Conservation Assessment for the Pallid Bat (*Antrozous pallidus*) in Oregon and Washington

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Disclaimer

This Conservation Assessment was prepared to compile the published and unpublished information on the pallid bat (Antrozous pallidus). 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: Pallid bat (*Antrozous pallidus*)

Taxonomic Group: Mammal

Management Status: The International Union for Conservation of Nature (IUCN) lists the pallid bat as of least concern based on its widespread range and occurrence in protected areas, the lack of evidence suggesting population declines, and large populations (Arroyo-Cabrales and de Grammont 2008). The USFS Region 6 and the BLM list the species as Sensitive in Oregon (Hayes and Wiles 2013, Interagency Special Status/Sensitive Species Program 2015). Pallid bats are also identified as a species requiring specific Standards and Guidelines under the Forest Service and BLM Northwest Forest Plan (USDA and USDI 1994a), as amended by the 2001 Survey and Manage Standards and Guidelines (USDA and USDI 2001). Pallid bats are listed as a Sensitive Species, Vulnerable Category by the Oregon Department of Fish and Wildlife (ODFW 2008, Oregon Biodiversity Information Center (ORBIC) 2013). ORBIC ranks pallid bats as rare or uncommon, imperiled and very vulnerable to extirpation (S2 in Oregon, ORBIC 2013). Pallid bats are considered a State Monitor species in Washington (Hayes and Wiles 2013). The Washington Natural Heritage Program ranks pallid bats as S3S4 for the state, or rare or uncommon, but apparently secure with many occurrences (Washington Natural Heritage Program 2014).

Specific Habitat: Pallid bats occur in semi-arid and arid landscapes in western North America. They are found primarily in grasslands, shrub-steppe, and desert environments with rocky outcrops, but also dry open oak or ponderosa forest, and open farmland. They utilize open vegetation at ground level up to a few meters above the ground for foraging, and roost sites that offer a range of thermal environments. Roosts are most commonly rock crevices but buildings, bridges, live trees and snags are also used.

Threats: On BLM and Forest Service lands in Oregon (where the species is listed by the agencies as Sensitive) the main threats to this species include habitat loss or degradation from energy development, juniper encroachment, grazing, urban expansion on adjacent lands, invasive species, climate change and mine closures. Disturbances from bridge repair work conducted in summer, as well as recreation activities may impact roosts. It is unknown whether this species may be threatened by impacts from white-nose syndrome.

Management Considerations: Active conservation and restoration of native shrub-steppe, savanna, and oak woodland habitat, as well as large snags, especially ponderosa pine and oaks, in forest ecotones adjacent to potential foraging habitats are critical management interventions to meet this species’ habitat use. Protection of roost sites from disturbance, conducting mine closures and bridge work such that bats are not impacted, and considering foraging and roosting sites when siting alternative-energy development will aid in conserving this species. Climate change may require additional management such as providing supplemental water sources. Great care should be taken to avoid facilitating the spread of white-nose syndrome into the pallid bat’s range and monitoring should avoid disturbance of hibernacula. For habitat features within the

Northwest Forest Plan (NWFP) area, including caves, abandoned mines, wooden bridges and buildings, management should follow the standards and guidelines identified in the 2001 NWFP amendment (USDA and USDI 2001). Among other things, these standards and guidelines direct the Agencies to prohibit timber harvest within 250 feet of any site thought to be occupied by the species, and develop management direction for the site, as necessary, to provide protection from vandalism, disturbance, and any activity that could change cave temperatures or drainage patterns.

Inventory, Monitoring, and Research Opportunities: Overwintering locations and behavior including migratory behavior are poorly known for the pallid bat. Little information was found on population status or trends in Oregon and Washington, although pallid bats have not been detected in the Willamette Valley of Oregon for nearly two decades and anecdotal reports of localized declines exist. Low detection probabilities during surveys and shifting roost use make monitoring trends in this species challenging. Pallid bat overwintering ecology and potential migratory behavior in the Pacific Northwest are essentially unknown. Understanding overwintering behavior will be crucial in assessing risk from white-nose syndrome and in long-term conservation management of critical overwintering habitat.

I. INTRODUCTION

Goal

Pallid bats (*Antrozous pallidus*) are widely distributed throughout western North America, including eastern and southwestern Oregon and central-eastern Washington (Verts and Carraway 1998, Johnson and Cassidy 1997). However, they are considered rare and vulnerable regionally (see Management Status below). Historic and current records indicate a possible range reduction in the past 50-100 years, particularly in western Oregon. The goal of this conservation assessment is to summarize existing knowledge across the range of the species to better inform management of pallid 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 pallid bats' range is also included. Although much is known about many aspects of the pallid bat's ecology and life history, 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.

Management Status

The IUCN lists the pallid bat as of least concern based on its widespread range and occurrence in protected areas, the lack of evidence suggesting population declines, and large populations (Arroyo-Cabrales and de Grammont 2008). NatureServe (2015) ranks this species as G5, indicating the species is secure globally. However, pallid bats are considered a species of concern by the US Fish and Wildlife Service Region 1 (Oregon Biodiversity Information Center 2013).

Pallid bats are listed as a Sensitive Species, Vulnerable Category by the Oregon Department of Fish and Wildlife (ODFW 2008, Oregon Biodiversity Information Center 2013). They are assigned a state rank of S2 by the Oregon Biodiversity Information Center (2013), a ranking given for either rarity or because the species is demonstrably vulnerable to extirpation in the state. Pallid bats are not considered threatened, endangered, or sensitive by the state of Washington, although they are considered a State Monitor species (Hayes and Wiles 2013). The Washington Natural Heritage Program ranks pallid bats as S3S4 for the state, classifying the species as rare or uncommon, but apparently secure with many occurrences (Washington Natural Heritage Program 2014).

In Oregon, the USFS Region 6 and BLM list pallid bats as Sensitive (Hayes and Wiles 2013, Interagency Special Status/Sensitive Species 2015). Pallid bats are also identified as a species requiring specific Standards and Guidelines under the Forest Service and BLM Northwest Forest Plan (USDA and USDI 1994a), as amended by the 2001 Survey and Manage Standards and Guidelines (USDA and USDI 2001). These 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 outcomes for this species by a panel of bat scientists (USDA and USDI 1994b).

II. CLASSIFICATION AND DESCRIPTION

Systematics

Pallid bats are in the family Vespertilionidae, also known as the evening bats, which is the largest family in the order Chiroptera (Verts and Carraway 1998). The order is currently made up of 6 subfamilies and 48 genera (Simmons 2005).

Initially, three distinct species in the genus *Antrozous* were recognized, but these were revised to six subspecies within *A. pallidus* based on morphology (Martin and Schmidly 1982). *Antrozous pallidus pacificus* extends down the Coast Range in Oregon south to San Bernadino and Los Angeles Counties. *Antrozous pallidus bunkerii* is found in the extreme eastern corner of the species' range, in Oklahoma and south-central Kansas, *A. p. packardii* is found along the Pacific coast of Mexico, and *A. p. minor* occurs in Baja California north through southeastern California, east through the southwestern corner of Arizona, and north into the southernmost tip of Nevada. *Antrozous pallidus pallidus* is the most widely distributed subspecies, covering the rest of the species' range on continental North America. Finally, *A. p. koopmani* occurs on the island of Cuba (Martin and Schmidley 1982).

One of the subspecies was elevated to a species in a new genus, *Bauerus dubiaquercus* (reviewed in Weyandt and Van Den Bussche 2007) and the others determined to be subspecies within *A. pallidus* (Martin and Schmidly 1982). More recent work with genetic tools suggested that pallid bats exhibit genetic variation consistent with repeated population fragmentation since the Pleistocene period, and that there are three distinct clades (Weyandt and Van Den Bussche 2007). Subsequent examination of both nuclear and mitochondrial DNA patterns in pallid bats led researchers to conclude that genetic structuring in pallid bats is a result of isolation by distance with male-mediated dispersal and female philopatry (Lack et al. 2010). There appear to be few barriers to male dispersal and there is substantial gene flow over large geographic regions (Lack et al. 2010).

The three clades identified by Weyandt and Van Den Bussche (2007) were broadly similar to those of Lack and colleagues (2010). However, California and British Columbia samples were distinct, and these studies did not obtain samples from the Pacific Northwest. The authors concluded that it is not clear whether the distinct genetics of pallid bat populations in California and British Columbia are indicative of real divergence or sampling error (Lack et al. 2010). Further work will be needed to determine if pallid bats of southwestern Oregon in particular represent a unique genetic contribution to the species.

There remain six (Verts and Caraway 1998) or seven (Simmons 2005) recognized subspecies of pallid bats currently, with *A. p. pacificus* and *A. p. pallidus* occurring in Oregon (Verts and Carraway 1998) and *A. p. pallidus* in Washington (Hayes and Wiles 2013).

Species Description

The pallid bat is a large, light-colored bat with large ears that are not joined at the base and eyes that are proportionally larger than most other insectivorous bats (Hermanson and O'Shea 1983, Verts and Carraway 1998). The pelage is wooly, creamy to light brown in color dorsally and paler ventrally (Verts and Carraway 1998). Its body mass ranges from 13.6 to 28.9 g, and adult females are typically slightly heavier than adult males (Hermanson and O'Shea 1983). Body measurements are total length: 92-135 mm; tail length: 35-53 mm; hind foot length: 11-16 mm; ear length: 21-37 mm; forearm length: 45-60 mm (Hermanson and O'Shea 1983). The tragus is long, more than half the length of the ear, pointed and serrate on the outer edge (Orr 1954, Verts and Carraway 1998). Pallid bats have a blunt muzzle with a ridge at its front above the nostrils, and pararhinal glands on the face that can exude a musky smell when the bat is disturbed (Orr 1954). In straight flight, pallid bats beat their wings 10-11 times per second, although they increase the rate when making turns (Orr 1954).

Comparison with Sympatric Species

Pallid bats are notable for their pale color and large eyes and ears. The ears of Townsend's big-eared bat (*Corynorhinus townsendii*) are similarly large, but they are joined at the base (Hermanson and O'Shea 1983). Townsend's bat pelage is comprised of hair with dark bases and light tips, whereas pallid bats' hairs are pale to the base (Verts and Carraway 1998). Pallid bats have broad wings and a distinctive blunt, ridged muzzle (Martin and Schmidly 1982). The pararhinal glands are not as distinct and protruding as in the Townsend's big-eared bat, which is also known as the lump-nosed bat (Figure 1). Pallid bats are occasionally found roosting with other bat species including *Tadarida brasiliensis mexicana* and *Myotis yumanensis* (Orr 1954, Licht and Leitner 1967a, Vaughan and O'Shea 1976, Hermanson and O'Shea 1983), but most frequently they occur in single-species roosts. This species is considered "quite social and chatty" (P. Ormsbee, *personal communication*), with many calls and vocalizations audible to the human ear.

Figure 1. Comparison of the similar species, pallid bat (left) and Townsend's big-eared bat (*Corynorhinus townsendii*, right). Photographs used here with permission from Michael Durham.

III. BIOLOGY AND ECOLOGY

Range, Distribution, and Abundance

The pallid bat is widely distributed throughout western North America, extending northward into southern British Columbia in the southern Okanagan Valley (Chapman et al. 1994), southward along the Pacific coastline into central Mexico south of Mexico City, and through the entire Baja peninsula (Verts and Carraway 1998, Arroyo-Cabrales and de Grammont 2008). The species extends eastward into Idaho, southwestern Wyoming, western Nebraska, western Oklahoma and Kansas, and the western half of Texas (Verts and Carraway 1998, Arroyo-Cabrales and de Grammont 2008). Various range maps show somewhat different boundaries along the eastern edge of the range. A distinct subspecies of pallid bat also occurs on the island of Cuba (Arroyo-Cabrales and de Grammont 2008).

In both Oregon and Washington, this species is most common east of the Cascade Mountains (P. Ormsbee, *personal communication*, Figures 2 and 3). Although documented occurrences are sparse in the state of Washington, pallid bat habitats occur in every central and eastern county in Washington except Pend Oreille County (Johnson and Cassidy 1997, Ferguson and Azerrad 2004, Figure 1). They have been recorded in the Yakima and Methow Valleys and the Okanagan Valley extending into British Columbia. More work is needed to better determine the actual distribution of pallid bats within Washington.

In Oregon, their range includes all of eastern Oregon with the exception of the Blue Mountains. West of the Cascade Mountains, pallid bats were found in the interior valleys of the Willamette Valley north as far as Linn and possibly Multnomah County (P. Ormsbee, *personal communication*), but these records are now decades old. One pallid bat was reported from Lane County in the late 1990s, but no confirmed sightings of this species have been made in western Oregon since that time despite extensive bridge surveys and other survey work (P. Ormsbee, *personal communication*). Local disappearances of roosts in southwest Oregon have also been reported (D. Clayton, *personal observation*). Pallid bats are still found in the valleys and foothills of the southern Klamath Mountain ecoregion in southwest Oregon, however, and range south to the northern California border (Verts and Carraway 1998, Figure 2). Pallid bats are documented in the Fremont-Winema and Rogue River-Siskiyou National Forests, the Burns, Lakeview, Medford, Prineville, Roseburg, and Vale BLM districts, and the Columbia River Gorge National Scenic Area (R. Huff, *personal communication*).

Habitat

Pallid bats occur over a broad elevation range, from between 178 feet (54 m) below sea level in Death Valley to 6700 feet (2042 m) in the mountains of Nevada (Orr 1954). They are found in semi-arid habitats such as deserts, shrub-steppe, grasslands, and canyon lands, but also in ponderosa woodlands, mixed conifer forest, oak woodland, and riparian forest (Verts and Carraway 1998, Hayes and Wiles 2013). Sources of water are usually present in their habitat (Orr 1954). In northern California, pallid bats have been associated with redwoods (*Sequoia sempervirens*), giant sequoias (*Sequoiadendron giganteum*), oak (*Quercus* spp.) and ponderosa pine (*Pinus ponderosa*) woodlands (reviewed in Ferguson and Azerrad 2004). In western

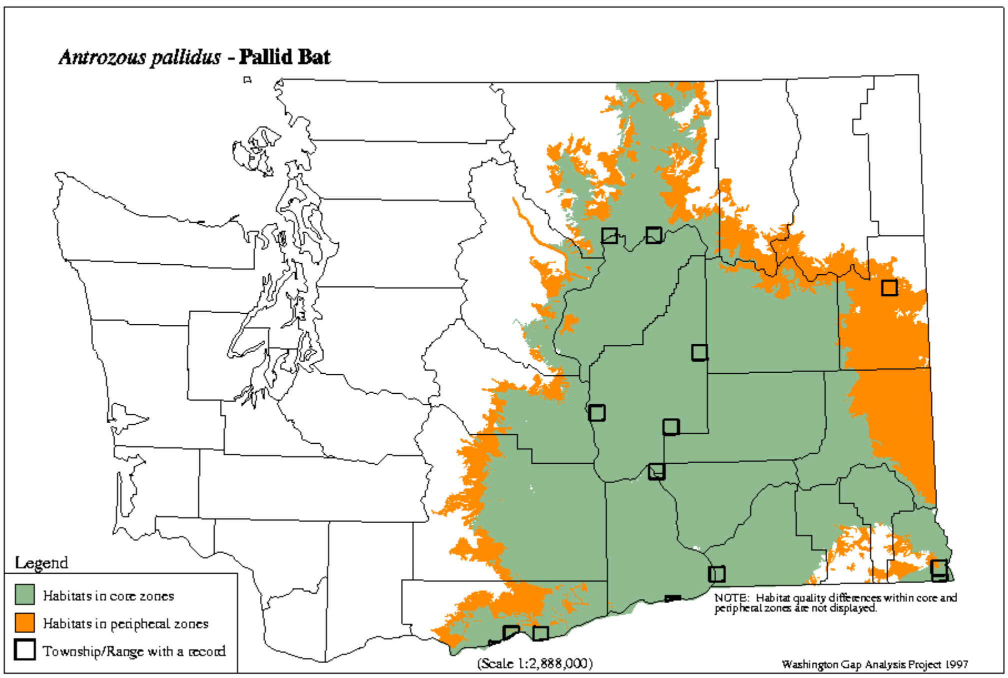

Figure 2. Potential range of the pallid bat (*Antrozous pallidus*) in Washington. Image from the Washington Gap Analysis Project, http://wdfw.wa.gov/conservation/gap/gapdata/mammals/gifs/anpa.gif

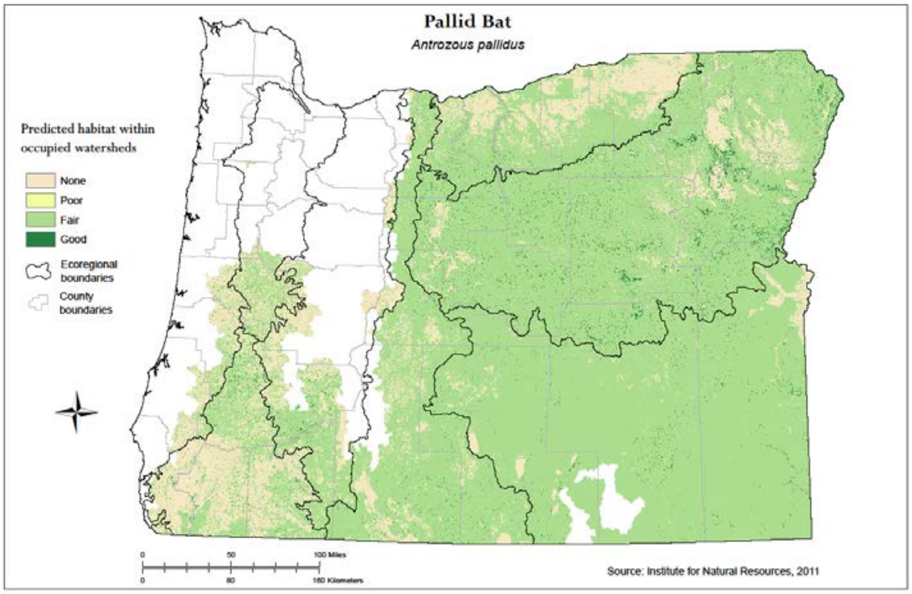

Figure 3. Potential range of the pallid bat (*Antrozous pallidus*) in Oregon. Image from Institute for Natural Resources 2011
http://oe.oregonexplorer.info/Wildlife/wildlifeviewer/?SciName=Mammalia&TaxLevel=order

Oregon, they occurred in the drier interior valleys (Verts and Carraway 1998). In southwestern Oregon, they have been captured in mixed conifer forests of Douglas-fir (*Pseudotsuga menziesii*) and western red-cedar (*Thuja plicata*) in lowland valleys (Cross and Waldien 1995, D. Clayton, *personal observation*). In the southern Oregon Cascades, they have been captured at elevations of 1600 m in mixed conifer forest (T. Kerwin, *personal communication*).

Roosting Habitat and Behavior

On a finer scale, the existence of suitable roost sites is a critical component of habitat for bats. Like many bat species, pallid bats utilize both day and night roosts. In addition, reproductive female pallid bats use maternity roosts. Usually night and day roosts are distinct although they may be in close proximity to each other (Hermanson and O'Shea 1983, Lewis 1993, 1994 but see Beck and Rudd 1960).

Choice of day roost varies depending on season and the reproductive status and sex of the bat. Day roosts are composed of both male and female bats until parturition. At that time, mature males leave the maternity roosts (Beck and Rudd 1960, O'Shea and Vaughan 1977).
Sites used for day roosts generally include rock cracks and crevices, caves, buildings, bridges, trees, and snags (reviewed in Ferguson and Azerrad 2004, Baker et al. 2008), and in one instance, a pile of burlap sacks in a barn (Beck and Rudd 1960). However, most often this species uses crevices and cracks in rocks or secondarily human structures throughout its range (Barbour and Davis 1969).

One documented exception was on the Rogue River-Siskiyou National Forest near Medford and Roseburg, Oregon. In this study, both male and lactating female pallid bats were found using snags as day roosts, and live trees were used as night roosts. Although rock crevices were available and also used, a majority of observations were of individuals using snags (Cross et al. 1996, D. Clayton, *personal communication*). Snags included ponderosa pines and oak species (*Quercus garrayana* and *Q. kellogii*, Cross et al. 1996).

There is some evidence that male and reproductive female bats do not overlap in their local ranges during the breeding season (Lewis 1996, Rambaldini and Brigham 2008, but see Baker et al. 2008). No studies have yet determined the extent to which this occurs, and whether the bats are spatially segregated regionally or simply using different roosts or habitats in the same area.

Day roosts used by maternity colonies are typically characterized by warm and stable temperatures (Vaughan and O'Shea 1976), which may help young bats develop and the mothers maintain lactation (Lewis 1993). Maternity roosts may shift in order to maintain an optimal thermal environment. In the John Day River region of Oregon, breeding female pallid bats roosted under horizontal rock slabs in cold weather and in vertical crevices in hot weather (Lewis 1996). In a study in Arizona, maternity roosts were found in thermally stable horizontal crevices, with a maximum recorded temperature of 31.5 °C and a range of 4 °C or less (Vaughan and O'Shea 1976).

Lactating females choose day roosts with consistently high temperatures for maximum development of their young, while pregnant females, non-breeding females and males choose cooler day roosts (Vaughan and O'Shea1976, Beasley and Leon 1986). Although yearling male bats are sometimes found in maternity roost sites, they typically do not use the same microsites as the lactating females and the young of the year (Beck and Rudd 1960). In southwestern Oregon, maternity roosts of pallid bats were also used by big brown bats (*Eptesicus fuscus*) and Mexican free-tailed bats (*Tadarida brasiliensis*, D. Clayton, *personal communication*).

Night roosts include shallow caves, cliff overhangs, cracks and crevices in structures such as bridges and buildings, and trees and snags (Hermanson and O'Shea 1983, Lewis 1994). Bats use night roosts for consumption of prey and to enter night torpor, usually in clusters of conspecifics (Hermanson and O'Shea 1983). Night roosts are characterized by easy access to flying bats but that offer shelter from wind and rain (Lewis 1994). They are also warmer and more thermally stable than ambient air (O'Shea and Vaughan 1977, Pierson et al. 1996). Bridges frequently meet these requirements and are used as night roosts.

In New Mexico, bridges constructed of timbers or concrete that had crevices were used by pallid bats, whereas bridges of steel or concrete I-beam construction that were smooth did not support roosts (Geluso and Mink 2009). However, wooden bridges in the Pacific Northwest are rarely used (Adam and Hayes 2000, P. Ormsbee, *personal communication*).

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 (Adam and Hayes 2000).

Pallid bats appear to form social groups that roost together (e.g., Lewis 1994). Individuals have unique and stable contact calls that are used at roost sites, which may facilitate roost-mate recognition and the maintenance of social groups through time (Arnold and Wilkinson 2011). Night roosts were used the least by lactating pallid bats, but they were heavily utilized by all bats in spring and fall, with up to 75% of the nocturnal activity period spent in the night roost (O'Shea and Vaughan 1977). In eastern Oregon, there was stronger fidelity to night roosts than to day roosts (Lewis 1994). Bats that roosted together at a night roost did not necessarily roost in the same day roost, and there appeared to be a social function because bats arrived at the night roost fairly early in the evening, and often arrived and departed in groups (Lewis 1994).

Female pallid bats in Oregon switched day roosts often, spending an average of 1.4 ± 0.7 days at the same roost before switching (Lewis 1996). Lactating females were as likely to move as pregnant bats, carrying their young to the new site, which was often less than 200 m from the previous day roost (Lewis 1996). Frequent roost switching prior to parturition and after young bats achieved flight was also noted in Arizona (O'Shea and Vaughan 1977). However, O'Shea and Vaughan (1977) reported high site fidelity to maternity roosts. Male bats roosting in the Okanagan Valley of British Columbia also switched day roosts every 4 ± 0.6 days (1-13 days range, Rambaldini and Brigham 2008). In the John Day Fossil Beds National Monument, pallid bats were found to utilize tall cliffs, and although they shifted roost sites frequently, they demonstrated fidelity to roosting areas (Rodhouse and Wright 2010).

Lewis (1996) found no correlation between day-roost switching and weather conditions or characteristics of the roosts themselves. Bats may switch roosts for a variety of reasons, including risk of predation, disturbance, parasites, acquainting young with roost locations, and response to changing roost conditions (O'Shea and Vaughan 1977, Lewis 1996).

Foraging Habitat

Pallid bats typically forage in open, uncluttered habitat with little vegetation at or within a few meters of the ground near suitable roosting sites. Although arid and semi-arid shrubland in proximity to rocky outcrops are considered primary habitat, studies of foraging bats have mostly occurred in dry forest environments. A number of studies describe these patterns of habitat use, which vary in relation to distribution of vegetation types of the region. In general, foraging occurs in open habitats with relatively little vegetation at or near ground level.

Foraging habitat in the Plumas National Forest of northern California included mixed conifer, white fir, wet meadows, montane chaparral, montane hardwood, ponderosa pine, grassland, montane riparian, and urban environments (Baker et al. 2008). In southern Nevada, pallid bats selected riparian woodland over riparian marsh, riparian shrubland, and mesquite bosque. However, the riparian woodland habitat had only sparse ground cover made up of grasses and small shrubs (Williams et al. 2006). Pallid bats in the Moses Coulee Reserve in central

Washington State foraged in shrub-steppe habitat but did not show strong selection for shrub-steppe over riparian vegetation (Rosier 2008). Sample sizes were small, however, and use of bat detectors may have underestimated the numbers of pallid bats present and their activity (Hayes and Willis 2013).

Although they are considered primarily a ground gleaner in shrub-steppe habitat, pallid bats forage in forested habitats in northern California, Oregon, and presumably Washington. In California, they have been observed foraging in mixed conifer forests (P. Ormsbee, *personal communication*). In Oregon, foraging pallid bats flew within the canopies of Douglas-fir trees and appeared to be gleaning insects there (D. Clayton, *personal communication*). They have been observed gleaning insects from grape vines (*D. Rambaldini to P. Ormsbee*, P. Ormsbee, *personal communication*). Pallid bats have also been observed in wind eddies at a cliff/forest edge in the Columbia River Basin, where the wind had apparently also trapped insects (P. Ormsbee, *personal communication*). Forest edge can also be valuable foraging and roosting habitat (P. Ormsbee, *personal communication*). Clearly, pallid bats' foraging behavior can be quite variable depending on circumstances and opportunities.

Foraging areas and roosts are typically in fairly close proximity to each other. Distances from foraging sites to day roosts of 0.5-1.5 km and distances from foraging sites to night roosts of <3 km have been reported primarily for reproductive females (Hermanson and O'Shea 1983, Lewis 1994). Researchers documented greater distances of 5-11 km between non-reproductive adults' day-roost sites and foraging grounds (Brown et al. 1997). There is some evidence that males and reproductive females do not share the same foraging ranges during the breeding season (e.g., Orr 1954, Beck and Rudd 1960, Vaughan and O'Shea 1976, Lewis 1994, Chapman et al. 1994, Brown et al. 1997, Morrell et al. 1999). However, differential habitat use has not been demonstrated other than by sex bias in captures.

Diet and Foraging Behavior

Pallid bats emerge from their roosts later than many other bat species, although the timing of emergence relative to sunset is variable. Orr (1954) reported that pallid bats emerged 45 minutes after sunset in June. On cool nights, some individuals may not emerge (O'Shea and Vaughan 1977). There are typically two activity periods bracketing a period of night roosting. The amount of time spent in the night roost or foraging prior to returning to the day roost varied seasonally (O'Shea and Vaughan 1997, Rambaldini and Brigham 2008). Less time was spent foraging in cooler weather, when there were fewer prey available and torpor was more frequent (O'Shea and Vaughan 1977). The number of bats per roost also declined in autumn, perhaps because food availability could not support the larger summer roosts (O'Shea and Vaughan 1977).

Pallid bats are opportunistic predators. One study documented wild arthropod prey from 4 classes, 13 orders, 25 families, and 34 genera (Lenhart et al. 2010). Prey taken in a laboratory setting included a variety of medium-large moths, orthopterans, chilopods, and neuropterans (Bell 1982). In the wild, they have been found to shift their diets throughout the seasons and geographically based on what prey are available (Rambaldini 2006, Lenhart et al. 2010). Jerusalem crickets (*Stenopelmatus* spp.) and scorpions (*Anuroctonus phaiodactylus*) were major prey items in California (Hatt 1923) and sphinx moths were also taken (Grinnell 1918 in Bell

1982). Other studies noted that orthopterans and coleopterans dominated the diet (Lenhart et al. 2010), but that pallid bats also took wind scorpions (Solpugida), moths (Lepidoptera), and flies (Diptera) as well as spiders, cicadas, and lizards (Johnston and Fenton 2001, Lenhart et al. 2010). General categories of prey are flightless, capable of flight but largely active on the ground, and organisms that may be capable of strong flight but that frequently land and sit on vegetation (O'Shea and Vaughan 1977). Pallid bats do not typically take prey that are in flight (Barbour and Davis, 1969, Bell 1982, O'Shea and Vaughan 1977). Although pallid bats are opportunistic feeders, they tended to take prey with a body length of 25-35 mm and 60-80 mm wing span when tested with a variety of potential prey species (Bell 1982).

Pallid bats are primarily ground gleaners. They forage by listening for audible noises made by prey on the ground, although echolocation is used for navigation during flight (Fuzessery et al. 1993). Pallid bats fly low to the ground (<10 m) and approach prey with direct, rapid flight, flying back and forth over prey items several times at low altitudes before landing next to the prey item and attacking it from the ground (Bell 1982). Pallid bats do not use either vision or echolocation while searching for prey on the ground (Fuzessery et al. 1993). Prey that are moving or calling from open areas are most vulnerable to predation (Bell 1982, Fuzessery et al. 1993). Pallid bats take prey such as scorpions, dobsonflies, and Jerusalem crickets that require special handling skills (Johnston and Fenton 2001). Presumably the young bats hunt with their mothers at first and learn critical foraging and handling skills. Pallid bats have demonstrated that they learn foraging techniques by observation of other bats in the laboratory (Gaudet and Fenton 1984).

Pallid bats frequently carry large prey to night roosts for consumption, where bats allow inedible parts of their prey fall to the ground. This allows identification of night roosts (Johnston and Fenton 2001, Lenhart et al. 2010) and also a rough idea of diet although soft-bodied prey or small insects that are consumed whole will not be represented (Johnston and Fenton 2001).

Pallid bats are opportunistic nectarivores of cardon cactus (*Pachycereus pringlei*) where the two species co-occur. Previously, it had been assumed that pallid bats visiting cardon flowers were gleaning insects attracted to the flowers, not consuming the nectar or at least doing so secondarily to foraging for insects (Herrera et al. 1993, Frick et al. 2009). Pallid bats consumed enough pollen and nectar during the spring bloom to temporarily alter their stable isotope ratios to fall halfway between nectarivorous and insectivorous bats (Frick et al. 2014). Pallid bats are more effective pollinators of cardon cacti than the specialized nectar-feeding lesser long-nosed bat, *Leptonycteris yerbabuenae*, delivering up to 8 times more pollen (Frick et al. 2013). Pallid bats are also now known to eat cardon cactus fruit (Aliperti et al. 2015), although seed dispersal has not yet been described. Whether pallid bats may participate in other such mutualisms in other parts of their range is not known.

Life History and Breeding Biology

Female pallid bats reach maturity and breed in their first year. Yearling males are not known to breed (Davis 1969). Spermatogenesis in male bats occurs in July-September (Beasley and Zucker 1984). Testes reach maximum size in late August to September (Orr 1954), although mating may occur into February (Barbour and Davis 1969). Female bats store the sperm prior to ovulating in April (Orr 1954, Hermanson and O'Shea 1983). In central coastal California, female pallid bats left winter roosts and formed a maternity roost 2 km from the overwinter roost in mid-April (Johnston et al. 2006). Wild bats in California gave birth in May or June (Orr 1954). Gestation is thought to be 53-71 days but the mother's body temperature affects fetal development (Orr 1954). Parturition in a given colony is far from synchronous (e.g., Beck and Rudd 1960, Brown 1976, Lewis 1993), and may be delayed in cool wet springs (Lewis 1993).

Litter size is typically two pups (Orr 1954, Bassett 1984) although yearling mothers often give birth to just one pup and appear to give birth later than experienced mothers (Davis 1969). Litter sizes of three have been reported in species accounts (e.g., Verts and Carraway 1998) and reports of three embryos have been published (summarized in Hermanson and O'Shea 1983), but no specific account of three pups clearly belonging to a single female were found (see also Barbour and Davis 1969). Although most female pallid bats breed in their first year, 11% did not breed as yearlings in a study in Arizona. Two-year-old females gave birth to twins 55% of the time, and this percentage increased as the mothers aged (Sidner 1997). Twinning has rarely been documented in the Pacific Northwest for any bats, including pallid bats (P. Ormsbee, *personal communication*).

Pallid bats may remain in the maternal roost for several days following birth, holding their young on their bodies during this time (Beck and Rudd 1960). After several days following parturition, mothers foraged for 20-30 minutes before returning to the roost, whereas non-lactating females might be absent from the day roost for up to 3 hours at a time (Beck and Rudd 1960). Young bats clustered together in their mothers' absence (Beck and Rudd 1960, Davis 1976). Although pallid bat mothers will carry their young to new day roosts, it is unlikely that the young are carried during foraging trips (Barbour and Davis 1969). It seems plausible that females might remove young in the middle of the night, not just before dawn, if a disturbance occurs and the females discover it.

Roost switching may confer a disadvantage on bats giving birth later in the season if maternity colonies tend to switch roosts more frequently as most young attain flight. Late-bearing mothers would then be forced to relocate their non-volant offspring more frequently to remain with their roostmates, incurring a substantial energetic and potential survival cost by doing so (P. Ormsbee, *personal communication*).

There are reports of pallid bats créching their young in a study of three roosts in California, where several young bats clustered together apparently under the protection of an adult female. In one instance, an adult female bat was found with 10 hairless young estimated to be less than a week old. Another colony contained a group of 10 young bats estimated to be 2 weeks old with two adult females, which quickly retreated. However, pallid bats only nurse their own young (Brown 1976). Female pallid bats in the laboratory would not retrieve or nurse a pup not their own, but in several trials, a female would investigate the calls of a distressed pup separated from its mother, return to the roosting females and emit a directive call next to the pup's mother. In two instances, the investigating female appeared to lead the mother to the pup (Brown 1976).

Young pallid bats are able to fly at about 6-7 weeks of age, when their forearms reach 50 mm in length (Orr 1954, Brown 1976). Weaning occurred in captivity several weeks after young bats could fly (Orr 1954, Brown 1976). Adult male bats begin roosting with the females and young again at this stage (Beck and Rudd 1960).

Pallid bats remain with their mothers through their first year (Beck and Rudd 1960, Brown 1976, O'Shea and Vaughan 1977). The occasional male bat found in nursery roosts is often the yearling offspring of one of the adult females (Beck and Rudd 1960, Sidner 1997). Russel Davis (*personal communication to P. Brown*, Brown 1976) suggested that maternity roosts formed by recruitment of females born in previous years into the roost as breeding females (Brown 1976). This hypothesis was confirmed in maternity roosts in Arizona (Sidner 1997), and could explain the apparent altruistic behavior noted by numerous researchers. Adult female bats showed strong philopatry to their natal roosts, even after mortality events such as road repair or vandalism killed many of the bats. However, an occasional adult female not born at the colony was found raising young in an established maternity colony (Sidner 1997).

Social behavior may be driven by physiological requirements such as thermoregulation. Pallid bats in loose clusters consumed less oxygen in the lab than when roosting alone (Trune and Slobodchikoff 1976), and they are most often found roosting in groups in the wild. Clusters of bats throughout the year typically number 20-200 individuals (Hermanson and O'Shea 1983). The mean group size of day-roosts of female pallid bats was 39.1 ± 25.4, with a range of 2-90 bats in eastern Oregon (Lewis 1996). Adult male bats have been found roosting alone during the summer (Brown et al. 1997), but they also have been found in groups of 60 animals in a day roost (Dalquest 1947) and over 100 individuals in a night roost. The bats were all males in these instances (Davis and Cockrum 1963) although non-breeding females will also roost with males.

Clustering is one response to environmental conditions, and torpor is another. The use of torpor occurs in both day and night roosts and by both young and adult bats of both sexes (e.g., Trune and Slobodchikoff 1976, O'Shea and Vaughan 1977, Rambaldini and Brigham 2008). Shallow torpor is used both during the day and at night if temperatures are cool, but the bats keep their body temperature well above ambient on cold nights. The use of torpor seemed to be highly individualistic under the same set of conditions (Rambaldini and Brigham 2008).

Non-breeding bats use torpor both during the breeding season and in spring and fall, and appear to choose roosts whose conditions support torpor. For example, pallid bats in Arizona used vertical rock crevices whose internal temperatures varied by 20 °C in the spring and fall (Vaughan and O'Shea 1976). Although researchers have reported finding an occasional lactating female in male summer roosts (Beck and Rudd 1960), these bats may have recently lost their pups. Lactation may continue for several weeks (Beasley and Leon 1986). Female bats that had lost their pups chose cooler microclimates in the laboratory than females with pups (Beasley and Leon 1986). If the females had recently lost pups, the change in roosting behavior would be consistent with what has been observed in the laboratory.

Torpor is also used under hot conditions, although behavioral responses are used as well. In a study of a pallid bat colony in an old barn in Solano County, California, researchers observed pallid bats moving out of their crevices and down the walls of the barn to remain in temperatures below 40 °C during the day. In the laboratory, pallid bats moved so that their tail was below 40 °C and their head was in a region of 36 °C (Licht and Leitner 1967b). *Myotis yumanensis* and

Tadarida brasiliensis mexicana were also present in the barn and seemed more tolerant of the heat than *A. pallidus*. Although cooler spots in the barn were present, bats did not elect to use them. The researchers suggested that based on observations of wild bats and experiments in the laboratory, there may be tradeoffs between roosting in cooler but more exposed sites and heat stress (Licht and Leitner 1967a, b).

In the laboratory, bats demonstrated hyperthermia at temperatures above 36 °C which conserved water, as bats use evaporative cooling. They maintained body temperatures of 40-41.5 °C without apparent stress, but became agitated and panted at body temperatures above 41.5 °C. Body temperatures above 43.5 °C were lethal (Licht and Leitner 1967b).

Consistent with their semi-arid range, pallid bats have a relatively high rate of urine concentration compared to bats found in more mesic habitats (Geluso 1978). Some individuals maintained body condition and mass on a diet of mealworms and no free water for a month in the laboratory, although ambient temperature was held below 25 °C (Geluso 1975). Compared to other species of desert-dwelling bats such as the spotted bat (*Euderma maculatum*), Townsend's big-eared bat (*Corynorhinus townsendii*), and fringe-tailed myotis (*Myotis thysanodes*), pallid bats were much more able to cope with water deprivation in the laboratory (Geluso 1978).

Pallid bats' overwintering ecology is not well described. They do not appear to migrate long distances as some species do, but reports of sudden appearances of bats for only a few weeks in October suggest that the animals stage between summer and winter roosts (Orr 1954). Overwintering strategies likely vary over the bats' geographic range, from short periods of torpor when conditions are not conducive to foraging to prolonged torpor in colder environments, as demonstrated in laboratory work (Orr 1954).

In California, pallid bats have been found in the winter at a variety of sites, including a crevice in a limestone quarry, an old cabin and buildings (Orr 1954). None of these sites would be suitable for extended torpor, suggesting that the bats maintain activity over the winter. In central coastal California, pallid bats were found to remain active throughout the winter on nights whose temperatures were >4 °C despite intermittent rain (Johnston et al. 2006). In this study, both males and females were found roosting together in an attic, although individual bats also utilized other day roosts nearby. These satellite roosts were not shared. These satellite roosts included trees in a riparian area, underneath a large rock, under a concrete outhouse foundation, and under a dry mop in a shed (Johnston et al. 2006). Individual bats emerged from day roosts intermittently every few days (Johnston et al. 2006).

Similarly, in New Mexico and Arizona, pallid bats were captured every month of the year in arid, low-elevation sites vegetated with pinion and juniper. More bats were captured on warmer nights, but the relationship between ambient air temperatures and numbers of bats captured was not strong. The temperatures at which pallid bats were captured were 5-18 °C (Geluso 2007). Pallid bats in southern Nevada were active at a spring year-round, although less so in fall and winter. They were netted at temperatures as low as -5 °C (O'Farrell et al. 1967, O'Farrell and Bradley 1970, Ruffner et al. 1979). Twente (1960) pointed out that few caves in Utah or southern Nevada would be cold enough for extended torpor, except at higher elevations. Whether bats undergo elevational migration in order to hibernate is unknown.

Very few hibernacula of pallid bats have been described. Crevices in the roof of an old mine tunnel at 4700 feet of elevation sheltered a colony of pallid bats three winters in a row in central Nevada. No other species of bat were found roosting in the crevices with the pallid bats (Alcorn 1944). Pallid bats found roosting in a small gypsum cavern of south-central Kansas used a crack in the ceiling of the cavern, where ambient temperature was found to be 10-12 °C (Twente 1955). Several of these individuals were banded in March, and relocated in a barn near Aetna, Kansas in May (Twente 1955).

It is not clear whether pallid bats in eastern Oregon and Washington migrate to more mild climates allowing intermittent activity, or whether they remain in extended bouts of torpor.

Movements and Territoriality

Very little is known of seasonal movements in this species, but several studies have used radio-telemetry to track the daily movements of pallid bats during the breeding season. Pallid bats remain in the same general area during the summer season, although they alternate day-roost sites, sometimes frequently. Their daily movements are timed to civil sunset in the summer, but patterns of movement change in autumn, when the animals may begin moving out of summer ranges.

Summer activity areas tend to be small. Based on a small sample of radio-tagged individuals, they varied by sex, and ranged from 1.56 km^2 (± 0.88 km^2 SE, n=6) for lactating females to 5.97 km^2 (± 2.69 km^2 SE, n=2) for post-lactating females (Baker et al. 2008). Two radio-tagged male bats foraged over an area of 4.12 ± 3.0 km^2. Individual bats flew over 5 km and up to an estimated 6.7 km between their roost and foraging sites (Baker et al. 2008). Other researchers have reported that "commuting" distances were typically less than 3 km (O'Shea and Vaughan 1977, Bell 1982, Johnston and Fenton 2001 cited in Baker et al. 2008) but another study documented that bats traveled distances of 5-11 km between day roosts and foraging areas in California (Brown et al. 1997).

Pallid bats do not appear to defend territories; no reports of aggressive behavior during foraging were found.

Population Trends

Little information was found on population sizes or trends of pallid bats in any part of their range. This species was once recorded as present west of the Cascades in the southern portion of the Willamette Valley (Verts and Carraway 1998) but extensive general surveys of bats conducted since then in that region have yielded no detections of pallid bats within the Willamette Valley. A single pallid bat was discovered in Lane County in the late 1990s (P. Ormsbee, *personal communication*).

Twinning may be less common in pallid bats in the Pacific Northwest than in more southern regions (P. Ormsbee, *personal communication*). This reduced reproductive output would need to be offset by higher survival rates in order for populations to be maintained. Lowered survivorship may occur for not only offspring born late in the season but also their mothers, who may be forced to carry their pups more often if maternity colonies begin to relocate more frequently later in the pup-rearing period when most young are volant (P. Ormsbee, *personal communication*).

Eight years of survey data from the Oregon and Washington Bat Grid monitoring effort were recently analyzed to establish conservation baselines for the region's bat species (Rodhouse et al. 2015). The Bat Grid was an omnibus effort, intended to survey for all bat species in Oregon and Washington. However, given the concern about potential rarity and detectability of pallid bats, the design of the Bat Grid was intentionally biased towards this species by doubling sampling east of the Cascades to specifically increase possible detections of pallid bats. Further, surveyors were instructed to seek out rock features and water bodies when present within the survey units because these habitat elements are associated with pallid bats (P. Ormsbee, *personal communication*). Despite this design, there were insufficient detections of pallid bats to create a distribution map. Estimated detection probability was extremely low, with a mean of approximately 0.1 and 95% credible intervals of approximately 0.0 to 0.2 (Rodhouse et al. 2015).

Pallid bats have been described as patchy throughout their range in Oregon and the Pacific Northwest, and although they seem to be locally abundant in some areas, they seem to either be declining or have disappeared from others (D. Clayton, *personal communication*, P. Ormsbee, *personal communication*). An omnibus survey such as the Bat Grid cannot distinguish between rarity and elusivity if data are too sparse (e.g., MacKenzie et al. 2006). More targeted monitoring of pallid bat habitat will be needed to raise detection rates, obtain enough data to create distribution maps, and detect regional trends.

Demographic studies were carried out with three maternity colonies in southeastern Arizona (Sidner 1997). This work confirmed that juvenile female bats remained with their natal colonies, with only occasional transient adult females noted. Annual survival varied with age. First-year survivorship for females was 0.46 ± 0.04 (n=20) while second-year survival was 0.66 ± 0.04 (n=19) and survival to the third year was 0.78 ± 0.04 (n=18). Survival rates dropped after the fifth year. In these colonies, only 10% of adult female pallid bats reached the age of 5 based on band returns (Sidner 1997).

Maternity roosts were marked by fairly stable numbers of adult females. One new colony grew from six females to a high of 119 adult females over the course of 12 years, primarily from the recruitment of females born into that colony in previous years (Sidner 1997). The three maternity colonies remained fairly stable over the course of a decade, although road repair and vandalism reduced one colony and ultimately destroyed another. Mean colony sizes were 66 ± 9.3, 33 ± 2.8 and 53 ± 5.4 bats (mean ± SE) respectively.

The record for longevity is 11 years for a male pallid bat, and 10 years for a female (Sidner 1997).

IV. CONSERVATION

Ecological and Biological Considerations

Pregnant and lactating female pallid bats are easily disturbed. They may vacate the roost if disturbed before giving birth, or move the pups within the roost if they have already been born (Beck and Rudd 1960). Although pallid bats may move nursery roosts fairly frequently (Lewis 1996), they do not always do so (O'Shea and Vaughan 1977). These roost sites may be limited in some areas, preventing the more typical switching behavior. Such sites are therefore particularly important for local conservation.

Bridges are used by pallid bats as night roosts and as maternity roosts. Bridge repair or replacement may modify bridge structure such that the crevices and other features used by the bats are eliminated (Geluso and Mink 2009). Bats used wooden roosting structures installed under flat-bottomed bridges in western Oregon, but were not found anywhere else on those bridges (Arnett and Hayes 2000).

Similarly, pallid bats have been documented using mines as both overwintering and night roosts (Alcorn 1944, Twente 1955, Hermanson and O'Shea 1985). Abandoned buildings also offer roosting opportunities (Orr 1954, Beck and Rudd 1960, Lewis 1994). Thus this species will use multiple types of anthropogenic structures.

Although this species is often associated with grassland or shrub-steppe habitat, pallid bats use other habitats for foraging as well, including dry forests such as ponderosa and oak. They also will use a variety of roost structures based on what is available, including large snags and live trees (Cross et al. 1995, Baker et al. 2008). This indicates a degree of flexibility in behavior and habitat use.

The probability of pallid bats' colonization of islands in the Gulf of California was affected by island isolation but less so than other bat species. Island area was more important than isolation in predicting likelihood of island colonization (Frick et al. 2008). This suggests that pallid bats may have better dispersal ability than some other bat species, even though they do not appear to undergo long-distance migrations.

Threats

Habitat loss

Direct loss of habitat from timber harvest, land conversion, mining, and development are major threats to the persistence of pallid bats. Development is a particular concern in foothill habitats and west of the Cascades as oak savannas continue to be lost to agricultural conversion and housing (P. Ormsbee, *personal communication*). Further loss of habitat may occur from invasive species, altered fire regimes, and climate change.

Although pallid bats typically roost in crevices in cliffs, buildings, or bridges, they roost in trees and snags in some parts of their range, including southwestern Oregon (Chapman et al. 1994, Cross et al. 1996, Baker et al. 2008). In these regions, timber harvest, hazard tree removal, and firewood cutting may all pose a threat to roost trees. Pallid bats also occasionally utilize caves and mines during the active season (Orr 1954, Howell 1980) and such features are used as hibernacula (Alcorn 1944, Twente 1955). Commercial mining may destroy hibernacula if abandoned mines that have been adopted by bats are reopened, or if they are closed without appropriate bat-friendly closures.

Demolition of abandoned buildings may also cause loss of maternity roosts in particular.

Bridge replacement may lead to the loss of roosts if the original structure is not replaced with a design offering the vertical structure needed by roosting bats (e.g., Pierson et al. 1996, Ferguson and Azerrad 2004). Bridges are well-documented as potential roost sites for pallid bats, including as maternity roosts (e.g., Davis 1969, Lewis 1994, Cross et al. 1996, Sidner 1997).

Habitat degradation

Land conversion for agriculture and other forms of development including large-scale energy projects may greatly reduce or eliminates the habitat value of those lands (e.g., Rambaldini and Brigham 2011). Pallid bats are not known to migrate and may be much less vulnerable to direct mortality than known migratory species such as the hoary bat (Arnett et al. 2008). Such projects may impact habitat quality for pallid bats by altering vegetation patterns and prey availability, and increased mortality could occur if wind projects are located near maternity roosts or hibernacula (Arnett and Baerwald 2013). However, conversion of native to non-native habitat from wind development that potentially reduces insect heterogeneity and increases fire risk is likely to negatively impact this species more than direct blade kills. Currently, there are no known kill records for this species (Arnett and Baerwald 2013, Johnston 2014).

Grazing in areas where pallid bats forage may reduce vegetative structural clutter and hence improve foraging habitat, but grazing could also reduce prey availability (Chapman et al. 1994). Grazing may also facilitate the spread of invasive plants, which may reduce prey availability or create conditions poorly suited for pallid bats. Road edges and roads themselves may offer foraging opportunities for pallid bats, but their low-altitude flight puts them at risk of vehicular collisions (Chapman et al. 1994).

Altered fire regimes may dramatically change vegetation composition and structure, rendering it unsuitable by removing roost trees and destroying the prey base. Similarly, invasive species may render habitat unsuitable, and in some cases, increase fire risk. Fire can significantly reduce foraging habitat and prey.

Pesticide use has been raised as a threat in the context of reducing prey availability, but there are no records of pesticides affecting pallid bats (Chapman et al. 1994). However, insecticides used in circumstances such as grasshopper outbreaks or for control of invasive insect species could affect prey availability. This is particularly true of insecticides such as *Bacillus thuringiensis kurstaki*, which are often touted for their low toxicity to non-target organisms but which can dramatically decrease insect prey. Use of herbicides to remove invasive species could lead to improved foraging habitat by increasing vegetative diversity and hence prey species diversity, and removing thick vegetation that may prevent foraging. Alternatively, herbicides may reduce food supply for invertebrates eaten by bats. Potential impacts of pesticides need to be evaluated on a case-by-case basis.

Climate change

Climate change has the potential to alter basic life-history patterns such as life-history phenology and overwintering behavior, create mismatches between predator and prey phenology (Jones and Rebolo 2013), and alter habitat through altered rainfall or temperature regimes. Fire and drought may bring dramatic changes to habitat and reduce water availability. In addition, altered ecological relationships and entire communities may result from the spread of some species' ranges while others contract. This may affect prey availability or spread of disease. Finally, genetic diversity may be disrupted as populations become isolated by changing conditions (Razgour et al. 2013).

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 (e.g., 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 (e.g., Michalak et al. 2014, Mote et al. 2014, Creutzburg et al. 2015). These changes may alter pallid bat distribution and abundance concurrent with changes in water and prey distribution and abundance, availability of newly suitable roost sites, and possibly altered winter ecology.

Disease

The disease White Nose Syndrome (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). How swiftly the disease will reach into the range of the pallid bat 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. Hibernation behavior may affect infection risk (Langwig et al. 2012). So too may the length of time spent in torpor; although bats infected in the laboratory manifested lesions 83 days after entering torpor, bats in the wild did not appear to show signs of infection until roughly 120 days into torpor (Lorch et al. 2011).

Other 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 (*Cornorhinus 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).

So little is understood of either the overwintering biology of pallid bats or their potential resistance to WNS infection that it is very difficult to assess the risk posed by WNS. However, the devastating consequences of this disease are so clear that great precautions should be taken to prevent its spread beyond its current range.

Disturbance

No information was found regarding the response of roosting bats to management activities that generated substantial noise, such as use of chainsaws, operation of heavy equipment, or blasting. However, pallid bats are easily disturbed while roosting, particularly in warm weather while the bats are not torpid (O'Shea and Vaughan 1977).

In regions where pallid bats rely on rocky outcrops to provide roost sites, disturbance from recreational activities such as rock climbing or caving may cause roost abandonment (O'Shea and Vaughan 1999). Human recreation and vandalism may force roost abandonment at particularly sensitive times in the species' life cycle. Bats are particularly vulnerable to disturbance during hibernation, when arousal from torpor costs critical energy stores at a time when food is not available. Less benign disturbance in the form of vandalism is a documented source of destruction of maternity colonies, for example in the case of a maternity colony under a bridge where females and their pups were killed by people shooting at them (Sidner 1997).

Research activities also have the potential for negative impacts. Bats were observed leaving night roosts in live ponderosa pine trees following human disturbance and did not return to the site where they were caught and radio-tagged while the radios were still transmitting (Chapman et al. 1994). These findings highlight the impact research can have on this species. Although one long-term research project did not cause abandonment of roosts despite daily disturbance during roost searches and occasional netting (O'Shea and Vaughan 1977, 1999), research that has included capture and banding, roost counts, and other disturbance has been linked to declines in bat populations (summarized in Ellison 2008).

Management Considerations

Northwest Forest Plan

Although only part of the range of the pallid bat in Washington and Oregon overlaps with the Northwest Forest Plan, the standards and guidelines may also 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 guidelines must be followed where the NWFP overlaps with the range of the pallid bat. These standards and 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" (USDA and USDI 2001: 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 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 (USDA and USDI 1994: C-41 to C-43). 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".

Management for recruitment and maintenance of large snags may benefit not only pallid bats, which have been documented using large snags extensively as roost sites in southwestern Oregon (Cross et al. 1996), but many other organisms as well. Although logging has not typically been identified as a threat to this species, the heavier reliance on tree roosts in southwestern Oregon suggests that snag and large-tree retention in areas slated for timber harvest may help pallid bats.

Habitat loss

The Northwest Forest Plan offers buffer sizes that are considered protective of bat roosts in areas subjected to timber harvest. If abandoned mines are considered for renewed extraction, careful and thorough evaluation of bat use first may prevent unintended destruction of important roost sites. Hibernacula are particularly poorly described for pallid bats and existing information is insufficient to identify potential overwintering sites based on characteristics alone.

If mines are to be gated or otherwise blocked to prevent human access, the techniques used should follow best practices as identified by Bat Conservation International for gates and other structures to allow continued access by bats and as little disruption to internal microclimates as possible. Bat Conservation International maintains several resources for managing mines and caves (http://twofivel.batcon.org/index.php/resources/for-specific-issues/caves-mines) including information on gates. Currently, the BLM contracts with Bat Conservation International to assess abandoned mines for bat use prior to closure and recommend appropriate closures. The BLM then uses these recommendations in closing the mines (R. Huff, *personal communication*).

Before demolition, buildings should be assessed to determine bat usage and importance. Buildings used as maternity roosts should be protected from disturbance and demolition. Nursery roosts may coexist with human activity in the same structure provided the roosts themselves are not disturbed and if continued use by the bats is not deemed a threat to the people. Abandoned buildings may require maintenance to retain characteristics that make them favorable for the bats if the roost is considered significant. Additionally, such buildings may need to be protected from vandalism or other disturbance. If a building determined to be important to pallid bats must be demolished, a similar structure may be provided close by to provide an alternate roost site. Specific guidance can be found in the memorandum referenced above and may be useful for guiding management outside of the NWFP boundaries.

Bridges that are replaced with structures lacking suitable crevices can be retrofitted with bat boxes to offer roosting locations to local bats (Arnett and Hayes 2000, see also the memorandum referenced above). If summer maintenance work must be done on bridges that serve as maternity roosts, bats should be excluded during maintenance and construction activities. Alternate habitat should be provided during the disturbance, and bridges can be retrofitted with bat boxes if the design may not support continued bat use (D. Clayton, *personal communication*).

Habitat degradation

Grazing should be monitored to ensure that vegetation heterogeneity and structure is maintained, both in the form of forage plant height and species diversity. Possible tools include lowering stocking rates, decreasing rotation times, or use of portable fencing.

Altered fire regimes may be inescapable with changing climatic conditions, but efforts to control invasive vegetation that increase fire risk and severity and to replace such species with native vegetation may help alleviate fire risk. Disturbed areas can be replanted with native vegetation before invasive vegetation establishes.

Invasive species may dramatically alter the vegetative component of habitat either by outcompeting native plant species and reducing structural diversity, or in the case of invasive invertebrates, by killing dominant native vegetation. In both cases, invasive species may lead to dramatically reduced habitat quality as well as altered fire regimes.

Protecting and restoring shrub-steppe habitat in the vicinity of rocky outcrops has the potential to benefit both pallid bats and other sensitive species such as sage grouse or pygmy rabbits. Actions may include road closures and removal, controlling encroaching juniper, and controlling non-native invasive species. Similarly, restoration and protection of remaining oak savanna and dry forest habitat west of the Cascades in Oregon will benefit multiple species.

Use of herbicides or pesticides in the course of either invasive species removal or restoration may be warranted, but potential for direct exposure to pesticides as well as loss of foraging habitat and prey base in the interim before new vegetation becomes established should be considered, particularly if the area is in close proximity to known roost sites. Impacts may be mitigated by conducting invasive species control and restoration activities in blocks designed to leave some foraging habitat undisturbed at any given time.

Climate change

As climate change brings increasing risk of fire and drought to much of western North America, management tools including supplementing water sources and construction of artificial roosts (Jones and Rebolo 2013) may be desirable in some locations. Because of the uncertainty in climate projections, managers will need to remain aware of changes in conditions and adapt management strategies as needed.

Water troughs may be an important source of water for pallid 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).

Disease
White-Nose Syndrome is a very serious threat to all bats in North America that undergo torpor. 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 on items such as equipment and clothing.

Little is known regarding the selection of hibernacula in this species, so decontamination 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. 2013, 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 for development to reduce disease transmission and disturbance risks.

Efforts to inventory, monitor and prepare for WNS in the Pacific Northwest are best focused on those habitats and bat species most susceptible to the fungus based on what can be inferred from regions of North America where WNS already occurs. Such efforts could overlap with habitat used by pallid bats, such as cave or mine sites (P. Ormsbee, *personal communication*).

Disturbance
Known maternity roosts should be left undisturbed while young bats are present, and hibernacula in particular should be protected because arousal from torpor is highly energetically expensive, and alternate suitable sites may not be readily available.

Disturbance from vandalism may be best managed by managing public access to known roosts, by not advertising the presence of the roosts and making the roosts difficult to reach through road or trail closures or removal. The difficulty of keeping the locations of sensitive sites from being posted widely on the internet may now be too great to consider secrecy a viable management alternative. General public education about the importance of bats, their roles in insect control, and lower risk of disease transmission if bats are left alone may help reduce risk of vandalism and disturbance, although it is unlikely to eliminate them. Preventing easy access combined with education may be the most effective management strategy for many roost sites.

The timing of bridge work may need to be adjusted to avoid disturbance or death of bats in maternity colonies (Sidner 1997). Surveying bridges during June and July in areas where pallid bats are suspected or known to breed will help identify possible conflicts before maintenance and repair work is scheduled.

V. INVENTORY, MONITORING, AND RESEARCH OPPORTUNITIES

Data and Information Gaps

The winter ecology of this species is poorly described, particularly the extent to which it may use long-term torpor in hibernacula in the northern extent of its range. Understanding the use of hibernacula and identifying their locations will be crucial to effective conservation and management, although obtaining this knowledge has proven intractable in the past. Likewise, little is known of how pallid bats may segregate by sex during the breeding season, which is also important in protecting key habitat features such as roost sites. Answering these questions may be aided by continued advances in radio-tagging and tracking technology.

The population dynamics of this species are essentially unknown.

Inventory and Monitoring

Clear inventory and monitoring objectives are critical before implementing any inventory or monitoring approach, particularly when there is potential to use methods that create disturbance for the targeted species. An extensive discussion and analysis of the efficacy of monitoring bat populations, particularly using roost sites such as caves and mines, for monitoring bats can be found in O'Shea and colleagues (2003). Identifying roost sites, particularly maternity roosts and overwintering roosts, will be a critical aspect of developing protective management strategies specific to these sites. A good example of this type of site monitoring is available on the Deschutes NF and their winter cave surveys. Data collection is a collaborative effort with the local caver association, and data is used to assess specific cave management strategies. Given the pallid bat's propensity to switch roosts frequently during summer, regular collection of guano can be an effective way to determine and monitor use trends at specific roosts with minimum disturbance to bats (P. Ormsbee, *personal communication*). Inventory of known roost sites can help in monitoring and conservation efforts by identifying sites for consideration of further management or protection. Collection of auxiliary data will be necessary to understand potential shifts in range and will require carefully formulated hypotheses and methodology. Without such information inferring causation for patterns of change will be nearly impossible.

Dynamic distribution models have been created for the region's bat species (Rodhouse et al. 2015). The eight years of data used in that effort did not detect any pallid bats west of the Cascade Range, and the species was so rarely encountered that predictive maps of occurrence could not be generated (Rodhouse et al. 2015). In addition, the models did not find evidence of an association between pallid bats and cliffs and canyons. This may have been a result of the very low estimated detection probability or possibly the broader niche-breadth in roosting substrates in pallid bats (Rodhouse et al. 2015). Another possible weakness of these studies is that lower-elevation sites were underrepresented (D. Clayton, *personal communication*, T. Kerwin, *personal communication*). Surveys that target lower-elevation suitable habitat in particular may help fill data gaps.

Pallid bats have been found to associate with cliffs and canyons in studies of their natural history, although not exclusively so (Vaughan and O'Shea 1976, Rabe et al. 1998), so the lack of association found by Rodhouse and colleagues (2015) may be a result of the sparse data used in the model. Further work on survey design to increase detection probability will be necessary in order to utilize dynamic distribution models for this species and to evaluate regional population trends. More targeted survey protocols that are currently being developed and tested may greatly enhance the detection probability and hence the value of monitoring data for this species (P. Ormsbee, *personal communication*).

The Plan for the North American Bat Monitoring Program, NABat (Loeb et al. 2015) is designed to focus on regional to range-wide scales. However, one goal of the program is to support more localized monitoring efforts with guidance and data management assistance. NABat also intends to facilitate the collection of more localized data such that it can be aggregated to support more broad-scale analysis. Monitoring efforts must be coordinated with NABat to produce the desired information and sharing information will allow adaptive monitoring approaches to be successful.

Research

There is some suggestion that pallid bats may be under-detected using acoustic surveys relative to captures (Hayes and Wiles 2013, D. Clayton, *personal communication*). Acoustic surveys are recommended for monitoring pallid bats in the NABat protocols (Loeb et al. 2015). Evaluating the extent of the detection bias and determining methods of improving detection probability will aid greatly in increasing the quality and hence the usefulness of monitoring data, particularly in light of recent low estimated detection probabilities using standard protocols (Rodhouse et al. 2015). For example, use of ultraviolet lights to attract insects also increased bat detections in New South Wales, Australia, and allowed better recordings of calls for identification (Adams et al. 2005). Unfortunately, this did not work well with pallid bats in a trial run (P. Ormsbee, *personal communication*), but efforts to modify and refine techniques to increase detection rates should continue.

Better information on how pallid bats respond to habitat disturbances will aid management and conservation efforts. For example, no data were found to guide management activities that generate noise or smoke in proximity to bat roosts. If such activities must be conducted near an active maternity roost or hibernacula, monitoring to document the bats' response may help guide future management decisions. Similarly, more information regarding the risks that wind-energy development may pose to pallid bats is needed. Research aimed at understanding seasonal movements of pallid bats may help in identifying whether there are common corridors of movement, and whether these movements occur in areas suitable for wind power.

Currently, there is insufficient genetic data to evaluate the degree of isolation of pallid bats in the Pacific Northwest from populations farther south. It is unknown if pallid bats in southwestern Oregon show genetic ties with populations of *A. p. pacificus* to the south, such as occurs with other taxa in the region such as Fisher (*Martes pennanti*, P. Ormsbee, *personal communication*). Genetic research may help determine whether these populations are indeed distinct, or whether sufficient gene flow exists to prevent population divergence.

Understanding the wintering ecology of pallid bats will be necessary to evaluate and manage risks posed by WNS and climate change. Research into how WNS could affect bats utilizing shorter periods of torpor between more extended periods of arousal will help assess the risk of this disease. Similarly, understanding the limits of the pallid bat's flexibility in diet and habitat use may help in understanding the limits of the species' ability to adapt to changing environmental conditions in the face of climate change.

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 refuges and forecast changes in bat distributions (Dawson et al. 2011, Jones and Rebolo 2013). Research to better understand how pallid bats 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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U.S. Department of Agriculture, Forest Service; U.S. Department of Interior, Bureau of Land Management. 1994a**.** 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].

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Appendix A: Protection for caves, mines, and abandoned wooden bridges and buildings

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: 37-38).

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: 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: C-41 to C-43).

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.

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].