PATRIOT RENEWABLES
Canton Mountain Wind, LLC

Attachment 7-2
Spring 2010 Bird and Bat Biological Survey Report

Spring 2010 – Bird and Bat Biological Survey Report

Canton Mountain Wind Project

Canton, Maine

Prepared for:

PATRIOT RENEWABLES

By:

Tetra Tech, Inc.
451 Presumpscot St.
Portland, Maine 04103

August 2010

TABLE OF CONTENTS

EXECUTIVE SUMMARY ES-1
1.0 INTRODUCTION 1-1
2.0 AVIAN RADAR STUDY 2-1
3.0 RAPTOR MIGRATION STUDY 3-1
4.0 MIGRANT STOPOVER STUDY 4-1
5.0 BAT ACOUSTIC SURVEY 5-1
6.0 BREEDING BIRD SURVEYS 6-1
7.0 REFERENCES 7-1

LIST OF FIGURES

Figure 1-0. Canton Mountain Project Area location map. 1-2
Figure 2-0. Canton Moutain avian radar unit, spring 2010. 2-1
Figure 3-0. Raptor survey location at Canton Mountain, spring 2010. 3-2
Figure 3-1. View from the raptor survey location at Canton Mountain, spring 2010. 3-3
Figure 4-0. Migrant stopover survey locations at Canton Mountain, spring 2010. 4-2
Figure 4-1. Species richness and total number of individuals detected by point-count location during migrant stopover surveys at Canton Mountain, spring 2010. 4-4
Figure 4-2. Species richness and total number of individuals detected by point-count location during migrant stopover surveys at Canton Mountain, spring 2010 4-4
Figure 5-0. Bat detector locations at Canton Mountain, spring 2010. 5-2
Figure 5-1. Location of the Radar Detector at the Project Area, spring 2010. 5-3
Figure 5-2. Location of the Stake Detector at the Project Area, spring 2010. 5-3
Figure 5-3. Total number of bat call sequences (*n* = 90) recorded per night by the Radar Detector at the Project Area, April 14 to May 31, 2010. 5-7
Figure 5-4. Total number of bat call sequences (*n* = 71) recorded per night by the Stake Detector at the Project Area, April 14 to May 31, 2010. 5-8
Figure 5-5. Total number of bat call sequences (*n* = 90) recorded per hour by the Radar Detector at the Project Area, April 14 to May 31, 2010. 5-9
Figure 5-6. Total number of bat call sequences (*n* = 71) recorded per hour by the Stake Detector at the Project Area, April 14 to May 31, 2010. 5-10
Figure 6-0. Breeding bird survey locations at Canton Mountain, spring 2010. 6-2

LIST OF TABLES

Table 3-0. Daily summary of migrating raptors at Canton Mountain, spring 2010. 3-5

Table 3-1. Hourly summary of migrating raptors at Canton Mountain, spring 2010. 3-5

Table 3-2. Flight locations of migrating raptors at Canton Mountain, spring 2010. 3-6

Table 3-3. Flight locations and minimum flight height of migrating raptors at Canton Mountain, spring 2010.....3-6

Table 3-4. Flight locations and minimum flight height of migrating raptors at Canton Mountain, spring 2010.....3-7

Table 3-5. Flight heights of migrating raptors at Canton Mountain, spring 2010.....3-7

Table 4-0. Summary of migrant stopover surveys at Canton Mountain, spring 2010.....4-3

Table 5-0. Summary of acoustic monitoring survey effort by detector at the Project Area, April14 to May 31, 2010. 5-5

Table 5-1. Summary of bat call sequences and probable species recorded at the Project Area, July 15 to May 31, 2010.....5-6

Table 6-0. Summary of breeding bird surveys at Canton Mountain, spring 2010. 6-3

Table 6-1. Summary of breeding bird surveys by date at Canton Mountain, spring 2010.....6-3

APPENDICES

Appendix A. Avian radar survey data and report

Appendix B. Raptor survey data

Appendix C. Migrant stopover survey data

Appendix D. Breeding bird survey data

EXECUTIVE SUMMARY

During spring 2010, Tetra Tech, Inc. (Tetra Tech) conducted field surveys to document avian and bat activity at the Canton Mountain Wind Project (Project Area) in Canton, Maine. The surveys were initiated by Patriot Renewables, LLC as part of the planning and permitting process for proposed wind energy development on Canton Mountain. The spring 2010 surveys were the first of the two migratory seasons to be sampled during the overall study. Spring surveys included an avian radar survey, visual raptor migration survey, migrant stopover survey, breeding bird survey, and bat acoustic 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. The spring 2010 surveys also help to create a baseline dataset for comparison with any post-construction surveys at the Project Area.

Avian Radar Study

Radar data was collected across a 35-day/night window from April 20 – May 23, 2010 at the proposed Canton Mountain Wind Project. The MERLIN avian radar system uses horizontal and vertical radars simultaneously to automatically and continuously record bird and bat activity in the vicinity of the proposed project. The Vertical Surveillance Radar (VSR) data provides both count and altitude information on biological targets, while the Horizontal Surveillance Radar (HSR) provides target directions. Biological targets include bats and large insects as well as birds, and individual targets can be counted more than once if they fly in and out of the radar beam. Nights were defined as 45 minutes before sunset to 45 minutes after sunrise and days consisted of the remaining time period.

During spring sampling period nightly target passage rates were variable, ranging from 3.4 to 3,198.8 targets / km / hr, with a nightly average of 627.6 targets / km / hr. The majority of all targets (71.6%) detected during nights of spring migration were above the top of rotor swept zone (RSZ) of the proposed turbine (rotor swept zone 36 – 130 m above ground level (AGL). Nightly target passage rates averaged 452.4 targets / km / hr above the RSZ, and only 122.3 and 52.9 targets / km / hr within and below the RSZ respectively.

The vertical beam (calculation of passage rates and flight heights) collected information on biological targets from both the ridge and western side-slope airspace. The average mean target height over all nights of spring migration 2010 was 217.2 m (range 106.8 – 388.4 m) and the average median height was 157.8 m (range 46.3 – 354.1 m). Radar studies have shown that birds flying over valleys and side slopes may fly at lower elevations than birds flying directly over ridges. This may be one reason why flight heights are a little lower at Canton Mountain than other radar studies in Maine. As would be expected during spring migration, 90.3% of nights had target movements predominantly in the northeast direction.

Raptor Migration Study

During spring 2010, raptor surveys were conducted for 10 days between April 15 and May 15 for a total of 60 hours of survey. A total of 112 raptors, representing 8 species, were observed and recorded. This produced an overall observation rate of 1.87 birds/hr. Daily count totals ranged from 0 to 51 birds (Table 3-0). The highest count of raptors (51 observations) was recorded on April 21, 2010; temperatures were between 14°C and 18°C (57°F and 65°F) with

light west winds in the morning and then a shift to west-southwest winds in the afternoon. The lowest count (0 observations) occurred on May 12, 2010, with winds mostly from the northwest and temperatures between 8°C and 16°C (46°F and 60°F). The Project Area had relatively low passage rates when compared to data from Bradbury Mountain hawk watch.

Broad-winged hawks (*Buteo platypterus*) (*n* = 48) and turkey vultures (*Cathartes aura*) (*n* = 26) were the most common species observed. Red-tailed hawks (*Buteo jamaicensis*) (*n* = 10) and sharp-shinned hawks (*Accipiter striatus*) (*n* = 7) were the next most abundant species. The remaining four species were observed five or fewer times, per species. No federally or state listed endangered, threatened, or rare raptor species were observed at Canton Mountain during raptor migration surveys.

Raptor flight paths were generally northbound but varied in location from survey to survey, with observations of raptors moving north along the western 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 meters (m).

Migrant Stopover Study

During spring 2010, Tetra Tech biologists conducted standardized migrant stopover surveys along a single transect on Canton Mountain to determine the number and species of migrant stopover birds. During the spring migration season, each point was sampled on 10 different days. Points were chosen for their elevation gradients and representative habitat types. All birds that were visually or audibly detected at each survey point were recorded during 5-minute sampling periods. Survey points were distributed across varying elevations and targeted two major habitat types: mixed deciduous hardwood and mixed spruce and fir. A total of 728 individual birds were documented, representing 48 species. Overall relative abundance was 66.18 birds/survey. Seven avian species of special concern were documented including American redstart (*Setophaga ruticilla*), black-and-white warbler (*Mniotilta varia*), chestnut-sided warbler (*Dendroica pensylvanica*), evening grosbeak (*Coccothraustes vespertinus),* white-throated sparrow (*Zonotrichia albicollis*), wood thrush (*Hylocichla mustelina) and* yellow warbler (*Dendroica petechia*). No federally listed threatened or endangered species were documented.

Bat Acoustic Study

Bat acoustic detectors (Anabat SD-1) were deployed from April 14, 2010 to May 31, 2010 at two different locations within the Project Area. The 'Radar Detector' was suspended from the base of the avian radar unit and the 'Stake Detector' was deployed in a small clearing near the ridgeline, north of the Radar Detector. A total of 161 bat call sequences representing four bat species were recorded during the spring 2010 monitoring period. The monitoring effort for this 48-night period resulted in 88 detector-nights (number of detectors multiplied by the number of nights deployed) of recordings. Detectors monitored bat echolocation calls for approximately 12 hours per night, resulting in a total of 1,056 detector-hours. The Radar Detector had the highest rate of detection (1.9 call sequences/night) followed by the Stake Detector (1.8 call sequences/night). The Radar Detector and Stake Detector recordings may represent the same bat.

The majority (86 percent) of call sequences (*n* = 147) recorded were identified as *Myotis* species, and consisted primarily of northern myotis (*Myotis septentrionalis*) and some little brown myotis (*Myotis lucifugus)* call sequences. Three Maine state-listed species of special

concern were documented during the survey period: eastern red bat (*Lasiurus borealis*), silver-haired bat (*Lasionycteris noctivagans*), and hoary bat (*Lasiurus cinereus*). A minority of calls (4 percent) were categorized as silver-haired bat (*n* = 7) and eastern red bat (*n* = 1). A total of four hoary bat call sequences were recorded during the spring survey period. No calls of federally listed bat species were identified during the survey.

Breeding Bird Survey

Tetra Tech biologists conducted standardized surveys along one transect with 10 survey points during the 2010 breeding season. During the breeding bird survey, each point was sampled on three different days. The points were chosen for their elevation gradient and representative habitat types. A total of 262 birds representing 47 species were documented during the 2010 breeding bird surveys on Canton Mountain. The ovenbird was the most abundant species observed, followed by red-eyed vireo (*Vireo olivaceus)*, black-and-white warbler, black-throated green warbler (*Dendroica virens*), hermit thrush, and chestnut-sided warbler. No federally listed threatened or endangered species were observed during the 2010 breeding bird surveys at Canton Mountain. Five species of special concern were observed: American redstart, black-and-white warbler, chestnut-sided warbler, white-throated sparrow, and wood thrush. These birds represented about 19 percent of all birds observed.

1.0 INTRODUCTION

1.1 Project Overview

Patriot Renewables, LLC (Patriot) is proposing to develop a wind energy facility in northern Oxford County, Maine (Figure 1-0). The proposed wind project location is on Canton Mountain in the Town of Canton, Maine. To-date, Patriot has conducted an evaluation of site characteristics including existing habitat types, geology, physical constraints, and information on logistical considerations. The following bird and bat report presents baseline biological data collected during the spring 2010 migration season and summer breeding season. Specific data collection efforts during the fall season included an avian radar study; raptor migration survey; migrant stopover surveys; breeding bird survey, and a bat acoustic survey.

1.2 Project Area Description

The Canton Wind project is located in Oxford County in the western mountains of Maine (Project Area). The Project Area is located 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 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) (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 steep slopes with elevations from approximately 182 m to 547 m (600 ft to 1,500 ft) above sea level.

1.3 Goals and Objectives

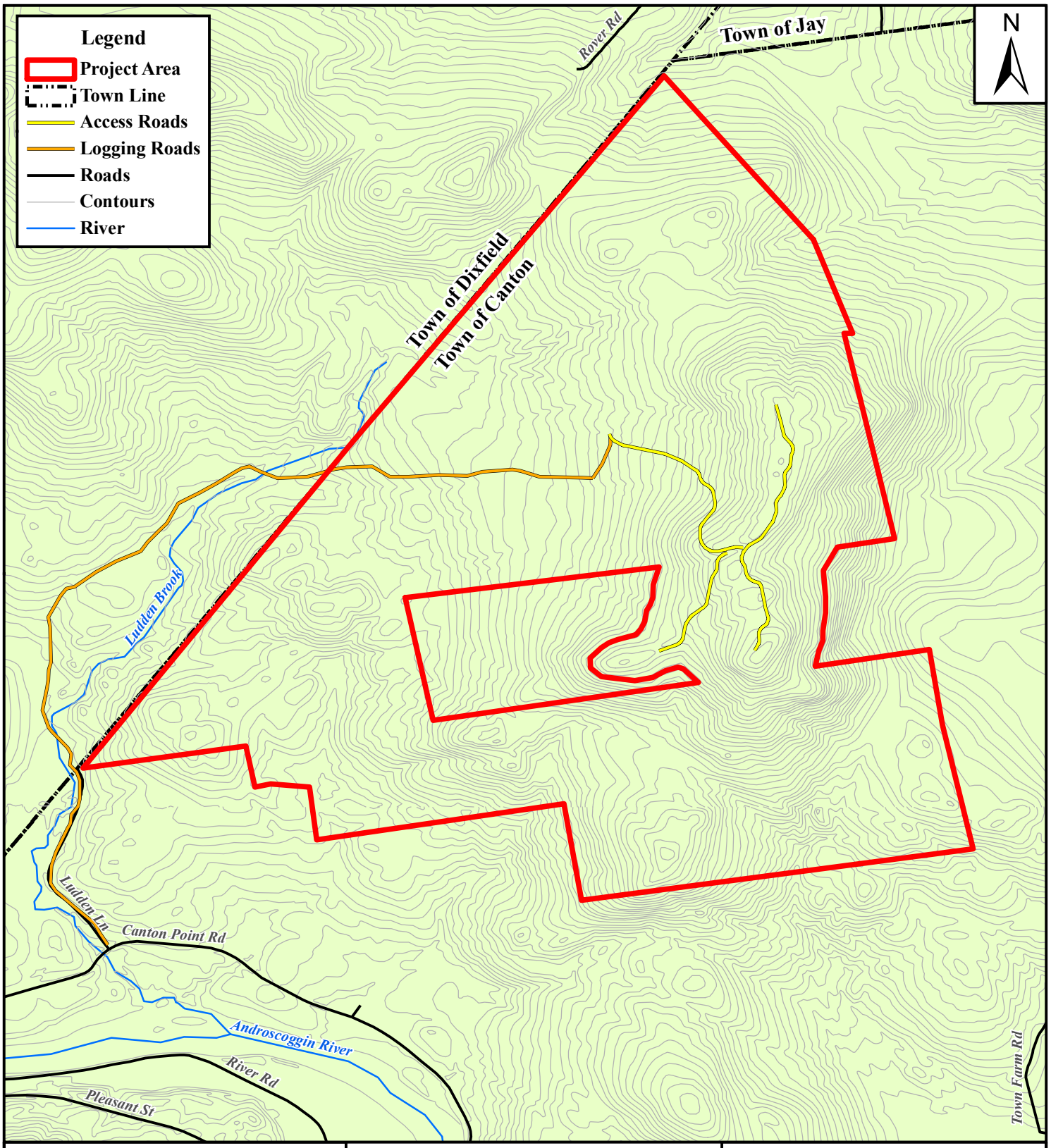
The goal of the field studies was to identify the spatial and temporal use of the Project Area by birds and bats during spring 2010. Objectives for the avian survey were to:

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 rotor swept zone 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) identif y the breeding birds in the Project Area.

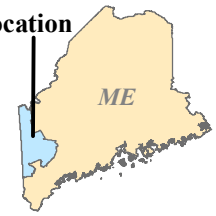
Objectives for the bat survey were to:

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, we used a rotor swept zone of 36–130 m (118–427 ft); this may change slightly depending on the turbine model selected.



Project Location



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

0 1,250 2,500 5,000 Feet

0 300 600 1,200 Meters

Figure 1-0 Canton Mountain Wind Project, Canton, Maine.

Prepared For: PATRIOT RENEWABLES

Prepared By: TETRA TECH

Date: 07/10

P:GIS/Projects/Canton/MXD/Figure1_0.mxd

2.0 AVIAN RADAR STUDY

2.1 Introduction

Tetra Tech, in conjunction with DeTect, Inc., conducted a spring avian radar migration survey for 35 days and nights of near continuous operation from April 20 to May 23, 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 side slope below the Canton Mountain ridge proper (Appendix A). 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.

Results 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 rotor swept zone of 36 to 130 m (118 to 427 ft), the percentage of targets flying below, within, and above the rotor swept zone were 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 Moutain avian radar unit, spring 2010.

3.0 RAPTOR MIGRATION STUDY

3.1 Introduction

Raptor migration can be influenced by topography, geography, weather, and season. Raptors are known to use ridgelines and particularly warm air updrafts (thermals) as their main source of lift during migration in temperate latitudes (Brandes and Ombalski 2004). The Canton Mountain raptor migration surveys were initiated to document the presence of migrating raptors through the proposed Project Area during the spring 2010 migration season. A standardized protocol was used to collect data on multiple aspects of each observed raptor in flight.

This section summarizes observations and results of raptor migration activity at Canton Mountain during the spring 2010 raptor migration season. Data on seasonal timing, species, flight height, flight location, and flight type are presented and discussed. Additionally, data from Canton Mountain are compared with other local raptor migration counts in order to gain a greater regional perspective.

3.2 Methods

Tetra Tech biologists conducted standardized visual counts of migrating raptors from one survey location (Figure 3-0) on the western side slope of Canton Mountain that provided views of the ridge, western side slopes, and valleys to the south, west, and north (Figure 3-1). The view to the east was limited and was obscured by a heavily wooded ridge. The elevation of the observation point is approximately 457 m (1,500 ft). Surveys were conducted on 10 days from approximately 09:00 hours to 15:00 hours Eastern Daylight Time (EDT) within the recommended sampling window of mid-April to mid-May 2010. This time period was targeted in order 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.

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

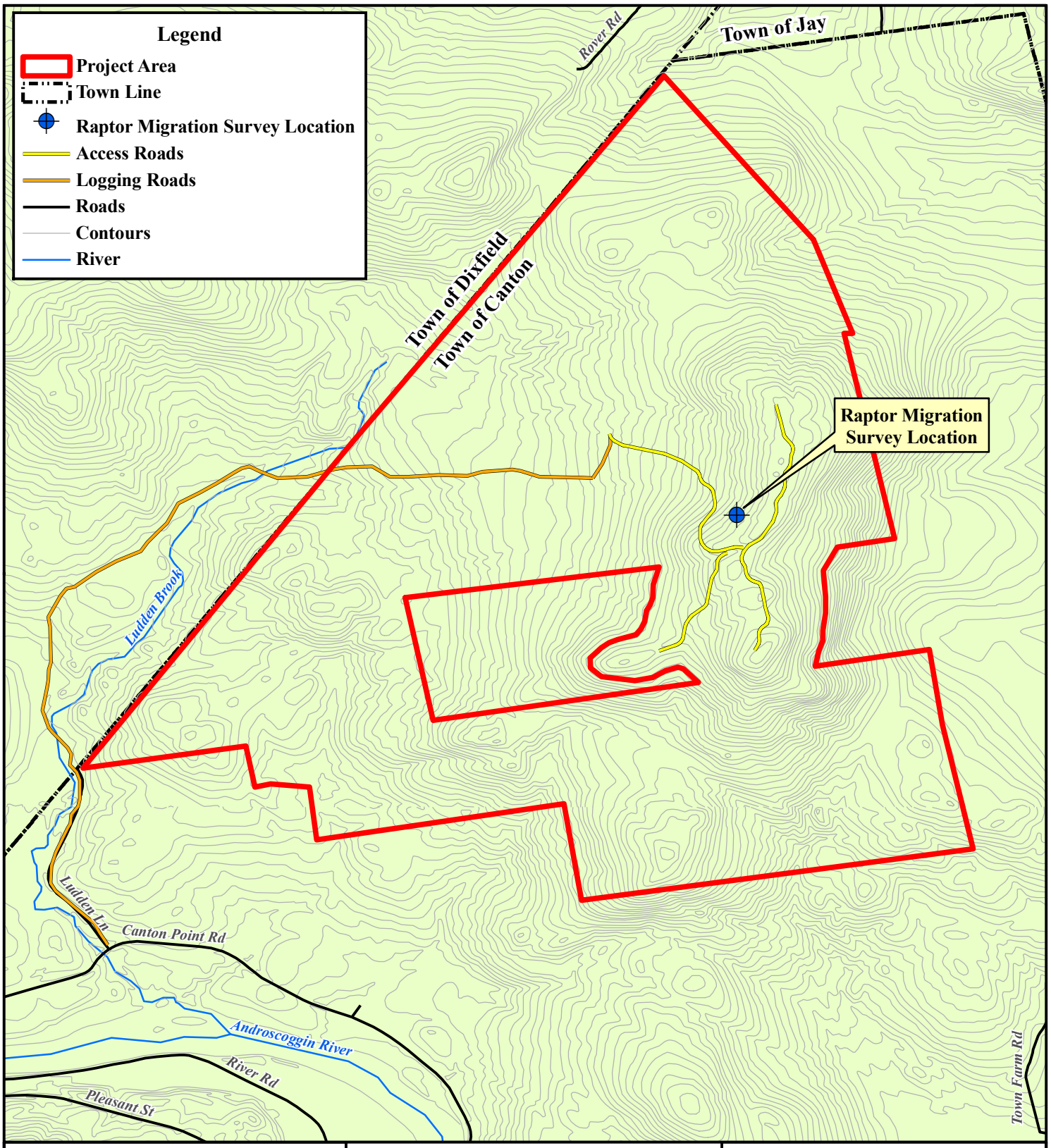
1) Species and number of birds. Age and sex were recorded when determination was possible.

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

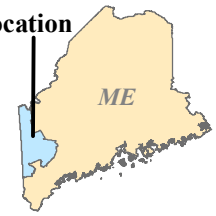
3) Weather data for each hour of observation, including wind speed and direction, air temperature, percent cloud cover, precipitation, and visibility.

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

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



Project Location



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

0 1,250 2,500 5,000 Feet

0 300 600 1,200 Meters

Figure 3-0 Raptor Migration Survey Location at Canton Mountain Wind Project-Spring 2010

Prepared For: PATRIOT RENEWABLES

Prepared By: TETRA TECH

Date: 07/10

P:GIS/Projects/Canton/MXD/Figure3_0.mxd

Figure 3-1. View from the raptor survey location at Canton Mountain, spring 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 and followed methodology used by the Hawk Migration Association of North America (HMANA) (HMANA 2005).

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

7 = no predominant height

Flight type was recorded as either 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 northerly 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 (below wind turbine rotor swept zone), 36−130 m (within rotor swept zone), and greater than 130 m (above rotor swept zone). Flight heights were visually estimated after training with a laser range finder.

Survey results including the total counts and passage rates from the 2010 spring raptor migration surveys at Canton Mountain were compared to results from surveys conducted on the same days at Bradbury Mountain State Park in Pownal, Maine. Bradbury Mountain is an isolated hill at an elevation of 148 m (485 ft) above sea level that rises from the coastal plain approximately 69 km (43 mi) south of Canton Mountain. Organized spring migration raptor counts have been conducted at Bradbury Mountain for the last seven years (2004−2010).

3.3 Results

Total survey effort included 60 hours of direct, visual observation during 10 days between April 15 and May 13, 2010. A total of 112 migrating raptors, representing 8 species, were observed and recorded (Table 3-0). This produced an overall observation rate of 1.87 birds/hr. Daily count totals ranged from 0 to 51 birds (Table 3-0). The highest count of raptors (51 observations) was recorded on April 21, 2010, with temperatures between 14°C and 18°C (57°F and 65°F) and light west winds in the morning and that shifted to west-southwest winds in the afternoon. The lowest counts (0 observations) occurred on May 12, 2010, with winds mostly from the northwest and temperatures between 8°C and 16°C (46°F and 60°F).

Table 3-0. Daily summary of migrating raptors at Canton Mountain, spring 2010.

Species	4/15/10	4/21/10	4/30/10	5/1/10	5/4/10	5/5/10	5/7/10	5/11/10	5/12/10	5/13/10	Grand Total
American kestrel		1	1								2
Broad-winged hawk	1	26	10	10			1				48
Cooper's hawk		4	1								5
Northern goshawk			3								3
Osprey		1	4			1					6
Red-tailed hawk		4	2	2			1	1			10
Sharp-shinned hawk		3	1	1		1	1				7
Turkey vulture	4	11	2	5		1		2		1	26
Unidentified buteo				1							1
Unidentified falcon				1							1
Unidentified raptor		1	2								3
Daily Total	5	51	26	20	0	3	3	3	0	1	112
Survey Effort (hrs)	5	7	6	6	6	6	6	6	6	6	60
Raptors/Hour	1.00	7.29	4.33	3.33	0.00	0.50	0.50	0.50	0.00	0.17	1.87

Broad-winged hawks (*Buteo platypterus*) (*n* = 48) and turkey vultures (*Cathartes aura*) (*n* = 26) were the most common species observed. Red-tailed hawks (*Buteo jamaicensis*) (*n* = 10) and sharp-shinned hawks (*Accipiter striatus*) (*n* = 7) were the next-most abundant species. The remaining four species had 6 or fewer observations per species. No federally or state-listed endangered, threatened, or rare raptor species were observed at Canton Mountain during raptor migration surveys.

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 (09:00 to 10:00) then increased until 12:00 to 13:00 where a lull of activity was recorded. After 13:00, observations increased again and the majority of migrating raptors (*n* = 28) were observed between the hours of 14:00 to 15:00. This coincides with the time of day when stronger thermals, providing optimal flight conditions for migrating raptors, are likely to occur.

Table 3-1. Hourly summary of migrating raptors at Canton Mountain, spring 2010.

Species	09:00–10:00	10:00–11:00	11:00–12:00	12:00–13:00	13:00–14:00	14:00–15:00	15:00–16:00	16:00–17:00	Grand Total
American kestrel		1				1			2
Broad-winged hawk	2	4	6		8	17	3	8	48
Cooper's hawk				2	1	1	1		5
Northern goshawk			1	1	1				3
Osprey	1	3		1		1			6
Red-tailed hawk	1	1		3	3	2			10
Sharp-shinned hawk			4		1			2	7
Turkey vulture	3	9	4	4		6			26
Unidentified buteo		1							1
Unidentified falcon					1				1
Unidentified raptor			2		1				3
Survey Effort (hrs)	8.5	9.5	10	10	10	10	1	1	60
Grand Total	7	19	17	11	16	28	4	10	112

The weather during the spring 2010 survey season was generally dry with high pressure systems. Temperatures ranged from 8°C to 23°C (46°F to 73°F). Winds were not often optimal, with a prevailing northwest wind for most of the surveys.

Flight locations varied between observations, but the majority of observations recorded were of migrants flying along the ridge, western side slopes, and valley (*n* = 29). The second-most common observation was raptor flights in the valleys (*n* = 27) (Table 3-2). 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 location changes were documented with detailed notes. Flight paths were hand drawn on topographic maps (Appendix B).

Table 3-2. Flight locations of migrating raptors at Canton Mountain, spring 2010.

Species	Valley	Ridge	Side slope	Valley, ridge, side slope	Valley, side slope	Ridge, side slope	Grand Total
American kestrel		1	1				2
Broad-winged hawk	12	11	3	13	1	8	48
Cooper's hawk	1	1	2	1			5
Northern goshawk			1			2	3
Osprey			2	1	1	2	6
Red-tailed hawk	3	1	1	5			10
Sharp-shinned hawk	1	4	1			1	7
Turkey vulture	7	1	6	8	3	1	26
Unidentified buteo	1						1
Unidentified falcon	1						1
Unidentified raptor	1		1	1			3
Grand Total	27	19	18	29	5	14	112

Approximately 55 percent of the migrating raptors (n = 62) flew over the ridge at one point during their northern flight. Of those raptors, only 19 were observed strictly flying along the ridge. Table 3-3 and Table 3-4 provide a breakdown of location and flight height. Of the 62 birds that flew over the ridge, only 16 (25%) of these migrating raptors had a minimum flight height within the rotor-swept zone (Figure 3-3).

Table 3-3. Flight locations and minimum flight height of migrating raptors at Canton Mountain, spring 2010.

Maximum Flight Heights	Valley only	Ridge only	Side slope only	Valley, ridge, side slope	Valley, side slope	Ridge, side slope	Grand Total
0-35m	1	3	2	0	0	1	7
36 to 130m	6	2	4	2	0	7	21
> 130m	20	14	12	27	5	6	84
Total	27	19	18	29	5	14	112

Meanwhile, only 11 of the 62 (18%) raptors that flew at some point over the ridge had a maximum flight height within the rotor swept zone (Figure 3-4). Most raptors that passed over the ridge flew at heights greater than 130 m.

Table 3-4. Flight locations and minimum flight height of migrating raptors at Canton Mountain, spring 2010.

Minimum Flight Heights	Valley only	Ridge only	Side slope only	Valley, ridge, side slope	Valley, side slope	Ridge, side slope	Grand Total
0-35m	4	2	1	1	0	5	13
36 to 130m	8	3	7	7	3	6	34
> 130m	15	14	10	21	2	3	65
Total	27	19	18	29	5	14	112

Of the raptors observed migrating through or near Canton Mountain, most migrating raptor flight heights were not within the rotor swept zone (Tables 3-3, 3-4, and 3-5). However, some of each species of raptor observed flew within the rotor swept zone heights, between 36 m and 130 m (118 ft and 427 ft), at some point during their flights. Flight heights at the start of a raptor observation varied, with the majority (58 percent, 65 observations) of migrants flying above 130 m (427 ft) (i.e., above turbines), followed by 30 percent of migrants (34 observations) flying between 36 m and 130 m (118 ft and 427 ft) (i.e., within rotor swept zone), and 12 percent (13 observations) below 35 m (115 ft).

Flight heights at the end of a raptor observation were also variable, with the majority (75 percent, 84 observations) of migrants flying above 130 m (427 ft), followed by 19 percent (21 observations) of migrants flying between 36 m and 130 m (118 ft and 427 ft), and 6 percent (7 observations) flying below 35 m (115 ft).

Table 3-5. Flight heights of migrating raptors at Canton Mountain, spring 2010.

	Flight Height Start			Flight Height End		
Species	0-35m	36 to 130m	> 130m	0-35m	36 to 130m	> 130m
American kestrel			2			2
Broad-winged hawk	4	10	34	1	6	41
Cooper's hawk		2	3		2	3
Northern goshawk		2	1		1	2
Osprey	2	2	2		2	4
Red-tailed hawk	3	2	5		3	7
Sharp-shinned hawk	2	2	3	2	1	4
Turkey vulture	1	11	14	3	4	19
Unidentified buteo		1				1
Unidentified falcon	1				1	
Unidentified raptor		2	1	1	1	1
Grand Total	13	34	65	7	21	84

Data from Canton Mountain was compared to hawkwatch count data for the same survey dates from Bradbury Mountain in Pownal, Maine (Appendix B, Table 1). The Bradbury Mountain hawkwatch followed the same standardized HMANA data collection methods as were used by Tetra Tech at Canton Mountain.

Overall, raptor survey results indicate that there is a far greater amount of spring-time raptor migration at Bradbury Mountain than at Canton Mountain when the same days are compared (Appendix B**,** Table 1). Over the course of the same 10 days surveyed, a total of 1,418 raptors were recorded at Bradbury Mountain, compared to 112 raptors observed at Canton Mountain. Hourly passage rates averaged 17.84 birds/hr at Bradbury Mountain, compared to 1.87 birds/hr at Canton Mountain. Bradbury Mountain logged 79.5 survey hours while Canton Mountain logged 60 survey hours. Fifteen species were recorded at Bradbury Mountain compared to eight species recorded at Canton Mountain over the same survey dates.

The comparison of Bradbury Mountain hawkwatch data to the data from Canton shows that during the spring migration period there is a larger concentration of migrant raptors along the coast than in the interior of Maine. Raptors are known to migrate over broad areas and use topographic features such as ridges and water, which tend to channel the concentration of migrants (Dunne et al. 1988, Sibley 2001). The near-coastal location of Bradbury Mountain likely influences the magnitude of migration there. Bradbury Mountain is approximately 10 km (6 mi) from the coast, while Canton Mountain is approximately 97 km (60 mi).

3.4 Discussion

A total of 112 raptors were observed at Canton Mountain during the spring survey period. Eight species, ranging from small falcon species to medium-sized hawks, were observed at varying heights above ground level and at different times of day. Raptor activity was greatest during the 14:00 to 15:00 hour, which coincides with the time of day of peak thermal activity. The majority of observations were broad-winged hawks (n = 48) and turkey vultures (n = 26). Turkey vultures are not technically classified as raptors but are diurnal migrants, and are ecologically similar to raptors in regard to flight patterns and migration routes. As a result, turkey vultures are routinely recorded during hawk counts nationwide. Although, most of the broad-winged hawks observed flew over the ridge during their northern movement through the Project Area, the majority of the flight heights were above 130 m (above the rotor-swept zone).

Weather was a factor in the amount of raptor migration activity observed at Canton Mountain. The weather during the spring was much hotter and drier than usual. Due to this, there was abundant high pressure with prevailing northwest winds for most of the surveys. Migrating raptors try to avoid flying into a headwind and the largest flights of raptors are typically characterized by a strong tailwind.

Raptor flight paths were generally northbound but varied in location from survey to survey, with observations of raptors moving north along the western 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). Due to the forested landscape and uniform elevation of Canton Mountain, observation of raptor movements on the east side was not possible. Most of the initial and ending flight heights of raptors were above 130 m (427 ft). The majority of raptors observed over Canton Mountain appeared to exhibit migrant raptor behavior with wings tucked behind (falcons and accipiters) and/or circling/thermaling flight (mostly buteos). Some raptors (e.g., red-tailed hawk and American kestrel) used updrafts and thermals to kite above the site to hunt the

ridgeline, side slopes, and valleys for prey. There is at least one pair of red-tailed hawks that resides in the Project Area.

The observed flight heights and locations at Canton Mountain demonstrate that only 18% and 25% of the migrating raptors that flew within the rotor swept zone when considering maximum and minimum flight heights, respectively. Most of these raptor flight paths were a combination of side slope, ridge, and valley movements. Migrants that fly within and below the rotor swept zone may be at higher risk of collision with the turbines than migrants that fly above the rotor swept zone.

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, such as raptors, some shorebirds, and waterfowl, can be visually documented during migration; whereas nocturnal migrants 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. Field surveys were designed to target migrant stopover and staging in order to understand how and when species use particular locations. Migrant stopover surveys were conducted at Canton Mountain during spring 2010 to document use of the Project Area, including temporal and spatial trends.

Weather, time of day, and habitat availability all influence when, where, and how birds migrate, and where they choose to stopover. Because nocturnal migrants fly at night, they are potentially at risk from collision with any unseen obstacle, whether it is a building, radio tower, or wind turbine. All migratory bird species are protected under the Migratory Bird Treaty Act of 1918.

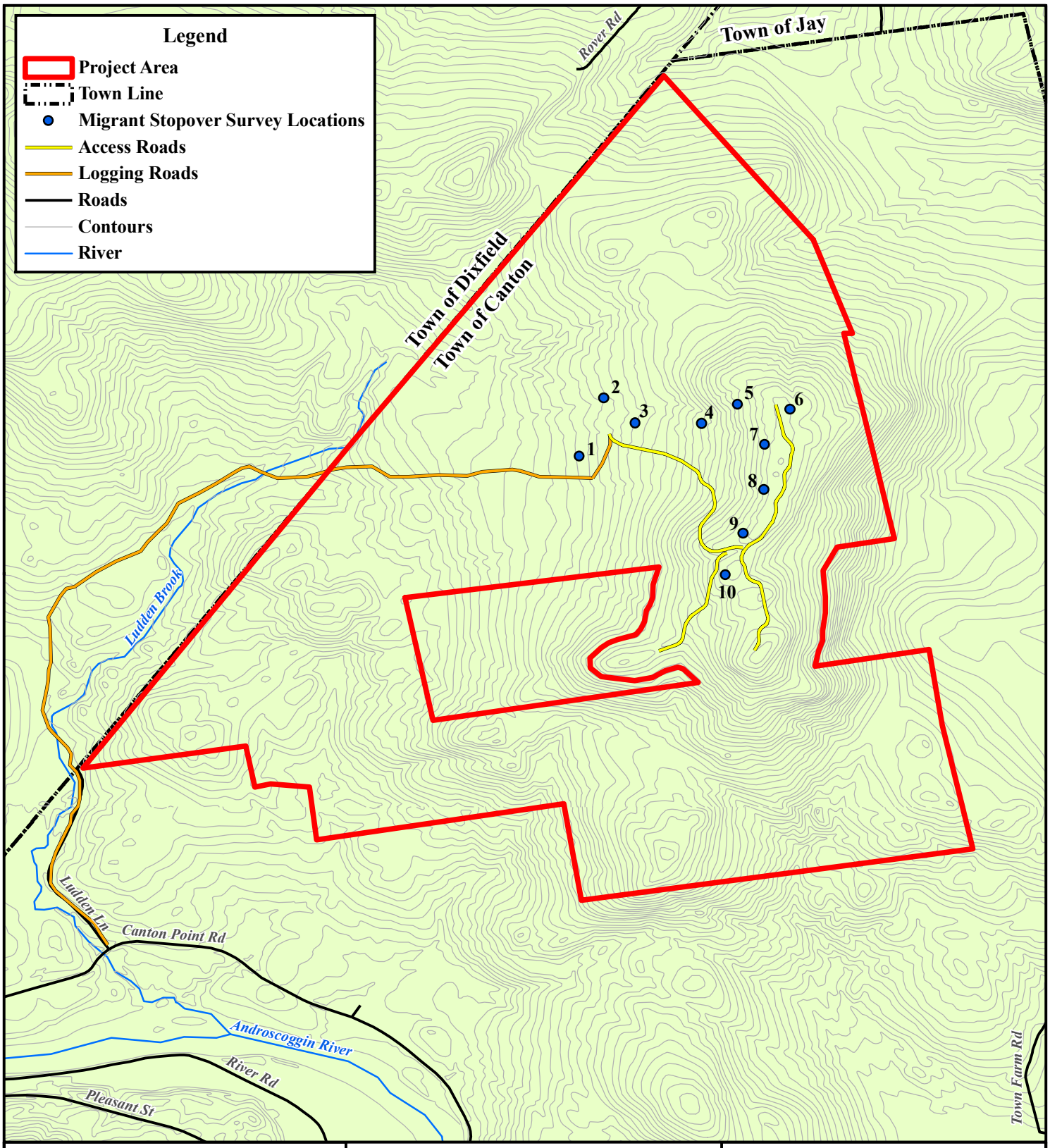
This section summarizes observations made at Canton Mountain during the spring 2010 migrant stopover surveys. Data on species composition, diversity, abundance, and location within the Project Area are presented and discussed.

4.2 Methods

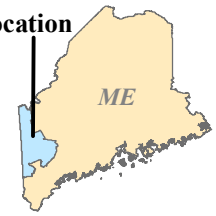
Tetra Tech biologists conducted standardized surveys along one transect with 10 survey points (Figure 4-0). During the spring migration season, each point was sampled on 10 different days. Points were chosen for elevation gradients and representative habitat types and were spaced approximately 0.18 km (0.11 mi) apart using a handheld Global Positioning System (GPS) 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 fir (*Abies balsamea*) species along the ridge.



Project Location



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

0 1,250 2,500 5,000 Feet

0 300 600 1,200 Meters

Figure 4-0 Migrant Stopover Survey Locations at Canton Mountain Wind Project-Spring 2010

Prepared For: PATRIOT RENEWABLES

Prepared By: TETRA TECH

Date: 07/10

P:GIS/Projects/Canton/MXD/Figure4_0.mxd

4.3 Results

A total of 728 birds, representing 48 species, were observed and recorded during the spring 2010 Canton Mountain avian migrant stopover surveys (Table 4-0; Appendix C). All birds detected during surveys were considered migrants. However, it is likely that some of these species are year-round residents of the Project Area.

Table 4-0. Summary of migrant stopover surveys at Canton Mountain, spring 2010.

Point	Elevation (ft)	Species Richness/ Point	Total Number of Individuals/ Point
1	1,075	27	92
2	1,120	29	85
3	1,160	31	78
4	1,325	28	70
5	1,475	22	55
6	1,499	23	71
7	1,525	22	65
8	1,525	25	76
9	1,525	20	74
10	1,491	20	62
All Points		48	728

The number of different bird species detected (species richness) at each point ranged from 20 to 31 birds. The relative abundance (mean number of birds detected per survey) was 66.18 birds/survey (Appendix C, Tables 1 and 2). The five most abundant bird species were: ovenbird (*Seiurus aurocapillus*) (9.09 birds/survey), black-capped chickadee (*Poecile atricapilla*) (4.64 birds/survey), myrtle warbler (*Dendroica c. coronata*) (4.27 birds/survey), black-and-white warbler (*Mniotilta varia*) (4.18 birds/survey), and chestnut-sided warbler (*Dendroica pensylvanica*) (3.36 birds/survey). Species richness and the number of individuals observed generally declined with increasing elevation (Table 4-0 and Figure 4-1).

The following birds were observed at all ten survey points (100 percent frequency) during the 10-day survey: black-and-white warbler, black-capped chickadees, black-throated blue warbler (*Dendroica caerulescens*), hermit thrush *(Catharus guttatus)*, and ovenbird. The remaining birds had frequencies below 100 percent and can be referenced in Appendix C, Table 1.

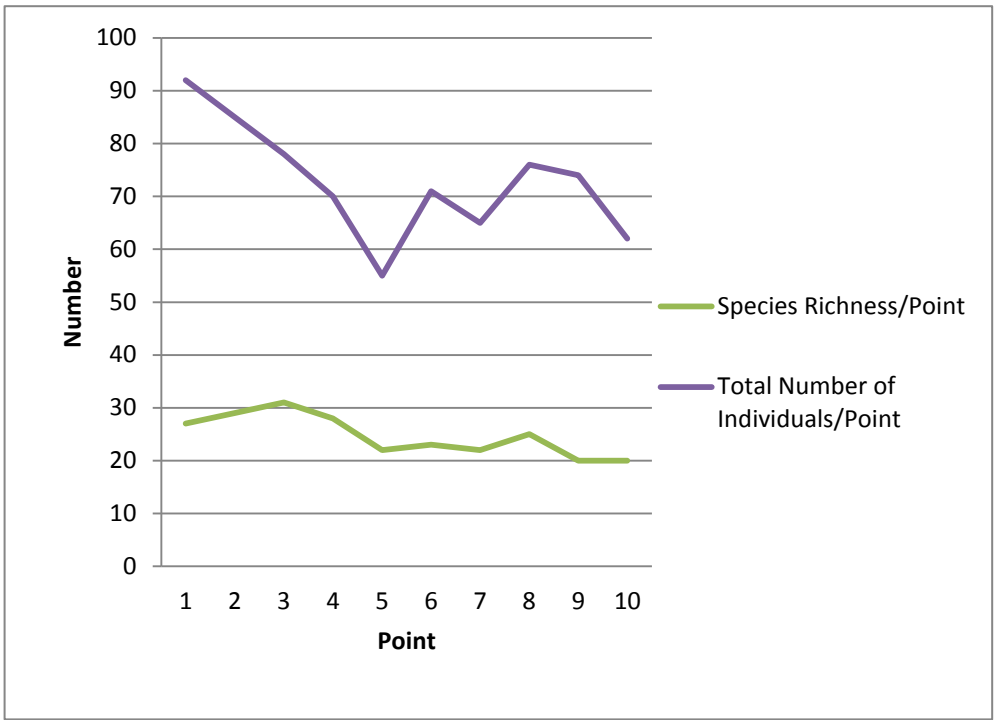


Figure 4-1. Species richness and total number of individuals detected by point-count location during migrant stopover surveys at Canton Mountain, spring 2010.

It also appears that species richness and the number of individuals increased over the survey period (Figure 4-2). The greatest species richness occurred on May 19, 2010, and the greatest number of birds detected occurred on May 1, 2010. The most frequently observed species by survey date were black-capped chickadee (100 percent), hermit thrush (90.9 percent), white-throated sparrow (*Zonotrichia albicollis*) (90.9 percent), black-and-white warbler (81.8 percent), and blue jay (*Cyanocitta cristata*) (81.8 percent).

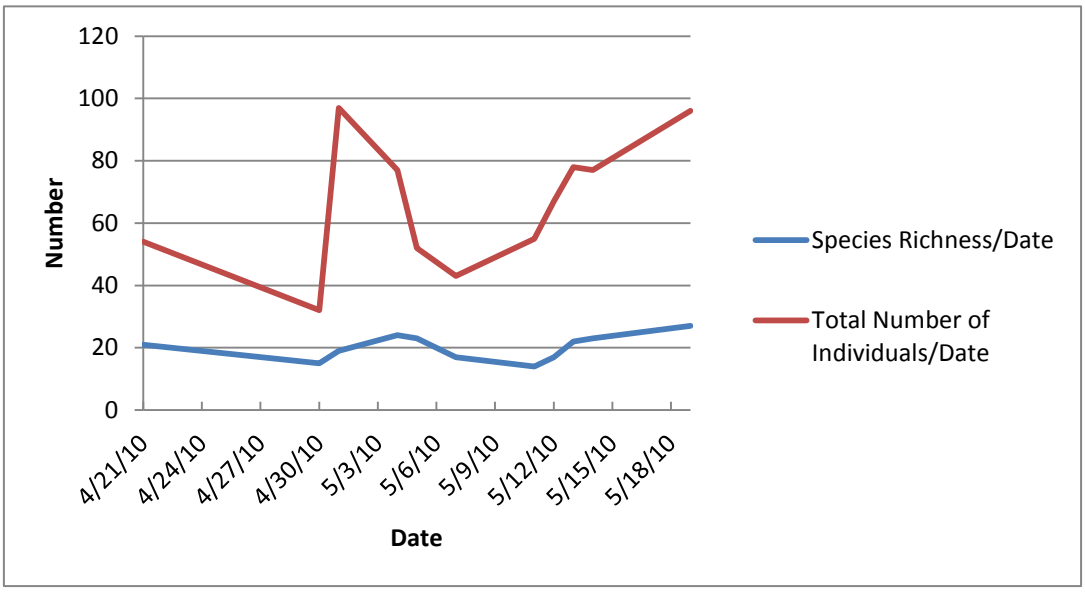


Figure 4-2. Species richness and total number of individuals detected by point-count location during migrant stopover surveys at Canton Mountain, spring 2010

Of the 48 species observed during the spring 2010 migrant stopover surveys at Canton Mountain, 6 species are listed as Species of Special Concern by MDIFW (MDIFW 2009). These species include: American redstart (*Setophaga ruticilla*), black-and-white warbler, chestnut-sided warbler, evening grosbeak (*Coccothraustes vespertinus),* white-throated sparrow, wood thrush (*Hylocichla mustelina)* and yellow warbler (*Dendroica petechia*). All of these species are considered long-distance migrants. No endangered or threatened species were observed during the 10 mornings of migrant stopover surveys.

4.4 Discussion

Canton Mountain appears to provide stopover habitat for a suite of migrant avian species as well as habitat for year-round species. All migrant stopover species that were observed and recorded during the spring 2010 surveys are species typically found in the habitat types and elevations in this region of Maine. The majority of these species are common throughout the region, although six of the documented species at Canton Mountain are considered species of special concern by MDIFW (MDIFW 2009). No federal or state listed threatened or endangered species were observed during spring 2010 migrant stopover surveys at Canton Mountain.

The six species of special concern documented during the survey included American redstart, black-and-white warbler, evening grosbeak, white-throated sparrow, wood thrush, and yellow warbler. Most of these species were found at varying elevations and habitat types across the survey locations. There were two exceptions, the evening grosbeak and yellow warbler, which were exclusively observed only once on different days, both at Point-Count # 2 at 341 m (1,120 ft) elevation. The habitat around Point-Count # 2 was mostly deciduous with a nearby creek. The remaining Species of Special Concern were documented in both closed canopy deciduous forests (black-and-white warbler and wood thrush) and mixed-coniferous forests (American redstart and white-throated sparrow).

The Canton Mountain migrant stopover surveys documented an overall species richness of 48 different species for the entire site and an overall relative abundance of 66.18 birds/survey. Overall, it appears that 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).

5.0 BAT ACOUSTIC SURVEY

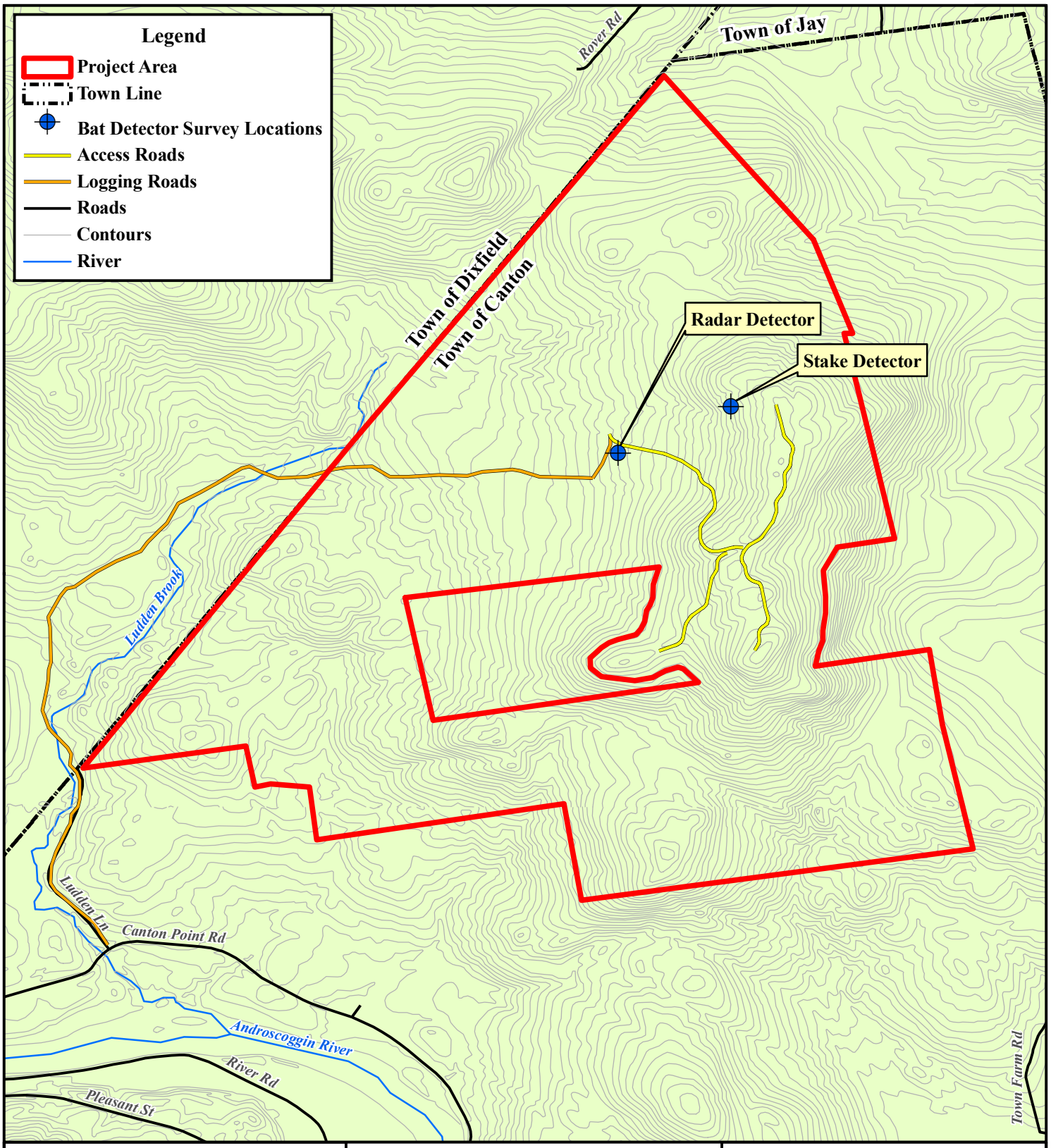
5.1 Introduction

Patriot contracted Tetra Tech Inc, to conduct a spring migration period passive acoustic bat monitoring study at the Canton Mountain Wind Project. The goals of the study were to quantify bat use of the Project Area and to identify potential bat impacts associated with building and operating the proposed facility. This section presents the results of 48 initial nights of monitoring for bat activity levels using two ultrasonic acoustic recorders (Anabat SD-1, Titley Scientific, Inc.) during the spring migration period. Detectors were deployed from April 14, 2010, to May 31, 2010, at two different locations within the Project Area (Figure 5-0). The 'Radar Detector' was suspended from a tree near the radar unit and the 'Stake Detector' was deployed in a small clearing near the ridgeline, north of the Radar Detector. The acoustic survey effort will continue through the summer and fall of 2010.

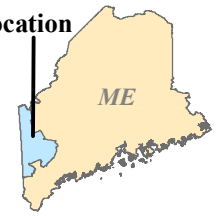
5.2 Methods

From April 14 to May 31, 2010, two detectors were operational within the Project Area. The Radar Detector was suspended from a tree at a height of approximately 8 m (24 ft), at an elevation of 356 m (1,167 ft). A second Anabat SD-1 unit was deployed on a 2 m (6 ft) stake at an elevation of 449 m (1,473 ft) in a small clearing near the ridgeline (Figures 5-1 and 5-2).

To ensure that the greatest period of bat activity was surveyed, the detectors were programmed to begin recording 45 minutes before sunset and stop recording 45 minutes after sunrise each day. These survey periods are consistent with the MDIFW recommended bat monitoring guidelines and were reviewed by the MDIFW prior to commencement of the survey.



Project Location



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

0 1,250 2,500 5,000 Feet

0 300 600 1,200 Meters

Figure 5-0 Bat Detector Survey Locations at Canton Mountain Wind Project-Spring 2010

Prepared For: PATRIOT RENEWABLES

Prepared By: TETRA TECH

Date: 07/10

P:GIS/Projects/Canton/MXD/Figure5_0.mxd

Figure 5-1. Location of the Radar Detector at the Project Area, spring 2010.

Figure 5-2. Location of the Stake Detector at the Project Area, spring 2010.

Each detector (Radar and Stake) consisted of an Anabat SD-1 detector powered by a 5-watt solar panel and a 12-volt battery encased in a waterproof housing. The housing suspends the Anabat microphone downward and a plastic deflector shield angled at 45 degrees below the microphone facilitates recording of the airspace surrounding the detector. Each detector was manually checked by Tetra Tech staff every 2 weeks between April 14 and May 31, 2010. During the 1.5-month survey period, the Radar Detector was fully operational and collected data during the entire 48-night period. The Stake Detector powered down for a period of 8 nights during the survey period, resulting in a total of 40 nights of recordings.

5.2.1 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. To ensure comparability between data sets, the default settings for the CFCread© software were used during the file extraction process. 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 is, 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.

A qualitative visual comparison was made of recorded bat call sequences of sufficient length to 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 Szweczak 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 spatial use, was obtained using an Index of Activity (IA) modified from Miller (2001). The method is based on the presence/absence of a species occurrence within 1-minute time increments. Thus, IA was the sum of minute-increments with a species presence divided by the unit effort (IA = # minutes / detector-nights * 100). These calculations follow those employed by O'Farrell and Shanahan (2006). The IA calculations 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 differences in study effort.

5.3 Results

A total of 161 bat call sequences representing 4 bat species were recorded during the spring 2010 monitoring period (Table 5-0). The monitoring effort for this 48-night period resulted in 88 detector-nights (number of detectors multiplied by the number of nights deployed) of recordings. Detectors monitored bat echolocation calls for approximately 12 hours per night, resulting in a total of 1,056 detector-hours. The Radar Detector had the highest rate of detection (1.9 call sequences/night) followed closely by the Stake Detector (1.8 call sequences/night).

Table 5-0. Summary of acoustic monitoring survey effort by detector at the Project Area, April14 to May 31, 2010.

Detector	Deployment Dates	Number of Detector Nights	Total Number of Call Sequences	Average Call Sequences Per Night	Average Call Sequences Per Hour	Index of Activity*
Stake	April 14 – May 31, 2010	40	71	1.8	0.1	*137.5*
Radar	April 14 – May 31, 2010	48	90	1.9	0.2	*177.1*
* Index of Activity (IA) = # minutes with bat activity / detector-nights * 100						

Bat calls were identified to the lowest possible taxonomic level (Table 5-1). The majority (99 percent) of recorded calls were identified to genus level (*n* = 159); 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*) (Tables 5-1). Call sequences that did not meet the parameters required for genus level identification could not be classified to genus (*n* = 2) 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, and were therefore labeled as Middle Frequency Unknown (Fc = 24 to 38 kHz) call sequences. The Middle Frequency Unknown category could contain call sequences for silver-haired bat or big brown bat. Most Middle Frequency Unknown calls recorded during the spring period at the Project Area appeared to be fragments of silver-haired bat calls. A total of 12 calls (7 percent) were attributed to long-distance migratory bats, including hoary bat, silver-haired bat, and eastern red bat.

The majority (86 percent) of call sequences (*n* = 147) recorded were identified as *Myotis* species, and consisted primarily of northern myotis (*Myotis septentrionalis)* and likely some little brown myotis (*M. lucifugus)* call sequences. It is possible, but unlikely, that a portion of the unknown *Myotis* species call sequences were from eastern small-footed myotis (*M. leibii*), as none of the calls exhibited attributes consistent with reference calls from this species. A total of 134 calls were unmistakably northern myotis, which produce call sequences with relatively unique characteristics that can generally be accurately identified to species level. These calls are identified by the steep slope, high mean maximum frequency, high characteristic frequency and concentration of amplitude in the higher frequencies of the call pulses. Three Maine state-listed species of special concern were documented during the survey period: eastern red bat (*Lasiurus* borealis), silver-haired bat and hoary bat (MDIFW 2009). A minority of calls (4 percent) were categorized as silver-haired bat (*n* = 7). A total of 4 (7 percent) hoary bat call sequences were recorded during the spring survey period. No calls of federally listed bat species were identified during the survey.

The total number of call sequences recorded per night by each detector varied during the survey period. Most call sequences were recorded in May (Figures 5-4 and 5-5). Recorded call sequences peaked at the Radar Detector on May 28 (*n* = 13) and at the Stake Detector on May 5 (*n* = 28). All call sequences were recorded between the hours of 20:00 and 06:00 (Figures 5-3 and 5-4). Recorded call sequences, by hour, were relatively consistent between detector locations. At both detector locations, peak activity was recorded during the hour beginning at 20:00, with a secondary increase in activity within the hour beginning at 22:00. Activity generally declined throughout the night, with the lowest activity recorded during the 04:00 and 05:00 hours.

Table 5-1. Summary of bat call sequences and probable species recorded at the Project Area, July 15 to May 31, 2010.

Group	Characteristic Frequencies*	Species	Index of Activity**	Total Call Sequences
Low Frequency	12 kHz–24 kHz	Hoary bat	4.5	4
Middle Frequency	24 kHz–38 kHz	Big brown bat		
		Silver-haired bat	7.9	7
		Silver-haired bat/ Big brown bat		
		Unknown middle frequency call seq.	2.3	2
Eastern red bat	44–45 kHz	Eastern red bat	1.1	1
High Frequency (*Myotis* species)	46–52 kHz	Northern myotis	129.5	134
		Eastern small-footed myotis		
		Little brown myotis		
		Unknown *Myotis* species	13.6	13
		Unknown high frequency call seq.		

*** 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.**
****Index of Activity (IA) = # minutes with bat activity/detector-nights*100**

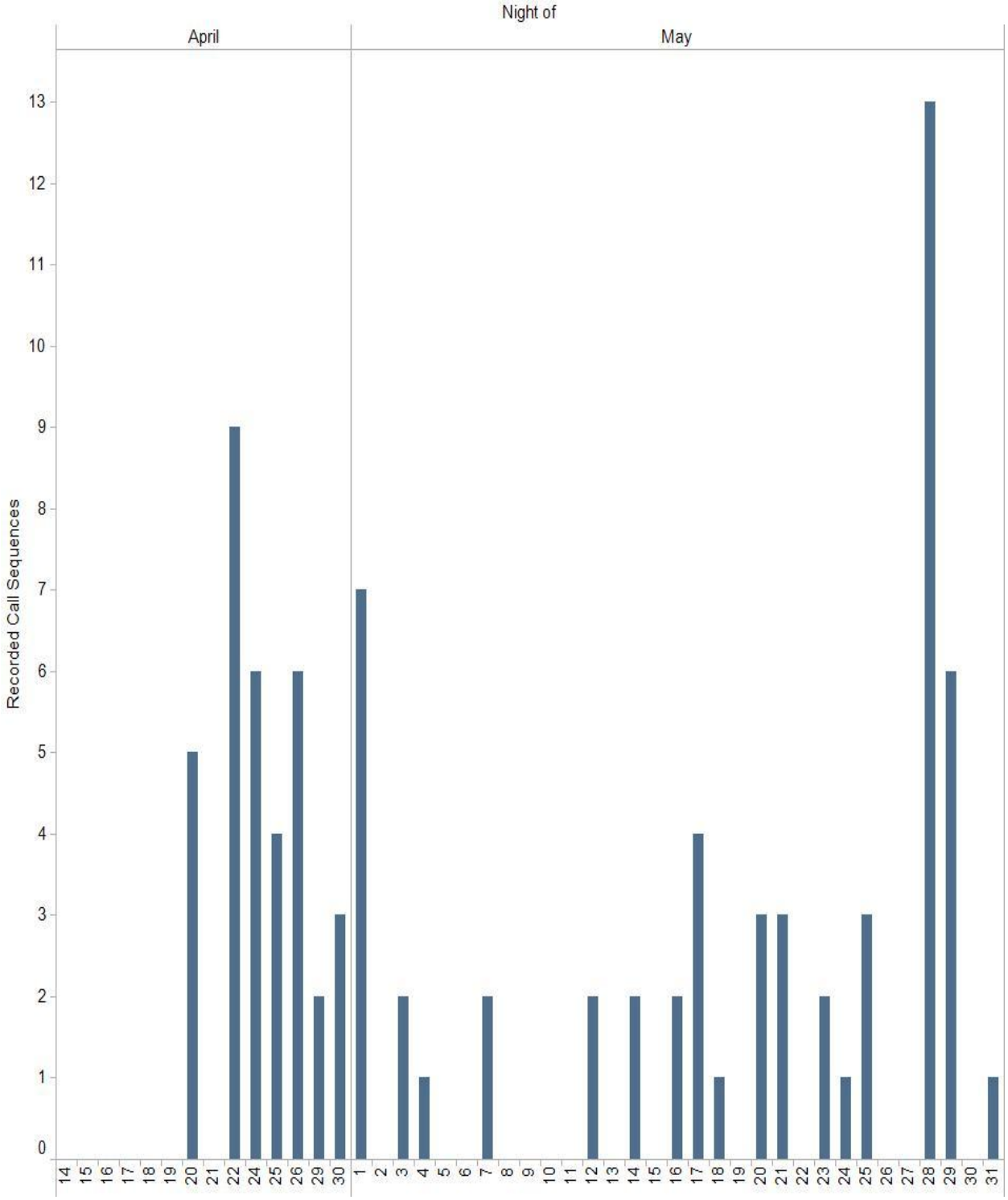


Figure 5-3. Total number of bat call sequences (*n* = 90) recorded per night by the Radar Detector at the Project Area, April 14 to May 31, 2010.

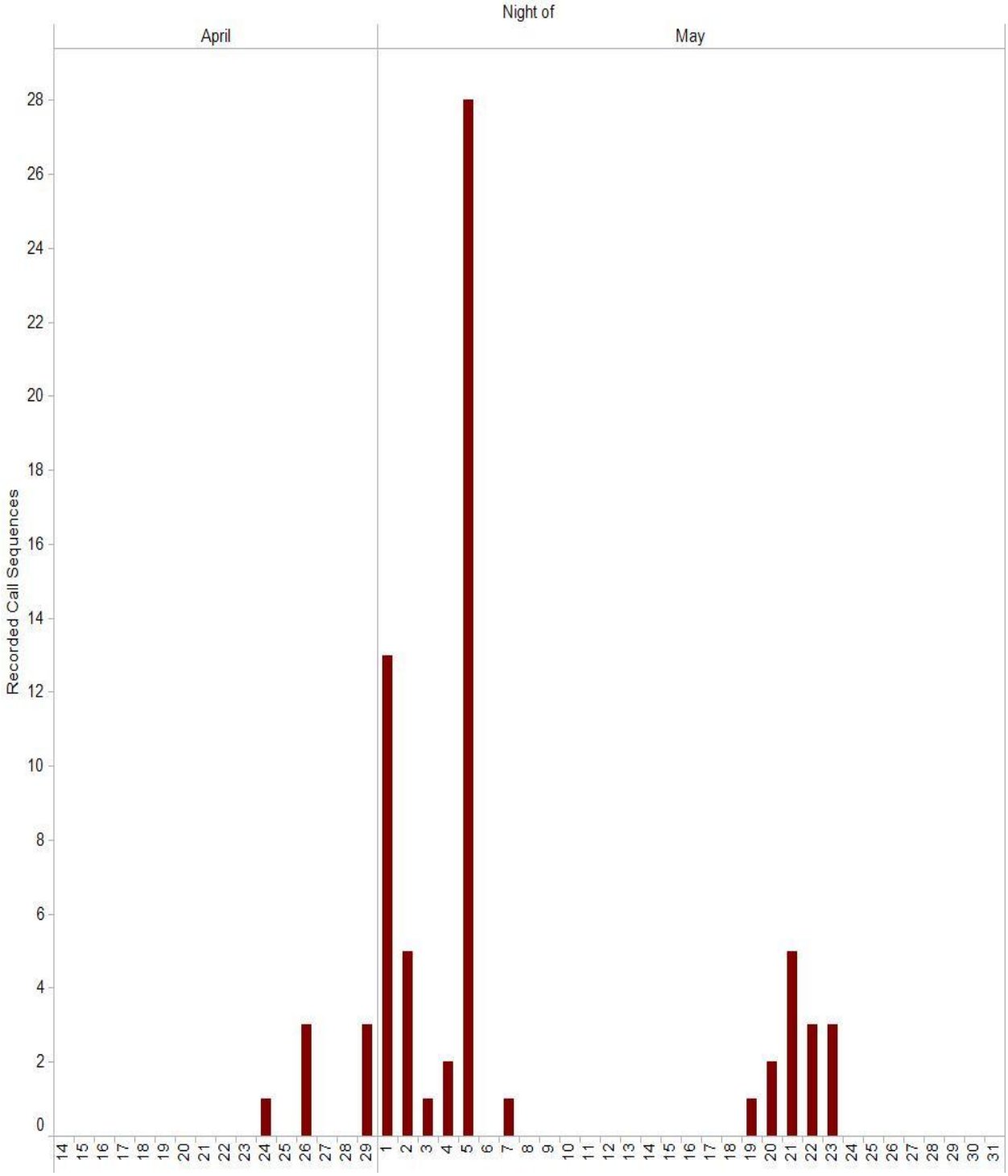


Figure 5-4. Total number of bat call sequences (*n* = 71) recorded per night by the Stake Detector at the Project Area, April 14 to May 31, 2010.

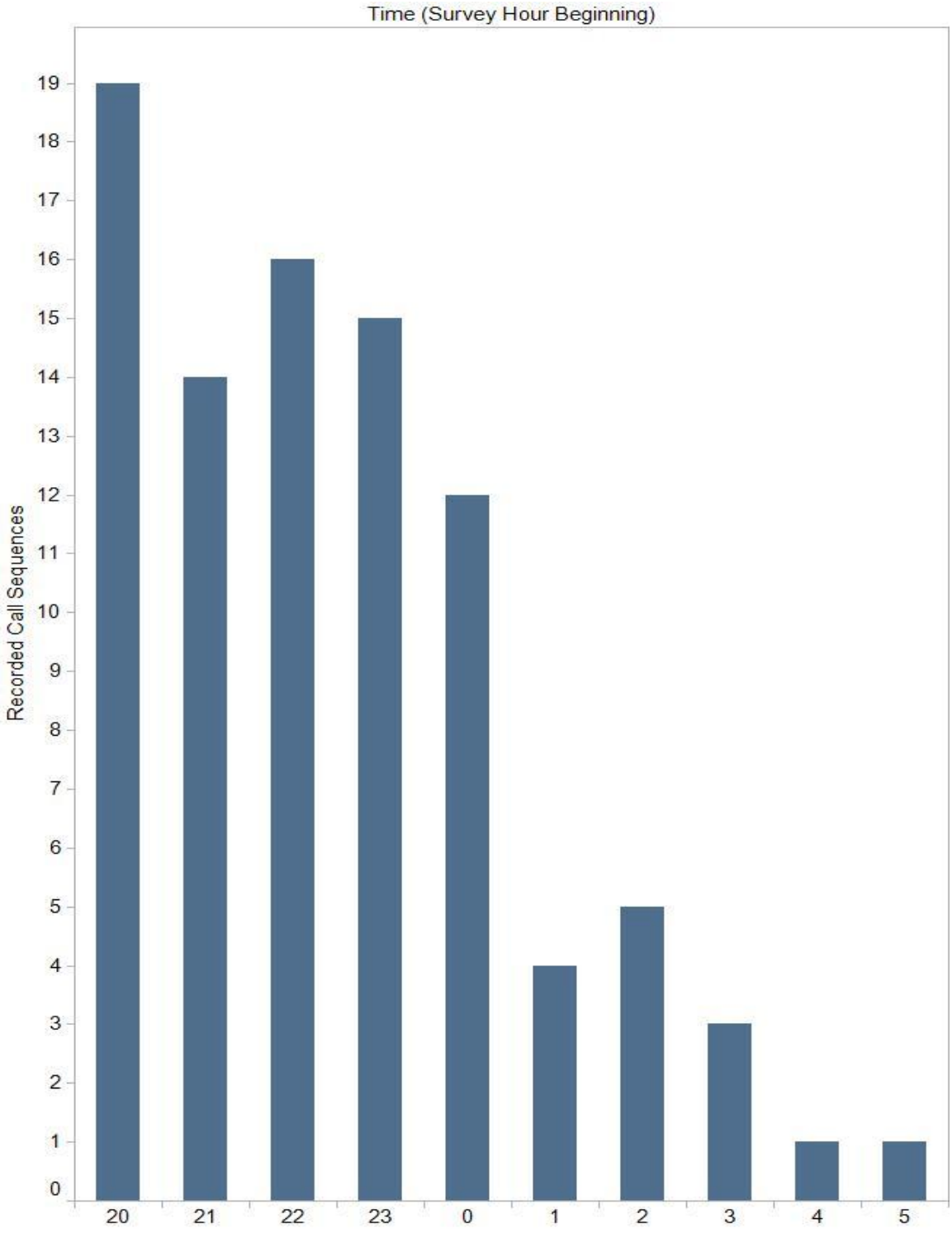


Figure 5-5. Total number of bat call sequences (*n* = 90) recorded per hour by the Radar Detector at the Project Area, April 14 to May 31, 2010.

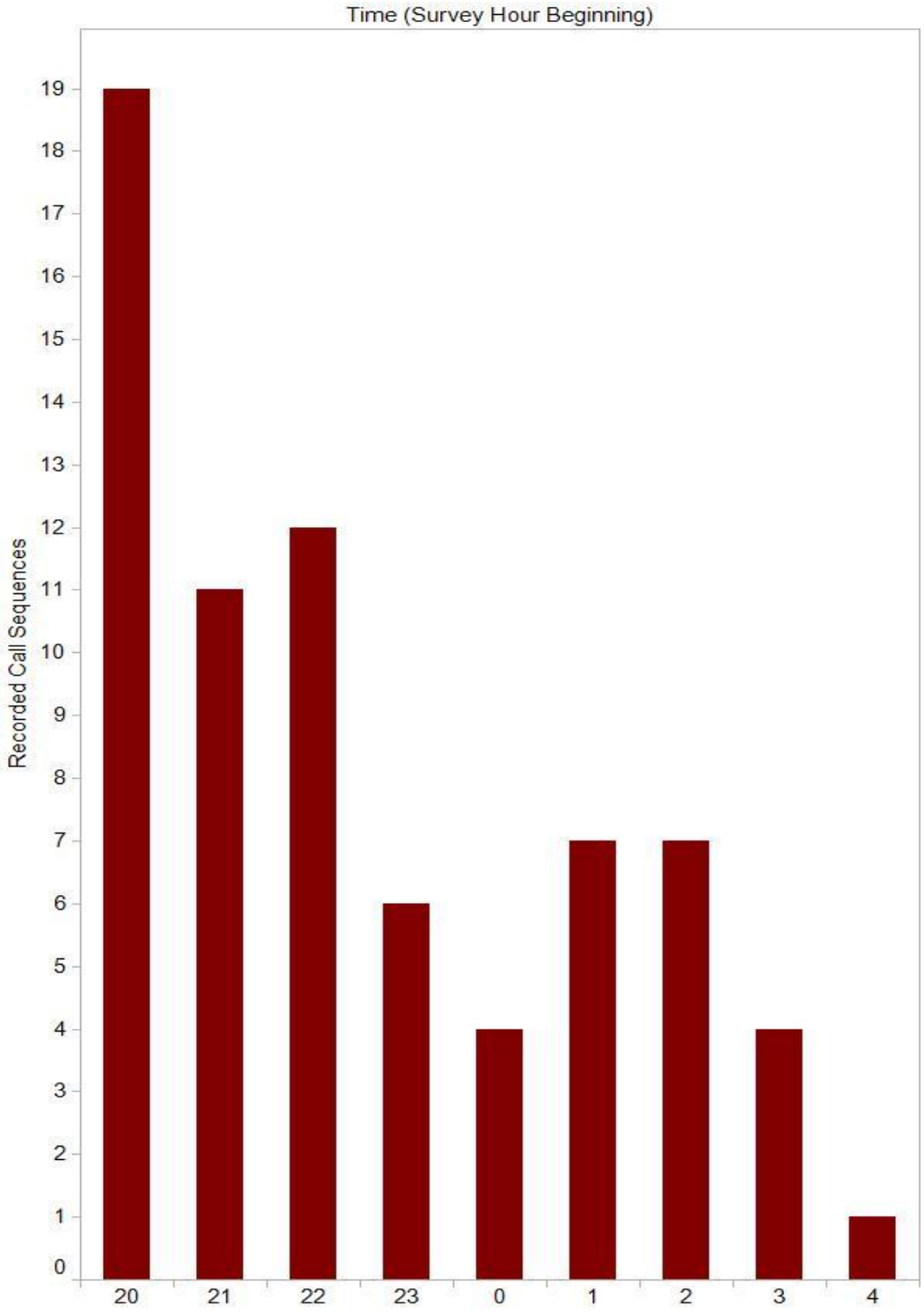


Figure 5-6. Total number of bat call sequences (*n* = 71) recorded per hour by the Stake Detector at the Project Area, April 14 to May 31, 2010.

5.4 Discussion

Current research shows that tree-roosting, migratory bat species have been the predominant species found during post-construction mortality studies at wind farms in North America (Arnett el 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 initial spring 2010 survey period; however, these species were recorded less frequently than non-migratory *Myotis* species. The presence of migratory species calls at sporadic intervals within the spring 2010 recordings from Canton Mountain indicates that these species moved through the Project Area, but were likely not residents. There were more *Myotis* species calls overall, indicating that the bat community of the Project Area likely consists of some summer resident *Myotis* species and occasional migratory bats during the migration periods.

There is an inherent difficulty in attempting to interpret the number of recorded call sequences as an indication of activity levels; however, detection rates do reflect a relative level of bat activity near the 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, such as at the Project Area, facilitates the characterization of localized bat occurrence.

The total number of bat call sequences recorded each night by a given detector may or may not reflect the absolute level of bat activity present at the Project Area, although some studies have suggested that there may be a relationship between the number of call pulses 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 skew the results between sampling locations (i.e., 40 detector-nights at the Stake Detector and 48 detector-nights at the Radar Detector). However, by calculating an Index of Activity coefficient, a comparison between sampling locations with different levels of effort becomes more valid.

The Stake sampling location recorded a total of 71 call sequences; these calls represented 55 minutes of bat activity out of 28,800 minutes of recordings, over 40 nights, yielding an Index of Activity (IA = minutes with bat activity / detector-nights * 100) value of 137.5. The Radar sampling location had a similarly small ratio of minutes of bat activity to total minutes of recording. The Radar detector recorded 90 call sequences during a total of 85 minutes of bat activity, out of 34,560 minutes of recording, over 48 nights, producing an Index of Activity of 177.1. Overall, the Radar location had a slightly higher rate of activity, likely due to the greater height of the detector and the larger size of the forest clearing the detector was located in. However, neither location produced a substantially high ratio of minutes of bat activity to total recording time; despite continuous nightly monitoring for a month and a half, only approximately 140 minutes of actual bat activity was recorded.

There did not appear to be an episode of increased recorded call sequences that could be definitively attributed to large-scale migration activity. At the Project Area, the relatively low number of call sequences (*n* = 12) and minutes of activity (12 min) that were definitively attributable to long-distance migratory species indicate that the area is not likely a major migratory corridor for these species of bats. The majority of call sequences recorded were *Myotis* species, largely northern myotis, a non-migratory species that is considered to be common, although not abundant, in heavily forested areas across northern New England (Brooks and Ford 2005).

It is expected that weather conditions, including mean nightly temperature and wind speed, contributed to the patterns of activity recorded by the acoustic detector sets. Overall, the increase in bat call sequences recorded in early and mid-May likely correlated with (1) increased foraging activity near the detectors due to 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) the area possibly being located in a transit corridor for bats leaving a roost and moving locally to an established area of concentrated food resource.

Call sequences from silver-haired bat, hoary bat, and eastern red bat, were recorded infrequently and were fairly evenly distributed over the course of the survey period. The distribution of these recorded call sequences throughout a 48-night period indicates that these individuals were either migrants moving through the area or local individuals utilizing the area infrequently for foraging. Overall, it appears there is low occurrence of long-distance migratory bats in the Project Area.

The observed bat occurrence pattern is consistent with the habitat types present along the ridgeline of the Project Area, as well as the known natural history and habitat associations of the four positively recorded species (hoary bat, silver-haired bat, eastern red bat, and northern myotis). Silver-haired bats, as well as other migrant bats, are relatively large-bodied and have large wing spans; this leads to increased utilization of open habitat, either above the forest canopy or in forest clearings created by natural disturbances or timber harvesting (Brooks and Ford 2005). The habitat adjacent to the Radar Detector was generally more open (cleared areas), whereas the habitat adjacent to the Stake Detector is denser, early successional forest. Therefore, it is not surprising that there was a higher detection rate of silver-haired bat at the Radar Detectors. Northern myotis calls were more evenly distributed between sampling locations. Northern myotis prefer to forage in dense vegetation and are capable of gleaning insects directly from foliage (Brooks and Ford 2005). The uniform presence of the species at both the Radar and Stake sampling locations was likely due to the dense understory and sub-canopy available at both locations.

The documented patterns of spatial distribution of species do not suggest the presence of a large bat migration corridor along the Project Area's ridgeline. If a substantial migration corridor did exist over the Project Area, one would expect the data to show a higher ratio of minutes of bat activity to detector nights. The sporadic and low-level occurrence of long-distance migratory species at both sampling locations indicates that few individuals use the ridgeline in the vicinity of the detector locations.

Bat acoustic surveys at the Project Area are ongoing, including the installation of additional detectors in late June 2010 on the meteorological measurement tower located on top of the ridgeline. Acoustic surveys will continue throughout the summer and into the fall migration period. This additional information will provide a full year of bat activity monitoring data from the Project Area and will help to paint a more comprehensive picture of the bat community present.

6.0 BREEDING BIRD SURVEYS

6.1 Introduction

The northeastern United States is known to have a high diversity of migratory birds that breed in various habitats across the region. Breeding bird surveys (BBS) were initiated on Canton Mountain in order to document relative abundance, frequency of detection, and species richness to better understand breeding bird use of the area. While the migrant stopover survey at Canton Mountain was designed to characterize birds migrating and stopping over in the Project Area, the breeding bird survey was conducted in early June, when migration has ceased and the birds are back on their breeding grounds. Breeding bird surveys were conducted on three days in early to mid June.

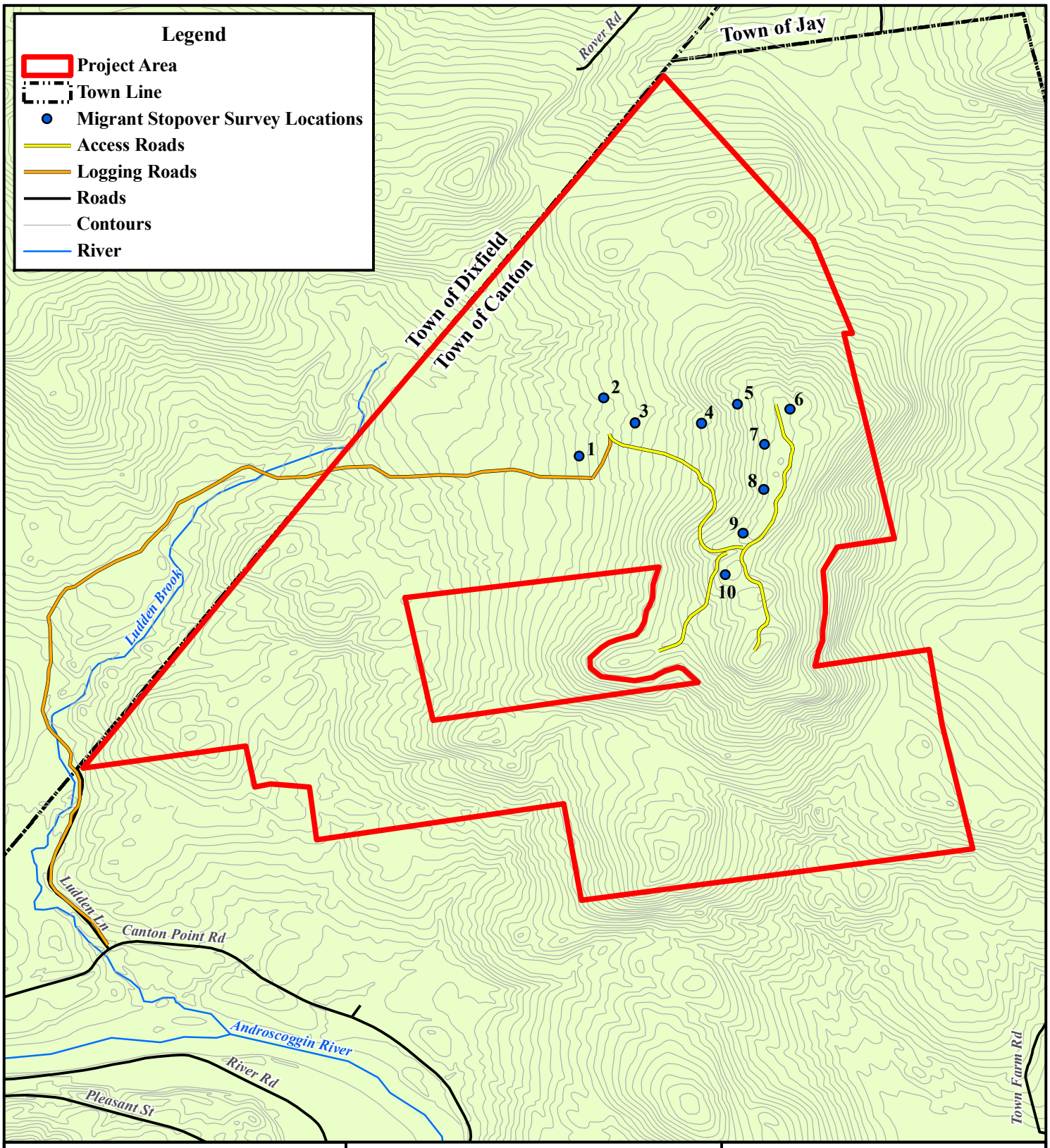
This section summarizes observations made at Canton Mountain during the 2010 breeding bird surveys. Data are presented and discussed on breeding bird species composition or species richness (number of different species occurring within a given area), relative species abundance (how common or rare a species is compared to other species within a given area), frequency, and location within the Project Area.

6.2 Methods

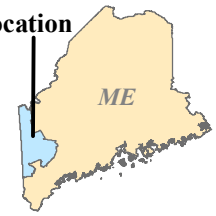
Tetra Tech biologists conducted standardized surveys along one transect with 10 survey points during the 2010 breeding season (Figure 5-0), and each point was sampled on three different days. Points were chosen for elevation gradients and representative habitat types. Points were spaced approximately 0.11 mi apart using a handheld Global Positioning System (GPS) to ensure individual birds were not counted twice. The length of the point count transect was 2.3 km (1.4 mi) in length. These surveys points were the same survey points sampled during migrant stopover surveys. Survey protocols established by the U.S. Geological Survey (USGS) Breeding Bird Survey (USGS 1998) were used as a basis for conducting the 2010 breeding bird surveys at Canton Mountain.

All transect points were sampled three times during the survey period. Surveys were conducted during optimal weather conditions with light winds, warm temperatures, and no precipitation. Surveys began as close to sunrise as possible in order to correspond with peak male song activities. Each point was surveyed for 10 minutes and all surveys ended before 10:00 hours. Every bird that was detected either audibly or visually was recorded onto a standardized data sheet. Each observed bird was identified by species and, depending on the time of detection, was categorized as having been detected during the first 3 minutes, within minutes 4 to 5, or within the last 5 minutes of the 10-minute survey period. Detections were also categorized as being less than or greater than 50 m (164 ft) from the survey point.

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 fir (*Abies balsamea*) species along the ridge.



Project Location



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

0 1,250 2,500 5,000 Feet

0 300 600 1,200 Meters

Figure 6-0 Breeding Bird Survey Locations at Canton Mountain Wind Project-Spring 2010

Prepared For: PATRIOT RENEWABLES

Prepared By: TETRA TECH

Date: 07/10

P:GIS/Projects/Canton/MXD/Figure6_0.mxd

6.3 Results

A total of 262 birds, representing 47 species, were observed and recorded during the 2010 Canton Mountain breeding bird surveys (Table 6-0). The number of observations at each point ranged from 17 to 32. The greatest number of birds detected occurred at Points # 6 and # 9 with the fewest occurring on Point # 10. The species richness or the number of different species observed at each point, ranged from 9 to 21 species/point. Point # 6 had the greatest species richness and point # 10 had the lowest.

Table 6-0. Summary of breeding bird surveys at Canton Mountain, spring 2010.

Point	Elevation (ft)	Species Richness	Total number of individuals
1	1,075	13	21
2	1,120	14	26
3	1,160	16	25
4	1,325	12	24
5	1,475	19	31
6	1,499	21	32
7	1,525	17	24
8	1,525	15	30
9	1,525	20	32
10	1,491	9	17
Grand Total		47	262

The relative abundance of breeding birds observed was 87.33 birds/survey (Appendix D, Table 1 and Table 2). The number of individual birds observed increased over the survey period. The fewest birds (n = 73) were recorded on June 2, 2010, while the most birds (n = 104) were observed on June 16, 2010 (Figure 6-1). The six species with the highest relative abundances were ovenbird (10.0 birds/survey), red-eyed vireo (*Vireo olivaceus* [9.0 birds/survey]), black-and-white warbler (5.67 birds/survey), black-throated green warbler (5.33 birds/survey), hermit thrush (5.0 birds/survey), and chestnut-sided warbler (4.00 birds/survey).

Table 6-1. Summary of breeding bird surveys by date at Canton Mountain, spring 2010.

Date	Species Richness	Total number of individuals
6/2/10	21	73
6/11/10	28	85
6/16/10	39	104
Grand Total	47	262

Ovenbird and black-and-white warbler were the only two species observed at all ten point-count locations. Frequencies for all species observed can be found in Appendix D Table 1 and Table 2. Approximately 72 percent of birds observed during the breeding bird survey were also observed during the 2010 spring migrant stopover survey at Canton Mountain.

Of the 47 species observed during the 2010 breeding bird survey at Canton Mountain, 5 species are listed as Species of Special Concern by MDIFW (MDIFW 2009). These species include: American redstart, black-and-white warbler, white-throated sparrow, wood thrush and yellow warbler. All of these species are considered long-distance migrants. No endangered or threatened species were observed during the 3 mornings of breeding bird surveys.

6.3 Discussion

A total of 262 birds representing 47 species and were documented during the 2010 breeding bird surveys on Canton Mountain. The ovenbird was the most abundant species observed followed by red-eyed vireo, black-and-white warbler, black-throated green warbler, hermit thrush and chestnut-sided warbler. Surveys were conducted on days with optimal weather and targeted the early morning hours, which are typically the time of highest detection for breeding birds.

Canton Mountain appears to provide a moderate level of breeding habitat for avian species. All breeding bird species that were observed and recorded during the 2010 breeding bird surveys are consistent with species typically found in the habitat types found on Canton Mountain. The majority of these species are common throughout the region, although 5 of the documented species are considered Species of Special Concern by MDIFW (MDIFW 2009). No threatened or endangered species were observed during the 2010 breeding bird surveys at Canton Mountain.

The five Species of Special Concern were American redstart, black-and-white warbler, chestnut-sided warbler, white-throated sparrow, and wood thrush. These birds represented about 19 percent of all birds observed. Overall relative abundances for each of these species varied for the entire Project Area. The species with greater relative abundance values were the black-and-white warbler, chestnut-sided warbler, and white-throated sparrow. Black-and-white warblers were detected at 100 percent of all survey points; white-throated sparrows and chestnut-sided warblers were detected at 60 percent of all survey points; and American redstarts and wood thrushes were detected at 40 percent of all points.

The overall relative abundance for the site was 87.33 birds/survey. Species richness and relative abundance appeared to increase somewhat with elevation. This may be influenced by the amount of available habitat on a ridgeline compared to the amount of available habitat on the side slopes. The ridge contained larger, more mature trees that formed a canopy. The side slopes had been heavily harvested and had an abundance of small saplings with very little canopy cover.

Breeding bird surveys produce an index of relative abundance rather than a complete count of breeding bird populations at a site (Sauer et al. 1997). Breeding bird surveys are typically used to detect trends in bird populations over the course of many years. Therefore, the 2010 breeding bird survey establishes a baseline for future data comparison to any potential post-construction surveys conducted at Canton Mountain.

7.0 REFERENCES

Arnett, E. B., K. Brown, W. P. Erickson, J. Fiedler, T. H. Henry, G. D. Johnson, J. Kerns, R. R. Kolford, C. P. Nicholson, T. O' Connell, M. Piorkowkski, and R. Tankersley, Jr. 2008. Patterns of bat fatalities at wind energy facilities in North America. Journal of Wildlife Management 72: 61–78.

Brandes, D. and D. W. Ombalski. 2004. Modeling raptor migration pathways using a fluid-flow analogy. Journal of Raptor Research 38: 195−207.

Brooks, R. T., and W. M. Ford. 2005. Bat activity in a forest landscape of central Massachusetts. Northeastern Naturalist 12: 447–462

Clark, W. S. and B. K. Wheeler. 2001. A field guide to hawks of North America. Houghton Mifflin Co., Boston, Massachusetts.

DeGraaf, R. M. and M. Yamasaki. 2001. New England wildlife: habitat, natural history, and distribution. University Press of New England., Lebanon, New Hampshire.

Dunne, P., D. Sibley, and C. Sutton. 1988. Hawks in flight. Houghton Mifflin Co., Boston, Massachusetts.

Gorresen, P.M., A. C. Miles, C. M. Todd, F. J. Bonaccorso and T. J. Weller. 2008. Assessing bat detectability and occupancy with multiple automated echolocation detectors. Journal of Mammalogy 89: 11–17.

Hawk Migration Association of North America (HMANA). 2005. Hawk Migration Association of North America. Daily reporting form instructions. <http://hmana.org/documents/drf2.xls>. Accessed 1 Mar 2009.

Kusch, J., C. Weber, S. Idelberger, and T. Koob. 2004. Foraging habitat preferences of bats in relation to food supply and spatial vegetation structures in a western European low mountain range forest. Folia Zoologica 53: 113–128.

Kunz, T. H., E. B. Arnett, W. P. Erickson, A. R. Hoar, G. D. Johnson, R. P. Larkin, M. D. Strickland, R. W. Thresher, and M. D. Tuttle. 2007. Ecological impacts of wind energy development on bats: questions, research needs, and hypotheses. Frontiers in Ecology and the Environment 5: 315–324.

Kusch, J., C. Weber, S. Idelberger, and T. Koob. 2004. Foraging habitat preferences of bats in relation to food supply and spatial vegetation structures in a western European low mountain rangeforest. Folia Zoologica 53: 113–128.

Liguori, J. Hawks from every angle. 2005. Princeton University Press, Princeton, New Jersey.

Maine Department of Inland Fisheries and Wildlife (MDIFW). 2009. <http://www.maine.gov/ifw/wildlife/species/endangered_species/pdfs/specialconcernspecies.pdf>. Accessed 27 Jul 2009.

Miller, B. W. 2001. A method for determining relative activity of free flying bats using a new activity index for acoustic monitoring. Acta Chiropterologica, 3:93–105.

O'Donnell, L, C. F. J. 2000. Influence of season, habitat, temperature, and invertebrate availability on nocturnal activity of the New Zealand long-tailed bat (*Chalinolobus tuberculatus*). New Zealand Journal of Zoology 27: 207–221

O'Farrell, M. J., and W. L. Gannon. 1999. A comparison of acoustic versus capture techniques for the inventory of bats. Journal of Mammalogy 80: 24–30.

O'Farrell, M. J., B. W. Miller, and W. L. Gannon. 1999. Qualitative identification of free-flying bats using the anabat detector. Journal of Mammalogy 80: 11–23.

O'Farrell, M.J. and S.A. Shanahan. 2006. Las Vegas Wash Bat Survey 2004 –2005. Prepared for Las Vegas Wash Coordination Committee. Las Vegas, Nevada.

Racey, P. A., and S. M. Swift. 1985. Feeding ecology of *Pipistrellus pipistrellus* (Chiroptera: Vespertilionidae) during pregnancy and lactation. Journal of Animal Ecology 54: 205–215.

Sibley, D. A. 2001. The Sibley guide to bird life and behavior. Chanticleer Press, New York, USA.

Szewczak, J. M., A. Corcoran, J. P. Kennedy, T. J. Weller, P. C. Orsmbee. 2008. Echolocation call characteristics of Pacific northwest bats. Presented during the proceedings of the Bat Conservation International Acoustic Monitoring Workshop, Tulelake, California.

U.S. Geological Survey (USGS). 1998. Instructions for conducting the North American breeding bird survey. <http://www.pwrc.usgs.gov/bbs/participate/instructions.html>. Accessed 24 June 2010.

Wheeler. B.K., and W.S Clark. 1995. A photographic guide to North American raptors. Academic Press, London, England.

APPENDIX A

Avian Radar Survey Data and Report

Draft MERLIN™ Avian Radar Survey for the proposed Canton Wind Project

Data Report for April 20 – May 23, 2010

Prepared for:

Tetra Tech
451 Presumpscot Street
Portland, ME 04103

Prepared by:

DeTect, Inc
1902 Wilson Ave
Panama City, Florida 32405
USA

July 31, 2010

DeTect Inc.
detection technologies

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.

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

Summary

This report presents radar data recorded at the proposed Canton Wind Project site during spring migration (April 20 – May 23, 2010). The MERLIN avian radar system uses horizontal and vertical radars simultaneously to automatically and continuously record bird and bat activity in the vicinity of the proposed project. The Vertical Surveillance Radar (VSR) data provides both count and altitude information on targets, while the Horizontal Surveillance Radar (HSR) provides target directions.

During the spring 2010 sampling period nightly target passage rates were variable, ranging from 3.4 to 3,198.8 targets / km / hr, with a nightly average of 627.6 targets / km / hr. This was greater than the average target passage rates during days (138.2 targets / km / hr). Analysis of hourly activity verified that target passage rates were greatest at night, particularly early night (8 pm – 1 am), but a secondary activity peak around noon and 1 pm also existed.

The majority of all targets (71.6%) detected during nights of spring sampling period were well above the top of rotor swept zone (RSZ) of the proposed turbine (36 – 130 m above ground level (AGL)); fewer targets were recorded above the RSZ during days (57.5%). A total of 19.8% and 33.6% of targets were within the RSZ during nights and days, respectively, and 8.6% and 9.0% were below the RSZ during nights and days, respectively. Nightly target passage rates averaged 452.4 targets / km / hr above the RSZ, and only 122.3 and 52.9 targets / km / hr within and below the RSZ, respectively. Daily target passage rates averaged 79.8 targets / km / hr above the RSZ, and 45.9 and 12.4 targets / km / hr within and below the RSZ, respectively. The RSZ was considered the height criteria for the entire vertical radar beam, which included airspace outside (sideslope) the proposed turbines (ridge).

The vertical beam (calculation of passage rates and flight heights) collected information on biological targets from both the ridge and western side-slope airspace. The average mean target height over all nights of spring migration 2010 was 217.2 m (range 106.8 – 388.4 m) and the average median height was 157.8 m (range 46.3 – 354.1 m). Radar studies have shown that birds flying over valleys and side slopes may fly at lower elevations than birds flying directly over ridges. This may be one reason why flight heights are a little lower at Canton Mountain than other radar studies in Maine.

The average mean target height over all nights of spring sampling period was 217.2 m (range 106.8 – 388.4 m) and the average median height was 157.8 m (range 46.3 – 354.1 m). During days, the average mean target height was slightly higher at 227.1 m (range 153.7 – 688.7 m) and the average median height was 171.9 m (range 73.7 – 713.6 m). Several mean and many median heights occurred within the rotor swept zone altitudes during nights; only 3 median target heights occurred within the rotor swept zone during days.

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

As would be expected during spring migration, 90.3% of nights had target movements predominantly in the northeast direction. Radar data from the horizontal radar indicated an average target direction of northeast during both nights (41.0°) and days (42.8°). The concentration of target movements, however, was much greater during nights (average r = 0.77) than days (average r = 0.43). Target passage rates were greatest on nights providing a good south tailwind and lowest on nights with winds opposing primary target direction (north, northwest and west). Nights having rain on site during a portion of the night, and low visibility at two nearby airports, tended to have greater target passage rates. Target passage rates were greater during nights than days, but mean target heights slightly lower; direction concentration was more dispersed during days than nights.

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

Table of Contents

INTRODUCTION 1

Objectives 1

STUDY AREA 1

METHODS 4

Radar Equipment and Data Collection 4

MERLIN Avian Radar System 4

Vertical Scanning Radar (VSR) Operation 5

Horizontal Scanning Radar (HSR) Operation 8

Radar Data Collection, Processing and Analysis 11

MERLIN Avian Radar Processing Software 11

Data Analysis 12

Radar Data 12

Vertical Radar Data - Target Counts and Altitudes 12

Horizontal Radar Data - Target Directions 13

Weather Data 14

RESULTS 15

Vertical Radar 15

Targets Passage Rates Over Time 15

Altitudinal Distribution of Targets 17

Horizontal Radar 23

Target Directions 23

Weather Data 26

Target Passage Rates and Weather Associations 27

DISCUSSION 29

Literature Cited 31

Appendix A – Comparing Target Passage Rates 32

Appendix B - Glossary 37

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

Appendix C - Abbreviations 38

Appendix D – Target Counts, Passage Rates, Mean and Median Heights.....39

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

List of Figures

Figure 1. Location of MERLIN Avian Radar System at the proposed Canton Wind Project site. 2

Figure 2. MERLIN Avian Radar unit at the Canton Wind Project site. 3

Figure 3. Illustration of beam coverage of the horizontal scanning radar (HSR) and the vertical scanning radar (VSR). 5

Figure 4. Vertical radar image from the proposed Canton Wind Project site showing a high target passage rate during a 60 minute interval on the night of April 24, 2010. 6

Figure 5. Vertical radar image from the proposed Canton Wind Project site showing a low target passage rate during a 60 minute interval on the night of April 26, 2010. 7

Figure 6. Horizontal radar image from the proposed Canton Wind Project site showing a high target passage rate during a 60 minute interval on the night of May 21, 2010. 9

Figure 7. Horizontal radar image from the proposed Canton Wind Project site showing a low target passage rate during a 60 minute interval on the night of May 6, 2010. 10

Figure 8. Target passage rates at the proposed Canton Wind Project site during days and nights of the spring 2010 sampling period. 16

Figure 9. Average target passage rates at the proposed Canton Wind Project site during days and nights of the spring 2010 sampling period. 16

Figure 10. Hourly activity (average target passage rates) at the proposed Canton Wind Project site during the spring 2010 sampling period. 17

Figure 11. Average hourly target heights AGL at the proposed Canton Wind Project site during the spring 2010 sampling period 17

Figure 12. Number of targets occurring in each 50-meter increments adjusted AGL at the proposed Canton Wind Project site during the spring 2010 sampling period. 18

Figure 13. Target passage rates below, at, and above the rotor swept zone (RSZ) at the proposed Canton Wind Project site during nights of the spring 2010 sampling period. 19

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

Figure 14. Target passage rates below, at, and above the rotor swept zone (RSZ) at the proposed Canton Wind Project site during days of the spring 2010 sampling period.....20

Figure 15. Mean and median heights of targets at the proposed Canton Wind Project site during nights of the spring 2010 sampling period.....21

Figure 16. Mean and median heights of targets at the proposed Canton Wind Project site during days of the spring 2010 sampling period.....22

Figure 17. Average mean and median target heights for days, nights, and all time during the spring 2010 sampling period. 23

Figure 18. Distribution of average daily and nightly target movements at the proposed Canton Wind Project site during the spring 2010 sampling period.....24

Figure 19. Distribution of average daily and nightly target movements at the proposed Canton Wind Project site during the spring 2010 sampling period.....24

Figure 20. Distribution of daily and nightly wind directions at the proposed Canton Wind Project site during the spring 2010 sampling period.....26

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

List of Tables

Table 1. Effort of radar monitoring during the spring sampling period at the proposed Canton Wind Project site.....15

Table 2. Average direction and concentration of targets at the proposed Canton Wind Project site during the spring 2010 sampling period. 25

Table 3. Average weather conditions during days and nights at the proposed Canton Wind Project site, and low visibility observations from two nearby airports, during the spring 2010 sampling period. 27

Table 4. Characteristics of target movement at the proposed Canton Wind Project site during nights categorized by average nightly wind direction, spring 2010 sampling period.....28

Table 5. Weather characteristics and target passage rates at the proposed Canton Wind Project site during nights categorized by average target direction, spring 2010 sampling period. 28

Table 6. Average weather values at the proposed Canton Wind Project site on nights sorted by target passage rate, spring 2010 sampling period. 29

Table 7. Target counts, passage rates, mean and median heights during days of the spring 2010 sampling period. 40

Table 8. Target counts, passage rates, mean and median heights during nights of the spring 2010 sampling period. 41

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

MERLIN™ Avian Radar Survey
Data Report for April 20 – May 23, 2010

INTRODUCTION

DeTect Inc. (DeTect) was contracted by Tetra Tech to conduct an Avian Radar Survey at the proposed Canton 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 spring migration season (April 20 – May 23, 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 Wind Project is located in Oxford County in the western mountains of Maine (Project Area) (Figure 1). The Project Area is located on 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 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) (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 steep slopes with elevations from approximately 182 m to 547 m (600 ft to 1,500 ft) above sea level.

The radar unit was located within the proposed project area, and was situated on the western side slope, about 118 m (390 ft) downslope from the Canton Mountain ridge for which turbine locations are proposed (Figure 1). This location provided an elevated view of the surrounding area and was relatively unobstructed by trees, buildings, or other obstacles (Figure 2) and 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

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

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 western half of the vertical beam was scanning uphill; this difference in ground level was adjusted for in the vertical radar data.

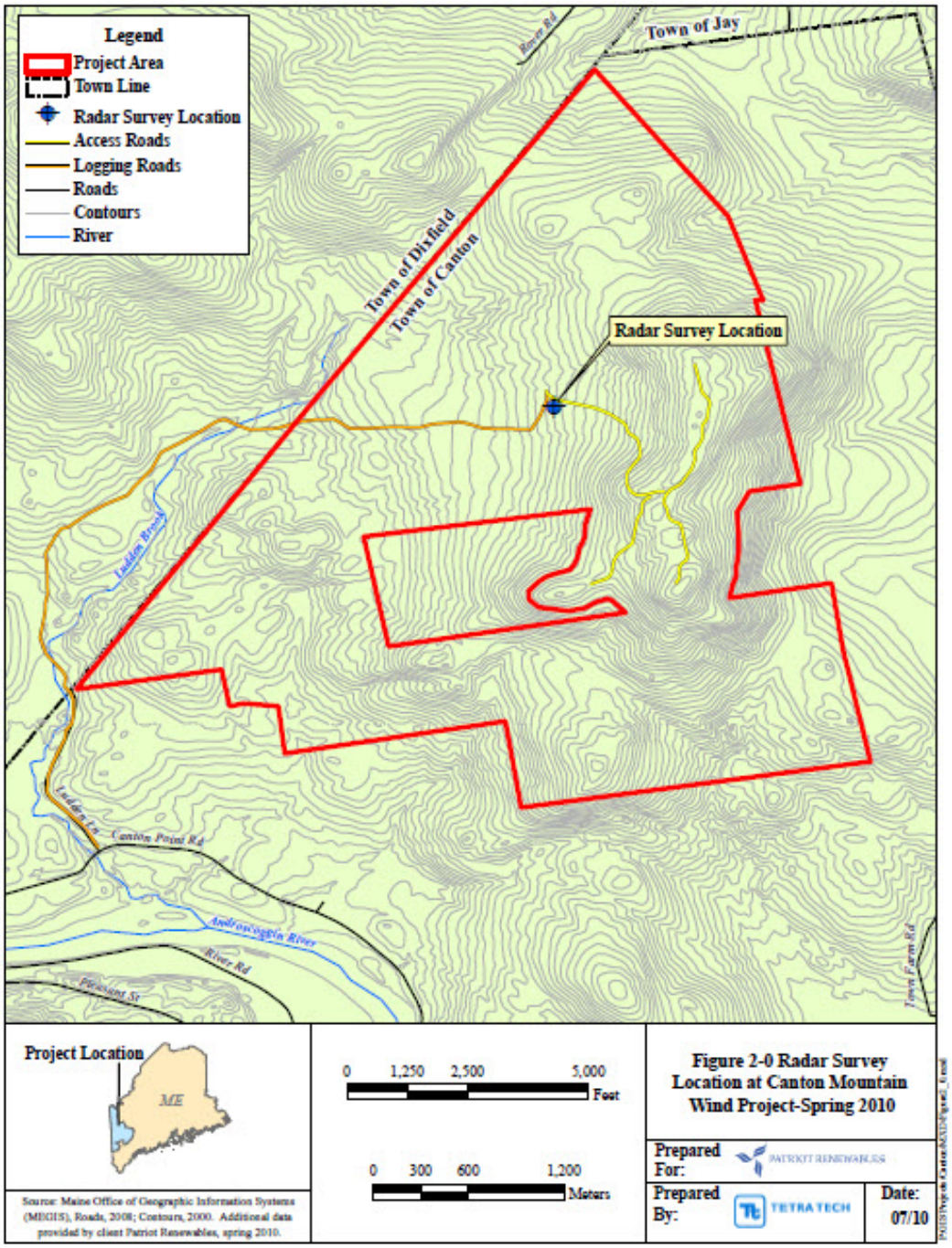


Figure 1. Location of MERLIN Avian Radar System at the proposed Canton Wind Project site.

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

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

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

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, Inc. of Panama City, Florida, specifically for bird detection and tracking. Since 2003, the MERLIN technology has also been extensively used for 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 XS2530e MERLIN Avian Radar System was used to survey the proposed Canton Wind Project site. The MERLIN radar system precisely tracks targets within avian size ranges, displays the data in real-time (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 model bird movements in the study area.

The MERLIN system used for this project has dual marine radar sensors: a 25-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 (satellite) 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 (390 ft) below the elevation of the Canton Mountain ridge for which turbine locations are proposed. This site 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

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

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 0.75nm to either side and above the radar. The VSR in this configuration outputs the lowest power density, but provides high spatial resolution data with low side lobe returns to provide optimal detection of bird targets as they pass through the study site. Since 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. The VSR data is 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 & 5 respectively.

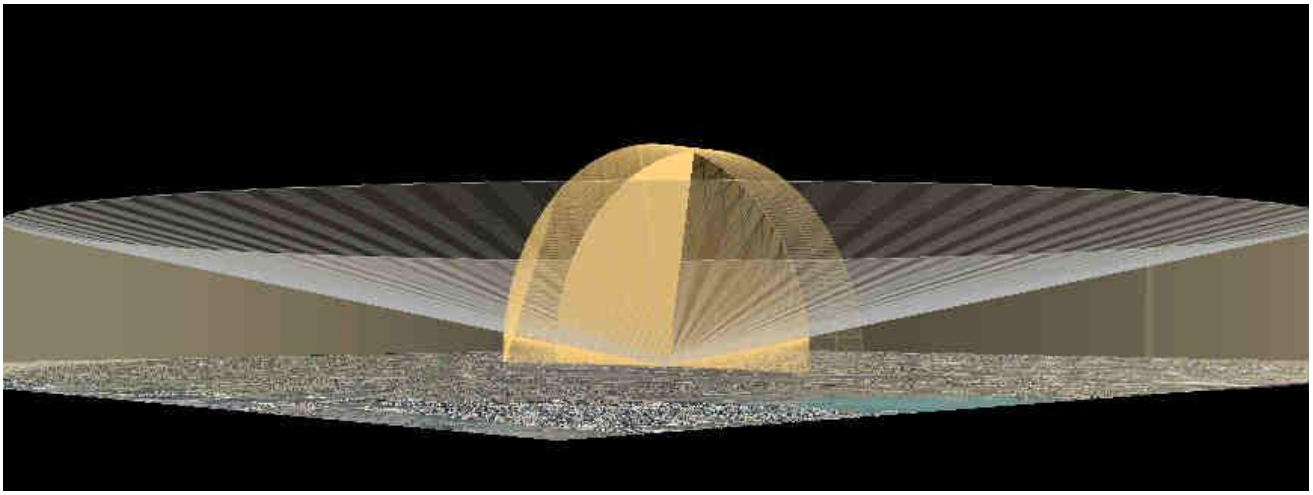
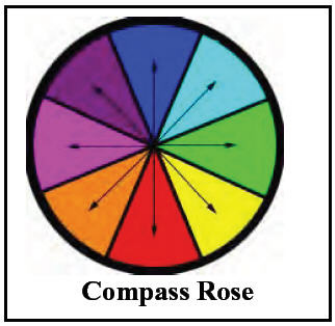


Figure 3. Illustration of beam coverage of the horizontal scanning radar (HSR) and the vertical scanning radar (VSR).

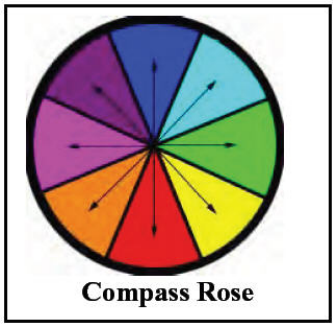
The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

Figure 4. Vertical radar image from the proposed Canton Wind Project site showing a high target passage rate during a 60 minute interval on the night of April 24, 2010. Target direction is color-coded to correspond with the compass rose below.



The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

Figure 5. Vertical radar image from the proposed Canton Wind Project site showing a low target passage rate during a 60 minute interval on the night of April 26, 2010. Target direction is color-coded to correspond with the compass rose below.



The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

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 provides highest possible spatial (range) resolution data with low side lobe returns to provide optimal detection of bird targets as they move across the study site. The HSR data is 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 & 7 respectively.

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

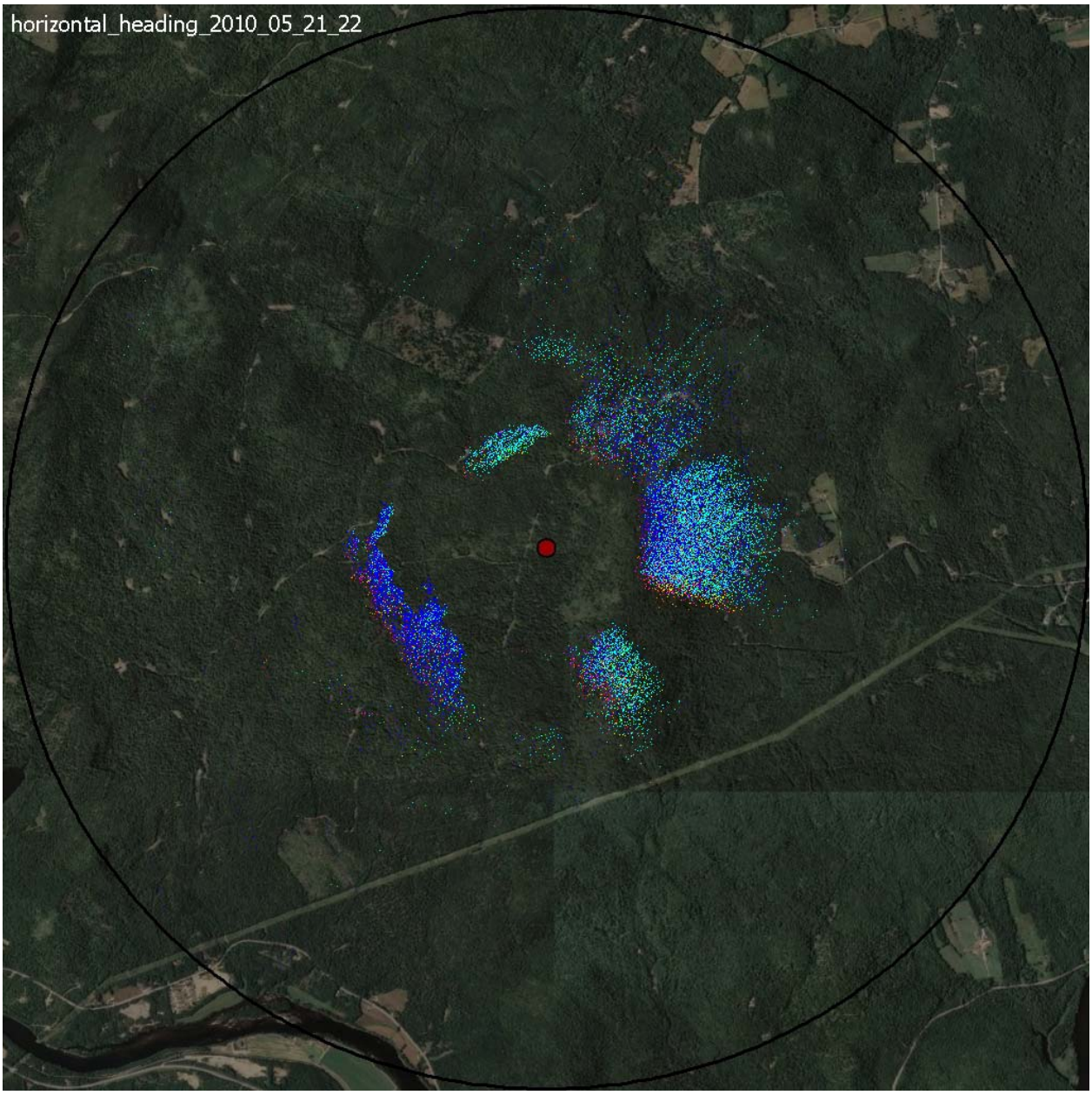
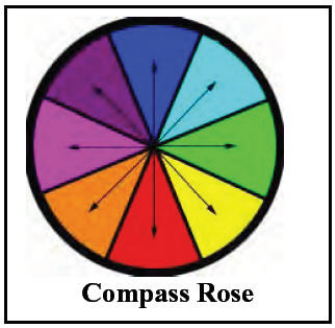


Figure 6. Horizontal radar image from the proposed Canton Wind Project site showing a high target passage rate during a 60 minute interval on the night of May 21, 2010. Target direction is color-coded to correspond with the compass rose below.



The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

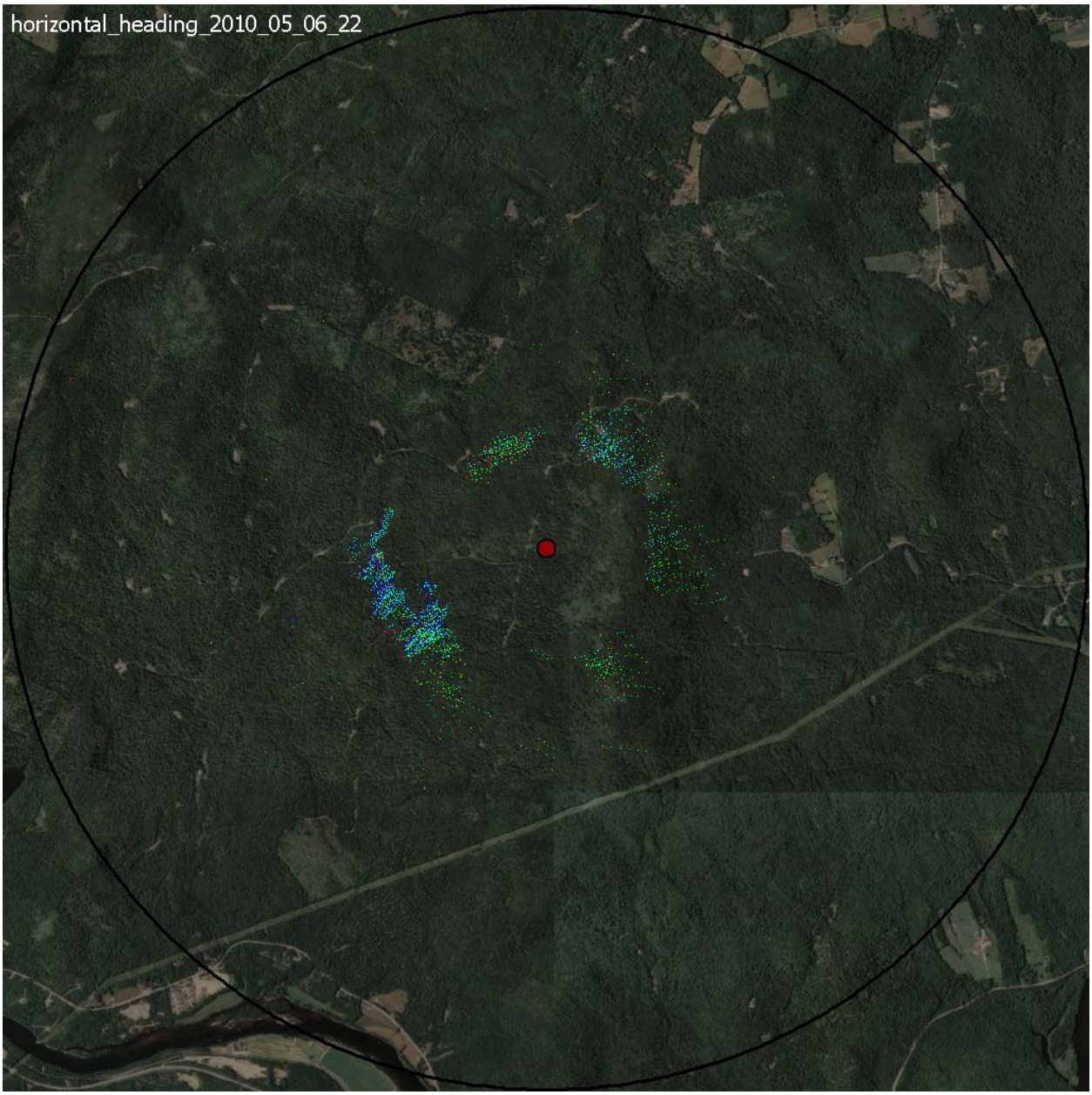
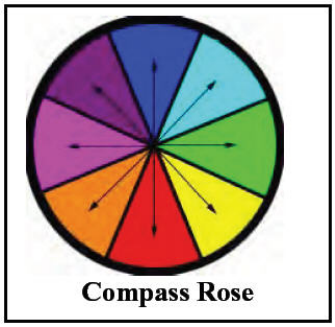


Figure 7. Horizontal radar image from the proposed Canton Wind Project site showing a low target passage rate during a 60 minute interval on the night of May 6, 2010. Target direction is color-coded to correspond with the compass rose below.



The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

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 is 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. "Raw" or unprocessed radar data from the VSR radar was also recorded in full resolution for detailed, off-site analysis, playback, and reprocessing.

All VSR and HSR target data and system metadata was written to internal system databases, and all radar data was 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 and 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 applies when

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

interpreting the screen data, but with the MERLIN software this is accomplished 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 it is 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 was minimized from the survey counts.

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 was analyzed for the spring sampling period of 2010 (April 20 – May 23). 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 was 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, etc.), 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.

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

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

(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 western 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, 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 and 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, as well as to group targets into one of three categories: below rotor swept zone, within rotor swept zone, or above rotor swept zone 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 zone (RSZ) of 36 m to 130 m AGL. The RSZ was considered the height criteria for the entire vertical radar beam, which included airspace outside (sideslope) the proposed turbines (ridge). 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 one-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 minute 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 rotor swept zone, 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 was used to develop information on the movement of targets throughout the project area. As targets were detected on the horizontal scanning radar (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)

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

and day (remaining time period), and the overall distribution plotted for all nights and days using Microsoft Office 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 was collected from the radar weather station on site. Recordings of wind speed (m/s), wind direction (16 directions), temperature (°F), and precipitation (inches) were recorded every 30 minutes and used to derive nightly and daily averages. The mean angle and angular concentration (*r*) of wind directions were calculated using Zar, 1999.

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

RESULTS

The MERLIN Avian Radar System operated continuously (24 hours a day) during the spring 2010 sampling period, from April 20 – May 23, 2010. Of the 805.0 hours available during this sampling period, 761.2 hours of vertical radar (94.6% of available time) and 738.0 hours of horizontal radar (91.8% of available time) were collected (Table 1).

The vertical (x-band) radar had additional down-time because rain blocks the smaller wavelength of this radar so few if any targets are discernable, compared to the longer wavelength of the horizontal (s-band) radar which allows almost all targets to be detected in rain with the help of digital processing. Therefore, of the 761.2 hours of vertical radar data, an additional 128.8 hours were removed because rain prevented the collection of radar data (16.9% of radar time, 16.0% of the sampling period). This left 634.3 hours of useable vertical radar data (83.3% of radar time, 78.8% of the sampling period; Table 1). Only 27.0 hours of horizontal radar data were removed because of rain (3.7% of radar time, 3.4% of the sampling period), leaving 711.9 hours of useable horizontal radar data (96.3% of radar time, 88.4% of the sampling period; Table 1).

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

	Available Time in Spring 2010 Samping Period	Time radar collected data	Radar downtime	Radar data with rain	Useable radar data
Vertical Radar (hrs)	805.0	761.2	43.8	128.8	634.3
Horizontal Radar (hrs)	805.0	738.9	66.1	27.0	711.9

Vertical Radar

Data collected from the vertical scanning radar (VSR) was used to quantify target movements through the project area. Data is 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 at the height of the rotor swept zone for this spring 2010 sampling period (Appendix D).

Targets Passage Rates Over Time

Nightly target passage rates varied throughout the spring 2010 sampling period (Figure 8), and the average nightly target passage rate was more than three times the daily passage rage (Figure 9). Nightly target passage rates ranged from 3.4 targets / km / hr to 3,198.8 targets / km / hr and averaged 627.6 targets /

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

km / hr. Daily target passage rates were lower (average 143.0 targets / km / hr) and ranged from 1.5 targets / km / hr to 502.9 targets / km / hr.

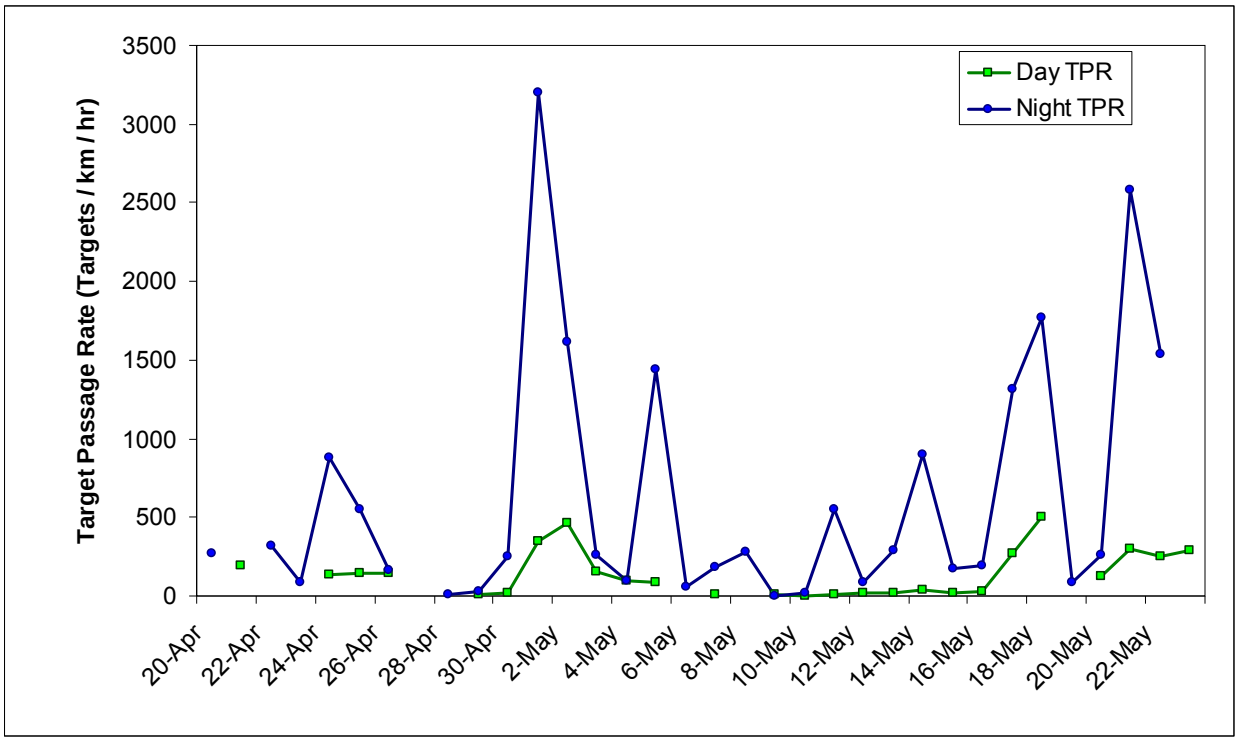


Figure 8. Target passage rates at the proposed Canton Wind Project site during days and nights of the spring 2010 sampling period.

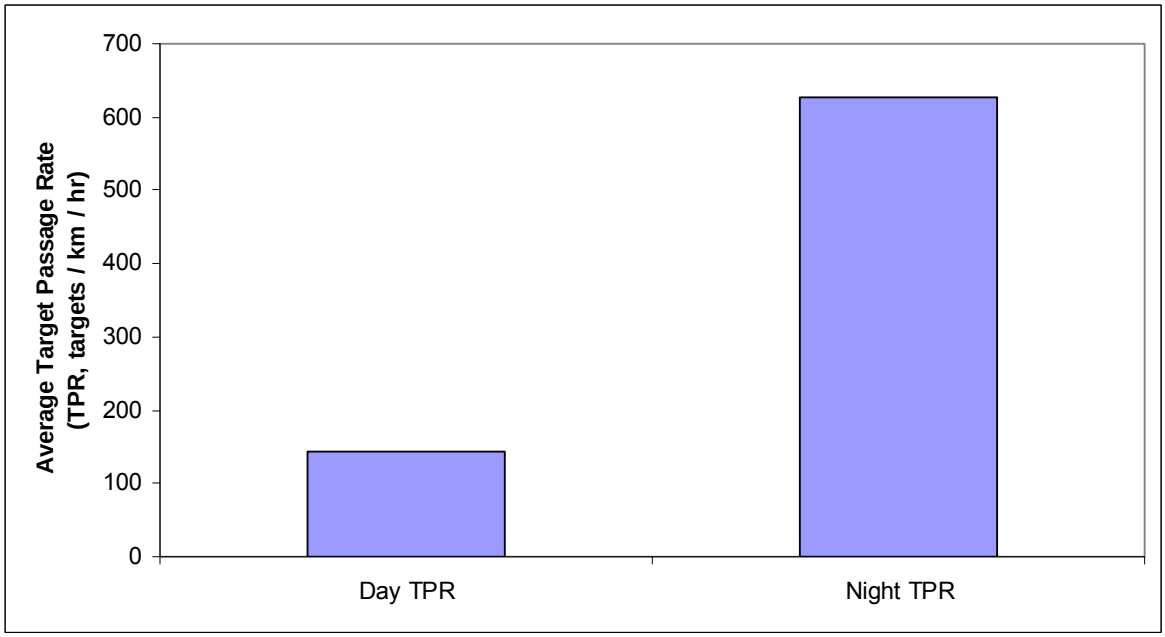


Figure 9. Average target passage rates at the proposed Canton Wind Project site during days and nights of the spring 2010 sampling period.

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

Average target passage rates also differed hourly throughout the spring 2010 sampling period (Figure 10) and were greatest during the early hours of night (hours 20 – 0, 8 pm through 1 am) with a much smaller peak around noon.

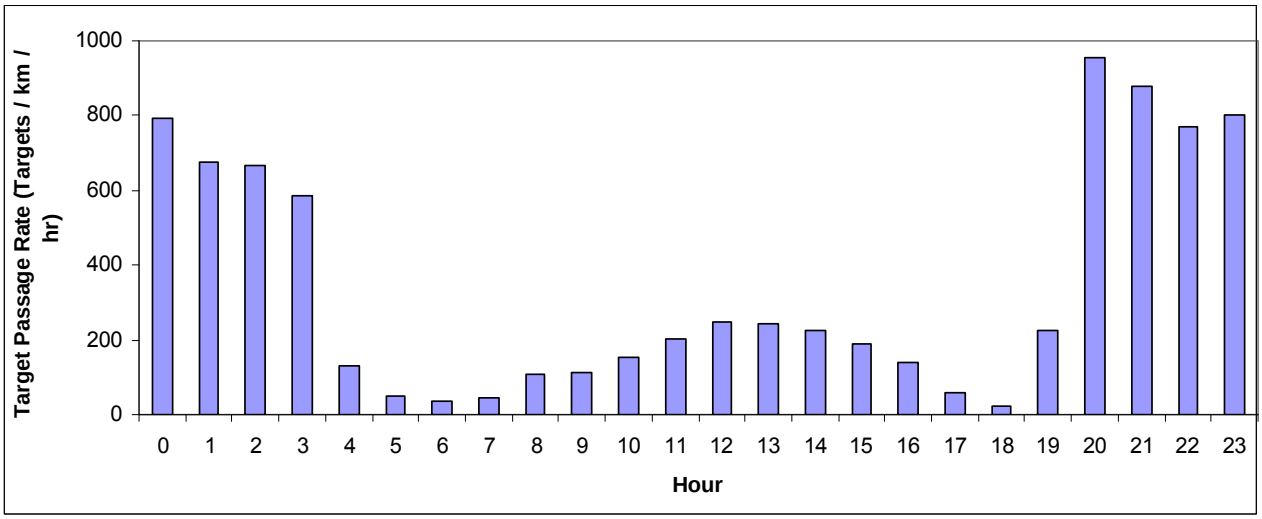


Figure 10. Hourly activity (average target passage rates) at the proposed Canton Wind Project site during the spring 2010 sampling period.

Altitudinal Distribution of Targets

Average hourly target heights varied, ranging between 157.7 m during hour 17 and 374.0 m during hour 4 (Figure 11).

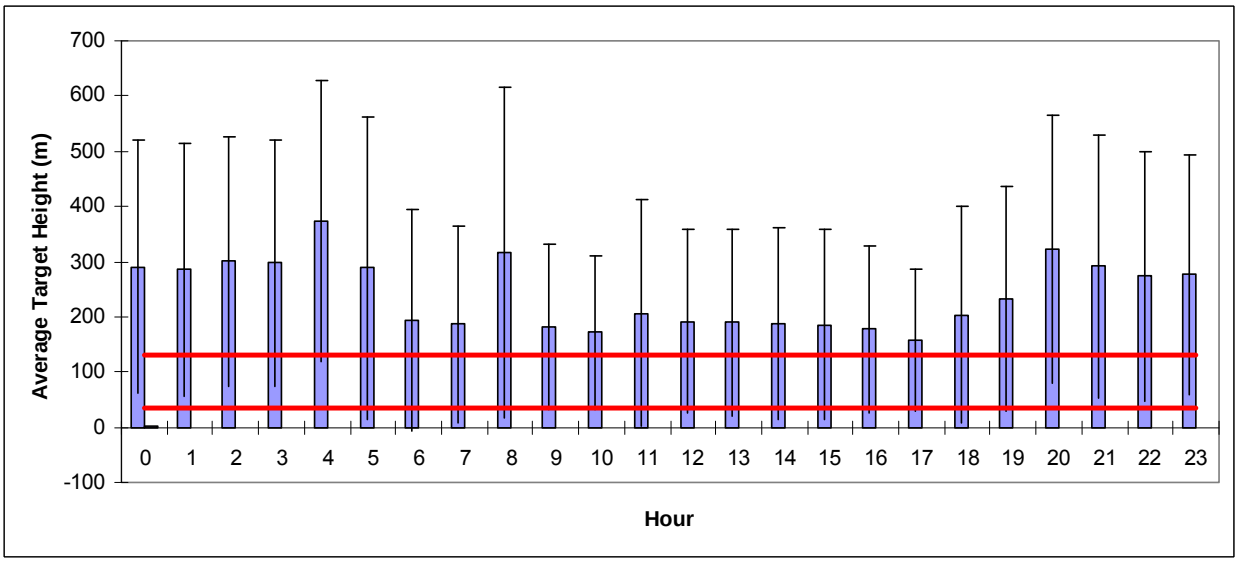


Figure 11. Average hourly target heights AGL at the proposed Canton Wind Project site during the spring 2010 sampling period. Whisker line represent one standard deviation for each hour and red lines represent the rotor swept zone (36 - 130 m AGL).

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

Most targets were generally well above the rotor swept zone during the spring 2010 sampling period (Figure 12).

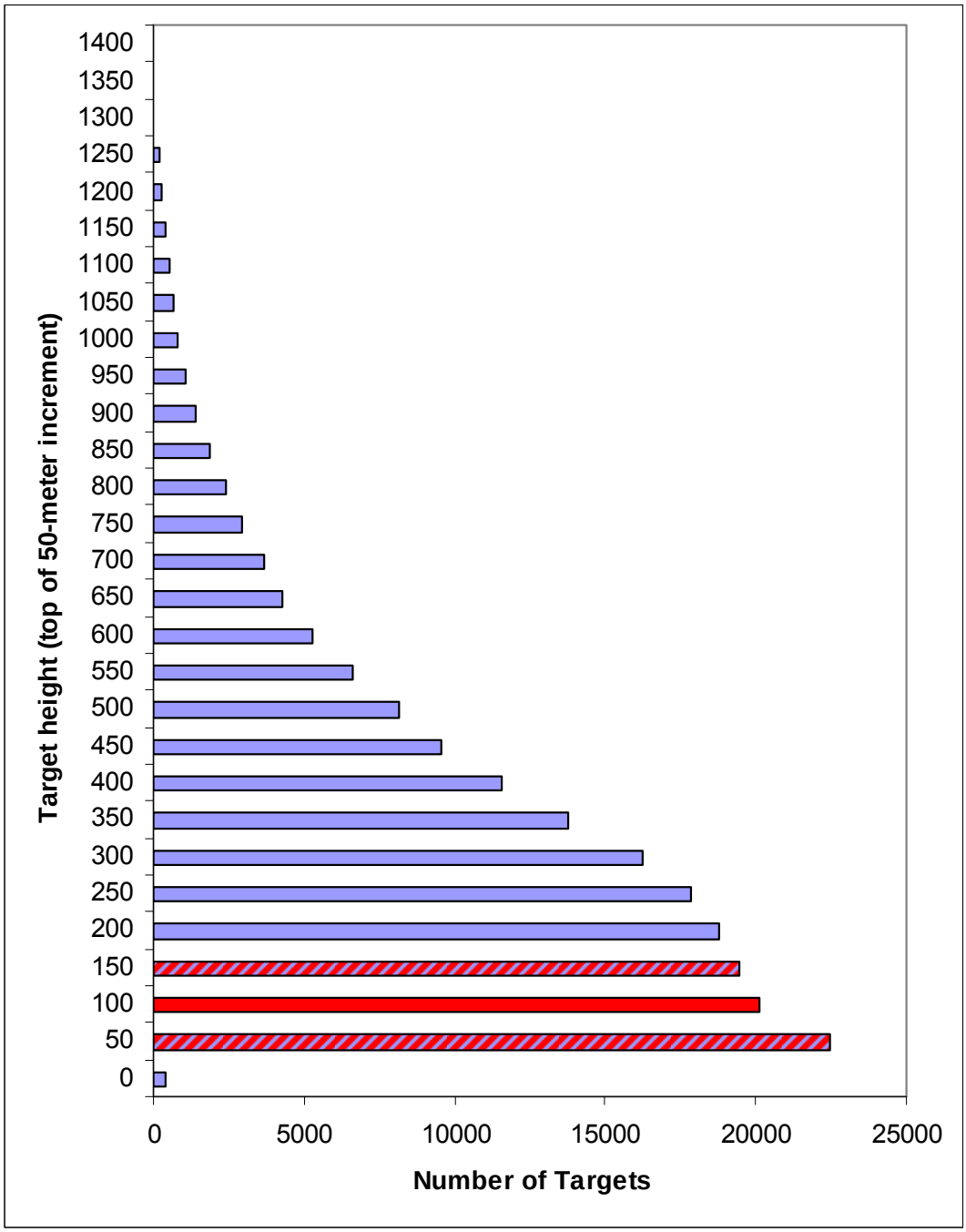


Figure 12. Number of targets occurring in each 50-meter increments adjusted AGL at the proposed Canton Wind Project site during the spring 2010 sampling period. Red indicates rotor swept heights, and red hashed indicates altitudes partially within rotor swept heights. Note: the height of the radar unit 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.

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

Nights - Targets were detected up to 1,271 m adjusted AGL, with the majority detected above the rotor swept zone (RSZ) of 36 – 130 m AGL (Figure 13). Of all targets that were detected by the vertical radar during nights of the spring 2010 sampling period, 71.6% were above the RSZ, 19.8% were within the RSZ, and 8.6% below the RSZ. Nightly percentages of targets within the RSZ ranged from a minimum of 9.4% to a maximum of 46.5%, with an average of 28.7%. Nightly target passage rates averaged 452.4 targets / km / hr above the RSZ, 122.3 targets / km / hr within the RSZ, and 52.9 targets / km / hr below the RSZ. (All nightly counts, passage rates, and percent in RSZ can be found in Appendix D).

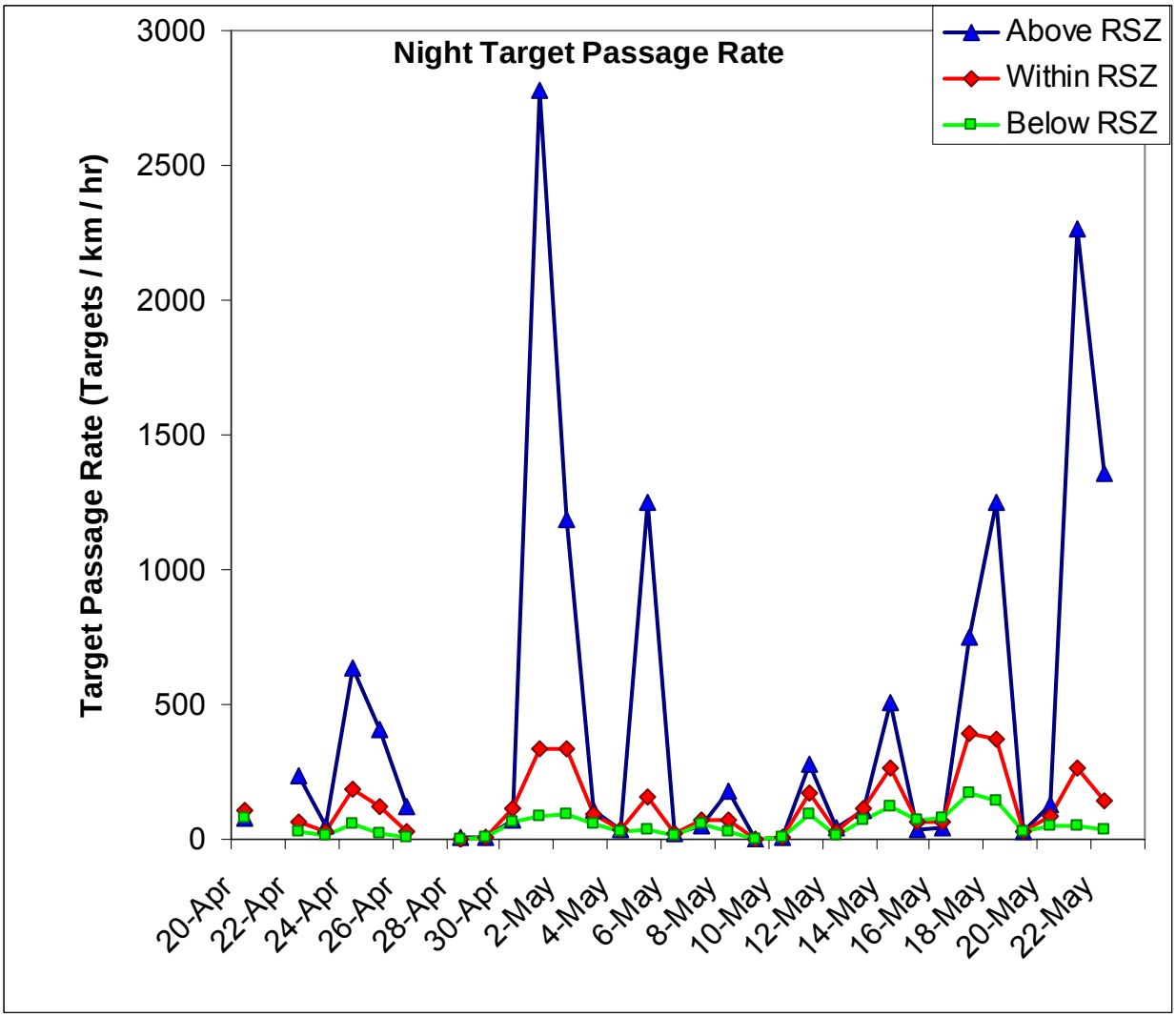


Figure 13. Target passage rates below, at, and above the rotor swept zone (RSZ) at the proposed Canton Wind Project site during nights of the spring 2010 sampling period.

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

Days - Targets were detected up to 1,271 m adjusted AGL and, similar to nights, the majority were detected above the rotor swept zone (RSZ) of 36 – 130 m AGL (Figure 14). Of all targets that were detected by the vertical radar during days of the spring 2010 sampling period, 57.4% were above the RSZ, 33.6% were within the RSZ, and 9.0% below the RSZ. Daily percentages of targets within the RSZ ranged from a minimum of 23.7% to a maximum of 47.4%, with an average of 33.1%. Daily target passage rates averaged 82.6 targets / km / hr above the RSZ, 47.6 targets / km / hr within the RSZ, and 12.8 targets / km / hr below the RSZ. (All daily counts, passage rates, and percent in RSZ can be found in Appendix D).

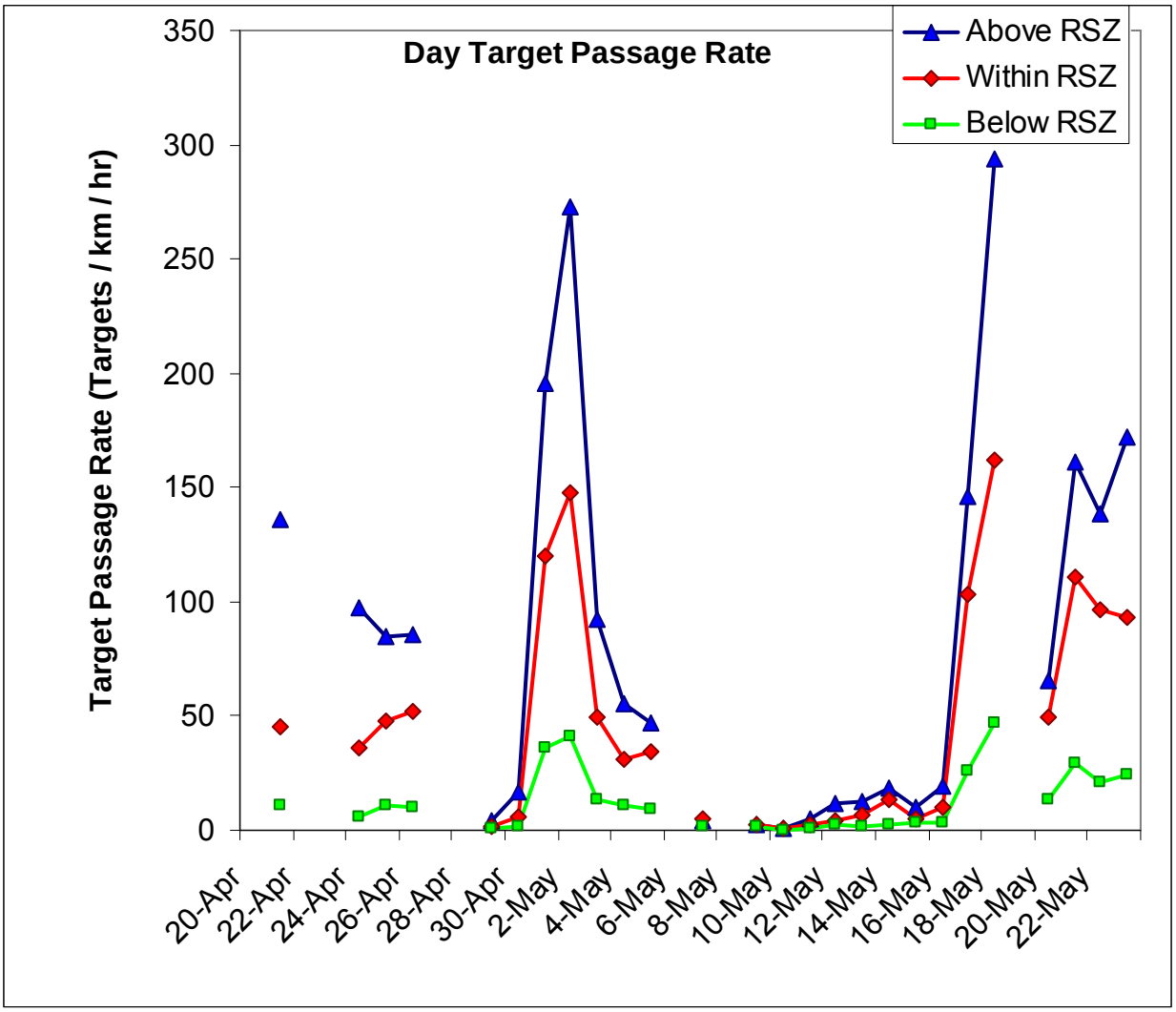


Figure 14. Target passage rates below, at, and above the rotor swept zone (RSZ) at the proposed Canton Wind Project site during days of the spring 2010 sampling period.

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

Nights - Mean target heights detected during the spring 2010 sampling period were generally above the RSZ of 36-130 m (118.1 – 426.5 ft) AGL, while many median target heights occurred within the RSZ (Figure 15). The average mean target height over all nights of the sampling period was 217.2 m (712.6 ft) AGL (range 106.8 – 388.4 m), while the average median height was 157.8 m (517.7 ft) AGL (range 46.3 – 354.1 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 291.6 m (956.7 ft) and the median target height was 240.7 (789.7 ft) (Figure 17).

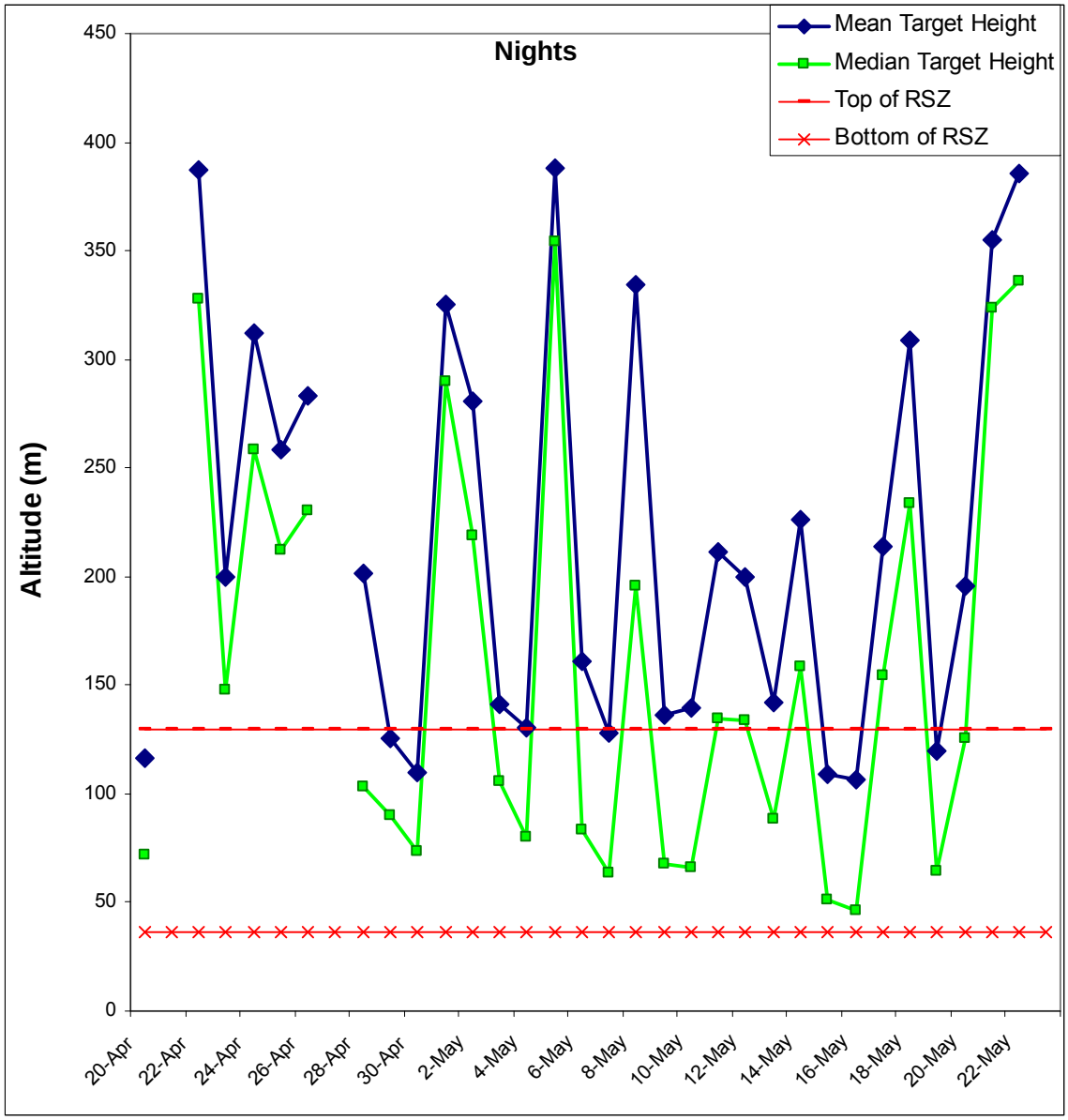


Figure 15. Mean and median heights of targets at the proposed Canton Wind Project site during nights of the spring 2010 sampling period.

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

Days - Mean and median heights of targets detected during days of the spring 2010 sampling period were generally above the RSZ of 36-130 m (118.1 – 426.5 ft) AGL except for a few medians values (Figure 16). The average mean target height over all days of the sampling period was 209.3 m (686.7 ft) AGL (range 153.7 – 372.3 m), while the average median height was 151.1 m (495.7 ft) AGL (range 73.7 – 211.5 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 198.4 m (650.9 ft) and the median target height was 152.4 (500.0 ft) (Figure 17).

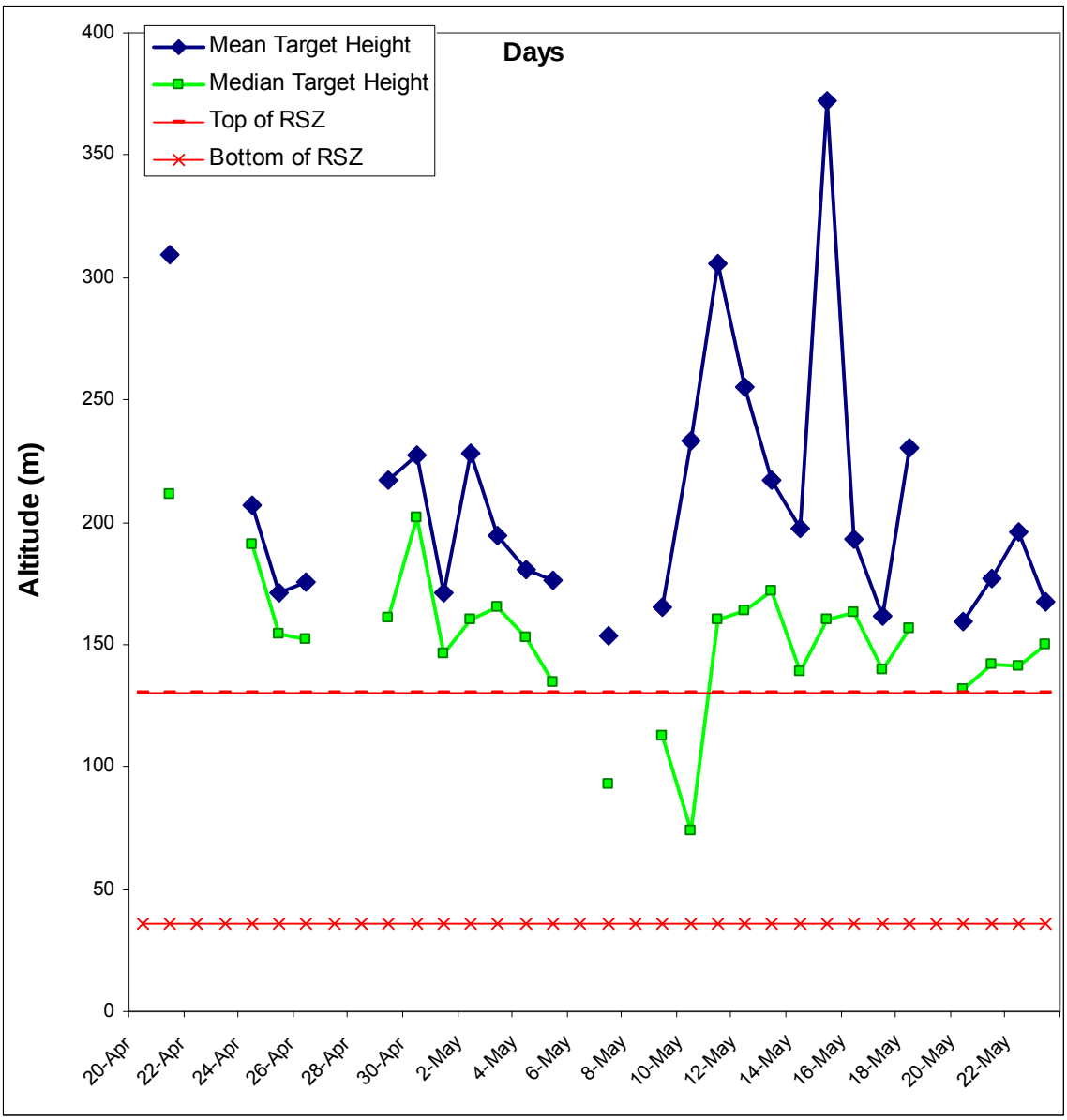


Figure 16. Mean and median heights of targets at the proposed Canton Wind Project site during days of the spring 2010 sampling period.

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

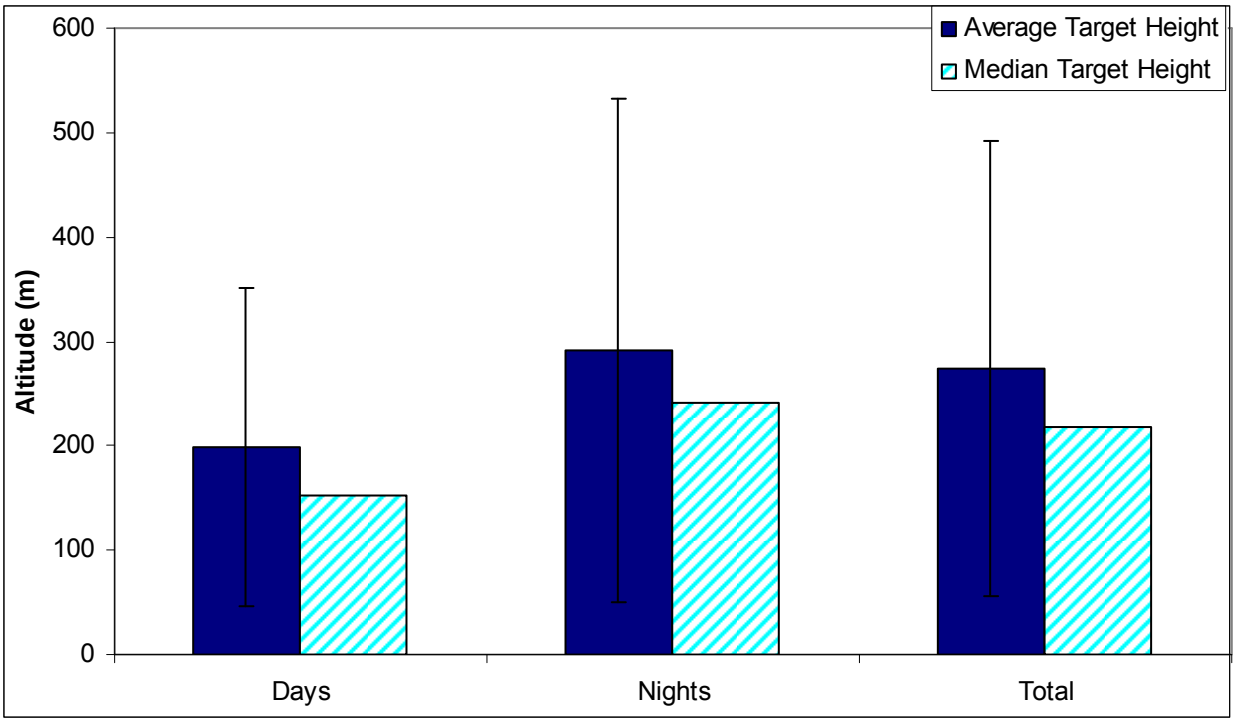


Figure 17. Average mean and median target heights for days, nights, and all time during the spring 2010 sampling period. Error bars represent one standard deviation.

Horizontal Radar

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

Target Directions

The average flight direction of all targets during nights of the sampling period was 41° (northeast), and 28 of the 31 nights with horizontal radar data (90.3%) had average target movements that were predominantly northeast (Figures 18 & 19). Daily target movements also were predominantly northeast (22 of 30 days with horizontal radar data, 73.3%) and averaged 43° (northeast). Nightly target directions were fairly concentrated (average r = 0.71), as indicated by the large portion of high angular concentration values in Table 2 (90.3% were 0.5 or higher), while the majority of daily movements were much less concentrated (average r = 0.39, 80.0% angular dispersion values were less than 0.5) indicating more dispersed movement of targets during the day.

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

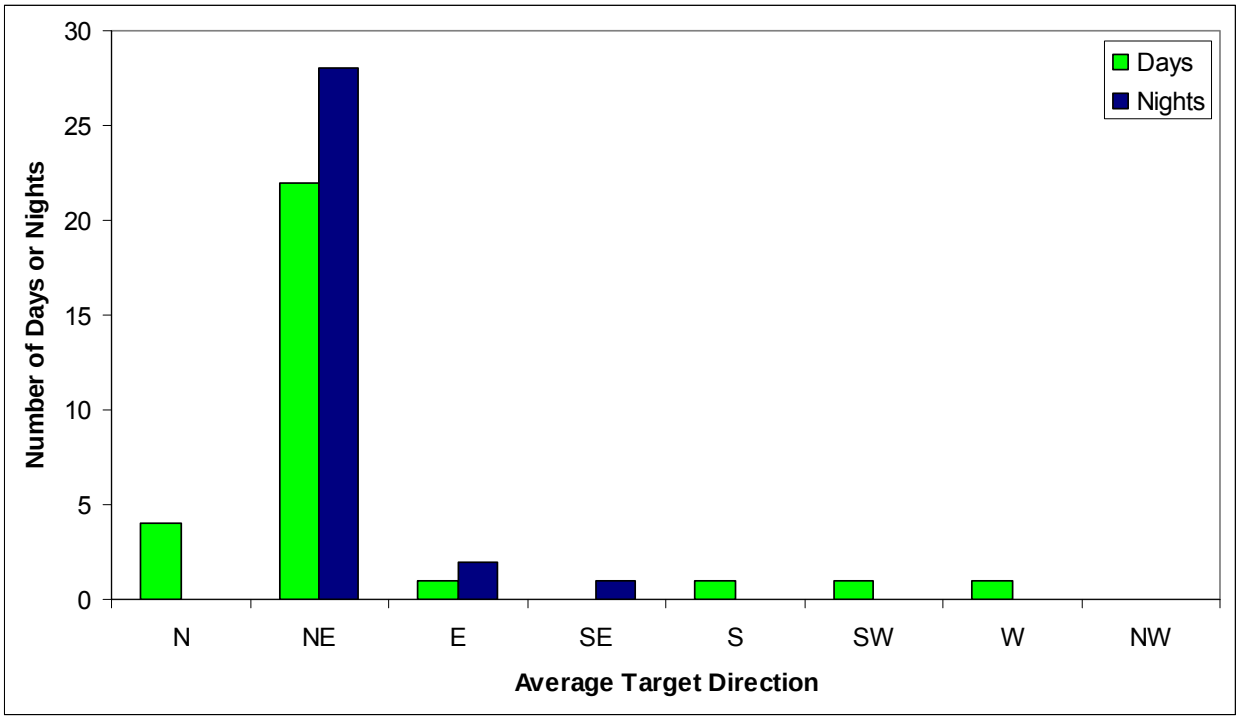


Figure 18. Distribution of average daily and nightly target movements at the proposed Canton Wind Project site during the spring 2010 sampling period.

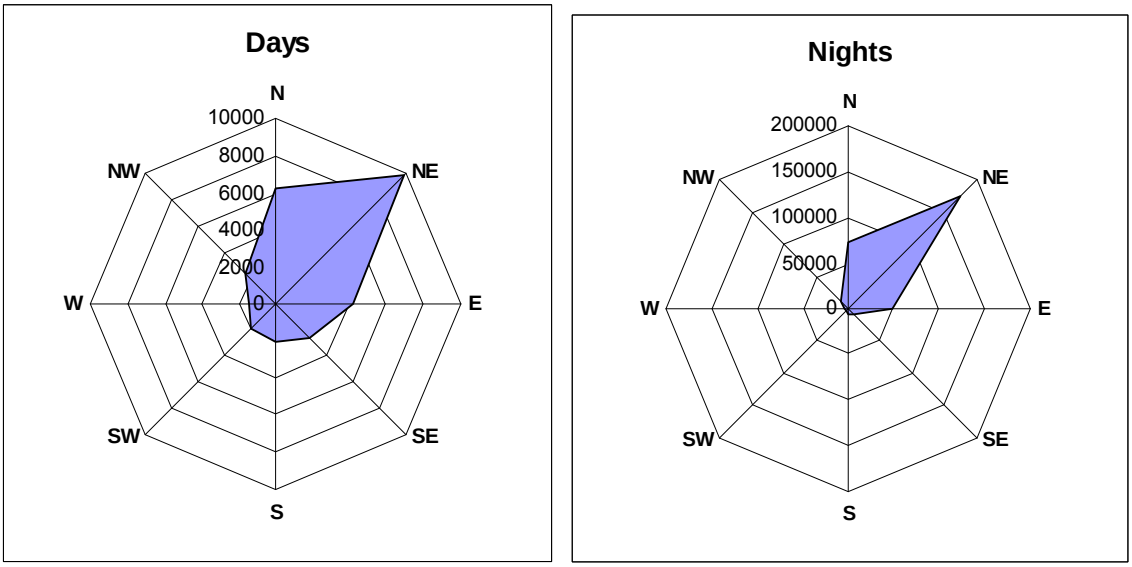


Figure 19. Distribution of average daily and nightly target movements at the proposed Canton Wind Project site during the spring 2010 sampling period.

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

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

Date	Average Bearing (Degrees)	Direction	Angular Concentration (*r*)	Average Bearing (Degrees)	Direction	Angular Concentration (*r*)
20-Apr						
21-Apr	340.3		0.24			
22-Apr	291.7		0.92	43.4	NE	0.67
23-Apr	176.7	S	0.11	74.0	E	0.61
24-Apr	41.7	NE	0.15	33.9	NE	0.81
25-Apr	20.2	N	0.14	40.4	NE	0.85
26-Apr	46.8	NE	0.10	40.8	NE	0.58
27-Apr	229.6	SW	0.23	25.5	NE	0.22
28-Apr				77.7	E	0.56
29-Apr	47.5	NE	0.20	52.3	NE	0.70
30-Apr	37.8	NE	0.41	38.8	NE	0.89
1-May	35.5	NE	0.55	29.4	NE	0.77
2-May	36.4	NE	0.70	31.7	NE	0.85
3-May	57.0	NE	0.62	47.5	NE	0.78
4-May	44.8	NE	0.45	50.6	NE	0.63
5-May	25.6	NE	0.35	27.5	NE	0.82
6-May	70.2	E	0.50	61.9	NE	0.79
7-May	26.5	NE	0.34	26.4	NE	0.72
8-May	7.5	N	0.32	40.6	NE	0.82
9-May	51.0	NE	0.37	113.7	SE	0.30
10-May	36.1	NE	0.29	50.4	NE	0.52
11-May	12.2	N	0.17	40.1	NE	0.77
12-May	33.3	NE	0.49	44.6	NE	0.43
13-May	60.9	NE	0.31	49.1	NE	0.85
14-May	25.5	NE	0.34	46.9	NE	0.79
15-May	39.6	NE	0.65	47.5	NE	0.75
16-May	46.4	NE	0.36	42.4	NE	0.75
17-May	5.7	N	0.35	35.3	NE	0.80
18-May	33.7	NE	0.65	57.7	NE	0.81
19-May	286.2	W	0.48	62.6	NE	0.74
20-May	50.8	NE	0.46	46.2	NE	0.76
21-May	25.9	NE	0.45	31.0	NE	0.87
22-May	37.3	NE	0.57	48.5	NE	0.80
23-May	36.4	NE	0.47			

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

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

Weather Data

Table 3 presents averages of wind speed, temperature, wind direction, and total precipitation during days and nights, and the presence of low visibility conditions at nearby airports during nights. Nightly wind speeds averaged 3.1 m/s (6.9 mph) and daily wind speeds averaged 5.0 m/s (11.2 mph). Average wind directions were varied but were predominantly west during both nights and days (Figure 20). Temperatures averaged 10.2° C (50.4° F) during nights and 14.4° C (58.0° F) during days. During the 34-day spring sampling period, measurable rain was collected by the radar weather station on 4 of the 20 nights with weather data and 6 of the 22 days with weather data. The vertical radar data indicated precipitation in the radar scanned area on 14 of the 31 nights with weather data and 10 of the 28 days with weather data.

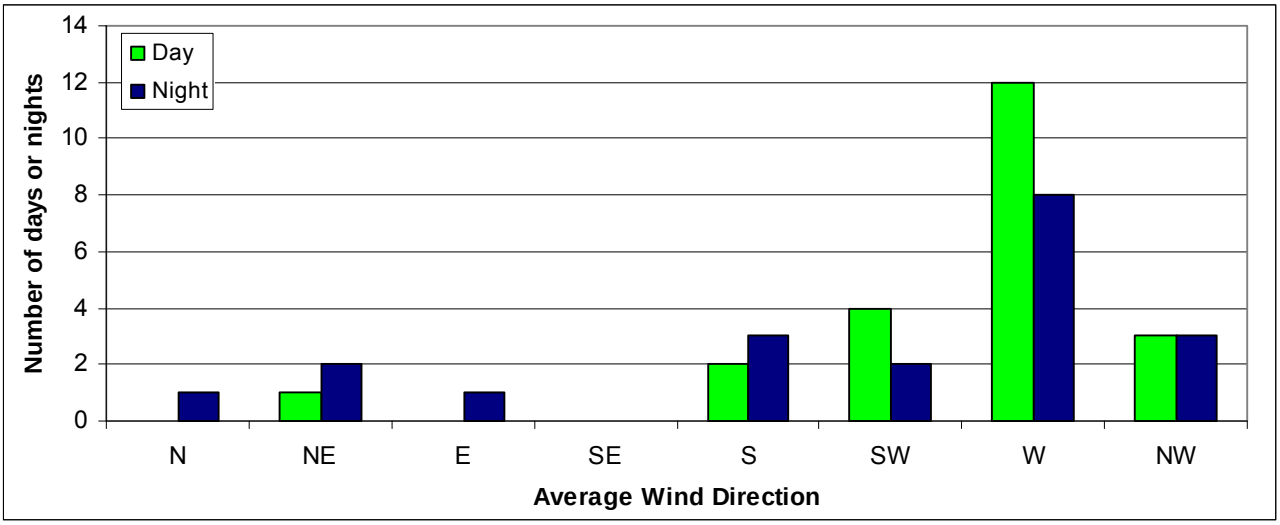


Figure 20. Distribution of daily and nightly wind directions at the proposed Canton Wind Project site during the spring 2010 sampling period.

Visibility records were accessed from two nearby airports: Auburn/Lewiston Municipal Airport (LEW, ~32 miles south, elevation 288 ft / 89 m) and Eastern Slopes Regional Airport (IZG, ~49 miles southwest, elevation 450 ft / 137 m). Low visibility occurred on portions of 2 nights at LEW and 6 nights at IZG during the 34-day spring sampling period. On these nights the percent of observations with low visibility ranged from 9.7 – 35.5% at LEW and 5.9 – 20.0% at IZG. It is important to note that visibility observations are taken more frequently during low visibility conditions, so not all observations represent equal amounts of time, and these results may be greater than if equal time were assigned to each observation. Therefore, these visibility results are likely conservative and actual percentages based on time would be lower than reported here. However, the temporal trends in visibility should be the same, despite the higher numbers of low visibility observations. Overall, these observations indicate that low visibility conditions were infrequent at the nearby airports during the spring 2010 sampling period.

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

Table 3. Average weather conditions during days and nights at the proposed Canton Wind Project site, and low visibility observations from two nearby airports, during the spring 2010 sampling period.

	Day					Night						
Date	Average Wind Speed (m/s)	Average Temperature (°F)	Average Wind Bearing	Inches of Rain	Minutes of Rain on VSR Radar	Average Wind Speed (m/s)	Average Temperature (°F)	Average Wind Bearing	Inches of Rain	Minutes of Rain on VSR Radar	% observations with low visibility	
											LEW	IZG
20-Apr	4.0	42.9	NW	0.01	107	2.4	51.7	W	0	13		
21-Apr	4.2	60.3	SW	0	15	-	-	-	-	-		
22-Apr	-	-	-	-	-	-	-	-	-	309	9.7%	9.5%
23-Apr	-	-	-	-	-	-	-	-	-	24		
24-Apr	-	-	-	-	0	-	-	-	-	0		
25-Apr	-	-	-	-	0	-	-	-	-	0		
26-Apr	-	-	-	-	0	-	-	-	-	38		
27-Apr	-	-	-	-	-	-	-	-	-	-		
28-Apr	-	-	-	-	-	-	-	-	-	123		
29-Apr	9.9	39.7	W	0	255	6.9	44.9	W	0	0		
30-Apr	10.0	58.9	W	0	0	2.4	52.5	W	0	0		
1-May	4.2	69.7	W	0	31	0.4	61.5	S	0.02	209		
2-May	2.1	75.4	S	0.02	30	0.4	71.2	S	0	0		
3-May	5.4	77.3	SW	0	135	8.2	64.5	W	0	0		
4-May	3.7	65.1	W	0.14	319	5.7	54.9	W	0	56		
5-May	5.5	68.4	W	0	0	0.9	58.2	S	0	0		
6-May	4.6	57.5	SW	0.37	345	11.3	49.5	W	0.01	30		
7-May	8.6	55.2	W	0	0	1.3	46.8	W	0.12	307		
8-May	0.9	42.6	SW	0.37	-	2.7	41.0	SW	0.04	96		
9-May	11.3	41.6	W	0.01	0	8.0	35.4	W	0	0		
10-May	5.9	38.9	W	0	0	1.4	33.4	NW	0	0		
11-May	4.2	51.9	NW	0	0	1.7	41.8	NE	0	0		13.8%
12-May	2.5	56.5	NW	0	0	1.8	42.4	NE	0	0		
13-May	5.5	58.2	W	0	0	1.2	49.8	NW	0	0		
14-May	2.6	59.1	W	0	0	0.7	51.4	SW	0	15		9.1%
15-May	5.6	59.2	W	0	255	1.2	50.3	NW	0	15		
16-May	6.2	63.4	W	0	0	1.7	52.5	N	0	0		
17-May	2.2	69.5	NE	0	0	1.8	53.8	E	0	0		5.9%
18-May	1.7	65.3	S	0	155	-	-	-	-	230		
19-May	-	-	-	-	-	-	-	-	-	54		9.1%
20-May	-	-	-	-	0	-	-	-	-	0		
21-May	-	-	-	-	0	-	-	-	-	0		
22-May	-	-	-	-	0	-	-	-	-	0	35.5%	20.0%
23-May	-	-	-	-	0	-	-	-	-	-		

Target Passage Rates and Weather Associations

Target passage rates were the greatest on nights with winds out of the east and the south (Table 4), and were moderately inversely correlated with wind speed (r = -0.44). Ninety percent of individual nights had target movements averaging northeast, and when nights were grouped by average wind direction, nightly target directions averaged northeast. The average target concentration ranged from 0.60 when wind directions were from the northeast and west, to a maximum of 0.81 when winds were from the south (Table 4).

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

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

Wind Direction	N	NE	E	SE	S	SW	W	NW
# nights	1	2	1	0	3	2	8	3
Average Target Passage Rate (targets/km/hr)	190.5	315.0	1314.5	-	2084.5	590.3	143.3	161.5
Average Target Bearing (degrees)	42.4	42.3	35.3	-	29.5	43.7	54.7	49.0
Corresponding Target Direction	NE	NE	NE	-	NE	NE	NE	NE
Concentration of Average Target Bearings	0.75	1.00	0.80	-	1.00	1.00	0.91	1.00
Average Angular Concentration of Targets	0.75	0.60	0.80	-	0.81	0.80	0.60	0.71

When nights were grouped by average target direction, target passage rates were by far the greatest during nights with northeast movements (Table 5). On nights with target directions averaging other than northeast, target passage rates were much lower.

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

Target Direction	N	NE	E	SE	S	SW	W	NW
# nights	0	28	2	1	0	0	0	0
Average Target Passage Rate (targets/km/hr)	-	706.9	49.3	3.4	-	-	-	-
Average Angular Concentration of Targets	-	0.73	0.59	0.30	-	-	-	-
Average Wind Direction (degrees)	-	270.8	-	274.0	-	-	-	-
Corresponding Wind Direction	-	W	-	W	-	-	-	-
Concentration of Average Wind Bearings	-	0.41	-	1.00	-	-	-	-
Average Angular Concentration of Wind	-	0.75	-	0.99	-	-	-	-
Average Wind Speed (m/s)	-	2.9	-	8.0	-	-	-	-
Average Temperature (°C)	-	51.1	-	35.4	-	-	-	-
% nights with either rain or low visibility	-	50%	-	0%	-	-	-	-

Rain and low visibility occurred more frequently on nights with greater target passage rates (Table 6).

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

Table 6. Average weather values at the proposed Canton Wind Project site on nights sorted by target passage rate, spring 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	Inches of Rain	Minutes of Rain on VSR Radar	% observations with low visibility	
								LEW	IZG
1-May	3198.8	335.2	0.4	61.5	S	0.02	209		
21-May	2585.1	265.6	-	-	-	-	0		
18-May	1770.8	375.0	-	-	-	-	230		
2-May	1612.3	336.1	0.4	71.2	S	0	0		
22-May	1541.6	145.0	-	-	-	-	0	35.5%	20.0%
5-May	1442.3	155.5	0.9	58.2	S	0	0		
17-May	1314.5	389.6	1.8	53.8	E	0	0		5.9%
14-May	896.9	267.3	0.7	51.4	SW	0	15		9.1%
24-Apr	877.7	186.7	-	-	-	-	0		
25-Apr	548.2	119.1	-	-	-	-	0		
11-May	546.5	173.1	1.7	41.8	NE	0	0		13.8%
22-Apr	322.8	62.6	-	-	-	-	309	9.7%	9.5%
13-May	292.3	111.6	1.2	49.8	NW	0	0		
8-May	283.7	72.2	2.7	41.0	SW	0.04	96		
20-Apr	266.6	108.2	2.4	51.7	W	0	13		
20-May	260.9	85.9	-	-	-	-	0		
3-May	257.0	94.8	8.2	64.5	W	0	0		
30-Apr	248.9	115.7	2.4	52.5	W	0	0		
16-May	190.5	64.5	1.7	52.5	N	0	0		
7-May	183.1	73.3	1.3	46.8	W	0.12	307		
15-May	173.4	65.2	1.2	50.3	NW	0	15		
26-Apr	160.3	30.6	-	-	-	-	38		
4-May	101.2	37.1	5.7	54.9	W	0	56		
19-May	90.4	30.4	-	-	-	-	54		9.1%
23-Apr	87.6	25.7	-	-	-	-	24		
12-May	83.6	25.1	1.8	42.4	NE	0	0		
6-May	57.5	18.4	11.3	49.5	W	0.01	30		
29-Apr	28.3	9.9	6.9	44.9	W	0	0		
10-May	18.9	5.9	1.4	33.4	NW	0	0		
28-Apr	11.0	3.5	-	-	-	-	123		
9-May	3.4	1.5	8.0	35.4	W	0	0		
21-Apr	-	-	-	-	-	-	-		
27-Apr	-	-	-	-	-	-	-		
23-May	-	-	-	-	-	-	-		

DISCUSSION

This radar survey collected near-continuous data from the proposed Canton Wind Project site from April 20 – May 23, 2010, during the spring migration season. Radar data was collected during 94.6% of available time for the vertical radar and 91.8% of available time for the horizontal radar. Rain obscuration made some of this radar data unusable, decreasing data collection during the sampling period to 78.8% and 88.4% of available time for the vertical and horizontal radars respectively.

Nightly target passage rates varied, ranging from 3.4 – 3,198.8 targets / km / hr and averaging 627.6 targets / km / hr during the spring sampling period. Target passage rates during daytime were generally lower with an average of 138.2 targets / km / hr, and ranged from 1.5 to 502.9 targets / km / hr. When separated into 24 hours of the day, hourly target passage rates were greatest during hours

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

20 – 0 (8 pm – 1 am, Figure 10). The nights with the five greatest target passage rates at this site occurred throughout the month of May, on May 1, 2, 18, 21, and 22.

The overall mean and median flights were slightly lower than other regional radar studies but the majority of flight heights were still above the rotor swept zone (130 meters). Most importantly, on days with the greatest magnitude of migration, flight heights were even greater than the mean and median heights reported. The vertical beam (calculation of both passage rates and flight heights) collected information on biological targets from both the ridge and western side-slope airspace. Radar studies have shown that birds flying over valleys and side slopes may fly at lower elevations than birds flying directly over ridges. This may be one reason why flight heights were a little lower at Canton Mountain than other nearby radar studies. The lower flight heights observed at Canton Mountain may also be attributable to: lower elevation of Canton Mountain, the juxtaposition of Canton Mountain and the surrounding lower elevation mountains, and/or the Androscoggin river valley south of the project area.

Mean target heights were unexpectedly greater during days than nights (227.1 and 217.2 m AGL respectively), as were median target heights (171.9 m and 157.8 m AGL respectively). Nighttime had a more extreme range in target height means and medians than days. This may be a result of nights with greater migration driving up target heights and nights without migration having mostly low levels of low altitude movements. This is supported by a positive correlation between mean target heights and target passage rates during nights ($r = 0.66$). A moderately inverse correlation between mean target heights and target passage rates during days ($r = -0.24$) is indicative of daily local movements, where higher activity levels occurred at lower altitudes.

Target passage rates were greatest on nights providing a good south tailwind to the predominantly northeasterly target movement, although a relatively high target passage rates also occurred on the one night with winds from the east. Nights with winds from the north, northwest, and west (directions generally opposing spring migration movements) had the lowest average target passage rates. Target passage rates were moderately inversely correlated with wind speed, meaning target passage rates were greater on nights with lower wind speeds. Nights with rain on site and low visibility at two nearby airports also tended to have greater target passage rates.

The majority of all targets (71.6%) detected during nights of the spring 2010 sampling period were above the top of rotor swept zone (RSZ) of the proposed turbine; fewer targets were recorded above the rotor swept height during days (57.5%). Several means and many median target heights occurred within the rotor swept zone heights during nights, although mean and median target heights were quite variable throughout the sampling period. Only three median target heights occurred within the rotor swept zone during days.

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

Literature Cited

Cooper, B. A., R. H. Day, R. J. Ritchie, and C. L. Cranor. 1991. An improved marine radar system for studies of bird migration. Journal of Field Ornithology 62: 367-377.

Harmata, A. R., K. M. Podruzny, J. R. Zelenak, and M. L. Morrison. 1999. Using marine surveillance radar to study bird movements and impact assessment. Wildlife Society Bulletin 27:44-52.

Kerlinger, P. and F. R. Moore. 1989. Atmospheric structure and avian migration. Pages 109 – 141 *in* D. M. Power editor. Current Ornithology, Vol. 6. Plenum Press, New York, USA.

Manville, A. M. II. 2005. Bird strikes and electrocutions at power lines, communication towers, and wind turbines: state of the art and state of the science – next steps towards mitigation. Bird Conservation Implementation in the Americas: Proceedings of the third International Partners in Flight Conference 2002, C.J. Ralph and T.D. Rich, editors. U.S.D.A., Forest Service General Technical Report GTR-PSW-191.

Morrison, M. L. 2006. Bird movements and behaviors in the Gulf Coast Region: relation to potential wind-energy developments. NREL/SR-500-39572. Golden, Colorado, USA.

Zar, J. H. 1999. Biostatistical Analysis. Fourth edition. Prentice-Hall, Englewood Cliffs, New Jersey, USA.

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

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 ABR and 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 digitize the data manually 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 between 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 typically records higher counts.

Higher resolution data

The MERLIN system uses a radar computer interface (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 to 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

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

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 to 4,096 samples in one rotation of the antenna. So 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 is 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 is part of an increasing or decreasing trend, the extrapolation may result in a significant difference between the estimated and actual number. Therefore, sampled data 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 is 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

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

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 as the high dynamic range of the data (typically 4,096 levels) makes 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 when 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

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

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 dependant 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 would likely create artificially low passage rates and ignore 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 Systems 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-

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

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, 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.

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

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 was 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.

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

Appendix C - Abbreviations

AGL – Above Ground Level

HSR – Horizontal Scanning Radar

km – kilometer

m – meter

mi – mile

nm – Nautical miles (approximately 1.15 miles)

RSA – Rotor Swept Area

RSZ – Rotor Swept Zone

VSR – Vertical Scanning Radar

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

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

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

Table 7. Target counts, passage rates, mean and median heights during days of the spring 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)
4/20/10 5:34	4/20/10 17:47	733	103	107	55	7.5%	1	7	36	44	1.1	7.6	39.3	48.0	15.9%	225.6	214.8
4/21/10 5:32	4/21/10 17:48	736	593	15	578	78.5%	103	439	1312	1854	10.7	45.6	136.2	192.5	23.7%	309.1	211.5
4/22/10 5:31	4/22/10 17:50	739															
4/23/10 5:29	4/23/10 17:51	742															
4/24/10 5:27	4/24/10 17:52	745	745	0	745	100.0%	73	453	1213	1739	5.9	36.5	97.7	140.1	26.0%	206.8	190.8
4/25/10 5:26	4/25/10 17:53	747	747	0	747	100.0%	138	594	1054	1786	11.1	47.7	84.7	143.5	33.3%	171.2	154.5
4/26/10 5:24	4/26/10 17:54	750	750	0	750	100.0%	128	653	1072	1853	10.2	52.2	85.8	148.2	35.2%	175.5	152.1
4/27/10 5:23	4/27/10 17:56	753															
4/28/10 5:21	4/28/10 17:57	756															
4/29/10 5:20	4/29/10 17:58	758	758	255	503	66.4%	8	17	36	61	1.0	2.0	4.3	7.3	27.9%	217.3	161.2
4/30/10 5:18	4/30/10 17:59	761	761	0	761	100.0%	22	74	209	305	1.7	5.8	16.5	24.0	24.3%	227.6	201.7
5/1/10 5:17	5/1/10 18:01	764	764	31	733	95.9%	446	1471	2389	4306	36.5	120.4	195.6	352.5	34.2%	171.2	146.6
5/2/10 5:15	5/2/10 18:02	767	767	30	737	96.1%	501	1813	3352	5666	40.8	147.6	272.9	461.3	32.0%	228.0	160.0
5/3/10 5:14	5/3/10 18:03	769	769	135	634	82.4%	146	520	978	1644	13.8	49.2	92.6	155.6	31.6%	194.7	165.5
5/4/10 5:12	5/4/10 18:04	772	772	319	453	58.7%	83	235	417	735	11.0	31.1	55.2	97.4	32.0%	180.9	152.7
5/5/10 5:11	5/5/10 18:05	774	743	0	743	96.0%	119	428	580	1127	9.6	34.6	46.8	91.0	38.0%	176.1	134.7
5/6/10 5:10	5/6/10 18:07	777	777	525	252	32.4%	11	17	55	83	2.6	4.0	13.1	19.8	20.5%	688.7	713.6
5/7/10 5:08	5/7/10 18:08	780	780	0	780	100.0%	27	64	55	146	2.1	4.9	4.2	11.2	43.8%	153.7	92.8
5/8/10 5:07	5/8/10 18:09	782															
5/9/10 5:06	5/9/10 18:10	784	784	0	784	100.0%	18	30	34	82	1.4	2.3	2.6	6.3	36.6%	164.9	112.4
5/10/10 5:05	5/10/10 18:11	786	786	0	786	100.0%	4	9	6	19	0.3	0.7	0.5	1.5	47.4%	233.6	73.7
5/11/10 5:03	5/11/10 18:13	790	790	0	790	100.0%	15	30	61	106	1.1	2.3	4.6	8.1	28.3%	305.4	160.4
5/12/10 5:02	5/12/10 18:14	792	792	0	792	100.0%	32	58	150	240	2.4	4.4	11.4	18.2	24.2%	255.3	164.1
5/13/10 5:01	5/13/10 18:15	794	794	0	794	100.0%	27	85	167	279	2.0	6.4	12.6	21.1	30.5%	217.0	171.6
5/14/10 5:00	5/14/10 18:16	796	796	0	796	100.0%	36	175	240	451	2.7	13.2	18.1	34.0	38.8%	197.1	138.9
5/15/10 4:59	5/15/10 18:17	798	798	255	543	68.0%	33	47	94	174	3.6	5.2	10.4	19.2	27.0%	372.3	160.3
5/16/10 4:58	5/16/10 18:18	800	800	0	800	100.0%	45	139	259	443	3.4	10.4	19.4	33.2	31.4%	193.2	162.7
5/17/10 4:57	5/17/10 18:19	802	802	0	802	100.0%	349	1376	1948	3673	26.1	102.9	145.7	274.8	37.5%	161.4	139.9
5/18/10 4:56	5/18/10 18:20	804	802	155	649	80.7%	510	1755	3175	5440	47.1	162.2	293.5	502.9	32.3%	230.4	156.3
5/19/10 4:55	5/19/10 18:21	806															
5/20/10 4:54	5/20/10 18:23	809	809	0	809	100.0%	184	670	882	1736	13.6	49.7	65.4	128.8	38.6%	159.4	131.9
5/21/10 4:53	5/21/10 18:24	811	811	0	811	100.0%	400	1493	2176	4069	29.6	110.5	161.0	301.0	36.7%	176.6	141.7
5/22/10 4:52	5/22/10 18:25	813	813	0	813	100.0%	279	1312	1872	3463	20.6	96.8	138.2	255.6	37.9%	195.9	140.8
5/23/10 4:51	5/23/10 18:26	815	489	0	489	60.0%	197	761	1404	2362	24.2	93.4	172.3	289.8	32.2%	167.7	149.9

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

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

Table 8. Target counts, passage rates, mean and median heights during nights of the spring 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)
4/20/10 17:47	4/21/10 5:32	705	701	13	692	98.2%	925	1248	902	3075	80.2	108.2	78.2	266.6	40.6%	116.2	71.9
4/21/10 17:48	4/22/10 5:31	703															
4/22/10 17:50	4/23/10 5:29	699	697	309	390	55.8%	171	407	1520	2098	26.3	62.6	233.8	322.8	19.4%	387.2	327.9
4/23/10 17:51	4/24/10 5:27	696	696	24	672	96.6%	155	288	538	981	13.8	25.7	48.0	87.6	29.4%	199.8	148.1
4/24/10 17:52	4/25/10 5:26	694	694	0	694	100.0%	648	2159	7345	10152	56.0	186.7	635.0	877.7	21.3%	312.1	258.1
4/25/10 17:53	4/26/10 5:24	691	691	0	691	100.0%	264	1372	4678	6314	22.9	119.1	406.2	548.2	21.7%	258.7	212.1
4/26/10 17:54	4/27/10 5:23	689	689	38	651	94.5%	72	332	1335	1739	6.6	30.6	123.0	160.3	19.1%	283.1	230.1
4/27/10 17:56	4/28/10 5:21	685															
4/28/10 17:57	4/29/10 5:20	683	683	123	560	82.0%	27	33	43	103	2.9	3.5	4.6	11.0	32.0%	201.2	103.0
4/29/10 17:58	4/30/10 5:18	680	680	0	680	100.0%	92	112	117	321	8.1	9.9	10.3	28.3	34.9%	125.8	90.2
4/30/10 17:59	5/1/10 5:17	678	678	0	678	100.0%	719	1307	787	2813	63.6	115.7	69.6	248.9	46.5%	109.4	73.7
5/1/10 18:01	5/2/10 5:15	674	674	209	465	69.0%	677	2598	21516	24791	87.4	335.2	2776.3	3198.8	10.5%	325.4	289.5
5/2/10 18:02	5/3/10 5:14	672	672	0	672	100.0%	1020	3764	13274	18058	91.1	336.1	1185.2	1612.3	20.8%	280.8	218.5
5/3/10 18:03	5/4/10 5:12	669	669	0	669	100.0%	625	1057	1183	2865	56.1	94.8	106.1	257.0	36.9%	141.0	105.4
5/4/10 18:04	5/5/10 5:11	667	667	56	611	91.6%	290	378	363	1031	28.5	37.1	35.6	101.2	36.7%	130.4	79.8
5/5/10 18:05	5/6/10 5:10	665	665	0	665	100.0%	403	1723	13859	15985	36.4	155.5	1250.4	1442.3	10.8%	388.4	354.1
5/6/10 18:07	5/7/10 5:08	661	661	30	631	95.5%	175	193	237	605	16.6	18.4	22.5	57.5	31.9%	160.6	83.5
5/7/10 18:08	5/8/10 5:07	659	659	307	352	53.4%	343	430	301	1074	58.5	73.3	51.3	183.1	40.0%	128.0	63.7
5/8/10 18:09	5/9/10 5:06	657	657	96	561	85.4%	292	675	1686	2653	31.2	72.2	180.3	283.7	25.4%	334.7	195.9
5/9/10 18:10	5/10/10 5:05	655	655	0	655	100.0%	13	16	8	37	1.2	1.5	0.7	3.4	43.2%	136.4	67.3
5/10/10 18:11	5/11/10 5:03	652	652	0	652	100.0%	76	64	65	205	7.0	5.9	6.0	18.9	31.2%	139.3	66.4
5/11/10 18:13	5/12/10 5:02	649	649	0	649	100.0%	1030	1872	3009	5911	95.2	173.1	278.2	546.5	31.7%	211.4	134.4
5/12/10 18:14	5/13/10 5:01	647	647	0	647	100.0%	167	271	463	901	15.5	25.1	42.9	83.6	30.1%	200.0	133.5
5/13/10 18:15	5/14/10 5:00	645	645	0	645	100.0%	782	1200	1160	3142	72.7	111.6	107.9	292.3	38.2%	141.7	88.7
5/14/10 18:16	5/15/10 4:59	643	643	15	628	97.7%	1307	2798	5283	9388	124.9	267.3	504.7	896.9	29.8%	226.1	158.6
5/15/10 18:17	5/16/10 4:58	641	641	15	626	97.7%	723	680	406	1809	69.3	65.2	38.9	173.4	37.6%	109.3	51.5
5/16/10 18:18	5/17/10 4:57	639	639	0	639	100.0%	874	687	468	2029	82.1	64.5	43.9	190.5	33.9%	106.8	46.3
5/17/10 18:19	5/18/10 4:56	637	637	0	637	100.0%	1845	4136	7975	13956	173.8	389.6	751.2	1314.5	29.6%	214.2	154.8
5/18/10 18:20	5/19/10 4:55	635	635	230	405	63.8%	976	2531	8446	11953	144.6	375.0	1251.3	1770.8	21.2%	308.8	233.4
5/19/10 18:21	5/20/10 4:54	633	633	54	579	91.5%	309	293	270	872	32.0	30.4	28.0	90.4	33.6%	119.7	64.6
5/20/10 18:23	5/21/10 4:53	630	630	0	630	100.0%	495	902	1342	2739	47.1	85.9	127.8	260.9	32.9%	196.0	125.5
5/21/10 18:24	5/22/10 4:52	628	628	0	628	100.0%	556	2780	23721	27057	53.1	265.6	2266.3	2585.1	10.3%	354.9	323.7
5/22/10 18:25	5/23/10 4:51	626	626	0	626	100.0%	381	1513	14190	16084	36.5	145.0	1360.1	1541.6	9.4%	385.9	336.5
5/23/10 18:26	5/24/10 4:50	624															

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

The information contained and/or attached to this document is for intended recipient(s) only and may not be distributed to third parties in any form without the express written consent of Tetra Tech. This communication contains confidential, proprietary and/or privileged information and, the recipient(s) hereby agree to treat it as such. If you have received this in error, immediately and permanently delete this e-mail and all attachments from your computer and destroy any printed copies.

APPENDIX B

Raptor Survey Data

Appendix B Table 1. Comparison of raptor migration data from Canton Mountain to Bradbury Mountain hawkwatches on the same survey dates- Spring 2010																						
A- Canton Mt B- Bradbury Mt	**4/15/10**		**4/21/10**		**4/30/10**		**5/1/10**		**5/4/10**		**5/5/10**		**5/7/10**		**5/11/10**		**5/12/10**		**5/13/2010**		**Grand toal**	
	A	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**
American kestrel		1	1	47	1			12				1									2	61
Bald eagle		1						1													0	2
Broad-winged hawk	1	7	26	397	10	179	10	298		30		8	1	11		12		1		3	48	946
Cooper's hawk			4	8	1			2								1		1			5	12
Golden eagle																					0	0
Merlin		1		4		3		12		1											0	21
Northern goshawk					3																3	0
Northern harrier				5		1		5				1		1				1			0	14
Osprey		6	1	29	4	43		26		4	1	11		3		4		5		3	6	134
Peregrine falcon				1				1													0	2
Red-shouldered hawk																					0	0
Red-tailed hawk		1	4	3	2		2	1					1		1						10	5
Rough-legged hawk																					0	0
Sharp-shinned hawk		11	3	91	1	12	1	66		4	1	13	1	1		5		3		1	7	207
Turkey vulture	4	4	11	5	2		5				1				2				1		26	9
Unidentified accipiter				2																	0	2
Unidentified buteo							1														1	0
Unidentified eagle																					0	0
Unidentified falcon							1														1	0
Unidentified raptor			1	1	2	1		1													3	3
Grand Total	**5**	**32**	**51**	**593**	**26**	**239**	**20**	**425**	**0**	**39**	**3**	**34**	**3**	**16**	**3**	**22**	**0**	**11**	**1**	**7**	**112**	**1418**
Survey Effort (hour)	5.00	8.00	7.00	8.00	6.00	8.00	6.00	8.25	6.00	7.25	6.00	8.00	6.00	8.00	6.00	8.00	6.00	8.00	6.00	8.00	**60.0**	**79.5**
Raptors/hour	**1.00**	**4.00**	**7.29**	**74.13**	**4.33**	**29.88**	**3.33**	**51.52**	**0.00**	**5.38**	**0.50**	**4.25**	**0.50**	**2.00**	**0.50**	**2.75**	**0.00**	**1.38**	**0.17**	**0.88**	**1.87**	**17.84**

4/15/10 Canton Mt, ME

DeLorme Topo USA® 7.0

Data use subject to license.

© DeLorme. DeLorme Topo USA® 7.0.

www.delorme.com

TN

MN (16.1°W)

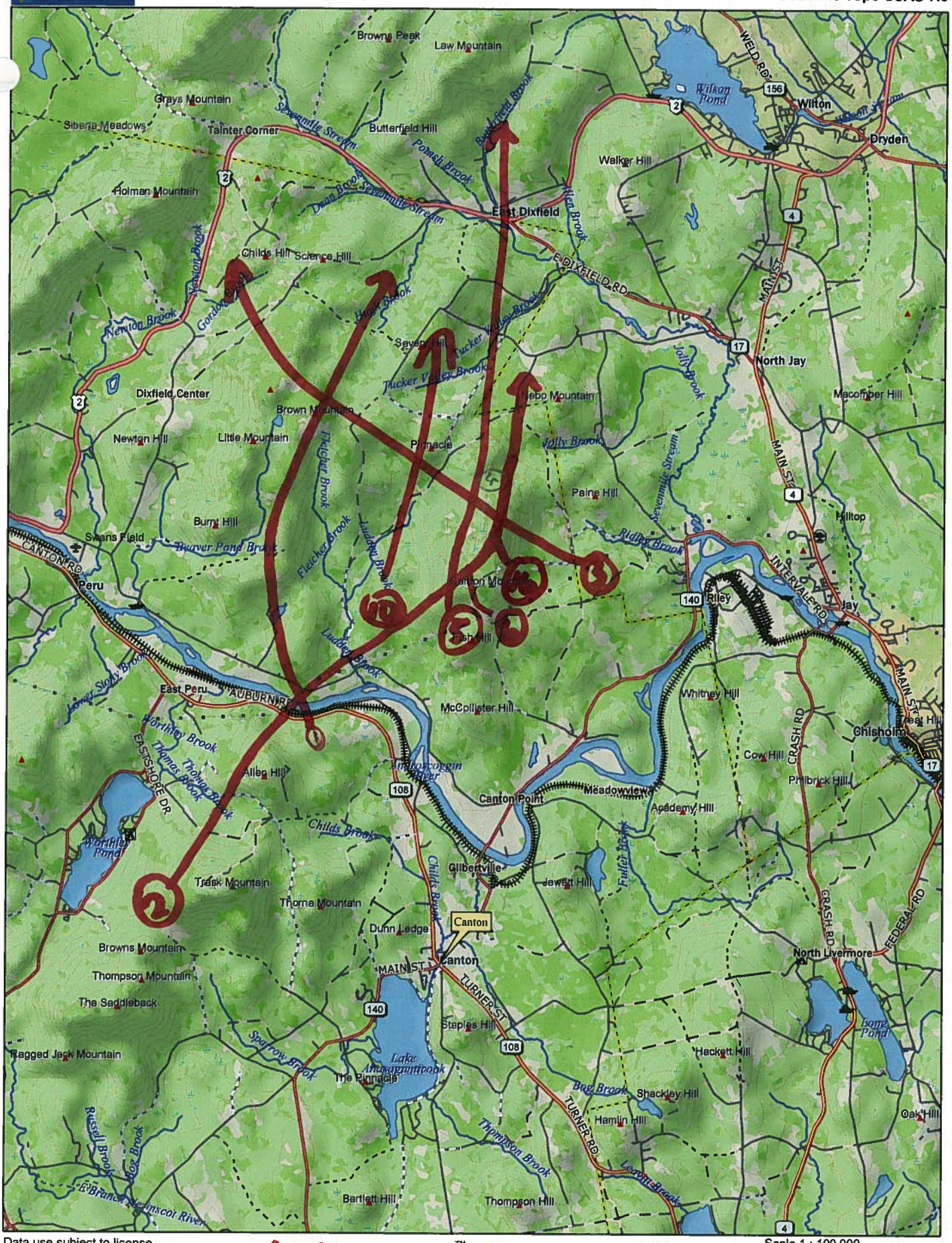
B-2

Scale 1 : 100,000

1" = 1.58 mi

Data Zoom 11-0

DeLorme Topo USA® 7.0



Data use subject to license.

© DeLorme. DeLorme Topo USA® 7.0.

www.delorme.com

4/21/10

MN (16.1°W)

B-3

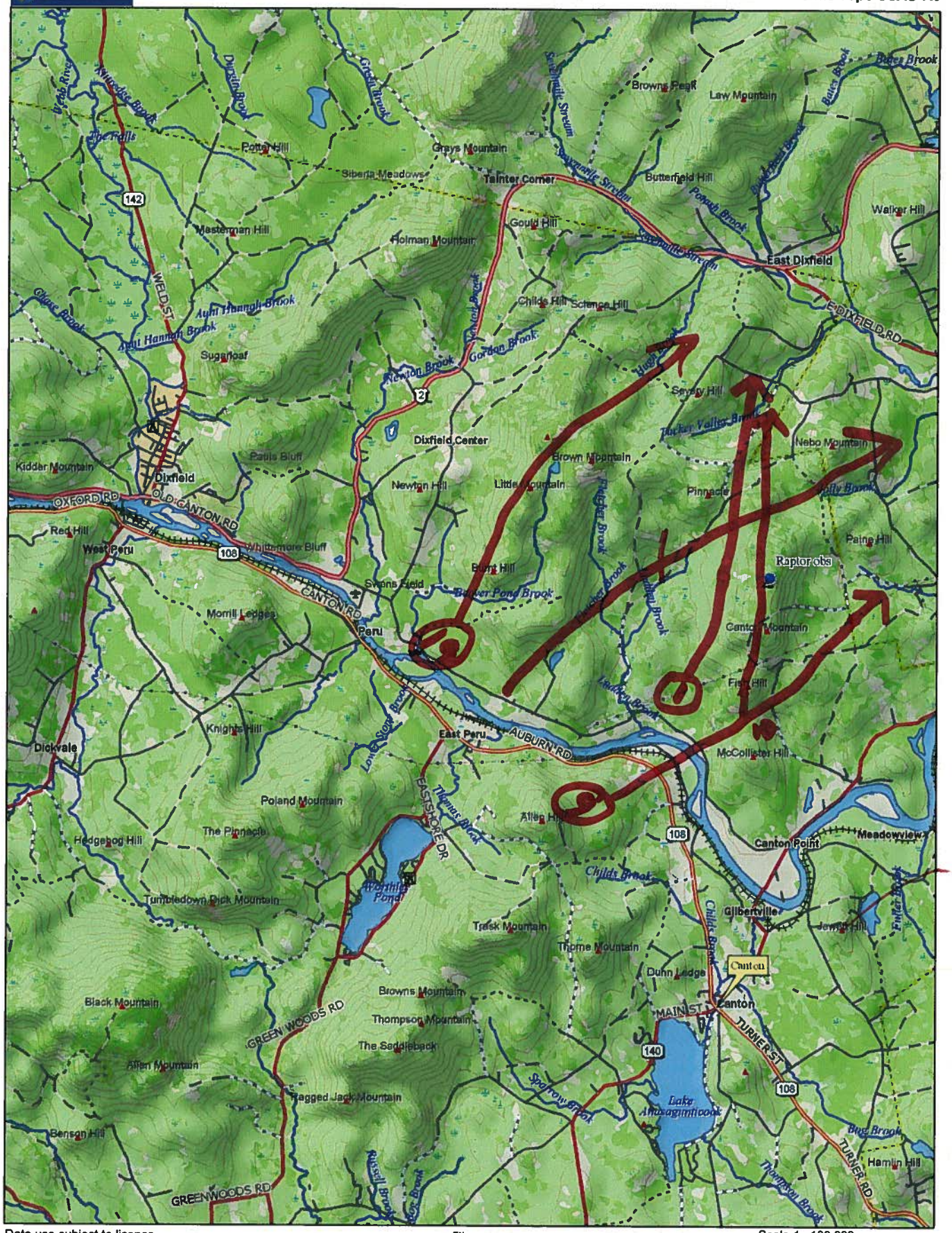
Canton, ME

Scale 1 : 100,000

1" = 1.58 mi

Data Zoom 11-0

DeLorme Topo USA® 7.0



Data use subject to license.

© DeLorme. DeLorme Topo USA® 7.0.

www.delorme.com

TN

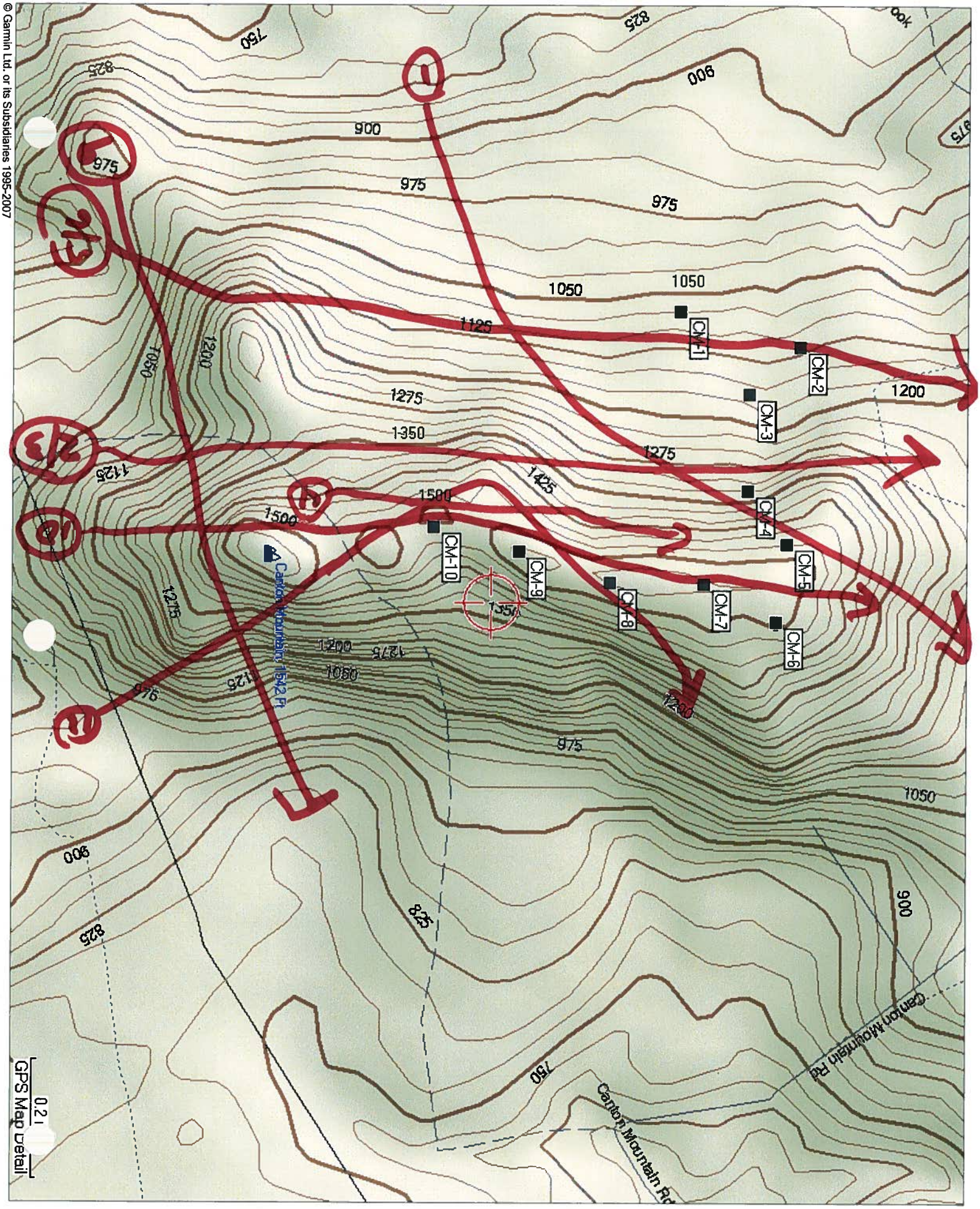
MN (16.1°W)

Scale 1 : 100,000

1" = 1.58 mi

Data Zoom 11-0

4/30/10 Canton Maine

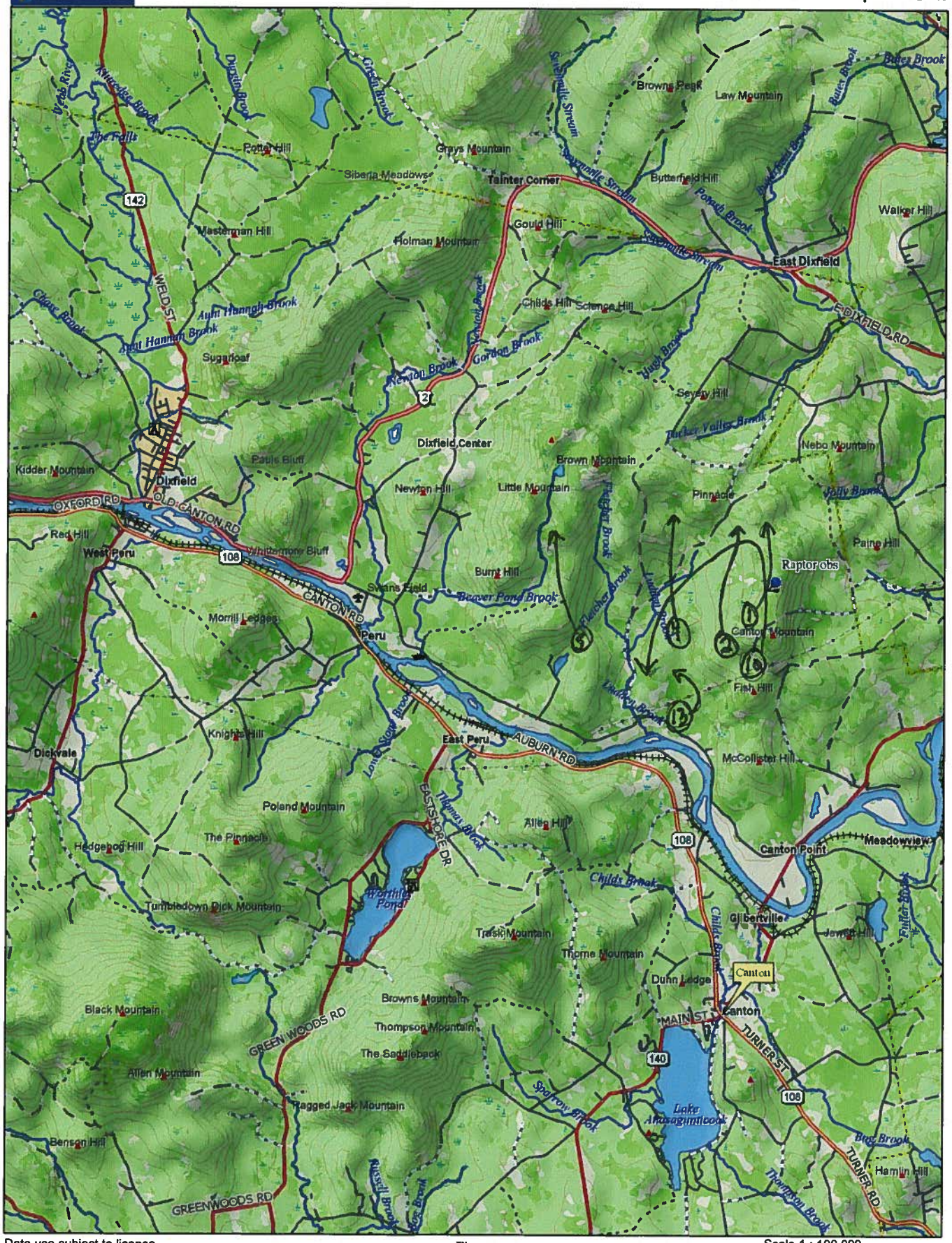


© Garmin Ltd. or its Subsidiaries 1995-2007

4/30/10 Cantor NF

5/1/10 Canton Mt

DeLorme Topo USA® 7.0



Data use subject to license.

© DeLorme. DeLorme Topo USA® 7.0.

www.delorme.com

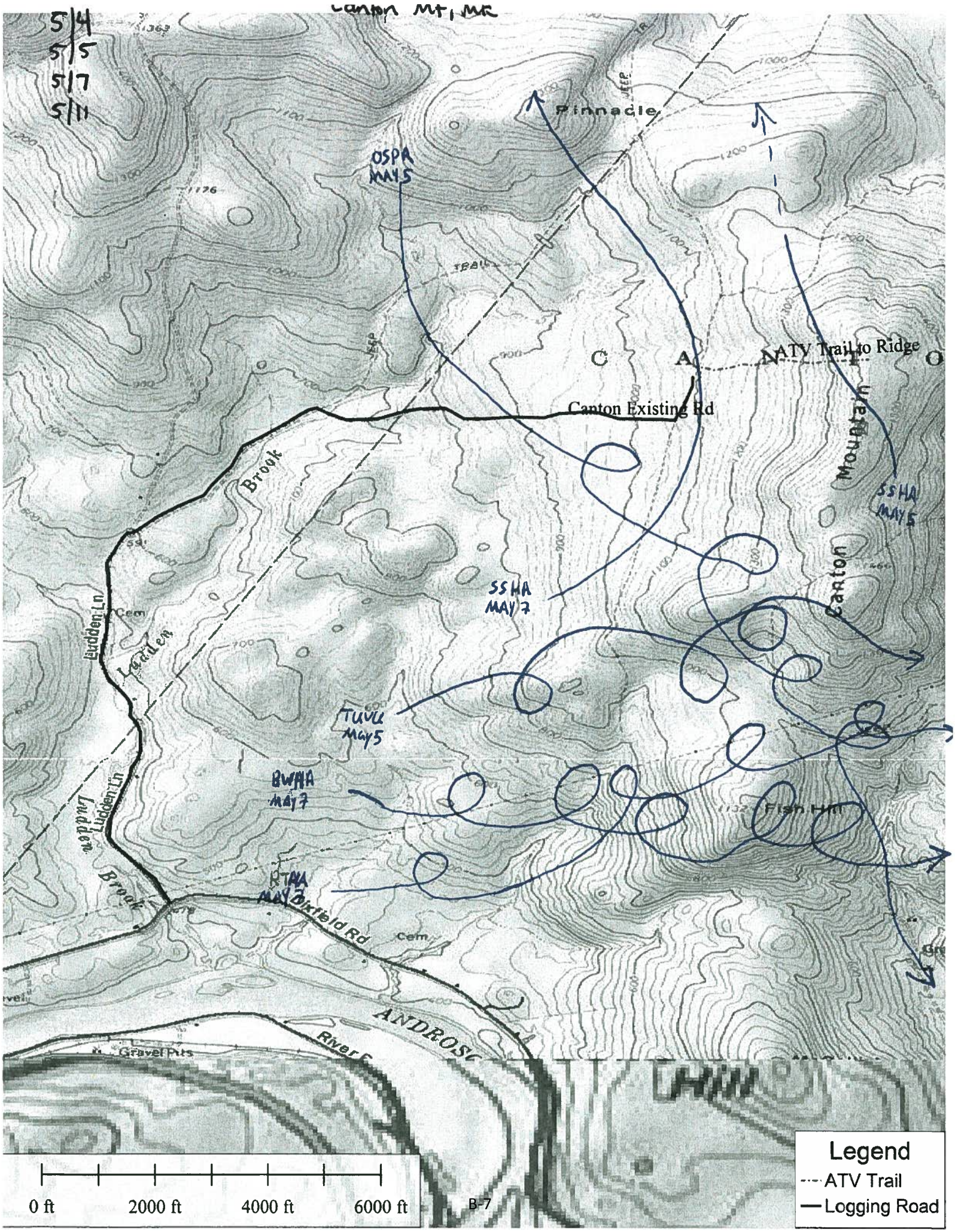
TN

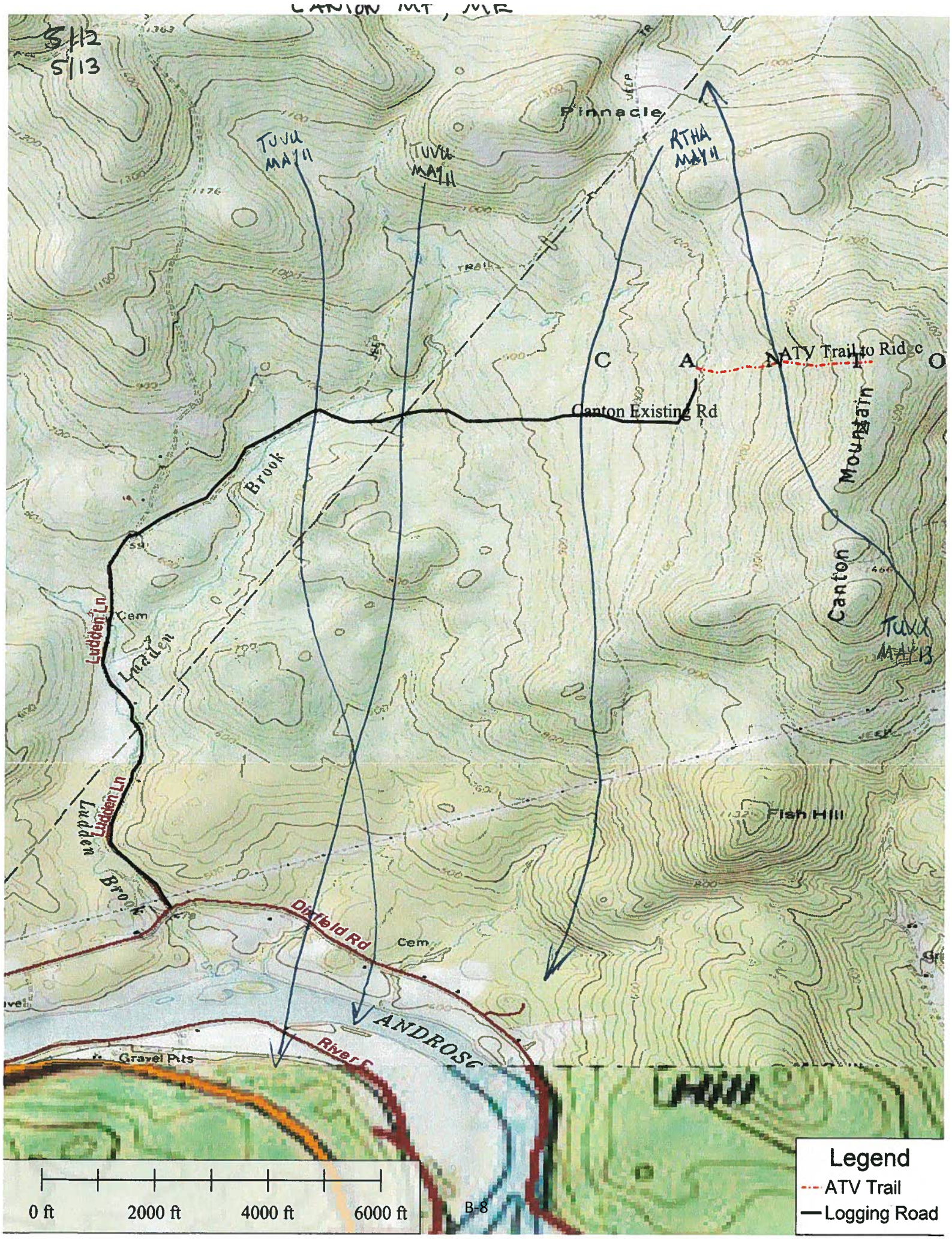
MN (16.1°W)

Scale 1 : 100,000

1" = 1.58 mi

Data Zoom 11-0


Canton Mt, MR
5/4
5/5
5/7
5/11
Pinnacle
OSPA
MAY5
ATV Trail to Ridge
Canton Existing Rd
Brook
Mountain
SSHA
MAY5
SSHA
MAY7
Canton
Ludden Ln
Ludden
TUVU
May5
BWHA
MAY7
Fish Hill
Ludden Ln
Brook
RTHA
MAY7
Bixfield Rd
Cem
ANDROSC
River
Gravel Pits
0 ft
2000 ft
4000 ft
6000 ft
Legend
ATV Trail
Logging Road


CANTON MT, ME
5/12
5/13
Pinnacle
TUVU MAY11
TUVU MAY11
RTHA MAY11
TUVU MAY13
ATV Trail to Ridge
C A N T O N
Canton Existing Rd
Canton Mountain
Brook
Ludden Ln
Ludden
Ludden Brook
Cem
Fish Hill
Dixfield Rd
ANDROSC
River
Gravel Pits
0 ft
2000 ft
4000 ft
6000 ft
Legend
ATV Trail
Logging Road

APPENDIX C

Migrant Stopover Survey Data

Appendix C Table 1. Summary of migrant stopover surveys by point at Canton Mountain, Spring 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	1		2			1					4	30.0%
American goldfinch	1	7	3	4		2	2	2		1	22	80.0%
American redstart	2	1	1	2	1	1	3	2		5	18	90.0%
American robin	4	4	1	1							10	40.0%
Black-and-white warbler	6	1	9	5	3	3	6	4	5	4	46	100.0%
Blackburnian warbler				1	1	5	4	2	2		15	60.0%
Black-capped chickadee	10	8	4	4	10	5	2	3	3	2	51	100.0%
Black-throated blue warbler	3	4	2	2	2	4	1	2	6	1	27	100.0%
Black-throated green warbler	1	2		1	2		1	2	2		11	70.0%
Blue jay	8	1	2	4	1	3	5	2		5	31	90.0%
Blue-headed vireo	1	1	2	1	5	6		3	2		21	80.0%
Broad-winged hawk										2	2	10.0%
Brown creeper						2			1		3	20.0%
Canada geese				2							2	10.0%
Cedar waxwing		8									8	10.0%
Chestnut-sided warbler		2	2	2	1	1	4	7	10	8	37	90.0%
Common loon	1							1			2	20.0%
Common raven		2	2	2	2					3	11	50.0%
Common yellowthroat	2	2	1	1						1	7	50.0%
Dark-eyed junco	2		1	4	2	4	2	4	2	2	23	90.0%
Downy woodpecker	2	2	1	1	1	1	1				9	70.0%
Evening grosbeak		1									1	10.0%
Golden-crowned kinglet					1	4	4	3	3		15	50.0%
Gray catbird	1		1								2	20.0%
Hairy woodpecker	1			1	1			2	4		9	50.0%
Hermit thrush	5	4	4	3	6	4	3	1	1	5	36	100.0%
Magnolia warbler			1		1	1		1			4	40.0%
Mourning dove	2		1		1		2	2		1	9	60.0%
Myrtle warbler	5	2	4	5	2	8	5	6	6	4	47	100.0%
Nashville warbler		1	1				1	2	5	2	12	60.0%
Northern flicker		1		2							3	20.0%
Ovenbird	12	14	12	14	9	7	11	9	6	6	100	100.0%
Pileated woodpecker		2		1						2	5	30.0%
Purple finch	2	2	3		1	2	3				13	60.0%
Red-breasted nuthatch		1		1		3	1		1		7	50.0%
Red-tailed hawk									1		1	10.0%
Rose-breasted grosbeak	1	1	6								8	30.0%
Ruby-crowned kinglet			1								1	10.0%
Ruffed grouse	2	2	1	1	1			1			8	60.0%
Scarlet tanager	1			1		1	1				4	40.0%
Swainson's thrush				1							1	10.0%
Unknown bird			1								1	10.0%
White-breasted nuthatch			1	2				2	2	1	8	50.0%
White-throated sparrow	5	2	3				2	8	10	6	36	70.0%
Winter wren		1	1			1		1			4	40.0%
Wood thrush	6	5	3								14	30.0%
Yellow warbler		1									1	10.0%
Yellow-bellied sapsucker	5		1	1	1	2	1	4	2	1	18	90.0%
Grand Total	92	85	78	70	55	71	65	76	74	62	728	
Species Richness	27	29	31	28	22	23	22	25	20	20	48	

Appendix C Table 2. Summary of migrant stopover surveys by date at Canton Mountain, Spring 2010														
Species	4/21/10	4/30/10	5/1/10	5/4/10	5/5/10	5/7/10	5/11/10	5/12/10	5/13/10	5/14/10	5/19/10	Grand Total	Relative Abundance	Frequency
American crow	3	1										4	0.36	18.2%
American goldfinch	6	1	7	6	2							22	2.00	45.5%
American redstart								3	3	5	7	18	1.64	36.4%
American robin	3	1	2	3	1							10	0.91	45.5%
Black-and-white warbler			1	6	3	3	7	5	5	7	9	46	4.18	81.8%
Blackburnian warbler	1				1	2	2	3	2	2	2	15	1.36	72.7%
Black-capped chickadee	5	4	18	3	5	4	3	3	2	3	1	51	4.64	100.0%
Black-throated blue warbler	1			1	1	1		10	5	2	6	27	2.45	72.7%
Black-throated green warbler							1	1	3	4	2	11	1.00	45.5%
Blue jay	6		2	4	2	2	5		6	3	1	31	2.82	81.8%
Blue-headed vireo		1	1	6	3	3				2	5	21	1.91	63.6%
Broad-winged hawk	1		1									2	0.18	18.2%
Brown creeper	1			2								3	0.27	18.2%
Canada geese			2									2	0.18	9.1%
Cedar waxwing			8									8	0.73	9.1%
Chestnut-sided warbler						2	12	7	5	5	6	37	3.36	54.5%
Common loon					2							2	0.18	9.1%
Common raven	2	4	5									11	1.00	27.3%
Common yellowthroat				1	1				1	2	2	7	0.64	45.5%
Dark-eyed junco	6	1	9	1	1	1			3	1		23	2.09	72.7%
Downy woodpecker	2	1	1					1	1	2	1	9	0.82	63.6%
Evening grosbeak					1							1	0.09	9.1%
Golden-crowned kinglet		4	4		3	4						15	1.36	36.4%
Gray catbird											2	2	0.18	9.1%
Hairy woodpecker				1	1	1		1	1	2	2	9	0.82	63.6%
Hermit thrush	1		2	4	1	1	5	3	5	6	8	36	3.27	90.9%
Magnolia warbler											4	4	0.36	9.1%
Mourning dove			2	6							1	9	0.82	27.3%
Myrtle warbler		8	16	6	6	5				3	3	47	4.27	63.6%
Nashville warbler							3	3	2	2	2	12	1.09	45.5%
Northern flicker	2			1								3	0.27	18.2%
Ovenbird				9	9	7	8	13	20	16	18	100	9.09	72.7%
Pileated woodpecker	2			1				1			1	5	0.45	36.4%
Purple finch							2	5	3	1	2	13	1.18	45.5%
Red-breasted nuthatch		1	4	1					1			7	0.64	36.4%
Red-tailed hawk	1											1	0.09	9.1%
Rose-breasted grosbeak	2	1		3	1	1						8	0.73	45.5%
Ruby-crowned kinglet					1							1	0.09	9.1%
Ruffed grouse	2	1		2				1		2		8	0.73	45.5%
Scarlet tanager									2	1	1	4	0.36	27.3%
Swainson's thrush					1							1	0.09	9.1%
Unknown bird		1										1	0.09	9.1%
White-breasted nuthatch	3			1		1	1		1		1	8	0.73	54.5%
White-throated sparrow	2		9	2	3	3	3	4	3	3	4	36	3.27	90.9%
Winter wren	2	2										4	0.36	18.2%
Wood thrush				4	2	2	1		2	1	2	14	1.27	63.6%
Yellow warbler											1	1	0.09	9.1%
Yellow-bellied sapsucker			3	3	1		2	3	2	2	2	18	1.64	72.7%
Grand Total	54	32	97	77	52	43	55	67	78	77	96	728	66.18	
Species Richness	21	15	19	24	23	17	14	17	22	23	27	48		

APPENDIX D

Breeding Bird Survey Data

Appendix D Table 1. Summary of breeding birds by date at Canton Mountain, Summer 2010						
Species	6/2/10	6/11/10	6/16/10	Grand Total	Relative Abundance	Frequency
American goldfinch			1	1	0.33	33.3%
American redstart	3	1	1	5	1.67	100.0%
American robin	2	1	2	5	1.67	100.0%
American woodcock		1	1	2	0.67	66.7%
Bay-breasted warbler			1	1	0.33	33.3%
Black-and-white warbler	5	6	6	17	5.67	100.0%
Blackburnian warbler	1	4	2	7	2.33	100.0%
Black-capped chickadee		2	6	8	2.67	66.7%
Black-throated blue warbler	1	6	3	10	3.33	100.0%
Black-throated green warbler	8	4	4	16	5.33	100.0%
Blue jay		2	1	3	1.00	66.7%
Blue-headed vireo	1	1	1	3	1.00	100.0%
Broad-winged hawk			1	1	0.33	33.3%
Brown creeper			1	1	0.33	33.3%
Cape may warbler			1	1	0.33	33.3%
Cedar waxwing	2			2	0.67	33.3%
Chestnut-sided warbler	3	7	2	12	4.00	100.0%
Chipping sparrow	2			2	0.67	33.3%
Common yellowthroat		2		2	0.67	33.3%
Dark-eyed junco	2	4	3	9	3.00	100.0%
Eastern towhee			2	2	0.67	33.3%
Eastern wood pewee		1		1	0.33	33.3%
Golden-crowned kinglet			4	4	1.33	33.3%
Hairy woodpecker		1		1	0.33	33.3%
Hermit thrush	4	7	4	15	5.00	100.0%
Magnolia warbler		1		1	0.33	33.3%
Mourning dove		1	6	7	2.33	66.7%
Mourning warbler			1	1	0.33	33.3%
Nashville warbler	5	1	2	8	2.67	100.0%
Northern flicker	1		1	2	0.67	66.7%
Ovenbird	12	10	8	30	10.00	100.0%
Pileated woodpecker	1	1	1	3	1.00	100.0%
Pine warbler			2	2	0.67	33.3%
Red-breasted nuthatch			3	3	1.00	33.3%
Red-eyed vireo	10	9	8	27	9.00	100.0%
Rose-breasted grosbeak		4	3	7	2.33	66.7%
Ruffed grouse	2		1	3	1.00	66.7%
Scarlet tanager			1	1	0.33	33.3%
Veery		1	2	3	1.00	66.7%
White-breasted nuthatch	2			2	0.67	33.3%
White-throated sparrow	2	1	7	10	3.33	100.0%
Winter wren		1	4	5	1.67	66.7%
Wood thrush		1	4	5	1.67	66.7%
Yellow-rumped warbler	4	4	2	10	3.33	100.0%
Yellow-throated vireo			1	1	0.33	33.3%
Grand Total	73	85	104	262	87.33	
Species Richness	21	28	39	47		

Appendix D Table 2. Summary of breeding birds by point at Canton Mountain, Summer 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 goldfinch								1			1	10.0%
American redstart			1			1	2		1		5	40.0%
American robin		2	1	1			1				5	40.0%
American woodcock			1						1		2	20.0%
Bay-breasted warbler							1				1	10.0%
Black-and-white warbler	2	1	1	3	3	1	1	1	3	1	17	100.0%
Blackburnian warbler						3		4			7	20.0%
Black-capped chickadee	1				1		1	1	1	3	8	60.0%
Black-throated blue warbler	1	4		2		2	1				10	50.0%
Black-throated green warbler	2	1	1	1	3	1		3	1	3	16	90.0%
Blue jay			1					2			3	20.0%
Blue-headed vireo						2	1				3	20.0%
Broad-winged hawk				1							1	10.0%
Brown creeper							1				1	10.0%
Cape may warbler						1					1	10.0%
Cedar waxwing					2						2	10.0%
Chestnut-sided warbler	3	1	2	1	2				3		12	60.0%
Chipping sparrow									1	1	2	20.0%
Common yellowthroat			1		1						2	20.0%
Dark-eyed junco						3	1	1	2	2	9	50.0%
Eastern towhee	1	1									2	20.0%
Eastern wood pewee				1							1	10.0%
Golden-crowned kinglet					1	1	1		1		4	40.0%
Hairy woodpecker		1									1	10.0%
Hermit thrush	1		3	1	2		2	2	2	2	15	80.0%
Magnolia warbler									1		1	10.0%
Mourning dove	1		1		1	1	1		2		7	60.0%
Mourning warbler					1						1	10.0%
Nashville warbler					1	1	2	2	2		8	50.0%
Northern flicker					1	1					2	20.0%
Ovenbird	1	4	3	4	2	3	5	6	1	1	30	100.0%
Pileated woodpecker		1		2							3	20.0%
Pine warbler				1	1						2	20.0%
Red-breasted nuthatch			1			1		1			3	30.0%
Red-eyed vireo	4	4	3	6	4	1		1	1	3	27	90.0%
Rose-breasted grosbeak	1	2	2						2		7	40.0%
Ruffed grouse		1				1		1			3	30.0%
Scarlet tanager									1		1	10.0%
Veery	2								1		3	20.0%
White-breasted nuthatch						1	1				2	20.0%
White-throated sparrow					2	2	1	1	3	1	10	60.0%
Winter wren		2	1		1	1					5	40.0%
Wood thrush	1	1	2		1						5	40.0%
Yellow-rumped warbler					1	3	1	3	2		10	50.0%
Yellow-throated vireo						1					1	10.0%
Grand Total	21	26	25	24	31	32	24	30	32	17	262	
Species Richness	13	14	16	12	19	21	17	15	20	9	47	