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Conservation Assessment for the Fringed Bat in the Black Hills National Forest South Dakota and Wyoming

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for the
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Dr. Cheryl A. Schmidt received her Ph.D. from Texas Tech University in 1995 under the direction of Dr. Robert J. Baker. She has conducted surveys of small mammals and bats, and worked on the ecology of these groups in South America, Mexico, the southwestern United States, Missouri, and the northern Great Plains, including the Black Hills region. Dr. Schmidt is currently an Associate Professor of Biology at Central Missouri State, an adjunct faculty member at Black Hills State University, and a consultant for BS Biological Services. In the summer of 2002 she began small mammal and bat inventories of National Park Service lands in the Northern Great Plains under a cooperative agreement between the National Park Service, the Rocky Mountain Research Station in Rapid City, SD and Colorado State University. She is a member of a team of biologists from South Dakota working with the SD Game Fish & Parks to develop a statewide management plan for bats. In addition, she is working with several groups in western South Dakota to develop research projects addressing foraging habitats and diet for bats in the Black Hills and other areas of western South Dakota.

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INTRODUCTION

This conservation assessment addresses the biology of the Fringed Bat (*Myotis thysanodes*) across its range in North America, with emphasis on its biology and conservation status in the Black Hills of South Dakota and Wyoming. The purpose of this assessment is to assimilate current knowledge about this species from various sources to provide an informed and objective overview of this species' status within the Black Hills. Primary literature (peer-reviewed scientific publications) was the main information source utilized and all sources are cited. However, to ensure as complete coverage possible, other sources such as reports submitted to various agencies such as the Black Hills National Forest and the South Dakota Game Fish and Parks, were examined and information used from these sources is cited so that the reader can individually assess the value of such information. Information from academic documents such as Masters Theses and Doctoral Dissertations was also considered and incorporated where appropriate, with full citations. Finally, government-operated websites such as those for South Dakota Game, Fish & Parks, were accessed to obtain current information not available from the aforementioned sources.

While there is some information for *Myotis thysanodes* from the Black Hills region, extrapolation about certain aspects of this bat's biology from other areas within its range was necessary. Where specific kinds of information were lacking for the Black Hills region, such information from other parts of its range was provided when available. Furthermore, even when certain aspects of this bat's biology are reported from the Black Hills region, information about variation in those aspects across the range of the species are included, to provide a comprehensive view of *Myotis thysanodes.*

CURRENT MANAGEMENT SITUATION

Management Status

Myotis thysanodes ranges across most of the western United States, extending northward into southcentral British Columbia, and southward into Chiapas, Mexico. A disjunct population of this species, recognized as a distinct subspecies, *Myotis thysanodes pahasapensis*, occurs in the Black Hills region of Wyoming and South Dakota and extends down into western Nebraska. The subspecies occupying the western United States, southcentral British Columbia, and northcentral Mexico *is Myotis thysanodes thysanodes*. The subspecies occupying Chiapas, Mexico is *M. t. aztecus*.

Existing Management Plans, Assessments, Or Conservation Strategies

No existing management plans, assessments, or conservation strategies have been found to date.

REVIEW OF TECHNICAL KNOWLEDGE

Systematics

Myotis thysanodes, is the only long-eared member of the genus *Myotis* (Family Vespertilionidae) with a distinctive fringe of visible hairs on the free edge of the uropatagium (Barbour and Davis

1969). This is a rather large *Myotis*, with external measurements for the species summarized as follows: length of head and body 43-59mm; length of tail 34-45mm; length of ear 16-20mm; length of forearm 40-47mm (O'Farrell and Studier 1980). *Myotis thysanodes pahasapensis*, the subspecies which occupies the Black Hills region, is characterized as a medium-sized subspecies with a long ear, short forearm, narrow skull, shallow braincase and attenuated rostrum (Jones and Genoways 1967). External measurements for *M. t. pahasapensis* are: total length 94.4±3.22mm; tail length 41.0±1.94mm; hind foot length 10.6±0.92mm; ear length 18.5±0.95mm; and forearm length 41.1±1.20mm (Turner 1974). Sexual dimorphism is presented by this species, with females having larger forearm lengths, and larger head and body (Williams and Findley 1979).

Dorsal and ventral pelage are not as distinctly bicolored as in many Vespertilionids, with color ranging from yellowish brown to reddish brown and darker olivaceous tones (Barbour and Davis 1969; O'Farrell and Studier 1980). Jones and Genoways (1967) reported that *M. t. pahasapensis* has greater contrast between dorsal pelage color and the color of the membranes (wings and interfemoral membrane) than expressed by *M. t. thysanodes*.

Myotis thysanodes is probably most easily confused with *Myotis evotis*. Jones and Genoways (1967) suggested that, in the Black Hills region, the smaller (usually shorter) ears, longer forearm, and substantial fringe of hairs on the posterior edge of the uropatagium of *M. thysanodes pahasapensis* should distinguish it from *M. evotis*.

Vernacular names for *Myotis thysanodes* include Fringed bat, Fringed Myotis, and Fringe-tailed bat (Barbour and Davis 1969; Jones and Genoways 1967).

Distribution And Abundance

Distribution Recognized In Primary Literature

Overall Range

Myotis thysanodes ranges across most of the western United States, extending northward into southcentral British Columbia, and southward into Chiapas, Mexico (O'Farrell and Studier 1980; Holroyd et al. 1994). A disjunct *population* of this species, recognized as a distinct subspecies, *Myotis thysanodes pahasapensis*, occurs in the Black Hills region of Wyoming and South Dakota and extends down into western Nebraska. The subspecies occupying the western United States, southcentral British Columbia, and northcentral Mexico *is Myotis thysanodes thysanodes*. The subspecies occupying Chiapas, Mexico is *M. t. aztecus*.

Local Distribution

In the Black Hills region, the fringed bat has been recorded from Custer County in South Dakota and Weston County in Wyoming (Jones and Genoways 1967). Turner and Jones (1968) increased the known distribution of *M. t. pahasapensis* to include Fall River and Pennington Counties of South Dakota. Turner (1974) reported the known elevation range of this species from the Black Hills to be between 1140m and 1860m (3800 - 6200 feet). Tigner and Aney (1994) reported location of a nursery colony of fringed bats in Meade County, South Dakota. Jones and Choate (1978) reported *M. t. pahasapensis* from Jackson and Lawrence Counties in South Dakota. Czaplewski et al. (1979) documented *M. t. pahasapensis* from Banner, Dawes and Sioux Counties of Western Nebraska. They also reported that one bat captured 1.6km (1mi) south and 28.8km (18mi) east of Valentine in Key Paha County, Nebraska was identified as *M.t.*

pahasapensis before escaping. The authors did not treat this capture as documentation of occurrence of this species due to lack of a specimen (Czaplewski et al. 1979). Clark and Stromberg (1987) indicated known localities of *M. thysanodes pahasapensis* from Weston, Platte, Laramie and Albany Counties of Wyoming and assume a range that includes surrounding counties along the border with South Dakota.

Additional Information From Federal, State, And Other Records

The South Dakota Natural Heritage Program (2002) reports localities of this species in Lawrence County of South Dakota, in addition to the above South Dakota counties. Wyoming Game and Fish Department (Luce et al. 1999) reports *M. thysanodes* from latilongs 7, 14, 21, and 28 which appear to include Crook, Weston, Niobrara, Goshen and Laramie Counties, as well as latilongs 5, 6, 19 and 23 which appear to include Sheridan, Johnson, Campbell, Matrona, Albany and Sweetwater Counties. It should be noted that bats from latilong 23, Sweetwater County, may be *M. t. thysanodes*, instead of the Black Hills subspecies.

Estimates Of Local Abundance

The South Dakota Natural Heritage program lists *M. thysanodes* as S2, with a state rank of S2 indicating that the species is considered imperiled because of rarity (6-20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extinction throughout its range. Wyoming Game and Fish lists this species as a Species of Special Concern (SSC2; Luce et al. 1999). While these are not specific estimates of local abundance, in lieu of any such estimates in the known literature, they serve as indicators of the perceived abundance of this bat in the region. Colorado and Montana officially list this species as rare (Clark and Stromberg 1987).

Habitat Associations

Myotis thysanodes occupies a variety of habitats including mid-elevation desert, grass and woodland habitats, and is found at higher elevations in spruce-fir habitat and in mixed timber of ponderosa pine, white spruce and aspen (Clark and Stromberg 1987; Wild 1974; Jones 1965; O'Farrell and Studier 1980).

Roosting Ecology

Maternity Roosts

While *M. thysanodes* has been reported to roost in caves, mine tunnels, and buildings, the only maternity colonies of this species which have been studied occurred in buildings (O'Farrell and Studier 1973; Tigner and Aney 1994) and caves (Baker 1962). O'Farrell and Studier (1973) reported a detailed study of the use of a seminary attic in New Mexico as a maternity roost by this species. The attic of this seminary building was relatively open, with a high ceiling which provided a range of microclimates among which the bats could and did move throughout the maternity period (O'Farrell and Studier 1973). Tigner and Aney (1994) reported that the attic used as a maternity colony in the northern Black Hills was also large and open. O'Farrell and Studier (1973) reported that only one adult male was ever observed in the maternity colony, and that was early in the season (18 April).

Rabe et al. (1998) reported characteristics of ponderosa pine snag roosts used by five species of reproductive bats, including *M. thysanodes*, on the Coconino National Forest in northern

Arizona. While this study did not specifically address snag roosts used by fringed bats, but grouped snags used by all five species, in lieu of species-specific information about tree roosts used as maternity colonies, the information should be considered for *M. thysanodes.* The following is a bulleted summary of the findings of Rabe et al. (1998):

-Roost snags were larger in dbh than random snags.*

-Roost snags had more loose bark than random snags.*

-Roost snags sites were characterized by

1) higher tree densities,

2) greater tree species diversity,

3) greater basal area,

4) higher density of snags* and logs,

5) greater slope, and

6) closer to water than random snag sites.

(*Indicate the three most important characteristics.)

Cryan (1997) reported on roost sites of 6 lactating females in the southern Black Hills of South Dakota. These bats were found roosting in rock crevices of rocky ridges and steep-walled canyons in areas with relatively high snag densities. Rock crevices used by reproductive fringed bat females typically faced southeast or southwest, were at lower elevations, and occurred in the ecotone between oak/juniper and ponderosa pine forests. Cryan et al. (2001) reported that two lactating females were found roosting in cavities and cracks of the trunks of ponderosa pine snags (rather than beneath exfoliated bark) with a mean decay stage of 6.9 $\pm$ 0.2 (*sensu* Thomas et al. 1979), mean dbh of 43.3 $\pm$ 12.1cm, and mean height of 6.9 $\pm$ 6.3m.

Hibernacula

Relatively little is known about the requirements for hibernation by this species. Turner and Jones (1968) reported two hibernating M. thysanodes pahasapensis in a cave in Pennington Co., where the ambient temperature in the cave was approximately 5oC. Martin and Hawks (1972) reported that *M. thysanodes* was found hibernating primarily in the “Heavenly Room” of Jewel Cave, in the Black Hills of South Dakota, and that the fringed bats tended to isolate themselves from other species hibernating in the same cave room. They also reported that this species tended to hibernate in a head-up position, clinging with both the hind feet and the thumbs, with the forearms slightly spread out. In concurrence with the findings of Martin and Hawks (1972), Arita (1993) classified this species as a “segregationist,” preferring caves or rooms in caves occupied by few bats species. Arita (1993) also reported that, in Mexico, *M. thysanodes* was usually present at hibernacula in low population sizes (usually <100 individuals).

Summer (Day) Roosts (Of Males And Non-Reproductive Females)

Pearson et al. (1952) reported that caves, mine tunnels and buildings may all be used as day roosts by *M. thysanodes*. Holroyd et al. (1994) indicated that this species may also use rock crevices as day roosts and this was supported by the work of Cryan (1997) which reported the use of rock crevices by two male *M. thysanodes* in the southern Black Hills.

Weller and Zabel (2001) characterized day roosts of M. thysanodes in a Douglas-fir forest of northern California. The remainder of this paragraph is a summary of their findings. They identified a total of 52 day roosts in 23 different trees, all of which were snags (20 Douglas-fir, 2 sugar pine, and 1 ponderosa pine). Bats were observed to emerge both from beneath exfoliating bark and from broken tops of the snags. Mean snag dbh was 120.8 $\pm$ 5.3cm, mean snag height was 40.5 $\pm$ 2.9m, mean snag density was 10.8 $\pm$ 0.9 snags/0.1ha. Probability of use of a snag increased with height of snag relative to canopy height. Decay class 2 and 3 snags (sensu Cline et al. 1980; Class 2 and 3 snags usually had broken tops, few branches, and sloughing bark) were used as roosts disproportionate to their availability in both roost plots and random plots.

Night Roosts

Pearson et al. (1952) reported that caves, mine tunnels and buildings may all be used as night roosts by *M. thysanodes*. Holroyd et al. (1994) indicated that this species may also use rock crevices as night roosts. Adam and Hayes (2000) examined the use of different types of bridges as night roosts by bats, including *M. thysanodes*, in the Oregon Coast Range. Of the bridge types examined (concrete cast-in-place with chambers on underside, concrete flat-bottom, I-beam with concrete or steel girders, and wooden), bats primarily used the concrete cast-in-place bridges as night roosts, probably because the chamber walls restricted airflow thereby conserving heat (Adam and Hayes 2000). Bat use of these bridges as night roosts peaked between 0300 and 0430h, with bats generally departing before 0600h, indicating that they were not used as day roosts (Adam and Hayes 2000).

Interim Roosts

No literature was found which provided information on the use of interim roosts by this species.

Foraging Habits

Holroyd et al. (1994) reported *M. thysanodes* in British Columbia foraging over thick *Scirpus* along the edge of a lake, and along the heavily vegetated edges of a creek in a valley bottom. Seidman and Zabel (2001) examined bat use of intermittent stream habitat in northwestern California. They reported that *M. thysanodes* was captured more frequently along large (mean channel width of 7.0 $\pm$ 1.2m) intermittent streams, than along medium (mean channel width of 1.9 $\pm$ 0.0m) or smaller intermittent streams or in proximal upland habitats (Seidman and Zabel 2001).

Prey Species

Black (1974) characterized the fringed bat as a beetle strategist based on a 73% frequency of beetle occurrence in fecal pellets, with 36% frequency of occurrence of moths. Whitacker et al. (1977) examined four stomachs of *M. thysanodes* from western Oregon, and found that three of the four stomachs contained Lepidoptera (moths), totaling 46.2% of the total volume. Other prey taxa observed included Phalangida (harvestmen; 26.2%), Gryllidae (crickets; 16.3%), Tipulidae (flies; 6.3%) and Araneida (spiders; 5.0%); three of which – Phalangida, Araneida, and Gryllidae – were or could be flightless forms and totaled 47.5% of the volume (Whitaker et al. 1977). Warner (1985) reported that fecal samples of 68 *M. thysanodes* from Arizona presented the following percent frequencies of occurrence: Coleoptera (90%), Lepidoptera (62%), Diptera (53%), Neuroptera (24%) and Hymenoptera (9%), with Hemiptera, Homoptera, and Araneida also observed.

<u>Characteristics Of Prey Species</u>

Freeman (1981) conducted principal components analysis of 14 cranial measurements of 41 species of vespertilionid bats and then regressed the PC loadings against a prey hardness scale. The first principal components axis related to robustness of the skull, with bats on the negative end having more robust skulls, and bats on the positive end having more "gracile skulls" (Freeman 1981). *Myotis thysanodes* fell out on the first principal components axis at a value of about +0.15-0.20 indicating a mildly gracile skull. Freeman (1981) also ranked the hardness of the prey items for these 41 bat species on a scale of 1 (softest; e.g. Neuroptera and Diptera) to 5 (hardest; Coleoptera), and calculated a weighted average of the food habits for each species. According to this scheme, *M. thysanodes* prey items had a weighted average of 3.01, indicative of the variety of food items taken by this species (Freeman 1981).

Reproduction And Development

Life History Characteristics

O'Farrell and Studier (1973) conducted the only detailed study of *M. thysanodes* reproduction found in the literature. The entirety of this paragraph is a summary of their findings. The maternity colony studied occupied an attic at the Montezuma Seminary in New Mexico. The building was located on a south-facing slope at the edge of a pinyon-juniper and short-grass prairie, with the Gallinas River about 400m away. The study was conducted from early April to late September 1970. Female *M. thysanodes* arrived at the maternity colony in a very short period, beginning on 18 April and peaking by 8 May. While all females examined histologically had sperm in the uterus upon arriving at the maternity colony, none so observed between 19-28 April had ovulated. By 15 May, all histologically examined *M. thysanodes* were pregnant. Hence, ovulation, fertilization and implantation all occurred between 18 April and 15 May. Gestation was calculated at 50-60 days, and parturition was synchronous, occurring between 25 June and 7 July. Females became secretive 1.5 weeks before parturition. During this time they occurred in clumps of a few bats hiding in cracks between and behind beams in the attic. At this time they were extremely sensitive to disturbance. After parturition, the young were deposited in a cluster with other young, this cluster being apart from adult roosting clusters. Females would nurse their young in this cluster, but then either return to adult clusters or roost solitarily. Occasionally, a young bat would fall to the floor. It would produce a distress call and a female, not necessarily believed to be the young bat's mother, would drop to the floor, allow the young to attach, and then return it to the cluster of other young. At night, while most of the adults were out foraging, there were always 2-10 adults in attendance with the young. During the post-parturition period, females nursing their young could be approached and even touched without flying. At 16.5 days post-birth, the young were capable of limited flight. By 20.5 days the flight of the young bats was indistinguishable from that of adult flight. Based on these data, the authors characterized *M. thysanodes* as relatively precocial for Vespertilionids (O'Farrell and Studier 1973).

Survival And Reproduction

Relatively little is known about survival rates in *M. thysanodes*. O'Farrell and Studier (1973) estimated neonate mortality at about 1% for *M. thysanodes* at a maternity colony in New Mexico.

O'Farrell and Studier (1973) witnessed the birth of a fringed bat. The event was remarkable in that it took place in the normal head-down position. Vespertilionid bats typically give birth in a head-up position, with the uropatagium folded ventrally to catch the newborn bat. The mother bat observed by O'Farrell and Studier (1973) immediately ate the placenta.

Cryan (1997) reported that, in the southern Black Hills of South Dakota, 84% of female *M. thysanodes* examined were reproductive.

Local Density Estimates

No literature was found which provided local density estimates for *Myotis thysanodes*, although Cryan (1997) did indicate that this species was the third most commonly captured (n=233) species during his study, outnumbered only by *Eptesicus fuscus* (n=392) and *M. volans* (n=314).

Limiting Factors

No discrete limiting factors were identified for this species in the literature. However, the sensitivity of this species to disturbance during the pre-parturition period (O'Farrell and Studier 1973), combined with its apparent selection of roost sites which are occupied by few other bats (whether due to social or microclimatic pressures; Martin and Hawks 1972; Arita 1993), would suggest that roost site availability and disturbance act as limiting factors for this species.

Patterns Of Dispersal

Myotis thysanodes is believed to migrate although little is known about the geographic extent or pattern of migration (O'Farrell and Studier 1980). While fall fat composition and deposition patterns are consistent with preparation for hibernation, variation of these activities among years suggest that fringed bats migrate relatively short distances to lower elevations or latitudes where they can be periodically active during the winter (O'Farrell and Studier 1980). The fact that adult females remain in the maternity roost after first the juvenile males and then the juvenile females leave the nursery, further suggests a relative lack of preparation for extended hibernation (O'Farrell and Studier 1975). Cryan et al. (2000) surveyed lower elevation (1000-1910m) water sources in the southern Black Hills of South Dakota, to determine the elevation distribution of bats in the Black Hills during the summer months. Of the 1197 captures, representing seven species, 149 were male *M. thysanodes* (mean capture elevation = 1,570m), 31 were reproductive females (mean capture elevation = 1,405m), and 7 were non-reproductive females (mean capture elevation = 1,504m). These results led Cryan et al. (2000) to emphasize the need to consider differences between sexes in elevational distribution in order to fully understand habitat needs for this species in the Black Hills.

Metapopulation Structure

No literature was found which addressed the metapopulation structure of *M. thysanodes*. While O'Farrell and Studier (1975) suggested that the uniform arrival of females at the maternity roost and their synchronized parturition period suggest that each group of females either hibernates together or re-forms a single population prior to or in the process of returning to the maternity colony, there are no empirical data on such movements. Therefore, it is difficult to even make predictions about metapopulation structure for this species.

Community Ecology

Predators

No records of predation on *M.* thysanodes were found in the literature.

Competitors (e.g. For Roost Sites And Food)

Perkins (1996) reported a study examining the relative influence of foraging competition and roost-site competition on the distribution of bats in northeastern Oregon. The remainder of this paragraph summarizes key findings from Perkins' report presented at the Bats and Forest Symposium in 1995. It should be noted that there are individuals who question whether or not Perkins was able to document competition *per se*. Nonetheless, given the difficulty of ever truly demonstrating competition, the results are provided here as they represent our current understanding of competition for this species. *Myotis thysanodes* competed with other moth specialists, specifically *Corynorhinus townsendii* and *Myotis volans* for foraging habitat. Reproductive female fringed bats demonstrated foraging patterns which were significantly separated from male fringed bats. Non-reproductive females and males showed no such segregation. Based on the length of the forearm, Perkins (1996) divided bats in his northeastern Oregon study area into large- (*Eptesicus fuscus* and *Lasionycteris noctivagans*), medium- (*Myotis evotis*, *M. volans*, and *M. thysanodes*), and small- (*M. lucifugus, M. ciliolabrum*, and *M. californicus*) sized groups. He found that middle-sized bats and small bats were found foraging together less often than expected in 73% of cases (Perkins 1996). However, previous authors (e.g. Bell (1980) reported no such competition among paired bat species in habitats similar to that of Perkins (1996). Perkins (1996) suggested, therefore, that differences in distribution between bat species was more likely due to competition for roost sites than to competition for food resources. In summary, *M. thysanodes* probably faces the greatest foraging competition from conspecifics and from *Myotis evotis* and *M. volans* due to their similar size and preference for Lepidopterans. Fringed bats also probably compete for forage with another moth strategist, *Corynorhinus townsendii*. While competition for roost sites probably occurs, until roost site selection criteria for *M. thysanodes* are clearly elucidated, it is difficult to predict with whom they would compete the most.

Parasites, Disease

A number of ectoparasites have been recorded for *Myotis thysanodes*, including

- *Spinturnix* (Spinturnicidae; Bradshaw and Ross 1961; Krutzsch 1955; Rudnick 1960)[1]
- *Trombicula myotis* (Argasidae; Bradshaw and Ross 1961)[1]
- *Leptotrombidium myotis* (Turner and Jones 1968)
- *Cimex pilosellus* (Cimicidae; Bradsaw and Ross 1961)[1]
- *Basilia forcipata* (Nycteribiidae; Bradshaw and Ross 1961)[1]
- *Myodopsylla collinsi* (Ischnopsillyidae; Bradshaw and Ross 1961)[1]
- *Ichoronyssus* (Dermanyssidae; Krutzsch 1955)

[1]As cited in O'Farrell and Studier (1980).

Cain and Studier (1974) reported the endoparasite *Vampiroleips gertschi* (Cestoda) in two specimens of fringed bats. Constantine (1988) included *M. thysanodes* in a list of bats for which rabies infections had been documented.

Other Complex Interactions. Include Interactions With Other Bat Species

Please see Competitors, above.

Roost Site Vulnerability

Fringed bats have been reported to utilize a variety of roosts. While the predominant hibernaculum roost appears to be caves, summer roosts range from man-made structures to rock crevices, and snags. Caves, man-made structures, and snags are probably the most vulnerable roost types; caves due to human impacts, man-made structures due to potential threats from commensals such as *Rattus* (documented to prey on *Corynorhinus townsendii* roosting in abandoned buildings) and to intentional destruction of such buildings, and snags because the loose-bark stage of a snag is relatively ephemeral.

Risk Factors

Risk factors for this species are most likely related to roost sites and to disturbance during the pre-parturition period. While these bats have been documented to utilize a variety of structures for roost sites, each type of structure appears to have certain requirements for suitability (see above discussions of roosts). As such, availability and vulnerability of roost sites likely represent risk factors for this species. At this point in time, we probably know the least about the specific requirements for cave hibernation. Rock crevice roosts and snags have been fairly well characterized (Cryan 1997; Rabe et al. 1998). In addition, the sensitivity of pregnant *M. thysanodes* to disturbance during the pre-parturition period, a period during which bats are more exposed to human activities because they have moved out of their winter hibernacula, may also represent a risk factor.

Response To Habitat Changes

Management Activities

<u>Timber Harvest</u>

The 2001 Phase I Amendment to the Land Resource Management Plan ROD 3/97 (LRMP-ROD 3/97; US Forest Service 1997), implementing the selected alternative (Alternative 2), increased the number of acres for Commercial Thinning and Regeneration Opening, while reducing the number of acres for Overstory Removal, Shelterwood Seed Cut, and Seed Tree Cut. Increased areas of commercial thinning, as long as these activities are not conducted close to roosting sites, particularly during the summer/maternity period (mid-April through September), would not be anticipated to negatively impact fringed bats. Regeneration openings may provide temporary foraging areas for fringed bats, particularly if they are close to roosting areas and standing, open water. These bats are extremely sensitive to roost disturbance, including loud noise.

While the Land and Resource Management Plan ROD 3/97 (LRMP-ROD 3/97) did address the need to protect caves for bats (page II-43). The 2001 Phase I Amendment to the LRMP increased minimum hard snag requirements to 2 snags/acre for Ponderosa Pine forest on south and west slopes, and 4 snags/acre on north and east slopes (US Forest Service 2001). As such, the recommended snag densities approach those recommended by Rabe et al. (1998; 10.6snags/ha) for a community of bats, including *M. thysanodes*, in northern Arizona, but are well below those reported by Mattson et al. (1996; 21 snags/ha) for silver-haired bats in the Black Hills. Cryan et al. (2001) reported snag densities of 0.5 ± 0.8 snags/plot for this species, but the area of the plots was not provided so extension of this density to hectares is not possible. Weller and Zabel (2001) reported mean snag density of 10.8 ± 0.9 snags/0.1ha for roost sites of this species in northern California (see Day Roosts, above). The 2001 Phase I Amendment also specified that minimum snag diameter is greater than 25 cm (10 inches), and requires that 25% of the snags be greater than 50cm (20 inches) in diameter, or in the largest size class available. Mean dbh for snags used by reproductive females in the Black Hills was 43.3 ± 12.1cm (Cryan et al. 2001), while the mean day roost snag dbh in northern California was 120.8 ± 5.3cm (Weller and Zabel 2001).

Recreation

The increased interest in spelunking in the United States has the potential to negatively impact *M. thysanode* populations as these bats are very sensitive to disturbance and their low reproductive output requires considerable time for a population to rebound from a drop in numbers. Members of the National Speleological Society, and comparable local groups such as the Paha Sapa Grotto, are typically very supportive of cave conservation and, as such, are important resources for management agencies. Unfortunately, some individuals who are not members of such conservation-minded organizations, explore and abuse cave habitats. Other recreational activities that have the potential to negatively impact *M. thysanodes* in the Black Hills are rock climbing, since these bats have been documented to utilize rock crevices as summer and maternity roosts, and activities such as firearms practice and use of off-road vehicles which create substantial noise and may disturb reproductive females during the critical pre-parturition period.

Livestock Grazing

Rabe et al. (1998) reported data which suggest that livestock grazing is negatively associated, either directly or indirectly, with use of snags as roosts by a suite of bats, including *M. thysanodes*. At one study site where grazed and ungrazed areas were available to bats, nine out of 54 snags used as roosts were located in areas grazed by cattle, whereas 45 snags used as roosts were located in areas not grazed by cattle. At a second study site, where the entire area was grazed by cattle, 43 snags were used as roosts by bats. Obviously, such results are more likely due to some combination of effects on vegetative structure and composition, and perhaps resulting insect prey communities, rather than to direct disturbance of the roosts themselves.

Livestock grazing may indirectly benefit bat species through the construction of additional water sources (Chung-MacCoubrey 1996). Detailed studies of the impacts of grazing on this species are still needed.

Mining

No studies were found which addressed the impact of mining activities on *M. thysanodes*.

Prescribed Fire

To date, studies directly assessing the impact of fire regimes on fringed bats are not available. However, given that these bats prefer more open, mature forest with standing dead trees, such as might be maintained by regular prescribed burns, Rabe et al. (1998) suggested prescribed fire to facilitate snag recruitment and development of more open stands.

Fire Suppression

As mentioned above, the impact of various fire regimes on *Myotis thysanodes* has not been studied directly. However, Bock and Bock (1983) reported that fires occurred naturally in the Black Hills about every 10-25 years between 1820 and 1910. Brown and Sieg (1999) estimated fire intervals of 10-12 years in the ecotone between forest and prairie in the southeastern Black Hills, and intervals of roughly 19-24 years for more interior forest (near Jewel Cave) in the southern Black Hills. Suppression of fire in this region can produce doghair stands of ponderosa pine which are not suitable roosting or foraging habitat for most species of bats. In addition, when fires do occur in areas where fire suppression has been practiced, the fires are more likely to be large, hot burning fires that would destroy suitable roosting habitat for *M. thysanodes*, should it be determined to use snags in the Black Hills as it does in other areas of its range. Thus, fire suppression in the Black Hills would probably be more of a detriment than a benefit to the fringed bat populations of this region.

Non-Native Plant Establishment And Control

Characterized by some authors as a moth-strategist, and by others as a beetle-specialist, *Myotis thysanodes* consumes a variety of invertebrate prey. As arthropod diversity correlates with plant species diversity, this dietary variability would suggest the need for a diverse forest flora. Non-native plant establishment tends to reduce native plant diversity and could thus negatively impact the prey base for this bat.

Pesticide Application

Organochlorines used in the past (DDT, dieldrin, endrin, and heptachlor) and suspected of causing large-scale die-offs of bat populations, are now used much less widely and are not considered a major threat to bat populations (Clark 1981). While bats are often thought of as being extraordinarily sensitive to insecticides, recent research does not support this assumption (Clark 1981). No studies were found which examined the impact of organophosphate and carbamate insecticides on bats, even though the use of these compounds increased markedly in replacing organochlorines for agricultural use (Clark 1981).

Fuelwood Harvest

Maternity roosts recorded for this species are rock crevices (Cryan 1997; Cryan et al. 2001) and ponderosa pine snags (Cryan et al. 2001). Fuelwood harvest which permits only the removal of downed trees, or of snags under 29cm dbh [Weller and Zabel (2001) reported a minimum roost dbh of 58.5cm for *M.* thysanodes in northern California; however, *Lasionycteris noctivagans* in the Black Hills can utilize roosts down to 29cm dbh (Mattson et al. 1996)], may positively impact these bats by removing fuel load and thus reducing the potential for hot burning wildfires which would burn larger snags that serve as potential roost sites for these bats.

Natural Disturbance

Insect Epidemics

No literature was found which dealt with the impact of insect epidemics on fringed bats. Within the Black Hills, outbreaks of mountain pine beetle (*Dendroctonus ponderosae*) and pine engraver beetle (*Ips pini*) could be predicted to have a detrimental impact on *M. thysanodes* if the outbreaks went unchecked to the point that large areas of ponderosa pine were killed and downed, regardless of whether or not fringed bats in the Black Hills use snags as roost since small forest openings and wooded riparian areas also provide foraging habitat. In the interim, die-off of trees might provide a larger number of potential roosting sites and reduce potential competition with other cavity-nesting species, if such competition exists.

Wildfire

No literature is available which specifically addresses the impact of wildfires on populations of *Myotis thysanodes*. However, given that in other portions of this species'range it appears to prefer mature, open forest with a relatively high density of snags for roosting sites, certain predictions about the role of wildfire in the habitat ecology of fringed bats can be made. Early photographs from the Black Hills region indicate that many forested areas were more open with snags (Knight 1994). As mentioned above under Prescribed Fire and Fire Suppression, fire suppression leads to doghair stands of ponderosa pine which are unsuitable as roosting habitats for many snag-roosting species of bats. Furthermore, accumulation of fuel load results in wildfires burning much hotter and the potential for these wildfires to destroy large areas of suitable fringed bat foraging habitat. Frequent fires, similar to the fire regime in pre-settlement times (every 5-25 years; Knight 1994) would keep the fuel load reduced while maintaining the more mature and open forest preferred as roosting habitat by fringed bats in other portions of this species' range.

Wind Events

While no literature directly addressed the effects of wind events on fringed bats, the spatial scale of such events would probably determine the consequences for *M. thysanodes*. Small-scale events which break or down occasional trees would probably not have a detrimental effect on these bats, and may provide more roosting habitats if trees are not broken too low (and assuming fringed bats in the Black Hills use snag-roosts as they do elsewhere). On the other hand, large-scale events which down all or most of the trees in an area would be predicted to have a detrimental impact on this species.

Flooding

No literature is available that addressed the impact of flooding on *Myotis thysanodes*. As the rock crevices in which Cryan (1997) reported roosts of fringed bats in the southern Black Hills were in rocky ridges or steep-walled canyons, and the roosts had a mean height above the ground of 1.8m (range 0-8m), it is possible that flooding could have a negative impact on roosts located low to the ground in steep-walled canyons which experience flooding.

Other Weather Events

As this species occupies the Black Hills and regions considerably north and south of the Black Hills during the summer, it must be assumed that it has evolved to cope with the range of summer weather conditions experienced by the Black Hills region. The effects of other weather events on this species are not known.

SUMMARY

Myotis thysanodes ranges across most of the western United States, extending northward into southcentral British Columbia, southward into Chiapas, Mexico. A disjunct population of this species, recognized as a distinct subspecies, *Myotis thysanodes pahasapensis*, occurs in the Black Hills region of Wyoming and South Dakota and extends down into western Nebraska.

Myotis thysanodes occupies a variety of habitats including mid-elevation desert, grass and woodland habitats, and is found at higher elevations in spruce-fir habitat and in mixed timber of ponderosa pine, white spruce and aspen. In the Black Hills of South Dakota, it is one of the more commonly captured bats during summer mist-netting studies and tends to occur along ecotones between ponderosa pine and oak/juniper forests. Although this bat has been documented to use a variety of settings as maternity roosts, in the Black Hills the only maternity roosts reported to date were located in rock crevices of rocky ridges or steep-walled canyons.

Myotis thysanodes hibernates in caves or areas of cave systems that are not heavily populated by other species of bats. It is not known whether this is due to avoidance of other bats, or to selection of relatively unique microclimatic conditions.

REVIEW OF CONSERVATION PRACTICES

Management Practices

Rabe et al. (1998) made or implied the following recommendations for management of snags for bat habitat:

-Sufficient numbers of large trees should be retained for snag recruitment and existing snags should be preserved.

-Fuelwood cutting of large trees (>30.5cm dbh) should be prohibited.

-Thinning small trees to improve growth of remaining trees to expedite snag recruitment.

-Killing of large trees to create snags (in areas where natural processes have been impeded).

-Implementation of periodic prescribed fire to emulate historic fire regimes which thinned forests, promoted growth of large trees, and created snags by killing trees.

-Implementation of a long-term management plan to assure that sufficient numbers of large snags in the loose-bark stage are available to bats through time.

-Implementation of research to determine how long ponderosa pine snags remain in the loose-bark stage, and distribution of snag densities by snag stage.

Weller and Zabel (2001) reiterated the first two recommendations above, and added that snag roosts occurred outside riparian buffer zones mandated by most Forest Plans, and thus would need to be protected under snag-retention guidelines.

Models

Rabe et al. (1998), based on their study of five species of bats, constructed two different logistic models with characteristics of both snags and surrounding forest structure. The three variables common to both models (larger diameter, exfoliating bark, and higher snag densities) appeared to be the most critical factors in determining snag use as maternity roosts. Rabe et al. (1998) cautioned that application of their models to other forests would have to consider different management histories and consequent distributions of required snag types.

Cryan (1997) reported that a regression model predicting the number of females (of all species considered, not just *M. thysanodes*) had an r-square value of 0.29, with elevation, water surface area, and moon phase being significant ($p=0.05$) variables. A model for predicting sex ratios (of all species considered) had an r-square value of 0.36 with elevation and water surface area being significant variables at $p \leq 0.001$.

Weller and Zabel (2001) performed conditional logistic regression using a proportional hazards regression procedure (PROC PHREG; SAS Institute 1997) to develop univariate, bivariate, and multivariate models for discriminating between roost and random sites. They determined that the best univariate model for discriminating between roost and random sites included number of snags ≥30cm dbh; the best bivariate model added percentage canopy cover; and the best multivariate model included number of snags ≥30cm dbh, percentage canopy cover, and distance to nearest stream as the top three characters distinguishing between roost and random sites.

Inventory Methods

Inventory methods for bats traditionally included mist-netting over water sources, and more recently, the use of ultrasonic bat detectors. Mist-netting is limited in its effectiveness for most species by appropriate weather conditions and relative availability of water. Wind and rain make nets more visible to bats and reduce the ability to capture bats in the nets. In areas where numerous water sources are available, numbers of bats caught at any one water source can drop.

Acoustic inventory of bats provides advantages over mist-netting in that echolocating bats can be detected regardless of wind or rain. However, identification of echolocating bats to species requires the development of echolocation libraries for signal comparison, and the development of expertise on the part of the researcher in distinguishing among the echolocation sequences of the species in a given area. Incomplete call sequences can lead to erroneous species identification. Advances in molecular genetics are currently being implemented to facilitate determination of presence/absence based on assignment of fecal pellets from bridge and comparable roosts to species (Ormsbee et al. 2002).

Monitoring Methods

The literature provided no methods for monitoring *Myotis thysanodes* beyond conducting counts at hibernacula. The use of Geographic Information Systems can greatly facilitate habitat monitoring, assuming the characteristics for high-quality fringed bat habitat are known. Current information about roosting requirements for this species should provide an adequate starting point for this form of habitat monitoring.

Methods previously discussed for determining presence/absence (mist-netting and acoustic detection) can be used indirectly, under very specific conditions, for evaluating population trends and persistence. However, no models are available to predict the amount of each method required to detect various percentages of change in population size. Monitoring methods based on radio telemetry and/or mark and recapture may provide more information, but would also be very expensive, primarily in terms of personnel (time).

Regardless of the methodologies employed for inventorying and monitoring, it is critical that the study be designed and conducted by individuals with first-hand experience with the various techniques and detailed understanding of their assumptions and limitations.

ADDITIONAL INFORMATION NEEDS

Distribution

The work by Cryan (1997) pointed out the importance of elucidating elevational differences in summer distribution between genders of a number of bat species, including fringed bats. In the Black Hills, this information for *M. thysanodes* specifically would help make informed decisions relative to management of snags for roosting habitat, particularly for reproductive females.

Species Response To Stand Level Changes

As no literature was found which documented the response(s) of fringed bats to stand level changes, this information is desperately needed. Given the distinct isolation, topography and climate of the Black Hills, collection of these data in the Black Hills themselves would provide the best information upon which to base management plans for fringed bats in this area.

Roosting Habitat Adaptability

The diversity of roosts which have been documented for reproductive females of this species suggests a certain amount of plasticity or adaptability. Although Baker (1962) reported maternity colonies of fringed bats using caves in the vicinity of Carlsbad Caverns, New Mexico, no maternity colonies have been found utilizing caves in the Black Hills of South Dakota. Cryan (1997) found reproductive females of this species roosting in rock crevices in the southern Black Hills. These crevice roosts, situated in rock ridges or steep-walled canyons, tended to face southeast or southwest, and all were located in low elevation forests, typically at the ecotone between ponderosa pine and oak/juniper forest. Interestingly, many of the roosts reported by Cryan (1997) were in areas with relatively high snag densities. The nature of the snags relative to characteristics reported as important for fringed bat maternity roost selection by Rabe et al. (1998) was not reported. Further research to enhance our understanding of maternity roost and hibernacular requirements for this species in the Black Hills is needed.

Movement Patterns

Little is known about the movement patterns of this species beyond that between elevations from hibernacula to summer roosts in the southern Black Hills. It is not known whether or not they utilize interim roosts, or what the nature of those roosts might be. Tracking of reproductive females, as well as males and nonreproductive females, from hibernacula to summer roosts is needed to provide a complete picture of movements of this species in the Black Hills.

Foraging Behavior

No studies were found which focused on the foraging behavior of the population of fringed bats occupying the Black Hills of South Dakota and Wyoming. As such, this is an area requiring research. A standard approach to elucidating foraging habitat and behavior includes the following steps:

1) radiotag the bats and find out where they forage,
2) sample flying insects in the foraging areas with a variety of traps (e.g. Malaise and multidirectional impaction traps) to determine relative abundance of the different insect species,
3) conduct analysis of fecal samples from bats collected in the foraging areas to determine dietary preferences,
4) characterize foraging habitat, and

5) compare abundance of preferred prey species in foraging versus non-foraging areas. This information could be gathered in conjunction with the radio tracking study conducted to determine movements of adult females from winter to summer roosts. Identification of habitats used for foraging by *M. thysanodes* might also be augmented by the use of acoustic monitoring.

Demography

Elucidation of the age structure of populations of *M. thysanodes* remains to be achieved and could be critical in providing for better estimates of viability for this species in the Black Hills.

Table 1. Priorities and cost categories of research needs.

SUBJECT	PRIORITY*	JUSTIFICATION	COST**
Distribution	Intermediate	Determine extent of BHNF to be managed for *M. thysanodes*	Moderate
Species Response to Stand Level Changes	Intermediate	Understand the impact of stand level changes on distribution and foraging habitat	Moderate
Foraging Behavior	Intermediate	Ensure management of all habitats required	Moderate
Demography and Metapopulation Structure	Low	Allow predictions about habitat change on demographic and genetic structure of BHNF population of *M. thysanodes*	High

*Low: would refine or improve fringed bat management strategies; Intermediate: is required to develop comprehensive management strategies; High: is required to develop minimal science-based management strategies.
**Low: estimated cost $5,000-$25,000; Moderate: estimated cost $25,000-$100,000; High: estimated cost >$100,000.

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