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Conservation Assessment for the Long-Legged Myotis in the Black Hills National Forest South Dakota and Wyoming

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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 long-legged myotis (*Myotis volans*) 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.

While there is some information for *Myotis volans* 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 volans*.

CURRENT MANAGEMENT SITUATION

Management Status

Myotis volans, a former federal endangered species candidate, is currently considered a species of concern by the US Fish and Wildlife Service. Species of concern status is generally provided to species which are believed to have some combination of low numbers and limited distribution, or for which there is little information relative to basic ecology. The long-legged myotis is common across the western United States and is probably the most abundant species over large portions of this area (Barbour and Davis 1969). This species is considered to be the most common and widely distributed member of the genus *Myotis* in the Black Hills region (Jones and Genoways 1967; Turner 1974). Due to the distribution and abundance of this species in western South Dakota, it is not monitored by the South Dakota Natural Heritage Program (SDNHP 2002 http://www.state.sd.us/gfp/Diversity/RareAnimal.htm#MAMMALS). *Myotis volans* occurs in 25 of the 28 latilongs established for Wyoming, but is ranked as a Non-game Species of Special Concern – 2 (SSC2) by the Wyoming Game and Fish Department (Luce et al. 1999).

Existing Management Plans, Assessments, Or Conservation Strategies

No existing management plans, assessments, or conservation strategies were found for this species.

REVIEW OF TECHNICAL KNOWLEDGE

Systematics

The genus *Myotis* is in the chiropteran family Vespertilionidae. *Myotis* is the most widespread genus of bats in the world, both spatially and temporally, with the genus occupying virtually the entire geographic range of Vespertilionidae, and fossil *Myotis* dating back to the middle Oligocene of Europe (Vaughan 1986). *Myotis volans* shares assignment to the subgenus *Leuconoe* with only one other species from the Black Hills region, that being *M. lucifugus* (Nowak 1991; Nowak 1994). There are four subspecies in western North America: *M. volans volans, M. v. interior, M. v. amotus*, and *M. v. longicrus* (Hall 1981) and their distributions are described below. Vernacular names for this species include long-legged myotis, long-legged bat, and hairy-winged myotis (Barbour and Davis 1969; Warner and Czaplewski 1984).

Myotis volans can be distinguished from other North American congeners by the combination of its short, round ears which barely reach the nose when laid forward, small hindfeet, distinctly keeled calcar, and ventral pelage extending out onto the ventral surface of the wing to a line approximately from the elbow to the knee (Barbour and Davis 1969; Turner 1974; Warner and Czaplewski 1984). External measurements (in mm) for mainland forms of this species include: total length 83-106; tail length 32-49; hindfoot length 5-9; ear length 10-15; forearm length 37.0-41.2 (Warner and Czaplewski 1984). Jones et al. (1983) reported the total length for ten specimens from Harding County, South Dakota as averaging 96.9mm with a range of 87-104mm. Weights of adults from the Northern Plains ranged from 4.8g to 10.0g, with the majority of individuals falling in the range from 5.5-8.5g (Jones et al. 1983). Sexual dimorphism does occur in this species, with females having longer forearms and greater condylocanine lengths (Williams and Findley 1979).

Distribution And Abundance

Distribution Recognized In Primary Literature

Overall Range

Myotis volans ranges across most of western North America, extending from southeastern Alaska through the western and southern half of British Columbia and the southern half of Alberta, down the western edge of the Great Plains states and into central Mexico (Barbour and Davis 1969; Hall 1981; Warner and Czaplewski 1984; West 1993). The subspecies occupying most of Alaska, British Columbia, Alberta, and the coastal United States north of southern California is *M. v. longicrus* (Warner and Czaplewski 1984). The subspecies occupying most of the western United States, including the Black Hills region is *M. v. interior* (Hall 1981). *Myotis volans volans* occupies Baja California, while *M. v. amotus* occurs in an east-to-west band across the mountains of central Mexico including Veracruz, Mexico.

Local Distribution

While *M. volans* is common and widespread west of the Northern Great Plains, its distribution on the Northern Great Plains appears to be limited to northwestern Nebraska and the western parts of the Dakotas (Jones et al. 1983). Clark and Stromberg (1987) report *M. volans* to be one of the most widespread and abundant bats in Wyoming. This species has been reported from all counties occupied by the Black Hills, in both South Dakota and Wyoming (Clark and Stromberg 1987; Luce et al. 1999; Turner 1974). Turner (1974) described *M. volans* as the most abundant bat species in the Black Hills region. Cryan (1997) reported M. volans to be the second most frequently netted species in the southern Black Hills, outnumbered only by *Eptesicus fuscus*.

Additional Information From Federal, State, And Other Records

Information from South Dakota and Wyoming state records are incorporated in the section Management Status, above. No additional information from other state, or from federal records was found.

Estimates Of Local Abundance

Myotis volans is characterized as a colonial species (Barclay 1993), forming large aggregations during hibernation, and nursery colonies of 45 to 100 or more individuals (Clark and Stromberg 1987; Fitzgerald et al. 1994). Martin and Hawks (1972) reported a linear aggregation containing a minimum of 50 individuals in Jewel Cave in the Black Hills. Mattson and Bogan (1993) reported that *M. volans* was the most frequently caught *Myotis* in the southern Black Hills. Cryan (1997) reported that *M. volans* was the second most frequently mist-netted species (n=314) in the southern Black Hills, outnumbered only by *Eptesicus fuscus*.

Habitat Associations

Myotis volans is primarily associated with montane forests across western North America (Turner 1974). Jones (1965) reported that over 97% of the *M. volans* caught during an ecological study in New Mexico were caught in evergreen forest. The mainland forms of this species rarely occur in arid lowland areas (Warner and Czaplewski 1984), although Bell (1980) reported *M. volans* activity in riparian forests, juniper scrub, and desert areas near the Chiricahua Mountains of Arizona. Long-legged myotis typically occur at elevations between 2,000m and 3,000m (Warner and Czaplewski 1984). In the Black Hills, this species occurs primarily at elevations between 1370m and 1980m (4500 - 6500 feet; Turner 1974).

Roosting Ecology

Maternity Roosts

Reproductive females have been found in buildings (Dalquest and Ramage 1946; Tigner 1997), rock crevices (Quay 1948; Cryan 1997), under the bark of trees (Jones et al. 1973; Cryan 1997), and in hollow trees (Barclay 1993). Most reports indicate groups of females ranging from 5 or 6 individuals to several hundred (above references). Tigner (1997) reported a maternity roost in the attic of a building near Sturgis, SD in the northern Black Hills. This roost was made up of about 75 individuals, including non-volant young. The young were in a single cluster and attended by some adults, while the rest of the adults roosted in small clusters or individually (Tigner 1997).

Cryan (1997) characterized roost snags used by female *M. volans* in the southern Black Hills. Roost snags were significantly larger in dbh (mean = 46cm; range was 37-66cm) than random snags, had a greater mean decay stage (mean = 6.2, range of 3-7; *sensu* Thomas et al. 1979), were generally located on south-facing slopes, and were located an average of 0.55km from water (range 0.1 – 1.0km). Plots with roost snags were more open, had a significantly greater number of snags per unit area than the random plots and occurred within an elevational range of 1470m to 1570m (Cryan 1997). The elevational range of snag roosts reported by Cryan (1997; 1470m-1570m) falls within the range of greatest activity for this species reported by Turner (1974; 1370m-1980m), suggesting that these bats do not range widely in elevation to forage.

Hibernacula

M. volans has been reported to hibernate in caves in general (Barbour and Davis 1969), and specifically in Jewel Cave in the southern Black Hills (Jones and Genoways 1967; Martin and Hawks 1972). No reports were found which addressed specific thermal requirements in the hibernaculum for *M. volans*.

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

Although *M. volans* utilizes caves as hibernacula, and will roost in them temporarily at night, they do not appear to frequently use them as day roosts (Barbour and Davis 1969), although Turner (1974) reported the use of caves as day and night roosts by *M. volans* in the Black Hills. Jones et al. (1973) reported this species day-roosting under the bark of ponderosa pine. Vonhoff and Barclay (1996) examined roost-site selection and roosting ecology of four species of bats, including *Myotis volans*, in southern British Columbia. They radiotagged and tracked both male and female *M. volans*, so the discussion of their findings is included here instead of under maternity roosts *per se*. Vonhoff and Barclay (1996) found that these bats preferred snags in decay classes 4 and 5 (characterized generally by being dead, with reduced needles and twigs, bark loose, top often broken, heartwood hard to spongy, and sapwood spongy to soft), that were taller than surrounding trees (positively correlated with greater dbh), close to other available trees, and surrounded by a relatively open canopy.

Ormsbee and McComb (1998) reported on day roost use by female *M. volans* in central Oregon. As the reproductive condition of all tracked bats was not known, this report is included under day roosts instead of under maternity roosts. Ormsbee and McComb (1998) reported that roost snags had mean dbh of 97 $\pm$ 7cm, mean height of 38 $\pm$ 3m, and extended above the canopy. They also reported that a few *M. volans* used live trees as roost structures, with the live trees having even greater dbh than the snags.

Cryan (1997) reported a male *M. volans* roosting in rock crevices in the Black Hills, while females were found roosting in both rock crevices and tree snags. Cryan et al. (2001) tracked and characterized day roosts used by 10 *M. volans*, comprising individuals of both genders and various reproductive conditions, in the Black Hills of South Dakota. Bats in this study used trees in intermediate stages of decay (mean decay stage of 5.8 $\pm$ 1.2 *sensu* Thomas et al. 1979), trees with greater mean dbh (42.6 $\pm$ 3.2cm) than random trees, trees occurring in plots with larger spaces between trees (7.9 $\pm$ 4.7m) than random plots, and plots with higher snag densities (0.9 $\pm$ 1.0 snags/plot) than random plots.

Night Roosts

As indicated above under Day Roosts, this species readily enters and utilizes caves as night roosts (Barbour and Davis 1969; Turner 1974). Perlmeter (1996) studied 5 bridges in the Willamette National Forest of western Oregon. All 5 bridges were constructed of a rough aggregate concrete mixture, with individually partitioned and recessed chambers underneath. Nightly mean roost temperatures were significantly higher than ambient, and temperatures within individual chambers were relatively stable within a given night. Larger bridges, which maintained higher and more stable temperatures over the course of the night, supported large numbers of bats than did smaller, cooler bridges (Perlmeter 1996).

Adam and Hayes (2000) examined the use of different types of bridges as night roosts by bats 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 studies elucidating the use of interim roosts by this species were found.

Foraging Habits

Myotis volans is noted for emerging relatively early to feed, often while there is still sufficient daylight to be readily seen (Barbour and Davis 1969). This species forages over water and in openings in the woods (Barbour and Davis 1969). Turner (1974) reported foraging by this species over campgrounds, meadows and water courses in the Black Hills.

Seidman and Zabel (2001) examined bat use of intermittent stream habitat in northwestern California. They reported that *M.* volans was captured more frequently along large (mean channel width of 7.0 $\pm$ 1.2m) and medium (mean channel width of 1.9 $\pm$ 0.0m) intermittent streams, than along smaller intermittent streams or in proximal upland habitats (Seidman and Zabel 2001).

Fenton et al. (1980) reported that the majority of their captures of long-legged bats occurred at the mouth of a canyon over a fast-flowing creek lined with willows and alders. They also noted that at another river site this species tended to forage well above (up to about 10m over the canopy) the riverbank and associated vegetation, but did not forage over the river itself (Fenton et al. 1980).

Prey Species

Black (1974) characterized *M. volans* as a moth strategist with 96% frequency of occurrence of moths in fecal pellets examined and 17% occurrence of beetles. Other studies support Lepidoptera comprising the majority of this species' diet, but also indicate that long-legged bats consume a variety of other, primarily soft-bodied invertebrates, including flies, termites, lacewings, wasps, true bugs, leafhoppers, and small beetles (Jones et al. 1973; Warner 1985; Whitacker et al. 1977, 1981). Warner (1985) postulated that this species is an opportunistic feeder, taking suitable prey in approximate proportion to their availability at a given time and place. *M. volans* is known to feed on the spruce budworm moth (*Choristoneura fumiferana*), a major forest pest (Pierson 1998).

<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 principal components 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 volans* fell out on the first principal components axis at a value of about +0.18 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. volans* prey items had a weighted average of 2.23, indicative of the variety of soft-bodied food items taken by this species (Freeman 1981).

Reproduction And Development

Life History Characteristics

Long-legged myotis can be long-lived, with recapture data on banded individuals indicating a potential lifespan of at least 21 years (Warner and Czaplewski 1984). As with most temperate zone vespertilionids, reproductive output is limited to one offspring per year (Barclay 1993). Druecker (1972) reported evidence suggesting that males do not become sexually mature until their second year. Schowalter (1980), however, described most of the fall-caught juvenile males in Alberta as being reproductively active. First-year females are thought to be sexually mature (Warner and Czaplewski 1984).

Survival And Reproduction

Based on recaptures of banded individuals, *M. volans* is known to live a minimum of 21 years (Warner and Czaplewski 1984).

Druecker (1972) described in detail many aspects of the reproduction of *Myotis volans* from New Mexico and Arizona. The remainder of this paragraph is a summary of his findings. Copulation was documented as early as 28 August in this region, and Druecker (1972) concluded that the sperm are stored in the uterine glands in the distal ends of the uterine horns or in the utero-tubal junction (based on the distribution of sperm in females examined histologically). *M. volans* differed from other species in this study in having significant microgeographic variation in timing of ovulation, parturition and lactation in the New Mexico and Arizona region. Druecker reviewed works by other authors and summarized the timing of these events. Ovulation appeared to occur from March through May, parturition from early May through early August, and lactation from early May through late August (Druecker 1972).

Local Density Estimates

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

Limiting Factors

No studies specifically addressed limiting factors for this species. It could be anticipated that availability of suitable hibernacula, maternity roosts, and foraging areas could serve as limiting factors. However, until the necessary criteria for these three site classes are elucidated, it is unkown which is/are acting as limiting factors. The reported preference of this bat for snag roosts occurring in old-growth forest (Thomas 1988) and the continued reduction of old-growth forests in western North America suggest that availability of forests with sufficient distribution and density of large-diameter, tall snags for maternity roosting may be a limiting factor.

Patterns Of Dispersal

No studies were found which addressed dispersal in this species. To date, the only studies addressing movement for this species are those by Cryan and colleagues (Cryan 1997; Cryan et al. 2000) in the southern Black Hills, and Hoffmeister (1970). Neither of these studies provided appropriate data to make conclusions relative to dispersal in this species.

Metapopulation Structure

As mentioned above, patterns of dispersal for this species are not known. To date, no studies have addressed population genetic structure of this species. The metapopulation structure of this species is an area in need of research.

Community Ecology

Predators

No reports of predation on long-legged myotis were found in the literature. It can be assumed that they fall prey to the usual bat predators including raccoons, owls, and snakes.

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 volans* competed with other moth specialists, specifically *Corynorhinus townsendii* and *Myotis thysanodes* for foraging habitat. Reproductive female long-legged bats demonstrated foraging patterns which were significantly separated spatially from male long-legged 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 medium-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. volans* probably faces the greatest foraging competition from conspecifics and from *Myotis evotis* and *M. thysanodes* due to their similar size and preference for Lepidopterans. Long-legged 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. volans* -- and the other bat taxa with whom it is found -- are clearly elucidated, it is difficult to predict with whom they would compete the most.

Parasites, Disease

Ectoparasites recorded from Myotis *volans* include:

- mites: *Ichoronyssus britannicus* (Furman 1950[1])
  Pteracarus chalinolobus (Jameson and Chow 1952[1])
  Cryptonyssus desultorius (Whitaker et al. 1983[1])

	Macronyssus crosbi (Whitaker et al. 1983[1])	
	Spinturnix americanus (Whitaker et al 1983[1])	
	Spinturnix bakeri and *S. globosus* (Whitaker et al. 1983[1])	
	Notoedres sp. (Whitaker et al. 1983[1])	
	Acanthophthirius sp. (Whitaker et al. 1983)	
	Spinturnix sp. (Jones et al. 1973)	
- chiggers:	*Leptotrombidium myotis* (Jones and Genoways 1967; Turner and Jones 1968)	
- fleas:	*Myodopsyllus gentiles* (Anderson and Jones 1971; Jones et al. 1973)	
- bat bugs:	*Cimex piloselis* (Hansen 1964[1])	
- nycteribiid flies:	*Basilia forcipata* (Jones et al. 1973)	
	Basilia calverti (Fox and Stabler 1953[1])	

Rabies has been recorded in *Myotis volans* (Constantine 1979[1]).

[1] As cited in Warner and Czaplewski (1984)

Other Complex Interactions. Include Interactions With Other Bat Species

Lasionycteris noctivagans utilizes snags with mean dbh (in cm) of 27.5 $\pm$ 1.9 (Mattson et al. 1996), while *M. thysanodes* requires snags with a minimal dbh of 31.2cm (Rabe et al. 1998). *Myotis volans* prefers snags with dbh of 45cm or larger (range of 37-66cm; Cryan 1997). Thus it appears that there may be resource partitioning, relative to snag roost sites, among these species. However, it could also be that the different diameter snags provide microclimates to which the respective species are best adapted. Again, competition is a difficult interaction to prove.

Roost Site Vulnerability

The roosts of snag-roosting species are inherently vulnerable, particularly for those which roost underneath loose bark. The loose-bark stage of a snag is ephemeral, although no studies to date have quantified the longevity of this stage. This stage would undoubtedly vary by species, general climate, and microclimate. As *M. volans* uses caves as hibernacula, they face the same, primarily anthropogenic, challenges as other caverniculous hibernators.

Risk Factors

Although no studies were found which specifically addressed risk factors for this species, it can be assumed that potential risk factors will be closely associated with limiting factors. Availability of suitable hibernacula, maternity roosting sites, and foraging areas all represent risk factors for *M. volans* as they do for most species of bats.

Response To Habitat Changes

Management Activities

Timber Harvest

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, would not be anticipated to negatively impact long-legged bats. Regeneration openings may provide temporary foraging areas for *M.volans*, particularly if they are close to roosting areas and standing, open water. However, harvest activities close to known roosting sites of this species during the maternity roosting period would be anticipated to have negative impacts on the species. Additionally, the avoidance of trees used as maternity roosts may be important because some species of bats have been documented to roost in the same tree over a period of years (Willis et al. 2002).

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 in northern Arizona, but are well below that reported by Mattson et al. (1996; 21 snags/ha) for silver-haired bats in the Black Hills. Cryan et al. (2001) described *M. volans* snag-roost plots in the Black Hills as having a mean snag density of 0.9 ± 1 snag/plot (where 5 plots surrounding the roost were collected using the point-quarter method).

The 2001 Phase I Amendment also specified that minimum snag diameter is greater than 25cm (10 inches), and requires that 25% of the snags be greater than 50cm (20 inches) in diameter, or in the largest size class available. Cryan et al. (2001) reported a mean dbh of 42.6 ± 3.2cm (range not provided) for snags used as roosts by *M. volans*.

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) with Standard 3102 requiring protection of roosting caves and their microclimates during the design of timber harvest activities. Additional guidance in the LRMP on cave management, contained in Guideline 1401 (Page II-13) stated "Avoid ground disturbance within 100 feet of an opening of a natural cave." This distance was increased to 500 feet in the Phase I Amendment (US Forest Service 2001) and is to be treated as a standard.

Recreation

The increased interest in spelunking in the United States has the potential to negatively impact *M. volans* populations as, like most bats, they 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. These activities populations have great potential to negatively impact *M. volans* populations as it is during hibernation in caves that this species is found in the largest aggregations in the Black Hills.

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. volans*. 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. volans.*

Prescribed Fire

To date, studies directly assessing the impact of fire regimes on long-legged 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, it could be argued that prescribed fire could benefit this species. If fires are frequent enough to reduce the fuel load such that fires are of low enough intensity that large snags are not burned, then the reduction in understory density and height, and the maintenance of a more open forest should provide more suitable roosting sites for *Myotis volans.*.

Fire Suppression

As mentioned above, the impact of various fire regimes on *M. volans* 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 long-legged 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 snag-roosting species of bats. Thus, fire suppression in the Black Hills would probably be more of a detriment than a benefit to the long-legged bat populations of this region.

Non-Native Plant Establishment And Control

Characterized by some authors as a moth-strategist, and by others as opportunistic, *Myotis volans* consumes a variety of soft-bodied 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). However, Henny et al. (1982) reported that within the group of bat species studied in northeastern Oregon, *Myotis volans* and *M. californicus* showed the highest carcass residues of DDT and its metabolites after a single DDT spray application. Furthermore, these two species still presented carcass residue levels significantly higher than controls three years after the DDT application (Henny et al. 1982). Henny et al. (1982) were unable to determine whether or not these high residue levels negatively impacted the bats; nor could they correlate high residue levels with diet for these two species. 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).

<u>Fuelwood Harvest</u>

Fuelwood harvest which permits only the removal of downed trees, or of snags under 29cm dbh (Cryan (1997) reported a minimum dbh of 37cm for maternity roosts of *M. volans*, however, *Lasionycteris noctivagans* can utilize roosts down to 29cm dbh), 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. However, fuelwood harvest in the vicinity of maternity roosts should be avoided during the late spring and through the summer.

Natural Disturbance

<u>Insect Epidemics</u>

No literature was found which dealt with the impact of insect epidemics on long-legged 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. volans* if the outbreaks went unchecked to the point that large areas of ponderosa pine were killed and downed. 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. Although it is known that *M. volans* feeds on the spruce budworm moth (*Choristoneura fumiferana*), a major forest pest (Pierson, 1998), it is not known whether or not long-legged bats take either mountain pine beetle or pine engraver beetle during normal foraging. Given their low utilization of beetles, it is, however, unlikely.

<u>Wildfire</u>

No literature is available which specifically addresses the impact of wildfires on populations of *Myotis volans*. However, given that 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 long-legged bats can be made. Early photographs from the Black Hills region indicated 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 long-legged 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 these bats.

<u>Wind Events</u>

While no literature directly addresses the effects of wind events on long-legged bats, the spatial scale of such events would probably determine the consequences for *M. volans*. 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. 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 addresses the impact of flooding on *Myotis volans*. Most roost sites of this species averaged 0.55km (range of 0.1-1.0km) from permanent water sources (Cryan 1997); thus the direct impact of flooding on this species should be minimal in the Black Hills.

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 volans ranges across most of western North America, extending from southeastern Alaska through the western and southern half of British Columbia and the southern half of Alberta, down the western edge of the Great Plains states and into central Mexico. The subspecies occupying most of the western United States, including the Black Hills region is *M. v. interior.*

M. volans is reported to be one of the most widespread and abundant bats in Wyoming. This species has been reported from all counties occupied by the Black Hills, in both South Dakota and Wyoming. *M. volans* as been described by various authors as the most abundant bat species in the Black Hills region, and as the second most frequently netted species in the southern Black Hills, outnumbered only by *Eptesicus fuscus*.

Myotis volans is characterized as a colonial species, forming large aggregations during hibernation, and nursery colonies of 45 to several hundred individuals. *Myotis volans* is primarily associated with montane forests across western North America. In the Black Hills, this species occurs primarily at elevations between 1370m and 1980m (4500 - 6500 feet).

Reproductive females have been found in buildings, rock crevices, under the bark of trees, and in hollow trees. In the southern Black Hills, snag roosts were characterized as large (mean dbh = 46cm) ponderosa pine snags with loose bark, occurring in old growth forest on south-facing slopes within 0.5km of permanent water. Roost snag plots had eight times the density of snags found in random plots.

M. volans consumes primarily moths when available, but is an opportunistic feeder on other soft-bodied invertebrates. This species forages over open areas such as campgrounds and small forest clearings, and over vegetated riparian areas.

REVIEW OF CONSERVATION PRACTICES

Management Practices

Although no conservation plans or other management outlines were found that directly addressed the needs of long-legged bats, Vonhoff (1996) did propose general management practices that, based on available research, should provide the best opportunity to conserve suitable roosting habitat for snag-roosting bats. Vonhoff's (1996) recommendations included:

Selection Harvesting – following prescriptions that reduce understory and maintain areas of lower density, large-diameter trees with adequate canopy cover to retain a suitable microclimate.

Prescribed Fire – periodic, low-intensity burns to maintain open nature of forest stands.

Retention of large areas of forest with the above characteristics – small numbers of large trees left within cutblocks are not predicted to provide suitable roosting sites for snag-roosting species.

Recommendations made or implied by Rabe et al. (1998) reflect and expand upon the general guidelines put forth by Vonhoff (1996; above) and included the following:

-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. (*Based on the work by Mattson et al. (1996) on* Lasionycteris noctivagans *(minimum maternity roost dbh was 29cm), and Cryan (1997) on* Myotis volans *(minimum roost dbh was 37cm), to adapt this recommendation to the Black Hills National Forest, the minimum dbh would need to be decreased to **29**cm based on currently available data)*

-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.

Models

Rabe et al. (1998), based on their study of five species of bats *(including M. volans*), 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. volans*) 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 $p \leq 0.001$.

Ormsbee and McComb (1998) developed a logistic model via a PHREG procedure (SAS Institute 1992) that identified tree height (tall or taller than surrounding canopy for increased insolation) as a primary selective feature. Snag diameter, upland position (again thought to increase insolation), and proximity of day roosts to streams near night roosts were also important features elucidated by this model.

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. A study conducted by O'Farrell and Gannon (1999) indicated that use of a combination of capture and acoustic detection yields markedly better results for this species than either technique alone.

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 use of Geographic Information Systems can greatly facilitate habitat monitoring, assuming the characteristics for high-quality long-legged 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 long-legged bats. In the Black Hills, this information for *M. volans* specifically would help make informed decisions relative to management of snags for roosting habitat, particularly for reproductive females.

Virtually nothing is known about specific thermal requirements in the hibernaculum for this species. Elucidation of these parameters may help predict locations of additional hibernacula for *M. volans* in the Black Hills.

Species Response To Stand Level Changes

As no literature was found which documented the response(s) of long-legged 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 would provide the best information upon which to base management plans for *M. volans* in this area.

Roosting Habitat Adaptability

Cryan's (1997) description of female long-legged myotis using both rock crevices and tree snags, combined with other reports of maternity colonies in buildings (e.g. Tigner 1997) indicates that this species selects for specific roost parameters rather than specific types of roosts, showing a degree of roosting habitat adaptability within the limits of those, as yet to be defined, parameters. Hence, research is needed to determine what parameters reproductive *M. volans* seek in order to develop strategies for developing and conserving sufficient roosting habitat for this species in the Black Hills. The use of interim roosts by this species has not been documented and is another area in which research 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 long-legged bats occupying the Black Hills of South Dakota and Wyoming. As such, this is an area requiring research. Bat foraging studies available in the literature often fail to collect and analyze data about insect diversity and availability in conjunction with the bat diet studies. This information is needed to elucidate not only dietary preference, but also many other aspects of foraging ecology such as seasonal variation, differences between reproductive classes of individuals, and the potential for competition within and among bat species, and with other insectivores such as crepuscular birds.

Demography

Elucidation of the age structure of populations of *M. volans* 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	Low	Determine extent of BHNF to be managed for *M. volans*	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	Intermediate	Allow predictions about habitat change on demographic and genetic structure of BHNF population of *M. volans*	High

*Low: would refine or improve long-legged 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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