Conservation Assessment for the Spotted Bat (*Euderma maculatum*) in Oregon and Washington

Jennifer Gervais

June 2016

Oregon Wildlife Institute

Interagency Special Status and Sensitive Species Program
USDA Forest Service Region 6, Oregon and Washington
USDI Bureau of Land Management, Oregon and Washington

Disclaimer

This Conservation Assessment was prepared to compile the published and unpublished information on the spotted bat (Euderma maculatum). 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: Spotted bat (*Euderma maculatum*)

Taxonomic Group: Mammal

Management Status: The International Union for Conservation of Nature (IUCN) lists this species as of least concern because it has a widespread distribution, occurs in protected areas, has large populations, and there is no evidence of population declines (Arroyo-Cabrales and Álvarez-Castañeda 2008). NatureServe (2015) lists the spotted bat as G3G4, or globally vulnerable to extirpation or extinction but apparently secure. The spotted bat is a State Monitored Species in Washington (Hayes and Wiles 2013). The Washington Natural Heritage Program lists the species as S3 in Washington, or vulnerable to extirpation (Hayes and Wiles 2013). The Oregon Biodiversity Information Center (ORBIC) ranks spotted bats as threatened with extirpation in Oregon (S2) but secure elsewhere (ORBIC 2013). The Oregon Department of Fish and Wildlife considers spotted bats as Sensitive Vulnerable (ORBIC 2013). The species is listed as Sensitive in Oregon by both the Forest Service and BLM.

Range: The known range of the spotted bat extends from the Okanagan Valley of British Columbia south through eastern Oregon and Washington to Montana and south through Wyoming, Colorado and New Mexico to the east and eastern California and Nevada to the west. The range extends south through north-central Mexico (Arroyo-Cabrales and Álvarez-Castañeda 2008). In Oregon, the species has been documented in Crook, Deschutes, Gilliam, Grant, Harney, Jefferson, Lake, Malheur, Morrow, Wallowa, Wasco, and Wheeler counties, representing 12 of 18 counties in the state with habitat most likely to support spotted bats (Ormsbee et al. 2010, Verts and Carraway 1998). In Washington, there are reliable records for Benton, Chelan, Douglas, Ferry, Grant, Kittitas, Lincoln, Okanogan, Pend Oreille, and Yakima Counties (Ormsbee et al. 2010).

Specific Habitat: Spotted bats primarily rely on crevices and caves in tall cliffs for roosting, which likely determine their distribution. They also have been documented night roosting in conifers and aspen, sometimes traveling long distances from day roosts to do so (Rabe et al. 1998, Ormsbee et al. 2007). Foraging habitat is variable, including marshes, meadows, riparian zones, shrub-steppe, and open ponderosa pine forest, across a gradient of low arid habitat to high-elevation mountain habitat (reviewed in Hayes and Wiles 2013). Hibernacula have not been described.

Threats: The primary threats to this species in Oregon and Washington are habitat conversion that compromises native floral heterogeneity and loss of water sources that in turn reduces insect diversity and drinking water. Specific mechanisms include grazing and fire that reduce shrub-steppe flora heterogeneity and introduce invasive species such as cheat grass. Both may dilute insect diversity including moths. Juniper encroachment reduces native open shrub-steppe and grassland used for foraging and surface water used for drinking. Energy-related development such as wind and solar installations reduce native habitat and degrade habitat through disturbance and introduction of invasive species. Urban expansion and encroachment of conifers into meadow systems remove foraging habitat. Climate change will likely have multiple effects on vegetation, prey abundance and distribution, fire regimes, and other factors, but particularly it is expected to reduce critical water sources in xeric habitats. Additionally, fire and logging in aspen and conifer groves associated with forest meadow systems may reduce habitat suitability in vicinities where this species is known or suspected. This is of particular concern in the John Day, Crooked, and Snake River systems in Oregon and the Okanogan Basin in Washington. Lesser threats include recreational activities such as rock climbing and commercial activities such as mining or quarrying of rock features that serve as roosts. Pesticide use may reduce prey availability, and environmental contaminants may result in toxic accumulation in bats. White-nose syndrome (WNS) may negatively impact spotted bats. Threats to this species are enhanced by its patchy distribution and possibly low numbers.

Management Considerations: Protecting and restoring native shrub-steppe habitat, especially in the vicinity of rock features, will benefit this and other species of concern such as sage grouse. Possible actions include reduction of grazing, removing or closing roads, protecting sensitive areas from additional road building, juniper removal in encroached areas, and re-establishing native vegetation. Energy development is most likely to impact spotted bats through habitat degradation rather than direct mortality. Protecting natural water sources and installing and maintaining water sources such as guzzlers and tanks in xeric habitats may help reduce impacts from drought related to climate change. Rock features where potential roosting habitat is likely to occur should be protected from recreation, mining, quarrying and other sources of disturbance or destruction. Protection and restoration of meadow systems and associated forest patches in areas where this species is known or suspected to occur will provide foraging and night-roosting opportunities. Efforts to inventory, monitor and prepare for WNS in the range of spotted bats in the Pacific Northwest are best focused on those habitats and species most susceptible to the fungus based on research in regions where WNS has already become established. Efforts to manage WNS may affect spotted bats to the extent that the species uses cave or mine sites identified as at risk from the disease.

Inventory, Monitoring, and Research Opportunities: This species has been consistently found to be more widespread than anticipated, and further surveying is likely to reveal as-yet undiscovered populations. A formal inventory and monitoring strategy to establish a baseline and detect future shifts in distribution and abundance of this species in Oregon and Washington is warranted. Because omnibus survey approaches such as The Bat Grid and NABat are ineffective tools for the spotted bat, targeted surveys for this species would be advised (P. Ormsbee, *personal communication*). More information is needed about all aspects of the spotted bat's life history, particularly whether it migrates out of the region in winter, and hibernacula locations and characteristics if the species remains. Identifying important roost sites for spotted bats and determining its distribution in Washington and Oregon will be a crucial first step to protecting key habitat features, but identifying characteristics of foraging habitat is also needed for the conservation of this species.

I. INTRODUCTION

Goal

Spotted bats are a widely distributed and rare to locally common species about which relatively little is known. The goal of this conservation assessment is to summarize existing knowledge across the range of the species to better inform management of spotted 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 spotted bat's range are also included. Despite the breadth of sources used, this assessment should not be viewed as complete. Relatively little is known about many aspects of the spotted bat's ecology and life history. New discoveries regarding its range, ecology, population dynamics, and life history will be made in the future. In addition, unpublished reports regarding occurrence, behavior, or life history are very likely to exist beyond what was found for this assessment.

Management Status

The International Union for Conservation of Nature (IUCN) lists this species as of least concern because it has a widespread distribution, occurs in protected areas, has large populations, and the lack of evidence of population declines (Arroyo-Cabrales and Álvarez-Castañeda 2008). NatureServe (2015) lists the spotted bat as G3G4, or globally vulnerable to extirpation or extinction but apparently secure. The spotted bat is a State Monitored Species in Washington (Hayes and Wiles 2013). The Washington Natural Heritage Program lists the spotted bat as S3 in Washington, or vulnerable to extirpation (Hayes and Wiles 2013). The Oregon Biodiversity Information Center (ORBIC) ranks spotted bats as threatened with extirpation in Oregon (S2) but secure elsewhere (ORBIC 2013). The Oregon Department of Fish and Wildlife considers spotted bats as Sensitive Vulnerable. The species is listed as Sensitive in Oregon by both the Forest Service and BLM.

II. CLASSIFICATION AND DESCRIPTION

Systematics

The species was first described by Allen in 1892 (Watkins 1977). It is a monotypic genus (Watkins 1977), a classification upheld by several genetics studies despite some early question regarding the genus *Idionycteris* (e.g., Tumlison and Douglas 1992, Bogdanowicz et al. 1998, Hoofer and van Den Bussche 2001). No subspecies are currently recognized (Simmons 2005).

Species Description

The spotted bat is striking in its markings and unlike any other North American bat. Its dorsal pelage is black with prominent white spots on each shoulder and at the base of the tail, with white at the base of the pinkish-red ears (Watkins 1977). The ventral pelage is white but the hairs have black bases (Verts and Carraway 1998). The ears are large, 45-50 mm from notch to tip when they are fully extended. There is no basal lobe on the tragus. The forearm is 48-51 mm including the elbow and wrist, the total length of the body is 107-115 mm, and the tail is 47-50 mm. The wings are attached to the base of the last caudal vertebrata. There is also a circular bare patch of skin 10 mm in diameter on the throat, which is not visible unless the head is extended (Watkins 1977). The ears are curled into “ram’s horns” when the bat is at rest or torpid (Constantine 1961).

Comparison with Sympatric Species

The spotted bat is unique and unmistakable among North American bats in its appearance. The echolocation calls are audible to the human ear, and are distinguishable from other species (e.g., Bogan et al. 1998: Appendix A), although there is substantial intraspecific variation (Obrist 1995).

III. BIOLOGY AND ECOLOGY

Range, Distribution, and Abundance

The current known geographic range of the spotted bat extends from the Okanagan Valley of British Columbia through eastern Oregon and Washington to Montana and south through Wyoming, Colorado and New Mexico to the east and eastern California and Nevada to the west. The range extends south through north-central Mexico (Arroyo-Cabrales and Álvarez-Castañeda 2008). In Washington, spotted bats are reported from Benton, Chelan, Douglas, Ferry, Grant, Kittitas, Lincoln, Okanogan, Pend Oreille, and Yakima Counties (Hayes and Wiles 2013 p. 74, Ormsbee et al. 2010, Figure 1). In Oregon, spotted bats have been found in Crook, Deschutes, Gilliam, Grant, Harney, Jefferson, Lake, Malheur, Morrow, Wallowa, Wasco, and Wheeler counties (Ormsbee et al. 2010, Figure 2).

There have been frequent reports in the literature that have extended our knowledge of the range of spotted bats by hundreds of kilometers as new locations for this species are discovered (e.g., Easterla 1970, McMahon et al. 1981, Perry et al. 1997, Pierson and Rainey 1998, O’Shea et al. 2011). It is highly likely that further refinements will continue to be made to our understanding of the distribution and occurrence of this species and further extension of range boundaries will follow.

Spotted bats have been found at elevations ranging from below sea level to over 3200 m (Reynolds 1981, Pierson and Rainey 1998). They are widely distributed among a variety of habitats. Suitable roost sites in tall, xeric cliffs appear to limit their distribution (see Habitat section below).

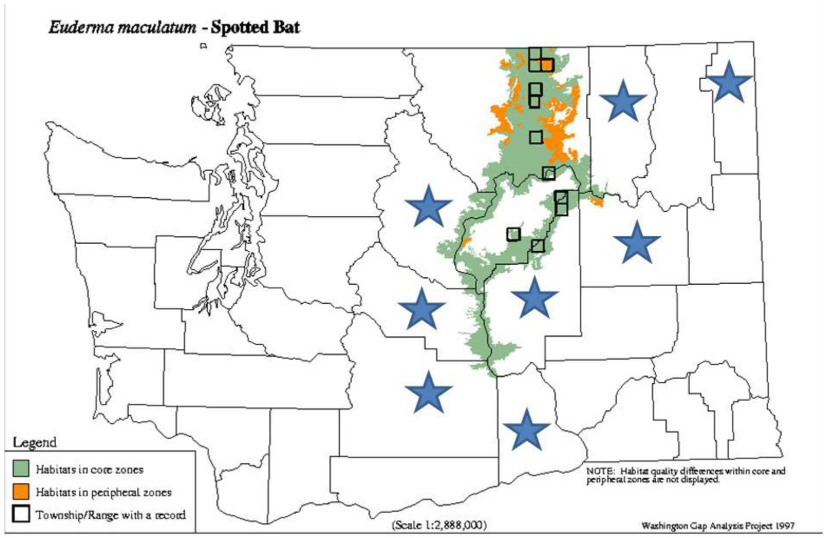

Figure 1. Potential range of the spotted bat (*Euderma maculatum*) in Washington and location of spotted bat occurrences based on museum specimens, research reports, and a compilation of reported sightings (Sarell and McGuinness 1993 in Johnson and Cassidy 1997). Since this range map was constructed, the species has also been documented in Ferry, Chelan, Yakima, Douglas, Pend Oreille, Kittitas, Lincoln, and Benton Counties (indicated by stars, Ormsbee et al. 2010). Image modified from Washington Gap Analysis Project (Johnson and Cassidy 1997)
http://wdfw.wa.gov/conservation/gap/gapdata/mammals/gifs/anpa.gif

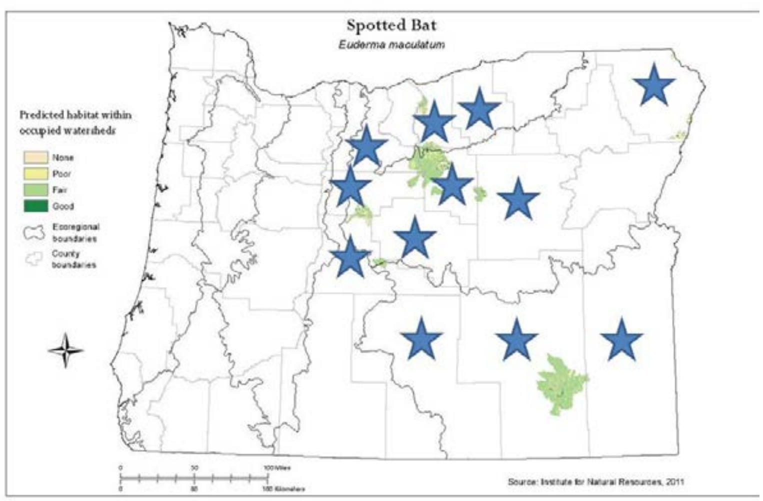

Figure 2. Potential range of the spotted bat (*Euderma maculatum*) in Oregon. Image from Institute for Natural Resources 2011
http://oe.oregonexplorer.info/Wildlife/wildlifeviewer/?SciName=Mammalia&TaxLevel=order This map does not reflect all documented occurrences of the species in Oregon. Since this this range map was constructed, the species has been documented in Crook, Deschutes, Gilliam, Grant, Harney, Jefferson, Lake, Malheur, Morrow, Wallowa, Wasco, and Wheeler Counties (Ormsbee et al. 2010), indicated by blue stars.

Spotted bats are usually described as uncommon even in regions where they are known to occur (e.g., Fenton et al. 1987, Morrison and Fox 2009, O'Shea et al. 2011). However, greater numbers have been found in some locations, such as the Okanagan Valley of British Columbia (Leonard and Fenton 1983), the North Kaibab and surrounding canyon country (Rabe et al. 1998, Chambers et al. 2011), Fort Pearce Wash, northern Arizona (Ruffner et al. 1979), and Dinosaur National Monument in Colorado (Navo et al. 1992, Storz 1995). This is also true of the most recent thorough survey published for Oregon (Rodhouse et al. 2005). Survey results likely reflect the limitations of the survey strategy for this species, confounding interpretations concerning rarity (P. Ormsbee, *personal communication*). Although they have been described as locally common, spotted bats never appear to be abundant (but see Priday and Luce 1999).

Habitat

Spotted bats use crevices in tall, sheer cliffs that are barren of vegetation. Foraging is conducted in open habitats nearby (summarized in Chambers et al. 2011). The importance of both these day roosts and the foraging habitat is underscored by the distances that spotted bats will travel (up to 43 km), and that they undertake elevational gains of up to 2000 m (e.g., Rabe et al. 1998, Siders et al. 1999, Chambers et al. 2011) in order to utilize both of these features daily. In one instance, bats shared commuting routes up side canyons to reach their foraging grounds (Chambers et al. 2011).

Female bats selected south-southwest facing cliffs during the breeding season, whereas male bats' roost orientation did not differ from random in northern Arizona (Chambers et al. 2011). Roosts were generally in the upper third of tall, vertical sandstone cliffs 130-850 m in height. In New Mexico, spotted bats were also noted in crevices located in the upper reaches of tall, south-facing cliffs (Bogan et al. 1998) although occasionally spotted bats have been found roosting within 10 m of the ground (Bogan et al. 1998). Similar roosting habitat was noted in Colorado, with signals of radio-tagged bats detected 10-15 m above the ground in the cliff faces (O'Shea et al. 2011). In the Okanagan Valley of British Columbia, roosts were found in east- and west-facing cliffs approximately 100 m in height (Leonard and Fenton 1983). No details of location of roosts on those cliffs were given. In eastern Washington, this species has been documented in communal roosts in cliffs and mines and heard or captured emerging from mines (Ormsbee et al. 2010).

Climbers in Arizona found a mummified spotted bat estimated to be 10,000 years old in a cave still being used by spotted bats (Mikesic and Chambers 2004). This suggests that suitable roosts are rare enough to be consistently utilized for many generations of bats, and are thus of considerable conservation value.

Foraging habitat is highly varied, and likely reflects any suitable open habitat available within commuting distance to the bats' roosts. Vegetation types used by foraging spotted bats are diverse, and moth availability and abundance are likely defining characteristics. In northern and high-elevation sites in Arizona, spotted bats have been repeatedly documented flying in subalpine meadows surrounded by ponderosa pine (*Pinus ponderosa*), aspen (*Populus tremuloides*), white fir (*Abies concolor*), and Douglas-fir (*Pseudotsuga menziesii*, Rabe et al. 1998, Siders et al. 1999, Chambers et al. 2011).

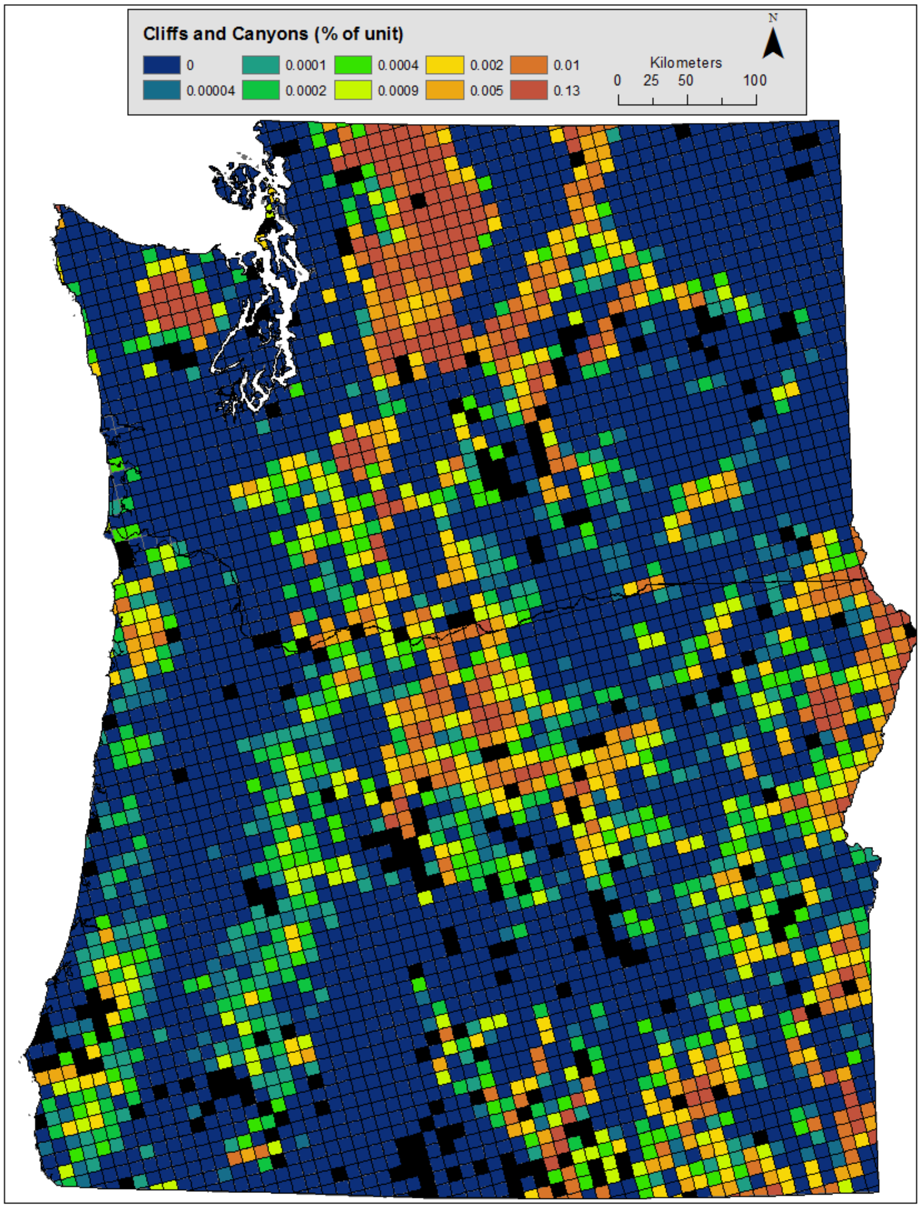

Figure 3. Map of cliff and canyon habitat in Oregon and Washington, indicating potential habitat for the spotted bat east of the Cascades. Image from Rodhouse et al. 2015, available from the Interagency Special Status/Sensitive Species Program (http://www.fs.fed.us/r6/sfpnw/issssp/species-index/fauna-mammals-bats-grid-monitoring.shtml).

This diversity is demonstrated throughout the spotted bat's range. In the White-Inyo mountain ranges of eastern California and Nevada, foraging spotted bats were heard in Mojave mixed desert scrub, Great Basin desert scrub, and pinyon-juniper forest (Szewczak et al. 1998). Elsewhere in California, spotted bats were found foraging on the edges of mixed conifer-hardwood habitat at 800-1500 m elevation. Lower-elevation sites included oak-conifer habitat made up of black oak (*Quercus kellogii*), ponderosa pine, and incense-cedar (*Libocedrus decurrens*) whereas higher elevation foraging sites included giant sequoias (*Sequoiadendron giganteum*), red fir (*Abies magnifica*), white fir, and lodge pole pine (*Pinus contorta*, Pierson and Rainey 1998). In all cases, foraging locations were within 10 km of tall cliffs (Pierson and Rainey 1998). The use of habitat adjacent to cliffs was also noted in north-central Wyoming, where bats were detected in rugged cliff habitat adjacent to juniper (*Juniperus scopulorum*), sagebrush (*Artemisia tridentata*), and grassland habitat (Priday and Luce 1999).

Presence of water is another common habitat characteristic, although distances from day roosts to nearest permanent water can be quite large. Distances of up to 18 km have been documented (Chambers et al 2011). Spotted bats are frequently caught in nets set up over cattle ponds and small water bodies, indicating their use of these features (e.g., Bogan et al. 1998, Geluso 2000, Chambers et al. 2011, O'Shea et al. 2011). Other studies noting foraging in proximity to water include work from Colorado, British Columbia, and Oregon.

In Dinosaur National Monument, Colorado, spotted bats foraged over the canyon river bottom, pinyon-juniper habitat, over sand and gravel bars, in riparian habitat, and over campgrounds (Navo et al. 1992, Storz 1995). Similar habitats were used in a riparian area in the Mojave Desert, although the riparian marsh and mesquite bosque were most commonly used (Williams et al. 2006). In the Okanagan Valley in British Columbia, spotted bats foraged over marsh habitat and in open ponderosa pine woodlands or in clearings adjacent to them (Woodsworth et al. 1981, Leonard and Fenton 1983, Wai-Ping and Fenton 1989). Clearings ranged from 0.84 to 20 ha in size, with bats moving 0.5-3 km between them (Woodsworth et al. 1981, Leonard and Fenton 1983). Interestingly, open areas without bordering ponderosa pine were not used (Leonard and Fenton 1983).

In eastern Oregon, spotted bats were found in the John Day, Deschutes, and Crooked River watersheds, foraging over irrigated fields, abandoned fields, and low upland slopes of juniper and sagebrush (Rodhouse et al. 2005). Use of hayfields was also noted in British Columbia (Leonard and Fenton 1983). In Washington, spotted bats were detected foraging over a golf course adjacent to the Columbia River (Gitzen et al. 2001). Although spotted bats have been associated with large rock features such as coulees and cliffs in Oregon and Washington, captures, sightings, and aural detections have occurred with equal frequency at water features ranging from small streams to large lakes (P. Ormsbee, *personal communication,* Ormsbee et al. 2010).

Choice of higher-elevation foraging areas in Arizona may not merely be selected because of prey availability, but also to reduce heat and water stress in lactating bats (Chambers et al. 2011). Lactating bats require far more water than non-reproductive females (Adams and Hayes 2008).

Diet and Foraging Behavior

Spotted bats forage principally on moths with body lengths of 5-12 mm reported (reviewed in Easterla and Whittaker 1972). This has been substantiated by studies of stomach contents (Easterla and Whitaker 1972) and stable isotope analysis of living bats (Painter et al. 2009). These moths are often in the family Noctuidae (Hayes and Wiles 2013). Spotted bats will also eat beetles occasionally (Easterla and Whittaker 1972). An observation that is often cited of a spotted bat diving to the ground to consume a grasshopper followed 24 hours in captivity without food intake (Poché and Bailie 1974). Given the circumstances, it is unlikely to be representative of typical foraging behavior.

Spotted bats locate relatively large prey over relatively long distances (Woodsworth et al. 1981). Echolocation calls of this species place an emphasis on 10 kHz, suggesting that the minimum size of a detectable prey item would be about 10 mm in diameter (Leonard and Fenton 1984). Examination of audiograms of moths suggested limited ability to detect spotted bats' echolocation calls (Woodsworth et al. 1981), making them vulnerable prey. Studies conducted on species of moths found in the Okanagan Valley of British Columbia determined that most local moth species' ears did not detect spotted bats' echolocation pulses until the bats were less than 1 m distant (Fullard and Dawson 1997).

Foraging patterns during the summer are fairly well-described. Spotted bats typically leave their roosts at or just before dark (Leonard and Fenton 1983, Wai-Ping and Fenton 1989, Chambers et al. 2011). They may feed on their way to their main foraging sites (Wai-Ping and Fenton 1989) or commute using fast, direct flight if the intervening landscape is relatively devoid of habitat for foraging (Chambers et al. 2011). Although foraging behavior of individual bats during the summer can be highly predictable in time and space (Woodsworth et al. 1981, Wai-Ping and Fenton 1989, Siders et al. 1999), this may depend on specific site characteristics (Rodhouse et al. 2005) and season as the foraging patterns changed over the period of spring to fall (Woodsworth et al. 1981, Leonard and Fenton 1983, Wai-Ping and Fenton 1989).

Within the main foraging area, spotted bats fly in elliptical patterns of 40-70 m to 200-300 m long axis at heights of 3-50 m above the ground, often within 20 m of forest edges (Woodsworth et al. 1981, Leonard and Fenton 1983, Wai-Ping and Fenton 1989, Storz 1995, Rodhouse et al. 2005). "Trap-lining", or repeated sequential visits to a series of meadows, has also been noted (Wordsworth et al. 1981, Rabe et al. 1998, Wai-Ping and Fenton 1989), although other studies found their foraging behavior to be unpredictable (Rodhouse et al. 2005).

Spotted bats in some regions and in some years foraged all night without roosting (e.g., British Columbia, Leonard and Fenton 1983, and Oregon, Rodhouse et al. 2005), whereas other studies in Arizona documented night roosting in trees near foraging areas (e.g., Rabe et al. 1998, Siders et al. 1999). This behavior may well be reflective of both energetic demands during lactation and the availability and abundance of prey. Spotted bats return to their day roosts at least an hour before sunrise (Siders et al. 1999, Rodhouse et al. 2005, Chambers et al. 2011).

Although there was some effect of season on the foraging behavior of spotted bats, moonlight, cloud cover, or light to moderate rain have not been noted to affect foraging activity (Leonard and Fenton 1983, Wai-Ping and Fenton 1989).

Life History and Breeding Biology

We still know little of the life history and breeding biology of spotted bats. The timing and location of mating behavior is unknown. Based on the few reports of either captive bats giving birth or dissection of post-partum females, spotted bats give birth to a single large pup approximately 20-25% of the mother's body weight (Findley and Jones 1965, Easterla 1971, 1976). Based on these data, and reports of captures of lactating females (e.g., Chambers et al. 2011), spotted bats give birth in early-mid June in the southern extent of their range, with a possible late June birth pulse in British Columbia (Wordsworth et al. 1981). Juveniles have been seen flying as early as late July (O'Shea et al. 2011). Juvenile bats appear to forage with their mothers at least initially (Bogan et al. 1998, O'Shea et al. 2011).

Some accounts indicate that female spotted bats do not form nursery colonies, but roost singly with their pups at this stage of their life cycle (Leonard and Fenton 1983, Rabe et al. 1998, Siders et al. 1999, Chambers et al. 2011). There are currently two reported exceptions (Bogan et al. 1998, O'Shea et al. 2011). Two radio-tagged juvenile bats were found roosting in south-facing high cliffs in small groups in New Mexico's Los Alamos Canyon (Bogan et al. 1998). The researchers reported that the bats changed their day roosts frequently. They were seen exiting roosts in small groups of up to 30 bats that could not always be counted accurately because of the roosts' heights and low light conditions. A crack 6 m from the canyon floor contained 5 bats in late August. In Mesa Verde National Park in Colorado, researchers identified roosts by following radio-tagged lactating females. They observed two roosts of 12 and 18 bats, respectively, emerging from crevices at the onset of darkness. Some of these bats were seen to emerge then circle, calling, until joined by a second bat. All individuals had dispersed 35 minutes after the first bat emerged (O'Shea et al. 2011). These roosts were 10-15 m from the ground. Bats may share the same crevice but roost separately within it (Chambers et al. 2011). No accounts to date suggest clustering behavior.

Very little is known of the overwintering behavior of this species. Spotted bats were captured in January and February in Fort Pierce Wash, Arizona, on nights with temperatures ranging from 0-6 °C (Ruffner et al. 1979). A spotted bat was found roosting from the ceiling of a warehouse in Albuquerque, NM in January three years in a row. The bat disappeared from the warehouse each year in mid-February. In the fourth year, a spotted bat was killed, and no further use of the warehouse was noted (Sherwin and Gannon 2005). This is some evidence for roost-site fidelity. Another spotted bat was found in a building in March (Geluso 2000). Spotted bats have not been found in any hibernacula of other species. Two spotted bats were recovered out of Lake Billy Chinook in Oregon a week apart in late winter of 2012 (P. Ormsbee, *personal communication*).

In eastern Oregon, spotted bats were active from May to mid-October, the entire interval in which surveys were conducted. Both auditory and mist-netting techniques were used (Rodhouse et al. 2005). However, a number of sites surveyed yielded single detections in August and September, and two radio-tagged males disappeared in late August, suggesting that spotted bats may begin moving into fall or winter habitat at this time (Rodhouse et al. 2005). Spotted bats may undergo elevational migration seasonally (Geluso 2000, Rodhouse et al. 2005, Sherwin and Gannon 2005, Hayes and Wiles 2013) although evidence to date is anecdotal.

Movements and Territoriality

A few studies have collected data from radio-tagged bats. Based on these studies, spotted bats forage alone and they may use the same foraging areas nightly (Woodsworth et al. 1981, Wai-Ping and Fenton 1989, Rabe et al. 1998). Individual spotted bats avoid temporal overlap when they use the same foraging areas (e.g., Wordsworth et al. 1981, Leonard and Fenton 1983, Storz 1995). Spotted bats presented with taped calls of foraging conspecifics circled the speakers and vocalized in what seemed to be aggressive displays (Leonard and Fenton 1984).

Only one study to date has estimated size of activity area. In northern Arizona's House Rock Valley, the 95% minimum convex polygon activity area was 297 ± 25 km^2 based on a minimum of 30 locations for four bats in late June to early August 2005. These locations were made within two weeks, and do not reflect potential seasonal shifts in activity area or home range use (Chambers et al. 2011). Individual bats appear faithful to foraging sites at least in summer (Woodsworth et al. 1981, Wai-Ping and Fenton 1989, Storz 1995, Rabe et al. 1998, Chambers et al. 2011), although movements to new foraging and roosting areas have also been documented (Chambers et al. 2011).

Spotted bats may undertake long nightly commutes to travel between suitable roost sites and foraging sites in summer. In Arizona, bats have been found roosting in the cliffs of the Grand Canyon and other canyons, and flying up to 48 km straight-line distance and climbing up to 2000 m elevation to reach subalpine meadows to forage (Rabe et al. 1998, Siders et al. 1999, Chambers et al. 2011).

Spotted bats, including lactating females, change day-roost sites at least occasionally in summer and may travel relatively long distances between them. A lactating female has been documented traveling to a new roost 14 km from her previous one, and a non-reproductive female traveled 30 km between day roosts (Chambers et al. 2011). However, 4 other lactating females did not move over the 10 days they were monitored (Chambers et al. 2011). Up to two roosts were used by each bat over nine days in New Mexico (Bogan et al. 1998), but 4 females tracked in the Okanagan Valley remained in the same day-roosts for up to 3 weeks, and the one female who did switch her roost did so only for one night (Wai-Ping and Fenton 1989). Four male bats captured at their roost as they emerged relocated to a new roost the following night, perhaps in response to the disturbance (Chambers et al. 2011). Young bats were also reported to change roosts frequently (Bogan et al. 1998).

Population Trends

No information was found for any aspect of the population ecology of spotted bats other than that they bear only one young a year (Findley and Jones 1965, Easterla 1971, 1976). Although Luce and Kenaith (2007) included a population model in their conservation assessment, the vital rates assigned to the life cycle were purely speculative. However, it is highly likely that spotted bat demographics are comparable to other cave- or crevice-roosting bats that raise only one pup. The population dynamics of spotted bats are completely unknown.

IV. CONSERVATION

Ecological and Biological Considerations

Spotted bats are highly dependent on vertical rock faces with appropriate cracks and crevices and little vegetation. Their roosts are often highly inaccessible and many are in protected areas (Chambers et al. 2011). Spotted bats utilize a wide variety of habitats and do not appear to congregate in a few vulnerable roosts as other vulnerable species of bats do. Although they have been found in desert habitat, the fact that they are often captured by mist nets set up over water suggests that they are dependent on free water availability. Maintaining conditions that support robust populations of moths in areas known to be used by foraging spotted bats is crucial to the conservation of the bats and may require active management of vegetation. Use of pesticides may affect spotted bats through altered community dynamics, particularly prey diversity and abundance. Herbicides may affect moth populations through changes in vegetative diversity and abundance and insecticides may have direct effects on prey abundance. Riparian zones can be degraded from overgrazing and the moth community impacted (Hammond and Miller 1998).

Direct mortality or reduced survival or reproduction from exposure to environmental contaminants either through bioaccumulation in prey or from polluted water sources may be a concern in some localities (e.g., Clark and Hothem 1991, Brasso and Cristol 2008).

Threats

Relatively few direct threats have been identified for spotted bats. The primary threat to this species in Oregon and Washington is loss or degradation of foraging habitat and resulting impacts on their prey, which can occur from logging, land conversion, development, invasive species, overgrazing, or altered fire regimes and other impacts from climate change. WNS is a potential threat as well. These and other threats are discussed in more detail below. Spotted bats may be more vulnerable than other species of bats because in addition to their patchy distribution, they rely on very specific roost sites, and their population sizes are apparently small.

Habitat loss

Direct loss of habitat such as water sources and roost sites from timber harvest, land conversion, mining or quarrying, and development are major threats to the persistence of the spotted bat. Habitat may be lost also from invasive species, spread of native species such as juniper in shrub-steppe systems that alter surface water availability, and conversion of native habitats through energy development. In Washington, much of the wind energy infrastructure is located in shrub-steppe habitat in the Columbia Basin (Hayes and Wiles 2013). Although this species is not among those that have been documented as suffering direct mortalities from wind turbine collisions (Arnett and Baerwald 2013), finding a rare species during ground surveys may be particularly challenging (Arnett et al. 2008). A greater risk is from habitat degradation both directly from development and indirectly by fostering invasive plant species that may not support native prey.

Fire and logging are a particular concern for forest-meadow systems and their associated aspen and conifer groves. Areas of concern include the Crooked, John Day, and Snake River systems in Oregon, and the Okanagan Basin in Washington (P. Ormsbee, *personal communication*).

Habitat degradation

Factors that reduce habitat suitability by reducing floristic diversity and thus potentially impacting spotted bat prey include grazing, fire, and invasive species that disrupt the native invertebrate community. Although currently registered pesticides are unlikely to pose a direct risk to spotted bats, use of pesticides in habitat restoration or against invasive species may impact bats through reduced prey abundance, particularly the use of pesticides such as *Bacillus thuringiensis kurstaki* (*Btk*) against invasive moths. However, herbicides also can alter prey base indirectly by affecting host plants of larvae.

Degradation of water sources from pollution or contamination may affect spotted bats indirectly through reduction in the abundance of prey species or directly through ingestion of contaminated water or prey (e.g., Clark and Hothem 1991, Brasso and Cristol 2008).

The degradation of foraging habitat may also occur through road building and other development, directly by removing native vegetation and indirectly through facilitation of invasion of native species.

Climate Change

Climate change brought about by global warming likely represents the greatest threat to spotted bats in Washington and Oregon. Phenology of insect prey may shift out of phase with the life history of the bats (Jones and Rebolo 2013). Fire and drought may dramatically alter vegetation communities and the biota that depend upon them, and reduce surface water availability. Drought has already been implicated in poor reproductive success in bats in New Mexico (Bogan et al. 1998) and Colorado (O'Shea et al. 2011). Lactating bats may require much more water than non-reproductive individuals (Adams and Hayes 2008).

Overall, availability of surface water may decline as western states experience more frequent droughts. Water availability will also decline as a result of lower snowpack, earlier spring melt, and earlier peak flows (e.g., Barnett et al. 2008). Loss of surface water is a threat to biological communities in general. In addition, temperatures themselves may influence suitability of habitat for spotted bats. Heat and water stress were hypothesized as a possible driver behind the dramatic daily elevational movements in spotted bats in Arizona (Chambers et al. 2011).

Some specific projections regarding the impacts of climate change on eastern Washington and Oregon suggest that under a range of scenarios, dry sagebrush steppe is likely to decrease and mesic shrub-steppe increase, potentially with further expansion of juniper (*Juniperus occidentalis*). Summers are projected to become hotter and drier (Michalak et al. 2014, Mote et al. 2014, Creutzburg et al. 2015). Winters will be warmer and rainfall is projected to increase in the non-summer months (Michalak et al. 2014, Mote et al. 2014, Creutzburg et al. 2015). Spotted bats may lose foraging areas and water sources closer to their roosts, increasing their energetic costs or potentially making regions unsuitable because commuting distances become too great.

Disease
White-nose syndrome (WNS), caused by the fungus *Pseudogymnoascus destructans*, represents a serious threat to all 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). The location of that bat in Washington is within an adjacent county to where spotted bats have been detected in the state. How swiftly the disease will reach into the range of the spotted 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 in that species that cluster tightly may facilitate the spread of the fungus (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 *Pseudogymoascus 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 overwintering behavior of spotted bats is essentially unknown. If spotted bats maintain their solitary roosting habit when torpid over the winter, or if they remain torpid for relatively short periods of time, they may suffer less mortality than species that cluster tightly during hibernation or remain torpid for an extended period over the winter (Lorch et al. 2011, Langwig et al. 2012).

Disturbance
Spotted bats may be sensitive to roost disturbance (Chambers et al. 2011). Cliff habitat may need to be closed to recreational activities such as rock climbing during critical months of the bats' life cycle. Winter roosts of this species are virtually unknown, but winter hibernacula of all species of bats are vulnerable to disturbance.

Mine closures may be a concern for spotted bats, but their overwintering habits are largely unknown. Spotted bats have been found at inactive mine sites during echolocation surveys (Morrison and Fox 2009), but no documentation of the specific use of mines was found in the western Great Basin. However, use of mines by this species has been documented in Washington in late summer and early fall (Ormsbee et al. 2010).

Management Considerations

The greatest threats to this species' persistence involve loss of habitat, including foraging habitat and water sources. This can occur both as a result of loss through conversion or resource extraction or degradation such that prey are no longer available. Spotted bats can be difficult to detect because of their patchy distribution, rarity, dispersed and inaccessible roosting sites, and the fact that they fly well above most mist nets. This will present particular challenges to determining species' presence in order to protect important habitat, and to monitoring.

Habitat loss

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

Protecting remaining shrub-steppe habitat within the range of the spotted bat and performing restoration activities in regions that are overgrazed or highly modified from either exotic or native invasive species may help this and other native species of concern. Specific actions may include using rotational grazing or reducing grazing to maintain floristic structure and diversity, removal of encroaching juniper, protection of existing surface water resources, replacement or supplementation of water sources with structures such as tanks or guzzlers, and restoration of native vegetation.

Maintenance of forest clearings near tall cliffs where spotted bats occur protects foraging habitat. This may require active management if fire or similar processes originally created and maintained the landscape structure.

Habitat degradation

Spotted bats specialize primarily on medium-sized to large moths. Maintaining moth populations may require utilizing rotational grazing or limiting grazing, habitat restoration using native seed following disturbance or removal of exotic species such as cheatgrass, and juniper removal. Control of outbreaks of either native or introduced moth species in areas where spotted bats occur should be carefully undertaken to avoid destroying the bats' food base. In particular, care must be taken with *Bacillus thuringiensis kurstaki*, which has toxicity specific to moth and butterfly larvae. This pesticide has been used for gypsy moths (*Lymantria dispar*), Douglas-fir tussock moths (*Orgyia pseudotsugata*) and western spruce budworm (*Choristoneura occidentalis*), and has been shown to affect non-target species (summarized in Hayes and Wiles 2013).This may be especially important during the breeding season and late summer, when young bats are just beginning to forage on their own. Herbicides used to control exotic vegetation may reduce prey availability by removing required larval host plants or food sources for adult moths.

Forest practices in areas where spotted bats are known or suspected to occur should be evaluated to ensure that prey habitat is maintained and the configuration of meadows or other foraging habitat is not altered. This includes stands of adjacent trees that may serve as night roosts.

Surveys for spotted bats in regions where wind development occurs near high cliffs will help evaluate risks of direct mortality from this type of energy installation.

Road closures or removals may be considered for foraging areas known to be used by spotted bats, and such areas may be better preserved by preventing road building if roads are not already present.

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

Climate Change

Other than suitable day-roost sites, water may be a critical limiting resource. Maintenance of surface-water resources, including artificial ponds or stock tanks, may be necessary as climate patterns shift. This may be particularly important in areas known to support reproductive females.

Water troughs may be an important source of water for spotted bats in locations where access to free water is limited. Water troughs and tanks whose surfaces are divided by fencing or modified with support bars may be detrimental to bats, because these modifications make it more difficult for the bats to drink, and more likely that a bat is knocked into the water (Tuttle et al. 2006). Actions that would reduce the risks that modified tanks pose to bats include adding escape structures to tanks and troughs that allow bats to climb out, orienting tanks along fences so that the wire bisects the tanks on the long axis to maximize flight access, and maintaining water levels near the lip of the tank or trough (Tuttle et al. 2006).

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

Disease

All protocols developed to limit the spread of WNS should be followed during all research and monitoring activities (https://www.whitenosesyndrome.org/topics/decontamination) and researchers should bear in mind the ability of this disease to spread rapidly into regions where it has not been previously documented 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. 2011, Hoyt et al. 2014b). Precautions should be taken regardless of season of entry. In addition, disturbance to hibernacula while they are occupied may greatly increase the impact of the fungus if it is present, and should be avoided if at all possible. Developing new protocols and techniques for remote monitoring (e.g., Schwab and Mabee 2014) should be a priority for development to reduce disease transmission and disturbance risks.

In addition, public outreach to cavers and other recreational groups who may enter caves to educate people of the risks of inadvertently spreading the disease may help slow the spread of the fungus.

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. Efforts to manage WNS may affect spotted bats to the extent that the species uses cave or mine sites identified as at risk from the disease (P. Ormsbee, *personal communication*).

Disturbance

Spotted bats may be sensitive to disturbance at their roosts (Chambers et al. 2011) and although roost-switching is documented, there appears to be fairly high roost-site fidelity in some areas (Wai-Ping and Fenton 1989), perhaps because of the lack of suitable alternative crevices. Day roosts of spotted bats are typically inaccessible, and often are in protected areas (Chambers et al. 2011). However, where recreational activities such as rock-climbing occur, ensuring that such activities do not disturb reproductive female bats in particular may be necessary in some locations. This may require seasonal closures of roads or selected areas. Outreach to cavers, climbers, and other recreationalists should be undertaken to raise public awareness of the presence of the bats and their vulnerability.

V. INVENTORY, MONITORING, AND RESEARCH OPPORTUNITIES

Data and Information Gaps

The overwintering ecology of this species is poorly understood. Although elevational migration seems likely to occur in the southern portions of the species' range, it is not at all clear what overwintering strategy is used by bats in the north, where severe conditions occur even at low elevations. Determining overwintering behavior, hibernacula, and winter ranges will be vital to ensuring the conservation of this species' important habitat and evaluating potential risks posed by mine closures, disease, and climate change.

The demographics of this species are virtually unknown, although likely comparable to other crevice-roosting bat species that raise a single pup a year. Therefore, this may be less of an immediate need than understanding seasonal movements and overwintering strategies.

Inventory and Monitoring

Extensive surveys specifically targeting spotted bats and their habitat have not been conducted in either Washington or Oregon, although some work has been done locally (e.g., Gitzen et al. 2001, Rodhouse et al. 2005, Hayes and Wiles 2013). Locating populations of bats during each stage of their life cycle will be a critical first step in monitoring trends. The surveys proposed by the Plan for the North American Bat Monitoring Program, NABat (Loeb et al. 2015) are primarily designed to focus on regional to range-wide scales, and may add information regarding the overall range and abundance of spotted bats. However, these surveys are designed for the active season and will not identify winter activity patterns or hibernacula. In addition, they are omnibus surveys that may not adequately cover the range of the spotted bat or address detection difficulties specific to this species.

Spotted bats have been consistently found to be more widespread than anticipated and further surveying is likely to reveal as-yet undiscovered populations. A formal inventory and monitoring strategy to establish a baseline and future shifts in distribution of this species in Oregon and Washington is warranted. Because omnibus survey approaches such as The Bat Grid and NABat are ineffective tools for adequately monitoring the spotted bat (e.g., Rodhouse et al. 2015), developing an alternate approach that targets this species more effectively and at relatively low cost would be advised (P. Ormsbee, *personal communication*). Follow-up to implement this type of survey strategy would improve baseline information for this species.

In addition, one goal of the NABat 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 specific to spotted bats should be coordinated with NABat to share information so that adaptive monitoring will be facilitated.

Spotted bats use echolocation calls that are very low in frequency (Leonard and Fenton 1984). These lower frequencies may be filtered in bat detection equipment to reduce background noise (Pierson and Rainey 1998). Ensuring equipment is set to adequately detect the echolocation calls of spotted bats may be necessary. In addition, some researchers concluded that detectors do not have the same distance of detection as the human ear, because the echolocation calls of spotted bats are of only moderate intensity (Woodsworth et al. 1981). These concerns may not be valid with modern equipment. Reported detection distances of 75 to 250 m by the human ear have been reported (Woodsworth et al. 1981, Leonard and Fenton 1983, Pierson and Rainey 1998). Determining the distance of detection for auditory surveys in a study area will aid in interpreting survey results. If spotted bat calls are indeed poorly detected with standard recording equipment and monitoring protocols, adjustments may be needed to increase detection probability.

Monitoring activities should also follow WNS precautions to avoid possible spread of spores. Any bats caught in mist nets can be scored according to the Reichard wing index (Reichard and Kunz 2009) as part of monitoring for WNS.

Research

Much of this species' life history is poorly understood. The overwintering ecology of spotted bats is essentially unknown, although overwintering strategies may vary throughout its range. Determining overwintering strategies, particularly whether the species migrates in Oregon and Washington, will be vital to protecting important habitat for all phases of the life history and assessing the risk posed by WNS. Use of acoustic surveys in winter may shed light on winter ecology (e.g., Schwab and Mabee 2014). The increasing sophistication and miniaturization of radio tags and other tracking technology will make gathering information on movements more feasible. The demographics and population dynamics of this species are also virtually unknown.

Identification of roost features in Washington and Oregon is a necessary first step to protecting these crucial features. Similarly, understanding key elements of foraging habitat will greatly aid in conservation efforts.

Modeling approaches such as ecological niche modeling may be helpful in identifying how bats might respond to changes in climate, allowing management to identify possible refugia and forecasting changes in bat distributions (Dawson et al. 2011, Jones and Rebolo 2013). Development of a solid monitoring protocol will be needed to collect the data required for such efforts. Research to better understand how spotted 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.

Acknowledgements

I thank Nancy Williams, Wildlife Biologist, Border Field Office, Bureau of Land Management, and Julie York, Wildlife Biologist, Sisters Ranger District, Deschutes National Forest, for their thorough comments on final drafts of this Assessment. Additional comments were provided by Rob Huff, Interagency Special Status/Sensitive Species Program (ISSSSP) Conservation Planning Coordinator, Kelli Van Norman, ISSSSP Coordinator, and Mark Penninger, Wildlife Biologist, Wallowa-Whitman National Forest. Pat Ormsbee, retired US Forest Service and BLM bat biologist, also provided a thorough, comprehensive review of the document and shared additional unpublished data. Her perspectives and knowledge were particularly valuable in the shaping of this document. Rob Huff, Interagency Special Status and Sensitive Species Program Conservation Planning Coordinator, coordinated the reviews and reviewed the document himself. The considerable knowledge and expertise provided by the reviewers helped make this Conservation Assessment a more useful and practical document.

VI. LITERATURE CITED

Adams, R. A., and M. A. Hayes. 2008. Water availability and successful lactation by bats as related to climate change in arid regions of western North America. Journal of Animal Ecology 77:1115-1121.

Alves, D. M. C. C., L. C. Terribile, and D. Brito. 2014. The potential impact of white-nose syndrome on the conservation status of North American bats. PLoS ONE 9:e107395.

Arnett, E. B., and E. F. Baerwald. 2013. Impacts of wind energy development on bats: implications for conservation. Pp. 435-456 in R. A. Adams and S. C. Pederson, editors. *Bat Evolution, Ecology, and Conservation*. Springer, New York, New, York, USA.

Arnett, E. B., W. K. Brown, W. P. Erickson, J. K. Fiedler, B. L. Hamilton, T. H. Henry, A. Jain, G. D. Johnson, J. Kerns, R. R. Koford, C. P. Nicholson, T. J. O'Connell, M. D. Piorkowski, and R. D. Tankersley, Jr. 2008. Patterns of bat fatalities at wind energy facilities in North America. Journal of Wildlife Management 72:61-78.

Arroyo-Cabrales, J. & Álvarez-Castañeda, S.T. 2008. *Euderma maculatum*. The IUCN Red List of Threatened Species 2008: e.T8166A12894424. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T8166A12894424.en . Accessed 29 September 2015.

Barnett, T. P., D. W. Pierce, H. G. Hidalgo, C. Bonfils, B. D. Santer, T. Das, G. Bala, A. W. Wood, T. Nozawa, A. A. Mirin, D. R. Cayan, and M. D. Dettinger. 2008. Changes in the hydrology of the western United States. Science 319:1080-1083.

Bogan, M. A., T. J. O'Shea, P. M. Cryan, A. M. Ditto, W. H. Shaedla, E. W. Valdez, K. T. Castle, and L. E Ellison. 1998. A study of bat populations at Los Alamos National Laboratory and Bandelier National Monument, Jemez Mountains, New Mexico. Los Alamos National Laboratory General Technical Report LA-UR-98-2418, Los Alamos, NM.

Bogdanowicz, W., S. Kasper and R. D. Owen. 1998. Phylogeny of plecotine bats: reevaluation of morphological and chromosomal data. Journal of Mammalogy 79:78-90.

Brasso, R. L., and D. A. Cristol. 2008. Effects of mercury exposure on the reproductive success of tree swallows (*Tachycineta bicholor*). Ecotoxicology 17:133-141.

Brooks, R. T. 2011. Declines in summer bat activity in central New England 4 years following the initial detection of white-nose syndrome. Biodiversity Conservation 20:2537-2541.

Chambers, C. L., M. J. Herder, K. Yasuda, D. G. Mikesic, S. M. Dewhurst, W. M. Masters, and D. Vleck. 2011. Roosts and home ranges of spotted bats (*Euderma maculatum*) in northern Arizona. Canadian Journal of Zoology 89:1256-1267.

Clark, D. R., Jr., and R. L. Hothem. 1991. Mammal mortality at Arizona, California and Nevada gold mines using cyanide extraction. California Fish and Game 77:61-69.

Constantine, D. G. 1961. Spotted bat and big-free-tailed bat in northern New Mexco. Southwestern Naturalist 6:92-97.

Creutzburg, M. K., E. B. Henderson, and D. R. Conklin. 2015. Climate change and land management impact rangeland condition and sage-grouse habitat in southeastern Oregon. AIMS Environmental Science 2:203-236.

Dawson, T.P., S. T. Jackson, J. I. House, I. C. Prentice, and G. M. Mace. 2011. Beyond predictions: biodiversity conservation in a changing climate. Science 332:53-58.

Easterla, D. A. 1970. First records of the spotted bat in Texas and notes on its natural history. American Midland Naturalist 83:306-308.

Easterla, D. A. 1971. Notes on young and adults of the spotted bat, *Euderma maculatum*. Journal of Mammalogy 52:475-476.

Easterla, D. A. 1976. Notes on the second and third newborn of the spotted bat, *Euderma maculatum*, and comments on the species in Texas. American Midland Naturalist 96:499-501.

Easterla, D. A., and J. O. Whitaker, Jr. 1972. Food habits of some bats from Big Bend National Park, Texas. Journal of Mammalogy 53:887-890.

Fenton, M. B., D. C. Tennant, and J. Wyszecki. 1987. Using echolocation calls to measure the distribution of bats: the case of *Euderma maculatum*. Journal of Mammalogy 68:142-144.

Findley, J. S., and C. Jones. 1965. Comments on spotted bats. Journal of Mammalogy 46:679-680.

Frank, C. L., A. Michalski, A. A. McDonough, M. Rahimian, R. J. Rudd, and C. Herzog. 2014. The resistance of a North American bat species (*Eptesicus fuscus*) to white-nose syndrome (WNS). PLoS ONE 9(12):e113958. Doi:10.1371/journal.pone.0113958.

Fullard, J. H., and J. W. Dawson. 1997. The echolocation calls of the spotted bat *Euderma maculatum* are relatively inaudible to moths. Journal of Experimental Biology 200:129-137.

Geluso, K. 2000. Distribution of the spotted bat (*Euderma maculatum*) in Nevada, including notes on reproduction. Southwestern Naturalist 45:347-352.

Gitzen, R. A., S. D. West, and J. A. Baumgardt. 2001. A record of the spotted bat (*Euderma maculatum*) from Crescent Bar, Washington. Northwestern Naturalist 82:28-30.

Hammond, P. C., and J. C. Miller. 1998. Comparison of the biodiversity of Lepidoptera within three forested ecosystems. Annals of the Entomological Society of America 91:323-328.

Hayes, G., and G. J. Wiles 2013. State of Washington Bat Conservation Plan. Washington Department of Fish and Wildlife, Olympia, Washington. 138+viii pp.

Hoofer, S. R., and R. A. van Den Bussche. 2001. Phylogenetic relationships of plecotine bats and allies based on mitochondrial ribosomal sequences. Journal of Mammalogy 82:131-137.

Hoyt, J. R., T. L. Cheng, K. E. Langwig, M. H. Hee, W. F. Frick, and A. M. Kilpatrick. 2014a. Bacteria isolated from bats inhibits the growth of *Pseudogymnoascus destructans*, the causative agent of white-nose syndrome. PLoS ONE 10(4):e0121329. Doi:10.1371/journal.pone.0121329.

Hoyt, J. R., K. E. Langwig, J. Okoniewski, W. F. Frick, W. B. Stone, and A. M. Kilpatrick. 2014b. Long-term persistence of *Pseudogymnoascus destructans*, the causative agent of white-nose syndrome, in the absence of bats. EcoHealth. Doi: 10.1007/s10393-014-0981-4.

Huff, R. *Personal communication*. 2015. Rob Huff is the Interagency Special Status and Sensitive Species Program Conservation Planning Coordinator, Region 6 Forest Service and Oregon/Washington BLM, Portland, Oregon.

Johnson, R. E. and K. M. Cassidy. 1997. Washington Gap Project Mammal Distribution Models, version 5. Washington Cooperative Fish and Wildlife Research Unit, Seattle, WA. http://naturemappingfoundation.org/natmap/maps/wa/mammals/WA_spotted_bat.html accessed June 2015.

Jones, G., and H. Rebolo. 2013. Responses of bats to climate change: learning from the past and predicting the future. Pp. 457-478 in R. A. Adams and S. C. Pedersen, editors. *Bat Evolution, Ecology, and Conservation*. Springer, New York, New York, USA.

Langwig, K. E., W. F. Frick, J. T. Bried, A. C. Hicks, T. H. Kunz, and A. M. Kilpatrick. 2012. Sociality, density dependence and microclimates determine the persistence of populations suffering from a novel fungal disease, white-nose syndrome. Ecology Letters 15:1050-1057.

Leonard, M. L., and M. B. Fenton. 1983. Habitat use by spotted bats (*Euderma maculatum*, Chiroptera: Vespertilionidae): roosting and foraging behavior. Canadian Journal of Zoology 61: 1487-1491.

Leonard, M. L., and M. B. Fenton. 1984. Echolocation calls of *Euderma maculatum* (Vespertilionidae): use in orientation and communication. Journal of Mammalogy 65:122-126.

Loeb, S. C., T. J. Rodhouse, L. E. Ellison, C. L. Lausen, and others. 2015. A plan for the North American Bat Monitoring Program (NABat). General Technical Report SRS-208. USDA Forest Service Southern Research Station, Asheville, NC. 100 pp.

Lorch, J. M., C. U. Meteyer, M. J. Behr, J. G. Boyles, P. M. Cryan, A. C. Hicks, A. E. Ballmann, J. T. H. Coleman, D. N. Redell, D. M. Reeder, and D. S. Blehert. 2011. Experimental infection of bats with *Geomyces destructans* causes white-nose syndrome. Nature 480:376-379.

Luce, R. J., and D. Kenaith. 2007. Spotted bat (*Euderma maculatum*): a technical conservation assessment. Report for the USDA Forest Service, Rocky Mountain Region, Species Conservation Project. http://www.fs.fed.us/r2/projects/scp/assessments/spottedbat.pdf (Accessed August 25, 2015).

Maher, S. P., A. M. Kramer, J. T. Pulliam, M. A. Zokan, S. E. Bowden, H. D. Barton, K. Magori, and J. M. Drake. 2012. Spread of white-nose syndrome on a network regulated by geography and climate. Nature Communications 3:1306.

McMahon, E. E., C. C. Oakley, and S. P. Cross. 1981. First record of the spotted bat (*Euderma maculatum*) from Oregon. Great Basin Naturalist 41:270.

Michalak J. L., J. C. Withey, J. J. Lawler, S. Hall, and T. Nogeire. 2014. Climate vulnerability and adaptation in the Columbia Plateau, WA. Report prepared for the Great Northern Landscape Conservation Cooperative. https://www.sciencebase.gov/catalog/item/533c5408e4b0f4f326e3a15e.

Mikesic, D. G., and C. Chambers. 2004. Return of the (bat) mummy: a desert cave preserves a 10,000-year-old spotted bat. BATS Magazine 22:4 (http://www.batcon.org/resources/media-education/bats-magazine/bat_article/65)

Morrison, M. L, and S. Fox. 2009. Bats associated with inactive mines in the western Great Basin. Western North American Naturalist 69:134-137.

Mote, P., A. K. Snover, S. Capalbo, S. D. Eigenbrode, P. Glick, J. Littell, R. Raymondi, and S. Reeder. 2014. Ch. 21: Northwest. In: J. M. Melillo, T.C. Richmond, and G. W. Yohe, Editors. Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program, 487-513. doi:10.7930/J04Q7RWX.

NatureServe. 2015. NatureServe Explorer: *Euderma maculatum*. Accessed October 2015. http://explorer.natureserve.org/index.htm

Navo, K. W., J. A. Gore, and G. T. Skiba. 1992. Observations on the spotted bat, *Euderma maculatum*, in northwestern Colorado. Journal of Mammalogy 73:547-551.

Obrist, M. K. 1995. Flexible bat echolocation: the influence of individual, habitat and conspecifics on sonar signal design. Behavioural Ecology and Sociobiology 36:207-219.

Oregon Biodiversity Information Center (ORBIC). 2013. Rare, Threatened and Endangered Species of Oregon. Institute for Natural Resources, Portland State University, Portland, Oregon. 111 pp.

Ormsbee P.C., L. Risdal, and A. H. Hart. 2010. The Bat Database: A compilation of bat species detections and related attributes spanning 1883 to 2010 collected in the Pacific Northwest.

Ormsbee, P. *Personal communication*. 2016. Pat Ormsbee is a retired bat specialist, Region 6 Forest Service and Oregon/Washington BLM, Portland, Oregon.

Ormsbee, P.C., J. Kiser, and S.I. Perlmeter 2007. The importance of night roosts to the ecology of forest bats. Pp. 129-152 in M. J. Lacki, J. P. Hayes, and A. Kurta, editors. Bats in forests: Conservation and Management. The John Hopkins University Press, Baltimore, Maryland.

O'Shea, T. J., P. M. Cryan, E. A. Snider, E.W. Valdez, L. E. Ellison, and D. J. Neubaum. 2011. Bats of Mesa Verde National Park, Colorado: composition, reproduction, and roosting habits. Monographs of the Western North American Naturalist 5:1-19. doi:10.3398/042.005.0101

Painter, M. L., C. L. Chambers, M. Siders, R. R. Doucett, J. O. Whittaker, Jr., and D. L. Phillips. 2009. Diet of spotted bats (*Euderma maculatum*) in Arizona as indicated by fecal analysis and stable isotopes. Canadian Journal of Zoology 87:865-875.

Perry, T. W., P. M. Cryan, S. R. Davenport, and M. A. Bogan. 1997. New locality for Euderma maculatum (Chiroptera: Vespertilionidae) in New Mexico. Southwestern Naturalist 42:99-101.

Pierson, E. D., and W. E. Rainey. 1998. Distribution of the spotted bat, *Euderma maculatum*, in California. Journal of Mammalogy 79:1296-1305.

Poché, R. M, and G. L. Bailie. 1974. Notes on the spotted bat (*Euderma maculatum*) from southwest Utah. Great Basin Naturalist 34:254-256.

Priday, J., and B. Luce. 1999. New distributional records for spotted bat (*Euderma maculatum*) in Wyoming. Great Basin Naturalist 59:97-101.

Rabe, M. J., M. S. Siders, C. R. Miller, and T. K. Snow. 1998. Long foraging distance for a spotted bat (*Euderma maculatum*) in northern Arizona. Southwestern Naturalist 43:266-269.

Reichard, J. D., and T. H. Kunz. 2009. White-nose syndrome inflicts lasting injuries to the wings of little brown myotis (*Myotis lucifugus*). Acta Chiropterologica 11:457-464.

Reynolds, R. P. 1981. Elevational record for *Euderma maculatum* (Chiroptera: Vespertilionidae). Southwestern Naturalist 26:91-92.

Rodhouse, T. J., M. F. McCaffrey, and R. G. Wright. 2005. Distribution, foraging behavior, and capture results of the spotted bat (*Euderma maculatum*) in central Oregon. Western North American Naturalist 65:215-222.

Rodhouse, T. J., P. C. Ormsbee, K. M. Irvine, L. A. Vierling, J. M. Szewcak, and K. T. Vierling. 2015. Establishing conservation baselines with dynamic distribution models for bat populations facing imminent decline. Diversity and Distributions 2015:1-13. DOI: 10.1111/ddi.12372

Ruffner, G. A., R. M. Poche, M. Meierkord, and J. A. Neil. 1979. Winter bat activity over a desert wash in southwestern Utah. Southwestern Naturalist 24:447-453.

Schwab, N. A., and T. J. Mabee. 2014. Winter acoustic activity of bats in Montana. Northwestern Naturalist 95:13-27.

Sherwin, R. E., and W. L. Gannon. 2005. Documentation of an urban winter roost of the spotted bat (*Euderma maculatum*). Southwestern Naturalist 50:402-407.

Siders, M. S., M. J. Rabe, T. K. Snow, and K. Yasuda. 1999. Long foraging distances in two uncommon bat species (*Euderma maculatum* and *Eumops perotis*) in northern Arizona. In Proceedings of the 4th Biennial Conference of Research on the Colorado Plateau, Flagstaff, AZ, 6-10 November 1997. USGS/FRESC Report Ser. USGSFRESC/COPL/1999/16. Pp. 113-122.

Simmons, N. 2005. Order Chiroptera. Pp. 312-529 in D. Wilson and D. Reeder, Editors. Mammal Species of the World: A Taxonomic and Geographic Reference, third edition, Volume 1. Johns Hopkins University Press, Baltimore, Maryland.

Storz, J. F. 1995. Local distribution and foraging behavior of the spotted bat (*Euderma maculatum*) in northwestern Colorado and adjacent UT. Great Basin Naturalist 55:78-83.

Szewczak, J. M., S. M. Szewczak, M. L. Morrison, and L. S. Hall. 1998. Bats of the White and Inyo Mountains of California-Nevada. Great Basin Naturalist 58:66-75.

Tumlison, R., and M. E. Douglas. 1992. Parsimony analysis and the phylogeny of the plecotine bats (Chiroptera: Vespertilionidae). Journal of Mammalogy 73:276-285.

Tuttle, S. R., C. L. Chambers, and T. C. Theimer. 2006. Potential effects of livestock water-trough modifications on bats in northern Arizona. Wildlife Society Bulletin 34:602-608.

Vertz, B. J., and L. N. Carraway. 1998. Land Mammals of Oregon. University of California Press, Berkeley, California.

Wai-Ping, V., and M. B. Fenton. 1989. Ecology of spotted bat (*Euderma maculatum*) roosting and foraging behavior. Journal of Mammalogy 70:617-622.

Washington Department of Fish and Wildlife, US Geological Service, and US Fish and Wildlife Service. 2016. News Release, March 31, 2016. Bat with white-nose syndrome confirmed in Washington state. http://wdfw.wa.gov/news/mar3116b/

Watkins, L. C. 1977. *Euderma maculatum*. Mammalian Species 77:1-4.

Williams, N. *Personal communication*. Nancy Williams is a Wildlife Biologist in the Border Field Office of the BLM,Spokane, Washington.

Williams, J. A., M. J. O'Farrell, and B. R. Riddle. 2006. Habitat use by bats in a riparian corridor of the Mojave Desert in southern Nevada. Journal of Mammalogy 87:1145-1153.

Wood, W. F., and J. M. Szewczak. 2007. Volatile antimicrobial compounds in the pelage of the Mexican free-tailed bat, *Tadarida brasiliensis mexicana*. Biochemical Systematics and Ecology 35:566-568.

Woodsworth, G. C., G. P. Bell, and M. B. Fenton. 1981. Observations of the echolocation, feeding behavior, and habitat use of Euderma maculatum (Chiroptera: Vespertilionidae) in southcentral British Columbia. Canadian Journal of Zoology 59:1099-1102.

Zukal, J., H. Bandouchova, J. Brichta, A. Cmokova, K. S. Jaron, M. Kolarik, V. Kovacova, A. Kubátová, A. Nováková, O. Orlov, J. Pikula, P. Presetnik, J. Suba, A. Zaradníková, Jr., and N. Martínková. 2016. White-nose syndrome without borders: *Pseudogymnoascus destructans* infection tolerated in Europe and Palearctic Asia but not in North America. Nature Scientific Reports 6:19829 doi:10.1038/srep19829