Characteristics, Use, and Distribution of Day Roosts Selected by Female *Myotis volans* (Long-legged Myotis) in Forested Habitat of the Central Oregon Cascades

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ABSTRACT

I tracked female *Myotis volans* using radio-telemetry during July and August 1993, 1994, and 1995 in two drainages (Quentin Creek and Lookout Creek) of the Central Oregon Cascades. Analysis of the data indicates large snags and hollow cedar trees are important day roosts. Individuals radio-tagged at the same night roost did not use one common day roost. Individual bats roosted in one roost for several days, or used multiple day roosts within distinct areas. The area in Quentin Creek encompassing one night roost and all known day roosts covered 3,258 ha, and the area in Lookout Creek encompassed 6,391 ha. Distributing solitary day roosts and patches of roosts across the landscape, protecting the microclimate of roosts, and conducting further research on the types and distribution of day roosts would be reasonable steps towards providing day roost habitat for this species and gaining further understanding of its day roost ecology.

INTRODUCTION

Myotis volans is a forest-dwelling bat found in the Oregon Cascades. It inhabits arid rangelands and montane forests across the western United States and Canada (Nagorsen and Brigham 1993). This species was identified by the Forest Ecosystem Management Assessment Team (FEMAT) as being associated with old growth, in need of further study, and of concern because of the limited distribution of old-growth habitat within western Washington and Oregon, and northern California (Thomas et al. 1993). *M. volans* was federally listed in the USA as a Category 2 species in November 1994.

I collected data on day roost characteristics, use, and distribution for female *M. volans*. I explored five questions of interest concerning day roosts: (1) What are the physical characteristics of day roosts selected by female *M. volans*? (2) Do female *M. volans* found night roosting together, use one common day roost? (3) Do female *M. volans* use more than one day roost? (4) If they do use more than one day roost, how are the roosts distributed in relation to one another? (5) How large an area encompasses the night roosts and day roosts of female *M. volans* associated with the same night roost? This report presents a preliminary exploration of the data and further analysis is forthcoming.

STUDY AREA

Study sites were located in the central Oregon Cascades in the Willamette National Forest. I collected data in 1993, 1994, and 1995 in Lookout Creek drainage, which lies east of Blue River Reservoir; and in Quentin Creek drainage in 1994, which lies northeast of Blue River Reservoir. These sites were selected because they had accessible bridges that served as night roosts for female *M. volans* and the drainages were relatively accessible. A variety of potential day roosts were present (cliff faces, caves, snags, and trees) over a matrix of varying stand conditions (natural seral stages, managed stands with and without residual snags and trees).

METHODS AND MATERIALS

I captured female *M. volans* at two bridge sites between 0330 and 0430 h during July and August. Lactating and pregnant females were selected over females of unknown reproductive status. I radio-tagged 22 bats with 0.55 to 0.65-g BD-2B radio-transmitters (Holohil Systems Inc., Carp, Ontario). I radio-tagged one individual in both 1994 and 1995. Because it did not return to the same day roosts in 1995 as it had used in 1994, I counted it as two separate bats for my analysis.

A location for each radio-tagged bat that stayed within the study area was mapped daily based on compass readings, or roost location, for the life of the radio or until it was shed. Verification of an exact day roost for each radio-tagged bat was attempted once every 24 hours during daylight. Roost locations and characteristics, including species, DBH, height, and decay class (Appendix 1) were recorded.

The design of my study did not call for in-depth observations of bat activity at the day roosts. However, on six occasions I returned to four different roosts at dusk to observe radio-marked bats exiting from their day roosts (fly-out). Three of these roosts were *Psuedotsuega menziiesii* snags in decay classes 1 and 2. The fourth roost was a large-diameter *Thuja plicata* in decay class 0.5.

Statistical Methods

Simple statistics were calculated using Paradox version 4.5 (Borland Int. Inc.), and JMP statistical software version 3.1 (SAS Institute Inc.). I used simple linear regression to explore the relationship between the days a bat was radio-tracked and the number of roosts associated with it. For this analysis, I used "roost sites," which included both verified roosts, and compass locations of unique sites where a specific roost structure was not verified. The response variable—number of roost sites—was square-root-transformed as it was count data, and the transformation resulted in a more normal distribution. I also ran a simple linear regression of the days a bat was radio-tracked against the size of the area encompassing day roost sites of the individual (roost areas). I eliminated one outlier for this analysis as the roost area of this bat was over three times the size of the largest roost area used by the other bats.

JMP software was used for cluster analysis as a visual tool for mapping roost sites. I used GIS to determine distances between roosts, distances from day roosts to night roosts, and the area encompassing day roost sites (verified roosts and compass locations) for individual bats. This analysis was completed exclusive of roosts selected on the morning that a radio-marked bat was released. The area of landscape polygons encompassing day and night roosts for each drainage was measured using GIS.

RESULTS

Radio-Tracking

Out of 22 bats that I radio-tagged, I tracked 16 to day roosts. The other six bats were either not located after the first day, or the signal could not be pinned down to a distinct location. Fifteen bats were tracked for two or more days, and 13 of these used multiple roost sites (verified roosts and compass locations). The average number of days that bats (n = 16) were radio-tracked was 8.25 (SE = 1.3) and ranged from 1 to 24.

Physical Characteristics of Day Roosts

A total of 41 day roosts used by 16 individuals (one bat was radio-tracked during two separate seasons, and is accounted for twice) were located. Snags comprised 88% (n = 36) of all roosts. Live *P. menziiesii* (Douglas-fir) comprised 10% (n = 4), and one rock crevice was selected as a roost.

The average height of all roosts was 40.0 m (SE = 2.5) and ranged from 13.4 to 71.5 m. The average DBH for all snags and trees used as day roosts was 100.2 cm (SE = 6.08) and ranged from 34.0 to 194.0 cm. Nearly half (47%) of the snags were decay classes 1 and 2, *P. menziiesii* averaging 108 cm (SE = 7.4) DBH, and 45.8 m (SE = 2.9) tall. Nine (25%) of the snags used as day roosts were decay classes 3 and 4, *P. menziiesii* averaging 99.1 cm (SE = 10.1) DBH, and 32.7 m (SE = 5.7) tall. The remaining snags were *Tsuga heterophylla* (western hemlock) snags (14%, n = 5), mostly in decay classes 1 and 2 (n = 4), and *Thuja plicata* (western redcedar) snags (11%, n = 4), mostly in decay class 0.5 (n = 3).

Use of Day and Night Roosts

Bats were located at day roosts on 93 occasions. On two occasions, two bats that were radio-tagged at the same night roost were found using the same day roost at the same time. None of the radio-tagged bats were found using the same day roost at different times.

Multiple Day Roosts

The average number of days spent at a day roost for all radio-tagged bats (n = 16) was 2.16 (SE = 0.27) and ranged from 1 to 7 days. Fourteen bats were radio-tracked to day roost sites (verified roosts and compass locations) on more than one day. Thirteen of these bats used at least two roost sites over the time they were tracked.

There was a weak relationship between the number of days a bat was radio-tracked and the number of roost sites it used (one-tailed p-value = 0.02). This implies that the more days a bat is radio-tracked the more roost sites it will be found using. The number of days a bat was tracked did not affect the size of roost area (one-tailed p-value = 0.77). This implies that regardless of the number of days these bats were tracked, they tended to roost within a discrete area (n = 12).

Distribution of Roost Sites

Multiple day roost sites (verified roosts and compass locations) of individual bats occurred within an average area of 11.42 ha (SE = 3.9) for 12 bats, and within 175 ha for one bat. The average distance between day roosts (verified roosts only) of individual bats was 412.5 m for 11 bats, and 3,693 m for one bat.

The average distance of day roosts (exclusive of day roosts selected on the morning that a bat was released) from the night roost was 2.46 km and ranged from 0.71 km to 6.47 km. The area encompassing all day roosts (n = 26) and the night roost for Quentin Creek drainage covered 3,258 ha. The area encompassing all day roosts (n = 15) and the night roost for Lookout Creek drainage covered 6,391 ha.

Fly-Out

I witnessed 3 to 12 bats exit the *P. menziiesii* snags. Over 300 bats exited from the *Thuja plicata* roost on two separate occasions, and many of the bats were observed exiting and returning to the roost, behaviour that is typical of neonatal bats testing their flight skills (Perlmeter, 1995 and pers. comm.). Large accumulations of guano were present at the base of this and one other hollow tree in the same cedar grove. Three evenings later, not a single bat exited either roost. Sheets placed at the base of both roosts to catch guano indicated the bats did not return to either roost over the rest of the summer.

DISCUSSION

Roost Characteristics and Function

While relatively large-diameter, tall *P. menziiesii* snags dominate the type of roost selected by individual bats in this study, other types of day roosts may be of equal or more critical value to the ecology of *M. volans*. For instance, only a few *Thuja plicata* snags in decay class 0.5 were selected, and could be interpreted as minor contributors to the pool of day roosts. Fire-hollowed *Thuja plicata* are relatively rare compared to *P. menziiesii* snags, but provide large chambers or cavities that can house large numbers of bats, and provide different microclimate conditions compared to the cracks and crevices typical of *P. menziiesii* snags. The difference in physical characteristics, and the discrepancy in the number of bats I witnessed during fly-out indicate that different types of day roosts serve different functions. Further study to quantify these differences could be valuable in fully understanding the roost ecology of this species.

There could be many reasons for female *M. volans* to select different types of day roosts, and vary the number of roost-mates. One hypothesis is that reproductive females who are caring for altricial pups that are not able to thermoregulate, echolocate, or fly, increase the safety and energy conservation for themselves and their pups by roosting in one location as a large group. Once the pups are more independent of their mothers, learning a variety of roosts and foraging sites in smaller, less competitive groups could increase a pup's chance of survival.

Use

The low occurrence of radio-tagged bats day roosting together, and the fact that no two bats used the same day roost on separate occasions, suggest that the radio-tagged bats did not share a single common day roost. Too few bats were radio-tagged at any one time to draw conclusions about how these bats interact at the day roosts as a whole group.

The bats in this study generally used more than one day roost. Roosting habits of bats are variable and influenced by reproductive status, environmental conditions, such as proximity to food sources, parasite load, threat of predation, or microclimatic conditions, and social organization (Kunz 1982). Lewis (1995) reported similar factors influencing roost switching. The use of multiple roosts by female *M. volans* could be a result of any one or all of these influences.

Use of several roosts has been attributed to predator avoidance for some species of bats in tropical zones. In temperate regions, such as the Pacific Northwest, predation on bats by raptors and some mammals is probably opportunistic, and there is little evidence that bats are a major food source for other species of wildlife (Fenton 1983). Results from pellet analysis of *Strix occidentalis* (northern spotted owl) within the Oregon Cascades for an area encompassing this study site produced only occasional records of bat remains (Swindle, pers. comm.).

The linear regression results indicate that there is some sort of relationship between the number of tracking days and the number of roosts used by an individual, yet the results were weak, in part because of the small sample size. My analysis only included data for verified roosts or locations. There were occasions where a bat was tracked to a roost one day, not found the next, and relocated at the same or a different roost the day after. It is likely that the bat was at an alternate roost on the day it was not found, yet these events were not used in the analysis. An effective analysis of this type would require a larger sample size where the number of days that each bat is tracked covers more than a few days to offset occasions when a bat spends several days at one roost.

Distribution

I have reasonably strong evidence that the size of a roost area was not influenced by the number of days that a bat was tracked. While this supports the idea that some of these bats use discrete roost areas, again the sample size is small and further testing with a larger sample would be logical before inferring these results beyond the scope of this study.

The distribution of multiple day roosts for individual bats within relatively small areas is consistent with the work of Taylor and Savva (1988), who found several species of Tasmanian bats using multiple day roosts. They hypothesized that the bats' fidelity was to a roost area rather than to a specific roost. Kunz (1982) suggested that most bats use one or more alternate roosts, and found that fidelity to a home area rather than a specific roost was common among foliage-roosting bats. Kunz (1982) suggested that roost fidelity is partially based on abundance and permanence of roosts. Lewis (1995) reviewed roost fidelity and lability for 43 species of bats and found fidelity to be related to permanence of the roost and inversely related to roost availability. Because of the temporary nature of snags, using several roosts in a discrete area that provides desirable habitat conditions may be a better strategy than being loyal to one snag and risking the need to relocate at an inopportune time.

Selection of day roosts by female *M. volans* involves biological, environmental, and temporal considerations at more than one geographic or physical scale. This study and discussion barely scratches the complex surface of day roost selection. Humphrey (1975) hypothesized that the distribution of neartic bat species was associated with the availability of roost structures. His work indicated that nursery roosts are a prime resource in determining distribution and abundance of neartic bats. Ensuring adequate roost distribution and abundance for snag-dependent species, such as *M. volans*, in forested habitats of the Pacific Northwest will require maintenance of adequate snag resources over time, especially on lands designated for commercial forestry.

Solitary *P. menziiesii* snags and patches distributed across an entire watershed would provide one level of day roost habitat for female *M. volans*. Management strategies specific to identified roost areas may be the most effective approach to maintaining or increasing roost structures for these sites. Monitoring use and roost microclimates will be important in determining long-term use of these areas, and any changes to roost microclimates.

Maintaining the microclimate of hollow trees and rock outcrops used as roosts may require vegetation protection or management out to 240 m (Chen et al., 1993). In many cases, reserve buffers could be counter-productive to maintaining the microclimate around day roosts. If vegetation is left to grow within a buffer, it could change the temperature and air flow of the roost. Protection of roosts in harvest units, along stand edges, or in forest gaps may require removal of vegetation. Monitoring temperature and use at these more permanent roost structures would be valuable in designing appropriate management strategies.

Further study on the concept of day roost areas and day roost fidelity would be helpful in better understanding and managing for roost types and distribution. Day roosts are one component of the ecology of *M. volans*. Other components, such as foraging areas and hibernacula, are not well understood and may also play an important role in the distribution and stability of this species. The results of this study are from a limited geographic area with a relatively small sample size of bats, and I recommend taking this into consideration before applying the results to other areas.

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APPENDIX 1 Decay classes for snags (adapted from Neitro et al. 1985).

Typical attributes	Decay class				
	0.5	1	2	3	4
Percent dead	± 50%	100%	100%	100%	100%
Branches	80–100%	80–100%	few—no branches	limb stubs to none	none
Bark	80–100%	80–100%	varies	varies	0–50%
Condition	hard	hard	hard/soft	soft	soft
Height	± full	full—broken top	broken top	upper bole gone	less than 50% full