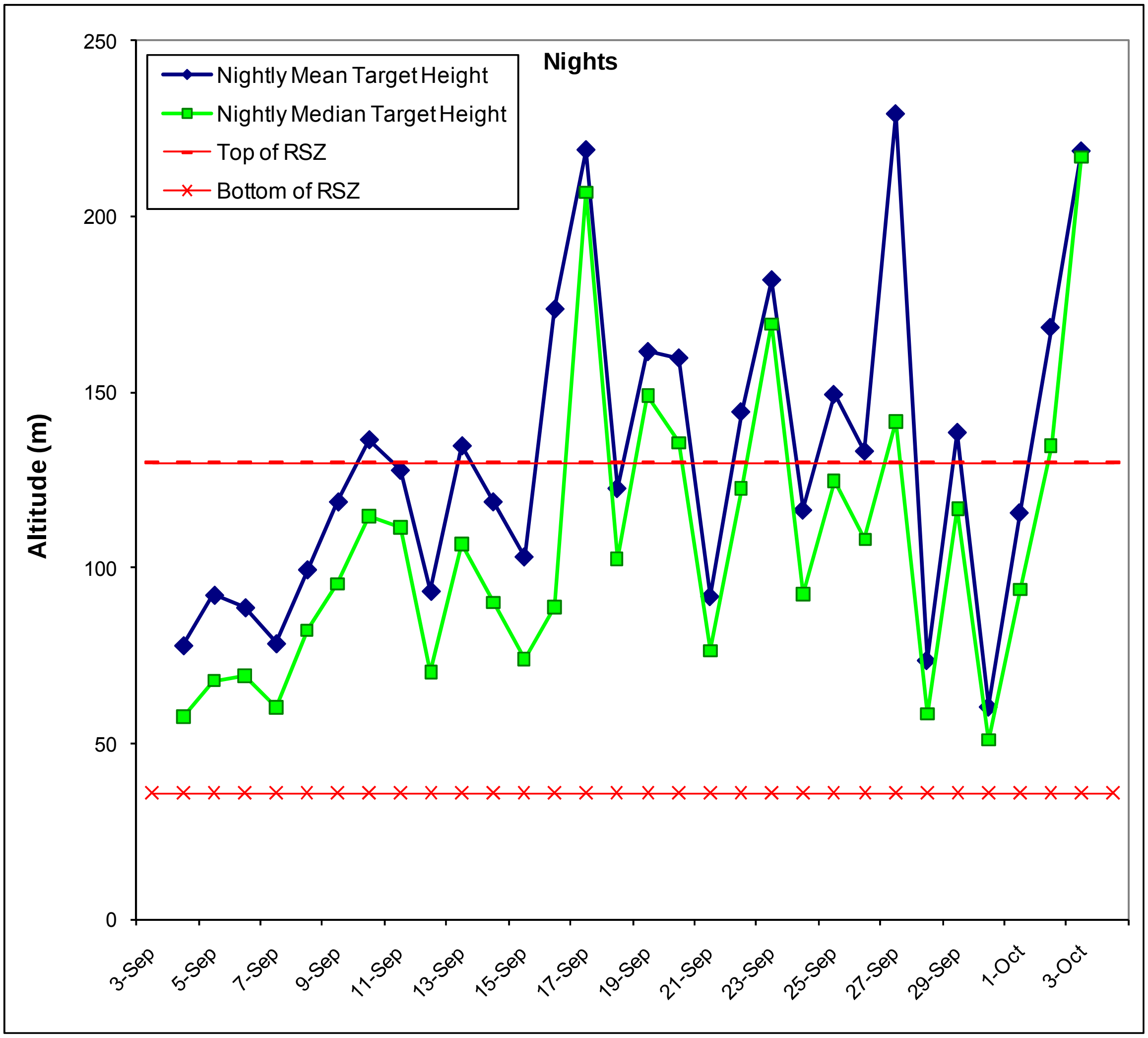

Figure 16. Mean and median heights of targets at the proposed Canton Mountain Wind Project site during nights of the fall 2010 sampling period.

Days – Mean and median heights of targets detected during days of the fall 2010 sampling period were generally within the RSZ heights of 36–130 m AGL (Figure 17). The average mean target height over all days of the sampling period was 126.3 m AGL (range 14.7–230.2 m), while the average median height was 83.1 m AGL (range 17.4–180.7 m). (All mean and median target height values can be found in Appendix D.) When all targets of the sampling period were grouped by day, the mean target height was 129.4 m and the median target height was 75.3 m (Figure 18).

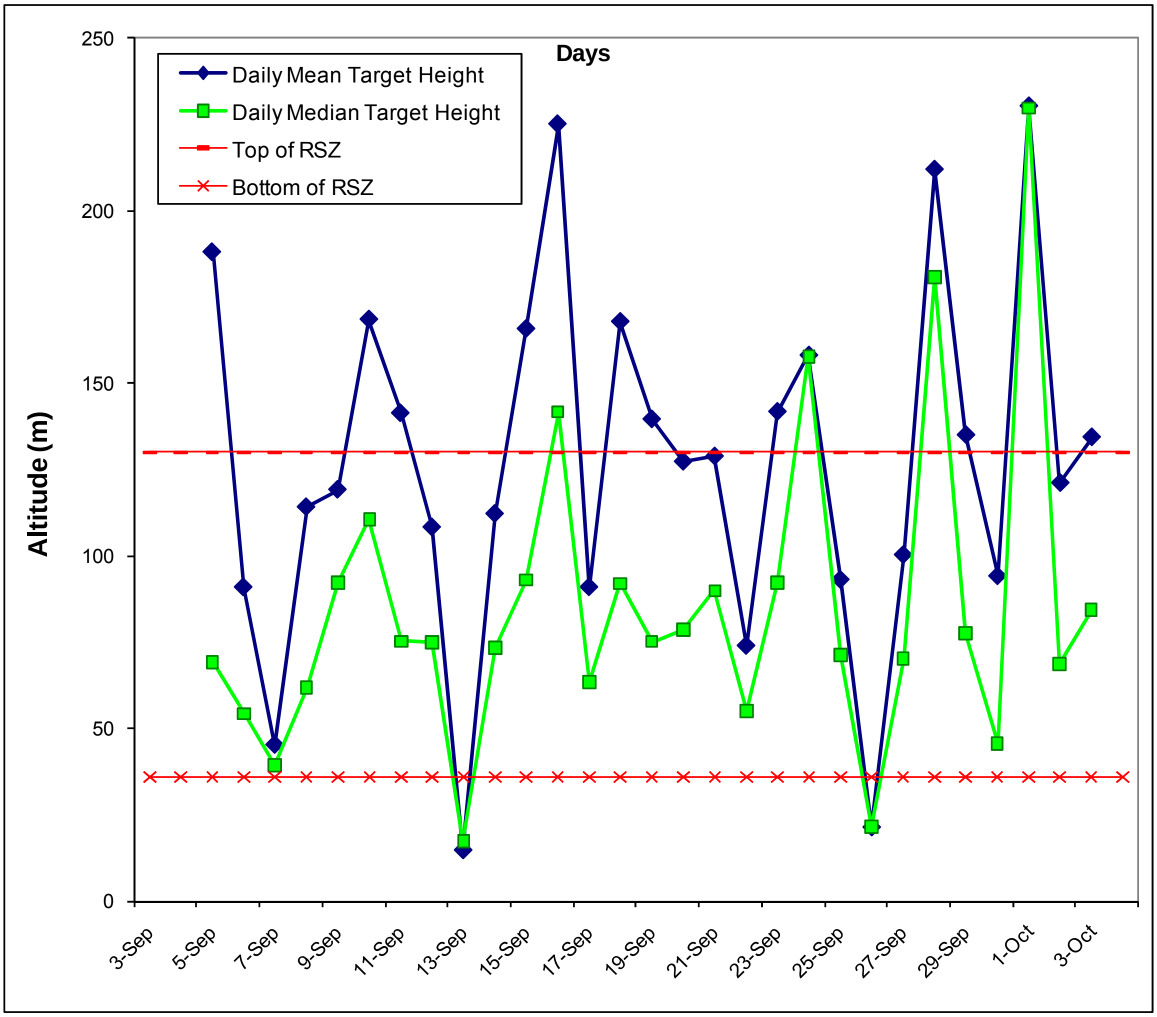

Figure 17. Mean and median heights of targets at the proposed Canton Mountain Wind Project site during days of the fall 2010 sampling period.

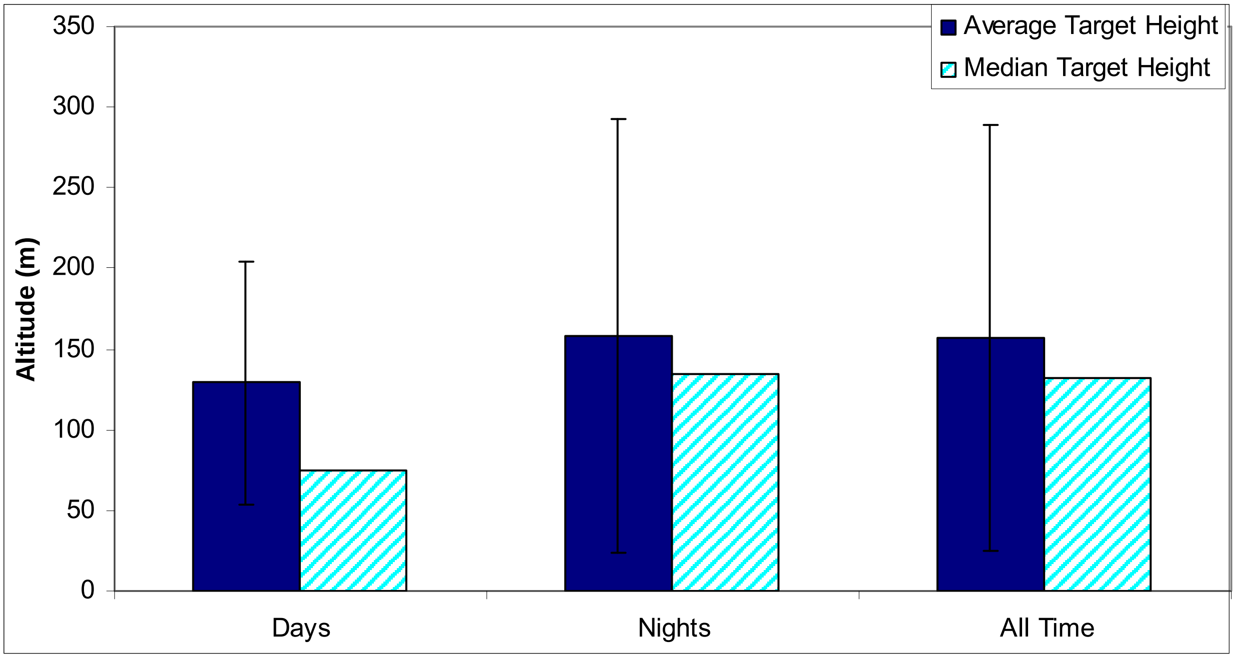

Figure 18. Average mean and median target heights at the proposed Canton Mountain Wind Project site for days, nights, and all time during the fall 2010 sampling period. Error bars represent one standard deviation.

Horizontal Radar

The Horizontal Surveillance Radar (HSR) was used to determine directional movements of targets during days and nights of the fall 2010 sampling period.

Target Directions

The average flight direction of all targets during nights of the sampling period was 231° (southwest), and 8 of the 24 nights with horizontal radar data (33.3%) had average target movements that were southwest, with another 38% either south or west (Figures 19 and 20). Daily target movements also were predominantly southwest (11 of 23 days with horizontal radar data, 47.8%) and averaged 233° (southwest). Nightly target directions were relatively concentrated (average r = 0.47), and a large portion of the angular concentration values were greater than 0.5 (79.2%, Table 2). In contrast, the majority of daily movements were less concentrated (average r = 0.28, 60.0% of angular dispersion values were less than 0.5) indicating more dispersed target movements during the day.

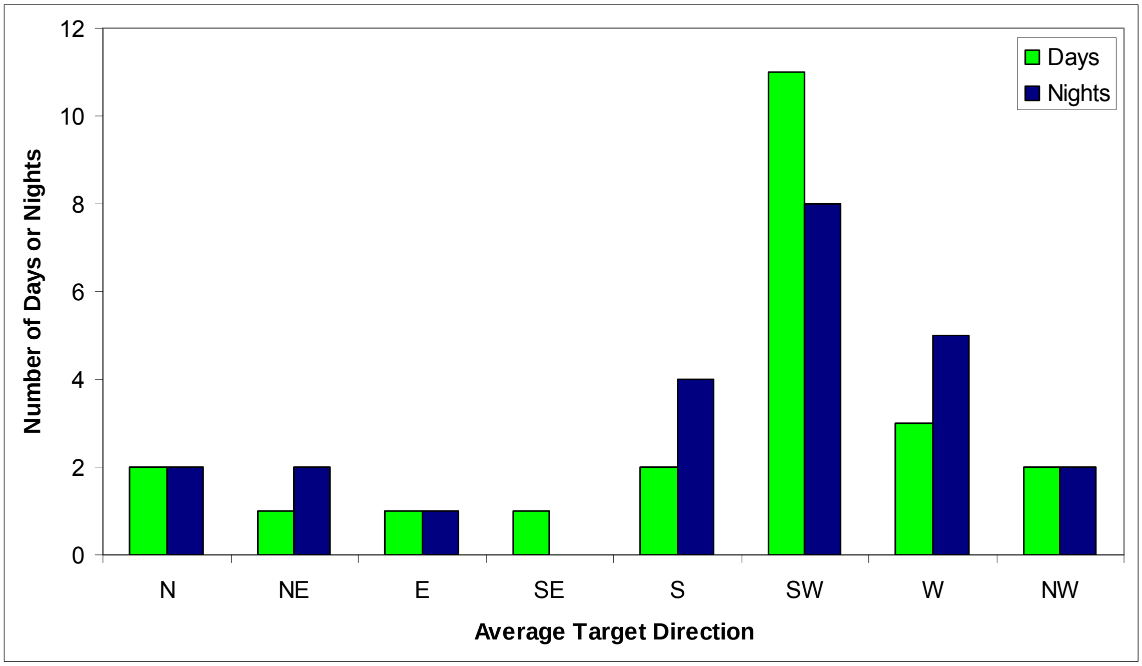

Figure 19. Distribution of average daily and nightly target movements at the proposed Canton Mountain Wind Project site during the fall 2010 sampling period.

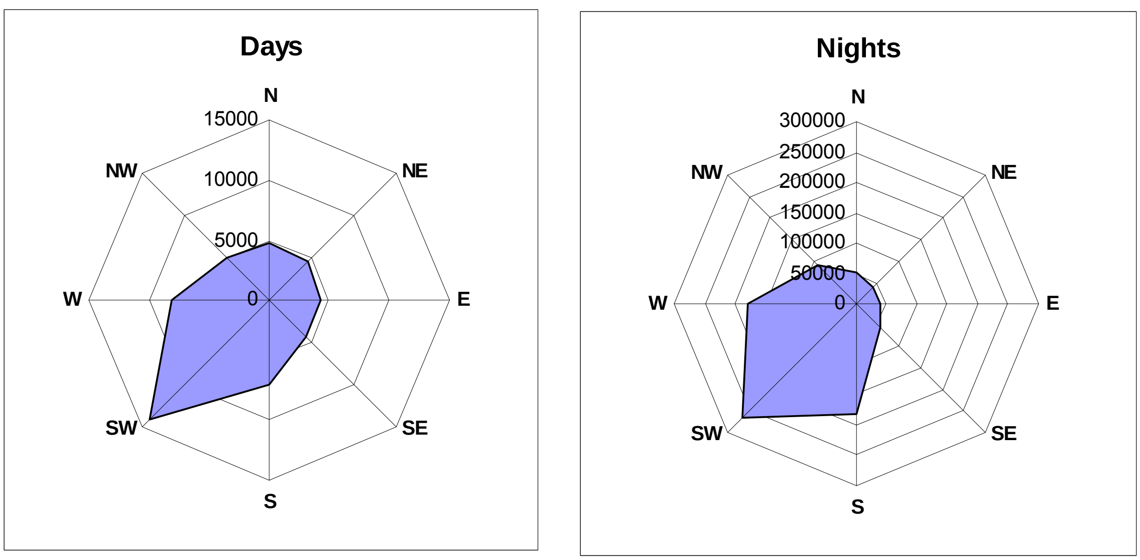

Figure 20. Distribution of average daily and nightly target movements at the proposed Canton Mountain Wind Project site during the fall 2010 sampling period.

Table 2. Average direction and concentration of targets at the proposed Canton Mountain Wind Project site during the fall 2010 sampling period.

	Days			Nights		
Date	Average Bearing (Degrees)	Direction	Angular Concentration (*r*)	Average Bearing (Degrees)	Direction	Angular Concentration (*r*)
3-Sep						
4-Sep						
5-Sep						
6-Sep						
7-Sep						
8-Sep						
9-Sep						
10-Sep				227.8	SW	0.57
11-Sep	229.7	SW	0.24	280.2	W	0.55
12-Sep	321.0	NW	0.14	278.7	W	0.26
13-Sep	12.5	N	0.08	77.7	E	0.33
14-Sep	97.9	E	0.25	186.7	S	0.44
15-Sep	142.8	SE	0.04	199.5	S	0.59
16-Sep	274.2	W	0.39	272.4	W	0.56
17-Sep	219.8	SW	0.81	240.7	SW	0.59
18-Sep	264.1	W	0.58	319.4	NW	0.52
19-Sep	238.7	SW	0.53	216.7	SW	0.59
20-Sep	213.6	SW	0.69	201.2	S	0.79
21-Sep	235.5	SW	0.19	357.0	N	0.61
22-Sep	226.4	SW	0.36	208.2	SW	0.68
23-Sep	217.2	SW	0.71	260.6	W	0.52
24-Sep	303.7	NW	0.10	27.6	NE	0.56
25-Sep	198.8	S	0.20	226.2	SW	0.57
26-Sep	236.4	SW	0.60	288.2	W	0.63
27-Sep	242.5	SW	0.65	296.4	NW	0.29
28-Sep	38.9	NE	0.39	28.4	NE	0.65
29-Sep	244.7	SW	0.18	240.5	SW	0.42
30-Sep	252.4	W	0.40	357.8	N	0.63
1-Oct	9.8	N	0.26	190.7	S	0.81
2-Oct	198.8	S	0.50	205.2	SW	0.59
3-Oct	232.2	SW	0.71	239.0	SW	0.71
4-Oct	235.2	SW	0.85			

*Periods with <50% of time recorded by radar and excluded from analysis
** Horizontal radar data not available from Sep 3 - 10 due to a malfunctioning radar computer interface card.

Weather Data

Table 3 presents averages of wind speed, temperature, wind direction, and total precipitation during days and nights. Nightly wind speeds averaged 7.0 m/s (15.7 mph) 60 m above ground level, and daily wind speeds averaged 6.4 m/s (14.3 mph). Average wind directions varied but were predominantly westerly during both nights and days (Figure 21). Temperatures averaged 11.8°C (53.2°F) during nights and 15.2°C (59.4°F) during days. During the 32-day fall sampling period, the vertical radar data indicated precipitation in the radar scanned area on four nights and two days.

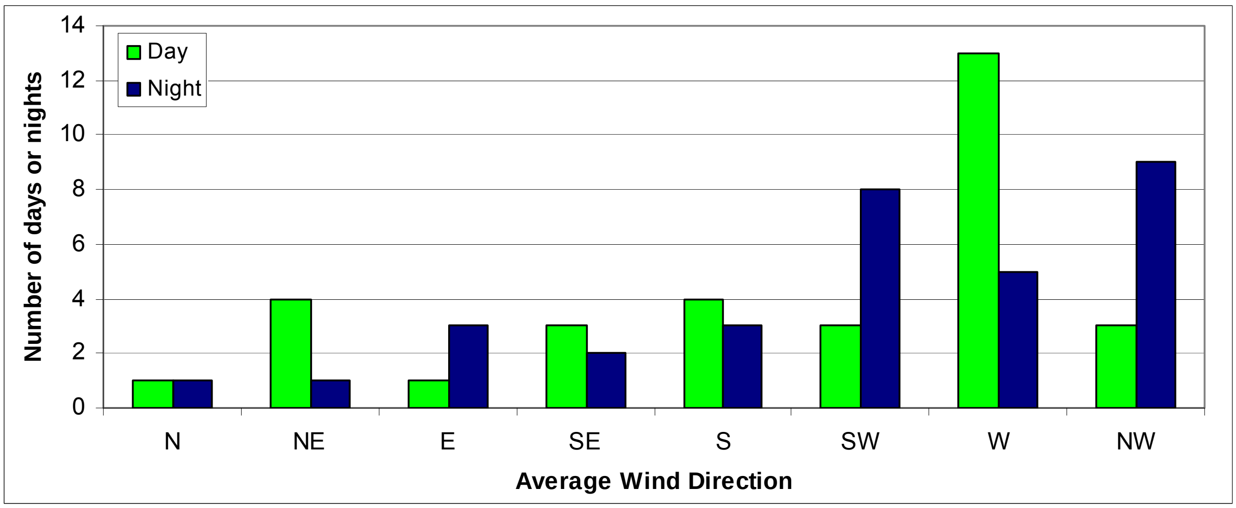

Figure 21. Distribution of daily and nightly wind directions at the proposed Canton Mountain Wind Project site during the fall 2010 sampling period.

Table 3. Average weather conditions during days and nights at the proposed Canton Mountain Wind Project site during the fall 2010 sampling period.

	Days					Nights				
Date	Average Wind Speed (m/s)	Average Temperature (°F)	Average Wind Bearing	Wind Direction	Minutes of Rain on VSR Radar	Average Wind Speed (m/s)	Average Temperature (°F)	Average Wind Bearing	Wind Direction	Minutes of Rain on VSR Radar
3-Sep	5.7	28.2	264.7	W	0	3.2	23.1	224.2	SW	60
4-Sep	4.4	27.0	195.7	S	0	4.8	19.7	68.4	E	0
5-Sep	11.1	20.3	289.1	W	0	10.8	12.9	257.7	W	0
6-Sep	10.9	15.2	261.4	W	0	8.2	11.0	257.5	W	0
7-Sep	5.9	17.8	248.9	W	0	6.8	14.2	242.7	SW	0
8-Sep	4.9	18.3	236.0	SW	0	6.2	16.6	207.3	SW	0
9-Sep	8.2	17.6	249.7	W	0	7.0	13.1	291.0	W	0
10-Sep	6.8	13.7	289.9	W	0	7.8	8.9	307.8	NW	0
11-Sep	7.9	11.9	320.5	NW	0	6.3	10.6	343.4	N	0
12-Sep	5.0	17.1	34.5	NE	0	6.4	11.0	116.3	SE	0
13-Sep	3.9	11.5	147.7	SE	0	5.1	8.2	190.1	S	0
14-Sep	4.9	9.6	191.6	S	0	5.2	10.3	217.2	SW	0
15-Sep	5.9	13.1	269.2	W	0	8.0	9.2	288.6	W	0
16-Sep	9.9	11.2	299.9	NW	0	8.3	7.8	292.9	NW	180
17-Sep	4.5	13.7	225.4	SW	0	7.5	9.3	84.5	E	0
18-Sep	6.1	12.1	27.5	NE	0	3.1	9.6	336.6	NW	0
19-Sep	3.6	15.6	190.1	S	0	6.1	9.6	230.9	SW	0
20-Sep	2.9	16.8	265.4	W	0	5.3	11.3	320.9	NW	0
21-Sep	7.6	14.3	348.2	N	0	8.4	7.3	314.4	NW	0
22-Sep	5.9	12.5	262.2	W	0	9.1	12.8	244.2	SW	0
23-Sep	8.6	19.6	267.3	W	0	7.4	13.9	294.9	NW	0
24-Sep	5.8	12.0	288.4	W	0	4.6	10.5	194.3	S	0
25-Sep	3.0	11.1	126.2	SE	0	8.5	14.9	226.9	SW	0
26-Sep	8.1	21.2	276.9	W	0	7.6	12.1	330.0	NW	0
27-Sep	7.9	8.0	65.3	NE	0	4.1	7.9	89.9	E	0
28-Sep	3.1	9.6	85.2	E	0	4.8	10.7	119.6	SE	15
29-Sep	7.6	15.9	195.8	S	0	9.0	17.9	208.0	SW	0
30-Sep	7.3	19.9	235.3	SW	150	3.5	15.9	267.0	W	0
1-Oct	5.5	16.0	148.1	SE	232	11.6	18.8	193.0	S	83
2-Oct	7.4	15.8	265.8	W	0	9.6	9.5	315.6	NW	0
3-Oct	9.7	9.7	295.5	NW	0	7.2	4.7	308.2	NW	0
4-Oct	3.9	9.9	54.9	NE	0	11.4	5.9	53.4	NE	0

Target Passage Rates and Weather Associations

Target passage rates were the greatest on nights with winds out of the southwest (Table 4), and were moderately correlated with wind speed (r = 0.32). When nights were grouped by average wind direction, there was no apparent pattern of nightly target directions; some average target directions were the same as the nightly wind direction, others were directly opposing, and there was no prevailing target direction overall. Average target bearings were moderately concentrated during all wind directions, with none being either very concentrated or very dispersed (range 0.44–0.61,Table 4).

Table 4. Characteristics of target movement at the proposed Canton Mountain Wind Project site during nights categorized by average nightly wind direction, fall 2010 sampling period.

Wind Direction	N	NE	E	SE	S	SW	W	NW
# nights	1	1	3	2	3	8	5	9
Average Target Passage Rate (targets/km/hr)	377.2	-	331.8	57.8	88.8	501.1	119.5	322.2
Average Target Bearing (degrees)	280.2	-	53.4	333.6	84.7	215.7	278.6	259.9
Corresponding Target Direction	W	-	NE	NW	E	SW	W	W
Concentration of Average Target Bearings	1.00	-	0.24	0.58	0.42	0.95	0.19	0.68
Average Angular Concentration of Targets	0.55	-	0.44	0.46	0.57	0.54	0.61	0.61

When nights were grouped by average target direction, target passage rates were the greatest during nights with southwest movements, which was also the most frequent direction in which targets moved during nights (Table 5). On nights with target directions averaging other than southwest, target passage rates were much lower. The average concentration of targets was moderate during all target directions (range 0.33–0.62). Average wind speeds were greatest when nightly target movements were towards the southwest, south, and west, but no pattern in temperature or occurrence of rain was apparent (Tables 5 and 6).

Table 5. Weather characteristics and target passage rates at the proposed Canton Mountain Wind Project site during nights categorized by average target direction, fall 2010 sampling period.

Target Direction	N	NE	E	SE	S	SW	W	NW
# nights	2	2	1	0	4	8	5	2
Average Target Passage Rate (targets/km/hr)	27.1	52.6	12.9	-	258.7	700.3	214.7	37.4
Average Angular Concentration of Targets	0.62	0.60	0.33	-	0.66	0.59	0.50	0.40
Average Wind Direction (degrees)	290.7	156.9	190.10	-	254.3	261.9	321.90	33.2
Corresponding Wind Direction	W	SE	S	-	W	W	NW	NE
Concentration of Average Wind Bearings	0.92	0.79	1.00	-	0.63	0.52	0.56	0.55
Average Angular Concentration of Wind	0.62	0.61	0.98	-	0.91	0.92	0.85	0.85
Average Wind Speed (m/s)	6.0	4.7	5.1	-	7.5	8.1	7.2	3.6
Average Temperature (°C)	11.6	10.6	8.2	-	12.4	10.9	11.1	8.8
% nights with rain	0%	50%	0%	-	25%	0%	20%	0%

Table 6. Average nightly weather values at the proposed Canton Mountain Wind Project site on nights sorted by target passage rate, fall 2010 sampling period.

Date	Nightly Target Passage Rate (targets/km/hr)	Nightly Target Passage Rate (targets/km/hr) at RSZ	Night Average Wind Speed (m/s)	Night Average Temperature (°F)	Night Average Wind Direction	Minutes of Rain on VSR Radar
4-Oct	-	-	11.4	5.9	NE	0
29-Sep	1220.2	537.1	9.0	17.9	SW	0
17-Sep	923.5	203.7	7.5	9.3	E	0
19-Sep	867.0	315.0	6.1	9.6	SW	0
2-Oct	830.3	306.8	9.6	9.5	NW	0
3-Oct	790.3	126.1	7.2	4.7	NW	0
3-Sep	642.0	199.2	3.2	23.1	SW	60
25-Sep	499.9	210.8	8.5	14.9	SW	0
23-Sep	432.2	123.1	7.4	13.9	NW	0
11-Sep	377.2	176.5	6.3	10.6	N	0
14-Sep	308.2	141.3	5.2	10.3	SW	0
20-Sep	284.6	115.2	5.3	11.3	NW	0
8-Sep	246.2	134.4	6.2	16.6	SW	0
10-Sep	240.9	113.3	7.8	8.9	NW	0
15-Sep	236.1	108.5	8.0	9.2	W	0
22-Sep	230.6	99.7	9.1	12.8	SW	0
1-Oct	205.7	111.1	11.6	18.8	S	83
26-Sep	199.0	92.8	7.6	12.1	NW	0
5-Sep	137.0	65.5	10.8	12.9	W	0
7-Sep	135.9	75.2	6.8	14.2	SW	0
9-Sep	122.4	60.8	7.0	13.1	W	0
6-Sep	91.0	49.8	8.2	11.0	W	0
18-Sep	72.4	33.7	3.1	9.6	NW	0
4-Sep	69.6	35.4	4.8	19.7	E	0
12-Sep	58.4	27.5	6.4	11.0	SE	0
28-Sep	57.2	34.9	4.8	10.7	SE	15
24-Sep	47.9	24.3	4.6	10.5	S	0
21-Sep	43.5	24.1	8.4	7.3	NW	0
13-Sep	12.9	6.0	5.1	8.2	S	0
30-Sep	10.8	6.5	3.5	15.9	W	0
16-Sep	6.6	3.7	8.3	7.8	NW	180
27-Sep	2.4	0.9	4.1	7.9	E	0

* Passage rates derived from nights having radar data during < 50% of nighttime.

DISCUSSION

This radar survey collected near-continuous data from the proposed Canton Mountain Wind Project site for 32 days from September 3–October 4, 2010, with the objective to sample bird and bat activity data during the fall migration season. Maine Department of Inland Fish and Wildlife had requested a 20 day/night survey. Radar data were collected during 93.6% of available time for the vertical radar and 73.3% of available time for the horizontal radar. Much of the downtime for the horizontal radar was due to failure of the radar computer interface (RCI) card. Rain obscuration made some of the recorded radar data unusable, decreasing data during the sampling period to 91.7% and 72.1% of available time for vertical and horizontal radars, respectively.

Nightly target passage rates during the fall 2010 sampling period varied, ranging from 2.4 to 1,220.2 targets/km/hr and averaging 292.0 targets/km/hr. Target passage rates during daytime were much lower with an average of 13.9 targets/km/hr, and ranged from 0.1 to 54.0 targets/km/hr. When separated into 24 hours of the day, hourly target passage rates were greatest during early night (hours 20–22, 8–11 pm, Figure 11) and were very low throughout the daylight hours. The nights with the five greatest target passage rates at this site occurred during late September and early October (September 29, 17, 19, and October 2 and 3, respectively). Target passage rates, in general, were much lower during the fall 2010 sampling period than the spring 2010 sampling period (average target passage rates during spring nights and days were 627.6 and 138.2 targets/km/hr, respectively).

The calculated target passage rates in this report may be different compared to other radar studies in the region for four main reasons: 1) type of radar system, 2) higher resolution radar data, 3) no extrapolation of survey time (sampling bias), and, 4) calculation of target passage rates using vertical instead of horizontal radar data. See Appendix A below for further discussion of these reasons.

As might be expected during fall migration, the majority of average nightly target movements were to the southwest or south (54.2%) and averaged 231° (southwest). Daily target movements also averaged southwest (233°) but were less concentrated than nightly target movements (nights: r = 0.47, days: r = 0.28); this difference in angular concentration is likely a reflection of both nocturnal migration and more dispersed, local movements during days.

Target passage rates were greatest on nights when target movements averaged southwest and winds were also from the southwest. Although the prominent southwest movement is not surprising during a fall migration time period, the frequency of the southwest movement and high passage rates into southwest headwinds is unexpected. The moderate correlation of target passage rates with wind speed is also surprising given the frequency of headwinds. Average target bearings were moderately concentrated during all wind directions and all target bearings. There were very few other correlations between weather and target rates, target directions, or directional concentration of targets. For example, some average target directions were the same as the nightly wind direction, others were directly opposing, and there was no prevailing target direction across wind directions. There was no apparent association between any target metric with either temperature or rain.

Mean target heights were greater during nights than days (157.9 and 129.4 m adjusted AGL respectively), as were median target heights (134.4 m and 75.3 m adjusted AGL respectively). More targets were also detected above the RSZ upper height limit during nights (51.5%) than days (27.0%). High-altitude and low-altitude nocturnal migration as well as local diurnal movements, are some of the likely explanations for temporal difference in target heights and target passage rates. However, target heights, in addition to passage rates, were low during the entire study period.

Approximately 60% of both nights and days had mean target heights within the RSZ heights, and more than 80% of median target heights occurred within the RSZ heights during the fall 2010 sampling period. Although the adjustment to target heights required to compensate for the 118 m ridge near the radar may partially explain the low target heights during the fall 2010 survey period, they were considerably lower than the target heights observed during nights of the spring 2010 sampling period at this site (spring mean: 291.6 m; spring median: 240.7 m), which applied the same compensation factor.

Seasonal differences at this site may partially or entirely explain the differences in target heights and passage rates observed between the spring and fall 2010 survey periods. The bulk of migration could have also been either earlier or later than the fall 2010 sampling period, leading to lower target heights and passage rates in the absence of large migration movements. However, the lower target heights and passage rates recorded during fall 2010 may indicate an absence of significant bird movement at greater altitudes and greater magnitudes than during the spring period at this site.

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Appendix A – Comparing Target Passage Rates

Types of radar systems

Small Mobile Radars vary in sophistication, from manual systems to semi-manual and fully automatic systems. Manual systems (as used by other consulting firms) require a skilled radar ornithologist to observe a standard marine radar display and record their observations of bird and bat activity. This type of system requires the operator to decide which targets are birds or bats and manually record the target count, size, direction, speed, and other data. Semi-manual systems capture a digital image from the marine radar and manually digitize the data for analysis, also conducted by a skilled observer. Fully automated systems (such as DeTect's MERLIN system) use computer-based programs to identify bird and bat targets and record target counts, size, speed, and other data. One of the main differences between the manual and semi-manual systems and DeTect's fully automatic system is consistency. The decisions the software makes regarding what is and isn't a bird or bat target and the measurement of target parameters is consistent across all conditions, whereas the other radar systems rely on human observers. Although skilled, their observations are susceptible to variability among observers, observer fatigue, and display saturation (when there are so many targets that the display is saturated and individuals cannot be distinguished) among other effects, all of which generally result in undercounting. The following are additional reasons DeTect's radar system counts may be different.

Higher resolution data

The MERLIN system uses an RCI card to digitize the analog signal coming from the radar receiver. This digitizes the voltage of the signal on a 12-bit scale ranging from zero (for no voltage) to 4,096 (for the maximum voltage or receiver saturation). These 4,096 levels of reflectivity provide a much more precise dataset than the 4–32 levels of data encoding used on standard marine radars, and allow better target categorization and measurement.

The RCI in MERLIN can also sample the receiver signal at a predefined rate up to 60 Mhz. A sampling rate this fast allows more range bins in a single radar pulse to be sampled. Although increasing the pulse length can also increase the sampling rate, the tradeoff is larger range bins and lower resolution imagery. Therefore, it is preferable to sacrifice radiated power (pulse length) for improved image resolution. The result of a short radar pulse sampled at 60 MHz is sub-sampling of range bins, which ultimately means that spatially small targets only dominate the sub range bins they occupy, and larger targets (with stronger returns) occupy all of the sub-sampled range bins and perhaps some adjacent range bins. This allows for greater distinction between differently sized targets and improved imagery resolution.

The RCI also allows the signal to be sub-sampled in azimuth. The data can be sampled with an azimuth resolution of 512–4,096 samples in one rotation of the antenna. Therefore, even if the antenna azimuth beam width is 2°, the very high azimuth resolution allows sub-sampling of the azimuth beam width, and the peak in radar return more precisely matches the location of the target than at lower azimuth resolution. The product of short pulse lengths, high signal sampling rate, and high azimuth sampling rate in MERLIN, is imagery with far superior resolution and reflectivity when rendered to an analog radar display compared to the standard off-the-share radar displays used on other radar systems. This difference is readily apparent even to the layman, and becomes even more powerful when coupled with MERLIN algorithms that use the high resolution data for further signal processing and to make precise measurements.

Sampling bias

Many radar studies with manual or semi-manual radar systems use a single radar, alternatively flipped, to cover both the vertical and horizontal planes. Samples are then collected for short periods of time (typically 15 minutes) and the data are extrapolated to an hour (as opposed to measuring the entire hour). Extrapolation may be relatively accurate if the trend in the numbers of targets is constant, but biological target activity tends to show continual changes in numbers of targets, and when the data being captured are part of an increasing or decreasing trend the extrapolation may result in a significant difference between the estimated and actual number. Therefore, sampled data from manual or semi-manual radar systems should be considered estimates and continuous data collection preferred, as it more accurately and completely measures actual passage rates. The MERLIN system collects continuous data sets from both the horizontal and vertical planes, eliminating the need for any extrapolation.

Calculating Target Passage Rates from VSR

There are a number of radar scanning and data collection methods in use, but for most applications the choice is the vertical scanning radar (VSR) and horizontal surveillance radar (HSR). A number of published studies to date have used HSR. The data from any radar are biased by 1) the amount of radar display lost to ground clutter, 2) the amount of display lost under the radar horizon, 3) the detectability of targets, and 4) the evenness of the sample volume. Each of these issues is discussed below by comparing horizontal scanning radar with vertical scanning radar.

<u>Ground clutter</u>
The amount of the radar display lost to ground clutter in the HSR is generally high unless the radar is situated on an elevated location with the ground falling away (in which case targets may pass below the radar horizon and not be

counted). When the ground clutter level gets too high and saturates the receiver, or is so high that the addition of a small target such as a bird does not significantly change the signal, the target is not "seen" on the radar screen and therefore not detected.

Automated high data resolution systems using CFAR (constant false alarm rate) algorithms and ground clutter mapping techniques such as MERLIN are significantly better than manual systems in the horizontal plane because the high dynamic range of the data (typically 4,096 levels) make it easier to "see" the contribution of a small target (as opposed to a human observer trying to visualize a difference on a radar display with little or no shade or color difference). The amount of display lost to ground clutter in an automated radar system can be minimized by the application of CFAR and ground clutter mapping techniques, but is not completely eliminated, even in MERLIN.

By contrast, vertical scanning radars look mostly at clear air, and only encounter ground clutter up to the height of the terrain, leaving much of the data clear of ground clutter. Small targets imaged against clear air have greater contrast, and therefore greater detection probability, than those imaged against a background of ground clutter, even if CFAR algorithms and ground clutter mapping techniques are applied. Accordingly, the VSR has a significant advantage over horizontal radar for detecting the actual number of targets passing through a study area.

Radar Horizon

Radar is a line of sight instrument; it cannot see targets behind terrain or through other obstacles. Anything that blocks the beam creates a "radar horizon" beyond which targets cannot be seen. With a HSR, a partially blocked beam will still illuminate some clear air and track targets, and an operator may not be aware that there is a radar horizon or that the sample volume is reduced. This amount of reduction of sampling volume is difficult to determine. By contrast, a VSR will readily show the "black holes" where either ground clutter or beam blockage prevents birds from being detected by the radar beam when plotting a large number of tracks. Occlusion can still be a factor in the VSR, but it is easy to determine the portions of airspace affected. If ground clutter or occlusion is a significant issue at a site with rolling terrain it can be quantified and factored into the subsequent data analysis.

Probability of Detection

Differences in radar settings such as radar gain and pulse-length, which determine maximum detection distances, as well as any clutter suppression algorithms, all vary by radar system and can affect the number of targets detected. Probability of detection is affected by these and other parameters within a radar system, but at the end of the processing chain it is the contrast of the target against the background noise that determines if a target is detected or lost. Therefore, anything that increases the amount of clear air against which targets are imaged and doesn't introduce a radar horizon, means more accurate count data.

Sample volume

With any type of radar, a volume of airspace is sampled. With HSR, this sample volume increases with range, even with the most sophisticated of antenna beam shaping techniques. Therefore, a HSR count is a sample of different volumes and altitudes as the range changes. A HSR sampling volume may also be distorted to different degrees throughout the scan by the influence of ground clutter and occlusion of the beam. This variability makes it difficult to accurately determine both the height and volume in which a passage rate occurs.

The volume to either side of the vertical beam in a VSR also increases with altitude, but if a tracking algorithm is used then the only difference between a target in the lower portion of the beam and the upper portion of the beam is how long the target stays in the beam, and not the number of targets detected. The increased volume at higher altitudes does not capture and track significantly more birds than at lower altitudes because sidelobes generally widen the effective beam width (generally 24°) at low altitudes, and most targets have sufficient time to be detected and tracked in the shorter period of time the targets are in the beam. So although the change in volume by altitude in the VSR adds some bias to the count data, the impact is not as large as that introduced by the HSR.

A VSR also samples much more airspace *above* the radar than a HSR. Although volume standardization can correct for the different amount of airspace sampled by HSR and VSR, it cannot correct for the different densities of birds, or bats, present at different altitudes. If different altitudes are sampled, simple volume standardization will only be accurate if target densities are equal across all altitudes, an assumption we know to be false. Bird and bat heights vary and are dependent upon a myriad of changing abiotic and biotic factors, which is why quantifying bird and bat activity at rotor swept altitudes is so critical. Nocturnal migration usually occurs at high altitudes; including targets from greater altitudes likely increases target passage rates. However, capping target counts at a given altitude (when calculating flight heights in VSR) likely creates artificially low passage rates and ignores the potential of collision risk if a fallout of nocturnally migrating birds were to occur.

Summary

The MERLIN Avian Radar System is likely to have greater target counts both because it is a fully automatic system and because it creates higher resolution images. Unlike fully automatic systems, manual and semi-manual radar systems are susceptible to observer fatigue and display saturation, both of which result in undercounting. In addition to lacking these human-induced biases, DeTect's MERLIN Avian Radar System also creates higher resolution images that are clearer and allow greater detection of targets present. The greater resolution of

DeTect's MERLIN Avian Radar System data is the result of using a vertically-positioned radar for the passage rate data (which has less ground clutter than horizontal radar), signal digitization on a 12-bit scale (enabling 4,096 levels of detectable reflectivity, compared to 4–32 levels on standard marine radars), a fast sampling rate (60 Mhz) coupled with shorter radar pulses (0.08 µsec), and sub-sampling of the azimuth beam width. MERLIN CFAR (constant false alarm rate) and ground clutter mapping techniques also decrease targets lost to clutter.

The observer bias inherent in manual and semi-manual radar systems introduces so many variables that reproducing the results becomes problematic. The effect of the biases and limitations of these types of systems on the actual activity is unknown. Therefore, one must be careful when comparing a manual radar study to an automated study. The former is likely biased downwards and probably imposes a false ceiling on the maximum numbers and types of targets counted. The latter may be biased upwards, but without limitation of the maximum numbers it can process and without extrapolation, the numbers are likely closer to the actual numbers moving through an area.

Given the different biases and limitations of the two sensors (VSR and HSR), one would expect to see the same trends, with target numbers generally going up and down in similar seasons. However, perfect correlation will not occur even if the sensors were side by side in the same season. Achieving correlation becomes even more difficult when comparing different studies at the same site in different years, or different studies in different years at different locations.

Automated radar systems that record accurate metadata allow for the capture of all the key parameters of the radar performance that permit another researcher with similar equipment and configuration to follow the methods and reproduce the results. Human interaction in the radar data collection process greatly increases the bias and limits reproducibility. The true reproducibility of a manual or semi-manual radar dataset will always be difficult because of the bias and limitations inherent in the datasets.

Appendix B – Glossary

1-km Front – Area extending 0.5 km on either side of the VSR forming a 1 km^2 area through which target passage rates are quantified. This area occurs entirely within the radar scanned zone.

Rotor Swept Area (RSA) - The circular area "swept" by the blades during operation of a wind turbine, specific to type of wind turbine.

Rotor Swept Zone (RSZ) – The 1-km wide band within the 1-km front that encompasses the lowest and highest points swept by a wind turbine's blades (RSA). Specific to each project and calculated using the manufacturer's specifications for the wind turbine proposed for the project.

Plot – A single scan of a target or other objects.

Target Passage Rate – Number of specified targets passing through a 1-km wide front during 1 hour. This rate is standardized for effort, or the proportion of minutes radar data were recorded during a given time period.

Target – Object detected by MERLIN Radar and identified by MERLIN software as a biological object (e.g., bird, bat, insect) based on scanned size, speed, and other characteristics.

Track – The entire sequence of target plots that are recorded as long as an object still fits the definition of a target.

Tracking – The MERLIN software begins to track a target after it has met the criteria of a biological target for three consecutive scans. The target continues to be tracked until either the target is lost, or target fails to meet the criteria for three consecutive scans.

Appendix C – Abbreviations

AGL – Above Ground Level

HSR – Horizontal Scanning Radar

km – kilometer

m – meter

mph – miles per hour

nm – Nautical miles (approximately 1.15 miles)

RCI – Radar Computer Interface

RSA – Rotor Swept Area

RSZ – Rotor Swept Zone

VSR – Vertical Scanning Radar

Appendix D – Target Counts, Passage Rates, Mean and Median Heights

Table 7. Target counts, passage rates, mean and median heights during days of the fall 2010 sampling period.

Sunrise + 45 minutes	Sunset - 45 minutes	Minutes in Day	Minutes Radar On	Minutes with Rain	Total Day Minutes	% Day with Data	Day Count Below RSZ	Day Count at RSZ	Day Count Above RSZ	Total Day Count	Day TPR Below RSZ	Day TPR at RSZ	Day TPR Above RSZ	Day TPR	% Targets at RSZ	Mean Target Height AGL (m)	Median Target Height AGL (m)
9/3/10 5:51	9/3/10 17:29	698	0	0	0	0.0	-	-	-	-	-	-	-	-	-	-	-
9/4/10 5:52	9/4/10 17:27	695	346	0	346	49.8	3	6	1	10	0.5	1.0	0.2	1.7	60.0%	118.3	54.6
9/5/10 5:53	9/5/10 17:25	692	692	0	692	100	10	24	11	45	0.9	2.1	1.0	3.9	53.3%	188.0	69.2
9/6/10 5:55	9/6/10 17:24	689	689	0	689	100	15	31	17	63	1.3	2.7	1.5	5.5	49.2%	90.9	54.3
9/7/10 5:56	9/7/10 17:22	686	686	0	686	100	11	13	0	24	1.0	1.1	0.0	2.1	54.2%	45.3	39.3
9/8/10 5:57	9/8/10 17:20	683	683	0	683	100	4	23	8	35	0.4	2.0	0.7	3.1	65.7%	114.1	61.9
9/9/10 5:58	9/9/10 17:18	680	680	0	680	100	14	18	15	47	1.2	1.6	1.3	4.1	38.3%	119.1	92.4
9/10/10 5:59	9/10/10 17:16	677	677	0	677	100	14	42	50	106	1.2	3.7	4.4	9.4	39.6%	168.5	110.6
9/11/10 6:00	9/11/10 17:14	674	674	0	674	100	106	362	139	607	9.4	32.2	12.4	54.0	59.6%	141.3	75.3
9/12/10 6:02	9/12/10 17:13	671	667	0	667	99.4	16	20	23	59	1.4	1.8	2.1	5.3	33.9%	108.3	75.0
9/13/10 6:03	9/13/10 17:11	668	668	0	668	100	3	0	0	3	0.3	0.0	0.0	0.3	0.0%	14.7	17.4
9/14/10 6:04	9/14/10 17:09	665	665	0	665	100	28	51	32	111	2.5	4.6	2.9	10.0	45.9%	112.2	73.5
9/15/10 6:05	9/15/10 17:07	662	626	0	626	94.6	20	36	39	95	1.9	3.5	3.7	9.1	37.9%	165.7	93.0
9/16/10 6:06	9/16/10 17:05	659	659	0	659	100	32	49	86	167	2.9	4.5	7.8	15.2	29.3%	225.0	141.7
9/17/10 6:07	9/17/10 17:03	656	656	0	656	100	132	293	63	488	12.1	26.8	5.8	44.6	60.0%	90.9	63.6
9/18/10 6:09	9/18/10 17:01	652	652	0	652	100	57	118	95	270	5.2	10.9	8.7	24.8	43.7%	167.8	92.0
9/19/10 6:10	9/19/10 16:59	649	649	0	649	100	70	81	75	226	6.5	7.5	6.9	20.9	35.8%	139.5	75.1
9/20/10 6:11	9/20/10 16:58	647	647	0	647	100	98	273	137	508	9.1	25.3	12.7	47.1	53.7%	127.3	78.8
9/21/10 6:12	9/21/10 16:56	644	644	0	644	100	10	28	13	51	0.9	2.6	1.2	4.8	54.9%	128.8	89.9
9/22/10 6:13	9/22/10 16:54	641	641	0	641	100	27	42	12	81	2.5	3.9	1.1	7.6	51.9%	73.9	55.2
9/23/10 6:14	9/23/10 16:52	638	638	0	638	100	15	26	26	67	1.4	2.4	2.4	6.3	38.8%	141.7	92.4
9/24/10 6:16	9/24/10 16:50	634	634	0	634	100	0	6	7	13	0.0	0.6	0.7	1.2	46.2%	158.0	157.6
9/25/10 6:17	9/25/10 16:48	631	631	0	631	100	52	166	49	267	4.9	15.8	4.7	25.4	62.2%	93.1	71.3
9/26/10 6:18	9/26/10 16:46	628	628	0	628	100	1	0	0	1	0.1	0.0	0.0	0.1	0.0%	21.3	21.3
9/27/10 6:19	9/27/10 16:44	625	625	0	625	100	24	43	22	89	2.3	4.1	2.1	8.5	48.3%	100.2	70.4
9/28/10 6:20	9/28/10 16:43	623	623	0	623	100	1	9	17	27	0.1	0.9	1.6	2.6	33.3%	211.9	180.7
9/29/10 6:22	9/29/10 16:41	619	619	0	619	100	49	96	67	212	4.7	9.3	6.5	20.5	45.3%	135.0	77.6
9/30/10 6:23	9/30/10 16:39	616	616	150	466	75.6	42	57	19	118	5.4	7.3	2.4	15.2	48.3%	94.1	45.6
10/1/10 6:24	10/1/10 16:37	613	613	363	250	40.8	0	1	2	3	0.0	0.2	0.5	0.7	33.3%	230.2	180.4
10/2/10 6:25	10/2/10 16:35	610	610	0	610	100	48	64	44	156	4.7	6.3	4.3	15.3	41.0%	121.1	68.7
10/3/10 6:26	10/3/10 16:33	607	607	0	607	100	55	219	97	371	5.4	21.6	9.6	36.7	59.0%	134.3	84.4
10/4/10 6:28	10/4/10 16:31	603	179	0	179	29.7	11	20	13	44	3.7	6.7	4.4	14.7	45.5%	100.3	75.3

TPR = Target Passage Rate (targets / km / hm), RSZ = Rotor Swept Zone (36 - 130 m), AGL = Above Ground Level

*Periods with <50% of time recorded by radar are excluded from analysis

Table 8. Target counts, passage rates, mean and median heights during nights of the fall 2010 sampling period.

Sunset + 45 minutes	Sunrise next day - 45 minutes	Minutes in Night	Minutes Radar On	Minutes with Rain	Total Night Minutes	% Night with Data	Night Count Below RSZ	Night Count at RSZ	Night Count Above RSZ	Total Night Count	Night TPR Below RSZ	Night TPR at RSZ	Night TPR Above RSZ	Night TPR	% Targets at RSZ	Mean Target Height AGL (m)	Median Target Height AGL (m)
9/3/10 17:29	9/4/10 5:52	743	207	60	147	19.8	205	488	880	1573	83.7	199.2	359.2	642.0	31.0%	325.8	160.3
9/4/10 17:27	9/5/10 5:53	746	649	0	649	87.0	236	383	134	753	21.8	35.4	12.4	69.6	50.9%	78.1	57.9
9/5/10 17:25	9/6/10 5:55	750	750	0	750	100	481	819	413	1713	38.5	65.5	33.0	137.0	47.8%	92.4	68.0
9/6/10 17:24	9/7/10 5:56	752	752	0	752	100	278	624	239	1141	22.2	49.8	19.1	91.0	54.7%	88.9	69.2
9/7/10 17:22	9/8/10 5:57	755	755	0	755	100	484	946	280	1710	38.5	75.2	22.3	135.9	55.3%	78.7	60.4
9/8/10 17:20	9/9/10 5:58	758	758	0	758	100	587	1698	825	3110	46.5	134.4	65.3	246.2	54.6%	99.7	82.3
9/9/10 17:18	9/10/10 5:59	761	761	0	761	100	228	771	553	1552	18.0	60.8	43.6	122.4	49.7%	119.0	95.6
9/10/10 17:16	9/11/10 6:00	764	763	0	763	99.9	287	1441	1336	3064	22.6	113.3	105.1	240.9	47.0%	136.6	114.6
9/11/10 17:14	9/12/10 6:02	768	767	0	767	99.9	581	2256	1985	4822	45.4	176.5	155.3	377.2	46.8%	127.9	111.6
9/12/10 17:13	9/13/10 6:03	770	770	0	770	100	207	353	190	750	16.1	27.5	14.8	58.4	47.1%	93.6	70.4
9/13/10 17:11	9/14/10 6:04	773	773	0	773	100	24	77	65	166	1.9	6.0	5.0	12.9	46.4%	134.9	106.7
9/14/10 17:09	9/15/10 6:05	776	776	0	776	100	774	1827	1385	3986	59.8	141.3	107.1	308.2	45.8%	119.0	90.2
9/15/10 17:07	9/16/10 6:06	779	779	0	779	100	756	1409	901	3066	58.2	108.5	69.4	236.1	46.0%	103.3	74.1
9/16/10 17:05	9/17/10 6:07	782	782	180	602	77.0	10	37	19	66	1.0	3.7	1.9	6.6	56.1%	173.8	88.8
9/17/10 17:03	9/18/10 6:09	786	785	0	785	99.9	340	2665	9077	12082	26.0	203.7	693.8	923.5	22.1%	219.0	207.0
9/18/10 17:01	9/19/10 6:10	789	789	0	789	100	136	443	373	952	10.3	33.7	28.4	72.4	46.5%	122.8	102.6
9/19/10 16:59	9/20/10 6:11	792	792	0	792	100	620	4158	6666	11444	47.0	315.0	505.0	867.0	36.3%	161.7	149.0
9/20/10 16:58	9/21/10 6:12	794	794	0	794	100	274	1525	1967	3766	20.7	115.2	148.6	284.6	40.5%	159.8	135.6
9/21/10 16:56	9/22/10 6:13	797	796	0	796	99.9	121	320	136	577	9.1	24.1	10.3	43.5	55.5%	92.1	76.5
9/22/10 16:54	9/23/10 6:14	800	800	0	800	100	307	1329	1439	3075	23.0	99.7	107.9	230.6	43.2%	144.5	122.8
9/23/10 16:52	9/24/10 6:16	804	804	0	804	100	203	1649	3940	5792	15.1	123.1	294.0	432.2	28.5%	182.0	169.5
9/24/10 16:50	9/25/10 6:17	807	806	0	806	99.9	100	326	217	643	7.4	24.3	16.2	47.9	50.7%	116.6	92.7
9/25/10 16:48	9/26/10 6:18	810	809	0	809	99.9	661	2842	3237	6740	49.0	210.8	240.1	499.9	42.2%	149.5	124.7
9/26/10 16:46	9/27/10 6:19	813	812	0	812	99.9	333	1256	1104	2693	24.6	92.8	81.6	199.0	46.6%	133.4	108.2
9/27/10 16:44	9/28/10 6:20	816	816	0	816	100	3	12	17	32	0.2	0.9	1.3	2.4	37.5%	229.2	141.6
9/28/10 16:43	9/29/10 6:22	819	819	15	804	98.2	207	468	92	767	15.4	34.9	6.9	57.2	61.0%	73.9	58.5
9/29/10 16:41	9/30/10 6:23	822	821	0	821	99.9	1866	7350	7481	16697	136.4	537.1	546.7	1220.2	44.0%	138.7	116.7
9/30/10 16:39	10/1/10 6:24	825	825	0	825	100	47	90	11	148	3.4	6.5	0.8	10.8	60.8%	60.7	51.1
10/1/10 16:37	10/2/10 6:25	828	828	83	745	90.0	330	1380	844	2554	26.6	111.1	68.0	205.7	54.0%	115.8	93.9
10/2/10 16:35	10/3/10 6:26	831	831	0	831	100	1322	4249	5928	11499	95.5	306.8	428.0	830.3	37.0%	168.5	134.7
10/3/10 16:33	10/4/10 6:28	835	835	0	835	100	188	1755	9056	10999	13.5	126.1	650.7	790.3	16.0%	218.6	217.0
10/4/10 16:31	10/5/10 6:29	838	0	0	0	0.0	-	-	-	-	-	-	-	-	-	-	-

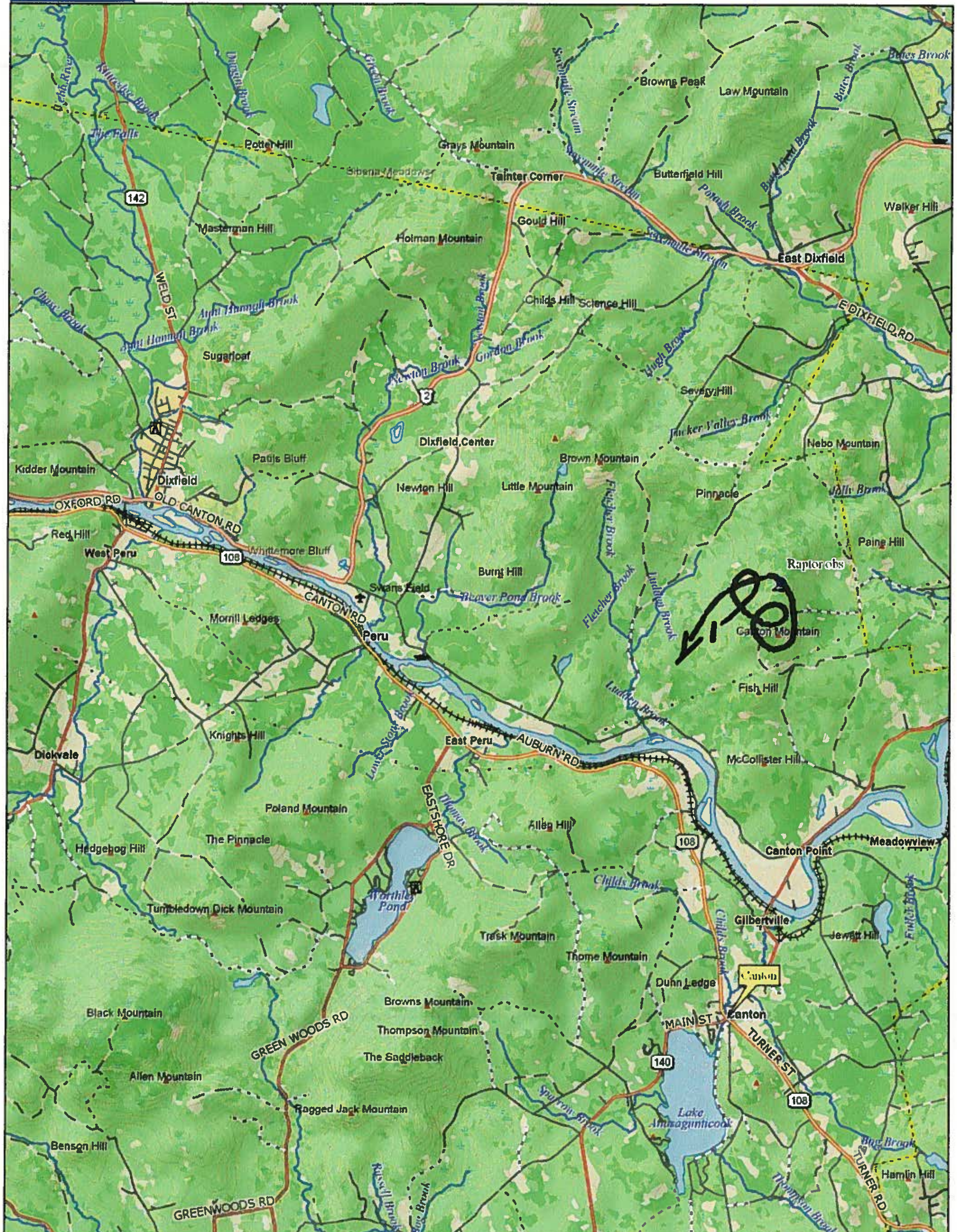
TPR = Target Passage Rate (targets / km / hm), RSZ = Rotor Swept Zone (36 - 130 m), AGL = Above Ground Level

*Periods with <50% of time recorded by radar are excluded from analysis

APPENDIX B

Raptor Survey Data

Appendix B Table 1. Comparison of raptor migration data from Canton Mountain Wind Project to Cadillac Mt hawkwatch on the same survey dates- Fall 2010																													
A- Canton Mt B- Cadillac Mt	**9/1/10**		**9/2/10**		**9/9/10**		**9/10/10**		**9/11/10**		**9/15/10**		**9/17/10**		**9/20/10**		**9/21/10**		**9/29/2010**		**9/30/2010**		**10/5/2010**		**10/13/2010**		**Grand toal**	
	A	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**
American kestrel		5		2		67		8		136		18		36	2	185		62					1	8		10	**3**	**537**
Bald eagle						1		2	1	4	1			3	2								1	1			**5**	**11**
Broad-winged hawk		1				7	2		21	54	11		15	151	6	17	2										**57**	**230**
Cooper's hawk					2	2			1	3	1			1	1	2		1					4	1			**9**	**10**
Golden eagle																											**0**	**0**
Merlin		4				8		2		4	1	3		1	1	8							1			2	**3**	**32**
Northern goshawk						1				2	1				1	1											**2**	**4**
Northern harrier		3				2		3		16		2		6	1	20		11					1	3		2	**2**	**68**
Osprey		1			2	12		9	1	23		5		4	1	11		1						4		5	**4**	**75**
Peregrine falcon						3		1	1	1																	**1**	**5**
Red-shouldered hawk															1	1											**1**	**1**
Red-tailed hawk					1			2		4			2	2	1	4	1						1	3	1		**7**	**15**
Rough-legged hawk																											**0**	**0**
Sharp-shinned hawk		5		10		41	1	9	5	195	2	40	2	54	7	120		66			2		3	9	2	80	**24**	**629**
Turkey vulture	1	1			3						1		3	1		1	2		3		3		4	6		4	**20**	**13**
Unidentified accipiter																1											**0**	**1**
Unidentified buteo											1																**1**	**0**
Unidentified eagle																											**0**	**0**
Unidentified falcon												1															**0**	**1**
Unidentified raptor		1		1		6		1	1	7	1			8									3	1		2	**5**	**27**
Grand Total	**1**	**21**	**0**	**13**	**8**	**150**	**3**	**37**	**31**	**449**	**20**	**69**	**22**	**267**	**24**	**377**	**5**	**153**	**3**	**0**	**5**	**0**	**19**	**36**	**3**	**105**	**144**	**1677**
Survey Effort (hour)	5.00	5.0	6.0	5.0	6.0	7.5	3.0	5.0	6.0	9.0	6.0	5.5	5.0	5.0	6.0	8.5	2.0	6.0	5.5	0.0	6.5	2.5	6.0	5.0	5.5	6.0	**66.5**	**70**
Raptors/hour	**0.20**	**4.20**	**0.00**	**2.60**	**1.33**	**20.00**	**1.00**	**7.40**	**5.17**	**49.89**	**3.33**	**12.55**	**4.40**	**53.40**	**4.00**	**44.35**	**2.50**	**25.50**	**0.55**	**0.00**	**0.77**	**0.00**	**3.17**	**7.20**	**0.55**	**17.50**	**2.17**	**23.96**



Scale 1 : 100,000
1" = 1.58 mi
Data Zoom 11-0

9/1/10 JRK

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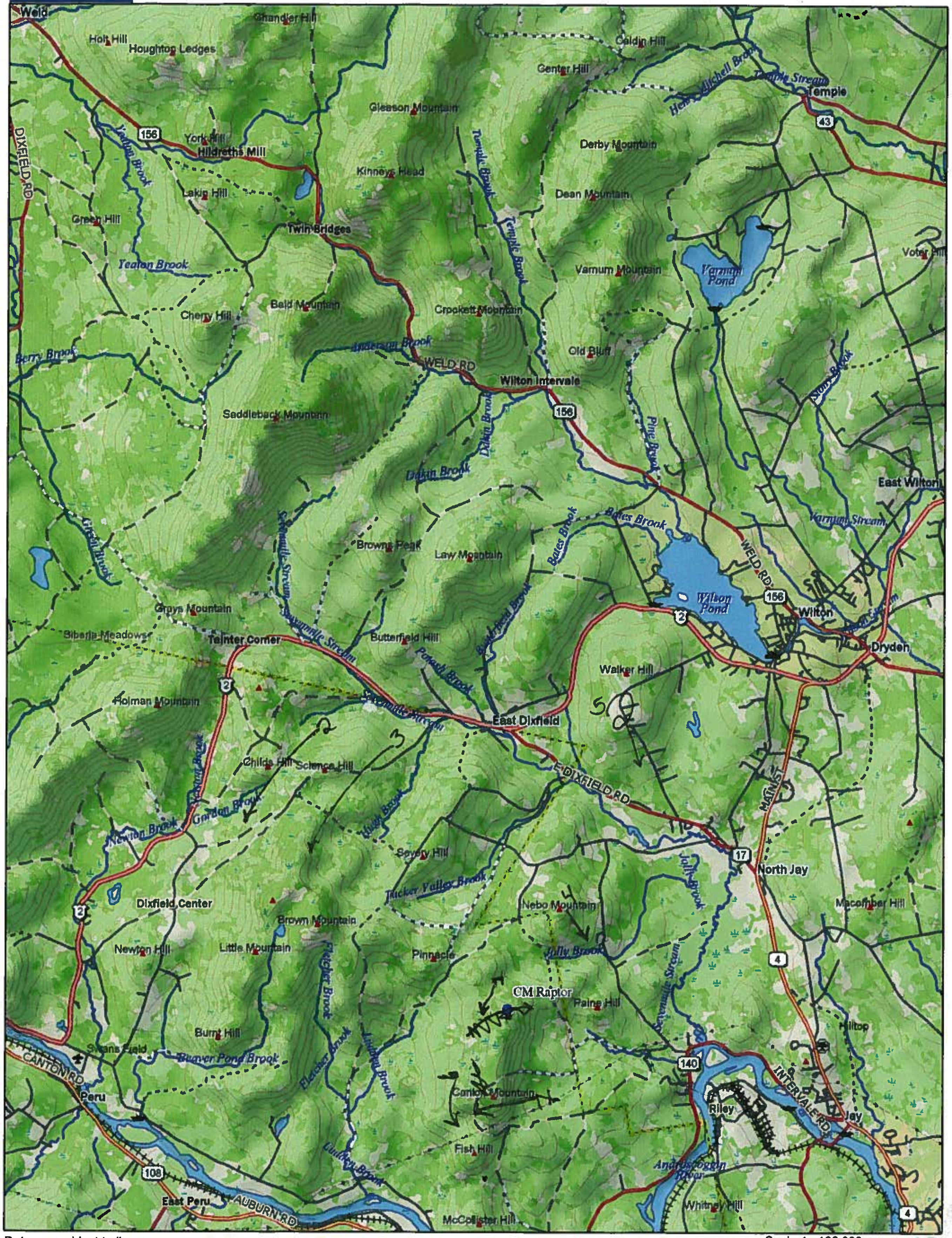

9/10 and 9/10

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TN
MN (16.1°W)

9/9 + 9/10

Scale 1 : 100,000

1" = 1.58 mi   Data Zoom 11-0

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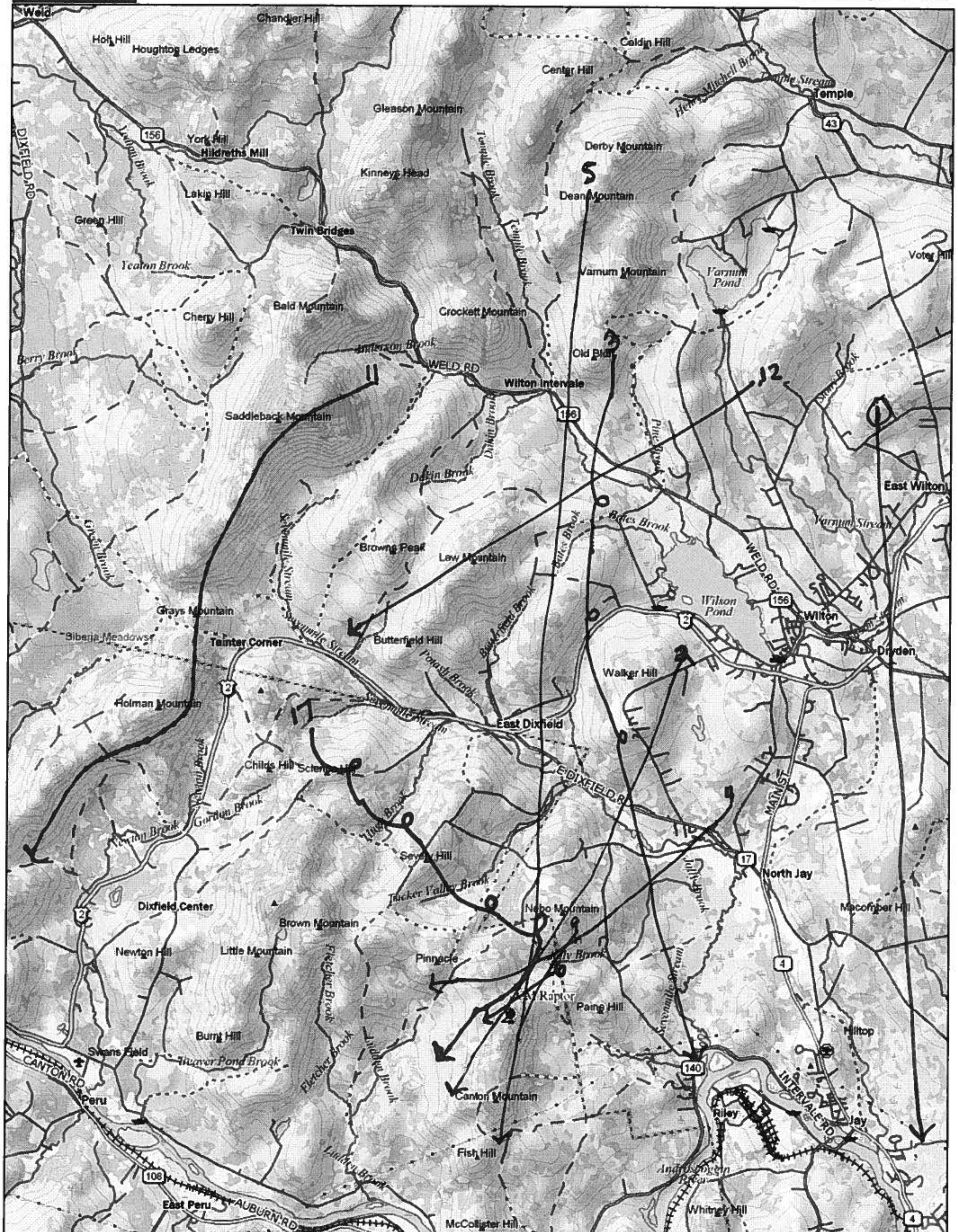

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Scale 1 : 100,000

1" = 1.58 mi

Data Zoom 11-0

9/11/10 Canton Mt, ME

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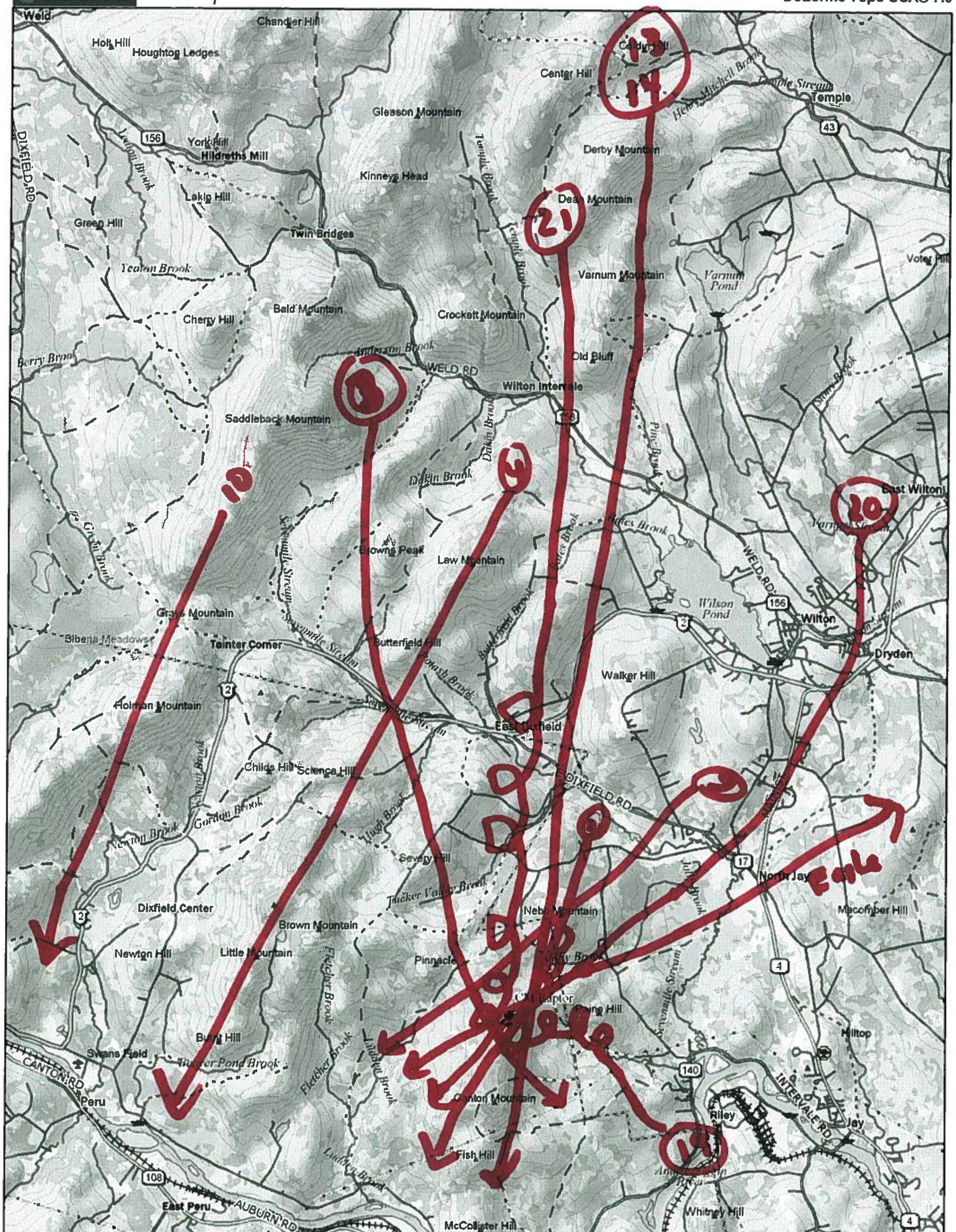

TN
MN (16.1°W)

Scale 1 : 100,000
1" = 1.58 mi
Data Zoom 11-0

Canton ME 9/17/2010 MSD

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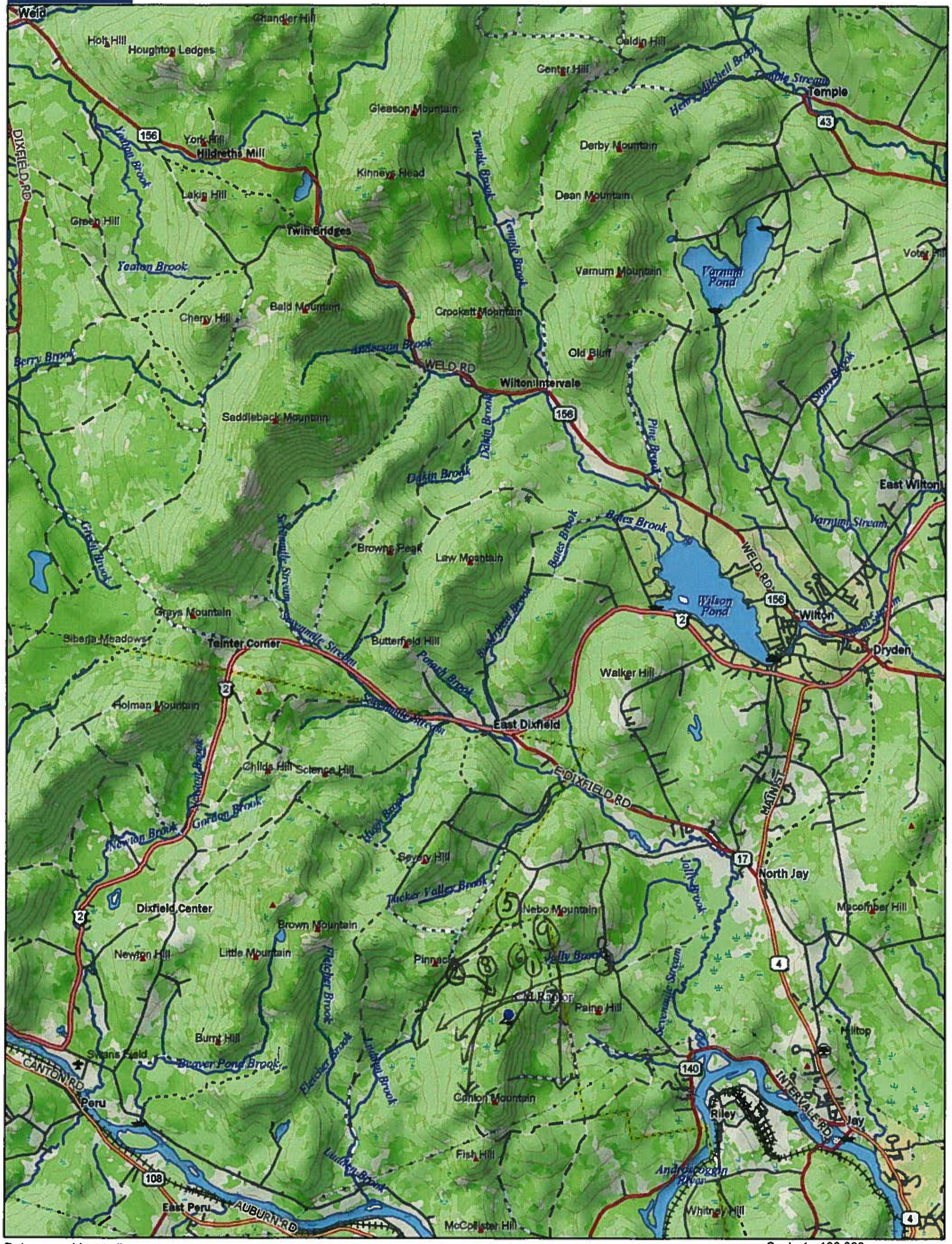

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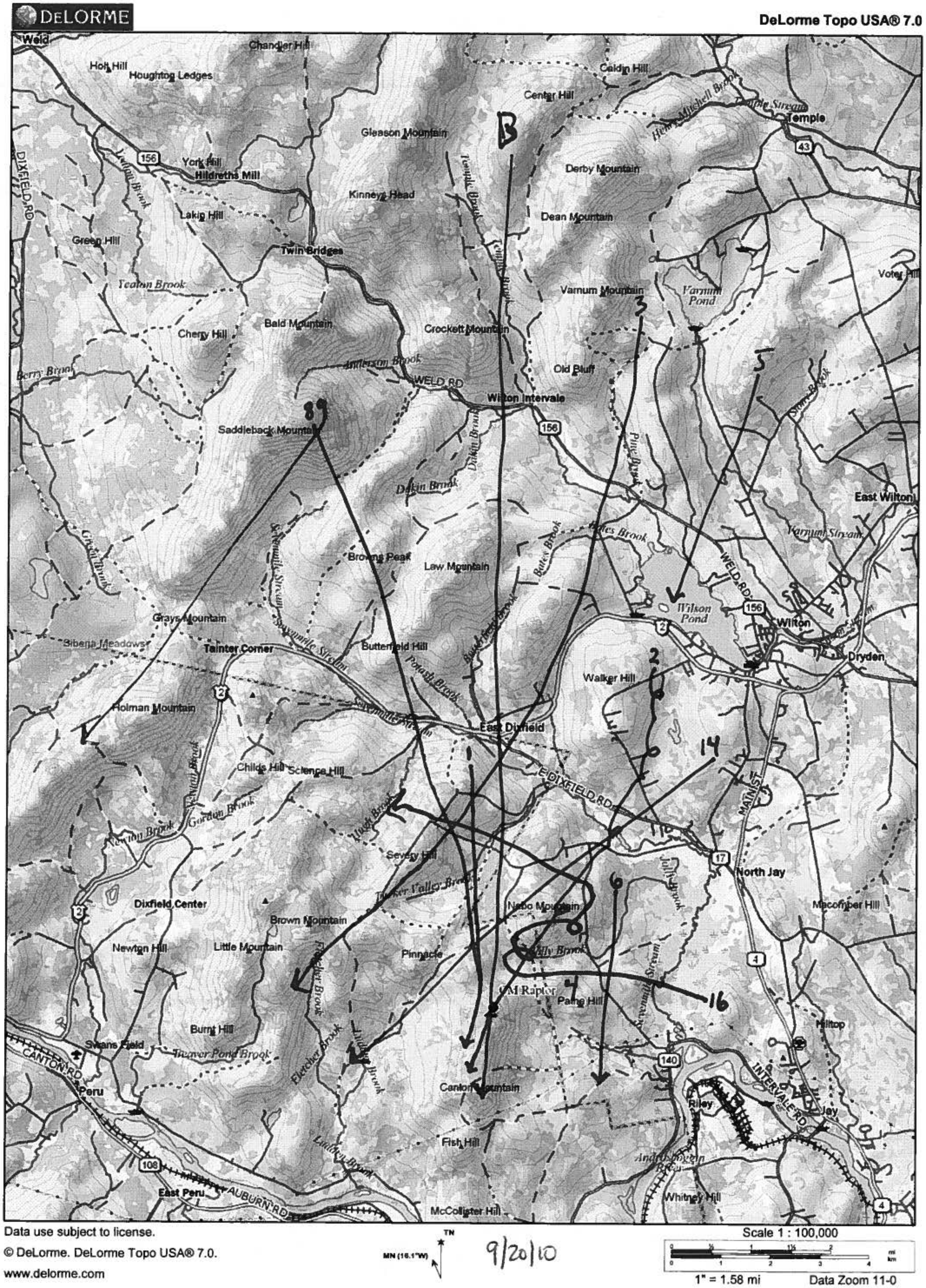
MN (16.1°W)

Scale 1 : 100,000

1" = 1.58 mi

Data Zoom 11-0


DELORME
Weld
Chandler Hill
Holt Hill
Houghton Ledges
Caldin Hill
Center Hill
Temple
Gleason Mountain
B
Derby Mountain
York Hill
Hildreths Mill
Kinney Head
Lakin Hill
Dean Mountain
Green Hill
Twin Bridges
Varnum Mountain
Varnum Pond
Voter Hill
Bald Mountain
Cherry Hill
Crockett Mountain
3
5
Old Bluff
WELD RD
Wilton Intervale
89
Saddleback Mountain
East Wilton
Browns Peak
Law Mountain
Wilson Pond
Wilton
Grays Mountain
Siberia Meadows
Tainter Corner
Butterfield Hill
Dryden
Walker Hill
2
Holman Mountain
East Dixfield
14
1
Childs Hill
Science Hill
E DIXFIELD RD
MAIN ST
North Jay
Severy Hill
6
Dixfield Center
Brown Mountain
Nebo Mountain
Macomber Hill
Newton Hill
Little Mountain
Pinnacle
CMI Raptor
Paine Hill
16
Hilltop
Burnt Hill
Swans Field
CANTON RD
Peru
Canton Mountain
Riley
INTERVALE RD
Jay
Fish Hill
East Peru
AUBURN RD
Whitney Hill
McCollister Hill
DIXFIELD RD
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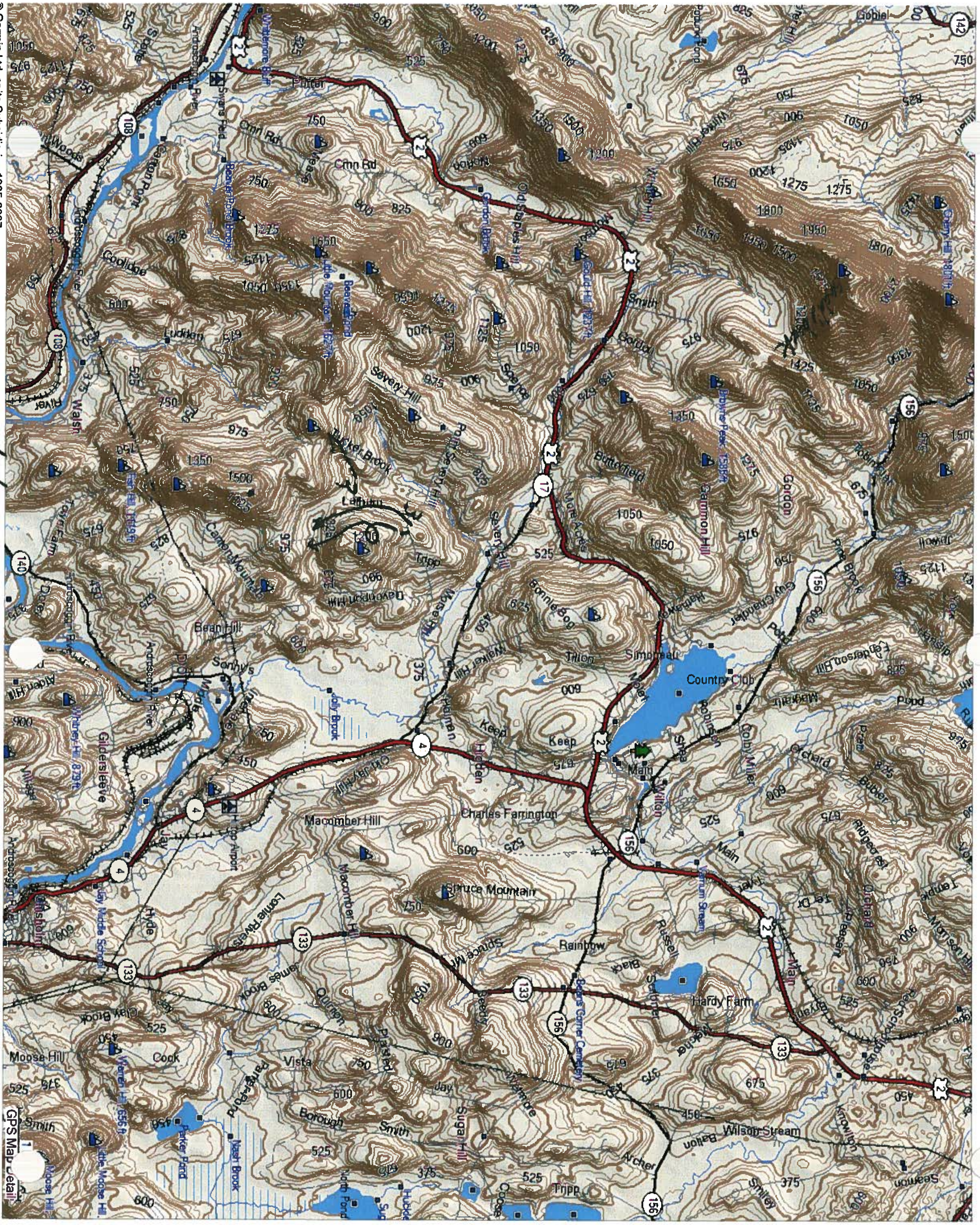
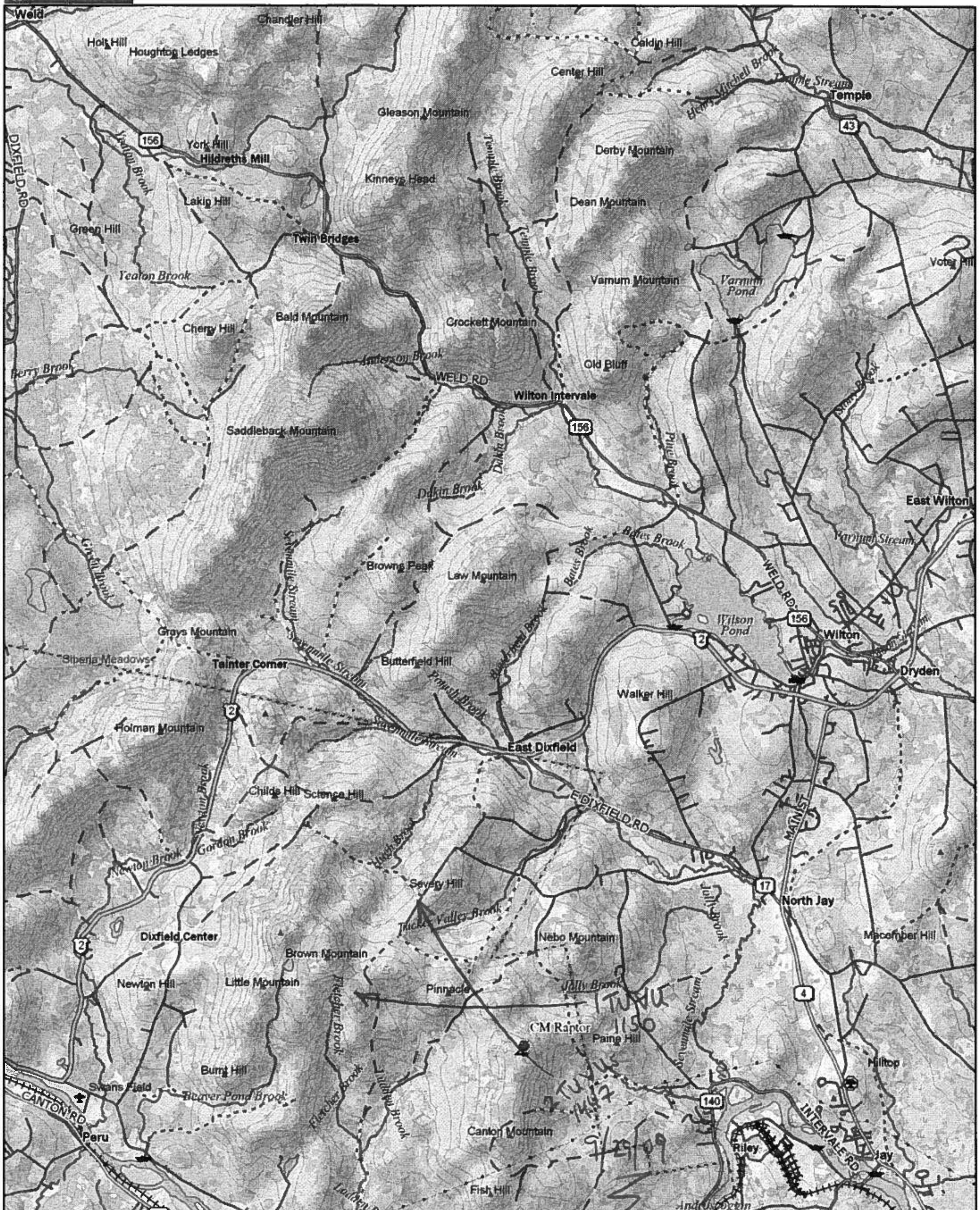
TN
MN (16.1°W)
9/20/10
Scale 1 : 100,000
1" = 1.58 mi
Data Zoom 11-0



Potter
Cmn Rd
Coolidge
Seven Hill
Tucker Brook
Lambert
Davenport Hill
Bean Hill
Sonny's
Jolly Brook
Holman
Keep
Charles Farrington
Macomber Hill
Spruce Mountain
Rainbow
Hardy Farm
Country Club
Simoneau
Main
Tilton
Bonnie Bog
Butterfield
Gammon Hill
Gordon
Smith
Gould Hill
Old Staples Hill
Wilson Stream
Archer
Tripp
Vista
Jay
Sugar Hill
Borough
Parker Pond
Moose Hill
Cook
Orchard
Temple
Bubier
Wheeler Hill
Knowlton
Seamon
Ballou
Hyde
Whitney Hill
Gilderslieve
Bragg
GPS Map Detail

9/2B-8

DELORME



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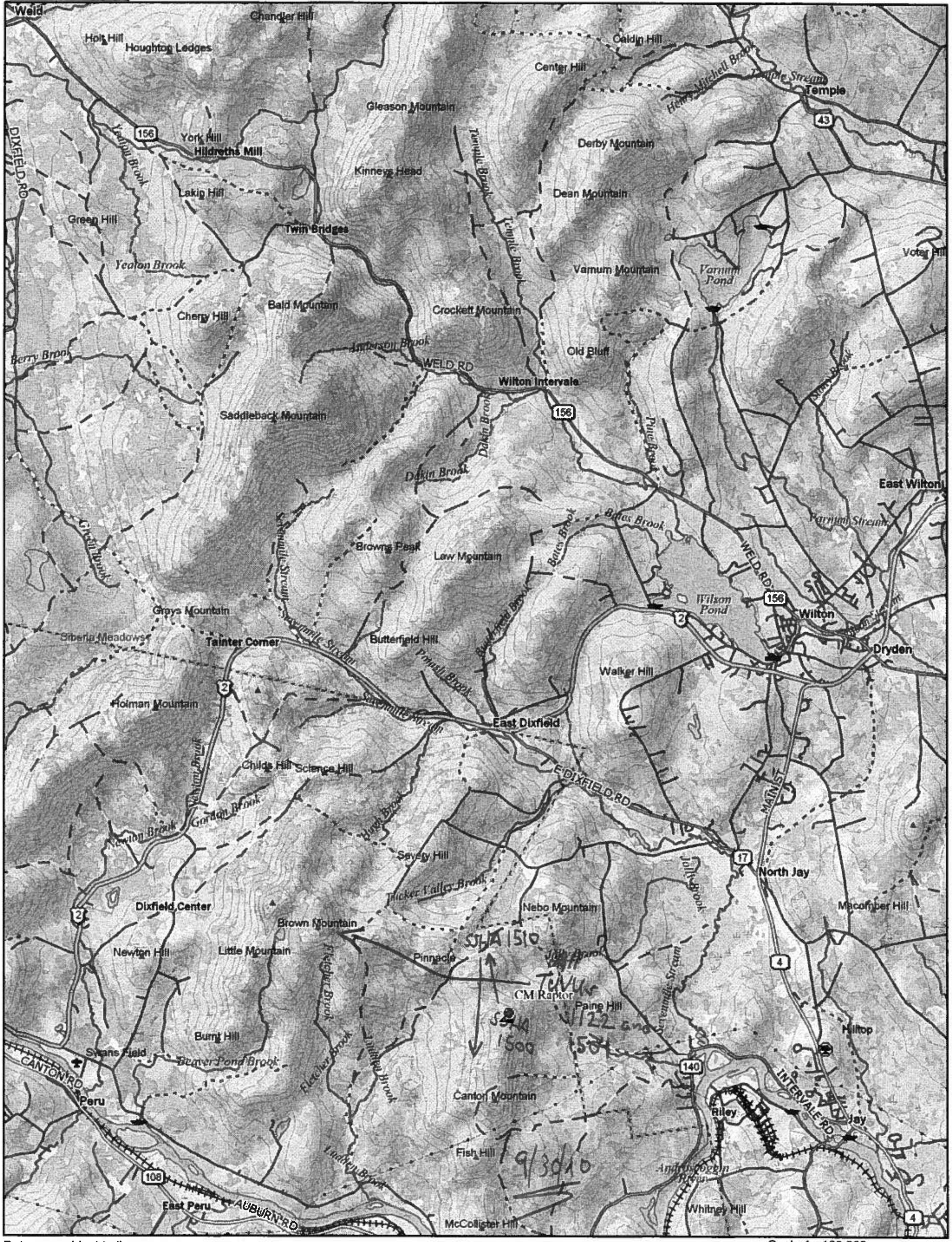
MN (16.1°W) TN

Scale 1 : 100,000

1" = 1.58 mi Data Zoom 11-0

9/29



TN

MN (16.1°W)

Scale 1 : 100,000

1" = 1.58 mi

Data Zoom 11-0

9/30

Timberwinds Project, Canton ME 10/5/10

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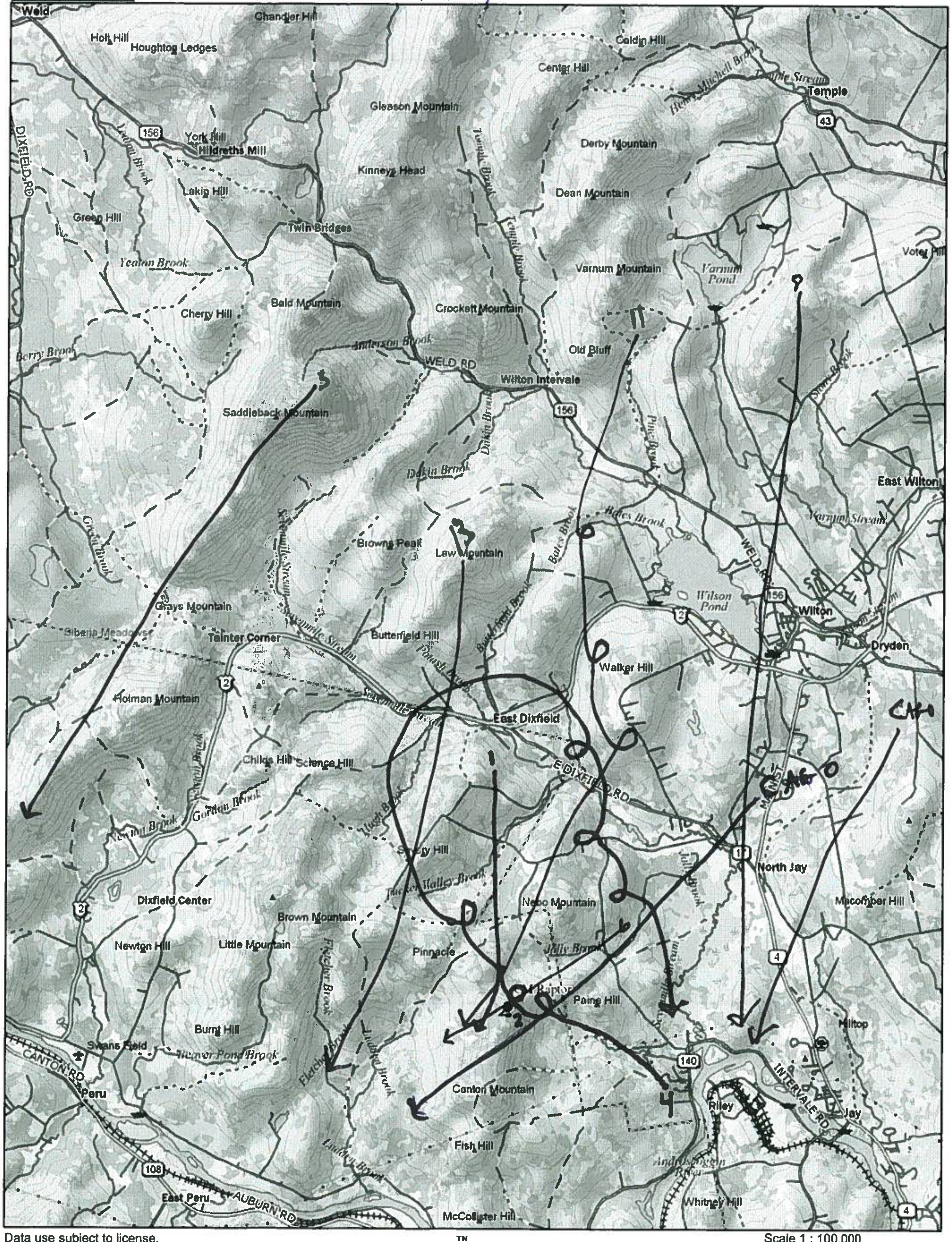

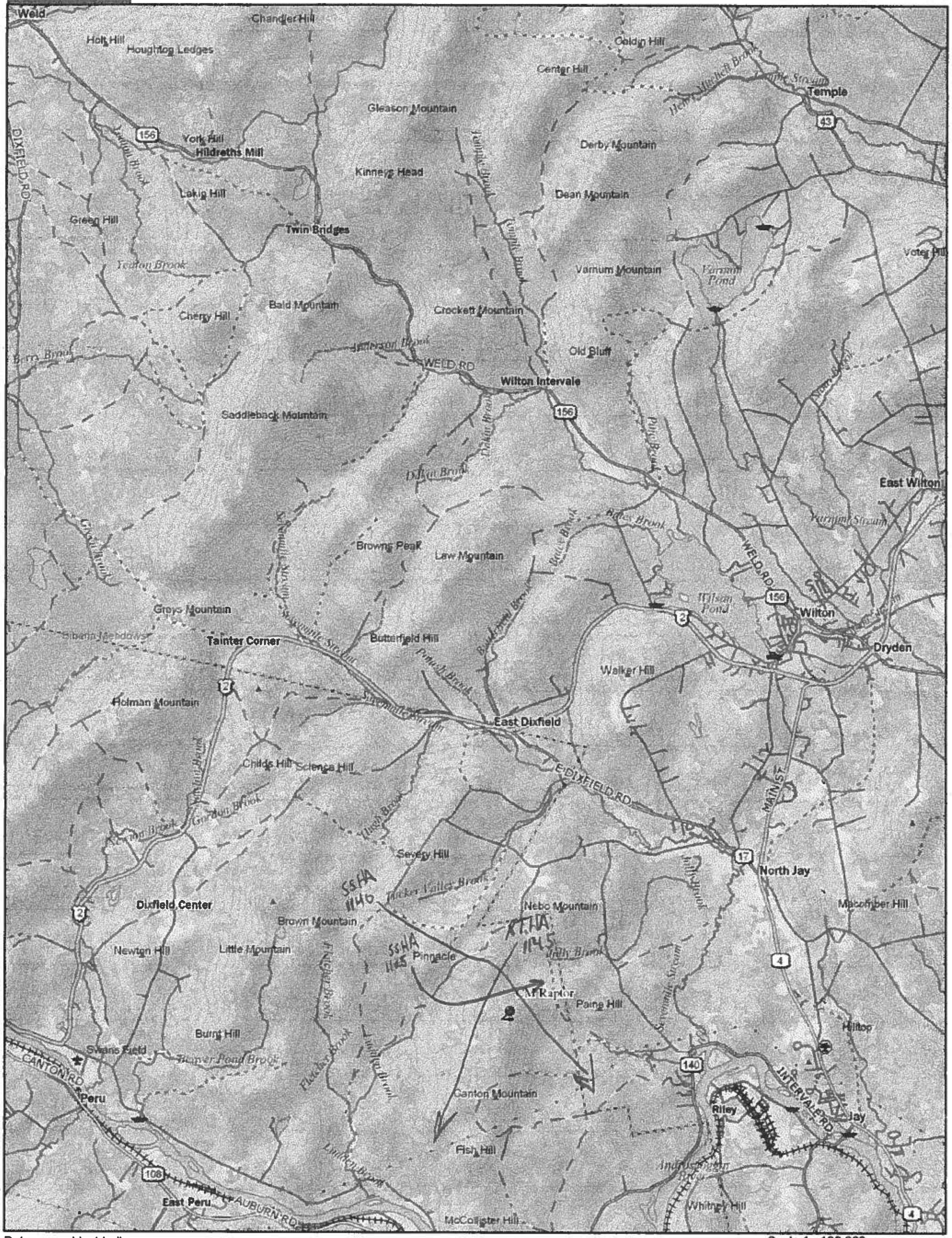

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TN
MN (15.1°W)

Scale 1 : 100,000

1" = 1.58 mi

Data Zoom 11-0

10/13

APPENDIX C

Migrant Stopover Survey Data

Appendix C Table 1. Summary of migrant stopover surveys by point at Canton Mountain Wind Project, Fall 2010												
Species	CM-1	CM-2	CM-3	CM-4	CM-5	CM-6	CM-7	CM-8	CM-9	CM-10	Grand Total	Frequency
American Crow	2	2	3	2	1		1				11	60%
American Goldfinch	1	1							4		6	30%
American Redstart		1									1	10%
American Robin	6	2		3				3	1		15	50%
American Woodcock	2	1	1								4	30%
Black-and-White Warbler		1	3	2		1			1		8	50%
Blackburnian Warbler						1		1			2	20%
Black-capped Chickadee	10	7	5	14	6	25	11	2	10	9	99	100%
Black-throated Blue Warbler		2	1	1	2	1		1	1		9	70%
Black-throated Green Warbler	1		1							2	4	30%
Blue Jay	9	7	16	5	11	4	2	4	9	4	71	100%
Blue-headed Vireo	3	2		1		3	2	5	1		17	70%
Brown Creeper							1				1	10%
Canada Goose		2									2	10%
Cape May Warbler							1				1	10%
Cedar Waxwing					6		1				7	20%
Chestnut-sided Warbler		1						1		1	3	30%
Common Raven	2				7	4		1	1	7	22	60%
Common Yellowthroat	7	4	1	2							14	40%
Cooper's Hawk					2						2	10%
Dark-eyed Junco	5	5	2	7	5	3	8	8	11	21	75	100%
Downy Woodpecker			2	1	1		2	1	1		8	60%
Eastern Wood-Pewee	1					1					2	20%
Golden-crowned Kinglet	1			1	4	17	6	2	2		33	70%
Hairy Woodpecker	1				1			1			3	30%
Hermit Thrush			2						2	1	5	30%
Magnolia Warbler					2	2	1				5	30%
Mourning Dove		1		4						2	7	30%
Myrtle Warbler	2	1	1	3	3		2	4			16	70%
Nashville Warbler		1	1				2	3	1		8	50%
Northern Flicker	4	4	2	2	1	1		1		2	17	80%
Northern Parula		1								1	2	20%
Ovenbird	1		3	2	1			2	2	1	12	70%
Pine Warbler		4									4	10%
Red-breasted Nuthatch	1	1		2	2	2		3	2	1	14	80%
Red-breasted Sapsucker	1										1	10%
Red-eyed Vireo	2	1	1	2							6	40%
Rose-breasted Grosbeak	1	1									2	20%
Ruby-crowned Kinglet	1	3	1			4	6	2	1		18	70%
Ruby-throated Hummingbird			1						1		2	20%
Ruffed Grouse				2	1	1				6	10	40%
Swainson's Thrush	1		2	2	1	2	7	3	1	3	22	90%
Unidentified Warbler		1	1			1			1	4	8	50%
White-breasted Nuthatch	1		2		1	4	2		2	1	13	70%
White-throated Sparrow	18	5	9	8	4	2	1	9	14	11	81	100%
Wild Turkey	3	8									11	20%
Wilson's Warbler	1										1	10%
Winter Wren	1			1							2	20%
Yellow-bellied Sapsucker				1	1	2	2		2		8	50%
Yellow-rumped warbler	2	3		3		2	4	5	1	2	22	80%
Grand Total	91	73	61	71	63	83	62	62	72	79	717	
Species Richness	29	28	22	23	21	21	19	21	23	18	50	

Appendix C Table 2. Summary of migrant stopover surveys by date at Canton Mountain Wind Project, Fall 2010

Species	9/1/10	9/2/10	9/10/10	9/17/10	9/19/10	9/21/10	9/23/10	9/29/10	9/30/10	10/4/10	10/13/10	Grand Total	Relative Abundance	Frequency
American Crow				2	3	1	1			4		11	1.00	45%
American Goldfinch						1	5					6	0.55	18%
American Redstart						1						1	0.09	9%
American Robin		2	2	6	4					1		15	1.36	45%
American Woodcock			1	1		2						4	0.36	27%
Black-and-White Warbler	2	2		4								8	0.73	27%
Blackburnian Warbler	1	1										2	0.18	18%
Black-capped Chickadee	2	2	4	23	12	8	6	11	7	20	4	99	9.00	100%
Black-throated Blue Warbler	4	1		1				2	1			9	0.82	45%
Black-throated Green Warbler		1		3								4	0.36	18%
Blue Jay	6	5	6	12	5	6	5	8	6	11	1	71	6.45	100%
Blue-headed Vireo	1			9	2	1	1		3			17	1.55	55%
Brown Creeper							1					1	0.09	9%
Canada Goose										2		2	0.18	9%
Cape May Warbler							1					1	0.09	9%
Cedar Waxwing				6			1					7	0.64	18%
Chestnut-sided Warbler		1	1			1						3	0.27	27%
Common Raven		1	2	9	4	2		2	1	1		22	2.00	73%
Common Yellowthroat		1	3			1	3	3	3			14	1.27	55%
Cooper's Hawk			2									2	0.18	9%
Dark-eyed Junco			1	19	18	10	3	5	6	13		75	6.82	73%
Downy Woodpecker	1	2		1	1			2	1			8	0.73	55%
Eastern Wood-Pewee		1			1							2	0.18	18%
Golden-crowned Kinglet	1	1	2	2	2	3	3	5	5	3	6	33	3.00	100%
Hairy Woodpecker		1				1		1				3	0.27	27%
Hermit Thrush	1	1		1	1				1			5	0.45	45%
Magnolia Warbler		1						3	1			5	0.45	27%
Mourning Dove	1	1		3				2				7	0.64	36%
Myrtle Warbler		3						2	11			16	1.45	27%
Nashville Warbler	3	1	2	1		1						8	0.73	45%
Northern Flicker			1	4	5	2	4			1		17	1.55	55%
Northern Parula			2									2	0.18	9%
Ovenbird	3	7		1		1						12	1.09	36%
Pine Warbler						4						4	0.36	9%
Red-breasted Nuthatch	1	2	1	4	2		1	2		1		14	1.27	73%
Red-breasted Sapsucker				1								1	0.09	9%
Red-eyed Vireo	4			2								6	0.55	18%
Rose-breasted Grosbeak	1			1								2	0.18	18%
Ruby-crowned Kinglet	3							4	10	1		18	1.64	36%
Ruby-throated Hummingbird	1		1									2	0.18	18%
Ruffed Grouse			2		2	4	2					10	0.91	36%
Swainson's Thrush				4	2			4	2	2	8	22	2.00	55%
Unidentified Warbler					3		1			4		8	0.73	27%
White-breasted Nuthatch	2			1			1	5	3		1	13	1.18	55%
White-throated Sparrow	1	1		17	19		6	13	18	3	3	81	7.36	82%
Wild Turkey			4			3				4		11	1.00	27%
Wilson's Warbler		1										1	0.09	9%
Winter Wren										2		2	0.18	9%
Yellow-bellied Sapsucker		2		1	2			1		2		8	0.73	45%
Yellow-rumped warbler				7	2		6			7		22	2.00	36%
Grand Total	39	42	37	146	90	53	51	75	79	82	23	717	65.18	
Species Richness	19	24	17	28	19	19	18	18	16	18	6	50		