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Conservation Assessment for the Northern Myotis in the Black Hills National Forest South Dakota and Wyoming

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for the
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INTRODUCTION

This conservation assessment addresses the biology of the northern myotis (*Myotis septentrionalis*) 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 as 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 septentrionalis* 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 septentrionalis.*

CURRENT MANAGEMENT SITUATION

Management Status

In Alberta, Canada *Myotis septentrionalis* is on the Blue list (Alberta Wildlife Management Division 1996) due to uncertainty about its population numbers and range. The Alberta Wildlife Management Division (1996) recognizes *M. septentrionalis* as a poorly known species that relies on very old trees for roosting, and recommends incorporation of habitat requirements into forest management. While, in the United States in general, this species is considered stable, it is infrequent at the western edge of its range which includes eastern Montana and Wyoming, and the western edge of the Dakotas and Nebraska. Consequently, this species is monitored by both the South Dakota Natural Heritage Program (SD NHP Rare Mammals website; SD NHP Report 2002), and the Wyoming Game and Fish Department (Luce et al. 1999; WYNDD Online 2002). Within the western portion of this species' range it is considered "rare and poorly understood" Foresman (2001).

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). The taxonomy of *M. septentrionalis* has undergone several changes, the significance of which is knowing what names to look for in literature from different times and geographic regions. Early literature (pre-1979) refers to this bat as *Myotis keenii septentrionalis*. In 1979, van Zyll de Jong concluded that the eastern populations of *M. keenii* were distinct from the western populations and recognized the eastern populations as *Myotis septentrionalis* (van Zyll de Jong 1979). As such, reference to *M. keenii* in regions outside of the Pacific Northwest of North America should be considered as *M. septentrionalis*. No subspecies are recognized for *Myotis septentrionalis* (Caceres and Barclay 2000). Vernacular names for this species include northern bat (Foster and Kurta 1999), northern long-eared bat (Caceras and Barclay 2000), and northern myotis (Nagorsen and Brigham 1993).

In the Black Hills region, the two taxa with which *Myotis septentrionalis* might be most easily confused are *Myotis lucifugus* and *M. evotis*. *M. septentrionalis* can be distinguished from *M. lucifugus* by its longer ears and tragus, a slight keel on the calcar, and relatively longer tail, combined with a pelage that is not as glossy as that of *M. lucifugus* (Caceres and Barclay 2000; Schwartz and Schwartz 1981). From *M. evotis, M. septentronalis* differs in having a darker pelage and lighter membranes, giving it an overall brown appearance (Caceres and Barclay 2000).

Sexual dimorphism occurs in *M. septentrionalis*, with females being larger and heavier than males (Williams and Findley 1979). Average and extreme external measurements (in mm) for ten specimens from Nebraska are: total length 93.5 (86-99); tail length 39.5 (36-43); hind foot length 9.3 (8-10); ear length 16.9 (16-18); and forearm length 35.3 (33.3-36.5) (Jones et al. 1983).

Distribution And Abundance

Distribution Recognized In Primary Literature

Overall Range

Myotis septentrionalis ranges across most of eastern North America, extending from central Quebec, Ontario and the southern half of Manitoba, south through all of the Dakotas, eastern Nebraska, Kansas and Oklahoma and then east to the Atlantic coast (Caceres and Barclay 2000). The southern edge of the range of this species dips south into Alabama, Georgia, and the very tip of the panhandle of northwestern Florida (Caceres and Barclay 2000). Along the northern portion of its range, *M. septentrionalis* extends across the central portion of Saskatchewan, the northern half of Alberta, and into the eastern third of British Columbia (Caceres and Barclay 2000).

Local Distribution

Turner (1974) reported *Myotis septentrionalis* from Pennington and Custer counties in South Dakota, and from Weston County in Wyoming. The South Dakota Natural Heritage program (2002) reported records of this species from the following additional counties: Meade, Lawrence, Jackson, Harding. Jackson and Lawrence counties are east and north of the Black

Hills region, respectively. Luce et al. (1999) reported records of *M. septentrionalis* from latilongs 7, and 21, and a historical record from latilong 8. Of these, only latilong 7 includes the Black Hills. Clark and Stromberg's (1987) map of occurrences of this species in Wyoming indicated records from Crook and Weston counties only.

Additional Information From Federal, State, And Other Records

Information from federal and state records (US and Canada) are incorporated in the section Management Status, above. No additional information from other state, or from federal records was found.

Estimates Of Local Abundance

Although Barclay (1993) characterized *M. septentrionalis* as a colonial species, and indeed aggregations can be found in hibernacula, during the summer nonreproductive bats roost singly or in small groups of less than 10 individuals, while maternity colonies are typically small with the largest reported being under 70 individuals (Caceres and Barclay 2000; Menzel et al. 2002). These behaviors make quantitative estimates of local abundance difficult; as a result most references to abundance are qualitative in nature. *Myotis septentrionalis* is referred to as "common" (Jones et al. 1983) and "abundant" (Tigner 1997) in the Black Hills. Mattson and Bogan (1993) captured 27 males and 11 females of this species during mist-netting over 22 different water sources in the southern Black Hills. Cryan (1997), based on combined data from various researchers mist-netting during May-September in the Black Hills from 1989 to 1996, reported capture of a total of 129 adult males and 47 adult females over the 7 year period. During that same 7-year timespan, 4 females and 58 males (total of 62) were captured at the entrance to Jewel Cave (Cryan 1997).

Habitat Associations

At the western edge of its range, *Myotis septentrionalis* is found in wooded riparian zones in badlands and prairies (Barclay 1993), to higher elevation conifer and deciduous woodlands (Czaplewski et al. 1979; Clark and Stromberg 1987; Nagorsen and Brigham 1993). In the Black Hills region, this species has been captured at elevations ranging from 1200m to 1950m (4000 - 6500ft; Turner 1974).

Roosting Ecology

Maternity Roosts

Maternity roosts of northern myotis have been reported in buildings (Barbour and Davis 1969; Tigner 1997), under loose bark and in crevices and cavities of deciduous trees (Barbour and Davis 1969; Clark et al. 1987; Foster and Kurta 1999; Novakowski 1956; and others), and in crevices and cavities of ponderosa pine trees (Cryan 1997). Maternity roosts are typically small in number with reported numbers of 5 (Clark et al. 1987), 10 (Tigner 1997), and 11-65 (Menzel et al. 2002) reproductive females per confirmed nursery colony.

Lacki and Schwierjohann (2001) reported day roost characteristics of northern bats in a mixed mesophytic forest in northeastern Kentucky. Maternity colonies were primarily found in cavities of hardwood snags or under the bark of shortleaf pine snags. Snag/tree height was not provided, but roost snag mean dbh (cm) ranged from 12.7 ± 2.38 for post-lactating bats to 30.3 ± 3.8 for pregnant bats. Pregnant, lactating, and post-lactating northern bats occurred in areas with snag densities (snags/ha) of 44.5 ± 0.4, 37.0 ± 0.15, and 32.0 ± 0.28, respectively.

Menzel et al. (2002) radiotracked lactating *M. septentrionalis* in the central Appalachians of West Virginia to find and characterize roost trees selected by maternity colonies of this species. The remainder of this paragraph is a synopsis of their findings. Twelve maternity roosts were identified, all in hardwoods. Eleven of the twelve roosts were in cavities; one was under a large piece of loose bark. Roosts were found in black locust trees more frequently than expected based on their abundance in the forest. Each roost tree occurred in a stand that had been subjected to a 40cm dbh diameter-limit harvest within the previous 10 years. As such, these stands presented multi-aged, complex overstory structure, with heterogeneous canopies and considerable variation in stocking. The structural complexity of vegetation surrounding roosts did not differ from that of surrounding, randomly located cavity trees. While height of roost trees did not differ from random cavity trees, height of the roost cavity itself did differ from cavities in random trees, with actual roost cavities being three meters higher (mean roost height of 10.8m ± 1.0m) than random cavities. Roost trees did not differ in dbh (mean 29.2m ± 1.6m) from random overstory cavity trees. Roost trees typically had little remaining bark, a broken top, and a firm bole with few or no limbs. The most important factor associated with roost site selection appeared to be distance to the nearest taller tree, with bats selecting roosts closer to taller trees. A second important factor was that understory vegetation surrounding roost trees was less dense than that surrounding random cavity trees. In summary, the implication of their results was that, in the absence of suitable old-growth forest, this species of bats has adapted to utilization of roost sites in intensively managed Allegheny hardwood-northern hardwood forests of the central Appalachians. However, as the authors pointed out, without roost data from other forest types, "the true conservation value of managed forests to bat populations in terms of maternity colony success and recruitment remains unknown" (Menzel et al. 2002).

Tigner (1997) reported a small nursery colony of not more than 10 individuals apparently roosting in a building in Wall, South Dakota (approximately 110km east of the Black Hills). Tigner (1997) also reported a maternity colony of approximately 75 individuals (including young) in the roof apex of a two-story brick building near Sturgis, SD.

The only other maternity roosts described from the Black Hills were those reported by Cryan (1997) and Cryan et al. (2001). The remainder of this paragraph is a summary of the findings from these two papers combined as the latter (Cryan et al. 2001) is the publication resulting from the thesis (Cryan 1997). Roost trees (all ponderosa pine) used by this species had a mean dbh of 39cm (range 21-52), which was significantly greater than random snags. The mean decay stage of roost snags was 5.5 ± 2.0 (*sensu* Thomas et al. 1979). Snag density was reported as 0.3 ± 0.6 snags/plot, and being six times greater than snag densities in surrounding or random plots. The 21 roosts located in this study occurred at elevations from 1140m to 1850m (mean roost elevation of 1593m), and were from 0.3km to 2.5km from the nearest permanent water (mean distance of 1.3km). The fact that these roosts occurred in areas where timber harvesting had occurred supports the preliminary observations of Menzel et al. (2002) – although for an entirely different forest ecosystem – that *M. septentrionalis* may have a greater ability to adapt to use of managed forests than some other bat species.

Hibernacula

Myotis septentrionalis hibernates in caves and mines (Barbour and Davis 1969; Caceres and Barclay 2000). Unlike *Myotis lucifugus* and *Corynorhinus townsendii* who also hibernate in caves, *M. septentrionalis* is generally not found in large aggregations during hibernation, perhaps because they tend to wedge into crevices and so are not as visible or easily counted. Martin and Hawks (1972) found no hibernating *M. septentrionalis* during an extensive survey of more than 100 caves and mines in the Black Hills during the winters of 1969-1970. Documentation of hibernation by this species in the Black Hills is limited to unpublished reports of undisclosed numbers of hibernating individuals in a single cave in the northern Black Hills (Tigner and Aney 1993, 1994) and possibly Jewel Cave (Tigner 1997).

Raesley and Gates (1987) used discriminant function analysis of eight variables to characterize hibernation site selection in Maryland and West Virginia by five species of bats including *M. septentrionalis*. The remainder of this paragraph is a summary of their findings for *M. septentrionalis*. *Myotis septentrionalis* hibernated in caves sites with the following mean conditions (and 95% CI):

-Relative humidity	65.2% (60.0-70.3)
-Wall temperature	6.1°C (5.7-6.5)
-Ambient temperature	6.9°C (6.5-7.4)
-Air flow (relative scale)	1.2rs (1.0-1.3)
-Projection length	0.10cm (0.08-0.11)
-Wall slope	41.9° (31.6-58.2)
-Wall distance	1.2cm (0.9-1.5)
-Bat distance	7.6cm (-0.5-15.6)

In summary, *M. septentrionalis* selected cooler areas of the hibernaculum, were most often found in crevices along the side wall, and tended to cluster at these locations.

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

Myotis septentrionalis adult males and nonreproductive females have been reported roosting in buildings, under shingles or behind shutters of buildings, underneath exfoliating bark and inside cavities or crevices of trees, and in caves, mines, and quarries (Foster and Kurta 1999; Jones et al. 1983; Nagorsen and Brigham 1993). In New Hampshire, *M. septentrionalis* roosted primarily in snags (39 out of 47 roosts), but also in live trees (8 out of 47 roosts; Sasse and Pekins 1996). Snag roosts had larger diameters (40.9±2.8cm), were taller (14.8±1.0m), had more bark (78±5.6%) and lower snag class values (2.8±0.3), than did available but unutilized snags (Sasse and Pekins 1996). In British Columbia, this species also roosted in tall trees in early decay stages, or in live trees in plots with less canopy closure than randomly available trees (Caceres and Barclay 2000).

Night Roosts

Northern myotis have been reported anecdotally to utilize mines and caves as night roosts (Barbour and Davis 1969; Holroyd et al. 1994; Nagorsen and Brigham 1993).

Interim Roosts

No studies elucidating the use of interim roosts by this species were found.

Foraging Habits

Myotis septentrionalis utilizes both aerial hawking and gleaning foraging strategies (Faure et al. 1993). Use of habitat for foraging is apparently diverse for this species. Some anecdotal reports of *M. septentrionalis* foraging indicated that this species forages beneath the canopy (Caceres and Barclay 2000; Nagorsen and Brigham 1993), while studies aimed specifically at elucidating foraging habitat for this species indicated that while it does forage below the canopy, it also forages within and above the canopy (Kalcounis et al. 1999). While some references indicated that *M. septentrionalis* forages in hillside and ridgetop vegetation rather than riparian areas (Clark and Stromberg 1987; foraging in Wyoming), other studies indicated that this bat does utilize riparian woodlands for foraging (Kunz 1973; foraging in Iowa). Kunz (1973) reported bimodal feeding activity for this species in Iowa, with the first bout peaking at about 1.5-2h after sunset and the second peak occurring at about eight hours after sunset.

Prey Species

The most prevalent prey group in the diet of *M. septentrionalis* is Lepidoptera, followed by Coleoptera, and minor contributions by Hymenoptera, Homoptera, Diptera, Trichoptera, Plecoptera, Neuroptera, and Ephemeroptera (Brack and Whitaker 2001; Griffith and Gates 1985). Brack and Whitaker (2001) reported temporal variation in composition of the diet, suggesting that *M. septentrionalis* is an opportunistic forager, taking prey largely in proportion to their availability.

Characteristics Of Prey Species

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 septentrionalis* fell out on the first principal components axis at a value of about +0.50 indicating a moderately 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. septentrionalis* prey items had a weighted average of 2.75 (Freeman 1981).

Reproduction And Development

Life History Characteristics

Mills (1971) and Schowalter (1980) reported swarming activity by *M. septentrionalis* at caves in Ohio and Alberta, respectively. Swarming occurred in August and September at both localities and numbers of *M. septentrionalis* were much higher in Ohio (578 captured over two years) than in Alberta (10 captured over two years; Mills 1971, Schowalter 1980). Longevity for this species, based on banded bat recovery data, is 18.5 years (Caceres and Barclay 2000).

Survival And Reproduction

As with most temperate zone vespertilionids, reproductive output is limited to one offspring per year (Barclay 1993). Mating occurs in late summer and fall, before these bats enter hibernation (Caceres and Barclay 2000). In Iowa, pregnant females were caught from 20 May through 23

June, and lactating females were taken from 23 June through 28 July (Kunz 1971). In more northern portions of this species' range, parturition may occur as late as mid-July (Caceres and Barclay 2000; van Zyll de Jong et al.1980). Subadults have been collected as early as July in Iowa and New Hampshire (Clark et al. 1987; Sasse and Pekins 1996), and in early August in Ohio (Mills 1971). In the Black Hills, Cryan (1997) reported that 41% of the females of this species captured after the first of July showed signs of reproduction.

Local Density Estimates

No literature was found which provided local density estimates for *Myotis septentrionalis.*

Limiting Factors

No studies found 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 unknown which is/are acting as limiting factors.

Patterns Of Dispersal

No studies were found which addressed dispersal *per se* in this species. Griffin (1940) reported that, during the winter months in New England, *M. septentrionalis* occasionally travel as far as 120 miles from one cave to another. Cryan (1997) reported that males and reproductive females were significantly separated elevationally during the summer with males captured at a mean elevation of 1579m and females at 1495m.

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 northern 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)

Kunz (1973) examined spatial and temporal patterns of activity for a guild of bats in Iowa, including *M. septentrionalis*. Both *M. septentrionalis* and *Lasionycteris noctivagans* display bimodal peaks in foraging activity, with the times of peak activity overlapping markedly between the two species. His results suggest that *M. septentrionalis* and *Lasionycteris noctivagans* may avoid competition for prey by establishing foraging territories at different sites.

No studies were found which assessed the potential for competition between *M. septentrionalis* and any other taxa for roost sites. Given that populations of this species in the eastern portion of its range have apparently adapted to roosting in managed forests, this plasticity may allow it to avoid competition with a number of more selectively constrained species.

Parasites, Disease

Ectoparasites recorded from *Myotis septentrionalis* include the following, all taken from Caceres and Barclay (2000) unless otherwise indicated:

Chiggers	Trombiculidae:	*Euschoengastia pipistrelli*
		Leptotrombidium myotis (Jones and Genoways 1967)
Other mites	Acarina:	*Acanthopthirus*
		Macronyssus crosbyi
		Spinturax americanus
		Olabidocarpus whitakeri
Batbugs	Cimicidae:	*Cimex adjunctus*

In addition, the following endoparasites (internal helminths) have been reported for *M. septentrionalis*: *Hymenolepis christensoni, Vampirolepis roundabushi, Prosthodendrium volaticum,* and *Plagiorchis vespertilionis* (Caceres and Barclay 2000). Rabies virus and equine encephalomyelitis have been reported from this species (Caceres and Barclay 2000).

Other Complex Interactions. Include Interactions With Other Bat Species

No literature was found which addressed ecological interactions of *M. septentrionalis* with other taxa beyond that already mentioned in Competitive Interactions, above.

Roost Site Vulnerability

As *M.* septentrionalis uses caves as hibernacula and, occasionally as summer roosts, they face the same, primarily anthropogenic, challenges as other cavernicolous hibernators (see Recreation below).

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 and, as such, are currently largely unknown. Availability of suitable hibernacula, maternity roosting sites, and foraging areas all represent potential risk factors for *M. septentrionalis* as they do for most species of bats.

Response To Habitat Changes

Management Activities

Timber Harvest

The 2001 Phase I Amendment (US Forest Service 2001) 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 and regeneration openings, as long as these activities are not conducted close to roosting sites, particularly during the reproductive season (roughly mid-April to September), would not be anticipated to negatively impact northern myotis. Commercial thinning which promotes larger diameter trees and, eventually, larger diameter snags, may provide future populations with improved snag roosting opportunities. Regeneration openings may provide temporary foraging areas for *M. septentrionalis,* particularly if they are close to roosting areas and water sources. The avoidance of trees used as maternity roosts (even when harvest activities take place during the time when bats are hibernating elsewhere) 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 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. Although no specific guidelines are available for maintenance of vegetation around caves, retention of adequate vegetative cover over and around the entrance of the cave to promote the appropriate range of microclimatic conditions within the cave (see conditions for *M. septentrionalis* under Hibernacula, above) would seem reasonable. Conversely, letting vegetation grow to the point that the entrance can no longer be safely accessed by flying bats would be anticipated to have negative impacts on those species utilizing the particular cave.

The 2001 Phase I Amendment to the LRMP increased minimum hard snag requirements to 2 snags/ha for Ponderosa Pine forest on south and west slopes, and 4 snags/ha on north and east slopes (US Forest Service 2001). While Cryan et al. (2001) reported snag densities of 0.3 ± 0.6 snags/plot for northern myotis in the Black Hills, what this transfers to in terms of snags/ha is unclear from the report. Lacki and Schwierjohann (2001) provided snag densities for day roost sites of various classes of reproductive female northern myotis ranging from 32 – 44.5 snags/ha (for details see Maternity Roosts, above).

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 roost snag dbh for northern myotis in the Black Hills of 39.0 ± 8.2cm.

Recreation

The increased interest in spelunking in the United States has the potential to negatively impact *M. septentrionalis* 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.

Livestock Grazing

No studies were found which addressed the impact of livestock grazing on northern myotis. Livestock grazing may indirectly benefit bat species through the construction of additional water sources (Chung-MacCoubrey 1996). Alternatively, it may have the potential to negatively impact bats by removing or altering vegetative composition and thereby affecting insect diversity or abundance. Detailed studies of the impacts of grazing on this species are needed.

Mining

No studies were found which addressed the impact of mining activities on *M. septentrionalis,* although these bats do often use abandoned mine works as roosting sites.

Prescribed Fire

To date, studies directly assessing the impact of fire regimes on *M. septentrionalis* are not available.

Fire Suppression

As mentioned above, the impact of various fire regimes on *M. septentrionalis* 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 any bats, even for highly maneuverable bats such as the northern myotis. Thus, fire suppression in the Black Hills would probably be more of a detriment than a benefit to the *M. septentrionalis* populations of this region.

Non-Native Plant Establishment And Control

Myotis septentrionalis consumes a variety of softer-bodied invertebrate prey, limited perhaps only by the size of prey it can physically take (Kunz 1973). 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

No studies directly addressing the impact of fuelwood harvest on *M. septentrionalis* were found. However, if fuelwood harvest allows the removal of standing dead tress, which it typically does, then this activity has the potential to negatively impact northern myotis by removing potential roosting sites. Fuelwood harvest which permits only the removal of downed trees, or of snags under 21cm 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.

Natural Disturbance

Insect Epidemics

No literature was found which dealt with the impact of insect epidemics on *M. septentrionalis*.

Wildfire

No literature is available which specifically addresses the impact of wildfires on populations of *Myotis septentrionalis.* 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 either roosting or foraging habitats for many 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 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 foraging habitat by bats.

Wind Events

While no literature directly addressed the effects of wind events on northern myotis, the spatial scale of such events would probably determine the consequences for this species. Small-scale events which break or down occasional trees would probably not have a detrimental effect on *M septentrionalis*, 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 roost site availability for this species.

Flooding

No literature is available that addresses the impact of flooding on *Myotis septentrionalis.* However, given that this species tends to roost a mean distance of 1.3km from water (range 0.3 – 2.5km), the impact of flooding on this species in the Black Hills would probably be minimal.

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 septentrionalis ranges across most of eastern North America, extending from central Quebec, Ontario and the southern half of Manitoba, south through all of the Dakotas, eastern Nebraska, Kansas and Oklahoma and then east to the Atlantic coast. In the Black Hills region, this species has been recorded from Custer, Lawrence, Meade and Pennington counties of South Dakota, and Crook and Weston counties of Wyoming.

Northern myotis hibernate in caves and mines, and utilize a variety of sites for summer (nonreproductive) and maternity roosts, including buildings, mines and caves, and snag roosts. Reproduction is limited to one offspring per year and estimates of proportion of females reproductive in the Black Hills are below 50%.

Although referred to as “common” and “abundant” in the Black Hills, year round residency of this species in the Black Hills has only recently been established. Foraging habitat and many other aspects of this bat’s biology are still poorly understood for the Black Hills region.

REVIEW OF CONSERVATION PRACTICES

Management Practices

No management plans or conservation strategies for management of primarily coniferous forests were found for this species. Lacki and Schwierjohann (2001) and Menzel et al. (2002) discussed management implications of their studies, but these were relative to mixed hardwood forests of Kentucky and West Virginia.

Models

Cryan (1997) reported that a regression model predicting the number of females (of all species considered, not just *M. septentrionalis*) 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 $p \leq 0.001$. Cryan et al (2000) refined the logistic regression model by fitting it with the GLIMMIX macro in SAS (Littell et al. 1996; as cited in Cryan et al. 2000). This new model indicated that the proportion of reproductive female *M. septentrionalis* decreased with increasing elevation at a faster rate than that for the other species in the study.

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 use of Geographic Information Systems can greatly facilitate habitat monitoring, assuming the characteristics for high-quality *M. septentrionalis* habitat are known. Current information about roosting requirements for this species may not 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

While *M. septentrionalis* is known to occur throughout most of the Black Hills and has been found hibernating in caves in the Black Hills, the location, characteristics, and distribution of both hibernacula and summer roosts for this species in the Black Hills need further study. Elucidation of this information is important for any attempt at developing management plans for this species.

Species Response To Stand Level Changes

As no literature was found which specifically documented the response(s) of northern myotis 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. septentrionalis* in this area. Until such responses are documented by the establishment of baseline data before stand changes are initiated, and then tracking species response after the changes, the work by Cryan et al. (2001) is the best available. Cryan et al. (2001) documented evidence of timber harvesting within roost plots of *M. septentrionalis*, indicating that this species has some tolerance for such changes.

Roosting Habitat Adaptability

This species has been documented to use a variety of settings for roosts: abandoned buildings, mines and caves, under loose bark of trees, in tree cavities. Studies in the eastern portion of this species' range suggest that northern myotis can and do adapt to management of forests. The location, distribution and characteristics of summer roosts for this species in the Black Hills National Forest is needed to develop management plans for this species. The use of interim roosts by this species has not been documented and is another area in which research is needed.

Movement Patterns

The work of Cryan (1997) addressed the summer distribution of this species in the southern Black Hills. However, movement patterns of this species from hibernacula to summer foraging/roosting grounds in the Black Hills are as yet undescribed. 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 northern myotis 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. septentrionalis* might also be augmented by the use of acoustic monitoring.

Demography

Elucidation of the age structure of populations of *M. septentrionalis* 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. septentrionalis*	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. septentrionalis*	High

*Low: would refine or improve northern myotis 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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