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| Conservation Assessment for the Fringed Myotis (*Myotis thysanodes*) in Oregon and Washington |
| Jennifer Gervais  March 2017 |
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**Interagency Special Status and Sensitive Species Program**

**USDA Forest Service Region 6, Oregon and Washington**

**USDI Bureau of Land Management, Oregon and Washington**

Disclaimer

*This Conservation Assessment was prepared to compile the published and unpublished information on the fringed myotis (Myotis thysanodes). If you have information that will assist in conserving this species or questions concerning this Conservation Assessment, please contact the interagency Conservation Planning Coordinator for Region 6 Forest Service, BLM OR/WA in Portland, Oregon, via the Interagency Special Status and Sensitive Species Program website at* http://www.fs.fed.us/r6/sfpnw/issssp/contactus/

# EXECUTIVE SUMMARY

**Species**: Fringed myotis (*Myotis thysanodes*)

**Taxonomic Group**: Mammal

**Management Status**: Globally the International Union for Conservation of Nature (IUCN) lists the fringed myotis as of least concern based on its wide distribution, occurrence in a number of protected areas, and the lack of evidence suggesting declines at rates that would qualify it for listing as threatened (Arroyo-Cabrales and Álvarez-Castañeda 2008). In Oregon and Washington, fringed myotis are identified as a species requiring specific Standards and Guidelines under the Northwest Forest Plan (USDA and USDI 1994a), as amended by the 2001 Survey and Manage Standards and Guidelines (USDA and USDI 2001), and are covered under westside Oregon BLM District Resource Management Plans (USDI BLM 2016a, b), which have specific management direction for bats. Fringed myotis are considered Sensitive in Oregon by the Forest Service and BLM. The Oregon Department of Fish and Wildlife also lists them in the Sensitive Species, Vulnerable category (Oregon Biodiversity Information Center (ORBIC) 2016). ORBIC ranks fringed myotis in Oregon as rare or uncommon, imperiled and very vulnerable to extirpation (S2 in Oregon, ORBIC 2016). In Washington, the fringed myotis is considered a state monitor species and is included on the Priority Habitats and Species list (Hayes and Wiles 2013). The Washington Natural Heritage Program ranks the fringed myotis as rare to uncommon (S3) and a species of concern (Washington Natural Heritage Program 2014).

**Specific Habitat:** Fringed myotis are found in a wide range of habitats from desert, grassland and shrub-steppe, to pinyon-juniper and pine-oak woodlands and ponderosa, spruce-fir, and Douglas-fir forests throughout the western US. In the Pacific Northwest, they are considered primarily a forest-dwelling species, inhabiting dry forests throughout the region and mesic forests west of the Cascade Range divide. They also are found to a lesser degree in non-forest xeric habitat although most often in the vicinity of forests or wooded riparian areas (Hayes 2003, Rodhouse et al. 2015). Day and night roost structures across the western US include snags, rock crevices, caves, mines, buildings, bridges, and green trees (O’Farrell and Studier 1980). Maternity roosts are primarily found in crevices of snags and rock features, and almost exclusively so in the Pacific Northwest. Hibernacula have not been described. In dry environments, they are found near water.

**Threats**: Loss of habitat through conversion and degradation is a major threat to this species. Second to loss of forested habitat is the loss of stand structural complexity, which supports both foraging and roosting activities. Fire and logging can remove roosting snags and reduce stand complexity. Reductions in floral diversity following fire, logging, and overgrazing can degrade foraging habitat by reducing insect diversity. Disturbances of native vegetation can enhance the spread of invasive plant species, which may further disrupt insect diversity and densities. Juniper encroachment reduces surface water needed for drinking. Energy-related development primarily poses threats through alteration of foraging habitat and facilitation of the spread of invasive species. Climate change will likely have multiple effects on vegetation, prey abundance and distribution, fire regimes, and other factors, but in particular it is expected to reduce water sources in xeric habitats vital to many wildlife species including the fringed myotis. Other threats include recreational caving, rock climbing, commercial mining and quarrying of roost habitat. Pesticide use and environmental contaminants may reduce prey availability and bioaccumulate in bats. White-nose Syndrome (WNS) has recently arrived in the northwest. Given that many *Myotis* species have been severely impacted in the eastern United States, WNS could negatively affect fringed myotis as well. Threats to this species are enhanced by its patchy distribution and general low abundances.

**Management Considerations**: Key conservation strategies for this species include the protection of roosting habitat in forested regions by maintaining relatively high densities of large snags, providing for future snag recruitment, the protection of foraging habitat by managing for structural and vegetative diversity, and avoiding the use of non-target pesticides. Protection of rock features within and adjacent to forests is also important for the preservation of potential roost structures. Abandoned mines and caves where potential roosting habitat is likely to occur should be protected from recreation, mining, quarrying, and other sources of disturbance or destruction. Protecting natural water sources and providing artificial sources such as tanks and guzzlers in xeric habitats may help reduce the impacts of droughts enhanced by climate change. Restoring native shrub-steppe and grassland habitat, especially in the vicinity of rock features and dry forests, will benefit this and other species of concern such as sage grouse. Possible actions include reduction in grazing, juniper removal in encroached areas, and re-establishment of diverse vegetation in degraded areas to support diverse and abundant prey. Energy development is most likely to impact fringed myotis through habitat degradation rather than direct mortality.

For habitat features within the range of the northern spotted owl, including caves, abandoned mines, wooden bridges and buildings, management follows the standards and guidelines identified in the 2001 Northwest Forest Plan (NWFP) amendment (USDA and USDI 2001), or the new westside Oregon BLM Resource Management Plans (USDI BLM 2016a, b). The BLM Plans include provisions for the establishment of a protective buffer within 250 feet of maternity sites or hibernacula in caves, abandoned mines, bridges, or buildings. For the NWFP area, caves, abandoned mines, wooden bridges and buildings, are to be protected from vandalism, disturbance, and any activity that could change cave temperatures or drainage patterns, contingent on safety concerns and legal requirements. In addition, for caves, abandoned mines, wooden bridges and buildings that are occupied by bats, the standards and guidelines prohibit timber harvest within 250 feet of the occupied site.

Five of the seven bat species most affected in the eastern US by WNS are in the genus *Myotis* (USFWS 2017). Therefore, the fringed myotis is considered a priority on which to focus preventative management. This includes inventorying and monitoring of populations, environmental conditions, and disease presence, and the development of methods to improve these in relation to the threat of WNS.

**Inventory, Monitoring, and Research Opportunities**: Fringed myotis were relatively uncommon and patchily distributed in recent omnibus survey efforts. Little of the overwintering ecology of this species is currently known. The recent discovery of WNS in western Washington adds urgency to understanding how the overwintering ecology of fringed myotis may affect the risk posed by this fungal disease. Attention to placement of detectors used for monitoring is essential to securing a robust detection probability for modeling population data for this species. Better elucidation of factors that limit this species’ distribution and habitat use would aid in its conservation.

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# I. INTRODUCTION

## Goal

Fringed myotis (*Myotis thysanodes*) are widely distributed throughout western North America, including much of Washington and Oregon (Johnson and Cassidy 1997, Verts and Carraway 1998). However, they are considered a species of concern at both federal and state levels (see Management Status below). The goal of this conservation assessment is to summarize existing knowledge across the range of the species to better inform management of fringed myotis bats and their habitats in Washington and Oregon.

## Scope

As much as possible, information gathered from Washington and Oregon was used in the writing of this conservation assessment. However, by necessity research and other sources from many parts of the fringed myotis’ range are also included. Although much is known about some aspects of the ecology and life history of fringed myotis, this assessment should not be considered complete. Published and unpublished reports regarding occurrence, behavior, or life history are very likely to exist beyond what was found for this assessment, and new information will continue to be available.

## Management Status

The International Union for Conservation of Nature (IUCN) lists the fringed myotis as of least concern based on its wide distribution, occurrence in a number of protected areas, and the lack of evidence suggesting declines at rates that would qualify it for listing as threatened (Arroyo-Cabrales and Álvarez-Castañeda 2008).

At the federal level, the fringed myotis is considered a Species of Concern by the US Fish and Wildlife Service (Hayes and Wiles 2013). The fringed myotis is identified as a species requiring specific Standards and Guidelines under the Northwest Forest Plan (USDA and USDI 1994a), as amended by the 2001 Survey and Manage Standards and Guidelines (USDA and USDI 2001). The Northwest Forest Plan standards and guidelines were thought to be necessary to ensure a reasonable assurance of the species’ persistence within the Northwest Forest Plan area by providing protection for certain habitat features, including caves and abandoned mines, wooden bridges, and buildings. These measures were considered necessary based on a review of the potential distribution for this species by a panel of bat scientists (USDA and USDI 1994b). For westside Oregon BLM Districts, management direction for bats is provided in their new Resource Management Plans (USDI BLM, 2016a, 2016b). The fringed myotis is also a Sensitive species in Oregon under the Forest Service and BLM Interagency Sensitive and Special Status Species Programs.

It is listed as a Sensitive Species, Vulnerable category by the Oregon Department of Fish and Wildlife (Oregon Biodiversity Information Center (ORBIC) 2016). ORBIC ranks fringed myotis as rare or uncommon, imperiled and very vulnerable to extirpation (S2 in Oregon, ORBIC 2016). In Washington, the fringed myotis is considered a state monitor species and is listed under priority habitats and species (Hayes and Wiles 2013). The Washington Natural Heritage Program ranks the fringed myotis as rare to uncommon (S3) and a species of concern for the state (Washington Natural Heritage Program 2014).

# II. CLASSIFICATION AND DESCRIPTION

## Systematics

Although the fringed myotis is morphologically and acoustically distinct from other myotis species, it overlaps genetically with two other long-eared myotis, *M. evotis* and *M. keeni*, and one subspecies of *M. lucifugus*, *M. l. carissama* (Zinck et al. 2004, Dewey 2006). Phylogenetic reconstructions in this genus are consistent with repeated evolutionary convergences such that morphological similarities do not reflect evolutionary relationships (Ruedi and Mayer 2001, Hoofer and Van Den Bussche 2003). Instead, current taxonomic classification of *Myotis* represents a paraphyletic clade (Reudi and Mayer 2001, Hoofer and Van Den Bussche 2003). This paraphyletic clade can be broken down into mixed-species clades that correspond to geographic regions. This pattern of lack of genetic divergence in contrast with the morphometric divergence suggests that the species within this clade are evolving more rapidly morphometrically than they are genetically (Dewey 2006, P. Ormsbee, *personal communication*).

The fringed myotis is considered to consist of three (Simmons 2005) or four (Kenaith 2003) subspecies, *M. t. aztecus*, *M. t. pahasapensis*, *M. t. vespertinus,* and *M. t. thysanodes*. Simmons (2005) recognizes *M. t. vespertinus* but not *M. t. thysanodes*, which is listed by O’Farrell and Studier (1980). The subspecies *M. t. pahasapensis* occurs in the Black Hills of South Dakota, Nebraska and Wyoming (O’Farrell and Studier 1980), and *M. t. aztecus* occurs in southern Mexico (O’Farrell and Studier 1980). *Myotis thysanodes vespertinus*, the Pacific fringe-tailed myotis, has been proposed as occurring west of the Cascades from Washington into northwestern California (Maser and Cross 1981, Manning and Jones 1988), but a definitive geographic boundary for this morphological variant is hard to delineate and genetic evidence has not been strong enough to support such a delineation (P. Ormsbee, *personal communication*). The bulk of the range is made up of *M. t. thysanodes* (O’Farrell and Studier 1980).

## Species Description

The fringed myotis is named for the diagnostic fringe of stiff hairs projecting 1.0-1.5 mm beyond the posterior border of the interfemoral membrane (Kenaith 2003). The forearm is usually more than 40 mm long. The ears are long, 16-20 mm (O’Farrell and Studier 1980, Nagorsen and Brigham 1993), and project 3-5 mm beyond the end of the nose when gently pushed forward (Christy and West 1993, Nagorsen and Brigham 1993, Ormsbee 2009). The large calcar or cartilage spur extending from the ankle along the interfemoral membrane typically has no keel (Verts and Carraway 1998, Nagorsen and Brigham 1993) although researchers have noted keels on the calcars of some individuals in the Pacific Northwest (Ormsbee et al. 2010, P. Ormsbee, *personal communication*). The dorsal pelage ranges from yellowish brown or brassy to dark brown with olive or reddish tones (Kenaith 2003). The bases of the dorsal hairs are very dark, and the ventral fur is lighter in color (Verts and Carraway 1998). Ears and wing membranes are black in color (Christy and West 1993). There seems to be geographic variation in pelage color, such that darker pelage occurs in northern specimens (Miller and Allen 1928 in O’Farrell and Studier 1980). The wings and tail membrane are thick, and the wing to tail aspect ratio is low, typical of slow, highly maneuverable bat species that glean (O’Farrell and Studier 1980).

## Comparison with Sympatric Species

In the PNW, the only two other myotis species that are nearly as large as the fringed myotis are the long-legged myotis (*M. volans*) and the western long-eared myotis (*M. evotis*). However, they are generally smaller in body size and forearm lengths (Nagorsen and Brigham 1993, Ormsbee 2009, P. Ormsbee, *personal communication*). Variation of forearm length and ear length occurs in fringed and western long-eared myotis with overlap between the two species (P. Ormsbee, *personal communication*). Other myotis species may have long ears in proportion to their body, but the ears are measurably shorter than those of the fringed myotis and generally do not extend beyond the nose when gently pushed forward (Nagorsen and Brigham 1993, Ormsbee 2009, P. Ormsbee, *personal communication*). The species most often confused with the fringed myotis is the western long-eared myotis. Although the western long-eared myotiscan have sparse hairs along the posterior border of the interfemoral membrane, it lacks the stiff, dense broom-like fringe of hairs that are diagnostic in fringed myotis (O’Farrell and Studier 1980, P. Ormsbee, *personal communication*).

# III. BIOLOGY AND ECOLOGY

## Range, Distribution, and Abundance

The fringed myotis occurs from southern British Columbia south through central Washington, where the distribution extends west to the Pacific coastline. The range continues south along the Pacific coast to central California, where the species occurs just inland through the northern edge of Baja California east across the head of the Sea of Cortez and south through western inland Mexico to Oaxaca (O’Farrell and Studier 1980). To the east, the range extends from British Columbia through central Idaho, the southwestern corner of Wyoming, the western half of Colorado and New Mexico, and south through west Texas into Mexico. *Myotis thysanodes pahasapensis* occupies a disjunct range in the Black Hills of western Wyoming, Nebraska, and South Dakota. The southernmost part of the range in Mexico is occupied by the subspecies *M. t. aztecus* (O’Farrell and Studier 1980).

The elevational range of this species is quite broad. The fringed myotis typically occurs at elevations of 1,200 to 2,100 meters (approximately 4,000-7,000 feet, O’Farrell and Studier 1980), although it has been captured at elevations of 2,500-2,850 m (8,000-9,500 feet) in New Mexico (Jones and Sutkus 1972, O’Farrell and Studier 1980). Along the Pacific coast, the fringed myotis occurs at very low elevations, essentially down to sea level (Orr 1956).

The fringed myotis seems to be generally uncommon throughout its range. This conclusion is based on capture frequency relative to other bat species in the same areas, with 0-13.7% of identified mist-net captures comprising this species within its geographic range (reviewed in Kenaith 2003). However, fringed myotis may be locally common. Relative capture rates of 13.7% were reported for *M. t. pahasapensis* in South Dakota (Cryan 1997 in Kenaith 2003) and up to 22.8% of captured bats that were identified were fringed myotis in northern Arizona (Herder 1998, 1999 in Kenaith 2003).

The species is similarly rather uncommon in the Pacific Northwest. Researchers who surveyed for bats including fringed myotis in southern and northwestern Oregon in Douglas-fir forests concluded that fringed myotis were widespread in northwestern Oregon but more common in the western rather than eastern Douglas-fir forests in southern Oregon (Cross 1976 in Christy and West 1993, Perkins 1983 in Christy and West 1993). Whittaker and colleagues (1977) stated that fringed myotis were rare in western Oregon with the exception of the Ashland area in the southwest. They did not indicate why that might be the case, although they did note that the species seemed to be associated with coniferous forests (Whitaker et al. 1977). Similarly, fringed myotis have been found roosting in Oregon Caves National Monument since 1958, and 86 were captured there in 2015, up from 17 in 2002 (T. Kerwin, *personal communication*). In central Washington, fringed myotis were the third most common species captured in mist nets after small-footed myotis and Yuma/little brown myotis in the first year of a study (Rosier and Rosenberg 2006). However, the relative and total numbers of fringed myotis captured declined the following year whereas other species’ captures doubled (Rosier and Rosenberg 2006).

Fringed myotis may be patchily distributed even within regions where they are known to occur. Within and among three years, maternity roosts were consistently located within the same small (200 m long) stretch of canyon in South Dakota (Cryan et al. 2001). Interestingly, 43 other sites in the study region with similar habitat did not seem to support reproductive females (Cryan et al. 2001). Capture data for fringed myotis in portions of the Okanogan-Wenatchee National Forest in Washington and the Fremont-Winema National Forest in Oregon suggested highly localized distributions, with nearly half of all captures in the Washington study site occurring at a single site near a large cliff and nearly half of all captures in the Oregon study site occurring at two sites (Lacki and Baker 2007). Habitat features that support roosting and foraging are likely responsible for the high variance in distribution, but the factors driving patterns of abundance are not currently understood.

Most recently, the Bat Grid survey data from Oregon and Washington suggested that fringed myotis were rare throughout the region with a patchy distribution (Rodhouse et al. 2015). Mapping of predicted distribution from a habitat-based model developed from extensive field surveys suggested that fringed myotis would be most likely to occur in northeastern Washington, with somewhat lower likelihood of occurrence in east-central and southern Washington, north-central Oregon, and the southern Oregon Cascades. East-central and south-central Oregon had very low predicted probabilities of occurrence (Rodhouse et al. 2015, Figure 3).

Survey data must be interpreted cautiously. Bat captures can vary dramatically between years and within seasons, reflecting life history shifts, shifts in the bat community, or even local decline. In addition, differences in survey techniques can lead to very different detection or capture probabilities even when densities or relative proportions are the same. Further, difficulties with differentiating fringed myotis and other bat species in early acoustic surveys make inference regarding rarity in these studies unreliable. The evolution of acoustic techniques

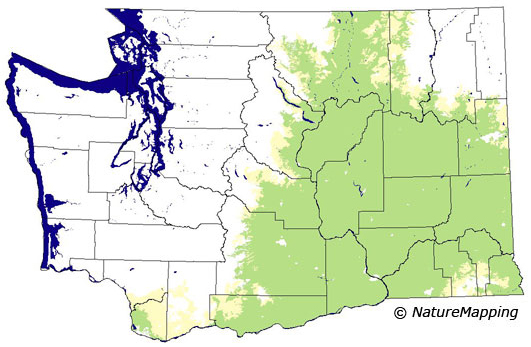


Figure 1. Potential breeding range of fringed myotis (*Myotis thysanodes*) in Washington based on predicted suitable habitat from habitat models. Image from the WA GAP Analysis Project (<http://naturemappingfoundation.org/natmap/maps/wa/mammals/WA_fringed_myotis.html>). Green indicates core habitat and yellow indicates marginal habitat. This map is not intended as guidance for specific projects, but instead provides a general view of potential habitat and species range within the state.



Figure 2. Potential range of fringed myotis (*Myotis thysanodes*) in Oregon based on predicted suitable habitat from habitat models. Images from Oregon Explorer Wildlife Viewer <http://oe.oregonexplorer.info/Wildlife/wildlifeviewer/?SciName=Mammalia&TaxLevel=order>. This map is not intended as guidance for specific projects, but instead provides a broad view of potential habitat and species range within the state.



Figure 3. Predicted probability of occurrence of the fringed myotis, *Myotis thysanodes*, based on Bat Grid data analyzed by Rodhouse et al. 2015. Occurrence and error maps as tif or GIS download format are available here: <http://www.fs.fed.us/r6/sfpnw/issssp/species-index/fauna-mammals-bats-grid-monitoring.shtml>.

for surveying bats now make the fringed myotis one of the easiest bats to identify acoustically using full-spectrum methods (P. Ormsbee, *personal communication*).

## Habitat

Throughout western North America, fringed myotis are found in a wide variety of habitats, from desert, sagebrush, grasslands, oak, pinion and juniper woodlands, pine-oak woodlands, mixed conifer and ponderosa pine forest, spruce-fir forest, and Douglas-fir forest (Barbour and Davis 1969, Black 1974, Christy and West 1993, Kenaith 2003). This species utilizes a variety of roosts, including rock crevices (Cryan et al. 2001, Lacki and Baker 2007), snags and living trees (Cross and Waldien 1995, Cross et al. 1996, Weller and Zabel 2001), and buildings (Musser and Durrant 1960, O’Farrell and Studier 1973). Bridges are used by fringed myotis as night roosts in Oregon (Cross and Waldien 1995, Cross et al. 1996, Adam and Hayes 2000) but rarely as day roosts, in contrast to their use of bridges as day roosts in New Mexico (Geluso and Mink 2009).

In Oregon and Washington, this species is considered primarily a forest-dwelling species that can also be found less frequently in shrub-steppe habitat where there are rock and canyon features for roosting and often in the vicinity of forest or treed habitat (Hayes 2003, Dewey 2006, Lacki and Baker 2007, Rodhouse et al. 2015). Modeled habitat associations based on the Bat Grid survey data collected in Oregon and Washington (Rodhouse et al. 2015) suggested associations with dry forest lands at low to moderate elevations, particularly Oregon’s Blue and Klamath Mountains, and Washington’s Mountains and Plateau regions. Another region of high probability of occurrence was in the Puget Sound lowland region in the rain shadow of the Olympic Mountains (Rodhouse et al. 2015, Figure 3). Predictions were generally corroborated by occurrence data, although the model predicted greater likelihood of occurrence in the Puget Sound region than suggested by actual occurrence data (Rodhouse et al. 2015).

Surveys for bats on Northwest Forest Plan lands have found that fringed myotis were more likely to occupy late-successional/old-growth forests than other stands, but the precision of the estimates was low. Estimated occupancy probability was 0.605 (± 0.162 SE, Weller 2008). This modeling exercise did not detect selection for reserves over late-seral/old-growth forest generally (Weller 2008). Training sessions for the Bat Grid monitoring project in the years 2003-2010 advised surveyors to target sites along smaller waterways or ponds in forested areas with large snags west of the Cascades in Oregon and Washington, and to target forested areas with large snags and rock features east of the Cascades in order to maximize detections of this species. Greater detection probabilities have been attained along forest edges and where trees are shorter and forest stands are more open (Ormsbee et al. 2010, P. Ormsbee, *personal communication*).

Unlike many other myotis species, fringed myotis are more associated with the upper canopy than the lower structural layers within forested habitat. Fringed myotis were detected most frequently in the canopy layer in northern California’s coastal redwoods (Kennedy et al. 2014). In the Oregon Coast Range, nightly activity of this species was most strongly associated with increasing percent cover in the canopy layer (Ober and Hayes 2008a). Similar results were found in western Washington (Hayes and Gruver 2000).

***Roosting Habitat and Behavior***

Across western North America, fringed myotis have been documented using a variety of roost types, including caves, mines, rock crevices, buildings, trees (Barbour and Davis 1969, O’Farrell and Studier 1980, Cryan et al. 2001, Cross et al. 1996, Lacki and Baker 2007) and snags (Cross and Waldien 1995, Weller and Zabel 2001, Lacki and Baker 2007). Although specific roost characteristics vary by study site, common patterns emerge overall.

Snags are considered key roost features, particularly as maternity sites for reproductive females (Lacki and Baker 2007, Weller and Zabel 2001, Mellen-McLean et al. 2012). Use of snags of a variety of species has been documented throughout the fringed myotis’ range. For example, in Arizona and South Dakota, reproductive female fringed myotis were found roosting in ponderosa snags (*Pinus ponderosa*, Rabe et al. 1998, Cryan et al. 2001). Two-thirds of the roosts in northwestern California were in Douglas-fir (*Pseudotsuga menziesii*) snags, although two were in sugar pine snags (*P. lanbertiana*) and one was in a ponderosa snag (Weller and Zabel 2001). Snags used in central Washington were all ponderosa pine, although in Oregon fringed myotis were also found roosting in a white fir (*Abies concolor*) stump and unidentified fallen log (Lacki and Baker 2007). In southwestern Oregon, snags were ponderosa pine, white fir, sugar pine, and unidentified fir species (Cross and Waldien 1995, Cross et al. 1996). In some instances, live ponderosa trees were used as roosts (Cross et al. 1996).

Snags used as roosts varied in their stages of decay. In South Dakota, the mean decay stage of trees utilized was 6.9 ± 0.2 on a scale from one to seven, where seven represented decomposed snags with no limbs or bark remaining (Cryan et al. 2001). The bats roosted within cracks or cavities in the tree trunks rather than under exfoliating bark. In northwestern California, roosts were comprised of snags that usually had exfoliating bark and broken tops with few remaining branches (Weller and Zabel 2001). Bats were observed emerging from underneath loose slabs of bark and from broken snag tops (Weller and Zabel 2001). In the Roseburg district of western Oregon, snags used as day roosts typically still retained their bark (Cross et al. 1996).

Despite the variability in species composition and decay stage, roost snags tended to be among the largest in diameter and tallest available, as is the case for many bat species (Kalcounis-Rüppell et al. 2005). In South Dakota, fringed myotis chose snags that were larger than random, but there was no difference in height between utilized and random snags (Cryan et al. 2001). Snag densities were also greater surrounding roost trees than random trees (Cryan et al. 2001).In northern California, roost snags were 58-167 cm (23-66 inches) diameter at breast height, and tall, ranging from 15.8-57.5 m (52-189 feet) in height. Snags used as roosts were 27 m (89 feet) taller and were 42 cm (17 inches) larger in diameter than random snags in the watershed, and 21 m (69 feet) taller and 30 cm (12 inches) larger in diameter than random snags near the roosts (Weller and Zabel 2001). In central Washington, similar to northwestern California, snags were larger in diameter, taller, and extended farther above the canopy than random snags (Lacki and Baker 2007). Roost snags were 82.6 (± 10.7 SE, n=6) cm (32.5 ±4.2 inches) DBH, whereas random snags were 52.8 (± 2.72 SE, n=50) cm (20.8±1.1 inches) DBH. Roost snags were 31.3 (±3.81) m (102.7±12.5 feet) tall whereas random snags were much shorter, only 14.4 (±1.29) m (47.2±4.2 feet) tall. Roost trees were 10.3 (±4.48) m (33.7±14.7 feet) above the mean canopy height, whereas random snags were slightly below canopy height (-2.5±1.28 m or -8.2±4.2 feet, Lacki and Baker 2007).

Roost snags also tended to be near watercourses. In northern California, roosts were 41 m (135 feet) closer to stream channels than random sites regardless of stream flow, and had 11% less canopy cover (Weller and Zabel 2001). Bats were active along small streams in this system even when those streams were dry (Seidman and Zabel 2001). In central Washington and Oregon, roost sites including snags and rock crevices tended to be closer to dry channels than perennial streams (0.49 ± 0.1 km [536 ± 110 yd.] versus 1.4 ± 0.36 km [1531 ± 394 yd.], respectively, Lacki and Baker 2007), so that bats may be selecting for movement corridors more than water sources.

Rock crevices are also used as day roosts by this species. Specific features and type of rock substrate used vary with the geology of the site. In South Dakota, female fringed myotis tended to roost in crevices deeper than 25 cm (9.8 inches), whereas males selected shallow crevices that were only slightly wider and deeper than their bodies (Cryan et al. 2001). In eastern and central Washington, basalt cliffs were day roosts for both male and female fringed myotis (Rosier and Rosenberg 2006, Lacki and Baker 2007). Additionally, on the Okanagan-Wenatchee National Forest, fringed myotis were most frequently found in cracks and crevices in rock although some roosting in snags was noted (Lacki and Baker 2007). In Oregon on the Fremont-Winema National Forest, fringed myotis used large rocks on wooded slopes or treeless boulder fields, roosting in crevices in or between large flat rocks. Such rocks were 32.3 (± 3.6 SE) cm 12.7 ± 1.4 inches) tall and 96.1 (±6.8 SE) cm (37.8 ± 2.7 inches) in diameter (Lacki and Baker 2007).

Rock roosts are typically made up of cracks or crevices of similar size. Dimensions of rock crevices used by fringed myotis in Washington and Oregon were similar among sites, 2.4 ± 0.16 cm (0.95 ± 0.06 inches) wide by 36.8 ± 2.75 cm (14.5 ± 1.1 inches) long. Cracks were oriented both horizontally (36 of 65 roosts) or vertically (29 of 65 roosts). Pregnant females selected horizontal crevices 59% of the time, whereas lactating and post-lactating females selected vertical crevices 61% and 75% of the time, respectively (Lacki and Baker 2007). Crevice roosts in Oregon were so shallow the bats were easily seen (Lacki and Baker 2007).

The relative reliance on snags versus rock for day roosts varies geographically and among individual bats. In South Dakota, one female bat selected both rocks and snags, whereas another female only used snags. The remaining 13 radio-tagged bats were only found in rock crevices (Cryan et al. 2001). In Oregon and Washington forests of predominantly ponderosa pine with grand fir (*Abies grandis*), white fir, and Douglas-fir just west of shrub-steppe habitat, where both suitable snags and rock crevices were available, rock substrate was utilized for day roosts more frequently than snags (Lacki and Baker 2007). This is in contrast to studies in northwestern California in mixed Douglas-fir, white fir, and oak (*Quercus spp*.) forest (Weller and Zabel 2001), Arizona (Rabe et al. 1998) and New Mexico (Chung-MacCoubrey 1996), where fringed myotis were only found using snags. In southwestern Oregon, fringed myotis were only found roosting in snags although sample sizes were small (Cross and Waldien 1994, Cross et al. 1996). Regions where rock roosts were utilized more heavily were all within the Intermountain Semi-Desert Province (Lacki and Baker 2007). The specific factors behind selection of snags versus rock roosts are not known.

Both day and night roosts used by fringed myotis may be located in human-made structures throughout their range (Johnston et al. 2004, Geluso and Mink 2009). Night roosts in particular have been located under bridges. Bridges in the Pacific Northwest, especially those on smaller waterways in forested habitat west of the Cascades, are considered prime night roost structures year-round for fringed myotis and other forest-dwelling bat species in the region (Ormsbee et al. 2010, P. Ormsbee, *personal communication*). Over 30 bridges have been identified as day and/or night roosts used by fringed myotis in Oregon and Washington. For example, bats in the Roseburg District of the BLM were captured at night roosts under bridges, although no details of those bridges were provided (Cross et al. 1996).

Bridge construction affects roost suitability and use by bats. In the Pacific Northwest, cast-in-place, girder, and concrete bridges with texture on the underside of the bridge tend to get used the most by most bat species (P. Ormsbee, *personal communication).* In western Oregon, bats selected larger concrete bridges that maintained higher night-time temperatures than did smaller ones. Solar radiation exposure was also important, as was the ambient air-bridge surface temperature differential (Keeley 1998 in Keeley and Tuttle 1999, Perlmeter 1996). Bats typically do not use crevices for night roosting, but utilize open areas between bridge supports that create protection from weather and wind (Pierson et al. 1996, Keeley and Tuttle 1999). Cast-in-place concrete bridges have a series of sheltered chambers, and these have been found to be heavily used by bats in the Oregon Coast Range and elsewhere (Adam and Hayes 2000, Erickson et al. 2003, P. Ormsbee, *personal communication*). The end cells of such bridges were particularly heavily utilized, presumably because their position on the bridge maintained heat most effectively (Perlmeter 1996, Adam and Hayes 2000). Although data for fringed myotis’ use of bridges is sparse, presumably these general observations hold for this species as well.

Fringed myotis will also utilize other human structures as roosts, particularly as maternity roosts. Buildings in particular have been used as roosts. One of the most thorough investigations into their biology was conducted on a maternity roost in the large, divided attic of the Montezuma Seminary in Montezuma, New Mexico, which had apparently been used by the bats for many years (O’Farrell and Studier 1973). A maternity colony numbering in the several thousands of bats of several species including fringed myotis was also studied in the attic of a three-story house in Las Vegas, New Mexico (O’Farrell and Studier 1973). These colony sizes are far greater than those reported in rock or tree roosts (Chung-MacCoubrey 1996, Weller and Zabel 2001, Lacki and Baker 2007), which ranged up to 118 bats but were frequently much lower. In Utah, the first report of a maternity colony in the state was in an old pioneer church numbering approximately 35 bats (Musser and Durrant 1968), a more typical colony size.

Mines may also serve as fringed myotis roosts, although records are sparse. A handful of mines have been documented being used by fringed myotis in the Pacific Northwest for roosting in the summer and fall. Mines likely serve as incidental roost sites for this species (Ormsbee et al. 2010, P. Ormsbee, *personal communication*). Two records exist of fringed myotis using mines in winter in Oregon have been found, although whether the bats were torpid when found was not recorded (Perkins et al. 1990).

Fidelity of fringed myotis to roost sites seems to vary with the roost type. In general, maternity colonies within buildings remained stable in numbers throughout the pup-rearing season (O’Farrell and Studier 1973), suggesting that the bats remained faithful to the roost. Within a building, however, a maternity colony frequently shifted position, apparently in response to microclimate changes (O’Farrell and Studier 1973, 1980). This was also reported for maternity roosts in caves (Dalquest 1947). However, lactating bats utilizing natural roosts in rocks or snags changed locations frequently (Cross and Waldien 1995, Cryan et al. 2001, Weller and Zabel 2001, Lacki and Baker 2007). The lack of fidelity to specific crevices and snags may be in response to microclimate changes. Even though specific roost sites are used transiently, there is evidence for fidelity by fringed myotis to small areas containing many roost sites (Cryan et al. 2001). These patterns are consistent with other species for the same roost types (Lewis 1995).

Numbers of days that roosts in rocks and snags were utilized before switching roosts ranged from 1.7 days (± 0.2 SE, range 1-5) in northern California (Weller and Zabel 2001), 1.79 ± 1.52 days in North Dakota (Cryan et al. 2001), and 1.8 ± 0.12 (SE, range = 1-16 days), for 5.5 ± 0.69 roosts per bat in Oregon and Washington (Lacki and Baker 2007). Roost sites tended to be within close proximity of each other and located in specific areas such as within a 25 m2 area of a boulder field in Oregon (Lacki and Baker 2007) or the same 200-m stretch of ravine in South Dakota (Cryan et al. 2001). In northern California, bats used 1-7 different day roosts each over 2-14 days of tracking, returning to the same roost 1.7 (± 0.2 SE) consecutive days with a range of 1-5 days in a row (Weller and Zabel 2001).

Roost microclimate conditions suitable for fringed myotis are suitable for other species of bats as well, so it is not surprising that roosts are shared among species. Fringed myotis have been documented sharing maternity roosts with little brown bats (*Myotis lucifugus*, O’Farrell and Studier 1975), Yuma myotis (*M. yumanensis*) and big brown bats (*Eptesicus fuscus*, Studier 1968), male pallid bats (*Antrozous pallidus*), male Townsend’s big-eared bats (*Corynorhinus townsendii*, Dalquest 1947) and male cave myotis (*M. velifer*, Baker 1962). Non-maternity roosts have been shared by little brown bats, big brown bats, Yuma myotis, pallid bats, Townsend’s big-eared bats, long-legged myotis, and California myotis (*M. californicus*, Dalquest 1947, O’Farrell and Studier 1973).

***Foraging Habitat***

Foraging habitat includes forest edges and forest clearings, including roads (Christy and West 1993, Kenaith 2003). Fringed myotis collected while foraging in western Oregon were hunting in coniferous forests (Whittaker et al. 1977). They have been observed foraging over water (Kenaith 2003), but little acoustic activity was noted directly above streams in the Oregon Coast Range (Ober and Hayes 2008b). They have been detected foraging in the upper forest canopy (Hayes and Gruver 2000, Kennedy et al. 2014). In central Washington, fringed myotis were detected foraging in upland shrub-steppe habitat roughly as often as in riparian areas (Rosier 2008). In the Oregon Coast Range, acoustic surveys that did not attempt to differentiate long-eared myotis from fringed myotis calls found that detections of this species pair were positively correlated with greater percent cover of trees in the canopy layer (Ober and Hayes 2008a). Related research conducted during the same study concluded that insect abundance was most strongly correlated with deciduous cover (Ober and Hayes 2008c). These two relationships suggest that fringed myotis are selecting foraging habitat where prey will be most abundant. Ober and Hayes (2008a) hypothesized that the energetically costly slow flight combined with gleaning and hawking foraging techniques may require fringed myotis to focus on foraging habitat with the greatest potential densities of prey.

Drinking water is an important resource for most bats including the fringed myotis. Its importance likely increases for female bats during lactation (O’Farrell et al. 1971, Mclean and Speakman 1999). Lactating female fringed myotis visited an artificial water source thirteen times more often than non-reproductive females, whose drinking patterns varied with ambient conditions. Lactating fringed myotis’ drinking patterns did not vary with temperature or humidity, however (Adams and Hayes 2008). Adult post-breeding female fringed myotis were estimated to turn over almost half their total body water in a single day, losing water primarily from evaporation but also through urination and defecation. In the laboratory, water gain from food was only slightly more than that obtained by drinking free water, 0.66 cm3 versus 0.63 cm3, respectively. Metabolically derived water was the main source at 1.48 cm3 (O’Farrell et al. 1971). Although fringed myotis occur in xeric habitat, they are poor urine concentrators and are likely to depend on surface water in xeric habitats (Geluso 1978).

Although water itself is a necessary resource, bats may choose water sources to help meet micronutrient needs. Bat captures, including those of fringed myotis, were greater at water holes with greater water hardness. Water hardness indicated greater levels of dissolved calcium. The researchers estimated that drinking from these water sources led to a significant acquisition of calcium (Adams et al. 2003). This may be particularly important for lactating bats.

## Diet and Foraging Behavior

Researchers have long noted the consumption of moths and beetles in particular by fringed myotis (Turner and Jones 1968, Black 1974). In Arizona, 90% of all fecal samples collected from mist-netted bats had Coleoptera remains, whereas 62% had Lepidoptera, and 53% contained Diptera (Warner 1985). Similarly, in New Mexico, of 11 fecal samples taken from fringed myotis sampled, 73% contained beetles and 36% contained moths (Black 1974).

Despite the heavy reliance on moths and beetles, fringed myotis will consume a wide variety of insects and other invertebrates. For example, in Arizona, 24% of fecal samples contained Neuroptera, 9% included Hymenoptera and Homoptera, and 4% of fecal samples contained Hemiptera (Warner 1985). Fringed myotis in the Oregon Coast Range primarily consumed larger invertebrates of terrestrial rather than of aquatic origin (Ober and Hayes 2008b). Prey found in fecal pellets in fringed myotis captured night-roosting under bridges in the Oregon Coast range included Araneae, Lepidoptera, Coleoptera, Homoptera, Diptera, Neuroptera and Orthoptera in order of volume. Ninety percent of 23 bats sampled had eaten Araneae and Lepidoptera, 75% of sampled bats had consumed Coleoptera, 65% Diptera, and less than half of the sampled bats had recently consumed all other identified taxa (Ober and Hayes 2008b), highlighting the opportunistic nature of fringed myotis’ diets. Somewhat different insect taxa were found in a study that collected bats from throughout western Oregon. Only four stomachs of *M. thysanodes* were examined, but the total volume was made up of 46% of Lepidoptera, found in three of the stomachs, Phalangida made up 26% of the total volume and was present in two stomachs, Gryllidae made up 16% of the total but was found in only one stomach, and one stomach also yielded a spider (Araneida) and crane fly (Tipulidae), both less than 10% by volume (Whittaker et al. 1977). In Grant County, Oregon, moths predominated in scats, but fringed myotis also consumed Diptera and Homoptera (Whittaker et al. 1981). Variation in prey species composition would be expected as a result of seasonal and geographic differences among collected samples.

Fringed myotis feed with a combination of aerial hawking and gleaning of insects and other invertebrates (O’Farrell and Studier 1980). This species is capable of low-speed, highly maneuverable flight that allows it to forage efficiently in vegetation (O’Farrell and Studier 1980, Findley and Wilson 1982). Its morphological characteristics relative to other bat species with different ecologies suggests that the fringed myotis is a hovering gleaner (Findley and Wilson 1982). The fringes on the uropatagium may aid in prey capture during gleaning; a specialized muscle allows the bat to curl the uropatagium and flair the hairs (Glass and Gannon 1994), creating a barrier to insects trying to scuttle out from underneath the bat. The hairs may add tactile sensitivity to the tail region (Glass and Gannon 1994). Fringed myotis are captured at water holes but given their morphology and flight characteristics, it is highly probable that they are drinking, not foraging over water (P. Ormsbee, *personal communication*).

Fringed myotis were speculated to be suited for hunting prey that is spatially and temporally variable (Findley and Wilson 1982). In eastern Washington, fringed myotis echolocation detections were positively correlated with insect biomass and minimum temperature rather than with specific foraging habitat. They showed no differential habitat use among cliff, shrub-steppe, or riparian habitats (Rosier 2008). These observations support the opportunistic-generalist theory and the theory that fringed myotis will target habitat with the greatest likely prey densities (Ober and Hayes 2008a).

## Life History and Breeding Biology

The life history of the fringed myotis follows that of many other North American vespertilionid bats that do not undertake long-distance migration, although the wintering ecology of this species is poorly known. The reproductive year begins in fall with copulation after females leave the maternity roosts (O’Farrell and Studier 1980). Delayed fertilization takes place in spring, followed by the movement of females to maternity colonies where they give birth. Pups are born in mid-summer. They are able to fly within a few weeks and reach adult size at that time. Non-reproductive females and male bats utilize separate roosts during this period, although non-reproductive females and males that are presumably in their first year are also sometimes present in maternity roosts. After the young bats have become independent in fall, the mothers leave the maternity roost presumably to gather at swarming sites and begin the breeding cycle again (O’Farrell and Studier 1975, 1980). Specific details of the life cycle are given below.

Most of what is known of the reproductive behavior of fringed myotis is from a single study site in New Mexico. It is highly likely that dates of arrival and parturition vary with latitude and severity of the winter. However, female fringed myotis first arrived at their maternity roosts in New Mexico in late April, and population size of adult females peaked in mid-June. Ovulation in New Mexico occurred in early May (O’Farrell and Studier 1973). Gestation is thought to be 50-60 days (O’Farrell and Studier 1980). Parturition seemed to occur primarily over a two-week period in New Mexico, suggesting that many of these females had overwintered together (O’Farrell and Studier 1973, 1975).

The stability of these roosts varies by roost type. Maternity colonies seem to remain in the same roost site only when they are using buildings or caves. Within large structures such as attics or caves, maternity colonies have been found to shift location frequently (Dalquest 1947, O’Farrell and Studier 1973, 1980), presumably to optimize microclimate conditions without the need to find a new roost to meet them. If rock crevices or snags are used, the bats shift roost sites every 1-3 nights although they will return to previously used roost sites (Cross and Waldien 1995, Cryan et al. 2001, Weller and Zabel 2001, Lacki and Baker 2007). When females switch roosts, they carry their non-volant young with them (Cryan et al. 2001). Social cohesion may be somewhat fluid. Radio-tagged reproductive females in South Dakota roosting in rock crevices were found sharing the same roost several nights in a row but in different roosts the next (Cryan et al. 2001). Although pregnant and lactating females in the northwest also shift roost sites frequently (Cross and Waldien 1995, Weller and Zabel 2001, Lacki and Baker 2007), the social aspects of the behavior in this region are currently unknown.

Some social cohesion may be maintained even when lactating females frequently shift roosts because fringed myotis have often been reported to share maternal duties. Fringed myotis leave their newborn young in clusters separate from the adults’ roost sites (Baker 1962, O’Farrell and Studier 1980). At night, 2-10 adult females remained with the cluster of young bats all night, and were thought to nurse pups not their own (O’Farrell and Studier 1973, O’Farrell and Studier 1980). In South Dakota, a maternity roost in a boulder crevice contained ten hairless young including a newborn following the departure of sixteen adult females, and a single adult female remained with the pups (Cryan et al. 2001).

Choice of microclimate has substantial implications for energy demand. Pregnant fringed myotis do not always regulate their body temperature in the late stages of pregnancy, when the fetus is demanding maximum energy. This period began 34 days before birth in laboratory studies (Studier et al. 1973). Similarly, only half of lactating fringed myotis regulated their body temperatures in ambient temperatures of 16 °C and 20 °C (61-68 °F) in the laboratory. Body temperatures of 24.3 °C (75.7 °F) are necessary for flight (Studier and O’Farrell 1972). In contrast, bats in the middle stages of pregnancy consistently regulated their body temperature (Studier and O’Farrell 1972). In the wild, the attic maternity roost under study consistently registered ambient temperatures high enough that the bats did not need to regulate body temperature during late pregnancy and lactation while they were in the roost (Studier and O’Farrell 1972). Instead, the bats moved together throughout the large, complex attic of the seminary throughout the day, apparently using the wide range of microclimates within the attic space to behaviorally thermoregulate (Studier and O’Farrell 1972). Movement of a maternity colony throughout a natural cavern has also been documented (Baker 1962). Maintaining an optimal thermal profile while minimizing energetic costs may be one of the drivers behind roost-switching behavior in fringed myotis utilizing rock crevices or snags, roosts that do not often offer multiple options in the same location.

Maternity colony size depends on roost structure. Numbers of breeding females in a maternity colony are typically up to several hundred (Barbour and Davis 1969). Caves in New Mexico supported maternity roosts of 100-300 individuals (Baker 1962). In buildings in New Mexico, however, colony sizes were estimated to be 1000-1200, (O’Farrell and Studier 1975). A second building contained a maternity roost of 200 fringed myotis (Studier 1968). In a population of fringed myotis using natural roosts in trees and rock crevices in South Dakota, maternity roosts were estimated to be made up of 16-24 adults (Cryan et al. 2001). Other studies found maximum maternity colony sizes of up to 118 adult bats (Chung MacCoubrey 1996, Weller and Zabel 2001, Lacki and Baker 2007. In Oregon and Washington, single females were often found in day roosts of rock crevices alone with their pups (Lacki and Baker 2007). Presumably in these instances the young bats were left entirely unattended while their mothers were foraging.

Fringed myotis will share maternity roosts with other species. In the New Mexico seminary attic, the dominant species was the little brown bat, which numbered roughly 15,000 breeding females to the thousand or so fringed myotis (O’Farrell and Studier 1975). Another attic supported 200 Yuma myotis, a dozen big brown bats, and 2,000-3,000 little brown bats in addition to 200 fringed myotis (Studier 1968). Rock and snag roosts seem less likely to support more than one species of bat, but numbers overall are far smaller.

Fringed myotis give birth to one large pup; litter size is likely the result of energetic constraints during lactation (Studier et al. 1973). Although pups are born blind and helpless, their development is rapid. Newborns’ eyes open and their ears unfurl after their first day. Pups could also regulate their body temperatures and utilize torpor as young as 4.6 days of age (Studier and O’Farrell 1972). At one week of age, their skin developed pigment and fur began to grow on the pigmented skin (O’Farrell and Studier 1973). Fringed myotis pups can fly by 16.5 days of age. However, only when they reach adult size in three weeks do they develop full flight ability (O’Farrell and Studier 1973).

Females and young remain in nursery roosts throughout the summer, although very little is known of the behavior of males and non-breeding females during this time period. In New Mexico, fringed myotis began to leave the maternity colonies in early August (O’Farrell and Studier 1975). The young bats left before their mothers, and juvenile males seemed to abandon the colony before the juvenile females. The adult females remained until September (O’Farrell and Studier 1975). At that time, they presumably disperse to swarming and overwintering sites, although few specifics are known for this portion in their life history. Exactly what they do next may vary geographically. In New Mexico, post-breeding female bats were not considered capable of hibernation upon leaving the maternity roosts based on their lack of fat deposits and strict regulation of body temperature during the post-lactating period (Studier and O’Farrell 1972, O’Farrell and Studier 1976). Studier and O’Farrell (1972) postulated that the bats remained active periodically throughout the winter in New Mexico. However, fringed myotis have been measured with fat deposits indicative of hibernation after they leave the maternity roost in British Columbia (Nagorsen and Brigham 1993). Overwintering ecology in the Pacific Northwest is currently unknown and may vary regionally depending on climate.

If fringed myotis do remain active during winter, where they go is still unknown. Geluso (2007) mist-netted at 24 sites for 5-13 nights each month from November to March for three years to determine winter activity of bats in south-central New Mexico. Sites varied from low-elevation arid land to mid-elevation pinyon-juniper forests. Only one male fringed myotis was ever captured, in November, out of 401 bats representing 12 species (Geluso 2007). In Arizona, Hoffmeister (1970) noted that fringed myotis disappeared from most of the state, and speculated that their winter range was greatly reduced from the summer range. Fringed myotis in winter were documented in southeastern Arizona and in the far west of the state in Mohave County, although no details regarding behavior or physiological state were given (Hoffmeister 1970).

In the northern extent of their range, however, fringed myotis face much colder winter temperatures than in New Mexico. One male and one unidentified fringed myotis were found in a cave at 4060 feet (1237 m) in February in South Dakota. The cave’s ambient temperature was estimated at 5 °C (Turner and Jones 1968). Fringed myotis have also been collected from mines in Lane and Baker Counties in Oregon in November 1983 and December 1984, respectively. No information regarding ambient temperatures or bat behavior or status was available with the specimens (Perkins et al. 1990). In summary, fall movements and overwintering ecology for this species are poorly known although they seem to vary geographically.

## Movements and Territoriality

Fringed myotis have been radio-tagged during a number of studies, providing some basic information regarding their daily movements. Distances between successive day roosts (primarily maternity roosts) in the Black Hills averaged 0.5 km (±0.5 SE, range 0.1-2.0 km, Cryan et al. 2001). During the summer, fringed myotis captured in northwestern California in mist nets over stream channels moved 424 m (± 57 SE, range 29-980 m) from capture sites to day roosts (Weller and Zabel 2001) and the bats moved an average of just 254 m between successive roosts (±61 m, range 7-641, Weller and Zabel 2001). Similarly, in eastern Washington and Oregon, fringed myotis moved 1.6 (± 0.34 SE) km from capture site to day roost (Lacki and Baker 2007). Movements between roosts and foraging areas in a shrub-steppe system have been estimated at as much as 6.6 km in eastern Washington, although topography greatly impeded data collection and precise distance estimation (Rosier and Rosenberg 2006). None of these studies noted any behaviors or movements that suggested territoriality in the sense that individual bats excluded or interfered with other individuals. However, it is likely that individual fringed myotis return to the same foraging areas and roosts in successive years, and even across generations, as is the case with other bat species (Sidner 1997, Pearson et al. 1952, Pierson and Rainey 1998, P. Ormsbee, *personal communication*).

Seasonal movements are poorly understood. In New Mexico, the relatively synchronized arrival of females to a maternity colony followed by a short birthing period suggested short-distance movements from overwintering habitat to the maternity roost (O’Farrell and Studier 1973, 1975). Maps of reported occurrences of fringed myotis in Arizona suggested a greatly reduced winter range, although no information was available on movements (Hoffmeister 1970). In southern Nevada, fringed myotis were only detected in a riparian corridor during the spring and fall, suggesting that they were simply moving through the area (Williams et al. 2006), although origin and destination were unknown. There may be regional differences in seasonal movements as well.

## Population Trends

The population dynamics of fringed myotis are essentially unknown. No demographic estimates other than of fecundity were found in the literature. Virtually all females seem to breed every year (O’Farrell and Studier 1980). Females give birth to one pup each year (O’Farrell and Studier 1980), and O’Farrell and Studier (1973) estimated a 1% mortality rate for neonate fringed myotis. Tuttle and Stevenson (1982) suggested that the overwinter survival of yearlings was 30-40%, reflecting a low juvenile recruitment rate. No estimates of annual survival rates for adults were found, although fringed myotis were among the millions of bats outfitted with federal bands from 1932 to 1972 (Ellison 2008). Bat Grid survey data collected over 8 years from 2003 to 2010 using both nets and acoustic surveys suggested a declining trend in fringed myotis populations throughout Oregon and Washington (Rodhouse et al. 2015). Location turnover in occupancy status was postulated to be quite high for this species (Rodhouse et al. 2015). This suggests that metapopulation dynamics could be an important feature of the bats’ biology.

# IV. CONSERVATION

## Ecological and Biological Considerations

In the Pacific Northwest, fringed myotis are considered primarily forest-dwelling bats of drier forest and to a lesser degree, mesic forests along the Pacific coast. They also inhabit xeric non-forest habitat occasionally as well, although they are typically found in the vicinity of forests (Hayes 2003, Dewey 2006, Rodhouse et al. 2015). Although fringed myotis can be found in dry environments such as arid grasslands and shrub-steppe habitats, they are not desert adapted and require free water, particularly during lactation. Factors limiting their range, distribution and abundance are otherwise unknown.

Their diet consists largely but not exclusively of phytophagous insects, in particular moths and beetles. They will eat a wide variety of insects and arthropods such as spiders, as is typical of bats in the genus *Myotis*. They forage using aerial hawking and gleaning foraging techniques, and when in forested environments, concentrate their activity in the canopy. Like many bat species, they may be most constrained by the availability of suitable roosts. Large snags are an important element in forested environments. Rock faces or boulder fields, particularly those with southern exposure, are also important for this species.

Of the Special Status and Sensitive bat species, the fringed myotis is representative of the majority of bat species in the Pacific Northwest because of its associations with forests and snags. Therefore, it serves as an umbrella species for forest-dwelling bats in the region. All but one (the western pipistrelle or canyon bat, *Parastrellus hesperus*) of the sixteen species of bats in Oregon and Washington rely on forested habitat to some extent for foraging, roosting, or other life history components (Hayes 2003, P. Ormsbee, *personal communication*). Steps taken to conserve fringed myotis populations should therefore benefit nearly all other bat species in the region.

## Threats

Direct threats to fringed myotis are primarily loss of roost sites such as snags through logging or fire, demolition of old buildings, mining and quarrying activities, and improper closure or filling in of abandoned mines. The primary indirect threat to fringed myotis in Oregon and Washington is degradation and loss of foraging habitat such that suitable insect abundance and diversity is no longer available. This can occur as vegetative diversity is reduced as a consequence of invasive species. Logging, overgrazing, land conversion, fire, and energy development are some mechanisms of foraging habitat loss. Climate change may affect fringed myotis through increased fire frequency and severity and subsequent habitat degradation, loss of water sources, or altered prey base. The disease white-nose syndrome (WNS) is a potential threat as well, although the magnitude and severity of this threat to fringed myotis is unclear. These and other threats are discussed in more detail below. Fringed myotis may be particularly vulnerable because of their patchy distribution and low densities.

***Habitat loss***

Loss of habitat is a major threat to fringed myotis. Primary forest roosting and foraging habitat is lost through fire and logging. Open habitat may also be lost to fire. Land conversion for energy development, urban or agricultural uses can affect both forest and shrub-steppe/savanna habitat used for foraging and roosting. Although spread of native species such as juniper in shrub-steppe systems may increase foraging and roosting opportunities for fringed myotis, the overall concomitant reduction of surface water sources may reduce drinking sites that are essential to fringed myotis’ ability to inhabit xeric habitat. Roost sites in rocks are vulnerable to mining and quarrying. Over a longer time scale, inadequate recruitment of large snags in forested environments as a result of fire or logging activities may be a primary issue.

A lesser threat of direct mortality may be posed by alternative energy development. In Washington, much of the wind energy infrastructure is located in shrub-steppe habitat in the Columbia Basin (Hayes and Wiles 2013). Although the fringed myotis is not among the species that have been documented as suffering direct mortalities from wind turbine collisions (Arnett and Baerwald 2013), finding a rare species during ground surveys may be particularly challenging (Arnett et al. 2008).

***Habitat degradation***

Habitat suitability can be reduced through the loss of structural and floristic diversity, which in turn may impact the prey base of fringed myotis. Forest management practices, grazing, fire, development, and invasive species may all impact physical structure and floristic composition. This in turn may disrupt the spatial and temporal abundance of the invertebrate community. The degradation of foraging habitat may also occur through road building and other development, directly by removing diverse vegetative communities necessary to support adequate prey and indirectly through facilitation of invasion of either native or non-native species that may similarly reduce floristic diversity. Energy development poses its greatest threat through habitat degradation both directly from development and indirectly by fostering invasive plant species that may not support adequate abundance and temporal distribution of prey (e.g., Burghardt et al. 2010, Litt et al. 2014).

Contaminants and pesticides are also of concern. Degradation of water sources from pollution or contamination may affect fringed myotis through ingestion of contaminated water (e.g., Clark and Hothem 1991, Brasso and Cristol 2008). Contaminants may include mining waste, toxic spills from industrial development (Clark and Hothem 1991), or chemicals such as pesticides that are deliberately introduced into the environment. These contaminants may be transferred into terrestrial food webs through stream insects (Walters et al. 2008, Sullivan and Rodewald 2012). Although currently registered pesticides are much less likely to pose a bioaccumulation risk to fringed myotis than previously used compounds such as organochlorine pesticides, use of pesticides in habitat restoration or against invasive species may impact bats through reduced prey abundance, particularly the use of pesticides such as *Bacillus thuringiensis kurstaki* (*Btk*) or insect growth regulators against invasive moths. Declines in lepidopteran abundance and diversity were noted following applications of diflubenzuron (trade name Dimilin) in West Virginia (Sample et al. 1993). Spraying *Bt* for tussock moth and spruce budworm in the Blue Mountains of Oregon reduced prey populations for 1-2 years, with a consequent decline in reproduction by bats (Perkins and Schommer 1991 in Pierson et al. 1999). Applications of *Bt* and other larvicides will impact moth populations the following year, when those larvae would have been adults. Herbicides also can alter prey base indirectly by affecting host plants of larvae. Similar concerns apply for the control of invasive beetles, although the specific pesticides used will vary.

***Climate change***

Climate change brought about by global warming likely represents a significant threat to fringed myotis and other bats in Washington and Oregon. Phenology of insect prey may shift out of phase with the life history of the bats (Jones and Rebolo 2013). Fire and drought may dramatically alter vegetation communities and the biota that depend upon them, and reduce surface water availability. This could be a major concern for lactating female bats in particular (Adams and Hayes 2008).

Overall, availability of surface water may decline as western states experience more frequent droughts. Water availability may also decline as a result of lower snowpack, earlier spring melt, and earlier peak flows (e.g., Barnett et al. 2008). Loss of surface water is a threat to biological communities in general. In addition, temperatures themselves may influence suitability of habitat for fringed myotis by altering the thermal regimes of their roosts, particularly the hibernacula.

Some specific projections regarding the impacts of climate change on eastern Washington and Oregon suggest that under a range of scenarios, dry sagebrush steppe is likely to decrease and mesic shrub-steppe increase, potentially with further expansion of juniper (*Juniperus occidentalis*). Summers are projected to become hotter and drier (Michalak et al. 2014, Mote et al. 2014, Creutzburg et al. 2015). Winters will be warmer and rainfall is projected to increase in the non-summer months (Michalak et al. 2014, Mote et al. 2014, Creutzburg et al. 2015). Although the eventual nature and extent of future environmental changes brought about by climate change are speculative, reductions in foraging habitat, roost sites, or water sources may further reduce the range of this patchily distributed and rare species.

***Disease***

WNS is a major threat to North American bat species that hibernate. WNS was discovered on a sick western *Myotis lucifugus* east of Seattle, in King County, Washington on March 2016, over 2,000 km from any previously known location for WNS (WA Dept. of Fish and Wildlife, US Geological Survey, and US Fish and Wildlife Service 2016, <https://www.whitenosesyndrome.org/resources/map>, dated May 10, 2016 and accessed May 11, 2016). A silver-haired bat (*Lasionycteris noctivagans*) collected for rabies testing was subsequently confirmed to test positive for the fungus that causes WNS (*Pseudogymnoascus destructans* (Pd) shortly thereafter, also within King County (Sleeman 2016, R. Huff, *personal communication*). This silver-haired bat did not have the lesions associated with WNS, and suggests that this species may be considered a carrier of the fungal pathogen, as it is in the eastern United States. How swiftly the disease will reach into the range of the fringed myotis is unclear, with modeling exercises reaching different conclusions (Maher et al. 2012, Alves et al. 2014). These models predicted a much longer time period before WNS was likely to occur in Washington. It is unknown how WNS arrived in Washington, and it may be a mystery that is never solved.

A number of factors may affect the severity of the disease. *Eptesicus fuscus* appears to be more resistant to WNS than many eastern species based on surveys (Brooks 2011, Langwig et al. 2012). *Pseudomonas* strains isolated on *E. fuscus* individuals inhibited growth of *Pseudogymnoascus destructans* in the laboratory (Frank et al. 2014, Hoyt et al. 2014a). Antimicrobial compounds have been isolated on the fur of *Tadarida brasiliensis mexicana* (Wood and Szewzak 2007). Although these compounds have not been tested for their effects on *P. destructans*, it suggests that some bat species in some geographic areas may be resistant to infection by WNS. Most recently, it appears that the mechanism of coexistence between the fungus and bats in the Palearctic is a result of tolerance rather than resistance, as fungal loads on infected bats were as heavy as those documented in heavily infected North American bats (Zukal et al. 2016). The mechanism for this tolerance is not yet understood.

The intense selection pressure on bat populations may already be enhancing the proportion of resistant individuals in some species, such as the Virginia subspecies of the Townsend’s big-eared bat (*Corynorhinus townsendii virginianus*, Grousd and Russell 2015) and even little brown bats (*Myotis lucifugus*, Maslo et al. 2015). Clarifying whether immunity is acquired or inherited will be vital to determining appropriate management responses (Maslo and Fefferman 2015).

Bat species whose populations overwinter in relatively few, large, dense aggregations, such as the little brown bat (*Myotis lucifugus*. Frick et al. 2010) are at particular risk from the effects of WNS. Risk is not only a function of the size of the hibernating colony, but on the bats’ behavior within the hibernaculum; species that are highly social have been among the most affected (Langwig et al. 2012). Such dramatic impacts at the population level may be reduced with the smaller hibernacula size suspected for many of the bat species overwintering in the Pacific Northwest (P. Ormsbee, *personal communication*). In addition, torpid bats that had been experimentally infected did not show signs of the fungal infection for nearly three months (Lorch et al. 2011), suggesting that prolonged torpor is also required.

How WNS might affect fringed myotis is not yet clear. *Myotis* species are among the most susceptible to WNS based on population declines in eastern North America, although the southeastern myotis, *Myotis austroriparius*, seems only to carry the fungus without becoming infected (<https://www.whitenosesyndrome.org/about/bats-affected-wns>). While the overwintering biology of fringed myotis is not well understood, there may be hope in the lack of evidence of large winter colonies for any of the *Myotis* speciesin the Pacific Northwest, despite decades of survey efforts to document such behavior (P. Ormsbee, *personal communication*). At this point even less is known about fringed myotis’ potential resistance to WNS infection than their wintering habits. Although this lack of information makes it difficult to assess the risk posed by WNS to fringed myotis, the potential consequences of this disease are so devastating, that calculated precautions should be taken to prevent its spread beyond its current range. Such precautions include providing robust roost, foraging, and watering habitats year round to optimize species fitness and resilience. Because of the susceptibility of many of the species in this genus, *Myotis* species in the Pacific Northwest may be particularly appropriate for preventive management, inventory, monitoring, and sampling with regard to WNS.

***Disturbance***

Fringed myotis have been noted to be sensitive to researchers’ lights in maternity colonies (O’Farrell and Studier 1973). Before pups were born, females became even more sensitive to researcher disturbance and withdrew to cracks in small groups rather than remaining in the open on the sides of beams in larger clusters. Nursing bats would allow close approach, however (O’Farrell and Studier 1973). Other researchers did not find fringed myotis to be very easily disturbed (Baker 1962), although in the laboratory Dalquest (1947) described them as “nervous, noisy *Myotis* [t*hysanodes*] scrambled about a great deal.”

Roosting bats, particularly females and pups at maternity sites, and hibernating bats are vulnerable to human disturbance that can be fatal to them. Care is always required to protect known or suspected roosts, particularly in bridges, buildings, mines, caves, or other structures. There are records of fringed myotis roosting in at least six buildings on Forest Service and BLM lands in Washington and Oregon (R. Huff, *personal communication*) and such structures or parts of structures used by bats should be protected from disturbance regardless of the bat species using them. Known or suspected hibernacula should be protected from disturbance during the winter, and closures to all human activities may be needed to prevent the spread of WNS. Bridge repairs and replacement can be disturbing or destructive to roosting bat colonies. Impacts to bats from repair or replacement bridge work should be assessed well in advance of the work to minimize disturbance and maximize mitigation.

Use of fire as a management tool may also pose risks to bats. Fire is now widely recognized as a natural process that creates necessary habitat features such as snags and that ultimately boosts prey populations (Carter et al. 2002, Perry 2012). Loss of vegetation can impact cave microclimate conditions, and may ultimately either reduce or enhance both underground and snag roosts. Effects must be considered on a case by case basis (Carter et al. 2002). In addition, controlled burns pose direct risks to bats in the form of heat, smoke, and toxic gas exposure (Carter et al. 2002, Perry 2012). Preliminary work evaluating these risks has been carried out in the southeastern US. Bats roosting in trees in warm weather were able to rouse and leave the roosts before flames and smoke reached their roost sites. However, bats roosting near or at ground level may be at greater risk, particularly if they are torpid when the fire occurs (Dickenson et al. 2009, Perry 2012). Caves and mines may have airflow characteristics that actively draw in smoke, which may then concentrate in the same regions where bats congregate (Carter et al. 2002).

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## Management Direction

Management direction specific to bats from larger-scale Forest Service and BLM planning efforts is presented below, and should be utilized by applicable field units. Additional management direction may be found in individual Forest Plans or BLM District Resource Management Plans and is not captured here.

***Northwest Forest Plan***

Although only part of the range of the fringed myotis in Washington and Oregon overlaps with the Northwest Forest Plan, the standards and guidelines may be useful tools for Forest Service and BLM units outside the NWFP boundaries.

For caves, abandoned mines, abandoned wooden bridges, and abandoned buildings within the NWFP area, specific standards and must be followed where the NWFP overlaps with the range of the fringed myotis. These guidelines are identified in the 2001 “Record of Decision and Standards and Guidelines for Amendments to the Survey and Manage, Protection Buffer, and other Mitigation Measures Standard and Guidelines” (Standards and Guidelines pages 37-38), and are listed in their entirety in Appendix A. Briefly, those standards and guidelines direct the BLM and Forest Service to:

…determine if each cave, abandoned mine, abandoned wooden bridge, and abandoned building that may be affected by the Agencies’ management activities warrants management as an occupied bat site. To make this determination, the Agencies may either conduct non-intrusive surveys to determine presence of bats, or may presume presence where conclusive surveys are not conducted. Criteria for defining non-intrusive surveys, survey conclusiveness and occupancy are to be described in the Survey Protocols and Management Recommendations, as appropriate. Individual species identification is not required in order to presume occupancy by target species. For sites occupied by bats, the Agencies will prohibit timber harvest within 250 feet of the site, and develop management direction for the site, as necessary, that includes an inventory and mapping of resources, and plans for protection of the site from vandalism, disturbance from road construction or blasting, and any activity that could change cave temperatures or drainage patterns. The size of the buffer, and types of activities allowed within the buffer, may be modified through the management direction developed for the specific site.

Additional direction on the management of buildings housing or thought to house bats has been provided for Forest Service units in the NWFP area, as a direction memorandum from the Regional Forester. The full content of the memorandum can be found at these two websites:

<http://www.fs.fed.us/r6/sfpnw/issssp/agency-direction/> and <http://www.blm.gov/or/plans/surveyandmanage/guidance.php>.

The memorandum provides additional direction as it relates to:

1. Safety Considerations When Conducting Bat Surveys

2. Survey Protocol for Determining Bat Use of Buildings

3. Management Recommendations for Buildings used by or assumed to be used by Bats

4. Bat Education and Information Sources, and

5. Plans for the Oregon Wedge Bat Box Design

The survey protocol for buildings, which is referenced in item 2 above, could also be applied to other potential roost sites such as caves and bridges.

The NWFP Bat standards and guidelines also reference snags and decadent trees as roost sites used by bats, and state that provisions for these habitat features are included in the standard and guideline for green tree patches in the Matrix. Those specific standards and guidelines are excerpted and included in Appendix B. A focus of the standards and guidelines, as they relate to bats, is “To the extent possible, patches and dispersed retention should include the largest, oldest live trees, decadent or leaning trees, and hard snags occurring in the unit. Patches should be retained indefinitely”.

***Westside Oregon BLM Resource Management Plans***

BLM lands in western Oregon within the range of the northern spotted owl have new records of decisions (BLM 2016a, 2016b) that dictate management on those lands. As with the NWFP standards and guidelines specific to bats, the management direction in the new BLM Resource Management Plans may be useful tools for other Forest Service and BLM units outside the range of the northern spotted owl in Oregon.

Management direction from the Plans specific to bats includes:

Sustainable Energy – Wind Energy Development: Locate turbines away from colonies where bats hibernate, breed, and raise their young; locate turbines outside of bat migration corridors or flight paths between colonies and feeding areas.

Sustainable Energy – Sustainable Energy Transmission Corridors: Install overhead lines such that the conductors parallel tree lines, employ bird flight diverters, or are otherwise screened so that bat and bird collision risk is reduced.

Wildlife – Bats

• Protect known maternity colonies and hibernacula for Bureau Sensitive bat species within caves, abandoned mines, bridges, and buildings with a 250-foot buffer:

* Maintain existing habitat conditions and protect the site from destruction or species disturbance, to the extent practicable consistent with safety and legal requirements.
* Prohibit blasting.
* Implement hazard fuel reduction treatments to protect the site from wildfire or to maintain site conditions conducive to the colony.

• Prohibit blasting during periods of reproduction and hibernation within 1 mile of known maternity colonies and hibernacula for Bureau Sensitive bat species within caves, abandoned mines, bridges, and buildings.

• Where white-nose syndrome is found in the bats residing within caves and abandoned mines, bridges, and buildings, prohibit human access except for monitoring, education, or research purposes.

Additional direction is provided for snag retention, creation, and target levels, as well as green tree retention. The details of management direction for snags and green tree retention are quite extensive, and the reader should review the two Resource Management Plans (USDI BLM 2016a, b) for additional information. For the Northwestern and Coastal Oregon Resource Management Plan, the bulk of the pertinent direction is included in pages 59-74. For the Southwestern Oregon Resource Management Plan, pages 58-87 provide the majority of the pertinent direction on snags and green tree retention.

## Management Considerations

Managing for fringed myotis in forested landscapes enhances the conservation of numerous other bat species because nearly all of them utilize similar habitat elements such as tall snags and complex vegetative structure. Fringed myotis therefore serve as an umbrella species. A number of factors are relevant to the conservation and management of forest bats in general and fringed myotis in particular.

The primary threats relevant to land managers include impacts to forest habitat used for roosting, foraging, and other life history components, loss of water sources, degradation of non-forested foraging habitat, and potential susceptibility to WNS. This section identifies management considerations that could be applied on any Forest Service or BLM lands in Oregon and Washington to help reduce or eliminate threats to fringed myotis. However, how management actions affect fringed myotis must be evaluated on a case-by-case basis to determine how the actions are modifying the environment and ultimately impact the bats (Kenaith 2004).

***Habitat loss***

Mines slated for closure should be assessed for use by bats and the type of closure method subsequently chosen should follow current best management practices determined by Bat Conservation International (BCI) or an appropriate agency. A decision matrix tool developed by BLM and BCI is available at <http://www.batgating.com/>. Currently, the BLM utilizes contractors from BCI to survey such mines and determine their potential for bat use. BCI makes recommendations for appropriate closures based on their findings, and the BLM uses these recommendations when closing the mines (R. Huff, *personal communication*).

Provisions should be made for the continued existence of suitable snag roost sites for this species. Forest management plans should include maintenance of large old snags at relatively high densities, and harvest should leave sufficient large trees so that replacement of snags is assured. Many studies have quantified characteristics of forest structure that are important to bats, particularly roost trees (e.g., Kalcounis-Rüppell et al. 2005). In addition, a valuable resource in this regard is DecAID advisor, which is an advisory tool to help managers decide what snag and dead wood resources are required to meet wildlife management goals, and help determine long-range management steps to achieve those goals. DecAID can be found at <https://www.fs.fed.us/r6/nr/wildlife/decaid/>.

Fringed myotis in central Washington relied more heavily on rocky crevices and rock features than snags for roost sites. Therefore, although snags are clearly important roost features, managing for snags should not occur at the expense of consideration of other structural features used as roosts (Lacki and Baker 2007). Snag density and size were also site-specific. Actual size of roost snags varied substantially from region to region (e.g., Cryan et al. 2001, Weller and Zabel 2001, Lacki and Baker 2007). However, all roost snags were large diameter and occurred in stands with greater densities of large live and dead trees relative to unused sites nearby (Lacki and Baker 2007). Protecting these characteristics from logging or other activities will aid a number of snag-dependent wildlife species as well as fringed myotis.

Although there are currently only six known fringed myotis roosts in buildings on Forest Service and BLM lands throughout Oregon or Washington (R. Huff, *personal communication*), buildings suspected to be used by bats should be protected as safety and legal requirements allow. Such buildings may be protected by conservation easements or by other agreements when they occur on private land.

***Habitat degradation***

Providing stand and structural diversity in forests is vital to maintaining foraging and roosting habitat for this species. Protecting remaining shrub-steppe habitat within the range of fringed myotis and performing restoration activities in regions that are overgrazed or highly modified from either exotic or native invasive species may help this and other native species of concern. Specific actions may include using rotational grazing or reducing grazing to maintain floristic structure and diversity, removal of encroaching juniper, protection of existing surface water resources, replacement or supplementation of water sources with structures such as tanks or guzzlers, and restoration of diverse vegetation capable of supporting a range of prey species.

Logging operations and other forest disturbances should be managed to maintain riparian-zone vegetation and as much floristic diversity as possible, particularly deciduous trees. This will help maintain insect abundance and diversity (Ober and Hayes 2008c), in addition to maintaining foraging habitat.

Water sources should be protected from degradation or contamination by overgrazing, logging, mining, or other activities. Any pesticides used in exotic species control or habitat restoration activities should be evaluated for their potential to contaminate nearby water sources.

***Climate change***

Water may be a critical limiting resource for this species in xeric habitats, and the availability of water is expected to decline in eastern Washington and Oregon. Artificial water sources, including water troughs, tanks, guzzlers and managed springs are important sources of water for fringed myotis and other bats in locations where access to free water is limited. Water troughs and tanks whose surfaces are divided by fencing or modified with support bars may be detrimental to bats, because these modifications make it more difficult for the bats to drink, and more likely that a bat is knocked into the water (Tuttle et al. 2006). Actions that would reduce the risks that modified tanks pose to bats include adding escape structures to tanks and troughs that allow bats to climb out, orienting tanks along fences so that the wire bisects the tanks on the long axis to maximize flight access, and maintaining water levels near the lip of the tank or trough (Tuttle et al. 2006).

Establishing an efficient and effective monitoring protocol for this species will be critical in tracking changes in distribution and abundance as climate change leads to regional impacts such as altered vegetation patterns, fire regimes, reductions in surface water availability, and other effects. Such information will help inform management efforts as areas of critical foraging habitat are likely to shift in response to changing conditions.

***Disease***

All protocols developed to limit the spread of WNS should be followed during all research and monitoring activities (<https://www.whitenosesyndrome.org/topics/decontamination>) and researchers should bear in mind the ability of this disease to spread rapidly into regions where it has not been previously documented. WNS can be easily spread on items such as equipment and clothing.

Little is known regarding the selection of hibernacula in this species, so decontamination or cleaning procedures designed to prevent spread of WNS should always be followed prior to entering any potential hibernacula such as mines and caves. Fungal spores may persist indefinitely in the environment (Lorch et al. 2011, Hoyt et al. 2014b). Precautions should be taken regardless of season of entry. In addition, disturbance to hibernacula while they are occupied may greatly increase the impact of the fungus if it is present, and should be avoided if at all possible. Developing new protocols and techniques for remote monitoring (e.g., Schwab and Mabee 2014) should be a priority to reduce disease transmission and disturbance risks.

Bats in the genus *Myotis* have proven in many cases to be particularly susceptible to WNS (USFWS 2017). Because of this, focusing disease monitoring efforts on fringed myotis is appropriate to track the spread of the fungus in the Pacific Northwest and to document its impacts.

***Disturbance***

Areas known to support fringed myotis roosts should be protected from disturbance, either by recreationalists or commercial activity. For example, radio tracking has shown that relatively small areas of ridge tops, boulder fields, or canyon habitat have been shown to support the majority of an area’s roosts (Cryan et al. 2001, Lacki and Baker 2007). If a fringed myotis roost is found occupying a building still in use by humans, steps should be taken to allow coexistence if at all possible. Rock quarries that have been abandoned but that are needed again for management activities may need surveying to confirm no bats are present, or disturbance avoided May through August to avoid impacting maternity roosts that may be present.

Other possible actions include restricting road building activity associated with timber harvest in addition to harvest activities during the early fall through early spring near hibernacula and from spring through fall for maternity roosts (Hayes and Wiles 2013). Existing forest canopy near occupied mines and caves should be left undisturbed to prevent changes in underground conditions and in prey populations. Buffers of 2.4 km from roosts for burning and 3.2 km from roosts for pesticide applications have been suggested (Pierson et al. 1999).

Bridge repair can be managed to minimize disturbance impacts on roosting bats. Repair work on bridges should be scheduled for when bats are seasonally absent. Replacement or major repairs should occur only after bats are professionally excluded using humane and accepted methods (Keeley and Tuttle 1999) by qualified personnel. Exclusion from the structure should occur in early spring prior to maternity season, before pregnant females arrive and pups are born or before potential hibernating bats arrive, such as in early fall. Bridge structures will need thorough surveys just prior to and during scheduled bridge work to insure absence of bats that may need removing. Bridges that are used by bats and replaced should include bat roosting habitat in the replacement design (Keeley and Tuttle 1999, Johnston et al. 2004, P. Ormsbee, *personal communication*).

Fire has the potential to both enhance and destroy habitat. This is particularly true for tree hollows and snags. In areas with few existing snags, large snags may need to be protected if possible from fire. Known roost trees are of particular value and concern. Vegetation overlying caves or mines known to be used by bats should be protected if possible. Loss or dramatic changes to vegetative cover may alter the microclimates within the mine or cave and affect roost suitability.

Risks posed by controlled fires can be reduced by planning burns to occur at times and during conditions when bats are unlikely to be torpid (Perry 2012). Consideration should be given to airflow in caves and potential movement of smoke during the planning process (Carter et al. 2002). Ignition techniques that start with lower-intensity, slow-moving fire may allow smoke and the noise of the fire to alert bats before the flames reach roost locations (Frame 2010). Consideration should be given to the availability of snags suitable for bat roosting near the burn area, as snags are likely to be lost within burned areas in the short term. In addition, consideration should also be given to the proximity of boulder fields or rocky outcrops used by bats, so that heat, smoke, and gasses do not pose risks to roosting bats.

# V. INVENTORY, MONITORING, AND RESEARCH OPPORTUNITIES

## Data and Information Gaps

The overwintering ecology of fringed myotis is almost completely unknown, as are possible regional seasonal movements. Overwintering behavior may vary regionally, such that fringed myotis on the west side of the Cascades Range may be active periodically throughout the winter whereas bats in eastern Washington and Oregon may utilize extended torpor. Determining overwintering behavior and the characteristics defining hibernacula will be vital to ensuring the conservation of this species’ critical habitat. In addition, such information may be vital to understanding the risk posed by WNS to this species.

Nothing is known regarding the population dynamics and demographic rates of fringed myotis, or its seasonal movements and potential metapopulation dynamics. Location turnover in occupancy status was postulated to be quite high for fringed myotis (Rodhouse et al. 2015). This suggests that metapopulation dynamics could be an important feature of the bats’ biology.

White-nose syndrome has now been documented in Washington (U.S. Geological Survey 2016, Sleeman 2016). As of December 2016, documented occurrences of the fungus have been limited to two bats within 50 miles of each other, in King County (R. Huff, *personal communication*). It is not yet known how quickly the fungus will spread as infected bats visit hibernacula.

## Inventory and Monitoring

Detection probabilities from the Bat Grid survey work were estimated at 0.18 (95% credible interval of approximately 0.1-0.32), and the distribution of fringed bats throughout the study area was considered to be patchy (Rodhouse et al. 2015). A study of Northwest Forest Plan lands estimated detection probability of fringed myotis as 0.252 (± 0.072 SE or 95% confidence intervals of 0.11-0.39, Weller 2008). Weller (2008) determined that this detection rate was too low to tease out use of reserve allocations from old-growth habitats; he suggested that conducting 16-24 repeated surveys rather than 4 would be necessary to detect any such difference.

Fringed myotis emit relatively low-intensity calls that may be difficult to detect (Weller 2008). Inventory and monitoring efforts that include acoustic methods and target this species need to incorporate consideration of low-intensity calls in deployment of detectors, call analysis, and calculations of detectability. Placement of detectors in locations free of physical clutter will improve detectability of low-intensity calls such as those of fringed myotis. Placing detectors along forest edges or openings in forest habitat that contain water sources will increase the likelihood of detecting this species.

Research

Ongoing efforts to understand the ecology of WNS and developing potential methods to limit its spread and severity or facilitate survival and adaptation to the disease will now need to be extended to the northwest.

The overwintering biology of the fringed myotis may vary throughout Oregon and Washington. Identifying key features of roosts and foraging habitat for this species will greatly aid in its conservation, and in helping to identify risk of WNS for this species. Use of acoustic surveys in winter may shed light on winter ecology (e.g., Schwab and Mabee 2014). The increasing sophistication and miniaturization of radio tags and other tracking technology will make gathering information on movements more feasible. Identification of roost features in Washington and Oregon is a necessary first step to protecting these crucial features. Similarly, understanding key elements of foraging habitat will greatly aid in conservation efforts.

Little is known regarding how to reduce the risk of controlled burns on bat populations. More work done to understand how bats respond to fire and under what conditions they are least vulnerable will aid in planning controlled burns.

Modeling approaches such as ecological niche modeling may be helpful in identifying how bats might respond to changes in climate, allowing management to identify possible refugia and forecasting changes in bat distributions (Dawson et al. 2011, Jones and Rebolo 2013). It may also assist in modeling the spread of WNS. Research to better understand how fringed myotis might be exposed to threats posed by changing climate, their sensitivity to such changes, and adaptive capacity (Dawson et al. 2011) will be needed for effective mitigation and conservation.

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# Appendix A: NWFP: protection for caves, mines, and abandoned bridges

Excerpt from the Record of Decision and Standards and Guidelines for Amendments to the Survey and Manage, Protection Buffer, and other Mitigation Measures Standard and Guidelines (USDA and USDI 2001).

**XI. Provide Additional Protection for Caves, Mines, and**

**Abandoned Wooden Bridges and Buildings that are Used as**

**Roost Sites for Bats**

**Standard and Guideline**

Most bat species occurring in the Pacific Northwest roost and hibernate in crevices or caverns in

protected sites. Suitable roost sites and hibernacula fall within a specific range of temperature and moisture conditions. Sites commonly used by bats include caves, mines, snags and decadent trees, wooden bridges, and old buildings. Provisions for retention of large snags and decadent trees are included in the standard and guideline for green tree patches in the Matrix. Caves and abandoned mines, wooden bridges and buildings, however, are extremely important roost and hibernation sites for which additional feasible protection measures are required to ensure their value as habitat is maintained.

This standard and guideline applies to all bat species that would benefit and that the reserves and

other standards and guidelines of the Northwest Forest Plan may not provide a reasonable assurance of persistence. In all land allocations, protect caves, and abandoned mines, wooden bridges and buildings used by bats from destruction, vandalism, and disturbance from road construction or blasting, or other activities that could change microclimate conditions or drainage patterns affecting use by bats. Protection of these structures must be contingent on safety concerns and legal requirements. Management of occupied sites will be consistent with the bats

Management Recommendation. Site-specific roost plans based on inventory and mapping of resources will be completed when such plans are a needed tool to protect or mitigate roost habitat for bats.

The Management Recommendation provides specific instructions for meeting the objectives and requirements of this standard and guideline. Management Recommendations for these species may be revised using the same process described in these standards and guidelines for preparing or revising Management Recommendations for Survey and Manage species. The Management

Recommendations may include guidelines for: (1) conducting searches; (2) identifying likely bat

use; (3) identifying appropriate circumstances for species identification; (4) establishing conditions under which specific mitigation measures will be applied to project activity plans; (5) describing various no-harvest buffer widths to fit specific habitat conditions; or, (6) other guidelines to help determine site-specific management needs.

For the purposes of this standard and guideline, caves are defined as in the Federal Cave Resources Protection Act of 1988 as:

“*Any naturally occurring void, cavity, recess, or system of interconnected*

*passages which occur beneath the surface of the earth or within a cliff or ledge*

*(...but not including any ... man-made excavation) and which is large enough to*

*permit an individual to enter, whether or not the entrance is naturally formed or*

*man-made.*”

**Management Recommendation**

This Management Recommendation is intended to provide additional feasible protection for roost sites for bats including the fringed myotis, silver-haired bat, long-eared myotis, long-legged myotis, pallid bat, and Townsend’s big-eared bat. This species list should be revised as necessary to include other bat species that: (1) would benefit from inclusion in this standard and guideline, and (2) the reserves and other standards and guidelines of the Northwest Forest Plan may not provide a reasonable assurance of persistence.

The Agencies will determine if each cave, abandoned mine, abandoned wooden bridge, and

abandoned building that may be affected by the Agencies’ management activities warrants

management as an occupied bat site. To make this determination, the Agencies may either conduct non-intrusive surveys to determine presence of bats, or may presume presence where conclusive surveys are not conducted. Criteria for defining non-intrusive surveys, survey conclusiveness and occupancy are to be described in the Survey Protocols and Management Recommendations, as appropriate. Individual species identification is not required in order to presume occupancy by target species. For sites occupied by bats, the Agencies will prohibit timber harvest within 250 feet of the site, and develop management direction for the site, as necessary, that includes an inventory and mapping of resources, and plans for protection of the site from vandalism, disturbance from road construction or blasting, and any activity that could change cave temperatures or drainage patterns. The size of the buffer, and types of activities allowed within the buffer, may be modified through the management direction developed for the specific site.

Townsend's big-eared bats are of concern to state wildlife agencies in both Washington and

Oregon. These bats are strongly associated with caves, and are extremely sensitive to disturbance, especially from recreational cavers. When Townsend's big-eared bats are found occupying caves or mines on federal land, the appropriate state agency should be notified, and management prescriptions for that site should include special consideration for potential impacts on this species.

**U.S. Department of Agriculture, Forest Service; U.S. Department of Interior, Bureau of Land Management. 2001.** Record of decision and standards and guidelines for amendments to the survey & manage, protection buffer, and other mitigation measures standards and guidelines. Portland, OR. 86 p.

# Appendix B: NWFP: green tree and snag retention in matrix management

Excerpt from the Record of decision for amendments to Forest Service and Bureau of Land Management planning documents within the range of the northern spotted owl (USDA and USDI 1994).

**Emphasize green-tree and snag retention in matrix management.**

Emphasize green-tree and snag retention in matrix management. For many species, benefits will be greatest if trees are retained in patches rather than singly. Because very small patches do not provide suitable microclimates for many of these organisms, patches should generally be larger than 2.5 acres.

Although many species would benefit from retention of patches, others may be favored by retention of single trees. Within the minimum constraints described in item C below, the relative proportion of patches vs. single trees retained must reflect local knowledge of individual species needs.

Retained patches should be protected for multiple rotations to provide support for those organisms that require very old forests.

Specific measures for green tree and snag retention follow. These measures are intended to be applied throughout the matrix forests. Their intent should be met in Adaptive Management Areas, but standards and guidelines are not prescribed for those areas.

A. For lands administered by the BLM in Oregon, follow standards and guidelines described separately for those lands below. For lands administered by the BLM in California, manage according to existing District Plans, which emphasize retention of old growth.

B. For all other lands, retain at least 15 percent of the area associated with each cutting unit (stand) except within the Oregon Coast Range and Olympic Peninsula Provinces. On the Mt. Baker-Snoqualmie National Forest, this retention guideline does not apply, but site-specific prescriptions should be developed to maintain biological diversity and ecosystem function, including retention of green trees (singly and in patches), snags and down logs. Exceptions are made for the Oregon Coast Range and Olympic Peninsula Provinces because substantial retention is provided by marbled murrelet and riparian protection measures. If, as a result of watershed analysis or any future delisting of the murrelet, protection is reduced significantly, green-tree retention standards and guidelines may be required in these provinces. Only matrix lands count toward the 15 percent.

This limitation does not apply to intermediate harvests (thinnings) in even-age young stands because leaving untreated portions of young stands would retard stand development and be detrimental to the objective of creating late-successional patches.

C. As a general guide, 70 percent of the total area to be retained should be aggregates of moderate to larger size (0.2 to 1 hectare or more) with the remainder as dispersed structures (individual trees, and possible including smaller clumps less than 0.2 ha.) Larger aggregates may be particularly important where adjacent areas have little late-successional habitat. To the extent possible, patches and dispersed retention should include the largest, oldest live trees, decadent or leaning trees, and hard snags occurring in the unit. Patches should be retained indefinitely.

D. As a minimum, snags are to be retained within the harvest unit at levels sufficient to support species of cavity-nesting birds at 40 percent of potential population levels based on published guidelines and models. The objective is to meet the 40 percent minimum standard throughout the matrix, with per-acre requirements met on average areas no larger than 40 acres. To the extent possible, snag management within harvest units should occur within the areas of green-tree retention. The needs of bats should also be considered in these standards and guidelines as those needs become better known. Snag recruitment trees left to meet an identified, near-term (less than 3 decades) snag deficit do not count toward green-tree retention requirements.

**Standards and Guidelines Specific to Northern Spotted Owl Habitat for Lands Administered by the Bureau of Land Management in Oregon** - For lands administered by the BLM in Oregon north of Grants Pass (see General Forest Management Area boundary in the Medford District Draft Resource Management Plan), and including the entire Coos Bay District, provide 640-acre blocks (Connectivity/Diversity Blocks) as currently spaced, that are managed on 150-year rotation. When an area is cut, 12 to 18 green trees per acre will be retained. There must be 25 to 30 percent of each block in late-successional forest at any point in time. Late-successional stands within Riparian Reserves contribute toward this percentage. In the remainder of the matrix (General Forest Management Area), retain 6 to 8 green trees per acre in harvest units.

For lands administered by the BLM in Oregon south of Grants Pass, retain 16 to 25 large green trees per acre in harvest units. Designated Conservation Areas, Reserved Pair Areas, and Residual Habitat Areas from the Final Draft Recovery Plan for the Northern Spotted Owl and other standards and guidelines of the BLM's Revised Preferred Alternative that are specific to northern spotted owls do not apply except as described below.

a. For lands administered by the BLM north of the Grants Pass line, and including all of the Coos Bay District, outside of the South Willamette-North Umpqua Area of Concern, implement the Connectivity/Diversity Block design from the Revised Preferred Alternative with District modifications that have been approved by the Scientific Advisory Group.

b. Apply additional matrix standards and guidelines to maintain the connectivity value of the I-5 Corridor (South Willamette/North Umpqua Area of Concern) in the Eugene District. Specifically, apply the Connectivity/Diversity Block standards and guidelines to all lands in the area designated as Deferred and Non-Deferred Old-Growth Emphasis Areas in the BLM's Revised Preferred Alternative.

Connectivity/Diversity Block standards or guidelines call for 150-year area control rotations. Overall, 25 to 30 percent of each block will be maintained in late-successional condition, and periodic timber sales will leave 12 to 18 green trees per acre. Riparian Reserves count toward the 25 to 30 percent if they are in late-successional condition. Riparian Reserves do not count toward the 150-year rotation of the area control.

c. Apply Connectivity/Diversity Block standards and guidelines to the entire area of seven Managed Pair Areas and two Reserved Pair Areas near the Medford/Roseburg District boundary and on a portion of the Coos Bay District surrounding Designated Conservation Area OD-33.

Pages C-41 to C-43

**U.S. Department of Agriculture, Forest Service; U.S. Department of Interior, Bureau of Land Management. 1994.** Record of decision for amendments to Forest Service and Bureau of Land Management planning documents within the range of the northern spotted owl. Portland, OR. 74 p. [plus attachment A: standards and guidelines].

Additional direction is provided for snag retention, creation, and target levels, as well as green tree retention.  The details of management direction for snags and green tree retention are quite extensive, and the reader should review the individual Resource Management Plans (USDI BLM 2016a, b) for additional information.   For the Northwestern and Coastal Oregon Resource Management Plan, the bulk of the pertinent direction is included in pages 59-74.  For the Southwestern Oregon Resource Management Plan, pages 58-87 provide the majority of the pertinent direction on snags and green tree retention.