Roost Use and Social Behaviour of Female Northern Long-eared Bats (*Myotis septentrionalis*) in Dollar Lake Provincial Park, Nova Scotia.

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Project Goal and Objectives

As stated in our grant application, our overall goal was to understand the roosting ecology, group dynamics and population genetics of adult female northern long-eared bat (*Myotis septentrionalis*) maternity colonies. A better understanding of each of these factors will improve our ability to conserve bats (Racey & Entwistle 2003), including northern long-eared bats which are particularly susceptible to habitat loss. Although there exist some data on the roosting ecology of northern long-eared bats (e.g., Lacki & Schwierjohann 2001, Broders & Forbes 2004, Broders et al. 2006, Garroway & Broders 2008), studies have generally overlooked roost-use differences within and between years, which may result in poor management recommendations. In addition, preliminary studies of female northern long-eared bat group dynamics suggest that metapopulations occur with limited movement between them. As a result of limited movement, northern long-eared bats may be particularly sensitive to habitat loss as they will not likely relocate to new areas. Therefore, to properly conserve northern long-eared bats we need a better understanding of their roosting ecology, group dynamics and population genetics. Moreover, an understanding of northern long-eared bat biology will likely contribute to our understanding of many temperate bat species as they tend to share similar life-histories. Within this goal, we had several objectives:

1. Determine whether roost use differs within and between years.
2. Determine whether roost fidelity (reuse) occurs within and between years.
3. Determine what external factors, such as roost characteristics, roost and ambient temperature, and climate, influence roost use and adult female northern long-eared bat aggregations.

4. Determine what demographic factors, such as age, reproductive condition and relatedness, influence adult female northern long-eared bat aggregations.
5. Determine the strength and patterns of social relationships in aggregations.
6. Determine whether bats roosting in geographically different roosting areas interact and whether they are genetically isolated from one another.
7. Determine how roosting ecology, group dynamics, and population genetics, could impact the management of northern long-eared bats.

Outline of the Work Completed

To address our research objectives, field work was conducted in Dollar Lake Provincial Park (DLPP), Nova Scotia from mid-May to mid-August in 2006 and 2007. During this time, bats were captured to determine sex, age, and reproductive condition. Tissue samples were taken from each wing and stored in ethanol for later molecular analyses. A passive induced transponder (PIT-tag) was then implanted subcutaneously between the shoulder blades of all newly captured individuals to allow individual identification. Roosts and female groups were then located using radio-telemetry. Once roosts were located, PIT-tag recorder antennae were placed around roost entrances to record the identity of all individuals in the roost, along with the date and time they entered or exited roosts. Group size at emergence was also visually estimated. These data were supplemented by those obtained in 2005 by Garroway & Broders (2008) to quantify patterns over a longer period.

To address Objectives 1-3, the following tree and site characteristics (within 18m radius of the roost tree) were measured: tree species, tree height, tree diameter at breast height, decay class (e.g., 2-7, where 2 is the lowest and 7 the highest amount of decay), roost-type (e.g., cavity, crack, exfoliating bark), height of roost entrance, percent canopy cover, dominant canopy species, average height of canopy, roost height relative to canopy height, percent of available trees (i.e., trees in decay class >2), number of deciduous trees, and number of coniferous trees.

Characteristic for roosts used during each reproductive period, including pregnancy, lactation and post-lactation, and among years will then be compared (Objective 1). Roost-residency time (# days tracked/# roosts used) and roost-reuse (# reused roosts/ total # roosts) were also calculated to compare roost fidelity across reproductive periods within summers and among years (Objective 2). Hourly values of ambient temperature, precipitation, and barometric pressure were obtained from Environment Canada (www.weatheroffice.ec.gc.ca) for the Stanfield International Airport which is located within 8km of DLPP. Ambient conditions will then be compared with roost characteristics and group size (Objective 3). Analyses for Objectives 1-3 will be completed in winter 2012. However, preliminary results are provided below.

Patriquin et al. (2010) details the work completed to address, or partially address, Objectives 4-6 regarding the social relationships of female northern long-eared bats. See Appendix A for a copy of this paper. To complete the remaining elements of Objectives 4-6, DNA was extracted from tissue samples from the wings of 73 individuals. Seven microsatellite loci of the nuclear DNA (nDNA) have been genotyped and the HVII of the control region of the mitochondrial DNA (mtDNA) has been sequenced. Pairwise relatedness will then be estimated and compared to pairwise associations obtained in Patriquin et al. (2010) (Objective 4 & 5). Average nDNA and mtDNA relatedness will also be compared within and between roosting areas (Objective 6). Molecular analyses will be completed in the summer of 2011. However, preliminary results are provided below.

Results

Analyses have yet to be completed for Objectives 1-3. However, preliminary results suggest that, in general, females roosted primarily in red maple trees and trees in lower decay stages (2-

3) in sites with high conifer abundance, which suggests females may be actively selecting maple trees as roosts (Table 1). Roost use also appeared to vary with reproductive period (Table 1). For example, it appears that females used taller trees with smaller diameters in sites with lower canopy cover and tree density during gestation. This suggests that during gestation females may be using roosts that are more easily accessed, or are perhaps more exposed to direct sunlight. Although females switched roosts almost daily, they reused more than 50% of the trees during gestation and lactation (Table 1), suggesting strong fidelity to particular trees. Inter-annual variation in roost-use has yet to be examined. It is likely that roost-use is driven by selection for optimal microclimates and therefore I proposed that roost-use and fidelity are linked to ambient conditions. However, climate data have yet to be summarized and analyzed.

Patriquin et al. (2010) details the results of the work completed to address, or partially address, Objectives 4-6 regarding the social relationships of female northern long-eared bats. See Appendix A for a copy of this paper. Preliminary results suggest genetic diversity of nDNA is moderate to high, with the number of alleles ranging from 16 to 30 and expected heterozygosities ranging from 0.87 to 0.99 (Table 2). This suggests these microsatellites offer good power to detect pairwise relatedness. Preliminary inspection also suggests moderate to high variation in mtDNA, which suggests good power to detect any existing differences between roosting areas.

Management implications

While many of the results are preliminary, trends suggest my findings could be important to management considerations for female northern long-eared bats, which are listed as Sensitive throughout most of Canada, including in Nova Scotia (CESCC 2006). For example, trends suggest intra-annual variation in roost-use as roost and site characteristics varied across reproductive periods. Though inter-annual variation in roost-use has yet to be examined, the trends discussed above are not consistent with the findings of Garroway & Broders (2008) who studied roost-use in the same population in 2005. This suggests there could be inter-annual variation in roost-use, which may be a result of variation in ambient conditions across years, though this has yet to be examined and therefore this is largely speculative at this time. Evidence from social analyses suggests that there are at least two socially-distinct groups of female northern long-eared bats in DLPP. Within each of these groups, females live in a network of interconnected subgroups that move regularly among multiple roosts. Despite this frequent movement among roosts, females regularly re-use particular trees at some point during the summer and across years.

Thus, when managing forests, rather than considering averaged results, it may be important to conserve a variety of tree types in an area to accommodate the varying needs of bats within and among years and to accommodate larger social networks. In addition, it is often suggested that low roost fidelity occurs when suitable roosts are abundant (e.g., Barclay & Brigham 2001). The high roost reuse in DLPP therefore suggests suitable roosts may be limited in the area, which is possible given that DLPP contains old growth forest that is critical to northern long-eared bats yet deemed an endangered ecosystem in Nova Scotia (Davis et al. 2001, Lacki and Schwierjohann 2001, Broders and Forbes 2004, Patriquin and Barclay 2003). If molecular analyses reveal that social groups and subgroups are genetically distinct, female northern long-eared bats likely show natal philopatry to areas in DLPP, as has been documented for this species in other areas (Arnold 2007). Natal philopatry could have important management implications as groups may not readily move to new areas if existing habitat is disturbed (Kerth et al. 2000, Kerth and Petit 2005). Thus, it is may also be important to conserve trees over a wide area to accommodate disconnected social groups. Of course the foraging needs of bats must also be taken into consideration, which were beyond the scope of my research.

Assessment of Achievements and Lessons Learned, Measured Against the Project Goals and Objectives

Patriquin et al. (2010) represents one of only a few studies to use social networks to understand the social relationships of bats, and is one of the first to demonstrate the long-term persistence of otherwise seemingly transient relationships. However, interpreting the results of the analyses used to address the social relationships of female northern long-eared bats proved more challenging than anticipated. This led to considerable delays in completing the remaining objectives of this project. Consequently, we have collaborated with Dr. Friso Palstra to assist in collecting molecular data to allow us to complete our remaining objectives in a timely manner.

Recommendations for the Follow-up Steps to the Project

As discussed above, it appears there are at least two socially distinct social groups in DLPP. Due to logistical constraints, most results come from one social group. Therefore, it would be useful to obtain more information about the roost use and social behaviour of female northern long-eared bats in the second social group in DLPP. This could offer insight into whether distinct social groups also use different resources, such as different roost types and foraging habitat. This, in turn, could have important management implications as it would further support the above recommendations that a variety of habitat must be conserved, rather than relying on "average" habitat preferences.

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Table 1. Tree and site characteristics, as well as fidelity to roosts used by female northern long-eared bats (*Myotis septentrionalis*) during gestation, lactation and post-lactation.

	Gestation	Lactation	Post-lactation
<u>Tree characteristics</u>			
prop. maple	0.5	0.72	0.45
prop. hemlock	0.25	0.16	0.14
prop. other species	0.25	0.12	0.41
mean dbh (± SE) (cm)	35.4 (2.3)	39.9 (1.3)	42.0 (2.1)
mean tree height (± SE) (m)	17.9 (0.9)	15.2 (0.5)	14.0 (0.9)
prop. decay 2-3	0.76	0.64	0.75
prop. decay 4-5	0.13	0.19	0.18
prop. decay 6-7	0.11	0.17	0.07
<u>Roost site characteristics</u>			
mean # potential roosts (± SE)	10.6 (0.6)	7.1 (0.2)	8.9 (0.8)
mean # deciduous (± SE)	33.5 (3.6)	35.8 (2.4)	46.4 (5.1)
mean # coniferous (± SE)	74.9 (7.6)	76.7 (5.3)	132.2 (14.7)
mean tree density (± SE)	108.4 (8.5)	112.5 (6.5)	178.6 (16.4)
mean canopy cover (± SE)	82.1 (3.6)	80.7 (1.6)	87.8 (2.2)
<u>Roost fidelity</u>			
mean residency time (± 95% CI) (days)	1.47 (0.40)	1.34 (0.24)	N/A
prop. reuse	0.57	0.51	0.13

Table 2. Forward and reverse primers used to genotype seven microsatellite loci and genetic diversity of loci.

Locus	Primer Sequences	# alleles	Expected heterozygosity
Mmy-E24	F: GCAGGTTCAATCCCTGACC	25	0.994
	R: AAAGCCAGACTCCAAATTCTG		
Mmy-G9	F: AGGGGACATACAAGAATCAACC	18	0.898
	R: TAATTTCTCCACTGAACTCCCC		
Mmy-D15	F: GCTCTCTGAAGAGGCCCTG	27	0.939
	R: ATTCCAAGAGTGACAGCATCC		
Mmy-F19	F: GCTAGCCATGGAGAAGGAAG	18	0.889
	R: CCCAAATCTGTCTTTCAGGC		
Mybe-15	F: TAAGGTATAAAGAGAAATACC	30	0.950
	R: AAAGGGTCTTGTTTAACTTT		
Efu-4	F: ATAGGCTCCCAGAAATAGC	17	0.907
	R: GATCACCACAAAATGTGC		
Efu-6	F: ATCACATTTTTGAAGCAT	16	0.867
	R: ATCTGTTTTCTCTCCTTAT		