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Roost-Site and Habitat Selection of the Long-Legged Myotis in a Managed Landscape on the East Slopes of the Cascade Range

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Jeffrey A. Taylor

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Richard W. Hill
Major professor

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ROOST-SITE AND HABITAT SELECTION OF THE LONG-LEGGED MYOTIS (*Myotis volans*) IN A MANAGED LANDSCAPE ON THE EAST SLOPES OF THE CASCADE RANGE

By

Jeffrey A. Taylor

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ABSTRACT

ROOST-SITE AND HABITAT SELECTION OF THE LONG-LEGGED MYOTIS IN A MANAGED LANDSCAPE ON THE EAST SLOPES OF THE CASCADE RANGE

By

Jeffrey A. Taylor

Habitat fragmentation is often considered one of the biggest threats to bats in the Pacific Northwest. Yet, few studies have focused on how bats use habitat in heavily fragmented areas. The Northwest Forest Plan was created because of concerns about how the loss of late-successional forests affected wildlife. This study focused on how *Myotis volans* uses habitat in the managed forests on the east slopes of the Cascade Range, including whether they will use retention such as live trees or snags left in harvest areas. During this study, male long-legged myotis were radio-tracked to their day-roost locations, which were primarily grand fir snags. Actual roosts were compared to random snags to see what features are driving selection. The results of this study found that *Myotis volans* prefers late-successional forests. They avoids harvest units, even when potential roost structures are available, but will use retention that provides large structures such as aggregate retention and shelterwoods. There is a high dichotomy in the types of roosts being used between the two study sites that appears to be based primarily on whether it is high or low canopy cover, which likely affects the microclimate of the roost.

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INTRODUCTION

Ecosystem management of Pacific Northwest forests has experienced many changes in recent years. An expansion of our understanding of forest ecosystem processes, a shift in values among the American public, and new laws and regulations regarding forestry practices have changed the ways that forest managers do business. The controversy over the northern spotted owl (*Strix occidentalis caurina*) and other late-successional species led ecologists, forest managers, and politicians to develop a comprehensive management plan for the conservation of wildlife, fisheries, and watersheds, while still meeting the mandate for continued timber harvests. In 1994, the Forest Ecosystem Management Assessment Team (FEMAT) developed the *Northwest Forest Plan* in an attempt to find an acceptable middle ground between these two objectives (FEMAT 1993).

In the five years since FEMAT developed the *Northwest Forest Plan*, the U.S. Forest Service has implemented a series of management prescriptions designed to provide more connectivity to the landscape and to "soften" the effects of timber harvesting on wildlife. These management prescriptions include leaving large structures in harvest areas such as live trees, standing dead trees (snags), and down woody debris. Collectively these structures are called retention. There are several major types of retention that are used as management prescriptions including dispersed and aggregate retention, shelterwoods, and riparian buffers (see Figure 2). Development and implementation of these management prescriptions requires adaptive management decisions (McIver and Bull 1998). That is because most people demand changes to occur within a political time frame. But, this time frame is far too short to monitor and study ecological responses to these prescriptions. Because these prescriptions are based on adaptive management decisions, many of these prescriptions have been implemented without strong evidence to show that they actually work in mitigating the effects of timber harvests on various wildlife species (McIver and Bull 1998, R. Mendez pers. comm.). Therefore, there is a need for research to determine whether these management prescriptions actually work for the wildlife species for which they were intended, so that these mitigation measures can be modified in the future to better suit the needs of wildlife.

One group of species for which management prescriptions have been intended is bats. In recent years, bat conservation has become a major issue for forest managers because of suspected population declines and the lack of basic knowledge about bat ecology. Bats rely on the habitat in which they live for roosting and foraging, and a loss of critical habitat features could result in the local extirpation of these organisms (Humphrey 1975, Thomas and West 1989). Habitat fragmentation is often considered one of the biggest threats to bat populations. However, few studies have studied bat ecology in heavily fragmented areas (Campbell 1996, Fenton 1997). Many of the studies on bats in the Pacific Northwest have focused on bat associations in old-growth forests (Thomas 1988, Thomas and West 1991, Christy 1993). In recent years, the conservation of bats has attracted the interest of timber companies and agricultural interests because of bats' high levels of insect consumption (Whitaker et al. 1977, Kunz 1982, Reis 1982, Whitaker 1993). In addition, many timber companies developing Habitat Conservation Plans (HCPs) with the U.S. Fish and Wildlife Service are now being required to include bats in their management plans (Hansen 1995). Landscape ecologists are also interested in bats because they are considered well suited as indicators of general environmental conditions because of their small size, mobility, and longevity (Fenton 1997).

Twelve species of bats occupy the forests of the Pacific Northwest. All are insectivorous and are in the family Vespertilionidae, order Chiroptera. Historically, little information has been available on bat ecology because they are nocturnal, volant creatures, which makes the study of them somewhat difficult. Until recently, information on habitat utilization for the small bat species of the genus *Myotis* has been primarily anecdotal. Information regarding roost-site selection and habitat use for *Myotis* species was nearly impossible to gather. Until the mid-1990's, the smallest radio-transmitters weighed greater than 0.8 grams. This was too large to attach to bats of this genus, because all *Myotis* species in the Pacific Northwest generally weigh less than 8.0 grams and these transmitters would weigh greater than 10% of a bat's weight (van Zyll de Jong 1985, Aldridge and Brigham 1988). However, recent advances in technology have reduced transmitter size to less than 0.5 grams, now allowing for telemetry to be conducted on bats as small as 6.0 grams, while keeping extra weight to less than 10% of body weight.

The long-legged myotis (*Myotis volans*) is one of the 12 species of bats that occupy the forests of the Pacific Northwest. It is the largest *Myotis* species in the Pacific Northwest (Nagorsen and Brigham 1993). This species occupies montane forests and semi-arid rangelands across much of the western United States and western Canada (Nagorsen and Brigham 1993). The U.S. Fish and Wildlife Service listed this species in 1994 as a category two species (USDI 1994). It was also identified by FEMAT as being associated with old growth forests, a species of concern due to reduced old-growth habitat, and in need of further study because little information is currently available on this species (FEMAT 1993).

It is now well known that many bat species in the western United States use snags in forests for day-roosting (Brigham 1991, Campbell et al. 1993, Betts 1996, Vanhof and Barclay 1996, Kalcounis and Brigham 1998, etc.). This is true of the long-legged myotis (Rabe et al. 1998, Ormsbee 1997, Frazier 1997). However, there is little information on how bats, including *Myotis volans*, select habitat for roosting, especially as compared to what is available in a landscape. Currently, only two studies have been published about the ecology of the long-legged myotis in the Pacific Northwest, and both were conducted primarily on females (Ormsbee 1997, Frazier 1997). Ormsbee (1997) studied exclusively female long-legged myotis in Oregon on the west slopes of the Cascades and found that they primarily roosted in Douglas firs *(Psdeuotsuga menziezii*) and partially alive, hollow western red cedars (*Thuja plicata*). Frazier (1997) worked mostly on females on the east slopes of the Cascades. He found that they roosted primarily in grand fir (*Abies grandis*) and ponderosa pine (*Pinus ponderosa*) snags. In addition to these studies, Rabe et al. (1998) studied exclusively female long-legged myotis in northern Arizona and found them to use only ponderosa pine snags. Information on male roosting behavior is apparently lacking in the literature. This is a relevant point because it is known that there are differences in roost structure selection and habitat use between males and females in many vespertilionid bat species due to differences in social behavior (Kunz 1982). The three previous studies on this species also focused on describing roosting habitat without adequately testing how his species chooses roost habitat as compared to availability.

One of the primary limitations in determining habitat use versus availability is determining what is "available habitat". If one could determine approximately how far away from a central point a bat will fly during any given night, then that distance can be used to determine the area available for selection. A home range estimate can also give researchers an idea of what distance bats will travel. However, determining the home range of a bat or even the distance a bat will travel in a night is nearly impossible using radio-telemetry because bats have high flight speeds and change direction frequently.

Previous studies of the long-legged myotis have compared habitat use to availability across an entire watershed (Frazier 1997, Ormsbee 1997). However, there is no ecological reason for selecting that scale of analysis because these units are based not on bat behavior but, rather, on hydrology. Watersheds can vary greatly in size, but in the western United States these areas can be quite large, often exceeding 50,000 ha. An area as large as a watershed is likely to be well beyond the normal home range of any individual bat. In order to scale down the area being used for analysis, one would need to find some way of identifying the area that is available to a bat on any given night.

One factor that may limit bat movement is their ecological tie to water. Several studies have shown that bats are ecologically tied to water sources and that limited water sources can limit the movements of individual bats (Tidemann and Flavel 1987, McNab 1982, Christy 1993, Marcot 1996, Ormsbee 1997). If a limited water source keeps individual bats in the same area night after night, then the distance that the bats travel from that water source to the furthest roost-site can be used to determine what the available habitat is for selection. Since the study area I used has limited and widely spaced water sources, it presents an opportunity to limit the distance a bat will travel during the study. The goal of this study was to learn about the ecology of *Myotis volans* in a managed landscape at three spatial scales. These spatial scales include:

- **Fine scale:** The actual roost structures being used at the two study sites.
- **Habitat scale:** Habitat use compared to availability within each site.
- **Landscape scale:** Does roost structure selection and habitat use shift across a landscape as habitat structure changes?

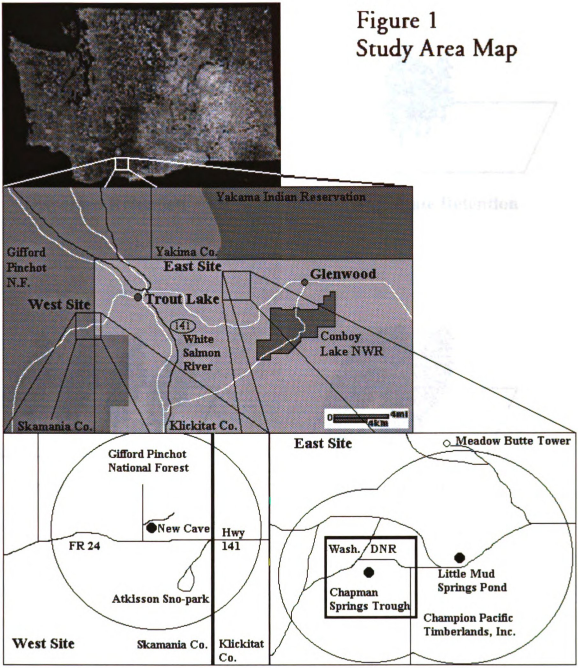
Male long-legged myotis were the ideal sex for this study because they are solitary and non-territorial. Females of this species roost in maternity colonies of a dozen to over two hundred, and therefore it would be expected that many of the females captured at a particular site would return to the same roost (U.S.F.S. unpubl. data). This would not allow much power in determining habitat use for this species. As males are solitary and were expected to be spread out across the landscape, each male would be an independent point for habitat analysis. This study used radio-telemetry of male long-legged myotis to determine the day-roost locations of this species at two sites, located approximately sixteen kilometers (10 mi.) apart. The primary null hypothesis for this study is: male long-legged myotis do not have particular habitat and roost structure preferences in this region. Thus, habitat use and roost-site selection are the same as randomly available. In addition, habitat use and roost-site selection do not change across the landscape.

Study Area

The study area for this project was located on the east slopes of the Cascade Range near the town of Trout Lake, Washington (Fig 1). Both study sites were located in the upper White Salmon River watershed (a National Wild and Scenic River). The geology and topography are dominated by a volcanic landscape associated with Mount Adams, 3742 m (12,276 ft). The elevation of the study area ranges between 640 m and 1064 m. The climate of this study area is typical for forests of the east slopes of the Cascades. This area experiences hot, dry summers with maximum daily temperatures averaging 28.2° C, but often exceeding 38° C in the hottest part of the summer (Worldclimate.Com 1996a). The average rainfall during July and August is less than 1.0 cm per month and humidity is low (Worldclimate.Com 1996b). Most of the water sources in the area are intermittent because of this annual summer drought, with the exception of two rivers that are fed by the glaciers of Mt. Adams. The long-legged myotis hibernates during the cold, wet months of October to April.

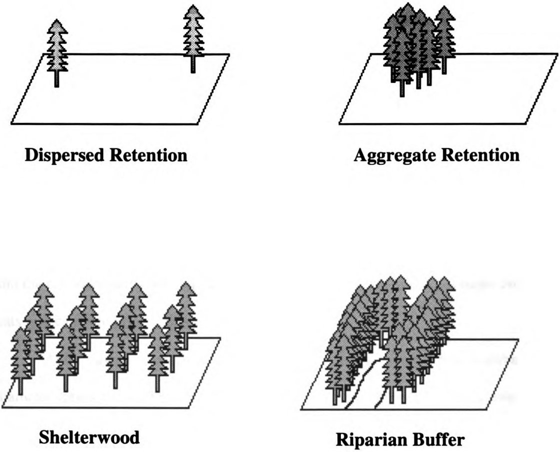
Within this study area were two study sites located approximately 16 km apart. They are oriented west to east and are hereafter called the west site and the east site. The west site is located primarily on the lands of the Mount Adams Ranger District, Gifford Pinchot National Forest (Fig. 1). The east site is located primarily on the lands of the private timber company Champion Pacific Timberlands, Inc. (CPTI) (Fig 1). Both sites also have some land managed by the Washington Department of Natural Resources. Precipitation decreases rapidly as a function of the distance east of the Cascade crest due to the rain shadow effect. Yearly precipitation in this study area decreases from approximately 150 cm at the west site to 110 cm at the east site. This results in a shifting vegetation structure across the study area. The primary species associated with the west site are grand fir (*Abies grandis*) and Douglas fir (*Pseudotsuga menzeisii*), with western hemlock (*Tsuga heterophylla*), western larch (*Larix occidentalis*), and ponderosa pine (*Pinus ponderosa*) being secondary constituents. The east site is in a transition zone. Douglas fir and grand fir remain dominant tree species, joined by ponderosa pine. However, western hemlock and western larch disappear from the landscape and Oregon white oak (*Quercus garryana*) becomes a secondary component of the forest. At the eastern edge of the east site, the forest structure shifts into a primarily pine/oak dominated forest, with fir species becoming a secondary component.

Figure 1
Study Area Map



Circles represent Available Habitat Areas described on page 16

Figure 2
Drawings of Retention Types



METHODS

Approval for the capture of these bats was granted by the University Committee on Research Involving Human or Animal Subjects at Michigan State University prior to any trapping, AUF # 03/97-048-00. In addition, the Washington Department of Fish and Wildlife granted scientific collector permits for 1997 and 1998. At the west site, bats were captured at a lava tube entrance known as New Cave. This is the only known available water source for approximately 2.0 km. The opening is about 3.0 m tall and 12.0 m across. A 3.0- x 12.0-m mist-net was strung across the entrance. Bats were captured as they entered the cave at dusk from the surrounding forests to drink and forage and the net was usually left in place until 1-2 hrs after sunset, unless the target number of bats was captured prior to that time.

At the east site, bats were captured at a 3.0-m diameter cattle trough and a 7.5-m diameter spring pond. These two trap sites are located approximately 400 m apart and are the only known water sources for approximately 2.6 km. A 3.0- x 7.0-m mist-net was placed over the cattle trough, while three to five mist-nets were strung around the perimeter of the pond.

All bats that were captured were identified and recorded to species and sex. If they were female, reproductive status was also recorded. All species other than *Myotis volans* were then released. All female *Myotis volans* were also released. Male long-legged myotis were placed into canvas bags and taken to the Mount Adams Ranger Station, where transmitters were placed on them. The transmitters used for this project were Holohil Systems (Carp, Ontario, Canada) 0.47 g or 0.51 g LB2 and Titley Electronics (Ballina, NSW, Australia) 0.50-g LT1 transmitters.

At the Mt. Adams Ranger Station, the transmitters were activated by soldering the leads together. The hair between the scapulae of each bat was trimmed close to skin level. Trimming allowed the glue to be in contact with the skin and prevented the transmitter from being lost if the fur of the bat was shed. Once the fur was trimmed, Skin-Bond® surgical adhesive (Smith and Nephew United, Largo, Florida) was applied to the area and the transmitter was placed on top. Some glue was also applied to the sides of the transmitter. Some of the long hairs on the periphery of the trim were placed into the glue to allow for a better hold. The bat was then placed back into the bag and returned to the place of capture for release. Day-roost location was determined the following morning. If there was no signal at the capture location the following morning, then a search for the signal was undertaken over a radius of about 2.0 km from the capture site. Once a signal was received, the bat was tracked to its day-roost. The range of a transmitter was usually about 1.0 km or greater.

In order to assure the accuracy of our roost-site locations, all investigators were tested prior to actually radio-tracking these bats. A second party placed transmitters in the forest and then all investigators were asked to locate those transmitters. Only after the transmitters were located by all that were radio-tracking during this study, was the principle investigator confident enough to trust the data of those investigators. In addition, three transmitters that were shed from the bats were located on the ground during this study. Considering these transmitters are less than the size of a dime and were laying in dense forest litter, to find them only increases my confidence that the roost-site locations for this study are accurate.

Once roosts were located various roost-site attributes were measured. Roost-site attributes included; roost-tree species, height, diameter at breast height (DBH), decay class, and canopy cover. In addition, a 15-meter radius plot (0.071 ha) was set up around each roost. Within this plot, average canopy height, average stem DBH, tree species, and the number of snags were recorded. Measurements for trees in the plot were only recorded if they were considered to be "canopy trees." Canopy trees were defined to be those that were at least 50% as tall as overlying canopy. This prevented seedling/sapling trees and stumps from being included in the analysis.

For every roost that was used, a random roost-site was also located to compare roost structure use to availability. The location of the random roost-site was determined using a random number table. From the actual roost-site a number was chosen at random to indicate the distance in meters and a second number chosen to indicate direction in degrees. Because over 95% of the actual roosts were snags, all random roosts were snags to simplify random roost selection and location. In addition, random snags had to be a minimum of 6.4 m tall and greater than 24.9 cm DBH to be used. These numbers were based on the smallest roost used by a bat in this study. These minimum numbers were used to assure that random snags were bat "useable" by preventing dead saplings or stumps from being included in the analysis. This helps to assure that the comparison is a conservative estimate of use to availability. The distance to a random snag had to be greater than 30 m from the actual roost to prevent an overlap of the plots and less than 200 m to assure the random roost was contained within the same stand. If the edge of the stand was less than 200 m in the selected direction, then the first snag located greater than 15 m from the edge was selected, to assure that the entire random plot was located within the stand. Once a random snag was found, all of the same measurements were taken as for an actual roost site.

For analysis of roost attributes, a series of paired t-tests with Bonferroni adjustments were used to compare actual roosts to random roosts at each site, as well as comparing the actual roost results from west site to east site. Statistical analysis was conducted using SYSTAT 8.0 (SPSS Inc. 1998). Twenty-two of the 35 bats used multiple roosts during this study. Roosts could not be weighted by the number of days they were used because the transmitter battery has a limited life and therefore does not allow for accurate knowledge of the mean number of days a roost would be potentially be used. This is especially problematic for those roosts that are used near the end of a battery's life. Thus, multiple roosts used by a single bat in such cases could not be treated as statistically independent. To avoid problems of nonindependence, the characteristics of all the roosts used by an individual were averaged, and the mean values were used in statistical analysis.

Analysis of use versus availability for snag species, snag class, and habitat selection was conducted using a computer program called "Resource Selection for Windows" created by Fred Leban, University of Idaho. This program used the statistical tests described by Johnson (1980) as the primary procedure for analysis.

The problem of non-independence also arose for use versus availability analysis. Therefore, the proportion of habitat used by an individual bat over the life of the transmitter was used. For example, a particular bat used two roosts during the time it was being tracked. One roost was in a shelterwood and the other was in a pine/oak stand. For that bat these stand types were weighted 0.5 and 0.5. If a bat used two roosts and both were in a pine/oak stand, then that stand type was weighted 1.0. Weighting by bat eliminates the problem of non-independence.

Snag class selection was analyzed using the same. Snag class categories were based on the criteria of Cline et al. (1980). There were five snag classes. Class 1 is the youngest decay class. Snags in this class tend to show very little decay, are generally intact, and most of the bark is still attached. Class 5 is the oldest decay class. Snags in this class have extensive decay, are broken down to a fraction of the original height, often riddled with woodpecker holes and other cavities, and have little, if any, bark remaining.

Available Habitat Areas

The Available Habitat Area (AHA) is defined to be the amount of area that was potentially available for any individual bat to use in an evening. Each study site had one AHA (see Fig 1). The AHA was created by drawing a radius from the water source to the furthest roost used by a bat captured at that water source. The west site AHA had a radius of 1.8 km. The east site AHA was two overlapping circles of radii 1.16 km and 1.56 km. The two overlapping circles resulted because the east site had two water sources.

A large majority of the bats stayed within 1 km of the water source. It is believed that bats stayed close because water sources are quite limited due to the annual summer drought. In addition, the water sources were also areas of locally high insect abundance. Nighttime telemetry indicated that many bats visited the same water source night after night to drink and forage. The theory behind the Available Habitat Area is that once a bat visits the water source at dusk, it can then leave in any direction afterwards to forage and find the next day's roost. Thus, a circle with a radius drawn from the water source to the farthest roost-site is in essence an estimate of the habitat available for selection by the bat once it leaves the water source. An Available Habitat Area is not a home range, because the actual area a bat travels through in an evening is not known. Instead an AHA estimates what is available area for a bat to select for roosting once it leaves the water source. This method is less arbitrary and results in a much smaller area of analysis than the "entire watershed" approach used by Ormsbee (1997) and Frazier (1997), because it is based on actual biological data. Within each circle, habitat polygons were mapped based on U.S.F.S. and C.P.T.I. aerial photos. Habitat polygons are sections of forest containing the same habitat structure. The aerial photos with habitat polygons were digitized for analysis in a G.I.S. Field reconnaissance confirmed the location and vegetation class of the polygons. This method was based on the work by Ganey and Balda (1994) and Blakesley et al. (1992).

Stand Type Classification

All habitat polygons were placed into one of eight vegetation stand types. These stand classifications were based on the work of Oliver and Larson (1990) and McGrath (1997). However, they were modified to meet the characteristics of the vegetation and management techniques of this study area. They are based on current available stand structure. Species composition is affected not only by natural successional processes, but also by timber practices and approximately 100 years of fire suppression.

Douglas fir (*Pseudotsuga menzeisii*) and grand fir (*Abies grandis*) are the dominant canopy trees in all but the pine/oak stand type. However, the secondary species composition of these stands gradually shifts across the precipitation gradient. At the west site, the secondary species consist of western hemlock (*Thuja plicata*), western larch (*Larix occidentalis*) and small amounts of ponderosa pine (*Pinus ponderosa*). At the east site, ponderosa pine joins grand fir and Douglas fir as one of the dominant species. Oregon white oak (*Quercus garryana*) becomes a secondary tree species, while western hemlock and western larch disappear from the landscape. At the eastern edge of the east site, the forests are dominated by ponderosa pine and Oregon white oak with firs becoming only a secondary component. In the results and discussion section, the term harvest units will be used. For this study harvest units were defined as the two earliest successional stages (SI and SE), as well as shelterwoods and aggregate retention.Below are the eight stand types.

Stand initiation (SI): Early-successional stage, mostly planted with Douglas fir, grand fir or ponderosa pine, and often containing several other species for "stand diversity". SI is exclusively caused by clear-cutting within this study area, but can potentially be caused by any stand replacement event such as fire. Stands are generally younger than 30 years of age. The average tree DBH is less than 13 cm. The canopy is less than 5.0 m high.

Shelterwood (SH): This is a management technique similar to the stand initiation stage, except that large overstory trees are left in moderate density, evenly distributed across the harvest unit. Shelterwoods tend to be dominated by Douglas firs, with a pine/fir understory. Many of the overstory trees are wind-damaged because of their exposure. This results in high tree mortality, as well as, many live trees with broken tops.

Aggregate Retention (AR): This is a patch of live trees of the pre-harvest stand density that was left in a harvest unit. These aggregates are too small to function as interior forest, especially in terms of stand microclimate. The aggregates are generally less than 0.5 hectares in area.

Stem-exclusion (SE): An early successional stage directly following stand initiation. In this stage, high stem density results in total canopy closure and prevents any further stems from growing in the understory. Stands are generally 30-50 years of age. Average tree DBH is 13-38 cm. The canopy height is 5-15 m.

Stem re-initiation small (SRS): A middle-successional stage. When natural or commercial thinning begins to eliminate some of the overstory trees, the canopy opens up or gaps are created, allowing new understory stems to begin growing. All understory trees are still seedlings. These stands are generally 50-80 years of age. The average dominant tree DBH is less than 38 cm. The canopy height is 15-30 m.

Stem re-initiation medium (SRM): A similar stage to stem re-initiation small, but more advanced. Gaps are present and most understory trees are seedlings to pole-sized. These stands are generally 70-100 years of age. The average dominant tree DBH is 38-53 cm DBH. The canopy height is 25-35 m.

Stem re-initiation large (SRL): A mature late-successional forest stand. Usually large gaps are present in the canopy and understory trees of all ages are present. These stands are generally greater than 100 years of age. The average dominant tree DBH is greater than 55 cm. The canopy height exceeds 35 m.

Middle to late successional pine/oak (PO): At the eastern edge of this study area the forest shifts from one dominated by Douglas fir/grand fir to one dominated by ponderosa pine and Oregon white oak. This pine/oak habitat does contain some fir component, but the structure of the stand is much different than the fir dominated stands. The canopy tends to be more open (between 30-70%) and understory trees of varying ages are present. As pines grow taller than the oaks, there is high canopy height diversity.

RESULTS

A total of 234 bats of 12 species were captured during this study (Table 1). Sixty-three of these bats were *Myotis volans,* 60 males and three females. Of the long-legged myotis captured, bats caught in the preliminary trapping phase and all females were released. All three females were captured at the west site. Transmitters were placed on a total of 50 male long-legged myotis. Roost-sites were located for 35 individuals, whereas roost sites were never located for 15 individuals. In August and September 1998, a faulty radio-receiver resulted in a reception range of only 100-400 meters, as opposed to the normal 1-2 km. It is probable that this faulty receiver is responsible for many of the 15 lost transmitters. Some transmitters may have been lost when transmitters fell off the bats into dense forests or bats left the study area.

Of the 35 bats located at least once, 18 were located at the west site and 17 at the east site. This resulted in location of 31 west site roosts and 33 east site roosts. The number of days a particular roost was used varied from 1-12 days.

Roost-site Attributes:

At the west site, long-legged myotis selected very tall, dominate snags, generally over 32 m in height and 68 cm DBH. Roost height and DBH were both significantly greater for actual roosts than random roosts (Table 2). The number of adjacent snags and overall stand DBH were not significantly greater for actual roosts than random roosts, but the means were greater for actual roosts than random roosts.

At the east site, it appears as though there is a very different pattern of selection. None of the roost-site attributes were significantly different between actual and random roosts except the number of snags per plot. In fact, the mean roost height, roost DBH, canopy height, stand DBH, and the number of trees per plot appear to be quite similar between actual roosts and random roosts (Table 3). Only the number of snags per plot is different, with the actual roost plots having significantly more snags than random roost plots. The west site measurements are significantly greater than the east site for every attribute, except the number of snags per plot (Table 4).

At both the west site and east site, random snags were significantly shorter than the canopy height of the stand (Table 5). This is to be expected, as dead trees are more likely to have their tops blown off by wind or destroyed through decay. At the east site, actual roost snags were also significantly below the canopy. However, at the west site, actual roost snags were at or above the canopy (Table 5).

Snag Species Selection:

Of the 64 roosts that were located, 61 were found in snags and three in live trees. The live tree roosts were two Douglas firs and one Oregon white oak. The characteristic that all three live tree roosts had in common with roost snags was cavities in the bark due to woodpeckers and natural decay.

At the west site, grand fir snags occur at approximately the same frequency as Douglas fir snags (Table 6). However, roost-site selection strongly favored grand fir snags. Over 77% of the snags that were used were grand firs, while only 6% were

Douglas firs. A few other snag species were used in small numbers, but in every case they resembled the grand firs in state of decay and bark exfoliation.

At the east site, grand fir snags are less abundant in relative terms than at the west site. Yet, bats were using grand firs significantly more than availability (Table 7). Douglas firs were used at about the same frequency as expected based on random selection. Ponderosa pine snags are the most prevalent species in the landscape. However, ponderosa pines were used significantly less than randomly selected snags (Table 7).

Snag Class Selection:

At the west site, Class 1 snags were selected significantly greater than expected (Table 8). By definition, these snags tend to be the largest, most intact snags available. As they are the youngest, they provide more stability and a longer standing life than those of more decayed classes. Class 2, the second youngest and intact class, showed no significant difference, and therefore was used as frequently as expected. Classes 3 and 4 were selected significantly less than expected (Table 8). These snags are in states of significant decay, and most have broken tops and little available exfoliating bark. While none of the actual roosts or random roosts in this study site were Class 5 snags, snags of this class are present in the landscape in relatively small numbers.

At the east site, it appears as though decay class selection is the opposite of the west site (Table 9). The youngest decay classes were used significantly less than expected, while the more decayed classes were selected more than expected. However, it should be noted that the two youngest decay classes were used 45% of the time at the east site. Thus, the avoidance of young snags at the east site does not seem severe.

Habitat Use Versus Availability:

At the west site, only one stand type was used significantly more than availability, that was the stem reinitiation large (SRL) or the late-successional forest stands (Table 10). Over 83% of the roosts were located in this stand type. While stem reinitiation medium (SRM) and stem reinitiation small (SRS) were used significantly less than availability, they were the only other forest types used at the west site. These are the other most mature stand types. These results seem to indicate that bats at the west site were selecting the most mature forest types available and were avoiding harvest units, even when retention was provided.

At the east site, SRM was used significantly more than availability (Table 11). As there was no SRL available at the east site, SRM was the most mature stand type available. Selecting the most mature stands is similar to the habitat selection at the west site. However, what is quite different about the east site from the west site is that bats were also found using snags left in harvest units.

While it appeared as though bats at the west site were avoiding retention snags in harvest units entirely, there were bats at the east site that used snags in harvest units. At the east site, 28% of the snags that were used were located in the harvest units. However, of these, only aggregate retention patches were used more often than expected. These aggregate retention patches resemble the older stand types in structure. At the east site pine/oak was also used significantly more than availability.

Table 1

Bat Species Captures on the East Slopes of the Cascades in Skamania and Klickitat Counties[1]

5/21/97 - 8/15/97 & 6/1/98 - 9/21/98

n= 234

Species	Common name	Total	Present West site	Present East site	Captured at a Cave
Myotis volans	long-legged myotis	63	✔	✔	✔
Myotis evotis	western long-eared myotis	50	✔	✔	✔
Myotis lucifugus/ Myotis yumanensis[2]	little brown myotis/ Yuma myotis	44	✔	✔	✔
Myotis keenii	Keen's long-eared myotis	15	✔		✔*
Myotis californicus	California myotis	9	✔	✔	✔
Myotis ciliolabrum	western small-footed myotis	8	✔	✔	✔
Myotis thysanodes	fringed myotis	4	✔		✔*
Eptesicus fuscus	big brown bat	29		✔	
Plecotus townsendii	Townsend's big-eared bat	6	✔		✔*
Lasionycteris noctavagans	silver-haired bat	3		✔	
Lasiurus cinereus	hoary bat	3		✔	

[1]This table does not represent absolute abundance. *Myotis volans* was captured the most because trapping focused on areas of known long-legged myotis activity. Therefore the sampling is biased. However, this data may give an idea of relative abundance. Preliminary trapping occurred at 10 cave sites, and 6 water sources across three watersheds in the region.

[2]*Myotis lucifugus* and *Myotis yumanensis* could not be positively distinguished in this study area. These two closely related species can hybridize and therefore were lumped together into one group.

*Cave roosting specialist species.

Table 2

Roost-site Attributes for *Myotis volans* at the West Site during 1997 and 1998

n=18

			TWO-WAY T-TEST PROBABILITIES	
CATEGORIES	MEAN ACTUAL ROOST	MEAN RANDOM ROOST	P-VALUE WITHOUT BONFERRONI ADJUSTMENT	BONFERRONI ADJUSTED P-VALUE
Roost Tree Height **SE=**	36.3 m 1.59	22.0 m 2.25	**< .0001**	**< .0001**
Roost Tree DBH **SE=**	72.4 cm 4.92	55.1 cm 3.82	**.009**	**.053**
Canopy Cover **SE=**	73.4 % 3.64	78.4 % 2.62	.272	.999
Canopy Height **SE=**	35.3 m 1.21	34.0 m 0.99	.419	.999
Stand DBH **SE=**	63.9 cm 4.11	55.2 cm 3.48	.112	.787
# Snags per plot* **SE=**	2.45 0.31	1.97 0.33	.299	.999
Live trees per ha **SE=**	164.5 17.4	176.7 25.0	.695	.999

*Plot size for this study is 0.071 ha. Snags per plot were used to emphasize clumps of snags around the roost.

Table 3

Roost-site Attributes for *Myotis volans* at the East Site during 1997 and 1998

n=17

			TWO-WAY T-TEST PROBABILITIES	
CATEGORIES	MEAN ACTUAL ROOST	MEAN RANDOM ROOST	P-VALUE WITHOUT BONFERRONI ADJUSTMENT	BONFERRONI ADJUSTED P-VALUE
Roost Tree Height **SE=**	16.9 m 5.06	17.2 m 5.22	.906	.999
Roost Tree DBH **SE=**	46.9 cm 1.28	43.7 cm 1.07	.599	.999
Canopy Cover **SE=**	43.13 % 5.55	48.14 % 6.02	.545	.999
Canopy Height **SE=**	23.4 m 4.60	23.1 m 4.46	.930	.999
Stand DBH **SE=**	46.1 cm 0.89	42.6 cm 2.13	.370	.999
# Snags per plot* **SE=**	2.82 0.42	1.78 0.23	**.038**	.264
Live trees per ha **SE=**	117.3 14.0	117.3 13.0	.999	.999

*Plot size for this study is 0.071 ha. Snags per plot were used to emphasize clumps of snags around the roost.

Table 4

Comparison of Roost-site Attributes Used by *Myotis volans* Between the West Site and the East Site

n=35

			TWO-WAY T-TEST PROBABILITIES	
CATEGORIES	WEST SITE ACTUAL ROOST PLOTS	EAST SITE ACTUAL ROOST PLOTS	P-VALUE WITHOUT BONFERRONI ADJUSTMENT	BONFERRONI ADJUSTED P-VALUE
Roost Height **SE=**	36.3 m 1.59	16.9 m 5.06	**< 0.001**	**< 0.001**
Roost DBH **SE=**	72.4 cm 4.92	46.9 cm 1.28	**< 0.001**	**< 0.001**
Canopy Cover **SE=**	73.4 % 3.64	43.13 % 5.55	**< 0.001**	**< 0.001**
Canopy Height **SE=**	35.3 m 1.21	23.4 m 4.60	**< 0.001**	**< 0.001**
Stand DBH **SE=**	63.9 cm 4.11	46.1 cm 0.89	**< 0.001**	**< 0.001**
# Snags per plot* **SE=**	2.45 0.31	2.82 0.42	NS	NS
Live Trees per ha **SE=**	164.5 17.4	117.3 14.0	**0.027**	NS

*Plot size for this study is 0.071 ha. Snags per plot were used to emphasize clumps of snags around the roost.

Table 5

Comparisons of the Roost Heights used by *Myotis volans* to the Canopy Height Around the Roost

			TWO-WAY T-TEST PROBABILITIES	
CATEGORIES	MEAN ROOST HEIGHT	MEAN CANOPY HEIGHT	P-VALUE WITHOUT BONFERRONI ADJUSTMENT	BONFERRONI ADJUSTED P-VALUE
West site Actual Plot	36.3 m	35.3 m	.791	.999
SE=	1.59	1.21		
West site Random Plot	22.0 m	34.0 m	**< .001**	**< .001**
SE=	2.25	0.99		
East site Actual Plot	16.9 m	23.4 m	**< .001**	**< .001**
SE=	5.06	4.60		
East site Random Plot	17.2 m	23.1 m	**< .001**	**< .001**
SE=	5.22	4.46		

Table 6

Snag Species Used by *Myotis volans* at the West Site during 1997 and 1998

SPECIES	% ACTUAL ROOSTS	% RANDOM ROOSTS	SELECTION CHOICE	P-VALUE
Grand fir	77.4	38.7	**Prefer**	**< 0.001**
Douglas fir	6.5	45.2	**Avoid**	**< 0.001**
Western hemlock	3.2	12.9	**Avoid**	**< 0.001**
Ponderosa pine	3.2	0.0	Expected	NS
Western red cedar	3.2	0.0	Expected	NS
Western larch	6.4	0.0	Expected	NS
Oregon white oak	0.0	0.0	NA	NA

The p-values above are based on the statistical tests described by Johnson 1980

Table 7

Snag Species Used by *Myotis volans* at the East Site during 1997 and 1998

SPECIES	% ACTUAL ROOSTS	% RANDOM ROOSTS	SELECTION CHOICE	P-VALUE
Grand fir	39.4	24.2	**Prefer**	**< 0.001**
Douglas fir	30.3	21.2	Expected	NS
Ponderosa pine	27.2	51.5	**Avoid**	**< 0.001**
Oregon white oak	3.0	0.0	Expected	NS
Western hemlock	0.0	0.0	NA	
Western red cedar	0.0	0.0	NA	
Western larch	0.0	0.0	NA	

The p-values above are based on the statistical tests described by Johnson 1980

Table 8

Snag Classes Used by *Myotis volans* at the West Site in 1997 and 1998

SNAG CLASS	% ACTUAL ROOSTS	% RANDOM ROOSTS	SELECTION CHOICE	P-VALUE
Class 1	60.9	33.2	**Prefer**	**< 0.001**
Class 2	22.8	23.5	Expected	NS
Class 3	16.3	36.0	**Avoid**	**< 0.001**
Class 4	0.0	7.3	**Avoid**	**< 0.001**
Class 5	0.0	0.0	NA	

Snag classes are based on those described by Cline et al. 1980
The p-values above are based on the statistical tests described by Johnson 1980

Table 9

Snag Classes Used by *Myotis volans* at the East Site in 1997 and 1998

SNAG CLASS	% ACTUAL ROOSTS	% RANDOM ROOSTS	SELECTION CHOICE	P-VALUE
Class 1	21.5	24.5	**Avoid**	**< 0.05**
Class 2	26.5	39.2	**Avoid**	**< 0.001**
Class 3	25.5	20.6	**Prefer**	**< 0.001**
Class 4	15.8	5.9	**Prefer**	**< 0.001**
Class 5	10.7	9.8	Expected	NS

Snag classes are based on those described by Cline et al. 1980
The p-values above are based on the statistical tests described by Johnson 1980

Table 10

Habitat Selection of *Myotis volans* at the West Site during 1997 and 1998

STAND TYPE CATEGORIES	% ACTUAL ROOSTS	% RANDOM ROOSTS	SELECTION CHOICE	P-VALUE
Stand initiation (SI)	0.0	17.0	**Avoid**	**< 0.001**
Shelterwood (SH)	0.0	8.0	**Avoid**	**< 0.001**
Aggregate retention (AR)	0.0	1.0	**Avoid**	**< 0.05**
Stem exclusion (SE)	0.0	15.0	**Avoid**	**< 0.001**
Stem Reinitiation small (SRS)	11.0	17.0	**Avoid**	**< 0.001**
Stem Reinitiation medium (SRM)	5.0	21.0	**Avoid**	**< 0.001**
Stem Reinitiation large (SRL)	83.4	21.0	**Prefer**	**< 0.001**
Pine/Oak	0.0	0.0	NA	NA

The p-values above are based on the statistical tests described by Johnson 1980

Table 11

Habitat Selection of *Myotis volans* at the East Site during 1997 and 1998

STAND TYPE CATEGORIES	% ACTUAL ROOSTS	% RANDOM ROOSTS	SELECTION CHOICE	P-VALUE
Stand initiation (SI)	8.8	36.0	**Avoid**	**< 0.001**
Shelterwood (SH)	8.8	8.0	Expected	NS
Aggregate retention (AR)	8.8	1.0	**Prefer**	**< 0.001**
Stem exclusion (SE)	2.0	5.0	**Avoid**	**< 0.001**
Stem Reinitiation small (SRS)	3.0	11.0	**Avoid**	**< 0.001**
Stem Reinitiation medium (SRM)	44.1	26.0	**Prefer**	**< 0.001**
Stem Reinitiation large (SRL)	0.0	0.0	NA	NA
Pine/Oak	24.4	13.0	**Prefer**	**< 0.001**

The p-values above are based on the statistical tests described by Johnson 1980

DISCUSSION

The long-legged myotis appears to show some very distinct patterns of roost-site selection and habitat use across the landscape. However, selection of roost-site characteristics does shift significantly across a landscape. This species appears to select the most mature forest stands available. At the east site, the oldest forest stands available were only of moderate maturity (SRM). *Myotis volans* selected these oldest stands. They also selected moderately mature stands of pine/oak, and aggregate retention patches that resembled the older stand types in structure, but not area (Table 11). However, when both the SRM and late-successional stands (SRL) were available at the west site, these bats selected the late-successional stands (Table 10). As this species selected the late-successional stands almost exclusively at the west site, it appears as though this species has a strong preference for these late-seral stages. However, when late-seral stages are not available to them, as at the east site, these bats shifted to the next oldest seral stage, SRM.

Some might note that at the east site this species did not use SRM exclusively. In fact, bats were occasionally found using retention snags within harvest units. This may lead to the conclusion that this species will roost in harvest units provided there is some retention. It should be noted, however, that the three earliest successional stages (SI, SE, SRS) were used less than availability (Table 11). Only in the cases in which large structures were left in relatively high densities, such as the shelterwoods and aggregate retention patches, did bats not avoid harvest units. Shelterwoods were only used about as much as expected from a random model and aggregate retention patches were used greater than availability (Table 11). Since these retention patches resemble more mature stand types in structure, but not in area, this finding might have been expected, especially where late-seral stage stands are lacking. The finding that bats never used retention structures within harvest units at the west site supports this conclusion.

The fact that bats did not use SRM exclusively at the east site may only indicate that SRM is marginal habitat for these bats. A stand structure of the maturity of SRM may not produce the ideal microclimate that these bats are looking for. This may force certain individuals to look elsewhere, sometimes seeking shelter in snags located within harvest units. The results of this study suggest that late-successional forests including possibly old-growth are the highly preferred habitat for this species. This conclusion is supported by Harris et al. (1982), Thomas (1988), and Thomas and West (1991). However, when those late-seral stages are not available, this species appears flexible enough to use younger successional stages, provided the necessary roosting structures (snags) are available. This is consistent with the results of Ormsbee (1997).

While individuals may be flexible enough to use roosting structures in less than ideal habitats, the implications are unclear for the population dynamics of this species. The relative population densities of the two study sites were not measured in this study. In fact, no studies of population densities have ever been done for this species. It is unclear whether the reproductive success of this species is affected by habitat quality. For this species to exhibit true habitat flexibility, it is not enough for individuals to use marginal habitats, in addition, a population must be able to be reproductively stable in that marginal habitat. It is possible that the east site could be a population sink. This site could be occupied by dispersing males that have little or no reproductive success in a marginal habitat. On the other hand, males may migrate in the late summer to breeding areas located in higher quality habitat further west where the females are. As no females were captured at the east site during this study, these scenarios are plausible. However, it is unknown whether migration actually occurs among males. Assessment of reproductive success and population dynamics is nearly impossible for bats species in North America. Mark/recapture studies often fail because rarely can anyone recapture marked bats. It is not even clear how long this species lives in the wild (van Zyll de Jong 1985). The only means of assessment of population size is generally head counts of hibernating bats (USFS unpubl. data). However, bats in a hibernaculum can arrive from many different places. Thus, this method does not allow for an assessment of a particular metapopulation. In addition, census by the method described can sometimes result in high mortality for the bats because of disturbance during such an energetically sensitive period of their lives.

Looking at finer scale roost-site selection, it appears that selection shifted from west to east. At the west site, there was very strong selection for the largest snags available. The structures bats selected at the west site were characterized as being Class 1 snags greater than 32 m tall. The snags were often at or above the top of the canopy (Table 5). Ormsbee (1997) found that female long-legged myotis also used snags that extended above the canopy. However, at the east site bats did not select snags that were any different from random and in fact they selected snags that were significantly below the top of the canopy (Table 5). East site bats selected all decay classes and showed some preference for the most decayed of those classes.

One possible explanation for this shift in snag size and decay class selection may be that snags located at the top of the canopy in closed canopy stands may produce a microclimate similar to smaller, more decayed snags in open canopy forest stands. Microclimate is an important factor for bats because of their unique physiology. Many bat species in North America go through torpor during the day. This is a time when they reduce their body temperature from 37° C to that of the ambient environment. This reduction in body temperature reduces their metabolism and allows them to conserve energy. However, when they emerge from torpor in the early evening, they must warm themselves back to their active temperature using their fat reserves. However, if a bat is roosting in a location that receives solar radiation in the late afternoon, this sunlight could heat their bodies and thus would reduce the need to burn fat. Therefore, it may be advantageous for bats to select roosts that will receive sunlight in the late afternoon, such as the west side of a snag that extends above the canopy in a closed-canopy stand or possibly a shorter snag in a more open canopy forest.

It would be very interesting to investigate the differences in microclimate in various potential roosts. A valuable study would be to compare the microclimate of potential roosts (i.e. under the exfoliating bark) in snags that extend above the canopy in closed-canopy stands to various decay classes and at various heights of open canopy stands.

While the size and class of the roosting snags may have differed from west to east, snag species selection did not. Grand fir was used significantly more than availability at both study sites (Tables 6,7). It was the only species of snag used more than expected from a random model. While the abundance of grand firs decreases as a function of the distance east of the Cascade crest, long-legged myotis continued to select grand fir at the east site. It is unclear, however, whether a reduced abundance of grand fir has any effect on population size. At Ormsbee's study area (1997), grand fir was not available and these bats primarily selected Douglas fir. However, when given equal abundance of Douglas fir and grand fir at the present study area, this species selected almost exclusively grand fir at the west site and selected grand fir more than expected at the east site. Rabe et al. (1999) found that this species used ponderosa pine exclusively in northern Arizona, but his site also lacked grand fir. When grand fir and ponderosa pine both exist in a landscape, *Myotis volans* used ponderosa pine significantly less than expected (Table 7).

The selection of grand fir may be because of the particular way that grand fir decays. Dead grand firs tend to display bark exfoliation that resembles shingles on a roof. As thin plates of bark peel away from the trunk, they provide accessible crevasses that these bats utilize for roosting. Douglas fir bark tends to stay tightly against the trunk until it sloughs away in large blocks, limiting the amount of exfoliating bark available for bats to use. In addition, it often leaves much larger spaces between the exfoliating bark and the trunk than grand fir, thus possibly affecting the microclimate under that bark. Ponderosa pine bark also appears to slough off in a similar manner. However, it should be noted that Douglas fir and ponderosa pine snags that were used by these bats appeared more similar in the way the bark was exfoliating to a grand fir than to most of the other Douglas fir and ponderosa pine snags in the landscape. The roosts of the other snag species that were used at the west site also had exfoliating bark that resembled grand fir.

It is difficult to quantify bark exfoliation for analysis. However, the outward appearance seems to indicate that shingle-like exfoliating bark is one of the characteristics that *Myotis volans* is selecting for. That may be related to the microclimate that type of exfoliation provides, as well as, other factors including protection against predators and the long-term stability of the roost-site. While any of the tree species are capable of producing suitable roosts, it appears that grand fir, in general, tends to provide the type of roost-site long-legged myotis are looking for more often than the other snag species in this landscape.

In selecting a roost-site, the long-legged myotis appear to select roosts surrounded by a higher local density of snags than at random sites in a stand (Table 3). This may be because a bat is more likely to find the structure it is looking for if there are several snags located together, rather than having to fly from snag to snag looking for the ideal site. This hints at visual apparency theory, which states that the more clumped together a certain feature is, the more likely that that feature will be apparent to the organism that is utilizing it (Fenney 1976).

MANAGEMENT IMPLICATIONS

Many forest managers on the east slopes of the Cascades have been focusing their efforts on providing dispersed retention snags within harvest units as a way to keep habitat in the landscape for wildlife (FEMAT 1993, R. Mendez pers. comm.). While this method may be successful for some species of wildlife, it does not appear to be a solution for *Myotis volans*. This species shows a strong preference for late-successional forest stands (Table 10). While this species appears willing to use aggregate retention patches that provide the structure of late-successional forests, these patches likely lack the microclimate regime of more continuous tracks of forest (Chen et al. 1995). It does appear as though leaving aggregate retention patches and using shelterwoods in clear-cuts can mitigate the effects of timber harvests to some degree. But, when given the choice between late-successional stands and aggregate retention patches, the bats avoid the retention patches (Table 10). If given a limited amount of timber to protect from harvest, it may be more useful for the management of this species to keep the timber connected in relatively large blocks of late-successional forest, rather than spreading it out as retention across the landscape.

In recent years, forest managers have been creating snags out of live trees for use by wildlife (T. Brown, R. Mendez pers. comm.). The long-legged myotis appears more likely to select small pockets of snags rather than solitary snags (Table 3). In cases in which forest managers wish to create additional snags for wildlife, it appears as though it would be advantageous for this and other bat species to create small, localized pockets of snags.

Several methods of snag creation are often used. Girdling kills the trees slowly and leaves the snags intact, while dynamiting destroys the top of the tree. When choosing a method, it appears as though girdling may be more preferable than blowing off the top for this bat species in closed canopy stands. Intact snags of the early decay classes were used almost exclusively at the west site and used nearly half of the time at the east site. These tall intact structures may provide a more suitable microclimate than the shorter snags that would result from having their tops blown off in closed canopy stands.

Another concern to forest managers on the east slopes of the Cascades is the prevalence of grand fir. Grand fir is not considered an optimal tree species by forest managers because of its susceptibility to fire, disease, and insect outbreaks. Historically, when there was an active fire regime, much of the east slope forests were dominated by fire-tolerant Douglas fir and ponderosa pine. Grand fir dominated stands were somewhat infrequent in this area and tended to be located only in areas of locally high moisture or humidity, such as north-facing slopes. For the most part grand fir was historically a secondary component of these forests. Grand fir often remained in the understory until large overstory trees fell and canopy gaps were formed allowing grand fir saplings to grow quickly to occupy the canopy gaps. However, 100 years of fire suppression has allowed grand fir to become one of the dominant canopy trees throughout the east slopes of the Cascades. These grand fir forests are more susceptible to catastrophic stand replacement fires than more fire-tolerant forests of Douglas fir and ponderosa pine. Insects are a particular concern where spruce budworm outbreaks are the worst, because spruce budworm seems to thrive on grand fir (CPTI, USFS, pers. comm.).

Despite these concerns, grand fir is an important wildlife species. This study has shown that the long-legged myotis prefers grand fir snags as roost structures. In addition, other bat species, small non-volant mammals, woodpeckers and many other bird species and utilize grand fir extensively (Harris et. al 1982, USFS unpub. data). While forest managers are attempting to return fire to the ecosystem and are attempting to control spruce budworm outbreaks, managers should also attempt to maintain a grand fir component to the forests. One suggestion to maintain the necessary grand fir component while limiting the susceptibility of the forest to fire or insects is to space out grand firs throughout a stand. When grand fir occurs in high densities, intraspecific competition and disease are more likely to stress the trees. High stress brings higher susceptibility to insects and disease and higher mortality. With higher mortality comes higher susceptibility to fire (R. Mendez pers. comm.). If grand firs are spaced apart in a stand to limit competition, the risks of stand-replacement events decrease substantially.

The long-legged myotis appears to be a somewhat adaptable species. It is not considered a common or abundant species on the east slopes of the Cascades, but it does not appear to be rare either. It occurs in a wide range of habitats throughout western North America. Even in a relatively small area, it appears to be able to utilize several different forest types, including closed-canopy grand fir stands and open-canopy pine/oak forests. However, despite this apparent flexibility, the species does appear to select roosts that are located in relatively continuous tracts of forest. Much still needs to learned about this species to assure its survival. First of all, solid population analysis techniques for bats need to be developed in order to monitor the abundance of this and other bat species through time. The microclimate requirements for day roosts need to be better understood so that roosting behavior can be better predicted and incorporated into management plans. Nighttime foraging patterns need to be assessed, so that managers can determine whether forestry practices affect foraging success or energy use. Biologists need to determine where individuals go to hibernate, so that managers can also protect this species during that critically sensitive period of their lives.

However, despite the many gaps in our understanding of bat ecology, it seems, based on the current information, that with careful stewardship of our forest resources, that the long-legged myotis should be able to persist in the managed landscape of the east slopes of the Cascade Range.

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