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Roost Tree Selection by Maternal Colonies of Northern Long-eared Myotis in an Intensively Managed Forest

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Abstract

We attached radio transmitters to 20 pregnant or lactating northern long-eared myotis (*Myotis septentrionalis*) and located 43 maternity colony roost trees in intensively managed hardwood forests in the Allegheny Mountains of east-central West Virginia. Maternity colonies ranged in size from 7 to 88 individuals. We compared 23 characteristics of the 43 roosts to 43 randomly selected trees with cavities or exfoliating bark. Roost trees selected by maternity colonies differed from randomly located roost trees in that they were taller, smaller in diameter, surrounded by more live overstory trees and snags, and surrounded by a higher basal area of other snags. Black locust (*Robinia pseudoacacia*) and black cherry (*Prunus serotina*) were used as day roosts more frequently than expected based on their abundance across this landscape. Intensively managed hardwood forests in the central Appalachians apparently provide adequate roosting habitat for northern long-eared myotis.

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Cover

The Shawnee National Forest is a nesting site for the northern long-eared bat (photo by Timothy C. Carter, Southern Illinois University).

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Introduction

Many North American bat species reside in forests and depend on living trees or snags for roosting sites (Barbour and Davis 1969, Humphrey et al. 1977, Kunz 1982, Vonhof and Barclay 1996). Roosts provide thermally stable environments and protection from the elements and predators (Kunz 1982). Initial research in roosting ecology focused on easily accessible manmade structures or caves (Kunz 1982, Betts 1996). Most early records of tree roost sites were anecdotal descriptions of single-tree colonies of bats (Humphrey et al. 1977, Kunz 1982, Barclay and Cash 1985). However, since the advent of miniaturized radio transmitters suitable for bats, there has been a renewed interest in roost ecology research (Kunz 1982, Cambell et al. 1996, Sasse and Perkins 1996, Vonhof and Barclay 1996, Foster and Kurta 1999).

In the western United States, old-growth forests are important bat roosting habitats (Thomas 1988, Ruggiero et al. 1991, Campbell et al. 1996, Zielinski and Gellman 1996). However, in the central Appalachians, extensive timber harvesting in the early 1900s and the more recent increase in forest harvesting over the last decade have resulted in many high-graded stands with 80- to 100-year-old unmerchantable residual trees and frequent canopy caps or even-aged clearcut stands 20 years old or younger (McGarigal and Fraser 1984, Rosenberg et al. 1988, Weakland 2000). Characteristics of snags and cavity trees in these intensively utilized forests differ from those in less intensively managed (locally, stands not entered since the early 1900s) or old-growth stands (McComb and Muller 1983, Rosenberg et al. 1988). Regionally, remaining old-growth stands are too small and disjunct to be biologically meaningful for bats.

Roost habitat destruction and alteration is thought to be one of the most detrimental factors influencing bats in eastern North America (Kunz 1982, Menzel et al. 2001). An understanding of roost requirements of common species, such as the northern long-eared myotis, is vital to bat conservation in the central Appalachians and elsewhere. Our study objectives were to determine if and where northern long-eared myotis maternity colonies roosted in intensively managed central Appalachian forest stands and to compare roost trees (and the surrounding habitat) with potential roost trees to identify important roost habitat characteristics.

Study Area

Our study was centered on the Westvaco Wildlife and Ecosystem Research Forest (WERF) and surrounding Westvaco Forest Resources properties. The WERF is a 3,360-ha area located in the unglaciated Allegheny Mountain and Plateau physiographic province of West Virginia (Fenneman 1938) in southwestern Randolph County (38° 42' N lat., 80° 3' W long.). Established by Westvaco Corp. in 1994, the area is reserved for the study of industrial forestry impacts on ecosystems and ecological processes in an Appalachian setting. Oldest forests on the WERF are second-growth stands that were established by natural regeneration following the extensive railroad logging that occurred in this portion of West Virginia from 1900 to 1930 (Clarkston 1993). Elevations range from 740 to 1200 m. Topography consists of steep side slopes with broad, plateau-like ridgetops and narrow valleys with small, high-gradient streams. The climate is cool and moist with average annual precipitation exceeding 155 cm (Strausbaugh and Core 1977). Soils on the area are classified as acidic and well-drained Inceptisols (Stephenson 1993). Overstory forest cover is primarily an Allegheny hardwood-northern hardwood type dominated by beech (*Fagus grandifolia*), yellow birch (*Betula alleghaniensis*), sugar maple (*Acer saccharum*), red maple (*A. rubrum*), black cherry (*Prunus serotina*), Fraser's magnolia (*Magnolia fraseri*) and red spruce (*Picea rubens*). Species from the cove hardwood and mixed mesophytic associations, including yellow-poplar (*Liriodendron tulipifera*), basswood (*Tilia americana*), sweet birch (*B. lenta*), and northern red oak (*Quercus rubra*) occur at lower elevations. Overtopped and suppressed or dead black locust (*Robinia pseudoacacia)* trees and snags are common in many forest stands. Riparian areas are characterized by eastern hemlock (*Tsuga canadensis*)-rhododendron (*Rhododendron maximum*) communities. In much of the upland area, rhododendron and striped maple (*A. pensylvanicum*) form dense understory thickets. An artifact of past forest management practices and white-tailed deer (*Odocoileus virginianus*) herbivory, a dense cover of hay-scented fern (*Dennstaedtia punctilobula*) occurs where the shrub layer is absent and the overstory canopy is not continuous (Ford and Rodrigue 2001). Recent (5 years old or younger) selection harvests and clearcuts are common on the area. Where regeneration is successful following harvest, stands are dominated by copious amounts of red maple, yellow birch, black cherry, fire cherry (*Prunus allegheniensis*), yellow poplar, American beech and black locust stems.

Materials and Methods

We captured northern long-eared myotis from June to August 1998 and from May to August 1999 using 12 x 2.4 m mist nets and high-net systems consisting of three nets stacked vertically (Gardner et al. 1989). Nets were positioned over streams, ephemeral pools, road ruts, and water-filled borrow pits. We defined a mist-net night as a single mist net open for at least 1 hour. Data collected from each captured bat included species, age, sex, mass, forearm length, and reproductive condition. We determined female reproductive condition by palpating the abdomen and inspecting the mammae and determined age-class by examining the degree of epiphyseal-diaphyseal fusion (Anthony 1988, Racey 1988).

We attached LB-2 radio transmitters (0.46 and 0.55 g; Holohil Systems Ltd., Woodlawn, ON) to 20 pregnant or lactating northern long-eared myotis. Transmitters were attached to the hair between the scapulae using Skin Bond® surgical adhesive (Pfizer Hospital Products Group, Inc., Largo, FL). Transmitters weighed less than 5 percent of any individual bat's body weight (Aldridge and Brigham 1988) and each had a battery life of approximately 21 days.

We located roosting northern long-eared myotis during the day using standard radiotelemetry techniques. We used R2000 ATS receivers (Advanced Telemetry Systems, Inc., Isanti, MN) and folding, three-element Yagi antennas to return to trees that evening to determine the exact location of roosts and relative sizes of the maternal colonies. All bats were tracked until they dropped the transmitter or the battery failed ($\bar{x}$ = 6 days; SE =2.5; n = 20).

To identify habitat features that might influence roost selection, we measured 23 characteristics of the roost tree and surrounding habitat. We compared these measurements to data from apparently suitable but unused roost trees that contained either a cavity or large plates of exfoliating bark (Betts 1997). We located random suitable trees by generating a set of Universal Transverse Mercator coordinates within 0.5 km of an actual roost tree. From that location, we walked concentric circles until we found a suitable tree with a cavity or exfoliating bark. We subjectively assessed the level of structural complexity within 1 m^2 directly in front of the portion of the tree considered the roost-area entrance. A complexity value of 1 indicated that there was no vegetation in front of the roost; a value of 5 indicated that the roost entrance was obscured by dense vegetation. We also measured height of the roost entrance, total tree height, and diameter at breast height (d.b.h.).

We measured 18 variables within 0.04-ha plots centered on the roost tree (Table 1). We recorded the distance from the roost tree to the nearest overstory tree and to the nearest taller overstory tree. Canopy density was measured using a spherical densiometer (Lemmon 1956) at 2 m from the bole of the roost tree on the same side as the roost. Overstory trees were defined as greater than 9.5 cm d.b.h, whereas understory trees were woody stems between 1.0 and 9.5 cm d.b.h. The percentage of overstory trees composed of conifers or snags was based on basal area. Shannon's measure of diversity, Pielou's measure of evenness, and simple species richness were used for both overstory and understory trees in these analyses (Pielou 1966). Understory density was recorded as the number of woody stems less than 9.5 cm d.b.h. within the 0.04-ha plot.

Characteristics of roost trees and random trees were compared using two sample *t*-tests testing a two-tailed alternative hypothesis of unequal means (SAS Institute 1990). Significance was set at alpha = 0.05. We recorded all trees by species along 12 randomly located transects ($\bar{x}$ = 153.0 m; SE = 31.9) to further evaluate tree species selection by comparing roost trees to the available tree species with possible roost sites (snags or live trees with cavities or exfoliating bark). We then compared the proportion of tree species used as roost trees to the proportion of available roost tree species using Chi-square analysis (SAS Institute 1990).

Results

We captured 168 bats of 8 species in 221 mist-net nights. These included 23 big brown bats (*Eptesicus fuscus*), 3 silver-haired bats (*Lasionycteris noctivagans*), 25 eastern red bats (*Lasiurus borealis*), 12 hoary bats (*Lasiurus cinereus*), 27 little brown bats (*Myotis lucifugus*), 61 northern long-eared myotis (*M. septentrionalis*), one Indiana bat (*M. sodalis*), and 16 eastern pipistrelles (*Pipistrellus subflavus*).

We located 43 roost trees used by northern long-eared myotis. Females changed roost location an average of every three days ($\bar{x}$ = 3; SE = 1.5). Many bats used the same roost tree simultaneously or over successive days. Based on our emergence counts, size of maternity colonies ranged from 7 to 88 individuals. On 22 June 1999, we counted 88 northern long-eared myotis exiting a cavity in a live black cherry. We found 15 roosts under exfoliating bark, whereas 28 were found in natural cavities.

The mean height of actual roosts was higher ($P = 0.003$) than that of the potential roost trees (Table 1). The complexity surrounding the roost entrance did not differ ($P = 0.4081$) between the actual roost and potential roosts. Although d.b.h. of roost trees was smaller ($P = 0.0249$) than that of potential roost trees, roost tree d.b.h. did not differ from that of other trees within the plot. Only 3 of the 18 site characteristics differed between roost and random sites (Table 1). The basal area of snags and percentage of snags in the overstory were higher surrounding roost trees than random trees ($P = 0.0425$; $P = 0.0376$). The number of stems in the overstory also was higher around roost trees than the potential roost trees ($P = 0.0403$).

Roosts were located in 11 tree species (Table 2). We found 13 (30 percent) roosts in black locust and nine (21 percent) in black cherry. Black locust comprised 9 percent of the available trees and black cherry 11 percent of the available trees. Black locust and black cherry were used more often than expected relative to the proportion available ($\chi^2 = 35.59$, 9 *df*, $P < 0.001$).

Table 1.—Comparison of means (± SE) of 23 characteristics between 43 roost trees used by maternity colonies of *Myotis septentrionalis* and 43 potential roost trees using two sample *t*-tests.

	Roost		Potential			
	Mean	SE	Mean	SE	*t*	*P*
Cavity characteristics						
Roost height (m)	10.8	0.6	7.7	0.6	-3.78	0.0003
Complexity	1.8	0.2	1.6	0.1	-0.83	0.4081
Tree characteristics						
Height of roost tree (m)	17.8	0.7	15.9	1.0	-1.63	0.1074
Diameter of roost tree (cm)	27.2	1.0	31.1	1.4	2.28	0.0249
Roost d.b.h. vs mean d.b.h. of plot	26.3	1.3	24.3	0.7	-1.46	0.1500
Site characteristics						
Nearest overstory tree (m)	1.6	0.2	2.1	0.4	1.13	0.2632
Nearest taller overstory tree (m)	2.8	0.4	3.6	0.6	1.19	0.2371
Difference in roost and canopy tree height	-1.6	1.8	-5.6	1.9	-1.52	0.1331
Percent canopy density	90.9	2.2	86.1	3.6	-1.14	0.2589
Degree of slope	18.0	1.7	19.0	1.2	0.57	0.5676
Number of overstory trees	24.8	1.3	20.7	1.5	-2.08	0.0403
Total basal area of plot	13.8	0.6	13.0	0.8	-0.76	0.4471
Basal area of snags	0.9	0.2	0.5	0.1	-2.07	0.0425
Percent snags in overstory	6.9	1.4	3.7	0.6	-2.13	0.0376
Conifer basal area	1.4	0.3	1.1	0.3	-0.54	0.5883
Percent conifers in overstory	9.9	2.3	8.6	2.1	-0.43	0.6695
Overstory richness	6.7	0.31	6.1	0.35	-1.29	0.1999
Overstory diversity	1.5	0.06	1.5	0.08	-0.25	0.800
Overstory evenness	0.8	0.02	0.8	0.04	-0.05	0.9602
Density of understory	9.7	1.5	8.5	1.0	-0.67	0.5067
Understory richness	2.4	0.20	2.4	0.22	0.00	1.000
Understory diversity	0.6	0.07	0.6	0.08	0.17	0.8626
Understory evenness	0.6	0.1	0.6	0.1	0.08	0.9397

Table 2.—Tree species chosen as roosts for maternity colonies by *Myotis septentrionalis* compared to available potential roost tree species.

Species	Maternal roosts	Percent	Potential roosts	Percent
Robinia pseudoacacia	13	30.2	27	9.0
Prunus serotina	9	20.9	32	10.7
Acer spp.	7	16.3	37	12.3
Quercus spp.	5	11.6	22	7.3
Magnolia spp.	4	9.3	25	8.3
Other	3	7.0	54	18
Fagus grandifolia	1	2.3	28	9.3
Betula spp.	1	2.3	50	16.7
Lirodendron tulipifera	0	0.0	13	4.3
Fraxinus americanus	0	0.0	12	4.0

Discussion

Similar to our results, Sasse and Perkins (1996) reported 36 northern long-eared myotis leaving a tree cavity in northern New Hampshire, whereas Foster and Kurta (1999) counted 60 individuals from a roost in Michigan. We also counted 77 and 64 bats from two other roosts within 1 km of the 88-exit count. We believe the large colony sizes we observed indicate that intensively managed forests in the central Appalachian do provide suitable habitat for northern long-eared myotis.

Tree-roosting bats generally select trees that are larger in diameter and taller than the surrounding stand (Sasse and Perkins 1996, Vonhof and Barclay 1996, Callahan et al. 1997, Foster and Kurta 1999). Presumably, these larger trees have increased solar exposure that aids in juvenile growth and development (Menzel et al. 2001). The aforementioned studies sharply contrast with this research indicating that northern long-eared myotis tended to select smaller trees in more cluttered stands. Moreover, our data challenges the assumption that in cool-temperate environments, tree-roosting bats will select roost to optimize solar exposure. We believe our most important discovery is that northern long-eared myotis roosted in localized areas with abundant snags. Whether northern long-eared myotis choose these sites and roosts from ease of initial discovery or the ability to have multiple alternate roosts in a more compact area is unknown.

We caution that lower roost heights for the potenial roost trees may be biased due to increased observer visibility, but northern long-eared myotis are small, very agile bats with low wing loading and aspect ratio with gleaning food habits well adapted to feed in or around vegetation (Barbour and Davis 1969, Faure et al. 1993, Findley 1993). Our roost data supports the hypothesis of Foster and Kurta (1999) that the increased agility allows northern long-eared myotis to easily exploit roosts in cluttered environments.

Across their distribution, northern long-eared myotis roost in many tree species. Mumford and Cope (1964) and Clark et al. (1987) found northern long-eared myotis roosting in elm (*Ulmus* spp.) in Indiana and Iowa. Sasse and Perkins (1996) observed roosts in American beech and sugar maple in New Hampshire. Working in Michigan, Foster and Kurta (1999) were the first to report silver maple (*Acer saccharinum*) and green ash (*Fraxinus pennsylvanica*) used as roosts. Our research is the first to identify the use of black locust and black cherry as roosts for this bat species. Both of these tree species were used in greater proportion than the relative proportion available in the surrounding forest stands.

Black locust is an intolerant pioneer species in the central Appalachians with quick regenerative response after a ground-clearing disturbance such as timber harvest. The species initially exhibits rapid growth, but is soon overtopped and suppressed by other more long-lived tree species. These overtopped and suppressed black locust usually die, leaving a rot-resistant snag that can remain standing for years. Black cherry also is an intolerant species that responds to complete overstory disturbance and removal by exhibiting rapid growth (Smith 1994, Harlow et al. 1996). Regionally, black cherry regenerates in such large numbers that high numbers of snags are inevitably available throughout most times during a forest stand's development (70- to 120-year rotation for sawtimber; 40- to 70-year rotation for fiber production). Black cherry also is resistant to rot and can produce large, quality roost snags. Our results support the hypothesis of Thomas (1988) that snag longevity is an important factor in bat roost selection.

Based on our findings, we believe roost availability for northern long-eared myotis is not a biologically limiting factor in intensively managed forests in the central Appalachians.

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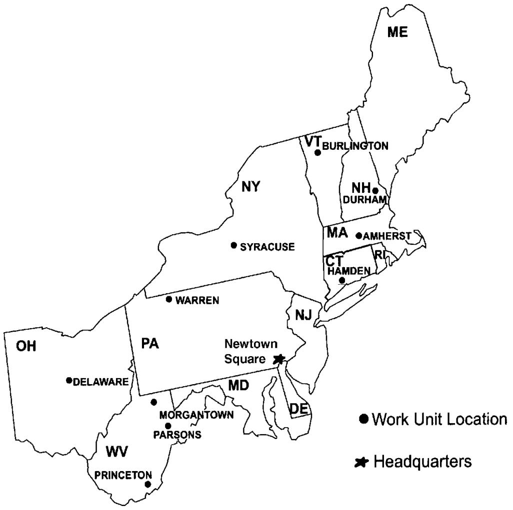
Presents data on the tree-roosting ecology of female northern long-eared myotis (*Myotis septentrionalis*) in managed hardwood forests in the Allegheny Mountains of West Virginia.

Keywords: black locust, cavities, *Myotis septentrionalis*, northern long-eared myotis, *Robinia pseudoacacia*, roost snag



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