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## Prince Edward Island National Park Bat Inventory and Monitoring 2015 – Technical Report

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Prepared for: Parks Canada Agency - Prince Edward Island National Park

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## Table of Contents

Table of Contents .....	i
Executive Summary .....	1
1. Introduction .....	3
1.1 Linking bat monitoring to Parks Canada’s integrated mandate .....	4
1.2 Components of this technical report .....	5
1.3 NABat .....	5
1.4 Responsibilities, team, and deadline .....	6
2. Methods .....	7
2.1 Stationary Acoustic Surveys for NABat Monitoring Program .....	7
2.1.1 Monitoring objectives .....	7
2.1.2 Sampling timeframe and study design .....	7
2.1.3 Equipment .....	8
2.1.4 Site description and detector placement .....	8
2.2 Mobile Acoustic Surveys for NABat Monitoring Program .....	14
2.2.1 Monitoring objectives .....	14
2.2.2 Study design .....	15
2.2.3 Equipment .....	15
2.3 Building surveys .....	16
2.3.1 Study design .....	16
2.3.2 Equipment .....	16
2.3.3 Buildings Monitored .....	16
2.4 Emergence counts at potential roosts .....	21
2.5 Visual inspections of potential roosts .....	21
2.6 Other acoustic monitoring sites .....	22
2.6.1 Study design .....	22
2.6.2 Equipment requirements .....	22
2.6.3 Cavendish Homestead Trail Well .....	22
2.6.4 Dalvay Woodland trail .....	23



2.7 Detector settings and data analysis .....	24
3. RESULTS.....	25
3.1 Stationary Acoustic Surveys for NABat Monitoring Program .....	25
3.1.1 Species diversity.....	25
3.1.2 Spatial and temporal comparison.....	26
3.1.3 Inter-annual comparison.....	27
3.2 Mobile Acoustic Surveys for NABat Monitoring Program .....	28
3.3 Building surveys .....	28
3.3.1 Brackley.....	28
3.3.2 Dalvay.....	28
3.3.3 Cavendish .....	28
3.3.4 Fort Amherst .....	29
3.4 Emergence counts at potential roosts .....	32
3.5 Visual surveys of potential roosts .....	32
3.6 Other acoustic monitoring sites.....	32
3.6.1 Cavendish Homestead Trail Well .....	32
3.6.2 Dalvay Woodland Trail .....	33
3.7 Discrepancies in Planned Monitoring Methodology .....	33
4. Discussion.....	34
4.1 Stationary Acoustic Surveys for NABat Monitoring Program .....	34
4.1.1 Species diversity.....	34
4.1.2 Spatial and temporal comparison.....	35
4.1.3 Inter-annual comparison.....	36
4.2 Mobile Acoustic Surveys for NABat Monitoring Program .....	36
4.3 Building surveys .....	37
4.4 Emergence counts at potential roosts .....	37
4.5 Visual surveys of potential roosts .....	37
4.6 Other acoustic monitoring sites.....	37
4.6.1 Cavendish Homestead Trail Well .....	37



4.6.2 Dalvay Woodland Trail .....	38
4.7 Discrepancies in Planned Monitoring Methodology .....	38
5. Recommendations .....	38
Appendix I: Stationary acoustic survey for NABat Monitoring Program detector locations, microphone positioning and relevant NABat data .....	40
Appendix II: Mobile transects routes .....	41
Appendix III: Building surveys detector locations and microphone positioning .....	45
Appendix IV: Other acoustic monitoring sites detector locations and microphone positioning .....	46
Appendix V: SM2+Bat and SM3 detector settings .....	47
Appendix VI: Landscape detector deployment dates, number of bat passes recorded, nightly average bat passes, and species identified .....	48
Acknowledgements.....	50
References .....	51



## Executive Summary

A bat inventory and monitoring study was conducted in Prince Edward Island National Park (PEINP) during the summer of 2015 to provide a better understanding of the species diversity and habitat associations of bats in the park. Additionally, the use of buildings as potential roosting sites for bats was investigated. Four sites monitored in 2004 were selected for monitoring again in 2015 so temporal comparisons could be made. The North American Bat Monitoring (NABat) program was adapted for PEINP to enable acoustic monitoring of bats at different habitat types (i.e., fresh water, coastal dune, wetland, and forest edge) in all three areas of PEINP (i.e., from west to east, Cavendish, Brackley-Dalvay and Greenwich). Buildings scheduled for demolition were acoustically and visually monitored to determine if they were used as roosts. Some additional anthropogenic structures and natural habitats were acoustically monitored to establish their potential use as roosting, swarming or hibernation sites for bats. The results of this study will assist PEINP staff in making management decisions as they relate to the conservation of bats and their habitat.

Acoustic monitoring indicated the magnitude of activity of bats in PEINP is relatively high in some habitats and there is a diversity of species of bats. The vast majority of bat passes recorded were from the endangered *Myotis* spp. (i.e., little brown and/or Northern myotis), but non-endangered migratory species were also detected, including hoary bats and silver-haired or big brown bats, but at a much lower magnitude of activity. In general, the magnitude of bat activity was highest at habitats associated with water (i.e., fresh water and wetland habitats) and in the late summer monitoring period. Since habitats associated with water are also good habitat for aquatic insects that are some of the preferred dietary species for bats, it is not surprising that the activity of bats was higher in these habitats. The increase in the late summer activity of bats is more difficult to attribute to any one specific factor with confidence. However, it is well documented that this is the period that young-of-the-year begin flying and foraging on their own, and while this suggests the possibility of successful reproduction in the Park's bat populations, this hypothesis cannot be confirmed with acoustic monitoring alone. The temporal trends in activity between 2004 and 2015 were not consistent with a substantial decline or increase in activity (Table I). Acoustic activity at monitored buildings was not compatible with any of them being a roosting site for bats. Considerable acoustic activity of the endangered Northern myotis was detected at a forest trail. Lastly, a well that was monitored did not have a sufficient magnitude of bat activity to suggest that it was a swarming or hibernation site.

To have better information for management decisions regarding the endangered little brown bat and Northern myotis in PEINP, it is highly recommended that the standard acoustic monitoring program that was developed for PEINP be continued for at least another two consecutive years. It is also recommended that a trapping and radio tagging study of endangered little brown bats and Northern myotis be added to the acoustic monitoring program so that critical roosting habitat for these species



can be identified on any land controlled by PEINP for appropriate protection and management purposes.

Table I: Summary of bat inventory and monitoring results for Prince Edward Island National Park for the summer 2015.

Species			Detection			
Name	Code	SAR Category	Location	Habitat Type <sup>1</sup>	Peak Abundance <sup>2</sup>	Temporal Trend (2004-2015) <sup>3</sup>
<i>Myotis</i> spp. <sup>4</sup>	<i>Myotis</i> spp.	Endangered	Brackley-Dalvay	1	LS	N/A
				2	LS	N/A
				3	ES	↑
				4	LS	N/A
			Greenwich	1	LS	N/A
				2	LS	N/A
				3	LS	N/A
				4	LS	↓
			Cavendish	1	LS	↑
				2	ES	N/A
				3	LS	N/A
				4	LS	↓
Hoary bat	LACI	None	Brackley-Dalvay	3	LS	N/A
			Cavendish	1	ES	N/A
				2	LS	N/A
Silver-haired bat/ Big brown bat	LANO-EPFU	None	Greenwich	3	ES	N/A
			Cavendish	3	LS	N/A

<sup>1</sup> 1 = Fresh water, 2 = Coastal dune, 3 = Wetland, 4 = Forest edge

<sup>2</sup> LS = Late Summer, ES = Early Summer

<sup>3</sup> ↑ = increasing temporal trend in bat activity, ↓ = a decreasing temporal trend in bat activity, N/A = not applicable because not all sites monitored in 2015 were previously monitored in 2004 and in the past, Silver and Big brown bats were not detected in PEINP.

<sup>4</sup> *Myotis* spp. includes the little brown bat and Northern myotis both of which are endangered species.



## 1. Introduction

Since the emergence of white-nose syndrome (WNS) in North America, there is growing concern for the conservation and management of bats and as a consequence, there is heightened interest in the monitoring and inventory of bat populations. *Pseudogymnoascus destructans* (formerly *Geomyces destructans*), an epizootic fungal pathogen believed to have been introduced from Europe (Leopardi et al. 2015), is the etiology of the disease WNS that has been causing mass mortality of bat populations in eastern North America since 2006 and continues to emerge in new North American geographic locations (Gargas et al. 2009; Minnis & Lindner 2013). Besides WNS, additional threats to bat populations have been documented, and in particular, the wind turbines of the rapidly developing wind power industry have been identified as a growing threat to migrating bats (Johnson et al. 2003). Since all species of bats in Canada are insectivorous, they may also be vulnerable to direct pesticide toxicity (Geluso et al. 1976) and/or suffer indirect effects from pesticides such as reduced prey abundance and availability. Lastly, bats are highly mobile on the landscape and some species are migratory. As a result, while some species of bats may use protected areas to meet certain requirements of their life histories, they may encounter threats when it becomes necessary to leave those areas to access resources for other aspects of their ecology. This combination of threats has heightened awareness about the health of bat populations, but in particular, the emergence of WNS has raised concern for the three Canadian bat species most affected by the disease such that in 2012 the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) completed emergency status assessments for the Tri-colored Bat (*Perimyotis subflavus*), Northern Myotis (*Myotis septentrionalis*), and Little Brown Myotis (*Myotis lucifugus*) that resulted in a recommendation to list these species as endangered. Subsequently, these three species were listed under the Species at Risk Act (SARA) in December 2014, enacting legal protections on individuals and their residences (e.g., roosts and hibernacula) (SARA 2015). Two additional species of bats found in British Columbia are also listed on schedule 1 of SARA [Pallid Bat (*Antrozous pallidus*) -threatened and Spotted Bat (*Euderma maculatum*) - special concern] (SARA 2015), and all species of bats that hibernate in Canada are vulnerable to WNS and may become threatened or endangered as the disease continues to spread in this country.

While some species of bats were among the most widespread and common mammals of Canada and are closely associated with humans, routinely using anthropogenic structures as roosts and breeding sites (e.g., buildings, kiosks, and bridges) (Lunde and Harestad 1986; Keeley and Tuttle 1999), many aspects of their life histories and ecology remain relatively poorly understood. The 20 bat species recorded in Canada (Naughton 2012) are almost entirely nocturnal, and during summer they typically use concealed, hard-to-access daytime roost sites (Kunz 1982; Fenton 1990). During the winter, some species hibernate in underground openings (e.g., caves and mines), which can be dangerous, difficult or impossible to access, and while additional overwintering habitat may exist (e.g., wells, buildings and other natural and anthropogenic structures), the use of these sites by bats in the winter is poorly documented (Whitaker and Gummer 2000). In general, many Canadian bat species are similar in appearance and size, and



vocalize outside the range of sounds audible to humans, the combination of which makes them difficult to identify without appropriate equipment (Adam 2003, Naughton 2012). As a result of these life history characteristics, bats are among the least understood vertebrates in Canada, and this lack of information may present challenges to Parks Canada sites in their efforts to protect bats.

The significant threats bat populations are currently experiencing and dearth of knowledge about them highlights the need to improve our understanding of the ecology, population status, and conservation of all Canadian bat species. This is especially true for those populations found in National Parks and National Historic Sites because of the high degree of protection these locations offer. Developing and implementing inventory and monitoring programs play a key role in this process by producing scientifically rigorous and accurate species-specific baseline data on the abundance, distribution, and population trends of bats. Precise information on the locations of bat summer roosts and winter hibernacula, as well as the patterns of habitat use for other aspects of their life histories (e.g., foraging and swarming) is integral for the protection of critical habitats for bats, and ultimately those species of bats that rely upon them.

The specific objectives of this monitoring study were to:

1. Identify the species of bats currently present in Prince Edward Island National Park (PEINP);
2. Collect preliminary data on the spatial and temporal distribution of these species to better understand what might be key habitat or critical areas for those species of bats in PEINP.

### **1.1 Linking bat monitoring to Parks Canada's integrated mandate**

Bat monitoring helps National Parks address other aspects of the Parks Canada Agency's integrated mandate. Because bats are long-lived species, are dependent upon specific habitats and landscape features, including roost and hibernation sites (e.g., snags, caves, and possibly anthropogenic structures), and are sensitive to a variety of ecosystem stressors, they may be good indicators of ecosystem health (Parks Canada 2015). Consequently bat communities are important to the ecological integrity of many National Parks, and, if a Park identifies it as a need, a standardised bat monitoring program can serve as one component of a Park's broader ecological integrity monitoring program. Parks Canada has developed comprehensive ecological integrity monitoring guidelines (Parks Canada 2011). These guidelines were used to provide guidance on the sampling design and quantitative analysis used for this study.

Bats can also play an important role in a National Park's visitor programs and education and outreach efforts. Most people are fascinated with bats because they are associated with the outdoors, healthy environments and conservation, but their cryptic behaviour makes observation of them difficult, adding to their mysterious appeal. No doubt, the widespread use of bats in popular culture also adds to this curiosity, for example, their association with well-known superheroes, monsters, and villains. This



common interest in bats makes them particularly amenable to engaging the public in visitor programs, including campfire programs or night walks, and education and outreach activities. These programs can make effective use of the information gained through a bat monitoring programs, particularly if presented in the context of conservation needs, Aboriginal knowledge and popular culture. Opportunities for public education and outreach were welcomed during this study, and in particular, local media requests were accommodated.

### **1.2 Components of this technical report**

Bats require diverse resources and exhibit dramatically different behaviours during the distinct periods of their annual cycle. Consequently, a variety of monitoring approaches were considered in the context of the time of year and the PEINP's obligations outlined in the Multi Species at Risk (MSAR) Action Plan (Giroux Personal communication).

Section 2 describes the acoustic survey methods used in this study to monitor the magnitude of activity of flying bats during summer at different habitat types and buildings, and the methods used to conduct potential roost emergence counts and visual surveys. The methods that were chosen are the most common and recommended current techniques for monitoring the status of bat populations (Battersby 2010; Britzke et al. 2013, Loeb et al. 2015).

Section 3 presents the results of the bat monitoring and inventory study in PEINP. Habitat use by bats is described and in addition, the use of various anthropogenic structures in the park as roosting sites for bats is reviewed.

Section 4 discusses the significance of the bat inventory and monitoring study's results.

Section 5 summarizes the main conclusions of the study and proposes future directions that could be explored to obtain a better understanding of the ecology of the bat populations in PEINP.

Lastly, appendices are included. These provide details on bat detector settings, road transects for mobile acoustic surveys, and additional findings.

### **1.3 NABat**

The current bat conservation concerns have accelerated the need for precise information on the population distribution, status and trends of bat species across North America. Therefore, the North American Bat Monitoring Program (NABat) was developed to ensure a consistent approach to the collection of this data throughout the continent (Loeb et al. 2015). In particular, NABat is a continental initiative being developed cooperatively by a broad range of government departments and nongovernmental organizations interested in bat conservation (see <https://my.usgs.gov/bpd/main/nabat>). NABat has the goal of leading coordinated bat monitoring to support regional and continental range-wide inferences about changes in the distributions and sizes of all North American bat populations. Therefore, this inventory and monitoring study for PEINP was



designed to be compatible with NABat so that site-level data could be attributed to the aggregated NABat database. However, since the land and adjacent crown properties managed by PEINP constitute a narrow strip of coastal habitat consisting of three separate areas, for the most part, the typical NABat methodology which involves sampling in 10x10 km cells could not be implemented only on land directly managed by PEINP. Therefore, the NABat protocol was adapted for PEINP, and this study incorporated one standard NABat cell which had one stationary acoustic monitoring site on land not managed by PEINP and two additional NABat cells that were modified to only include land directly managed by PEINP while still remaining applicable to the NABat protocol. This approach supports continental bat conservation efforts and helps PEINP interpret its observations in the context of broader regional, national, and continental trends in bat populations. Additionally, since other organizations and agencies are also using the NABat protocol to monitor provincial bat populations in Prince Edward Island, the data collected in PEINP will be compatible with those collected outside of the Park, and collaborating with these stakeholders will permit PEINP's Resource Conservation Staff to understand their data in the context of the local or provincial scale. Lastly, the inventory and monitoring study was developed so that it would be consistent with the standards set out in Parks Canada's consolidated guidelines for ecological integrity monitoring (Parks Canada 2011).

#### **1.4 Responsibilities, team, and deadline**

A Memorandum of Understanding between Parks Canada Agency and the University of Prince Edward Island (UPEI) facilitated the development of a proposal to monitor and inventory the bat populations of PEINP. The proposal for the study was produced by staff of the Canadian Wildlife Health Cooperative (CWHC), Atlantic Region, Department of Pathology and Microbiology, Atlantic Veterinary College, UPEI, specifically Dr. Scott McBurney and Mr. Jordi Segers as co-investigators, in collaboration with Dr. Hugh Broders, Department of Biology, Saint Mary's University and with input, guidance, and oversight provided by PEINP Field Unit Staff members Mr. Paul Giroux, Resource Conservation Manager and Mr. Rick Hawkins, Ecologist. Fieldwork and data analyses were performed by CWHC, Atlantic Region staff. PEINP Field Unit staff were actively engaged in the early stages of the inventory and monitoring study (proposal and first week of fieldwork: i.e., June 1 – 5) and were kept up to date on any major developments and all preliminary results. Dr. Broders was consulted for his expertise on Atlantic Canadian bat populations throughout the entirety of the study. Lastly, Ms. Lauren Grant was hired as a summer student field technician to do the field component of the study (Table 1).



Table 1: Team members, affiliation, and responsibilities during the completion of the bat inventory and monitoring study for PEINP

Team member	Affiliation	Responsibilities
Scott McBurney	CWHC/ UPEI	Co-investigator
Jordi Segers	CWHC/ UPEI	Co-investigator
Lauren Grant	CWHC/ UPEI	Field technician
Hugh Broders	Saint Mary’s University	Collaborator; proposal development, data collection, data analysis
Rick Hawkins	Parks Canada – PEINP	Ecologist
Paul Giroux	Parks Canada - PEINP	Resource Conservation Manager
Paul Ayles	Parks Canada – PEINP	Geomatics specialist and site consultant

## 2. Methods

Acoustic monitoring provides information on the identification, local activity levels, and distribution of bat species in the active season. Two approaches to acoustic surveys are employed in NABat, including stationary point acoustic surveys and mobile transect acoustic surveys (Loeb et al. 2015). One generalized random-tessellation stratified (GRTS) cell (i.e., a predetermined 100 km<sup>2</sup> unit of land surveyed with four stationary detectors and a mobile transect) was surveyed explicitly following the methodology of the NABat protocol and included a stationary acoustic monitoring site and a portion of mobile acoustic transect outside of the land managed by PEINP. The NABat methodology was adapted for two additional land units which did not follow the recommended standard 10 km X 10 km grid cell and was developed specifically for application to the narrow coastal land base solely managed by PEINP. The primary rationale for departure from the NABat protocol was to enhance the sampling design to yield sufficient data to make meaningful inferences about the status and trends of bats at the entire scale of PEINP. Buildings scheduled for demolishing were surveyed using acoustic detectors, emergence counts, or visual surveys. Additionally, some other key sites (i.e., a well and forested trail) were acoustically monitored at the request of field unit staff.

### 2.1 Stationary Acoustic Surveys for NABat Monitoring Program

#### 2.1.1 Monitoring objectives

The primary goal of the stationary point acoustic surveys was to identify diversity of species of bats, spatial and temporal bat activity, and critical habitat for the bat species in PEINP.

#### 2.1.2 Sampling timeframe and study design

Acoustic monitoring covered a representative sample of the entire area of PEINP, including the Cavendish, Brackley-Dalvay, and the Greenwich areas. Each area was sampled with four Wildlife Acoustics SM3 Bat Detectors, each at a different habitat type (i.e., coastal dune, forest edge, fresh water and wetland), for six to nine consecutive nights, at two separate times in the field season (i.e., early and late summer monitoring periods). After six to nine nights the detectors were collected from each site



and deployed with full batteries and formatted empty memory cards at the selected sites representing the four habitat types in the next area of the park scheduled for acoustic monitoring. Each night, all detectors were set to record the entire night from 15 minutes before sunset until 15 minutes after sunrise. Site selection for the acoustic detectors focused on maximizing bat detection at different habitat types (i.e., most likely commuting corridors and foraging sites, chosen based on literature and professional experience). This study design was developed to permit a spatial and temporal (i.e., early and late summer monitoring periods) comparison for magnitude of bat activity between the areas and habitat types of PEINP. Previous bat monitoring work in PEINP was reviewed (Henderson et al 2009; Corning 2005), and the unpublished data of Corning, Henderson, and Broders (2004) was used to select the stationary acoustic monitoring sites for some of the habitat types included in this study as long as these sites were compatible with our monitoring objectives. This resulted in four acoustically sampled sites in 2004 being included in this current study as part of the NABat Program described above.

### *2.1.3 Equipment*

The following equipment was used to conduct this study:

- 4 Wildlife Acoustics SM3 Bat Detectors
- 4 omnidirectional Wildlife Acoustics SM3 microphones
- Wildlife Acoustics Microphone Calibrator
- 9 32GB Kingston SDHC Cards
- 1 Garmin handheld GPS (set to datum WGS84)
- Suunto MC-2 Compass
- Wildlife Acoustics Kaleidoscope Pro software
- Duct tape
- Zip ties

### *2.1.4 Site description and detector placement*

Omnidirectional microphones were affixed to natural or anthropogenic structures (e.g., trees, posts etc.) at a height of 1 – 3 meters from the ground using non-destructive methods. The microphones were pointed away from cluttered habitat (e.g., forest interior, dunes, etc.) and angled near horizontal, but slightly downwards to remain weatherproof in inclement or rainy weather.

#### **2.1.4.1 Brackley-Dalvay Area**

The Brackley-Dalvay area stretches across the northern shore of PEI from the Western tip of Robinson's Island to the park boundary near Tracadie Harbour and is the central portion of PEINP. This portion of the Park also includes Blooming Point, but since it is predominately a sand spit surrounded by ocean, it was not considered suitable habitat for bats and thus, was not included in this study. The Brackley-Dalvay area of PEINP includes 1453.4ha of land. Figure 1 summarizes approximate detector locations and Appendix I summarizes exact detector locations, microphone positioning and NABat relevant data.



#### 2.1.4.1.1 Fresh Water Habitat Type

The site chosen for the fresh water habitat type is located on land not managed by PEINP. It is beside a man-made pond behind a farmer's field located on Kentyre Road in the town of Harrington, PE. The water body is 0.035 ha and surrounded on three sides by a predominantly deciduous forest. The microphone was fastened to an uncovered root system of a downed tree on the edge of the water body.

#### 2.1.4.1.2 Forest Edge Habitat Type

The site for the forest habitat type is located on Robinson's Island and is surrounded by a lightly used hiking trail. The microphone was placed on the edge of a deciduous forest (56.4ha). This forest is surrounded by a narrow coastal dune system on its eastern and western aspects and salt water on its northern and western aspects. The microphone was attached to a dead deciduous tree branch facing into a narrow trail on the forest edge.

#### 2.1.4.1.3 Coastal Dune Habitat Type

The microphone was placed on a small tree in the middle of a concave dune. The surrounding dune area is 32.8ha and is at the eastern base of the sand spit connecting Robinson's Island to the remainder of the Brackley-Dalvay area. This habitat type is separated from a larger dune system by a road to the North.

#### 2.1.4.1.4 Wetland Habitat Type

The Brackley-Dalvay area wetland is 6.3ha with an inconsistent water level. Throughout the acoustic monitoring period the water level declined, producing mudflats with small amount of remaining brackish water. The wetland is surrounded by fragmented deciduous forest and is separated from a small cottage community by a road and narrow strip of coastal dunes. The microphone was fastened to a coniferous tree branch at the edge of the mudflat. This location was selected because it was acoustically monitored by Corning, Henderson and Broders (unpublished data) for 1 night on August 19, 2004 which represents 31 and 59 nights after acoustic monitoring at this site in the current study.

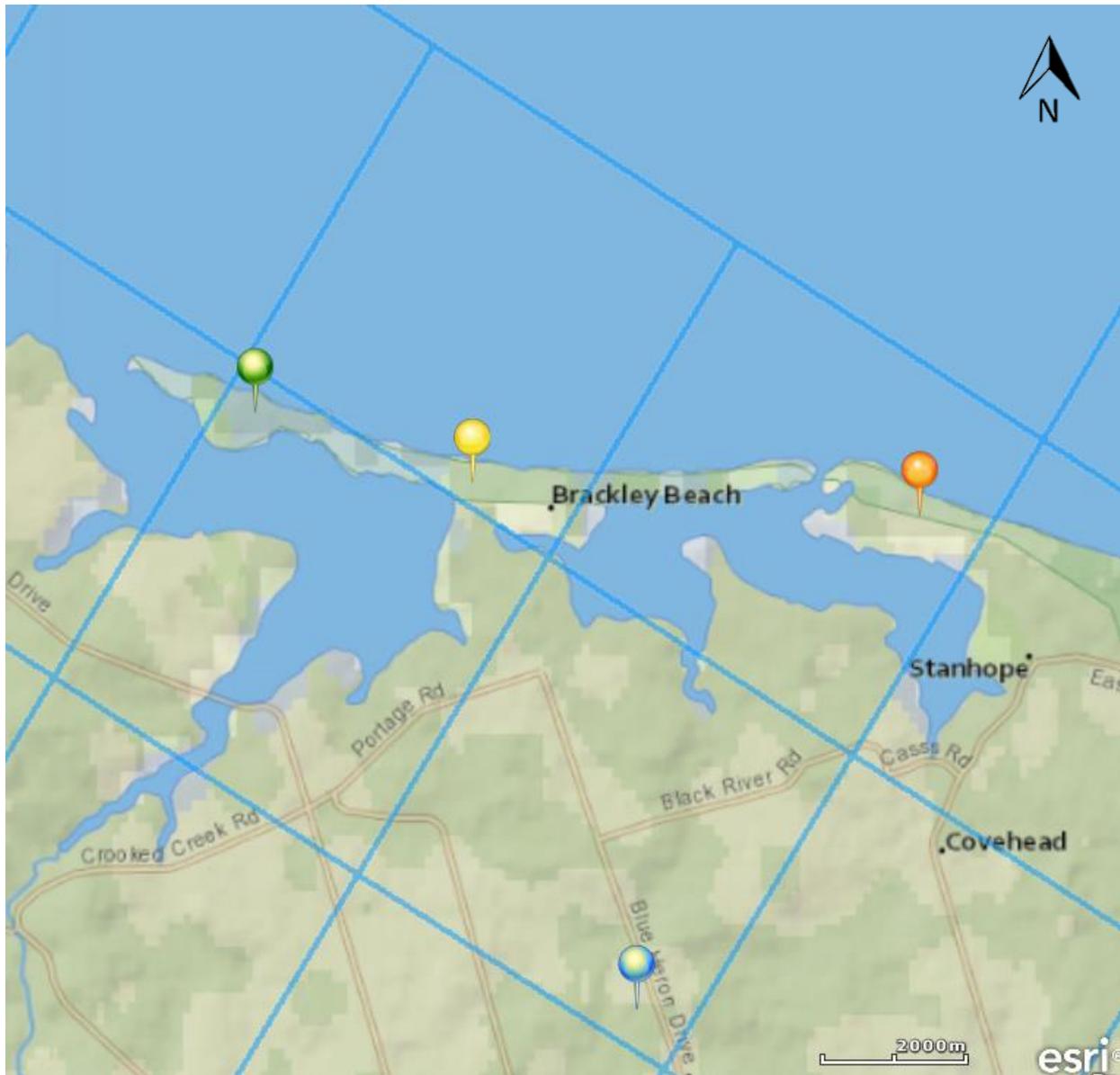


Figure 1: Detector locations in each habitat type (green is forest edge, yellow is coastal dune, blue is fresh water, orange is wetland) in the Brackley-Dalvey area of PEINP (NABat GRTS #214732). Blue squares represent NABat GRTS cells. Map sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, NASA, ESA, METI, NRCAN, GEBCO, NOAA, NGA, USGS.



#### **2.1.4.2 Greenwich Area**

Greenwich is the smallest and most eastern section of PEINP and contains a beach, hiking trail, sand spit, parabolic sand dune system, forested wetlands and fresh water bodies. The Greenwich portion of PEINP includes 628ha of land. Figure 2 summarizes approximate detector locations and Appendix I summarizes exact detector locations, microphone positioning and NABat relevant data.

##### **2.1.4.2.1 Fresh Water Habitat Type**

The fresh water habitat type in Greenwich is a 9.2ha narrow lake called Schooner Pond and is located south of a coastal dune system. It is surrounded on three sides by a mixed deciduous and coniferous forest. The microphone was attached to the branches of a shrub on the southeastern shore of the pond.

##### **2.1.4.2.2 Forest Edge Habitat Type**

The forest edge habitat type in Greenwich was adjacent to a parking lot and hiking trail. The microphone was placed on a coniferous tree pointing towards a large open area of grassland that is surrounded by forest on its northern and western aspects, the coast on its southern aspect, and a parking lot on its eastern aspect. The size of the forest area is 59.2ha. This location was selected because it was acoustically monitored by Corning, Henderson and Broders (unpublished data) for 1 night on August 14, 2004 which represents 17 and 47 nights after acoustic monitoring of this site in the current study.

##### **2.1.4.2.3 Coastal Dune Habitat Type**

The coastal dune habitat type in Greenwich is a 233ha peninsula with St. Peter's Bay bordering its southern side and the Gulf of St. Lawrence bordering its northern side. It terminates in the west at the entrance to St. Peter's Bay and is connected to a beach and dune system on its southern aspect. The microphone was placed on a small tree at the top of a dune.

##### **2.1.4.2.4 Wetland Habitat Type**

The 28.23ha wetland habitat type runs adjacent to the coastal dunes to the south of Greenwich beach and is surrounded by deciduous forest on its eastern, western and southern aspects. Some areas of the deciduous forest are flooded by the wetland. The microphone was attached to the branches of a shrub on the northeastern shore of the wetland, adjacent to the dunes.

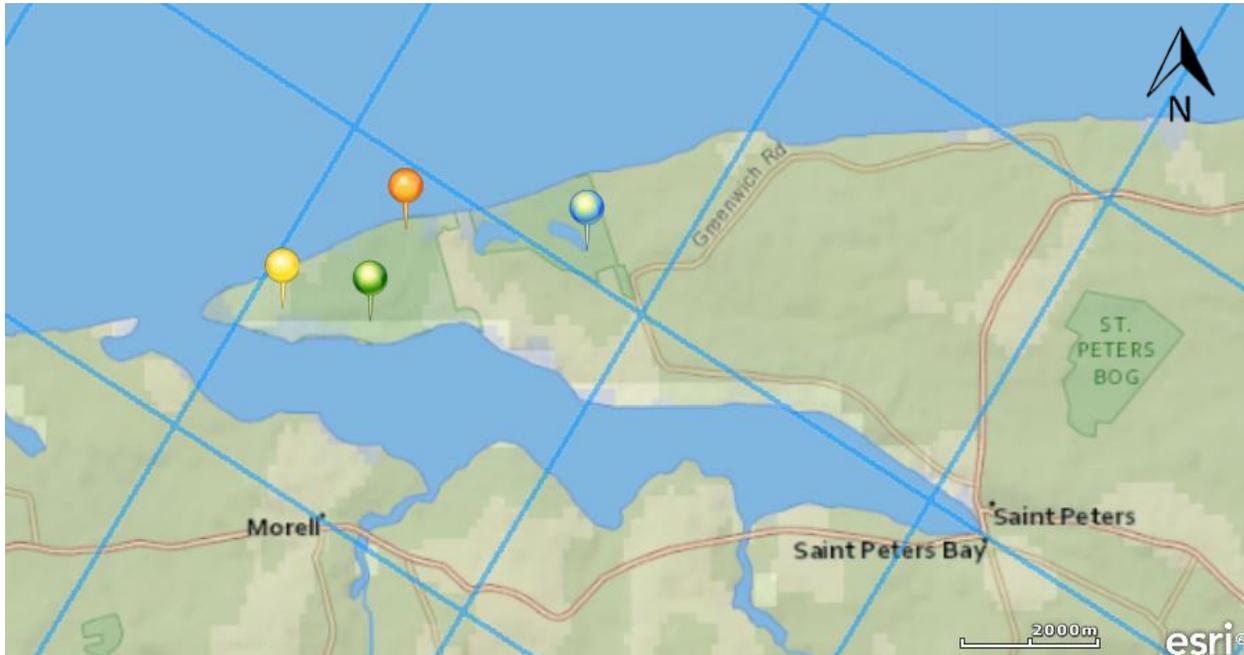


Figure 2: Detector locations in each habitat type (green is forest edge, yellow is coastal dune, blue is fresh water, orange is wetland) in the Greenwich area of PEINP. Blue squares represent NABat GRTS cells. Map sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, NASA, ESA, METI, NRCAN, GEBCO, NOAA, NGA, USGS.

#### 2.1.4.3 Cavendish Area

The Cavendish area is the most western portion of PEINP and includes the Green Gables Golf Course, Cavendish Campground, Cavendish Beach Complex, and Crown Land Properties. The western tip is a sand spit north of New London Bay. The eastern tip is a beach adjacent to North Rustico Harbour. The Cavendish area of PEINP includes 1493.9ha of land. Figure 3 summarizes approximate detector locations and Appendix I summarizes exact detector locations, microphone positioning and NABat relevant data.

##### 2.1.4.3.1 Fresh Water Habitat Type

Rollings Pond is a 2.5ha U-shaped pond near the eastern end of the Cavendish area, and it was chosen to represent the fresh water habitat type. The pond is surrounded by deciduous forest on its southern and western aspects, and is partially adjacent to two roads along its northern and eastern shores. Across the northern road is a narrow beach. The lake is adjacent to a similar sized wetland to the west. The microphone was attached to a dead tree nearest the center of the northern shore of the pond. This location was selected because it was acoustically monitored by Corning, Henderson and Broders (unpublished data) for 1 night on August 8, 2004 which represents 4 nights and 34 nights after acoustic monitoring of this site in the current study.



#### 2.1.4.3.2 Forest Edge Habitat Type

The forest edge habitat type is on the maintenance trail system of the Green Gables golf course in the center of a 65.5 ha forest. The detector was placed on the corner of the trail which could be used as a commuting corridor to bats. The microphone was attached to a coniferous tree branch. This location was selected because it was acoustically monitored by Corning, Henderson and Broders (unpublished data) for 1 night on July 29, 2004, the same date as one of the nights when this location was monitored in the current study.

#### 2.1.4.3.3 Coastal Dune Habitat Type

The coastal dune habitat type is 102 hectares. It is west of the Cavendish campground and at the base of the narrow sand spit adjacent to New London Bay. The microphone was mounted on the top of an old fence.

#### 2.1.4.3.4 Wetland Habitat Type

The wetland habitat type is 6.4ha and is east of the Cavendish campground with a 13.3ha fresh water body on its northern and eastern aspects and a narrow strip of forest and a road on its southern and western aspects, respectively. The microphone was mounted on the branch of a tree at the edge of the wetland habitat.

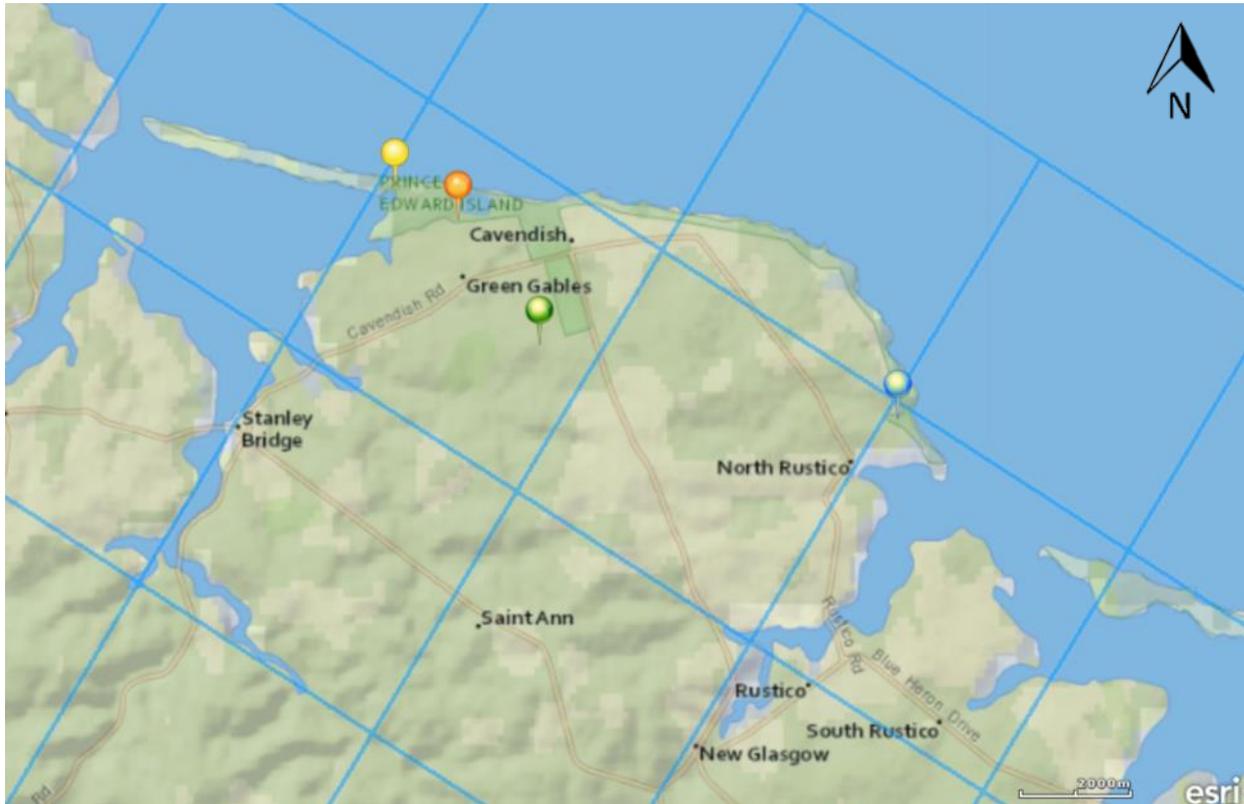


Figure 3: Detector locations in each habitat type (green is forest edge, yellow is coastal dune, blue is fresh water, orange is wetland) in the Cavendish area of PEINP. Blue squares represent NABat GRTS cells. Map sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, NASA, ESA, METI, NRCAN, GEBCO, NOAA, NGA, USGS.

## 2.2 Mobile Acoustic Surveys for NABat Monitoring Program

### 2.2.1 Monitoring objectives

A mobile acoustic survey involves attaching a directional microphone (i.e., an omnidirectional microphone placed into a housing or shield to make it directional) to the roof of a vehicle and slowly driving along a predetermined survey transect during early evening to acoustically monitor for bats. A Plan for the North American Bat Monitoring Program (NABat) states: “*There are several advantages and disadvantages of mobile transects compared to point surveys and vice versa. On mobile transects, each bat pass should represent a different individual as most bats do not fly faster than 32 kph (Grodzinski and others 2009, Hayward and Davis 1964, Kennedy and Best 1972, Patterson and Hardin 1969, Schaub and Schnitzler 2007). Thus, the number of passes of each species can be used as an index of relative abundance (Roche and others 2011). Road transects are also more cost-effective than stationary point surveys (Whitby and others 2014) and may be easier to implement in areas that are dominated by private land. However, some species may be over-represented whereas others may be under-represented, depending on their affinities for roads and roadside habitat (Roche and others 2011, Whitby and others 2014). Stationary point surveys remove the road bias associated with mobile transects and it*



*is easier to control for factors that may affect call quality and quantity. However, stationary points also require more time to deploy and it may be difficult to find sites in areas that are primarily in private ownership” (Loeb et al. 2015). Therefore, the data from mobile acoustic surveys augment those collected from stationary surveys, and where sufficient roads are available a mobile acoustic survey route should be sampled in each 10x10 km area where two or more stationary point surveys are being conducted.*

### 2.2.2 Study design

Within the boundaries of the PEINP and the surrounding crown land managed by PEINP, mobile transects of 9.3 to 25.8km were acoustically surveyed six times, between 17 June and 30 July, 2015. Transects were driven at approximately 30 km/h, and stopping or variation in speed occurred only when required. Areas with narrow, dense forest corridors and a low canopy were avoided or minimized to decrease the chance of recording fragmented calls caused by obstacles such as forest canopy. Three separate mobile transects surveyed acoustically. One transect was required for the standard NABat protocol and included land managed by PEINP in the Brackley Beach area as well as private lands outside of the Park’s jurisdiction. Lastly, there were two transects for the NABat protocol that were adapted specifically for lands managed by PEINP which combined the Cavendish and Brackley-Dalway areas of PEINP for one transect and included the Greenwich area of PEINP as another separate transect. This configuration of mobile transects fully represented the entire land base of PEINP. See Appendix II for driving transect directions and descriptions.

Each mobile transect was surveyed in a single night. To complement the stationary monitoring surveys, the mobile survey for a given area was driven during the same week that the stationary monitoring survey was being conducted in both the early and late summer monitoring periods. The mobile surveys began 15 minutes after sunset to target bats commuting from roosts to foraging sites. With the exception of the standard Brackley Beach NABat GRTS, acoustic recording was paused when exiting the Park areas and resumed when a new area of the Park was entered. Mobile transects were only driven on nights with low wind speeds (< ~10 km/h) and no rain or fog. All weather variables were recorded.

### 2.2.3 Equipment

Full spectrum recordings were made with a time-date stamp for each recording using a directional microphone pointed straight up to minimize road noise and reflections off the top of the vehicle and to detect bats flying straight overhead. The detector time was manually synchronized with a GPS unit to geo-reference the individual acoustic files.

Equipment used:

- 1 Wildlife Acoustics SM3 Bat Detector
- SM3 ultrasonic omnidirectional microphone
- Garmin GPS unit (set to datum WGS84)
- Car with sunroof



- Custom made microphone mount
- 1 directional Wildlife Acoustics SM3 horn microphone attachment

## 2.3 Building surveys

### 2.3.1 Study design

Magnitude of activity of bats was acoustically monitored with Wildlife Acoustic SM2+Bat and SM3Bat detectors at buildings and other anthropogenic structures to determine their potential use by bats as roosting sites. In the Brackley-Dalvay area, 11 buildings were acoustically monitored (10 at the Brackley day-use area and one near the Dalvay entrance to the Park). The interior of the attic of one building near the Dalvay office was only inspected visually for the presence of bats because of a time constraint that was associated with an impending construction project. At Cavendish five buildings were monitored (one at the homestead trail, two near Rollings pond, and two farm houses). Two buildings were monitored at Fort Amherst National Historic site. These buildings were immediately adjacent to each other and therefore, were monitored with one detector. At this site, an additional detector was placed at a forest edge 150meters from the buildings as a control (table 5).

### 2.3.2 Equipment

The following equipment was used to conduct this study:

- 2 Wildlife Acoustics SM3 Bat Detectors
- 2 Wildlife Acoustics SM2+Bat Detectors
- 2 omnidirectional Wildlife Acoustics SM3 microphones
- 2 omnidirectional Wildlife Acoustics SM2 microphones
- Wildlife Acoustics Microphone Calibrator
- 4 8GB SanDisk SDHC Cards
- 1 Garmin handheld GPS (set to datum WGS84)
- Suunto MC-2 Compass
- Wildlife Acoustics Kaleidoscope Pro software
- Duct tape
- Zip ties

### 2.3.3 Buildings Monitored

#### 2.3.3.1 Brackley Day-use Area

These ten wooden buildings comprise the former Brackley day-use area (Figure 4 and Appendix III), and they all served different purposes for the former campground (i.e., washroom, cooking area, etc.).



#### **2.3.3.2 Dalvay Activity Centre**

This former activity centre (Figure 4 and Appendix III) is a wooden structure located near the eastern entrance of the Brackley-Dalvay area. Bats have been observed emerging from under the roof of this building in the past (Hawkins Personal Communication).

#### **2.3.3.3 Dalvay Staff House**

This old staff house (Figure 5 and Appendix III) is currently used as an office and was slated for imminent renovations that could be a disturbance to bats potentially roosting inside. Therefore, time did not permit acoustic monitoring at this building so only a visual survey of the attic was done.

#### **2.3.3.4 Homestead Trail Building**

This wooden building (Figure 6 and Appendix III) is along a hiking/cycling trail facing away from an adjacent strip of woods. The building is dilapidated with loose boards and areas of partial collapse.

#### **2.3.3.5 Rollings Pond South Building**

The front door of this wooden building (Figure 6 and Appendix III) is missing and the floor has collapsed in several places. Traces of raccoon and coyote feces were identified inside the building.

#### **2.3.3.6 Rollings Pond North Building**

This wooden building (Figure 6 and Appendix III) is surrounded by dense vegetation. The building is completely overgrown with early succession forest, resulting in vegetation clutter between the microphone and the building. The building appeared in a better condition than the Rollings Pond South Building, but vegetation obstructed a safe and close inspection of the building.

#### **2.3.3.7 Simpson House**

This is a two-and-a-half storey wooden, heritage, farm house (Figure 6 and Appendix III). The house is occasionally occupied by Park staff and bat activity has been observed here (Hawkins personal communication).

#### **2.3.3.8 Sampson House**

This is a two-and-a-half storey wooden, heritage, farm house (Figure 6 and Appendix III). The house has not been inhabited by humans in recent years due to its deteriorating structure.

#### **2.3.3.9 Fort Amherst buildings**

These two decommissioned buildings are scheduled to be demolished. The buildings are immediately adjacent to each other in an open field and in close proximity to a service road (Figure 7 and Appendix III).

#### **2.3.3.10 Fort Amherst control**

The control site was on a forest edge overlooking a small field south of the buildings being monitored at this site (Figure 7 and Appendix III).

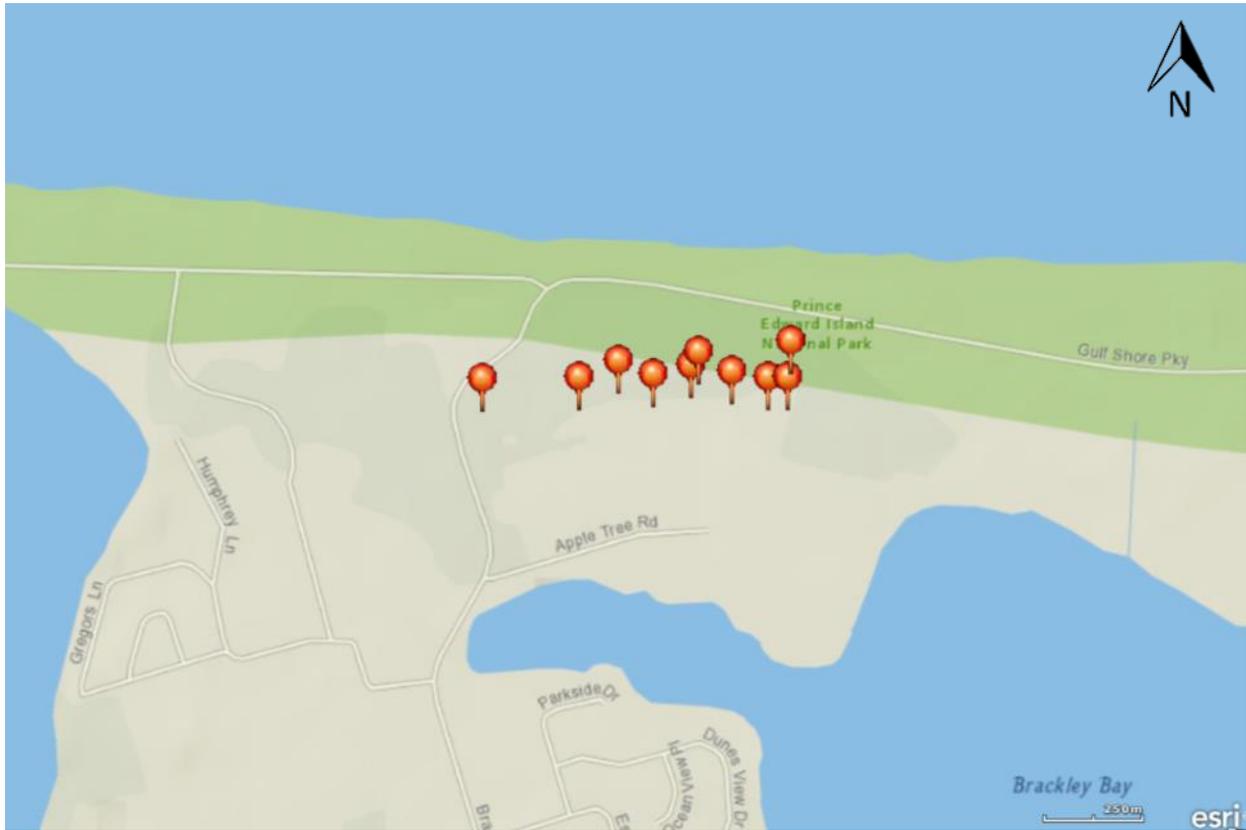


Figure 4: Detector locations at buildings surveyed in the Brackley Day-use Area; buildings 1 to 10 (left to right). Map sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, NASA, ESA, METI, NRCAN, GEBCO, NOAA, NGA, USGS.

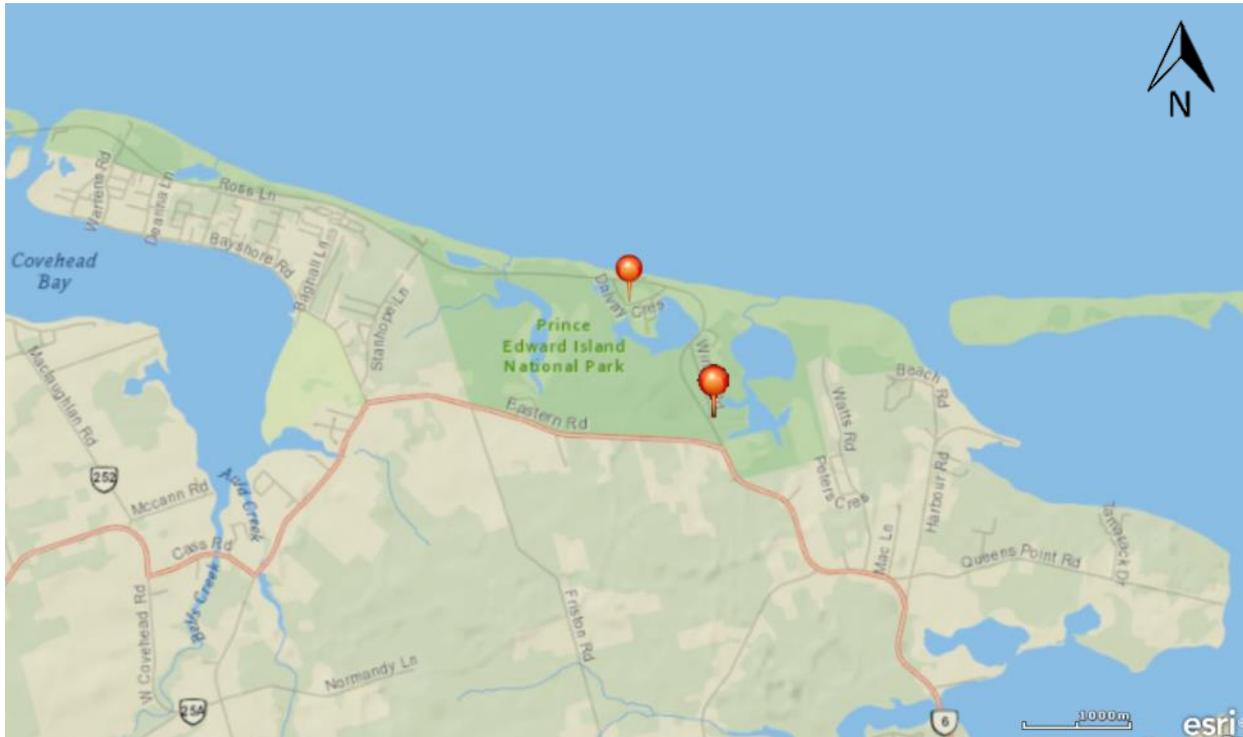


Figure 5: Detector locations at buildings surveyed in the Dalvey Area; Dalvey Staff House (left) and Dalvey Activity Centre (right). Map sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, NASA, ESA, METI, NRCAN, GEBCO, NOAA, NGA, USGS.

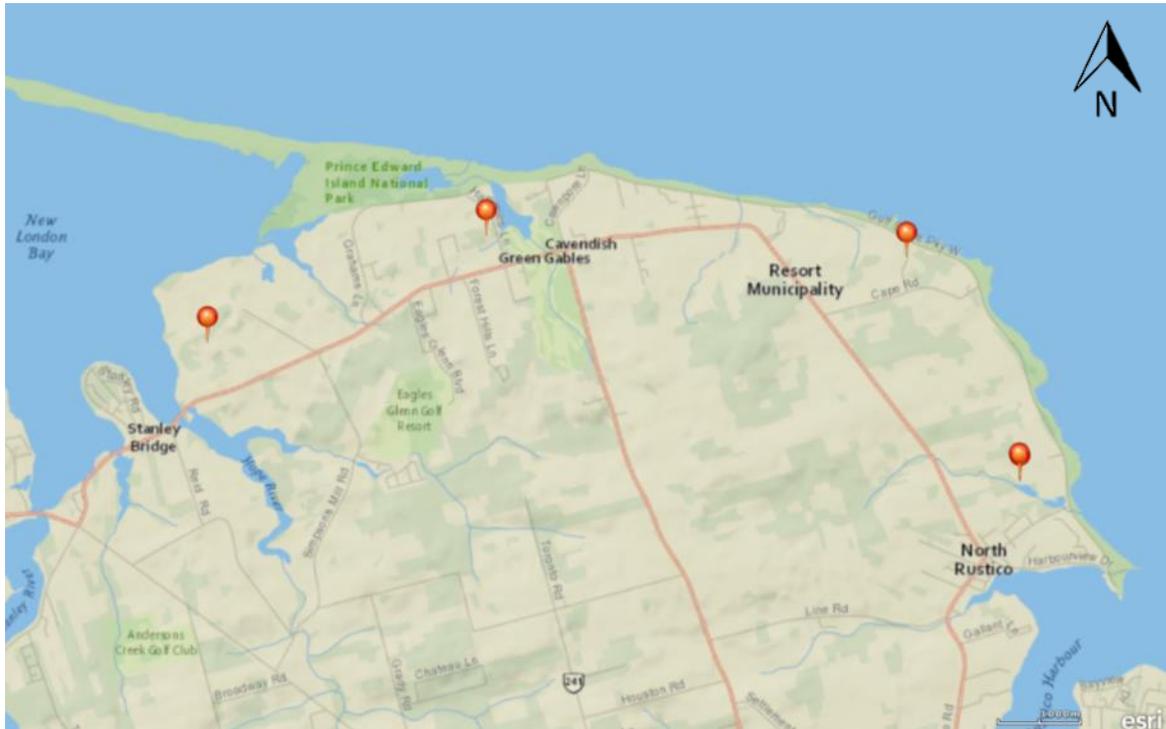


Figure 6: Detector locations at buildings surveyed in the Cavendish Area; Homestead Trail Building, Simpson House, Sampson House, Rollings Pond South Building, Rollings Pond North Building (left to right). Map sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, NASA, ESA, METI, NRCAN, GEBCO, NOAA, NGA, USGS.



Figure 7: Detector locations at buildings (inset: top) and control site (inset: bottom) surveyed at Fort Amherst. Map sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, NASA, ESA, METI, NRCAN, GEBCO, NOAA, NGA, USGS.

#### 2.4 Emergence counts at potential roosts

Emergence counts at buildings were only conducted when acoustic data indicated increased magnitude of bat activity in close proximity to sunset or sunrise. Counts were always done by at least two people sitting on opposite corners of the building so that all four walls of the building could be visually monitored simultaneously. Observations started 15 minutes before sunset and continued until bats were not observed emerging for more than 10 minutes or if no bats emerged, until one hour after sunset.

#### 2.5 Visual inspections of potential roosts

Visual inspections of potential roosts were only done when emergence counts were not sufficient or reliable in determining whether or not a building was a roosting site. Visual inspections were done by two observers wearing full Tyvek suits, boot covers, nitrile gloves, and respirators. This equipment was worn for protection of personal health as well as for biosecurity to prevent the potential transmission of



pathogens between sites. Headlamps were employed to conduct thorough visual inspections inside building attics and other dark areas of buildings.

## 2.6 Other acoustic monitoring sites

### 2.6.1 Study design

We were instructed to monitor these additional sites by PEINP staff. The purpose of monitoring the Cavendish homestead trail well was to determine its suitability as a swarming site and/or hibernaculum. The purpose of monitoring the Dalvay Woodland Trail was to determine the proportion of MYSE activity represented by the *Myotis* spp. passes at this site.

### 2.6.2 Equipment requirements

The following equipment was used to conduct this study:

- 2 Wildlife Acoustics SM3 Bat Detectors
- 2 omnidirectional Wildlife Acoustics SM3 microphones
- Wildlife Acoustics Microphone Calibrator
- 11 32GB Kingston SDHC Cards
- 1 Garmin handheld GPS (set to datum WGS84)
- Suunto MC-2 Compass
- Wildlife Acoustics Kaleidoscope Pro software
- Duct tape
- Zip ties

### 2.6.3 Cavendish Homestead Trail Well

This hand dug well is adjacent to the hiking/cycling trail underneath a mountain ash and surrounded by raspberry canes (Figure 8 and Appendix IV). Wells on PEI have been identified as swarming sites and hibernacula for bats so the Cavendish Homestead Trail Well was monitored as an additional request by Park staff.

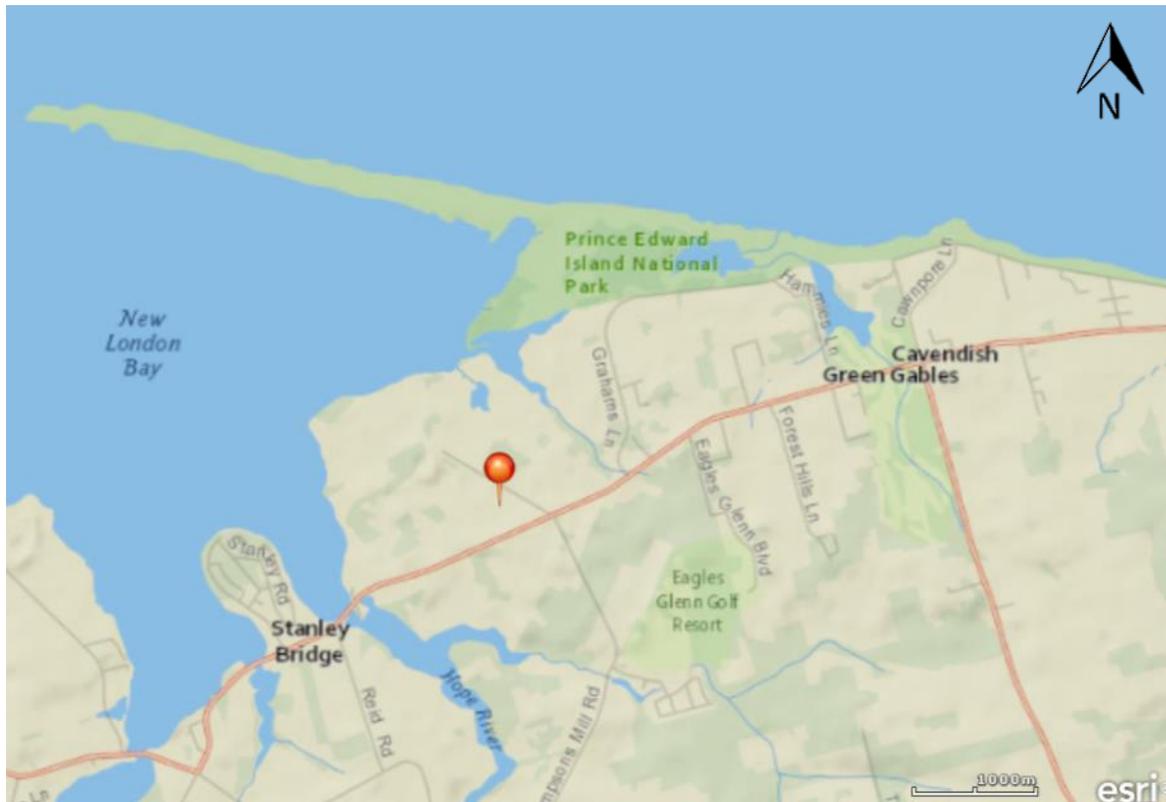


Figure 8: Detector location and at the Cavendish Homestead Trail Well in the PEINP

#### 2.6.4 Dalvay Woodland trail

The Dalvay Woodland trail is a forested trail system south of Dalvay Lake and formally accessible from the Dalvay visitor centre. The trail is in a mixed coniferous and deciduous forest roughly 128 hectares in size. The detector was placed at a trail intersection, and the microphone was mounted on top of a park sign (Figure 9 and Appendix IV). At the request of Park staff, the monitoring at this trail was targeted to specifically identify potentially suitable commuting and roosting habitat for *M. septentrionalis*. This site was not part of the NABat monitoring protocol.



Figure 9: Detector location at the Dalvay Woodland trail in PEINP

## 2.7 Detector settings and data analysis

Only SM3+Bat detectors (Wildlife Acoustics) were used to acoustically monitor the four habitat types in each area of PEINP. Buildings were acoustically monitored with a combination of SM2+Bat (Wildlife Acoustics) and SM3Bat detectors. The settings are summarized in Appendix V. The raw .WAV files from bat detectors were converted to .00# Zero Crossing (Division Ratio 8) files using Kaleidoscope Pro version 3.1.1.. The filter was set to 8-120 KHz, 2-500ms, with minimum number of calls set to 2. The noise files were kept. Automatic identification classifiers were set to 'Conservative' and only species from PEI and other eastern Canadian provinces were selected; EPFU (*Eptesicus fuscus* – big brown bat), LACI (*Lasiurus cinereus* – hoary bat), LABO (*L. borealis* – eastern red bat), LANO (*Lasiyonicteris noctivagans* – silver-haired bat), MYLE (*Myotis leibii* - Small-footed bat), MYLU (*M. lucifugus* – little brown myotis), MYSE (*M. septentrionalis* –Northern myotis), and PESU (*Perimyotis subflavus* – Tricolored bat) (Broders et al 2003; McAlpine et al. 2002a; McAlpine et al. 2002b; Naughton 2012; Segers et al 2013). Bat pass files were visually inspected and identified to genus level or species when possible. A bat pass was interpreted as a sequence of echolocation calls that was  $\geq 2$  echolocation calls in length but  $\leq 15$  seconds in total time. The number of bat passes over a period of time at a given location represented the magnitude of bat activity at that site. Due to overlap in echolocation calls of LANO and EPFU as well as MYSE and MYLU, any echolocation calls falling within the classification criteria for these species were classified as LANO/EPFU or *Myotis spp.*, respectively. Only at the Forest Trail



acoustic monitoring site were attempts made to specifically determine if bat passes were from *Myotis* spp. or MYSE specifically. This was done to estimate magnitude of MYSE activity at this site. Adams (2003) described the main difference between echolocation calls of MYLU and MYSE is in their upper frequencies where they sweep almost vertically down. This occurs at approximately 70 kHz for MYLU and approximately 80 kHz for MYSE. Therefore, only echolocation sequences containing two or more echolocation calls with a peak frequency of at least 80 kHz were classified as MYSE. Auto identification was used only for confirmation and the specific identification of bat passes were accomplished by direct examination of all of the data.

### 3. RESULTS

#### 3.1 Stationary Acoustic Surveys for NABat Monitoring Program

Sampling all three areas of PEINP took three to four weeks, after which the sampling methodology was repeated once, for seven weeks of acoustic monitoring for the entirety of PEINP, representing 56 acoustic detector nights at Brackley-Dalvay, 63.9 acoustic detector nights at Cavendish, and 54 acoustic detector nights at Greenwich equalling 173.9 acoustic detector nights for the entirety of PEINP. An additional detector was deployed in the Dalvay area to specifically target habitat that was potentially suitable for MYSE.

##### 3.1.1 Species diversity

During the 174 detector nights in the four habitat types in all areas of PEINP, 16,022 bat passes were recorded (Appendix VI), averaging 92.15 bat passes per night. *Myotis* species accounted for 15,941 bat passes or 99.5% of all bat passes, other bat species accounted for 74 bat passes or 0.46% of all bat passes, and 7 bat passes or 0.04% of all bat passes could not be identified to genus or species. The other bat species that were identified included LACI (65 bat passes) and LANO/EPFU (nine bat passes). Late summer at the Cavendish coastal dune habitat type, one unidentified bat pass most closely matched the characteristics of a LABO. However, the auto-ID result was not consistent among echolocation calls within the sequence and quantitative comparison with published metrics of LABO echolocation calls/sequences (Adam 2003) was not conclusive. Early summer at the Greenwich wetland habitat type, seven bat passes were identified as LANO/EPFU and were recorded from 22:43h to 22:45h (i.e., < two minutes) on 24 June 2015. Early summer at the Cavendish fresh water habitat type, one LACI pass was recorded on the night of 5 July 2015 at 22:51h. At this same site during late summer, one recorded bat echolocation call was a fragment too small to identify to species and since this did not meet our criteria of a bat pass this data was not interpreted. At the Brackley-Dalvay wetland habitat type, 57 LACI passes were recorded. All of these LACI passes were recorded on the night of 17 July 2015 within 29 minutes of each other (i.e., 22:34h – 23:03h). Fifteen bat passes included both LACI and *Myotis* spp.. Early summer at the Cavendish coastal dune habitat type, two bat passes were recorded separately on 2 and 4 July, 2015, but the echolocation calls within the sequences were too fragmented to confidently identify to species. These short and fragmented echolocation calls could have been a portion of a feeding buzz or a



social call. Late summer at the Cavendish coastal dune habitat type, five LACI passes were recorded on the nights of 1 and 2 August 2015. The echolocation calls in two additional bat passes recorded at this time could not confidently be identified to genus or species. Late summer at the Cavendish wetland habitat type, two LACI passes were recorded separately on the nights of 1 and 2 August 2015 and two LANO/EPFU passes were recorded on the night of 3 August 2015. The echolocation calls in two additional bat passes recorded at this habitat type were too short to be identified to genus or species.

### *3.1.2 Spatial and temporal comparison*

With the exception of the Cavendish coastal dune habitat type, each habitat type had a higher average number of bat passes recorded during the late summer surveys compared to the average of those recorded during the early summer surveys. Overall, average magnitude of bat activity increased between early and late summer from: 35.36 to 54.32 bat passes per night in the Brackley-Dalvay area; 4.68 to 6.97 bat passes per night in the Greenwich area; and 75.88 to 400.22 bat passes per night in the Cavendish area. Fresh water habitat types in late summer yielded the highest average nightly number of bat passes: 154.86 bat passes per night in the Brackley-Dalvay area; 15.56 bat passes per night in the Greenwich area; 1444.51 bat passes per night in the Cavendish area (Appendix VI).

In both the Brackley-Dalvay and Greenwich areas, the coastal dune and forest edge habitat types yielded low average nightly bat passes (< two passes per night) during early and late summer monitoring periods. In the Cavendish area, an average of 94 bat passes were recorded per night at the coastal dune habitat type, but this site was immediately adjacent to a brackish wetland (Figure 10).

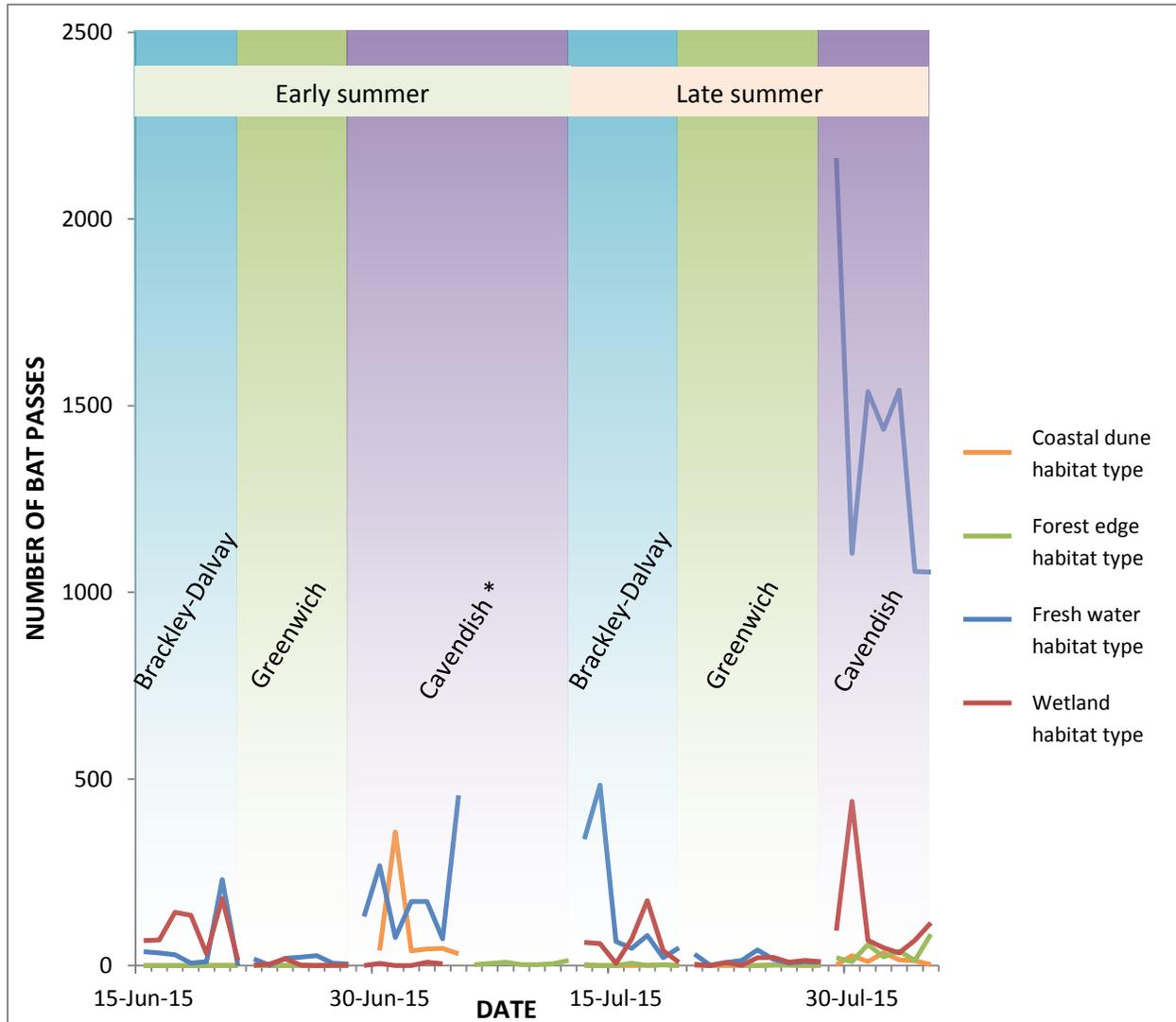


Figure 10: Graphs of nightly bat passes recorded by stationary acoustic detectors at the four habitat types for the Brackley-Dalvay, Cavendish, and Greenwich areas of PEINP in early and late summer.

\*Cavendish forest edge habitat type was monitored one week after the other Cavendish monitoring sites due to equipment difficulties.

### 3.1.3 Inter-annual comparison

In 2004, the Corning, Henderson, and Broders study (unpublished data) acoustically monitored for a single night at four of the same habitats that were included in the current monitoring study but using different methodology and equipment, including acoustic detectors (i.e. Titley Electronics Anabat II). In 2004 at the Brackley-Dalvay wetland habitat type, 13 bat passes were recorded, and in 2015, an average of 60.14 (range: 6 – 180) bat passes per night were recorded at this location. In 2004 at the Cavendish



forest edge habitat type, 46 bat passes were recorded, and in 2015, an average of 35.17 (range: 13 – 85) bat passes per night were recorded at this location. In 2004 at the Cavendish fresh water habitat type, 71 bat passes were recorded, and in 2015, an average of 1444.51 (range: 1074 – 2171) bat passes per night were recorded at this location. Finally, in 2004 at the Greenwich forest edge habitat type, 5 bat passes were recorded, and in 2015, an average of 1.89 (range: 0 – 6) bat passes per night were recorded at this location (Table 3).

### 3.2 Mobile Acoustic Surveys for NABat Monitoring Program

A total of 114.4km was driven in 374 minutes using the three different transects described above on six separate nights (i.e., each transect was driven two times, once in each of the early and late summer). Only one *Myotis* spp. pass was recorded during any of the mobile transects, and that bat pass was recorded on the Greenwich area transect on 21 July 2015 at 21:32h. The bat pass was recorded at N46°26'44.88" W62°38'47.04" while crossing a forested stream on highway 336 which is adjacent to PEINP land and about 400m before the end of the transect.

### 3.3 Building surveys

#### 3.3.1 Brackley

The average number of bat passes recorded at the Brackley day-use buildings ranged from 0.5 of a bat pass per night at building 8 to 10.25 bat passes per night at building 2 (Table 4). The earliest (evening) bat pass was recorded at 21:08:49 on 4 August 2015 at building 6, 29 minutes after sunset, followed by 12 additional bat passes within the next 3 minutes. Additional bat passes were not recorded at a similar time on the other nights this building was monitored. The latest (morning) bat pass was recorded at 4:48:56 on 6 August 2015 at building 6, 72 minutes before sunrise. The need for an emergence count at any of the buildings in the Brackley day-use area was not supported by this data.

#### 3.3.2 Dalvay

At the Dalvay Activity Centre, 719 bat passes were recorded over six nights (average = 179.75 bat passes per night; Table 4). The earliest (evening) bat pass was recorded at 21:38:45 on 6 July 2015, 22 minutes after sunset. The latest (morning) bat pass was recorded at 4:48:47 on 7 July 2015, 51 minutes before sunrise. The timing of bat passes on other monitoring nights was consistent with the pattern described here. These findings indicated that this location was possibly a roosting site (Rydell et al. 1996) so an emergence count was conducted here (Table 4).

#### 3.3.3 Cavendish

The number of bat passes recorded at Cavendish buildings ranged from nine at the Sampson house over five nights) to 544 at the Simpson house over 5 nights, giving an average of 1.8 and 108.8 bat passes per night at the Sampson and Simpson houses, respectively (Table 4). At the Simpson House, the earliest (evening) bat pass was recorded at 21:12:11 on 25 July 2015 (i.e., 20 minutes after sunset), and the latest (morning) bat pass was recorded at 5:06:55 on 28 July 2015 (i.e., 43 minutes before sunrise). The timing



or bat echolocation passes on other monitoring nights was consistent with the pattern described here. These findings indicated that this location was possibly a roosting site (Rydell et al. 1996) and an emergence count was conducted here (Table 4). Additional support for performing this count was that one bat pass on 25 July 2015 at 4:36h was identified as a LANO/EPFU pass, and since these species are not common on PEI, it would be very important to identify and confirm one of their roosting sites.

#### *3.3.4 Fort Amherst*

On four consecutive nights, one bat pass was recorded at the Fort Amherst control site and no passes were recorded at the buildings being monitored for their potential to be roosting sites (Table 4). Therefore, the need for an emergence count at Fort Amherst buildings was not supported by this data.



Table 3: Sampling dates and number of bat passes recorded at four identical habitat type locations in PEINP sampled acoustically with a similar technique in two separate years, 2004 and 2015

PEINP site	2004		2015					Average # of Bat Passes per Night	Increase or decrease in Bat Passes Between Monitoring Years
	Date of Monitoring Night	Total # of Bat Passes	Start Date of Monitoring	End Date of Monitoring	# of Monitoring Nights	# of Bat Passes	Range of Bat Passes per Night		
Cavendish forest edge	29-Jul	46	29-Jul	5-Aug	7	250	13 - 85	35.2	↓10.83
Brackley-Dalvay Wetland	19-Aug	13	13-Jul	20-Jul	7	421	6 - 180	60.1	↑47.14
Greenwich forest edge	14-Aug	5	20-Jul	29-Jul	9	17	0 - 6	1.9	↓3.11
Cavendish fresh water	8-Aug	71	29-Jul	5-Aug	6.9	9931	1074 - 2171	1444.5	↑1373.51



Table 4: Number of bat passes recorded and species identified at buildings in PEINP

Building Identification	Start Date of Monitoring	End Date of Monitoring	# of Monitoring Nights	# of Bat Passes	Average # Bat Passes per night	Emergence Count	Roost survey	Species manual ID
<b>Brackley-Dalvay</b>								
Building1	15/6/2015	19/6/2015	4	13	3.3	No	No	13 <i>Myotis</i> spp.
Building2	15/6/2015	19/6/2015	4	41	10.3	No	No	41 <i>Myotis</i> spp.
Building3	15/6/2015	19/6/2015	4	20	5	No	No	20 <i>Myotis</i> spp.
Building4	15/6/2015	19/6/2015	4	11	2.8	No	No	11 <i>Myotis</i> spp.
Building5	22/6/2015	26/6/2015	4	11	2.8	No	No	11 <i>Myotis</i> spp.
Building6	25/7/2015	7/8/2015	13	104	8	No	No	105 <i>Myotis</i> spp.
Building7	22/6/2015	26/6/2015	4	4	1	No	No	4 <i>Myotis</i> spp.
Building8	22/6/2015	26/6/2015	4	2	0.5	No	No	2 <i>Myotis</i> spp.
Building9	6/7/2015	10/7/2015	4	6	1.5	No	No	6 <i>Myotis</i> spp.
Building10	6/7/2015	10/7/2015	4	5	1.3	No	No	5 <i>Myotis</i> spp.
Dalvay Activity Centre	6/7/2015	10/7/2015	4	719	179.8	Yes	Yes	719 <i>Myotis</i> spp.
Dalvay Staff House	N/A	N/A	N/A	N/A	N/A	No	Yes	N/A
<b>Cavendish</b>								
Homestead building	30/6/2015	6/7/2015	6	34	5.7	No	No	34 <i>Myotis</i> spp.
Homestead Well	30/6/2015	6/7/2015	6	26	4.3	No	No	26 <i>Myotis</i> spp.
Homestead Well fall	14/08/2015	2/11/2015	74	681	9.2	No	No	681 <i>Myotis</i> spp.
Rollings Pond1	14/7/2015	19/7/2015	5	44	8.8	No	No	44 <i>Myotis</i> spp.
Rollings Pond2	14/7/2015	19/7/2015	5	20	4	No	No	20 <i>Myotis</i> spp.
Simpson House	23/7/2015	28/7/2015	5	544	108.8	Yes	No	543 <i>Myotis</i> spp. 1 LANO/EPFU**
Sampson House	23/7/2015	28/7/2015	5	9	1.8	No	No	9 <i>Myotis</i> spp.
<b>Fort Amherst</b>								
Fort Amherst buildings	26/7/2015	30/7/2015	4	0	0	No	No	N/A
Fort Amherst control	26/7/2015	30/7/2015	4	1	0.3	No	No	1 <i>Myotis</i> spp.

\*N/A = Not Applicable

\*\*LANO/EPFU = *Lasionycteris noctivagans*/*Eptesicus fuscus*



### **3.4 Emergence counts at potential roosts**

Timing of earliest and latest bat passes recorded at the Dalvay Activity Centre and Simpson House was consistent with that of a bat roosting site (Rydell et al. 1996). Therefore, emergence counts were conducted on 16 July 2015 and 30 July 2015 at the Dalvay Activity Centre and Simpson House respectively. Bats were not observed emerging from either building (Table 7).

### **3.5 Visual surveys of potential roosts**

Visual surveys were conducted at the Dalvay Staff House and the Dalvay Activity Centre on 23 June 2015 and 23 July 2015 respectively. Bats and/or signs of previous or current bat occupation (e.g., the presence of guano) were not observed at either site (Table 7).

### **3.6 Other acoustic monitoring sites**

#### *3.6.1 Cavendish Homestead Trail Well*

At the Homestead Trail well, in summer (i.e., 30 June 2015 – 6 July 2015) an average of 4.3 bat passes per night (average = 1 – 17 bat passes) were recorded on six consecutive nights. Average magnitude of bat activity over the fall monitoring period was 9.20 bat passes per night. However, the magnitude of activity was not consistent throughout the fall. In early fall on 74 consecutive nights (i.e., 14 August – 22 September), there was an average of 18.4 bat passes per night that was followed by a steep decline in magnitude of activity in late fall (i.e., 23 September – 31 October) when only an average of 0.95 of a bat pass per night (Figure 11) was recorded. These findings are not obviously compatible with those of a swarming site (Fenton 1969).

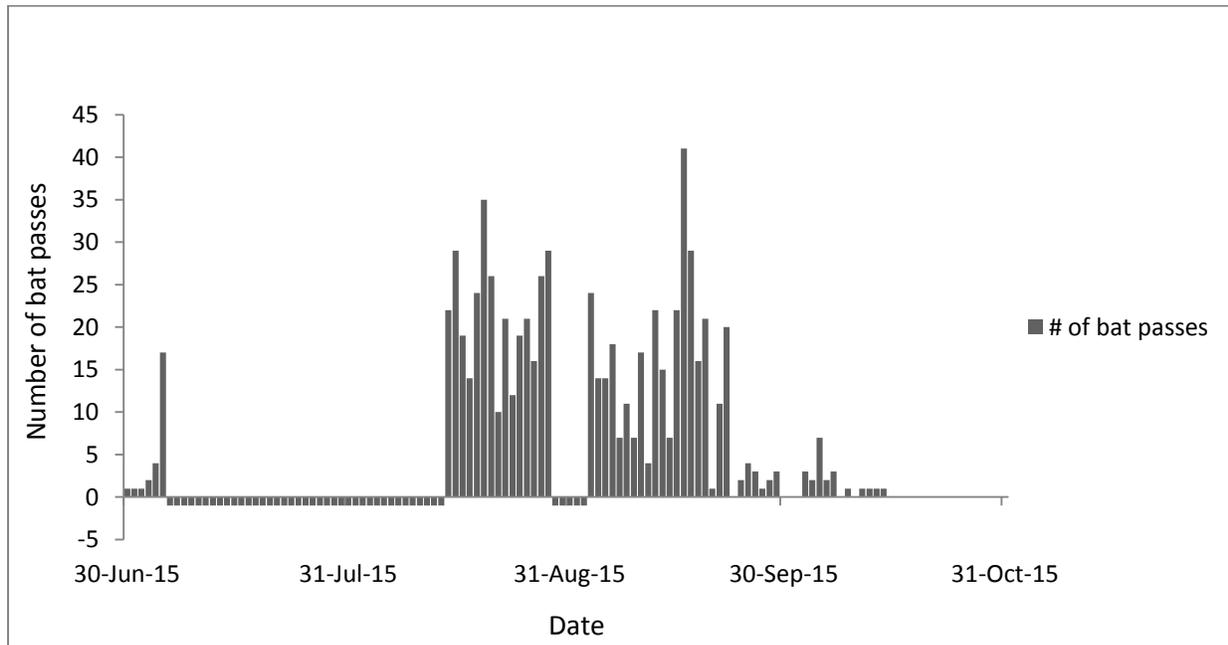


Figure 11: Number of nightly bat passes recorded at the Homestead trail well on six consecutive nights in the summer and 74 nights in the fall. Columns below zero indicate data is missing for that night.

### 3.6.2 Dalvay Woodland Trail

At the forested trail specifically monitored for magnitude of MYSE activity, 291 bat passes were recorded over six nights. Visual examination identified all bat passes as *Myotis* spp., but with closer analysis and visual inspection, 151 of these were more specifically identified as MYSE passes, accounting for 51.9% of all bat passes. While auto identification only classified 25.3% of these *Myotis* spp. passes at the forested trail as those of MYSE, it is important to note that at all other habitat types monitored in this study auto identification classified 0 – 12% (mean: 0.9%) of *Myotis* spp. passes as those of MYSE. Therefore, when these findings are examined together, the results indicate that the MYSE magnitude of activity at this forested trail in PEINP is more than double that of other habitat types suggesting that this site is likely used by foraging MYSE and may be a roosting area for MYSE, but further research would be required to confirm this possibility. Previous studies on MYSE roost use in Atlantic Canada indicate that males roost in more conifer-dominated (red spruce) forest stands and females in mature, shade-tolerant deciduous (sugar maple and yellow birch) forest stands in mid-stages of decay in the greater Fundy National Park ecosystem (Broders and Forbes 2004) and Broders et al. (2003) note the use of a live eastern hemlock with a split trunk by MYSE in Kejimikujik National Park.

### 3.7 Discrepancies in Planned Monitoring Methodology

Logistical difficulties in the field caused some inconsistencies in data collection. Due to unanticipated difficulties in acoustic detector deployment in the Cavendish area of the Park during the early summer



monitoring period, there was a one day delay in deploying two detectors. Subsequently, the schedule was followed and all four detectors for this monitoring period were retrieved on the same day to streamline work effort while maintaining consistency of data collection to as high a degree as possible. Unfortunately, this resulted in the loss of one night of monitoring for the coastal dune and wetland habitat types in the Cavendish area of the Park. The fresh water habitat type in the Cavendish area was only acoustically monitored for 6.9 nights during late summer period because the SD cards filled up due to an unanticipated high number of bat passes during this monitoring period. In the early summer monitoring period, every effort was made to not sample any sites in the Cavendish area of PEINP during the Cavendish Beach Music Festival because of a concern that magnitude of bat activity could be affected by the noise level associated with the concert, the lights around the concert venue and the higher amount of vehicular traffic associated with the concert. Unfortunately, due to equipment being sabotaged during the initial scheduled monitoring period at the forest edge habitat type near the concert grounds (i.e., microphone was disconnected and equipment was moved), this site had to be resampled during the festival. While the number of bat passes was lower during the festival than during the late summer monitoring period (which was also true for most of the other habitat types that were monitored), there does not appear to be a similar decline in the number of bat passes during the three nights of the festival compared to the four nights prior to the festival. All sites in the Greenwich area of the park were sampled for 9 nights each during late summer monitoring period. Lastly, while the majority of buildings in the Brackley day-use area were monitored in June or early July, Building 6 had to be monitored in late July to early August due a disconnected microphone on the first attempt in June.

## 4. Discussion

### 4.1 Stationary Acoustic Surveys for NABat Monitoring Program

#### 4.1.1 Species diversity

Most importantly for PEINP, *Myotis* spp. were detected in all three areas of the Park. The *Myotis* spp. designation includes both the endangered MYSE and MYLU, but unfortunately these species cannot be reliably separated based on acoustic monitoring so further study involving trapping of bats would be required to determine if one or both of these species are present in PEINP.

Prior to this current monitoring study, only three species of bats had ever been identified on PEI: MYLU, MYSE and LACI. MYLU and MYSE are resident species present in both summer (Henderson et al. 2009) and winter (Brown et al. 2007; McBurney unpublished data). Few previous records of LACI are documented for PEI; one physical record in 1999 (McAlpine et al 2002a) and one acoustic record in 2004 (Henderson et al 2009). PEI has no record of other bat species, particularly those that have been identified in other Atlantic Canadian provinces, including LANO, EPFU and PESU. However, during this monitoring study, evidence of the presence of LACI was identified in PEINP and acoustic data consistent with summer activity of LANO and/or EPFU which is a first report for the province. While EPFU is closely associated with human-occupied structures for roosting in the Canadian Maritime provinces (McAlpine



et al 2002b), this species forages in more natural areas. However, the habitat characteristics of the wetlands where these bat passes were recorded in PEINP are more typical for LANO (Adams 2003) which suggests in this case that the bat echolocation calls were more likely made by LANO rather than EPFU. The identification of non-*Myotis* spp. on PEI has been rare in the past, and these late summer (i.e., August) and fall reports were considered most consistent with the presence of solitary or migratory individuals and not resident breeding animals (McAlpine et al. 2002; Henderson et al. 2009). Interestingly, in this current monitoring study, echolocation calls of LACI and LANO/EPFU were recorded at several PEINP locations in both June and July which are findings more consistent with resident and possibly breeding bats of these species. However, this possibility cannot be confirmed with acoustic monitoring alone and would require additional research techniques (e.g., mist netting) to obtain the corroborating evidence required to make any further inferences. There was one bat pass that could not be identified but most closely resembled that of a LABO. However, both auto-ID and visual inspection of the sonogram were inconclusive. Therefore, there is reluctance to make any statements on the presence of LABO on PEI based on this data.

#### *4.1.2 Spatial and temporal comparison*

Bats were almost exclusively more active at the fresh water habitat types than at other habitat types monitored in PEINP, and the greatest magnitude of activity was recorded at Rollings Pond, a fresh water habitat type in the Cavendish area of the park during late summer. Magnitude of bat activity at Rollings Pond during late summer was considerably greater than at any other habitat type and greater than that recorded at the same location during early summer. A study by Fukui et al. (2006) suggests that the flux of aquatic insects emerging from water bodies is one of the most important factors affecting the distribution of bats. However, we did not monitor insect emergence as part of this study. Therefore, while this high magnitude of bat activity could have been the result of the emergence of insect prey at Rollings Pond, this remains speculative. In general, the greatest magnitude of activity at fresh water and wetland habitat types compared to coastal dunes and forest edge habitat types may be explained by the abundance of prey for bats found at or near fresh water aquatic ecosystems. MYLU in particular are known to forage over aquatic ecosystems (Fenton and Barclay 1980). In addition, a greater nightly magnitude of bat activity will be recorded when bats spend large amounts of time foraging over these aquatic sites in search of prey. This is directly opposed to other habitat types such as coastal dunes and forest edge which may serve primarily for commuting and would thus have a lesser magnitude of activity as a result of each bat passing the microphone only once as it commutes from one location to another.

The lowest magnitude of bat activity was recorded at the coastal dune habitat type throughout PEINP, with the exception of the Cavendish coastal dune habitat type during early summer monitoring period. However, the proximity of the Cavendish coastal dune habitat type to a brackish wetland and forest might have influenced the magnitude of bat activity at this location because the bats might have simply



been flying through the coastal dune habitat type to access the nearby forest for roosting or commuting (Broders et al. 2006) and/or the wetland for a foraging site (Roberts 1996).

Overall, a greater magnitude of bat activity was observed in the late summer monitoring period compared to the early summer monitoring period, and in the Cavendish area compared to the Brackley-Dalvay and Greenwich areas. Increased activity of bats in the late summer may be the result of multiple factors. One well described phenomenon is an increased magnitude of bat activity as a result of bat pups born in that year becoming volant (Adams 2003, Fenton and Barclay 1980). While this suggests the possibility of successful reproduction in the Park's bat population, this hypothesis cannot be confirmed with acoustic monitoring alone. . The cause of the greater magnitude of bat activity in the Cavendish area compared to other areas of PEINP was not investigated in this study.

#### *4.1.3 Inter-annual comparison*

In the 2004 monitoring study, each sampling site in PEINP was only monitored for one night and with different equipment (Corning, Henderson, and Broders, unpublished data). Therefore, any comparison between 2004 and 2015 data comes with great uncertainty. With this caveat in mind, magnitude of bat activity at the Cavendish area forest edge habitat type, Brackley-Dalvay area wetland habitat type, and Greenwich area forest edge habitat type were comparable and low both years (ratios of 46:35, 13:60, 5:2 respectively). In contrast, the observed magnitude of bat activity at the Cavendish fresh water habitat type was substantially higher in 2015 relative to 2004 (ratio of 71:1445). Based on these findings, there is no evidence of decline in the bat populations in PEINP since 2004. However, this data cannot be used to determine what impact WNS might have had on bat populations in the province or the Park in the intervening period between 2004 and 2015 because bat populations have not been monitored in PEINP since 2004 or since the emergence of WNS on PEI in 2013. Additionally, the equipment and methodology used in the 2004 survey varied substantially from the equipment and methods used in 2015, making it very difficult to make a direct comparison. Lastly, it must be recognized that the greater number of bat passes recorded at the Cavendish area fresh water habitat type could also be attributed to other factors such as weather conditions or insect emergence events. Therefore, monitoring surveys over the next several years using a similar protocol are recommended to determine the longer term trend in the magnitude of bat activity in PEINP as well as the possible impact of WNS on the Park's bat populations.

#### **4.2 Mobile Acoustic Surveys for NABat Monitoring Program**

While portions of mobile transects were adjacent to stationary acoustic monitoring sites and a high number of bat passes was recorded at these sites on the same night as the mobile transect was driven, only one bat pass was recorded during a mobile transect and that bat pass was recorded at a location that was not directly associated with a stationary detector site. The road network is limited inside PEINP, and therefore, the mobile transects were relatively short (i.e., equal to or less than the minimum of 25 km recommended by the NABat monitoring protocol). It is possible that the shorter lengths of some of



the mobile transects might have contributed to the low number of bat passes recorded while monitoring them. Also, mobile transects employ a directional microphone to record bat echolocation calls which is in contrast to the omnidirectional microphones used at the stationary acoustic monitoring sites. The directional microphone only records bat echolocation calls that are directly above the vehicle which limits the chances of recording bats foraging and/or commuting in suitable habitat sites adjacent to the road. While mobile acoustic monitoring transects are considered a good tool for monitoring bat populations in some circumstances, they may not be an effective technique to monitor for magnitude of bat activity in PEINP. However, it is recommended that they remain part of the bat monitoring program in PEINP in subsequent years to maintain consistency with the NABat monitoring program.

#### **4.3 Building surveys**

No anthropogenic structures acoustically monitored in PEINP were identified as summer roosts for bats.

#### **4.4 Emergence counts at potential roosts**

While acoustic detectors at two buildings, the Dalvay Activity centre and Simpson house, recorded a sufficient number of bat passes at times considered to be compatible with use of those buildings as summer roosts for bats, no bats were observed emerging from these buildings. Both buildings are surrounded by habitat that may be suitable for bats for commuting or foraging (i.e., forested corridors and standing, fresh water) (Broders 2006, Segers and Broders 2014).

#### **4.5 Visual surveys of potential roosts**

During internal surveys of buildings no signs of bats consistent with roosting activity were observed. While MYSE may have suitable roost trees inside PEINP (Broders et al 2006; Henderson et al 2009), female MYLU generally use buildings as roosts (Broders et al 2006; Fenton and Barclay 1980; Henderson et al 2009). Bats in PEINP were not using any of the surveyed buildings as roosting sites to any great extent. Suitable roosts may be located in other anthropogenic structures in PEINP or on properties adjacent to PEINP where there are many cottage communities and other buildings. Therefore, further research would be required to find the roosts of MYSE and MYLU that were acoustically detected in the Park. A proposed methodology for identification of bat roosting sites would require trapping bats at commuting routes (e.g., forested corridors) and radio tagging them so that they can be tracked back to their roosts. Identification of roosts is an essential component of protection of bat species in PEINP because these roosts are considered critical habitat. However, this would likely require cooperation with local land owners and other stakeholders and involve land outside of that currently managed by PEINP.

#### **4.6 Other acoustic monitoring sites**

##### ***4.6.1 Cavendish Homestead Trail Well***

While the number of bat passes recorded at the Homestead trail well was higher on average in fall than that recorded over the six nights in the summer, the overall magnitude of bat activity in the fall was not sufficient to confidently identify this location as a swarming site (Fenton 1969, Randall and Broders



2014). The peak of fall magnitude of bat activity was observed between 14 August and 22 September (max: 41 bat passes per night), after which the number of bat passes dropped to a level comparable to that recorded in the summer. Fenton (1969) defined swarming as “the flights of bats through hibernacula in late summer and early fall”. Swarming sites typically have a high magnitude of activity in August and September that is characterized by a very large number of bat passes. These sites function as mating grounds which permits gene flow to occur between bats from otherwise isolated summering colonies (Burns et al. 2014) and is reflected by the large number of bats that visit these sites (Fenton 1969). Therefore, acoustic monitoring should be combined with visual observations at the Cavendish Homestead Trail Well in an attempt to detect evidence of bat swarming behaviour at this site. Lastly, opportunistic winter monitoring of this site would be ideal. This would require weekly site visits throughout the winter to identify any bat carcasses that could be reflective of bat mortality from WNS. This strategy has been used to confirm bats’ use of wells as hibernacula on other parts of PEI (McBurney et al. unpublished data).

#### *4.6.2 Dalvay Woodland Trail*

Compared to proportion of classified MYSE passes by auto identification at other monitored habitat types and locations in PEINP, the Woodland Trail in the Brackley-Dalvay area of the Park had a considerably higher number of MYSE passes consistent with greater magnitude of MYSE activity at this location. Old growth forest is generally considered to be good habitat for MYSE (Broders et al. 2006), and since that habitat description is similar to the habitat found at the acoustic monitoring site on the Woodlands Trail in PEINP, the echolocation data collected at this location is consistent with the findings of Broders et al. (2006).

#### **4.7 Discrepancies in Planned Monitoring Methodology**

The discrepancies in the planned monitoring methodology did not appear to affect the outcome of our monitoring activities since the average magnitude of bat activity detected at these sites did not differ considerably from average magnitude of bat activity at the sites monitored according to our recommended protocol.

## **5. Recommendations**

The magnitude of activity of bats observed in PEINP suggests that bat activity in the Park is relatively high in some locations, both compared to the magnitude of bat activity observed in the park in the past and compared to other locations that have been monitoring post-WNS (Dzal et al. 2011, Ford et al. 2011, Segers and Broders 2014). Follow up monitoring and research would be required to fully understand trends in magnitude of bat activity and population structure that these data appear to represent.

For future acoustic surveys in PEINP, it is recommended to focus on habitat types that are now known to be suitable for bats in the Park (i.e., fresh water and wetland habitat types). Habitat types such as



coastal dunes do not require future acoustic monitoring. However, the NABat monitoring strategy should be followed to obtain the best dataset possible to understand ongoing bat population trends in PEINP (*"The temporal revisit design defines the survey effort of sample units over time. NABat will use an "always revisit" design (McDonald 2003) in which the same grid cells are surveyed every year for acoustic surveys [...]. This design is considered optimal for trend detection (MacKenzie and Royle 2005, Urquhart and others 1998) and has been successfully used for temporal trend detection of bat populations in Oregon and Washington within a dynamic occupancy modeling framework (Rodhouse and others 2012)"* (Loeb et al. 2015). We recommend that this monitoring is done for an additional two consecutive years to fully understand temporal trends of bat activity, particularly for the endangered species of bats in the park. The approximate funding required to address this recommendation would be similar to that allocated for this particular study (i.e., \$20,000 per year).

If it is a goal of PEINP to determine if female bats are reproductive and if roosting habitat is present on Park land, we recommend expanding this monitoring program to include a trapping and tracking component. Trapping bats at commuting routes would allow inferences to be made about species composition and ratio (e.g., MYSE vs. MYLU), sex ratio, and reproductive success of females. Tracking bats back to their roosts would permit the identification of this critical habitat for bats and could provide opportunities to cooperate with local land owners and other stakeholders to protect the bats currently using PEINP for other aspects of their ecology. This recommendation would best be handled as a graduate student project, and the amount of funding required would be \$35,000 per year.

To better understand the degree to which the Homestead Trail Well may be used by bats as a fall swarming site, more thorough summer and fall monitoring needs to be done. This would involve a longer acoustic monitoring interval in the summer and adding an acoustic monitoring control site for the entire monitoring period. In addition to acoustic monitoring, visual monitoring using Infrared technology could be employed to detect bat behaviours that would be consistent with those typically observed at a swarming site (e.g., social interactions in-flight, entering and exiting the hibernaculum). This work could be done in conjunction with the first recommendation described above with no additional cost.



## Appendix I: Stationary acoustic survey for NABat Monitoring Program detector locations, microphone positioning and relevant NABat data

<b>Brackley-Dalvay</b>	Fresh water	Forest Edge	Coastal Dune	Wetland
Coordinates	N46°21'50.7" W63°10'41.6"	N46°26'15.6" W63°14'47.0"	N46°25'44.1" W63°12'28.1"	N46°25'30.1" W63°07'41.6"
Microphone Orientation (°) (early summer/late summer)	0/16	293/282	90/112	350/3
Microphone Height (m)	1	2.5	1.5	3
NABat GRTS ID	214732	214732	214732	214732
NABat FID	236	237	239	238

<b>Greenwich</b>	Fresh water	Forest	Dune	Wetland
Coordinates	N46°27'07.8" W62°39'20.6"	N46°26'35.2" W62°41'48.0"	N46°26'41.2" W62°42'47.9"	N46°27'18.4" W62°41'23.7"
Microphone Orientation (°) (early summer/late summer)	218/218	81/100	216/222	281/245
Microphone Height (m)	2	2	1.5	2
NABat GRTS ID	198348	301805	301805	301805
NABat FID	223	345	345	345

<b>Cavendish</b>	Fresh water	Forest	Dune	Wetland
Coordinates	N46°27'53.0" W63°18'07.9"	N46°28'35.1" W63°23'08.9"	N46°30'06.3" W63°25'11.3"	N46°29'47.4" W63°24'17.8"
Microphone Orientation (°) (early summer/late summer)	161/162	274/281	22/17	265/281
Microphone Height (m)	2	1.75	2	1.5
NABat GRTS ID	246476	25292	25292	25292
NABat FID	273	37	37	37



## Appendix II: Mobile transects routes

NABat – Brackley: 25.6km

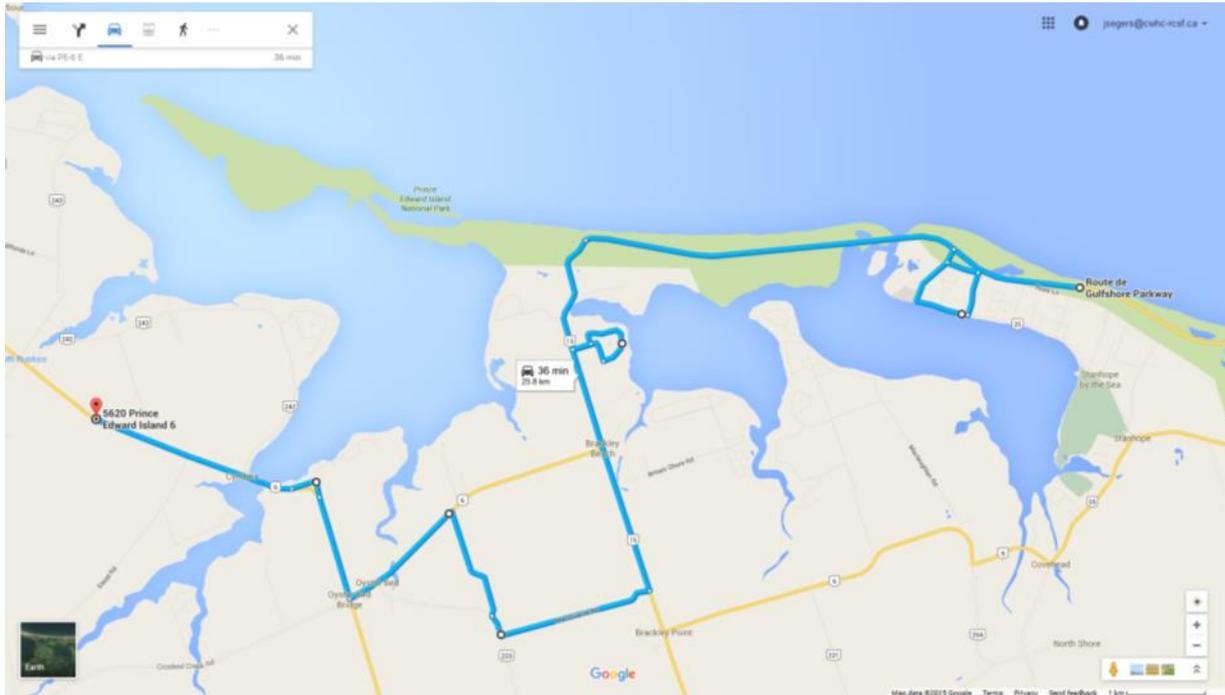


Fig. 3: Mobile acoustic survey route map for the Brackley area of PEINP, consistent with the NABat protocol

Start transect at: 5620 Prince Edward Island HW6  
New Glasgow, PE C0A 1N0  
Head southeast on PE-6 W toward Dump Rd  
Slight left onto Bonang Rd  
Turn right onto Camp Rd  
Slight left onto PE-6 W  
Turn left onto Portage Rd/PE-6 W  
Follow Ling Rd and MacQuarrie Rd to Brackley Point Rd/PE-15 N/PE-6 E  
Turn right onto Ling Rd  
Turn left onto Winsloe Rd/PE-223 S  
Turn left onto MacQuarrie Rd  
Turn left onto Brackley Point Rd/PE-15 N/PE-6 E (signs for Brackley Beach)  
Continue to follow Brackley Point Rd/PE-15 N  
Take Dunes View Dr to Brackley Point Rd/PE-15 N  
Turn right onto Estates Way, pass Dunes View Dr, follow road to the right



Turn left onto Dunes View Dr  
Turn right onto Estates Way  
Turn right onto Brackley Point Rd/PE-15 N  
Turn right onto Bayshore Rd/PE-25 S  
Turn left onto Deanna Ln  
Turn left onto MacMillan Ln  
Turn right onto Bayshore Rd/PE-25 N  
Turn right onto Route de Gulfshore Parkway  
York, PE COA 1P0

*Cavendish: 23.8km*

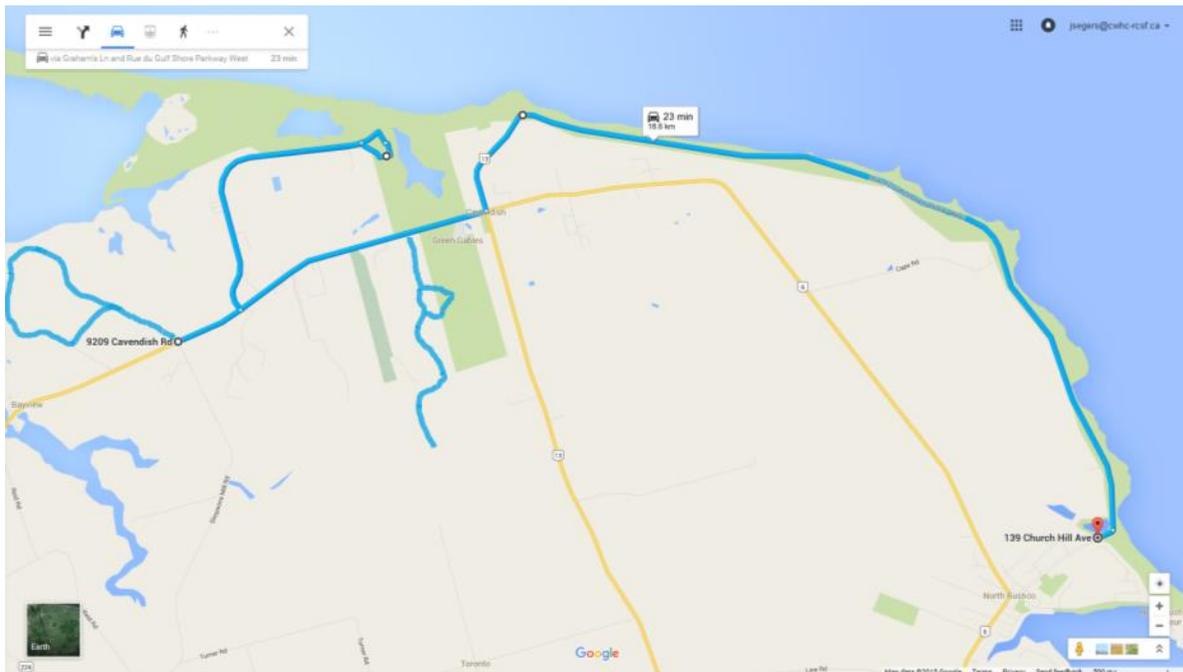


Fig. 4: Mobile acoustic survey route map for the Cavendish area of PEINP adapting the NABat Protocol

Enter the Homestead Trail from 9209 Cavendish Rd, New Glasgow, PE COA 1N0, head to the first trail intersection, start transect.

Head straight, bearing northwest, at the coast turn left, follow the loop back to the start intersection and turn left.

Exit the Homestead trail, turn left and head northeast on Cavendish Rd/PE-6 W toward Graham's Ln

Follow Graham's Ln to Cavendish Rd/PE-6 W

Turn left onto Graham's Ln

Turn right onto Hammies Ln



Turn left onto Graham's Ln  
Turn right to stay on Graham's Ln  
[switch detector off while backtracking]  
Take Rue du Gulf Shore Parkway West to Church Hill Ave  
[switch detector on]  
Turn left onto Cavendish Rd/PE-6 W  
Turn right onto Spruce Ln  
Turn first right (before the parking lot) onto the maintenance road  
Turn first right (before arriving at the maintenance buildings)  
Keep left at the fork. Take the next right and keep left  
Continue until trail become too rough to continue, turn around  
[switch detector off while backtracking]  
Return to maintenance road and turn right towards maintenance sheds  
[switch detector on]  
Turn left after first building  
Go around left of building and finish loop by turning left to the parking lot onto Spruce Lane  
Turn right onto Cavendish Rd/PE-6W  
Turn left onto Cawnpore Ln/PE-13 N (signs for Cavendish Beach E)  
Cawnpore Ln/PE-13 N turns slightly right and becomes Rue du Gulf Shore Parkway West  
Continue onto Church Hill Ave  
Destination at 139 Church Hill Ave, North Rustico, PE C0A 1X0



*Greenwich: 9.3km*

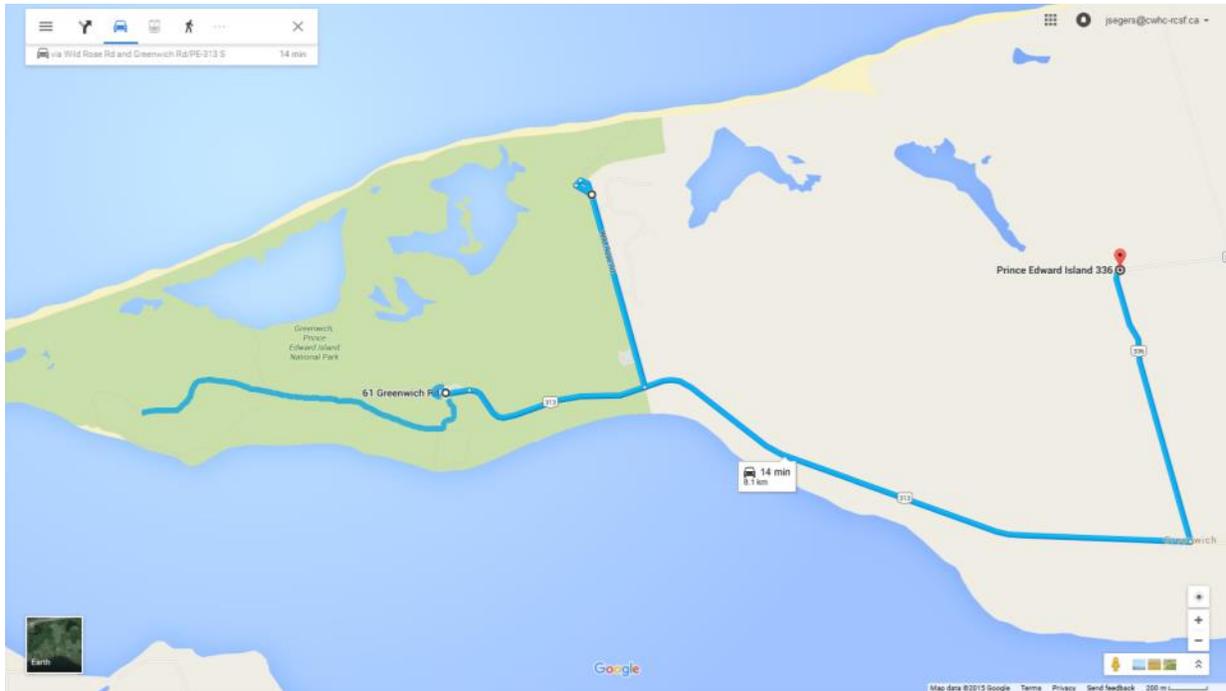


Fig. 5: Mobile acoustic survey route map for the Greenwich area of PEINP adapting the NABat protocol

From the 61 Greenwich Rd, St Peters Bay, PE COA 2A0 parking lot, enter the hiking trail  
Keep right, straight ahead at the intersection and turn around at the boardwalk  
[switch detector on]  
Follow hiking trail back  
Straight ahead at the first intersection, keep left to parking lot  
Loop counter clockwise on parking lot  
Head east on Greenwich Rd/PE-313 S  
Turn left onto Wild Rose Rd  
Loop counter clockwise on parking lot  
[switch detector off]  
Backtrack on Wild Rose Rd  
Turn left onto Greenwich Rd/PE-313 S  
[switch detector on]  
Turn left onto PE-336 E  
Destination at righthand turn, Prince Edward Island 336, St Peters Bay, PE COA 2A0y



## Appendix III: Building surveys detector locations and microphone positioning

Building	Coordinates	Mic Orientation (°)	Mic Height (m)
<b>Brackley-Dalvey</b>			
Building1	N46°25'36.00" W63°12'00.10"	185	0.5
Building2	N46°25'35.90" W63°11'49.40"	95	1
Building3	N46°25'37.30" W63°11'44.20"	214	1.5
Building4	N46°25'36.00" W63°11'40.00"	252	0.75
Building5	N46°25'36.68" W63°11'36.19"	250	1
Building6	N46°25'37.70" W63°11'35.30"	18	1
Building7	N46°25'36.33" W63°11'31.35"	23	1
Building8	N46°25'35.54" W63°11'27.05"	212	1
Building9	N46°25'35.66" W63°11'24.83"	240	1
Building10	N46°25'38.34" W63°11'23.90"	42	1
Dalvey Activity Centre	N46°24'20.33" W63°03'57.30"	240	1.25
Dalvey Staff House	N46°24'54.47" W63°4'33.80"	NA	NA
<b>Cavendish</b>			
Homestead building	N46°28'51.53" W63°26'3.65"	341	1
Rollings Pond1	N46°27'59.27" W63°18'27.72"	234	1.5
Rollings Pond2	N46°28'00.20" W63°18'27.07"	284	1
Simpson House	N46°29'33.52" W63°23'27.59"	222	2
Sampson House	N46°29'25.60" W63°19'31.72"	28	1.5
<b>Fort Amherst</b>			
Fort Amherst buildings	N46°11'38.71" W63°8'6.25"	12	3.5
Fort Amherst control	N46°11'34.86" W63°8'3.94"	29	1.7



## Appendix IV: Other acoustic monitoring sites detector locations and microphone positioning

Site	Coordinates	Mic Orientation (°)	Mic Height (m)
Homestead Well	N46°28'50.16" W63°25'22.27"	310	1
Homestead Well fall	N46°28'50.16" W63°25'22.27"	32	2
Woodland trail	N46°24'28.27" W63°4'21.25"	350	2



## Appendix V: SM2+Bat and SM3 detector settings

### Wildlife Acoustics SM2+Bat detector

Channels: Mono-L  
192,000 sample rate  
Dig HPF: FS12.  
Dig LPF: off  
Trg lvl: 18SNR  
Trg win: 2.0s  
Trg max length: 15s  
Div ratio: 16  
Nap trg lvl: off

### Wildlife Acoustics SM3 detector

HPF: off  
Gain: auto  
FS Wav auto: auto  
ZC: 8  
Frqmin: 16khz  
Frqmax: 192khz  
Dmin: 001.5  
Dmax: Off  
Trglvl: auto  
Trgwin: 3.0  
Trgmax: 15.0



## Appendix VI: Landscape detector deployment dates, number of bat passes recorded, nightly average bat passes, and species identified

Location	Deployment Date	Collection Date	# Recording Nights	# of Bat Passes	Average # of Bat Passes (per night)	Species		Other ID*
						# Myotis spp.	# Other	
<b>Brackley-Dalvay early</b>								
Fresh water	15/6/2015	22/6/2015	7	349	49.9	349	0	
Coastal Dune	15/6/2015	22/6/2015	7	1	0.1	1	0	
Wetland	15/6/2015	22/6/2015	7	640	91.4	640	0	
Forest Edge	15/6/2015	22/6/2015	7	0	0.0	0	0	
Overall			28	990	35.4	990	0	
<b>Brackley-Dalvay late</b>								
Fresh water	13/7/2015	20/7/2015	7	1084	154.9	1084	0	
Coastal Dune	13/7/2015	20/7/2015	7	7	1.0	7	0	
Wetland	13/7/2015	20/7/2015	7	421	60.1	364	57	57 LACI
Forest Edge	13/7/2015	20/7/2015	7	9	1.3	9	0	
Overall			28	1521	54.3	1464	57	
<b>Greenwich early</b>								
Fresh water	22/6/2015	29/6/2015	7	100	14.3	100	0	
Coastal Dune	22/6/2015	29/6/2015	7	3	0.4	3	0	
Wetland	22/6/2015	29/6/2015	7	27	3.9	20	7	7 LANO/EPFU
Forest Edge	22/6/2015	29/6/2015	7	1	0.1	1	0	
Overall			28	131	4.7	124	7	
<b>Greenwich late</b>								
Fresh water	20/7/2015	29/7/2015	9	140	15.6	140	0	
Coastal Dune	20/7/2015	29/7/2015	9	5	0.6	5	0	



Wetland	20/7/2015	29/7/2015	9	89	9.9	89	0		
Forest Edge	20/7/2015	29/7/2015	9	17	1.9	17	0		
Overall			36	251	6.8	251	0		
<b>Cavendish early</b>									
Fresh water	29/6/2015	6/7/2015	7	1346	192.3	1345	1	1 LACI	
Coastal Dune	30/6/2015	6/7/2015	6	564	94.0	562	2	2 UnID	
Wetland	30/6/2015	6/7/2015	6	20	3.3	20	0		
Forest Edge	6/7/2015	13/7/2015	7	43	6.1	43	0		
Overall			26	1973	75.9	1970	3		
<b>Cavendish late</b>									
Fresh water	29/7/2015	5/8/2015	6.875	9931	1444.5	9930	1	1 UnID	
Coastal Dune	29/7/2015	5/8/2015	7	106	15.1	99	7	5 LACI, 2 UnID	
Wetland	29/7/2015	5/8/2015	7	869	124.1	863	6	2 LACI, 2 LANO/EPFU, 2 UnID	
Forest Edge	29/7/2015	5/8/2015	7	250	35.7	250	0		
Overall			27.875	11156	400.2	11142	14		
Total			173.875	16022	92.2	15941	81		
Percentage						99.49	0.51		
<b>Additional site</b>									
<b>Woodland trail</b>	7/7/2015	13/7/2015	6	291	48.50	291	0	151 MYSE	

LACI = *Lasiurus cinereus*; LANO/EPFU = *Lasionycteris noctivagans* or *Eptesicus fuscus*; MYSE = *Myotis septentrionalis*



CANADIAN  
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