Determining species occurrence and vegetation preference of foraging Chiroptera: An acoustic survey using driving transects and geographic information systems

Amanda Vescovi
Wildlife Management, State University of New York College of Agriculture and Technology, Cobleskill, New York 12043

Kathy Schwager,
Environmental Protection Division, Brookhaven National Laboratory, Upton, New York 11973

ABSRACT

While intense population declines caused by white-nose syndrome have increased bat research efforts across the northeastern United States, existing knowledge of Long Island bat populations remains scarce. Static acoustic surveys have traditionally been used to determine bat presence, community composition, and habitat preference. Driving transects supplemented with geographic information systems (GIS) technology may allow researchers to more effectively monitor bat communities and note annual trends related to species occurrence and vegetation preference during foraging efforts. Bat echolocation calls were recorded during summer surveys (2011-2014) in Suffolk County, NY using binary acoustics software and were manually analyzed for individual species identification. Identified calls were then mapped using GIS and a 250 ft buffer was applied to each point to determine vegetation preference. A total of seven out of nine Chiropteran species were detected, in which *Myotis* spp. occurrence decreased by 1.3%, *E. fuscus/L. noctivagans* decreased by 25.6%, and *L. borealis* increased by 25.6%. Average percent cover of vegetation types suggested greater preference within areas of pitch pine forest (38.6%), oak forest (24.8%), and oak/pitch pine forest (17.7%). The methods used in this survey may allow researchers to assess much larger areas while reducing both time and costs associated with acoustic and vegetation data collection. Data suggests the importance of continual monitoring efforts of bat communities and the need for increased research efforts on vegetation preference of foraging bats.

INTRODUCTION

White-nose syndrome and population declines

Bat populations across the northeastern U.S. have undergone devastating declines due to the harmful effects of white-nose syndrome (WNS) (1). WNS, a fatal disease caused by a psychrophilic fungus (*Pseudogymnoascus destrucans*) inhabits caves, many of which are utilized by colonizing bats (i.e. *Myotis* spp.) as winter roosts during hibernation periods (1, 2). Fortunately, there are no caves on Long Island due to the islands terminal moraine system (3) which indicates that existing bat populations are either summer migrants or annual residents who maintain survival predominantly by roosting in manmade structures (T. Green, Brookhaven National Laboratory, personal communication). Not only have bats been found to be important bioindicators in relation to habitat loss and climate change (4), but have also provided economic relief at an estimated $22.9 billion per year within agricultural industries by contributing as pest managers (5). Such values indicate the need for increased monitoring efforts and understanding of bat ecology, especially within unique habitat types such as the Central Pine Barrens of Long Island where existing knowledge of bat populations is scarce.

Acoustic surveys through the use of driving transects

Stationary acoustic surveys have proven to be effective in gathering inventories of bat communities (6). Acoustical monitoring efforts have been used to investigate: habitat use and preference (7, 8), species occurrence (6, 9), species presence (10, 11), and activity patterns (8, 9). Although there have been no published reports on the use of driving transects for acoustic bat detection, there have been reports on the use of driving transects to monitor population trends of both large mammals (12) and avian raptors (13). Caro (12) demonstrated how driving transects may be used for long term monitoring efforts. Essentially, driving transects allow wildlife researchers to sample larger survey areas in a minimal amount of time.

Geographic information systems and vegetation preference

Vegetative data can be difficult to obtain, especially for larger survey areas. The use of Geographic information systems (GIS) on landscape structure and its associated relationships amongst small mammal communities has increased in recent years 14, 15). Jaberg and Guisan (14) discussed how landscape structure directly correlated to bat community composition and may be used to define habitat associations amongst various species. By using land cover map layers made available online, researchers may determine habitat or vegetation-type preferences.

Purpose of study

In order to better understand existing summer bat populations on Long Island, the following study has implemented the use of driving transects and GIS during foraging efforts to determine species occurrences and vegetation preferences respectively. It is anticipated that proposed methods will assist in both long-term monitoring practices and overall bat research efforts. Predictions from this study include a decrease in *Myotis* spp. from 2011 to 2014 and greater vegetation preferences within wooded areas.

MATERIALS AND METHODS

Driving Transects

Driving transects were created in Suffolk County, N.Y. during the year 2011 using DeLorme Street Atlas © software (DeLorme, Yarmouth, ME) (Figure 1). Each transect was approximately 20-25 mi. in length. Four proposed transects were created, however only three transects were utilized for the purposes of this study. In order to obtain maximum call efforts, transects were created in an attempt to avoid any major roads and highways, remain in the central pine barrens region, and include surrounding water sources (i.e. rivers, ponds, and streams). Rivers were of particular interest when creating transects due to existing associations of increased foraging activity found amongst bat communities (7).

Survey Protocol

All survey procedures were conducted in accordance with the *Bat Acoustic Survey Protocols* supplied by the NYSDEC (16). Surveys were conducted from 2011 – 2014, from June until early July. Temperature, chance of precipitation, and wind speed were checked prior to performing each survey. Appropriate conditions for conducting bat acoustic surveys consisted of temperatures >55°F, 0% chance of rain, and wind speeds of <15mph (16). Each survey began 30 min. after sunset and transects were driven at a speeds of 18- 22 mph.

Acoustics Equipment

Bat acoustic equipment was supplied by NYSDEC. An f/125 unidirectional microphone (Wildlife Acoustics ©) and GPS unit (DeLorme ©) were placed on the passenger side of a vehicle via magnet and connected to a PC laptop computer. Bat echolocation calls were recorded using the detector and SPECT'R III © binary acoustics software (Binary Acoustics Technology LLC., Tucson, AZ). SPECT'R III translated all high frequency calls to an audible range for human hearing and allowed for full spectrum call analysis for species identification purposes (Binary Acoustics Technology LLC., 2010). Delorme Street Atlas software was used to record GPS locations in decimal degrees along designated transects. Upon completion of each driving transect, a GPS log was saved and later used for GIS mapping efforts.

Species Identification

Bat echolocation calls were analyzed using SCAN'R © binary acoustics software (Binary Acoustics Technology LLC., Tucson, AZ). SCAN'R filtered all calls to determine those that were false and also displayed vocal parameters in kHz for individual call analysis (Binary Acoustics Technology LLC., 2010). All echolocation calls (i.e. search phase "pulses") were filtered via a chirp count of ≥ 5. Failed files were discarded, while those that passed were saved for individual species identification.

Acoustic parameters such as characteristic frequency (Fc) and characteristic slope (Sc) were used to manually identify each set of pulses according to a flowchart designed by Herzog (C. Herzog, New York State Department of Environmental Conservation, personal communication). A table demonstrating echolocation call characteristics of eastern bat species, created by Szewczak et al. (17), was used to supplement the flowchart, where pulse sets could not sufficiently be identified. Pulses of *E. fuscus* and *L. noctivagans* were categorized jointly as "*E. fuscus* or *L. noctivagans*" due to extensive similarities in both Fc and Sc call parameters. During the year 2014, *E. fuscus* and *L. noctivagans* pulses were categorized separately due to use of Szewczak et al.'s (17) identification chart, which allowed for an additional parameter (hi f) to be utilized in species identification efforts. However, to maintain consistency within the data, *E. fuscus* and *L. noctivagans* were categorized jointly when computing species occurrence estimates.

Geographic Information Systems

Successfully identified calls were then mapped using ArcGIS 10.1 © software (ESRI, Redlands, CA). A map layer containing vegetation within the Long Island

Central Pine Barrens Region was applied to the call map. A 250ft buffer was created around each data point (i.e. each identified call) and used to calculate percent cover per vegetation type for the years 2011 through 2014 (Figure 2).

RESULTS

Species Occurrence

A total of 7 out of 9 Chiropteran species were identified following survey efforts: big brown bat (*Eptesicus fuscus*), silver haired bat (*Lasionycteris noctivagans*), Eastern red bat (*Lasiurus borealis*), hoary bat (*L. cinereus*), little brown bat (*Myotis lucifugus*), Eastern small footed bat (*M. leibii*), and tricolored bat (*Pipistrellus subflavus*). Northern long-eared bat (*M. septentrionalis*) presence was not detected and one potential Indiana bat (*M. sodalist*) call set was unidentifiable and therefore discarded. Average percent occurrences were most abundant amongst *E. fuscus/ L. noctivagans* (70.2%) and *L. borealis* (26.7%). *Myotis* spp. occurrence decreased from 2011 to 2014 by 1.3% (Table 1). *E. fuscus/ L. noctivagans* occurrence decreased by a total of 25.6%, while *L. borealis* increased by 25.6%.

Vegetation Preference

Since roadways constituted a majority of the land cover area surrounding driving transects, developed roads demonstrated the greatest percent cover by an average of 64.7%. As a result, developed roads were removed from vegetation preference calculations. Average percent cover of vegetation types suggested greater preference within areas of pitch pine forest (38.6%), oak forest (24.8%), oak/pitch pine forest (17.7%), grass lawn (4.5%), agriculture (3.7%), and grassland (3.1%) (Table 2).

Difference in percent cover from the year 2011 to 2014 revealed a decrease in preference of pitch pine forest (-10.9%) and grassland (-5.7%) vegetation types and an increase in oak/pitch pine forest (+7.2%), oak forest (+3.0%), grass lawn (+2.1), and agriculture (+0.3%).

DISCUSSION

Species Occurrence

Despite the minimal increase in *M. lucifugus* during 2013, the prediction of continual declines in *Myotis* spp. occurrence was confirmed. Similar reductions were conveyed within summer surveys that compared pre-WNS and post-WNS data collected in Watertown, NY and central Massachusetts (18, 19). It is reasonable to conclude the decline in *Myotis* spp. was attributed to the self-induced spread of the fungus via dense clustering in caves during winter hibernaculum, a physiological response to inhibit evaporative water loss, thus making *Myotis* spp. more susceptible to the fungus (21).

Long-distance migratory species do not exhibit such behavior and habitually avoid use of caves by spending winters in regions with warmer climates and greater insect availability (22). For example, *L. borealis* migrate to southeastern parts of the US and northeastern parts of Mexico during winter months and return to northern areas of the US come spring and summer (21).

Increased *L. borealis* occurrences may have been attributed to such migratory behavior, but it is of greater likelihood that their use of trees as primary roosting sites (23) is what limits this species' contact with WNS. Moreover, *L. borealis* may be occupying newly available niches left by species infected with WNS. In addition, Cryan (21) explained an increase in *L.borealis* activity along the Northeast shoreline following the month of June.

Survey efforts occurred during this migration period, which more than likely resulted in increased occurrences.

Although *E. fuscus* demonstrated the greatest occurrences, as found in additional summer acoustic surveys (18, 19), declines were exhibited from 2011 – 2014. Unlike *L. borealis, E. fuscus,* a sedentary species (20) traveling less than 50km from winter to summer roosting sites (22), rely heavily on caves as winter hibernation sites (24), thus making them more vulnerable to WNS and explaining for decreased occurrences.

Vegetation Preferences

Although the distance between foraging areas and roost sites varies depending on individual species preference, site availability, distance to food and water, and morphology (22), it is implied that forested areas were of greatest preference due to high availability of potential tree roots. Kunz and Fenton (22) expressed how bats prefer the use of tree roosts when made available and use manmade structures only when necessary. Additional research efforts are needed to determine individual species preferences of pitch pine, oak, and mixed forest types. However, changes in vegetation preference from pitch pine to oak forests may have been directly correlated to increased *L. borealis* occurrences due to their preference of oaks as primary roosting sites (23). Other areas of research that pertain to this study and are in need of investigation include, insect availability within preferred vegetation types, greatest occurrences and distance to water, foraging activity in proximity to streetlights, and greatest activity in relation to vegetation.

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Table 1: Percent occurrence of identified species from 2011 to 2014.

	Occurrence (%)			
Species	**2011**	**2012**	**2013**	**2014**
Eptesicus fuscus /Lasionycteris noctivagans	82.9	77.0	63.6	57.3
Lasiurus borealis	14.6	21.7	30.3	40.1
Lasiurus cinereus	1.3	0.7	0.0	1.3
Myotis leibii	0.0	0.7	0.4	0.0
Myotis lucifugus	0.6	0.0	3.0	0.0
Myotis septentrionalis	0.0	0.0	0.0	0.0
Myotis sodalis	0.0	0.0	0.0	0.0
Pipistrellus subflavus	0.0	0.0	2.6	1.3

Table2: Percent cover of vegetation types from 2011-2014.

	% Cover			
Vegetation Type	**2011**	**2012**	**2013**	**2014**
Pitch Pine Forest	43.7	43.4	34.5	32.8
Oak Forest	23.9	22.2	26.0	27.0
Oak/ Pitch Pine Forest	12.7	18.1	20.0	19.9
Grass Lawn	3.3	4.2	5.1	5.4
Agriculture	3.4	3.9	3.7	3.7
Grassland	7.6	1.3	1.5	1.9
Pitch Pine / Oak Forest	0.4	3.4	2.7	2.6
Scrub Oak Shrubland	1.0	1.0	2.5	0.7
Freshwater Wetland	1.0	1.2	1.2	0.9
Successional Oak Forest	-	-	0.4	3.5
Sand / Sparse Vegetation	1.4	0.4	1.1	0.4
Water	0.2	0.7	0.4	0.9
Forested Wetland	0.4	0.1	0.5	0.0
Successional Pitch Pine / Oak Forest	0.4	0.0	0.2	0.1
Plantation	0.3	0.0	0.0	0.0
Tree Oak Scrub Oak Woodland	-	-	0.1	0.0
Pitch Pine Grass Savanna	0.0	-	0.0	0.1
Tree Oak Grass Savanna	0.0	0.0	0.0	0.0
Successional Pitch Pine Forest	0.0	-	0.0	-
Pitch Pine Tree Oak Scrub Oak Woodland	-	0.0	0.0	-
Pitch Pine Scrub Oak Woodland	-	-	0.0	-
Tree Oak Heath Woodland	-	0.0	0.0	0.0
Pitch Pine Heath Woodland	0.0	0.0	-	0.0
Dwarf Pine Plains 2	-	-	0.0	-

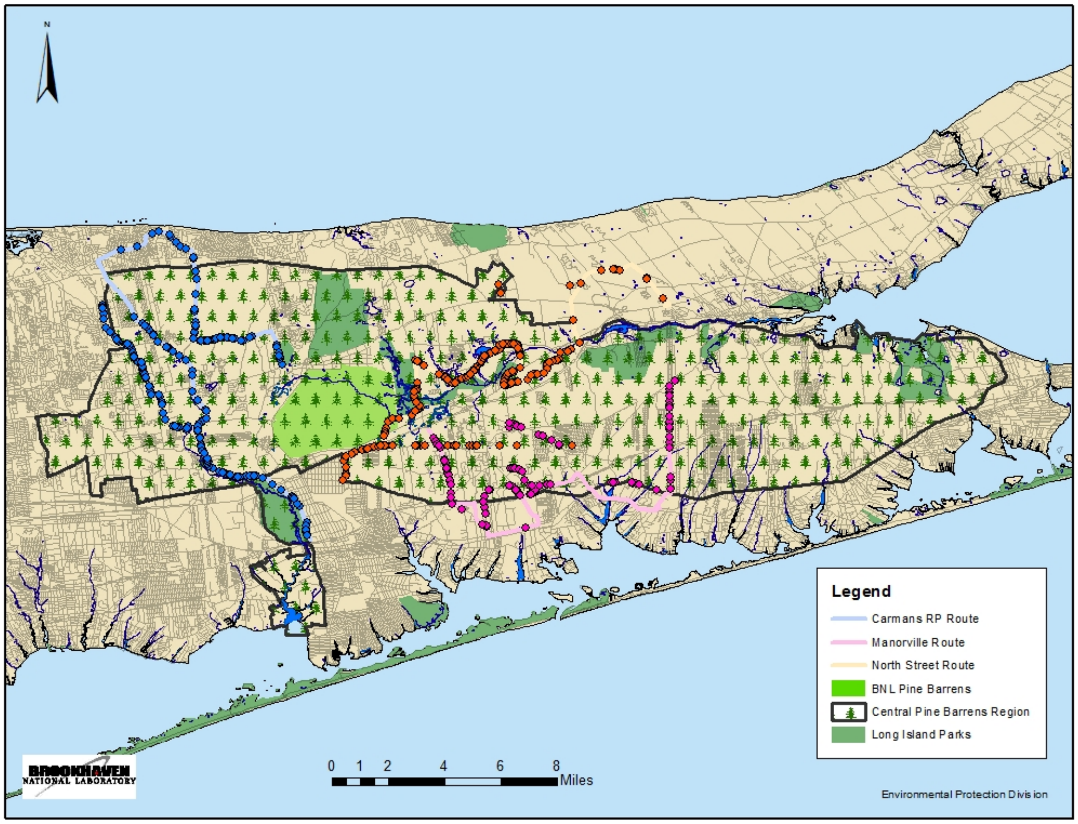

Figure 1: Map of study area displaying bat acoustic routes and identified calls within Suffolk County, NY, 2011-2014.

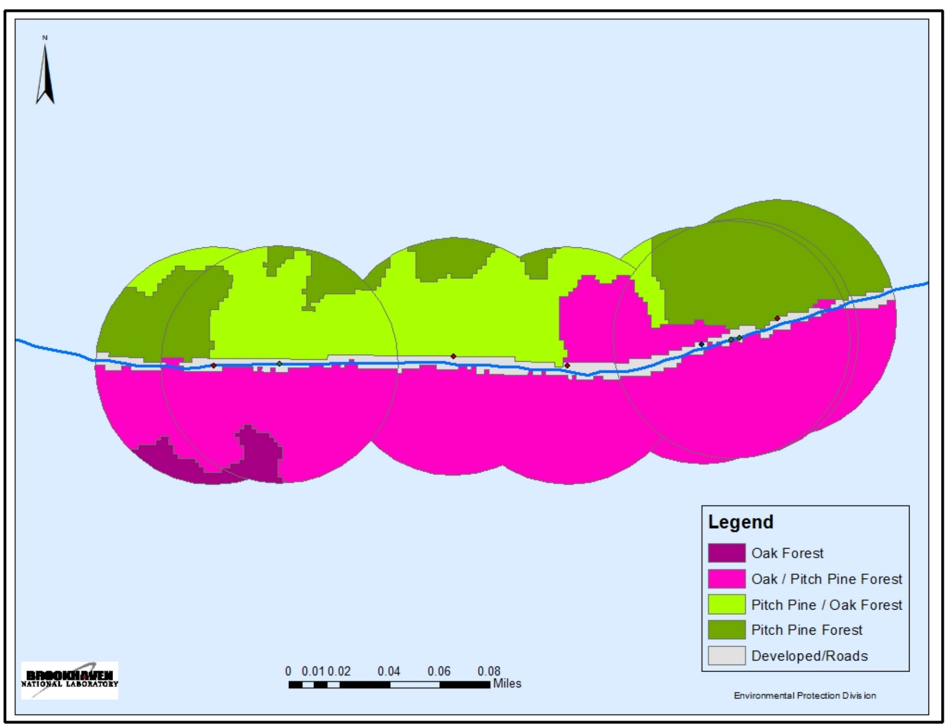

Figure 2: Example of buffers surrounding identified calls and corresponding vegetation-types, Suffolk County, NY, 2011-2014