BATS OF THE BLACK HILLS
A DESCRIPTION OF STATUS AND CONSERVATION NEEDS

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WILDLIFE DIVISION REPORT 2003-05
MARCH 2003

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INTRODUCTION

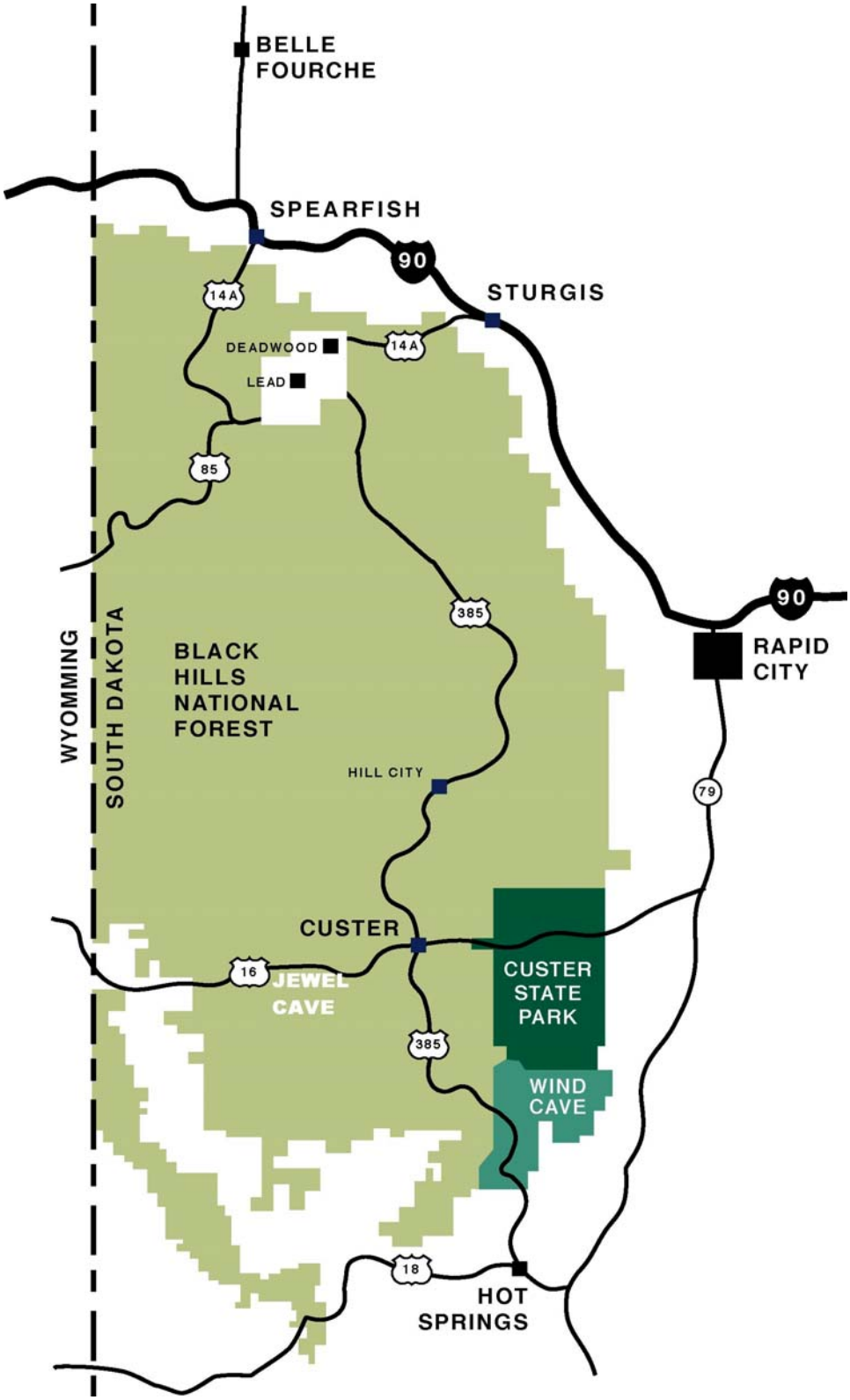
"**. . to most of us they are still nearly as unknown as the stars. .**" G.M. Allen *BATS*

Little has changed since that observation of bats was made in 1939. Despite the recent increase in the study of bats, they remain among the least understood and most maligned of animals. Falling victim to popularly held misconceptions and changes in habitat, few animals are as susceptible to human vagaries as bats (Hill and Smith 1984). In recent years, significant declines in bat populations have been documented worldwide, most in response to loss of roosting habitat (McCracken 1988). Reversing this trend will require widespread recognition of their ecological contributions as well as protection of foraging and roosting habitat (Kunz and Pierson 1994).

To gain a better understanding of bats and their requirements, this study was conducted to identify species residing in the Black Hills and their roosting habits. Each species was studied to gain insight about management actions needed to protect significant roosting and foraging sites.

This publication summarizes previous work conducted in the Black Hills, supplemented with results of fieldwork conducted primarily during the 1990s. The authors would like to acknowledge that much of the research cited during this period was funded by the South Dakota Department of Game, Fish and Parks, the Federal Aid in Wildlife Restoration Program, and the U.S. Forest Service.

The goal of this publication is to create a resource tool for others to use to continue the study of bats in the Black Hills. It is also a source of information in which species-specific management recommendations are made to protect the current populations within the region. It is hoped this publication will provide a summary of the information collected, and that by consolidating such findings, this work will suggest direction for future research, prevent costly duplication of effort, and enable informed responses to questions on management issues.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BAT SPECIES OF THE BLACK HILLS

Bats represent one of the most diverse groups of animals. Within the class of Mammalia, they are second only to rodents in total number of species. Their order, Chiroptera, is comprised of over 900 species, nearly a quarter of all mammal species. Chiroptera is then divided into two sub-orders, the Megachiroptera and the Microchiroptera (van Zyll de Jong 1985). The former are found only in the Old World tropics while the latter, to which all of the Black Hills' species belong, are represented in all but extreme arctic regions (van Zyll de Jong 1985). All bats found within the Black Hills belong to the family Vespertilionidae and are exclusively insectivorous (van Zyll de Jong 1985). Until recently, their importance as the primary predator of nocturnal flying insects, many of which are responsible for substantial damage to forests and crops, has gone largely unrecognized (Tuttle 1988).

The physiological adaptations of bats to their environment are highly specific and sophisticated. Fossil evidence suggests their unique morphological adaptations to the environment have been present for at least the last 50 million years (Habersetzer et al. 1994, Jepson 1970, Novacek 1985). While displaying such typical mammalian characteristics as fur bearing, live birth and nursing of young, bats are unique among mammals with their ability of sustained flight (Fenton 1992).

One of their more amazing characteristics is their use of echolocation in foraging and navigating. Bats emit ultrasonic pulses, then receive and interpret reflection of these pulses' echoes much like sonar systems (Griffin 1958). These echoes produce a "sound picture" within the bat's brain that enables it to forage and navigate with phenomenal speed and pinpoint accuracy.

Regional bat species diversity is typically linked to habitat diversity (Stebbings and Griffith 1986). Within the Black Hills, mixtures of forest, grassland, and riparian habitat coupled with the occurrence of numerous caves and abandoned mines combine to create diversity unique to the central plains of the United States.

The South Dakota Natural Heritage Program currently monitors five species of bats found within the Black Hills. The Wyoming Game and Fish Department (1996) has set objectives for bat inventories statewide. The following bat species can be found within the Black Hills of South Dakota and Wyoming and are known to be year-round residents (Anderson 1993, Choate and Jones 1981, Martin and Hawks 1972, Tigner and Aney 1994, Turner 1974, Worthington and Bogan 1993):

Species names used throughout this document are based upon current conventions as noted at NatureServe Explorer: An online encyclopedia of life [web application]. 2002. Version 1.6. Arlington, Virginia, USA: NatureServe. Available: http://www.natureserve.org/explorer.

Myotis ciliolabrum (Western Small-footed Myotis)

Myotis evotis (Long-eared Myotis)*

Myotis lucifugus (Little Brown Myotis)

Myotis septentrionalis (Northern Myotis)*

Myotis thysanodes pahasapensis (Fringed Myotis)*

Myotis volans (Long-legged Myotis)

Corynorhinus townsendii pallescens [formerly *Plecotus t. p.*] (Townsend's Big-eared Bat)*

Eptesicus fuscus (Big Brown Bat)

Three other species, considered "tree-roosting" bats, are migratory and winter in milder climates. These are:

Lasionycteris noctivagans (Silver-haired Bat)*

Lasiurus borealis (Eastern Red Bat)

Lasiurus cinereus (Hoary Bat)

*indicates species monitored by SD Natural Heritage Program

Based upon the presence of suitable habitat, Turner (1974) suggested another species, *Euderma maculatum* (Spotted Bat), may occur in the Black Hills, though there are no records to date.

A hibernaculum survey conducted at an abandoned mine in the central Black Hills on 01/07/03 yielded a single specimen of *Pipistrellus subflavus* (Eastern Pipistrelle). This is the first record for this species in the Black Hills. Additional regional records for this species include three identified hibernating in a cave in Goshen County, Wyoming (Grenier personal communication) and from Greeley, Colorado (Fitzgerald et al.1989).

Vocal signatures for this species were also recorded using the ANABAT detector system at McKenna Spring in the southern Black Hills (Mike O'Farrell [O'Farrell Biological Consulting, Las Vegas, Nevada] personal communication).

DATA COLLECTION

Surveys

A variety of survey methods has been employed to study bat populations in the Black Hills (Cryan and Bogan 1996, and others). One limiting factor directly affecting the ability to draw conclusions from survey work conducted to date is lack of historical data to serve as a baseline with which comparisons can be made. Changes in population dynamics and patterns of distribution within the Black Hills are difficult to assess based upon current information. As such, one of the more important contributions made by recent studies is the establishment of baseline population data. If collected regularly and objectively, future biologists can use the information to monitor population trends.

Historically, reported population sizes and declines were largely based upon hibernacula surveys (Humphrey 1975, Ransome 1990, Tuttle 1977). In the Black Hills, there are only three known hibernacula that contain more than 300 bats. Most support fewer than 25 bats. Given the well-documented colonial behavior of many of the region's species during hibernation, such numbers demonstrate a significant lack of information regarding wintering behaviors. An alternative premise suggests wintering bats of the region hibernate in cracks and fissures, a common feature of Black Hills geology. If true, hibernacula surveys as a basis for gauging population trends are untenable.

One long time resident, on whose property lies a popular "show cave," described bats emerging on a summer evening in 1932 as a "column of smoke." He recalls this daily emergence lasting several minutes. Today there are no known sites in the Black Hills whose numbers would compare with this observation.

Recent Black Hills studies have exploited newer technology, such as radio telemetry, to identify roost sites for poorly understood species (Cryan and Bogan 1996, Mattson 1994).

Banding

Tigner and Aney (1994) collected information via banding and year-round roost monitoring. Banding was the primary method used to collect seasonal range and roost fidelity data beginning in 1992. Surveys conducted since 1992 have reported no observations of bats banded during earlier studies.

Bats were banded only during the active time of year. No hibernating bats were banded or disturbed to read bands. Band numbers were often hidden by roosting posture or roosting location. As a result, information from winter observations was often limited to species and sex. Males were banded on the left forearm, while females were banded on the right. This distinction was rigidly observed to enable sex determination during hibernation surveys when bats could not be disturbed. See TABLE 1 for banding information.

Bats were captured with mist nets and harp traps outside night roosts and at foraging sites. Some were caught via static hand-held nets inside the roost. Captures within a roost were only used at roosting sites where exclusion from the roost was imminent, such as building remodeling or demolition, mine closure, and intentional roost exclusion.

Survey Bias

Environmental characteristics, such as surface water, may affect distribution patterns. Riparian areas, with their higher insect prey densities, consistently yield higher capture rates than uplands (Cross 1988). Capture rates were highest in the southern Black Hills where limited surface water likely served to concentrate insect prey.

Roost availability also affects species distribution (Kunz 1982, Tuttle and Stevenson 1982). Bats with specific roost requirements are more susceptible to changes in habitat than more opportunistic species. Human induced change, such as firewood collection, timber harvest, natural or deliberate mine closure, and disturbance or vandalism within natural caves all can influence roost availability resulting in changes in distribution. In addition to roost availability, proximity to other requirements, such as foraging areas, can affect distribution (Kunz 1982).

Population trend data for migratory bats must be interpreted with caution. Migratory species may be affected by factors unrelated to summer habitats (Thomas and LaVal 1988), such as pesticide exposure during migration or on wintering range (Clark 1981). Species that are characteristically more sedentary, but about which limited information has been collected, are also difficult to assess (Thomas and LaVal 1988).

Sex segregation during maternity and nursery season also affects survey results. Netting surveys conducted at foraging sites in the southern Black Hills yielded a male:female ratio of 2:1 in *Myotis* species (Cryan and Bogan 1996, Mattson 1994, Tigner unpublished data). Similar findings are characteristic of capture rates in the northern Black Hills (Tigner unpublished data). Such segregation is likely a result of different summer roosting requirements. Cryan and Bogan (1996) have also suggested this segregation may serve to demonstrate the importance of areas in which reproductive females occur.

In general, reproductive females were more frequently captured at lower elevations (Cryan and Bogan 1996, Mattson 1994, Tigner unpublished data). Selection of lower elevations by reproductive females may be a response to thermoregulatory requirements during the maternity/nursery season.

Number of nets and net placement affect the capture rate at a given location (Kunz and Kurta 1988). Netting surveys may yield disproportionately high numbers of species less adept at obstacle evasion. While none of the Hills species could be characterized as bumbling, *C. townsendii* is the species least susceptible to traditional capture methods. This species can be commonly observed flying through small openings in mist nets requiring folded wings. Similarly, this species frequently evades capture by harp traps. After several apparent

reconnaissance approaches, individuals will dive with folded wings through the top of the trap allowing momentum to carry them through the second bank of strings.

Natural population fluctuations also affect survey information. Poor foraging years or cold winters often result in high mortality or altered migration patterns (Ransome 1990). Without a historical perspective to gauge fluctuations, interpretation of "point-in-time" surveys becomes somewhat limited.

Seasonal variations in weather patterns may also affect population distribution. Variations between summers may yield different survey information. Such variations are important components in determining population trends.

Flooding may cause bat populations to decline. Many caves in the east-central region of the Black Hills exhibit historical evidence of complete flooding. While such flooding may only occur rarely, low reproductive rates in bats make population recovery slow. Such periodic cleansing may also remove evidence of historical use by bats.

BASIC BAT BIOLOGY AND ITS IMPLICATIONS

Understanding the biological adaptations that characterize bats is essential to design effective conservation objectives (Kunz 1982). It is beyond the scope of this report to detail all of these, but characteristics that may be affected by land management activities are discussed.

Hibernation

Increasing disturbance of known hibernacula throughout the Black Hills poses one of the most serious threats to year-round bat populations. Winter is one of the most critical times of year for bats (Ransome 1990). While some species demonstrate a degree of flexibility in summer roost site selection, diminished or non-existent winter food supplies require year-round resident species[1] to seek hibernacula that meet specific conditions. Some hypogeal species travel great distances to winter roosting sites (Fenton and Barclay 1980, Ransome 1990), but there is no information to suggest this behavior is characteristic of Black Hills species. Of the Black Hills' eight hypogeal species, seven[2] are confirmed year-round residents (Anderson 1993, Mattson and Bogan 1993, Tigner and Aney 1994).

During hibernation, bats lower their metabolic rate reducing the expenditure of stored energy (Ransome 1990). Each species has an optimal temperature range at which there is a minimum expenditure of these hibernal reserves (McNab 1974, Ransome 1990). Deviation from this optimal range requires the bat to regulate its metabolism. If the microclimate of the hibernaculum becomes too cold, stored reserves must be used to prevent the bat from freezing. In contrast, warm conditions prevent bats from lowering metabolic rates, and hibernal stores are depleted too rapidly. While winter survival can be completely dependent upon stored reserves, brief warm spells may also permit bats to supplement reserves by foraging and drinking (Ransome 1990).

In addition to temperature and relative humidity, physical environment is another important feature of suitable hibernacula (Ransome 1990). The hibernacula must contain an area that affords bats protection from predators. Bats are unable to evade predators during hibernation.

Thermoregulating behaviors exhibited by bats vary according to species (McNab 1974, Ransome 1990). Two of the more common behaviors adopted as means of maintaining stable temperatures are clustering and roosting within cracks and crevices (McNab 1974, Ransome 1990). If a hibernaculum microclimate becomes unsuitable, the bat will arouse from hibernation and seek conditions that are more favorable. Such movement may involve simple shifting within the hibernaculum or may require complete site abandonment and relocation (Ransome 1990).

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[1] *L. noctivagans, L. borealis* and *L. cinereus* are considered migratory.

[2] No winter records have been recorded for *Myotis evotis* in the Black Hills.

The habit of forming hibernation clusters can put large segments of bat populations at risk. Disturbing a small number of bats in a cluster may result in a cascade effect. The movement of a few bats in contact with other hibernators could disturb a large percentage of the collective roost (Thomas 1995). Identifying such sites and protecting them from disturbance is an important component of any conservation strategy for bats in the Black Hills.

Arousal from hibernation is extremely demanding on stored energy reserves. Each arousal that elevates a bat's body temperature to permit flight can cost 10 to 30 days of hibernal reserves (Tuttle 1991). Frequent disturbances within hibernacula can result in exhaustion of energy reserves resulting in starvation (Ransome 1990). Unusually cold winters or poor foraging seasons can result in lower hibernal reserves, thereby increasing susceptibility to disturbance (Tuttle 1991). In addition to environmental causes of arousal, human disturbance can be deleterious. Examples include spray-painting cave and mine interiors, constructing campfires, and discharging fireworks. Less obvious is the increase in ambient temperature caused by body heat dissipation and lighting sources. Noises generated by movement and talking can also disturb hibernating bats (Thomas 1995). Complete arousal from hibernation can be prolonged with the bat awakening after the source of disturbance has departed, leaving those responsible unaware of their impact.

Historically, hibernal requirements were probably met by the abundant natural caves found throughout the limestone periphery of the Black Hills. Based upon numbers, the largest known hibernacula in the Black Hills are located in natural caves. Through a variety of circumstances, many natural caves are no longer suitable. Commercial cave development, natural erosion, and human disturbance all contributed to a reduction in the number of available hibernacula.

Mining created artificial roosting and hibernacula alternatives for seven of the hypogeal bat species in the Black Hills. However, given the minimal amount of research conducted to date on mine utilization, it is difficult to determine the role mines play in sustaining bat populations. This relationship remains one of most important areas yet to be investigated. One abandoned mine identified in Custer County during the winter of 2002/03 contained the third largest collective of *Corynorhinus townsendii* yet identified in the Black Hills.

In the Black Hills, bats generally begin arriving at hibernacula in late September or early October. Depending upon weather conditions and the species, bats hibernate from October until April. Based upon observations of banded bats, hibernacula also serve as night roosts throughout the summer season. With two exceptions, all positive identifications in hibernacula were of bats banded at the same roost during the summer months.

Jewel Cave National Monument, located 18.5 km west of Custer, SD, is the largest known wintering site for bats in the Black Hills (Choate and Anderson 1997). Recent winter surveys yielded total counts of approximately 1200 bats comprised of seven species (Choate and Anderson 1997). These include: *Corynorhinus townsendii*, *Myotis ciliolabrum*, *Myotis lucifugus*, *Myotis septentrionalis*, *Myotis thysanodes pahasapensis*, *Myotis volans*, and *Eptesicus fuscus*. Jewel Cave serves as hibernacula to one of the largest known collectives of

Corynorhinus townsendii in the western United States (Worthington and Bogan 1993). As such, its ecological importance cannot be over-emphasized.

In addition to providing winter respite to resident species, Jewel Cave also contains large numbers of bats that are known to travel great distances to hibernacula (Fenton and Barclay 1980). For this reason, this cave may represent an important wintering location for bats from outside the immediate Black Hills region (Worthington and Bogan 1993).

While it is unknown when bats began using Jewel Cave, it has been an important hibernaculum since at least the 1950's (Worthington and Bogan 1993). Summer use of the cave is generally limited to night roosting, though small numbers were documented using the site as a day roost (Choate and Anderson 1997). All species that hibernate there have been documented using the site as a night roost (Choate and Anderson 1997, Mattson and Bogan 1993).

The documented success of this location as a hibernaculum for such a wide variety of species is likely attributable to two factors. First is the diversity of microclimate conditions found within the cave. As has been noted, differences in hibernaculum selection among species are well documented. The present number of species attests to the range of conditions.

The second important factor is the limited level of disturbance characteristic of the site. Bat access to the cave is via the original entrance, which is gated to restrict human access (Mattson and Bogan 1993). No winter tours are conducted through hibernal areas, and access is restricted from October through April to minimize disturbance to the bat population (Kate Cannon personal communication).

Reproduction

While significant variations occur among species, there are some general characteristics common to bat reproduction that are important considerations for conservation strategies.
In general, mating occurs in the fall of the year (Racey 1982). Females store the male's sperm until spring, whereupon fertilization and implantation occur (Racey 1982). Given poor environmental conditions, females can delay fertilization, implantation, and even gestational growth of the embryo by entering torpor until conditions are suitable (Racey 1982). Increased levels of precipitation and the resultant decrease in foraging activity delay reproduction and may prevent breeding entirely in some individuals (Grindal et al. 1992, Racey 1982).

Females begin to form maternity roosts upon emergence from hibernation in the spring. Such roosts are collectives of females that may have traveled to the site from a wide area. Requirements for such sites vary by species. Two important factors are proximity to foraging areas and roost temperature (Racey 1982).

Bats generally give birth to a single altricial pup and only once a year. As during hibernation, bats are particularly susceptible to disturbance at this time. Disruption of maternity roosts can

result in reabsorption of the embryo or spontaneous abortion. Disturbance at nursery roosts can result in the abandonment of non-volant pups.

In some species, nursery roosts may be completely different sites from maternity roosts. Again, proximity to foraging areas and roost temperatures are common requirements (Tuttle and Stevenson 1982). Warm roosting temperatures hasten parturition and development of the juveniles (Racey 1982). A roost's proximity to foraging areas is particularly important before the pups are volant (Tuttle and Stevenson 1982). Females have very high energy demands during this time of year. Long flights to foraging sites consume high levels of energy. Additionally, females must return to the nursery roost periodically throughout the night to nurse offspring. Once pups are volant, mastering foraging technique and accumulating body weight for successful hibernation are more efficient in areas with high insect densities close to the roosting site (Tuttle and Stevenson 1982).

Nursery roost members begin to disperse in the late summer and early fall when bats either migrate or return to hibernacula. Low reproductive rates, susceptibility to disturbance, and specific roost requirements are three important elements that underlie the need for conservation strategies and habitat management.

Night Roosts

Night roosts serve a variety of functions. One of the more important functions is to provide a resting site following a period of foraging (Kunz 1982). Generally, night roosts are found close to foraging areas and provide bats a secure resting spot for digesting and socializing (Kunz 1982).

While some individuals may be opportunistic in night roost selection, larger collective sites (e.g. caves, mines, buildings) found in the Black Hills are not atypical. Many smaller caves in the Hills are used exclusively as night roosts by several bat species. All caves and mines identified as hibernacula are also used by those same species as night roosts throughout the summer. Segregation of species at night roosts has not been observed in the Black Hills. One cave in the northern Hills [T5N R5E Sec 28] yielded all eight species known to roost underground during a single evening's netting (Tigner and Aney 1994).

Night roosts frequently contain scattered droppings throughout the interior. In addition, some species transport larger prey back to a favorite feeding perch within a night roost beneath which small piles of droppings and discarded insect parts may be found. One sheltered porch of an abandoned cabin, used as a feeding perch by *C. townsendii*, contained a piling of moth wings and other assorted insect bits that was 3 cm in depth.

Seasonally, night roosts within the interior of the Black Hills demonstrate very different patterns of use. Following hibernation, until mid-summer, bats netted at night roosts were almost exclusively adult males. This capture pattern continues until late summer when adult females and juveniles are routinely caught having returned from nursery roosts. Evidence for this

movement was displayed by the recovery of a banded *M. septentrionalis* in a building nursery roost at the periphery of the Black Hills near Sturgis, SD. The closest banding site was a night roost 13 km away.

Roost Fidelity

As noted, bats require specific roosting habitat that typically are used from year to year by the same bats and successive generations. Human residents of buildings with bat maternity roosts often notice and comment upon such seasonal use when seeking assistance with roost management. Accumulations of droppings frequently attest to the repeated use of summer roosts.

Strong roost fidelity may be due to a relative scarcity of suitable sites (Kunz 1982). This may be particularly true where bats continue to roost at sites with high disturbance levels. In addition, the permanency of the structure housing the roost may affect the degree of fidelity (Kunz 1982).

An understanding of roost fidelity and its potential impact on population dynamics is an important component for habitat managers. In a recent review of the literature on this subject, Lewis (1995) presents three benefits of roost fidelity. First, sites that provide high quality roosting conditions are more likely to show persistent use. Repeated use of quality sites eliminates energy depleting searches for alternate roosting sites.

Second, sites whose conditions are improved by occupancy may demonstrate higher levels of fidelity. The maintenance of roost microclimate resulting from collective inhabitance, as found within nursery roosts, may promote roost fidelity.

The third benefit is that of maintaining social relationships with other members of the species. For females that form maternity and nursery collectives, roost fidelity can serve to facilitate the collective's formation (Lewis 1995).

In addition to nursery roosts, site fidelity to night roosts and foraging areas has been observed in species residing in the Black Hills. While only limited information on reproductive behavior has been collected for most of the region's species, some differences have been noted. *M. lucifugus* and *E. fuscus* both demonstrated strong fidelity to maternity and nursery sites.

In contrast, maternity and nursery roosts of *M. t. pahasapensis* frequently change roost sites though some evidence of reuse may indicate a fidelity to a network of roosts (Cryan and Bogan 1996).

Mattson's (1994) study of *L. noctivagans* also demonstrated frequent roost-changing activity in maternity roosts. Such activity suggests potential benefits exceed the liabilities associated with frequent roost relocation (Cryan and Bogan 1996). Benefits may include avoidance of disturbance or parasites, predator evasion, roost microclimate selection, and minimization of flight distance to foraging areas (Lewis 1995).

Predation

Little information has been reported from the Black Hills on bat predation. Mattson (1995) observed owl predation on a probable juvenile *Lasionycteris noctivagans* resting on the bole of a roost tree. The species was thought to be an eastern screech-owl (*Otus asio*) or a northern saw-whet owl (*Aegolius acadicus*).

Backlund (personal communication) identified a skull of *L. cinereus* from the pellet of what was thought to be a long-eared owl (*Asio otus*) collected 100 km east of the Black Hills. Owls are one of the more common predators cited in the literature though no predators are known to be bat specialists (Fenton 1992).

While no evidence has been collected for owl predation at larger roosting sites in the Black Hills, Tuttle and Stevenson (1982) note that owl predation may be disrupted by human presence. Direct observation of predation at caves was made only while observers were concealed within a blind using night vision equipment.

In March 1992 two *C. townsendii* were identified hibernating in the lowest chamber of a natural cave [T3N R6E Sec 29]. While droppings and nests of the bushy-tailed woodrat (*Neotoma cinerea*) were present throughout the cave, no nests were located in the chamber in which the bats were hibernating. In November 1993 two *C. townsendii* were found in the same location, and a bushy-tailed woodrat nest had been constructed in the chamber. While two bats were observed hibernating in November of 1993, only a portion of a single forearm with a small attachment of wing membrane was found during a survey conducted in February 1994. It was located near the previously mentioned nest amid pieces of collected litter, providing circumstantial evidence of possible predation by this rodent species.

Raccoons (*Procyon lotor*) were frequently found in abandoned mines during winter surveys in the Black Hills. While no direct observations have been made in the Black Hills, this species is known to prey on bats (Barbour and Davis 1969). The same authors reported frequent predation of *L. borealis* by blue jays (*Cyanocitta cristata*). Other records of predation in the Black Hills include skunk, marten, voles, snakes, and raptors (Herreid 1961, Martin 1961, Sperry 1933, Nagorsen and Brigham 1993).

One of the more common predators is the domestic cat. Given the close association between many bat species and buildings, it is not a surprising relationship. In the United Kingdom, domestic cats are considered the single greatest predator of bats (Richardson 1985).

SPECIES ACCOUNTS AND IDENTIFICATION

"Bats are such unusual creatures that some effort is required to think of them as actual animals living in a world of common sense and concrete reality." D.R. Griffin *Listening In The Dark*

The following pages provide individual descriptions of the bat species found within the Black Hills region. These include general descriptions of physical characteristics with an emphasis on points that aid in distinguishing species. For a more definitive key, see van Zyll de Jong (1985).

A brief natural history for each species is also provided. This section includes information on seasonal roosting requirements, reproduction, and range. Wherever possible, such information is based upon observations made within the Black Hills. References are made to northern and southern Black Hills. Such references indicate an area north or south of a line bisecting the region that runs through Rapid City, SD. In the interest of protecting roosting sites, specific locations to all sites referenced in this report are filed with the South Dakota Department of Game, Fish and Parks, Black Hills National Forest, and Wyoming Game and Fish Department.

In-hand identification of most Black Hills bat species is fairly straightforward. The *Myotis* species are at times difficult to distinguish owing to individual variation found within identifying characteristics. The following descriptions attempt to highlight features most common and useful in identification of species in the Black Hills. Sex determination is easily accomplished with a captive animal, as males display a conspicuous penis. Roosting posture generally prevents sex identification during hibernation when individuals cannot be disturbed.

Juvenile field identification is achieved by illuminating through the metacarpal-phalangeal joints within the wing membrane. Incomplete bone ossification at the joints in juveniles appears as translucent bubbles within the distal ends of bones. In adults, this characteristic is absent. These bubbles become less apparent with age and by summer's end are difficult or impossible to identify in juveniles born in the spring. Juvenile joints frequently give a rounded, more swollen appearance when compared with adult joints. However, given individual variation, age identification based solely on the latter of these two characteristics is likely to be less reliable.

Pelage color is not a reliable characteristic for species identification because of the substantial differences occurring within species. The exception to this rule is the Eastern Red Bat (*L. borealis*), which generally displays a pelage significantly different from other species found within the Hills.

See TABLES 3 and 4 for forearm measurements and weights.

Myotis ciliolabrum[1] (Western Small-footed Myotis)

M. ciliolabrum is the smallest bat in the Black Hills with an average forearm length of 31.27 mm and average weight of 5.72 gm. The calcar is keeled and as noted by its common name, the foot is small with average length being 6.5 mm (van Zyll de Jong 1985). The skull has a flattened appearance, and the ears are relatively long with a narrow tragus approximately half of the ear length. Though variations in color exist, it is frequently seen with near cream-colored pelage, lighter ventrally accentuated by a black mask, ears, and membranes.

M. ciliolabrum is a year-round resident of the Black Hills. Regarding behavior, it is a very gentle bat when handled properly. While this species is common, local populations are usually small in number though exceptions do occur. The largest number captured during a single evening's netting occurred at the historic entrance of Jewel Cave National Monument. On 8/5/93, Mattson and Bogan (1993) reported capturing 93 individuals, consisting of 80 males and 13 females.

At this same location, Turner (1974) reported an evening's capture of 48 individuals, 43 males and 5 females, on 7/24/68. These captures occurred within a span of three hours (Barbour and Davis 1969).

Another large group, 27 individuals consisting of 17 males and 10 females, was netted entering a cave [T3N R6E Sec 32] on 9/2/92 (Tigner unpublished data). Between 1992 and 1995, excluding the preceding references, average capture rate for this species at night roosts throughout the Black Hills was 3.5 individuals (Tigner unpublished data).

The largest known hibernation site for this species was an abandoned mine near Mystic, SD [T2N R4E Sec 33]. The site was an adit with a single southwest-facing portal. It was approximately 110 meters in length with several short drifts and rooms. This mine had been monitored since 1992 yielding consistent bat numbers during winter surveys. Totals for *M. ciliolabrum*: 1992:21, 1993:15, 1994:21, 1995:18, 1998:38. Five other species used this mine as a hibernaculum. As is common with many of the Black Hills' mines, the portal was located in unstable material and collapsed sometime during 1999. Such events serve to highlight the importance of identifying and protecting the remaining sites providing suitable bat habitat.

During foraging, the flight pattern is slow and erratic with orienting echolocation calls characterized by more rapidly emitted pulses than other Black Hills' species. Based on studies in other areas, *M. ciliolabrum* feeds primarily upon small insects, such as Diptera, Coleoptera, Cicadellids, and Trichoptera (van Zyll de Jong 1985).

This species characteristically hibernates individually, and movement is minimal. Our data indicate little change in hibernacula populations between November and February. *M.*

[1]Earlier literature has referred to this species as *Myotis leibii* or (earlier) *Myotis subulatus* (Say bat)

ciliolabrum is commonly found hibernating in mines and caves. No clusters have been observed in the Black Hills. Martin and Hawks (1972) report finding a single crevice containing four individuals in a natural cave in the southern Hills. It is frequently found to inhabit narrow crevices but also roosts on the surface of vertical walls and from ceilings. Both behaviors have been observed simultaneously by different individuals within the same hibernaculum. Frequently forearms are splayed outward away from the body during hibernation. Such posturing behavior is likely to be thermoregulatory, designed to disperse body heat and lower body temperature (Bakken and Kunz 1988). It prefers cooler, drier hibernacula and is frequently found at the same winter sites as *C. townsendii*.

Although no exact locations of maternity or nursery roosts have been identified in the Black Hills of South Dakota or Wyoming, the region's numerous rocky outcrops and crevices seem to offer abundant summer roosting sites. Tuttle and Heaney (1974) describe nursery roosts in the Badlands of South Dakota, 115 km east of the Black Hills, as cracks and crevices in the clay and volcanic ash mixture characteristic of the area. All roosts contained up to four lactating females. Females typically give birth to a single pup (Barbour and Davis 1969), though twins were reported at a roost in the Badlands of South Dakota (Tuttle and Heaney 1974).

Adult females and juveniles were commonly netted at night roosts throughout the Black Hills during the active time of year. In contrast, from spring through midsummer, captures at night roosts of *Eptesicus* and other *Myotis* species were nearly always adult males. This suggests that females select maternity and nursery roosts in the Hills proper and do not move to other areas. Elevational gradient has been suggested as an important determinant in formation of maternity/nursery roosts (Cryan and Bogan 2000).

In contrast, *M. ciliolabrum* may be able to achieve roost thermal requirements by selecting sites that mitigate temperatures based upon other factors. One such roost, near an abandoned mine on Custer State Park, exists in rock outcroppings at an elevation of approximately 6250 feet. Towering well above the surrounding forest canopy, these rock faces have a clear southerly exposure. Summer surveys during 2001 and 2002 have included mist netting a small pool immediately adjacent to these rock faces. Both years have yielded *en masse* captures of lactating females of this species. Approximate number of bats arriving collectively at this pool was ten. Early capture times, before and at sunset, support the assumption that there is a nearby nursery roost.

Another explanation for wider distribution of reproductive females and smaller local populations may be the result of prey availability. Diet analysis might provide information concerning varying population density.

Although successfully captured at night roosts with both mist nets and harp traps, its small size often allows escape from the latter. It frequently becomes blocked and entangled by the first bank of strings, but escapes by retreating. Despite its small size, this bat is a strong flier and can take off from a level surface.

For bats in general, small access points into roosts increase predation threat and may be avoided (Tuttle and Taylor 1994). *M. ciliolabrum* demonstrates the widest acceptance of restrictive roost entry size at hibernacula. One example is based upon observations made at a natural cave on private property near Rapid City, SD. The only access into the cave was via a ceramic drain tile inserted into a solid wall built by the cave's owner to prevent unauthorized entry. The tile, approximately 15 cm in diameter and 35 cm in length, was installed to provide access to the solid door's locking mechanism. It is uncertain whether this bat can fly through this opening without landing given the narrowness and irregularity of the approach to the closure wall, which is approximately 20 m from the access point. Three *M. ciliolabrum* were the only bats identified using this site as a hibernaculum.

Based on existing information, hibernacula selection is somewhat of a paradox. High body fat to mass ratios allow large species to use relatively cold, dry hibernacula (Ransome 1990). Fat reserves serve as a buffer against harsh or fluctuating hibernacula conditions. Given its diminutive size, this species clearly does not fall into this category. However, it may be able to avoid harsh conditions by selecting crevices.

At present levels of understanding, the principle threat to this species may be the availability of suitable hibernacula. This supposition is probably true if, as has been suggested, abundant sites for maternity and nursery roosts are available throughout the natural terrain of the Black Hills. More information is needed on maternity and nursery roosts and hibernacula requirements for this species.

Reproductive females were recorded from both the northern Hills (one pregnant female on 7/5/94 at a natural cave night roost [T3N R6E Sec 32]) and southern Hills of South Dakota (one pregnant female while foraging on 7/7/95 at Lower Woodcock Spring).

Lactating females were captured on 7/14/93 (foraging, Keystone, SD sewage lagoons) and 7/7/94 (foraging, Hazelrodt Picnic Ground, SD). Post-lactating females were captured on 8/17/94 and 9/9/94.

Earliest capture of a volant juvenile was on 7/24/68 entering Jewel Cave (Turner 1974). Other captures of juveniles:
7/31/92 - eight entering natural cave [T3N R6E Sec 32]
8/05/92 - three entering natural cave [T3N R6E Sec 29]
8/27/92 - two entering natural cave [T4N R5E Sec 12]
9/11/93 - one netted foraging at Roby Spring (Mattson 1994)
9/13/94 - one entering natural cave [T5N R5E Sec 28]
9/20/94 - three entering natural cave [T3N R6E Sec 28].

Three banded individuals, 2 adult male and 1 adult female, have been recaptured. All three occurred at two natural caves in the northern Hills. Both sites serve as summer night roosts for both sexes where they were originally banded.

A banded female was found hibernating high on an interior wall in the first cave [T4N R5E Sec 16]. Height prevented reading the band. This same cave, surveyed on 3/4/93, served as a hibernaculum to a banded male found head-down in a vertical crevice in the ceiling.

A banded adult male was recaptured at the second cave [T3N R6E Sec 32] on 6/26/95. It was banded at the same site on 9/2/92. Age could not be determined at banding.

Myotis evotis (Long-eared Myotis)

M. evotis is of medium size, with an average forearm length of 38.17 mm and an average weight of 7.5 gm. *M. evotis* generally has a shorter forearm, range 36-41 mm, than *M. t. pahasapensis*, range 40-43 mm. Total ear length is a good distinguishing feature. The ear length, 17-22 mm, is substantially longer than that of *M. septentrionalis*, 15-18 mm, and proportionally longer than *M. t. pahasapensis*, 19-20 mm (van Zyll de Jong 1985). When pressed forward, ears extend a minimum of 5 mm beyond the nose tip and overall ear length exceeds 50 percent of the forearm length. *M. evotis* has variable brown pelage with contrasting blackish ears and wing membranes. Individuals caught in the Black Hills have darker brown pelage.

Very little information regarding winter hibernation exists, but *M. evotis* may use caves and mines (Manning and Jones 1989). No winter records were recorded for this species in the Black Hills. This species is found in a wide variety of habitat types though most are associated with forested areas (Manning and Jones 1989, Nagorsen and Brigham 1993). *M. evotis* forages on a variety of insects with beetles and moths comprising most of the diet (Black 1974).

This report represents an extension in range for this species as only one confirmed specimen has been reported from Harding County in the northwestern corner of the state (Andersen and Jones 1971, Jones and Choate 1978). Earlier specimens from the Hills purported to be *M. evotis* were determined to be *M. t. pahasapensis* (Jones and Choate 1978). Identification of *M. evotis* has been made in the field based on the following description by van Zyll de Jong (1985). *M. evotis* exhibits a slightly shorter forearm than *M. t. pahasapensis* with a longer overall ear length. There is no conspicuous fringe around the free edge of the uropatagium on *M. evotis*, though slight inconspicuous fringes do occur. The fringe on *M. evoti*s is sparser than on *M. t. pahasapensis*. Variation in the degree of conspicuousness can make the distinction between these two species difficult. Overall ear length was used as the determining factor. Bats whose ears, when pressed forward, extended 5 mm beyond the nose tip and were greater than 50 percent of the forearm length were classified as *M. evotis*.

M. evotis was captured at night roosts in both mist nets and harp trap. Six adult males were netted at night roosts in the northern Black Hills of South Dakota (T3N R6E Sec 32; T5N R5E Sec 28; T4N R5E Sec 16), one adult female and one adult male were netted foraging over a small woodland pond in Wyoming (T55N R63W Sec 26), one male was netted over a stock tank near Jewel Cave National Monument, and one nursery roost was found near Sturgis, SD. One non-reproductive adult female was netted foraging adjacent to the Cheyenne River near Cascade, SD.

The nursery roost, comprised of approximately 20 to 25 individuals, was located (7/26/93) in the attic of an older, two-story brick building, constructed circa 1900, in Sturgis, SD. Based upon observed variation in body size, this figure includes juveniles. The bats were roosting at the edge of a large metal exhaust vent under adjacent flashing and roofing. The cluster roosting location was characterized by access to both the outside and interior of the attic, though numerous other access points were available throughout the attic.

One non-reproductive adult female was roosting approximately 1 m from the area containing the rest of the roost. Because of the longer ear length and distance from other bats, this female was captured by hand for examination. Though no measurements were taken, ear length was greater than 50 percent of the forearm length with ear tips extending well beyond the nose tip. Fringe on the free edge of the uropatagium was very sparse and finer than typically seen on *M. t. pahasapensis.* When returned to its roosting spot, the bat quickly rejoined the others. The roost was used during the summer of 1993, but not during 1994 or 1995. Extensive restoration, which included construction work in the attic coupled with simultaneous work in adjacent buildings, may have caused the bats to abandon the site.

Priday and Luce (1995) reported three captures northwest of Sundance, WY. The first was netted at a night roost in a mine on 6/20/94. The remaining pair was netted over a nearby stream approximately 400 m away.

Based on capture data this bat appears to be less abundant than *M. t. pahasapensis.* Range for this species includes all of the Black Hills.

Myotis lucifugus (Little Brown Myotis)

M. lucifugus, medium in size, has an average forearm length of 37.49 mm and an average weight of 8.33 gm. The calcar is not keeled, which helps distinguish it from *M. volans*. Ear length is less than *M. septentrionalis* and does not extend beyond the nose tip when pressed forward. Tragus is blunt and approximately half the length of the ear. Pelage color varies considerably ranging from light or medium brown to very dark brown, and it displays a characteristic glossy appearance that helps distinguish it from morphologically similar *M. volans*. Wing membranes and ears are dark brown.

M. lucifugus is common throughout the United States and abundant in the Black Hills. It is the current record holder for age longevity at over 34 years (Davis and Hitchcock 1995). This is one of the more opportunistic species both in foraging habits and roost selection (Fenton and Barclay 1980). It can be found in a variety of habitat types and is known to roost in buildings, caves, mines, and trees (Fenton and Barclay 1980). *M. lucifugus* commonly feeds flying low over water surfaces with a shallow wing beat. Aquatic insects comprise a large portion of this species' diet (Fenton and Barclay 1980).

As is common with many Vespertilionid species, males roost individually or in small groups during the summer months, segregated from females. As evidence of its opportunistic roosting characteristics, maternity roosts are now found more commonly in buildings than in natural roosting sites (van Zyll de Jong 1985). Trees also function as nursery roosts (Fenton and Barclay 1980). In the Black Hills, all known maternity and nursery roosts are in buildings.

Females give birth to a single pup with juveniles becoming volant at three weeks of age (Fenton and Barclay 1980). The earliest volant juvenile was captured (7/4/70) near Custer, SD (Turner 1974).

Four maternity and nursery roosts were identified in both the southern and northern Black Hills and all show signs of a high degree of roost fidelity. All known maternity and nursery roosts for this species are located within 0.5 km of water. In South Dakota, the largest known maternity roost is located within an attic at a camp near Custer State Park. This roost was first recorded during the summer of 1970 when it contained 100 to 150 adults (Turner 1974). It was estimated to contain 200 bats during the summer of 1993 (Mattson 1994).

Another large maternity roost of approximately 100 individuals was identified in the gable of a two-story wood framed house near the McNenny Fish Hatchery in South Dakota (6/15/93). Because of extensive renovations, including complete removal of the roof, approximately 100 bats were hand-captured from behind a shutter (6/24/93). Thirty-five individuals, all pregnant females, were banded.

A separate roost containing 20 pregnant females was found on the same evening approximately 1 km from the first roost in the attic of a building at McNenny Fish Hatchery. The fourth maternity roost was located in the attic of a two-story brick building near Sturgis, SD on 7/26/93.

Approximate roost size was 50 adults. Surveyed the following year (7/6/94), this roost contained approximately 100, which included some juveniles of the year.

With the exception of *C. townsendii*, this is the only species for which a probable maternity roost was identified underground. On 5/20/93, a natural cave [T5N R5E Sec 28] near Sturgis, SD contained a cluster of 18 individuals including three banded females. Bands were not read to minimize disturbance to the roost. The cluster was located in a dome above a main passage. Females of this species were banded previously at this location.

M. lucifugus was routinely captured with mist nets and harp traps at night roosts throughout the Hills though usually in smaller numbers. During the spring and early summer, captures at night roosts were comprised almost exclusively of adult males. Absence of females at this time was likely due to their congregation in maternity and nursery roosts in other areas (Turner 1974). Juveniles and adult females became more common at night roosts during the latter part of the summer and early fall.

Two caves in the northern Hills yielded the highest capture rates [T3N R6E Sec 32 and T5N R5E Sec 28]. Both sites were monitored during the winters of 1992-1995 with neither being used as a hibernaculum. On 9/2/92, the former of the two caves yielded 25 individuals, 20 males including one confirmed juvenile and 5 females; while the latter, on 9/9/92, yielded 29 individuals, 15 males and 14 females.

The largest number of *M. lucifugus* netted at a foraging site was 42, netted within one hour at the sewage lagoons of Jewel Cave National Monument. These bats probably were a portion of the bats known to roost at Jewel Cave (Cryan and Bogan 1996).

This bat hibernated only in sites, including natural caves and mines, with relatively high humidity including natural caves and mines. During hibernation, individuals were often found with droplets of condensation covering the entire body. Conservation strategies for this species should include protection of hibernacula that contain relative humidity greater than 90 percent.

The largest hibernaculum in the Black Hills for this species is Jewel Cave. The Dungeon Room, in which most of the *M. lucifugus* and *M. volans* hibernate, has a relative humidity of greater than 90 percent. These species apparently arrive at similar times with numbers remaining constant throughout the winter season.

Another natural cave [T3S R2E Sec 3], 15 km north of Jewel Cave, also serves as a hibernation site to large number of *Myotis.* Approximately 300 individuals were recorded during winter surveys with largest numbers comprised of *M. lucifugus* and *M. volans*. These two species are morphologically similar and, owing to the height of hibernating clusters, not easily distinguishable during hibernation. Based upon observations at this site, *M. lucifugus* and *M. volans* have a tolerance to limited roost entry size. While the area in which the bats hibernate is spacious, ceiling height is approximately 3-4 m, access requires flight through a narrow passage.

Given *M. lucifugus*' affinity for roosting within man-made structures, its maternity and nursery roosts may be at greater risk than species relying upon more natural roosting sites. As such, this species is one that should benefit from an increased public awareness of bat-related benefits.

Myotis septentrionalis[1] (Northern Myotis)

M. septentrionalis is a medium-sized bat with an average forearm length of 36.07 mm and average weight of 7.13 gm. It is distinguished primarily by its ear length and tragus. Average overall ear length is 16.4 mm. This measurement is greater than *M. lucifugus*, 13.8 mm, and *M. volans*, 13.3 mm, but less than *M. thysanodes*, 19.5 mm, and *M. evotis*, 19.8 mm (van Zyll de Jong 1985). The tragus is long, narrow and pointed at the tip. *M. septentrionalis* frequently has a mask that is balder than similar *Myotis* species. Membranes, ears, and mask are generally medium to dark brown.

This bat routinely displays an aggressive attitude when netted. It constantly vocalizes from time of capture until release and frequently attempts to bite handlers. Illumination by flashlight in roosts often caused this bat to vocalize. Little information exists on the dietary preferences of this species, though some evidence indicates it is a generalist (Nagorsen and Brigham 1993, van Zyll de Jong 1985).

M. septentrionalis is abundant throughout the Black Hills region, however, winter occurrence was only recently confirmed (Worthington and Bogan 1993, Tigner and Aney 1993, Tigner and Aney 1994). During the course of one survey conducted between 1992 and 1995, only seven hibernating individuals were located (Tigner and Aney 1994, Tigner unpublished data). There are no hibernation records in Wyoming (Bob Luce personal communication). Sites selected for hibernation include both natural caves and abandoned mines.

Several common features are exhibited by all hibernacula where this species was identified. The first of these is relative humidity greater than 90 percent. All sites contained standing water with condensation accumulations throughout the interior. All bats roosted in crevices protected from normal airflow. Of the seven hibernacula identified for this species, five are abandoned mines and two are natural caves. The abandoned mines, varying in interior length from 5 m to 200 m, contained short side drifts off the main adit, and all possessed standing interior water. Crevices in these side workings were selected for hibernation. Three of the adits were completely sealed by snowfall.

The first natural cave hibernaculum [T5N R5E Sec 29], near Sturgis, SD, has a history of human disturbance. Shortly after this site was identified, in mid-December 1994, a campfire was built in the cave's interior causing abandonment by hibernating bats for the balance of the winter.

There were only a handful of records noted from the second natural cave, Jewel Cave National Monument (Worthington and Bogan 1993). Given this species' apparent affinity for crevices, they may be easily overlooked.

The largest number of *M. septentrionalis* found in a hibernaculum in the Black Hills was in an extensive abandoned mine near Hill City, SD. A conservative count from the survey conducted

[1]Earlier literature referred to this species as *Myotis keenii* or Keen's Myotis.

during the winter of 2002/03 was forty individuals. Similar numbers were found during the site's initial survey during the winter of 2000/01.

M. septentrionalis was captured at night roosts with both mist nets and harp trap. Only one maternity or nursery roost was located within the Black Hills (Tigner and Aney 1994). It was identified on 7/6/94 near Sturgis, SD in the roof apex of a two-story brick building. The roost was comprised of approximately 75 individuals, including juveniles. A banded adult female was observed within the main cluster, but to minimize disturbance the band was not read. The closest banding site was a cave night roost approximately 13 km from this location. The observation of this banded female provides direct evidence of movement from within the Hills to a maternity roost at the periphery. This identification also indicates the possibility of locally important maternity and nursery roosts.

A small maternity and nursery roost containing less than 10 individuals was identified in Wall, SD (6/30/94) approximately 110 km east of the Black Hills. One lactating female was captured emerging from beneath shake roofing of a United States Forest Service visitor center building.

Thirty-seven juveniles were netted between 1992 and 1995 (Tigner unpublished data). During a single evening's netting (8/18/92), 13 of these juveniles, 12 males and 1 female, were captured entering a natural cave night roost [T4N R5E Sec 16]. Seasonally, the earliest volant juvenile was captured on 7/26/68 entering a natural cave night roost [T2S R2E Sec 17] (Turner 1974). Three male juveniles were netted entering a cave [T3N R6E Sec 32] on 7/31/92.

Two post-lactating females were netted during the summer of 1994. On 7/29/94, the first was netted while foraging at Red Bat Pond near Whitewood, SD. The second was captured on 8/11/94 entering a natural cave night roost [T4N R5E Sec 12].

Based on banding recoveries, *M. septentrionalis* demonstrates fidelity to night roosts. Eleven banded individuals were recaptured. Seven recaptures occurred at night roosts where the bat was originally banded. Seven of these, all males, were banded as juveniles. The table below gives the banding/recapture dates of these seven *M. septentrionalis*.

Site Type	Original Band Date (Age at Banding)	Recapture Date (Age at Recap)	Time Length
Night Roost (Cave)	8/12/93 (J)	9/2/93 (J)	21 days
Night Roost (Cave)	8/18/92 (J)	9/16/92 (J)	29 days
Night Roost (Cave)	9/30/93 (J)	7/5/94 (A)	9 months
Night Roost (Cave)	9/2/92 (J)	8/12/93 (A)	11 months
Night Roost (Cave)	8/27/92 (J)	6/17/94 (A)	1 year 10 months
Night Roost (Cave)	9/9/92 (J)	8/24/99 (A)	6 years 9 months
Night Roost (Cave)	7/31/92 (J)	6/7/02 (A)	9 years 10 months

***Myotis septentrionalis* - NIGHT ROOST SAME SITE BANDING RECAPTURES**

The remaining four recaptures may be evidence for fidelity to a specific foraging area or a home range. One male juvenile has been netted on three occasions at the same stock tank. Captured and banded on 5/31/94, Mattson (personal communication) recaptured this bat at the original site 24 days later. This same individual was again recaptured on 7/11/99 at the same location (Tanya Dewey personal communication). The table below gives the details of these four recaptures.

Site Type	Original Band Date (Age/Sex at Banding)	Recapture Date[s] (Age at Recap)	Time Length
Stock Pond	8/11/92 (J / Male)	6/23/94 (A)	1 year 10 months
Stock Pond	7/29/94 (A / Female)	8/8/01 (A)	7 years
Stock Tank	5/31/94 (J / Male)	6/24/94 (A) 7/11/99 (A)	5 years 1 month

***Myotis septentrionalis* - FORAGING SAME SITE BANDING RECAPTURES**

More information is required on this species' maternity roost habits. If characteristically found in buildings, this species would benefit from increased public awareness of maternity roost importance. Hibernacula requirements need further study. Given its affinity for crevices, quantifying microclimate conditions as well as physical characteristics are two areas that warrant further examination.

Myotis thysanodes pahasapensis (Fringed Myotis)

M. t. pahasapensis is a bat of medium size. The average forearm length is 40.82 mm and average weight is 7.8 gm. The common name is derived from the fringe of conspicuous coarse hairs around the free edge of the uropatagium. As with many identifying characteristics, the fringe is variable. Fringe variation does not appear to be age or sex related. Ears are longer than other *Myotis* species with the notable exception of *M. evotis*. *M. evotis* displays a proportionately longer ear than *M. t. pahasapensis* with overall ear length in *M. t. pahasapensis* being less than 50 percent of the length of the forearm length (van Zyll de Jong 1985). Wing membranes and ears are very dark to black in color.

M. t. pahasapensis' known range is restricted to the Black Hills area (Jones and Choate 1978, van Zyll de Jong 1985). Beetles represent the largest prey group but moths are also taken (Black 1974). Though a year-round resident, hibernating individuals were difficult to locate. Because of a preference to hibernate in cracks and crevices, identification is difficult. During the course of surveys conducted during the winters of 1992-1995 a total of 10 individuals were found hibernating. Five of these were in abandoned mines, roosting individually in crevices. The remaining five, three of which were in crevices, were found in natural caves roosting individually.

Identification during hibernation was made via the longer ear length, black membranes and overall size. Two individuals were roosting on the surface of the rock. One was hanging, head down, approximately 1.5 m from the floor on a vertical surface. The other was hanging by both feet from the ceiling, in a room with maximum height of about 1 m, and swaying with the air currents in the cave [T6S R5E Sec. 21].

The largest number of this species found hibernating in a single location is four. This site, surveyed in January 2003, is an extensive abandoned mine in the central Black Hills containing standing water throughout its interior. Three were located in crevices in the rock and one was found on the rock's surface.

Given the comparatively low number of hibernating individuals discovered during the course of the survey, it is likely this species prefers cracks and fissures for hibernation. Such behavior would make location and identification difficult during winter. Martin and Hawks (1972) reported finding this species in Jewel Cave, frequently hibernating while facing up a vertical wall and clinging to the surface by both feet and thumbs with forearms slightly splayed away from the body. As noted under *M. ciliolabrum*, such posturing may be thermoregulatory in nature employed to lower body temperature by increasing exposed surface area (Bakken and Kunz 1988).

Using radio telemetry Cryan and Bogan (1996) conducted the most comprehensive study of roosting habitat in the southern Black Hills during the summer of 1995. Males were found to roost individually in rock crevices. Reproductive females formed communal maternity and nursery roosts in rock crevices that averaged 18.9 individuals (Cryan and Bogan 1996).

Maternity roosts were observed to move daily with evidence suggesting the possibility of roost fidelity (Cryan and Bogan 1996).

Maternity roosts have been identified in the northern and southern Black Hills of SD (Cryan and Bogan 1996, Tigner and Aney 1994). One maternity roost was in an attic of a two-story brick building near Sturgis, SD (6/8/94). The roost was divided into two locations approximately 1 m apart. The first was around an exhaust fan midway between the apex of the roof and the floor of the attic. The exhaust fan was located at the juncture of two wings of the building. The second location was closer to the floor, still at the roofline, around a black, cast iron standpipe. Both groups appeared to be of similar size, about 25 individuals, with apparent juveniles in both. Both sites appeared to contain crevices large enough for bats to exit. No bats were found during a survey of this site on 7/6/94. A single adult female was observed in this attic on 4/22/94, although no evidence of previous parturition or pregnancy was noted.

The earliest recorded volancy for juveniles is 8/10/68 (Turner 1974). This date compares well with later survey work which netted three juveniles entering a natural cave night roost [T4N R5E Sec. 16] on 8/18/92 and one juvenile netted foraging near Lower Woodcock Spring on 8/24/94.

M. t. pahasapensis was captured at night roosts with both mist nets and harp traps. The largest number caught during a single evening (5/22/94) was 12 adults, 11 male and 1 female, netted at Water Draw Spring (Mattson 1994). In addition, eight adult males and two non-parous females were netted entering a natural cave night roost [T3N R6E Sec. 32] on 9/2/92. One other significant series of captures occurred at a night roost [T4N R5E Sec. 12] on 9/10/93. Within a span of 15 minutes, eight individuals were netted entering the natural cave. Seven were post-lactating females and one an adult male displaying canines with greater than 50 percent wear. Effective closure of all openings at the cave's mouth was not achieved and other individuals were seen entering the cave at this same time.

A total of 75 individuals, 54 males and 21 females, were banded between 1992 and 1995. Five recaptures of banded individuals all occurred at the original banding site, all serving as night roosts. The first recapture was at a cave [T4N R5E Sec 16]. This juvenile male was originally banded on 8/18/92 and weighed 7 gm. He was recaptured on 9/16/92 and weighed 10 gm. Though recaptured within 30 days, the substantial difference in weights may be attributable to recent foraging activity rather than body weight increase.

The second recapture was at a natural cave night roost [T2S R2E Sec 16]. An adult male was banded on 8/25/94 and recaptured on 6/20/95. The three other recaptures all occurred at the same location, a natural cave [T3N R6E Sec 32] serving as a night roost. The first occurred on 5/20/94 and the last two on 9/20/94. All three adult males were originally banded on 9/2/92.

Males, when netted, were frequently found to have dirt or clay-like substance within their fur and crevices of the wing membrane. Such deposits were clearly present in early evening captures suggesting day roosting in soft soil crevices. One banded male, recaptured at a night roost, was found to have dirt between the band and the forearm. This dirt easily fell away when

the band was manipulated for removal and likely would have been groomed away by the bat. No evidence of injury to the bat was noted.

The following table provides a listing of band recaptures for this species.

Site Type	Original Band Date (Age/Sex at Banding)	Recapture Date[s] (Age at Recap)	Time Length
Night Roost (Cave)	8/18/92 (J / Male)	9/16/92 (J)	29 days
Night Roost (Cave)	9/2/92 (J / Male)	9/20/94 (A)	2 years
Night Roost (Cave)	9/2/92 (J / Male)	5/20/94 (A)	1 year 9 months
Night Roost (Cave)	9/2/92 (J / Male)	9/20/94 (A)	2 years
Night Roost (Cave)	8/25/94 (A / Male)	6/20/95 (A)	10 months

***Myotis thysanodes pahasapensis* – Band recaptures**

Additional information is needed on the maternity and nursery roost requirements and habits for this species. While roosts were found in a building and natural rock crevices, additional roost locations would improve the knowledge base. The frequent relocation of maternity and nursery roosts is unreported in this species and warrants additional study (Cryan and Bogan 1996). Locally abundant captures may be indicative of unique or significant habitat characteristics (Cryan and Bogan 1996). Such characteristics should be identified.

Hibernacula requirements also need to be quantified. It is far more commonly identified during the summer months than in winter hibernation. While this is likely in response to an apparent affinity for winter roosting in crevices, the extent to which these sites are available to this species remains unknown.

Myotis volans (Long-legged Myotis)

M. volans is a medium-sized bat with an average forearm length of 37.93 mm and average weight of 7.84 gm. It is very similar to *Myotis lucifugus* in morphology, and the two are often difficult or impossible to distinguish during hibernation. It often displays a more dense line of furring extending from elbow to knee on the ventral surface of the wing membrane. The calcar has a distinct keel that is weak or lacking in *M. lucifugus.* Pelage is varying shades of dull brown lacking the characteristic glossy sheen often found on *M. lucifugus*. The ears and wing membranes are generally darker brown. Owing to its shorter rostrum and steep forehead (van Zyll de Jong 1985), this species can occasionally be distinguished from *M. lucifugus* by the smaller appearing head relative to body size (Tigner personal observation).

M. volans is one of the more common species found within the Black Hills and is a year-round resident. It demonstrates close associations with coniferous forests, foraging throughout the forest canopy (Barbour and Davis 1969) and feeds primarily on small moths (Whitaker, Jr. J.O. et al. 1981*a*). Roosting sites identified in the Black Hills include caves, mines, trees, and rock crevices (Cryan and Bogan 1996, Tigner and Aney 1994).

This bat hibernates in abandoned mines, but larger numbers were observed in natural caves with the largest known population wintering in Jewel Cave. As with *M. lucifugus*, this species seems to have an affinity for hibernacula with higher humidity. It is often found with droplets of condensation covering the entire body while hanging from a wall or ceiling. The largest concentration in Jewel Cave was in the Dungeon Room where relative humidity is typically greater than 90 percent.

As noted under *M. lucifugus*, another natural cave [T3S R2E Sec 3], 15 km north of Jewel Cave, also serves as a hibernation site to a large number of *Myotis.* Approximately 300 individuals were recorded during winter surveys at this site, the largest proportion being *M. volans* and *M. lucifugus*.

While two studies suggested *M. volans* to be the most common bat in the Black Hills (Turner 1974, Mattson and Bogan 1993), there is little information on its reproductive habits. In the southern Black Hills, adult males have been found to roost solitarily during the summer in rock crevices in the southern Black Hills (Cryan and Bogan 1996). They are segregated from females, which congregate in maternity roosts. Only two maternity and nursery roosts have been identified for this species in the Black Hills.

The first roost was located in the attic of an H-shaped two-story brick building near Sturgis, SD. The roost identified on 7/6/94 was comprised of approximately 75 individuals, including non-volant pups. The pups were in one cluster of approximately 30 individuals, which included adults, near the apex of the roof against a brick wall. The remaining bats roosted in smaller clusters or individually throughout the same wing of the building. Two volant juvenile males, one volant juvenile female, and three lactating females were captured by hand for cursory examination. All juveniles flew without apparent difficulty when released.

It is thought most maternity roosts are probably located in tree cavities (van Zyll de Jong 1985). Using radio telemetry, one lactating female was located, in the southern Black Hills, roosting beneath the bark of a large snag, dbh 66 cm, with at least six other bats (Cryan and Bogan 1996). These bats were observed emerging, but species of the others was not confirmed.

M. volans was successfully captured at night roosts in both mist nets and harp traps. Excluding the volant juveniles mentioned above, the earliest capture of a volant juvenile was on 7/31/92 when 2 male juveniles were netted entering a natural cave [T3N R6E Sec 32] serving as a night roost. Of the 13 juvenile captures between 1992 and 1995, 11 were at night roosts in natural caves with the remaining 2 netted while foraging at Lower Woodcock Spring on 8/24/94. Turner (1974) reported a juvenile capture on 9/7/67 at Roby Springs, SD.

One juvenile netted at a cave [T4N R5E Sec 16] was banded on 8/18/92 and was recaptured at the same site on 9/16/92. Only two other recaptures were recorded during this study. Both occurred at the same cave [T3N R6E Sec 32] on 9/30/93. The first recapture was an adult male originally banded at this site on 9/2/92, and the second, an adult male, was banded at the site earlier in the season on 9/2/93.

Additional information is needed on maternity and nursery roost requirements for this species. Absence of reproductive females from many summer foraging areas throughout the Black Hills suggests the possible occurrence of important roosting sites or areas with certain characteristics (Cryan and Bogan 1996). Such concentrations may also make this species more susceptible to habitat changes. Identification of specific habitat requirements is necessary for development of effective conservation strategies.

Corynorhinus townsendii pallescens[1] (Townsend's Big-eared Bat)

C. townsendii is a medium-sized bat with an average forearm length of 44.31 mm and an average weight of 11.59 gm. Pelage color varies but is generally buff with paler dorsal fur. When awake, this bat is easily identified by its very long rabbit-like ears and characteristic bulbous nose lumps. However, when roosting, especially in torpor and during hibernation, the ears may be much less visible. It folds its long ears back leaving only the pointed tragus erect. The erect tragus gives the appearance of *Myotis*-like ear tips resulting in frequent misidentification by the untrained observer. Record for longevity for this species is greater than 21 years (Perkins 1994).

Observed evening emergence time varied but generally occurs at lower light levels, approximately 30 minutes after sunset. It was commonly observed exhibiting "light sampling behavior"[2] prior to evening emergence from caves and mines. Such behavior is likely designed to insure light levels are low enough to minimize risks of predation by diurnal birds of prey (Erkert 1982).

Diet studies found *C. townsendii* to be a lepidopteran specialist whose diet is comprised almost exclusively of moths (Pierson et al.1999). It is known to forage within a wide variety of habitat types (Pierson et al.1999) and has been observed foraging within the canopy at wooded edges within the Black Hills.

This species was observed repeatedly returning to a feeding perch to feed on captured prey. Two such examples were documented in the Black Hills. The first was within a sheltered entry porch of an abandoned cabin and was used simultaneously by at least two individuals. The quantity of insect wings at this site indicated repeated use. The moth wing pile was 3 cm at its greatest depth. The second location was a cave serving as a night roost. Both sites were characterized predominantly by accumulation of moth wings and fecal droppings immediately beneath the perch.

C. townsendii is the most frequently encountered underground species within the Black Hills. To some extent, this is attributable to the species' propensity to roost on the surface of the rock and often in the twilight areas between daylight and darkness. Such roosting behavior allows for easy discovery compared with species that roost in crevices or darker areas. Such roosting selection also renders this species particularly susceptible to casual human disturbance. *C. townsendii* is the only Black Hills' bat dependent year-round upon underground roosting sites. Nearly all records of this species in the Black Hills are from natural caves or abandoned mines.

C. townsendii demonstrates a high degree of roost fidelity (Humphrey and Kunz 1976). This was observed in the Black Hills as this species accounted for more than half of the recaptures of

[1] formerly *Plecotus townsendii pallescens;* see Frost and Timm 1992 and Tumlison and Douglas 1992 for a discussion of systematics.

[2] term coined by Twente (1955) for intermittently repeated return flights of short duration from roosting location within the cave/mine to the outside access point.

individuals banded between 1992 and 1995. Most were recaptured at the original banding site. *C. townsendii* is also considered sedentary and not known to migrate great distances between seasonal roosts (Kunz and Martin 1982). Some males were found to inhabit the same roost on a year-round basis.

In the Black Hills, males tend to roost individually during the summer months although small groups of three have been identified. One of the more common roosting sites for individual males is within short adits, 2 to 3 m in length, which are numerous throughout the region.

During seasonal surveys (four per year), two banded adult males were monitored at two separate abandoned mine adits. The first of these bats was monitored for three consecutive years and was absent during two fall surveys. The second was a year-round resident for two years and absent from one fall survey. Location within the mine is generally in the same vicinity during each survey. Individual males were observed within the same hibernaculum often at the same location during consecutive winters.

C. townsendii generally occurs in smaller numbers at night roosts. The largest number captured during an evening's trapping was five individuals. The site of these captures is also a large hibernaculum during the winter months. Netting surveys are likely to under-represent this species owing to its ability to avoid obstacles. *C. townsendii* also echolocates very softly and can be difficult to detect in the field on ultrasonic echolocation detectors.

While *C. townsendii* was successfully captured at night roosts with both mist nets and harp traps, the former were generally a more effective capture tool. When approaching a night roost staged with a harp trap, this species was observed turning back and departing resulting in no captures for the evening. Most individuals captured in the harp trap were males either entering at a high rate of speed or attempting to exit following day roosting at the site. Mist netting in open areas such as over water sources and meadows adjacent to forested areas rarely results in captures of this species. Most captures are achieved at restricted roost access points.

Females form maternity and nursery roosts and give birth to a single pup (Pearson et al. 1952). Roost fidelity to nursery roosts is high (Pearson et al. 1952). Only three confirmed maternity and nursery roosts were identified in the Black Hills. During the summer of 1993, two were located in natural caves in the northern Black Hills with the largest comprised of approximately 110 individuals, including juveniles. The other roost contained approximately 30 to 35 individuals during 1993 and 1994.

In circumstances unusual for this species, a nursery roost comprised of approximately 30 individuals was reported in an abandoned building south of Hot Springs, SD near Cascade Creek in July 1996 (Cryan 1997). Subsequent surveys yielded only isolated individuals using this location as a day roost with some evidence of night roosting (Luce 1998). High levels of disturbance associated with road construction in the immediate vicinity may have contributed to its abandonment as a maternity and nursery roost (Cryan 1997). Additionally, during the

summer of 1998, a feral cat was observed entering the area of the building previously used by the bats (Tigner unpublished data).

Mattson (1994) cites reference to a shelter cave within Wind Cave National Park containing 50 females in 1991 and 75 females in 1992. This roost was not used during 1993 possibly due to cooler weather conditions (Mattson 1994). Additionally, a small natural cave on private land east of Custer State Park reportedly contained approximately 40 individuals one day in early August of 1994 (Travis Vickers personal communication). This site was also a small shelter cave that gave no evidence of long-term use.

One maternity roost was identified in an abandoned mine near Rochford, SD during the summer of 2002. Approximate size of this roost was 20 adults. This site also serves as a hibernaculum for the species. This is the first abandoned mine documented to serve as a maternity roost in the Black Hills.

Known maternity and nursery roosts in the region are characterized by spacious interiors with inaccessible domes or wide expanse ceilings. Both characteristics have been noted in nursery roost selection in other areas (Pierson et al.1999). These sites have fewer signs of disturbance than typically seen at caves in the region due probably to more remote location and difficulty of access. Access points for both roosts are large openings in vertical rock faces that overlook steep perennial drainages.

Extensive cave and mine surveys in the southern Black Hills failed to locate maternity and nursery roosts (Mattson and Bogan 1993). Unknown roosting locations, coupled with the absence of females from netting surveys, have been termed the greatest mystery of bats in the southern Hills (Cryan and Bogan 1996). Given this species' sedentary lifestyle and the existence of one of the largest hibernating populations in the western United States at Jewel Cave National Monument, maternity roost location remains one of the most important questions to be answered.

Parturition dates for *C. townsendii* vary substantially in the Black Hills. Weather conditions can have a detrimental effect on breeding success (Grindal et al. 1992). The first nursery roost was identified on 6/6/92 and was comprised of 75 individuals, including juveniles. At this time, juveniles were capable of flight, which would place parturition in early to mid-May (van Zyll de Jong 1985, Pearson et al. 1952). The preceding winter was comparatively mild for the Black Hills with prolonged warm spells. These milder climatic conditions likely contributed to the early parturition date.

In contrast, the spring and summer of 1993 were unusually cool and wet. Surveys of the same site yielded very different results. To minimize the disturbance associated with roost entry, the cave's access was monitored using a night vision scope (6/20/93). Approximately 10 individuals were counted emerging. A physical survey of the site was conducted (8/20/93) when approximately 110 individuals, including juveniles, were identified. There was a wide range of juvenile ages, the majority of which were non-volant. At least five with minimal furring were seen clinging to their mothers placing them at less than one week in age and moving the

parturition date into August (Pearson et al. 1952). Unfavorable climatic conditions probably contributed to the delayed parturition. Survival of the first winter for young is estimated to be approximately 50 percent (Pearson et al. 1952). Such a late parturition date within the Black Hills almost certainly resulted in much higher, if not complete, mortality for the pups born in 1993.

The second maternity roost, found on 6/3/93, contained approximately 35 adults. The site was still in use on 7/7/93 and nearly the same size. There were no apparent juveniles, and all present were in torpor. The roost was abandoned by early August of 1993. Netting at the site on 9/3/93 yielded the capture of 11 adults, 1 male and 10 females. Seven of the females were parous though not lactating and three were non-reproductive. No juveniles were netted.

As further evidence of a poor reproductive season, no juvenile *C. townsendii* were captured in the Black Hills during summer 1993.

There were substantial increases in disturbance during the maternity season of 1994 at both sites. The larger of these two roosts was monitored (without entry) on 6/18/94 when approximately 15 individuals were observed exiting. At least two separate groups of people visited this site during July 1994. Vehicles and climbing equipment (required for access) were observed at the site on both occasions. An internal survey of the site conducted on 8/20/94 found no bats or evidence of use.

The second site was surveyed on 7/22/94. As no *C. townsendii* were observed within the cave, it was netted that same evening. In addition to other species, 27 *C. townsendii* were netted, the majority within a 30-minute period approximately one-half hour after sunset. Early captures were banded. This group consisted of seven lactating females, one probable pregnant female, six non-reproductive adult females, and one adult male. The balance were females, which were released upon extraction from the net to minimize further stress. The nets were closed to avoid stressing pregnant females. The early arrival of these bats *en masse* suggests another unknown roosting site in the area. To date this location has not been found. A daytime survey was conducted one week later when approximately 30 individuals were seen in a cluster. Upon observing the cluster, we immediately withdrew to minimize disturbance.

A survey of the site (8/20/94) found evidence of human activities. A large campfire was constructed within the cave's interior resulting in heavy deposition of soot on the upper portion. Three dead non-volant juvenile *C. townsendii* were on the floor of the cave. No adults were found. Such episodes highlight the need to protect important sites by restricting access during sensitive times of the year, as well as increasing public education.

In addition to this site's importance as a maternity roost, it also serves as the largest hibernaculum for this species in the northern Black Hills. During the first winter survey (1/27/94), there were 35 individuals. A survey conducted on 2/22/95 followed a week of unseasonably warm temperatures, and only seven individuals were identified. A survey conducted on 2/22/96 found 37 individuals (Oscar Martinez personal communication). In

addition to its importance for *C. townsendii,* this site serves as the largest hibernaculum for *E. fuscus.* High levels of disturbance have continued at this site. As a result, this site has been lost as significant bat habitat.

Hibernacula are generally cooler and drier than for most *Myotis* species and include both mines and caves. *C. townsendii* seems to prefer hibernacula with a temperature below 10ºC (Pierson et al.1999). Lone individuals were identified hibernating throughout an entire winter in mine adits as shallow as 3 m in length. Such sites had recorded temperatures below 0ºC.

One of the largest hibernating populations in the western United States is at Jewel Cave National Monument (Choate and Anderson 1997). Recent surveys found approximately 800 to 900 individuals (Choate and Anderson 1997). Hibernation surveys at this site identified this bat roosting individually and within clusters comprised of up to 90 to 100 individuals (Worthington 1992). Arrival generally begins in early October, with peak numbers being observed in late December (Mattson and Giannuzzi 1994). Depending upon weather conditions, departure generally occurs during April (Mattson and Giannuzzi 1994).

Similar patterns of arrival and dispersal are known at other hibernacula within the Black Hills. To prevent disturbance, access to hibernation areas within Jewel Cave is restricted during this period (Kate Cannon personal communication). Though varying methods of census were employed during winter, numbers at this site are not thought to be decreasing (Choate and Anderson 1997). More systematic surveys were used in recent counts. If continued, such surveys should serve to improve census accuracy and permit trend assessments (C. Giannuzzi and T.A. Mattson personal communication).

The only evidence of use by *C. townsendii* during the summer months in Jewel Cave is night roosting by adult males (Choate and Anderson 1997, Mattson and Bogan 1993). A male banded on 7/25/93 by Mattson was observed hibernating within Jewel Cave during two surveys conducted during the winter of 1993-94 (Tigner personal observation, C. Giannuzzi personal communication).

No other bats banded between 1992 and 1995 were observed wintering in Jewel Cave. It should be noted, however, that clustering commonly observed in *C. townsendii* and some *Myotis* species could easily mask the presence of a band. Given the lack of information on dispersal of this population, the possibility of migration to the site by bats from northern portions of the Black Hills cannot be eliminated. Should future research uncover a migration, the viewpoint of *C. townsendii* as a sedentary species might require reevaluation.

The second largest hibernating population was located in a natural cave 14 km north of Jewel Cave National Monument. This cave contained 300 hibernating individuals during the winter of 1994-95. Though located in close proximity to Jewel Cave, no evidence of common roosting was observed. Those *C. townsendii* banded at the site during summer also were observed hibernating here.

In recognition of this site's importance, it has recently been placed within a no treatment buffer zone by the United States Forest Service to minimize potential disturbance to the roost. A gate was installed to protect this site from disturbance during the winter. No historical data on population size for this site were located.

Supporting evidence of this species' sedentary lifestyle, most recaptures of banded individuals were recovered at the original banding site. All hibernacula with banded bats whose band could not be read served as night roosts where banding occurred previously.

Five exceptions to same location band recovery were recorded. The first of these was an adult male originally banded on 8/27/92 while entering a natural cave night roost [T4N R5E Sec 12]. It was observed hibernating in another cave [T4N R5E Sec 16] on 2/16/94. The distance between these two sites is approximately 5.5 km. During the same survey on 2/16/94, a banded adult female was found hibernating. She was banded on 8/20/93 at a natural cave serving as a nursery roost. The distance between these two locations is 4 km.

While surveying a privately owned cave on 1/12/94, a banded female was identified. Though the band number could not be read, this cave is approximately 1 km from the cave serving as a nursery roost for this species. Given the close proximity of these two sites, it is likely this female was banded at the nursery roost on 8/20/93.

Finally, on 9/13/94 an adult female was captured and banded at a natural cave [T5N R5E Sec 28] being used as a night roost. She was observed hibernating in a mine adit [T3N R5E Sec 18] on 2/1/95. The distance between these two sites is 17.5 km (11 miles) and is the longest distance for a band recovery for any bat species within the Black Hills.

A survey of an abandoned mine known to serve as a *Corynorhinus* hibernaculum on 1/8/03 yielded identification of a banded male *C. townsendii*. Closest banding site to this location for a male of this species was at a mine approximately 3.5 miles away (5.5 km). Band number could not be read owing to the height of the bat within the mine.

Site Type	Original Band Date (Age at Banding)	Recapture Date(s) (Age at Recap)	Time Length
Night Roost/Hibernacula (Cave)	6/3/93 (A)	1/27/94 (A)	7 months
Night Roost/Hibernacula (Cave)	9/16/92 (J)	4/8/93 (A) 11/24/97 12/01/99	7 months 5 years 7 years
Night Roost/Hibernacula (Mine)	6/15/93 (A)	10/25/93 (A) 12/21/93 3/7/94 12/1/94	4 months 6 months 9 months 1 year 6 months
Night Roost/Hibernacula (Cave)	4/29/93(A)	12/29/93 (A) 2/23/94	8 months 10 months
Night Roost (Cave)	6/3/93 (A)	9/3/93 (A)	3 months
Night Roost/Hibernacula (Cave)	6/3/93 (A)	1/27/94 (A)	7 months
Night Roost (Cave)	7/31/92 (J)	5/20/94 (A)	1 year 10 months
Night Roost (Cave)	6/3/93 (A)	7/22/94 (A)	1 year 1 month
Night Roost (Cave)	5/10/94 (A)	5/26/95 (A)	1 year
Night Roost (Cave)	9/20/92 (J)	7/9/93 (A)	10 months
Night Roost/Hibernacula (Cave)	6/3/93 (A)	12/28/99 (A)	7 years
Night Roost/Hibernacula (Cave)	8/18/92 (J)	4/8/93 (A)	8 months

***Corynorhinus townsendii*- NIGHT ROOST / HIBERNACULA - SAME SITE BAND RECAPTURES**

Site Type (Orig. Banding / Recap.)	Original Band Date (Age at Banding)	Recapture Date[s] (Age at Recap)	Time Length/Distance Between Captures
Cave / Cave	8/20/93 (A)	2/16/94 (A)	6 months / 4 km
Cave / Cave	8/27/92 (J)	2/16/94 (A)	1 year 6 mo. / 5.5 km
Cave / Mine	9/13/94 (A)	2/16/95 (A)	4 months / 17.5 km
Cave / Cave	8/20/93*	1/12/94	5 months / 1 km
Mine / Mine	6/15/93*	1/8/03	8.5 years / 5.5 km

***Corynorhinus townsendii*- DIFFERENT SITE BAND RECAPTURES**

*Probable; closest banding site for the species to the recapture location (no banding was conducted at the recap site)

Given our present knowledge about the species known to inhabit the Black Hills, *C. townsendii* is likely to be at greatest risk of significant population declines. This assessment is based upon *C. townsendii's* comparatively narrow range of acceptable roost requirements and its susceptibility to disturbance (Humphrey and Kunz 1976). Increasing disturbance levels at natural roosting sites coupled with closure of abandoned mines will, in the future, limit roost availability. Identification and protection of important roosting sites are important considerations.

C. townsendii accepts bat gates at hibernacula and at night roosts. While no maternity or nursery roosts have been gated in the Black Hills, gated, abandoned mines in Colorado and Wyoming are used by this species (K. Navo and B. Luce personal communications). Protection of important sites is presently considered the best management practice for this species.

A comprehensive conservation strategy has been completed for this species including an exhaustive review of the published literature (Pierson et al.1999).

Eptesicus fuscus (Big Brown Bat)

E. fuscus is a medium to large species with an average forearm length of 45.72 mm and an average weight of 17.54 gm. Pelage color varies substantially within the Black Hills but most frequently is a medium to dark brown. The fur is long with ears and membranes ranging from dark brown to black in color. Head and snout are broader than in *Myotis* species from which it can also be distinguished by its greater size.

It is the most common bat found roosting in buildings and is one of the more successful species within the Black Hills. Roost records include buildings, trees, railway tunnels, mines, caves, and at least one metal electrical fuse box. *E. fuscus* is found in a variety of hibernacula with varying microclimates. The variety of conditions is likely a result of its larger size and increased capacity for stored fat reserves (Kurta and Baker 1990).

E. fuscus was found hibernating in caves and mines and is the only species in the Black Hills known to hibernate in buildings. In colder locations, it is frequently found in crevices though it was observed roosting on rock surfaces. High relative humidity within hibernacula is not a requirement. Hibernation areas tend to be at spacious sites that do not require acrobatic flight through small passageways. Most of those hibernating at Jewel Cave were located in areas close to the historic entrance. Bat gates constructed to prevent unauthorized access into roosts did not deter this species. Monitoring at the two sites presently gated has shown they continue to use both sites as night roosts and hibernacula.

The largest known hibernaculum is a cave [T6N R4 Sec 6] in the northern Black Hills that contained approximately 100 individuals (1993-94 and 1994-95). Accurate counts are difficult due to the height and clustering in crevices, which is common at this site. It is also the largest hibernaculum in the northern Hills for *Corynorhinus*.

E. fuscus moves out of hibernacula earlier than *Myotis* species in the Black Hills. It is common for many to leave by the middle of March. Whether such hibernating groups are females, males, or a mixture of both is not known. It is likely the large body size allows for a wider range of acceptable roosting conditions during the early spring. As such, roosts considered marginal for hibernation may become acceptable with the approach of warmer weather.

Martin and Hawks (1972) suggested the possibility of female migration out of the Black Hills during winter. Subsequent hibernacula surveys identified four banded females at three separate caves, all located in the northern Black Hills. Band identification was not possible with three of these bats, because of height or clustering. All three of these sites were summer banding sites for females. The fourth banded female identified during hibernation was found on 2/23/94 and had been banded as an adult at the same location on 9/30/93. Turner (1974) also cites a record of a hibernating female being collected from a mine adit on 3/4/46 near Hill City, SD.

In addition to those banding recaptures previously mentioned, four other recaptures were recorded. All were recaptured at the original banding site. The first recapture was an adult male

banded originally at a natural cave night roost [T3N R6E Sec 32] on 7/31/92. It was recaptured while night roosting at the same location on 8/12/93. The second recapture also occurred at this location. An adult male was banded on 9/2/92 and recaptured within the hour exactly one year later on 9/2/93.

The remaining two recaptures both occurred at Red Bat Pond in the northern Black Hills. The first was a pregnant female originally banded on 5/27/94 weighing 16.5 gm. She was recaptured at the same site on 8/12/94 post-lactating, weighing 25.0 gm. Increase in weight likely represents recent foraging activity. Griffin (1958) cites a record of this species ingesting 4.0 gm of insect prey in 90 minutes of foraging. The second recapture at this location was an adult male originally banded at this site on 8/12/94 weighing 23.0 gm and recaptured on 6/23/95, weighing 16.5 gm.

Considered an opportunistic forager, this species is found routinely throughout a variety of habitat types and demonstrates flexibility in roost selection and foraging behavior (Brigham 1991, Kurta and Baker 1990). Powerful jaws allow it to feed on large hard-shelled beetles though other smaller prey is also taken (Kurta and Baker 1990). Black (1974), analyzing dietary habits of this species, considered it a beetle specialist.

Of 158 adults examined between 1992 and 1995, 33 individuals (21 percent), 15 males and 18 females, displayed noticeable wear to the canines ranging from a slight noticeable rounding of canine tips to near complete wear (Tigner unpublished data). While nutritional deficiencies may contribute to this condition, it is likely to be related to selection of hard-shelled insect prey.

Though a strong, fast flying bat, it lacks the acrobatic and evasive abilities of smaller *Myotis* species. Grounded individuals are often unable to resume flight without climbing to an elevated launching position. Emerging from maternity roosts, this species frequently dives 1 to 2 meters before achieving flight. This species will often bounce off mist nets erected over surface water, lose momentum, and land in the water. It is a capable swimmer and can be difficult to catch in deeper water.

Maternity and nursery roosts in buildings are frequently discovered by human occupants by vocalizations and movement during periods of warm weather. In addition, this bat's larger size, hence, easier visibility at emergence, helped to identify roosts. In the Black Hills, all known maternity roosts are located in buildings. However, maternity roosts are also known to occur in snags (Brigham 1991). Though not located, evidence suggests a maternity roost occurred near Red Bat Pond in the northern Black Hills during the summers of 1994 and 1995. Very early arrival of large numbers of pregnant and lactating females coupled with the absence of structures in the immediate vicinity suggest a tree roosting colony.

Large maternity roosts of several hundred are not uncommon in the Black Hills. The largest maternity roost, comprised of 300 adults, was around a chimney in the attic of a two-story brick building near Sturgis, SD. Similar buildings located near this site also contained large numbers. Fluctuations in numbers at specific locations suggest these roosts share individual members.

Shared locations were confirmed when a small roost of 30 females was captured, banded, and relocated to an adjacent building prior to installation of a sprinkler system. Banded females were then observed in three other roosts during subsequent surveys. A conservative estimate in the vicinity of these buildings was 1000 individuals.

Variation in parturition dates in the Black Hills was observed within and between seasons. One nursery roost, located at the South Dakota School of Mines and Technology at Rapid City in a building scheduled for demolition, contained 28 individuals (7/14/94). The group was comprised of 18 adult females, 14 lactating, 2 pregnant, 1 non-reproductive, 1 unrecorded reproductive condition, and 10 juveniles, 4 male and 6 female, all volant. Volancy begins between 18 and 35 days of age (Kurta and Baker 1990). The group was held in a single holding cage in a cool environment for two days, which induced torpor, banded and released at the original location following the building's demolition.

As this bat frequently selects buildings for roosting sites, it is likely to benefit from an appreciation of bats and their habitat requirements. Of particular importance is the development of a public education program including the proper methods of excluding roosts from buildings. Complaints of noise, large dropping deposits, and odor associated with urine accumulation are the most frequent reasons individuals seek help to exclude this bat.

Lasionycteris noctivagans (Silver-haired Bat)

The silver-haired bat is a medium sized bat with an average forearm length of 41.30 mm and an average weight of 12.31 gm. Pelage is dark, usually black, with silver-tipped hairs scattered throughout. Fur continues onto the uropatagium. Ears are rounded with a blunt, rounded tragus and ears and wing membranes are black in color. *L. noctivagans* is substantially smaller than *L. cinereus,* which also presents a frosted appearance.

L. noctivagans is considered a seasonal migrant arriving in spring and migrating south to warmer climates in the fall. In the Black Hills, the earliest record for a capture is on 5/5/94 when three adult females were netted at Roby Spring (Mattson 1994). Farther north, three individuals were observed foraging over Apex Pond on 5/11/94. Latest record in the season for this species was 9/16/94 for a pair foraging over beaver dam ponds on East Creek in Wyoming.

All captures of *L. noctivagans* occurred over water sources. Most were caught during July, though it was commonly netted as late as September in the southern Black Hills. This is substantially later than the region's other common seasonal migrant, *L. cinereus*, which is generally a rare capture by the end of August.

Two records of possible migrants were recorded at Ellsworth Air Force Base, 20 km east of the Black Hills. The first capture on 9/5/92 was a nulliparous adult female day roosting in the fork of a tree only 1 m from the ground. The second record (8/31/93) was a parous female captured while day roosting in a crevice on tree bark 1.5 m from the ground.

Evidence of the migratory habits was confirmed with the recapture of an adult male, in Denver, CO in October 1997, which was banded 7/29/94 at a woodland pond near Whitewood, SD (P. Murphy personal communication). The distance between the banding site and the recovery location is approximately 523 km. This distance is one of the longest documented for this species.

Turner (1974) cites a record of a *L. noctivagans* being collected from a cave on 11/19/67 near Rapid City, SD, apparently in hibernation, and surmises that some individuals may winter in the Black Hills.

Support for this was found during hibernacula surveys in a natural cave immediately adjacent to French Creek in Custer State Park. A survey conducted on 1/25/02 identified a single individual of this species in a vertical crevice. A follow-up survey was conducted on 3/6/02 and found a single specimen hibernating in a different nearby location, the first roost location being abandoned. The following winter, 2002-03, the site was again surveyed. Two individuals roosting separately were identified on 12/18/02. Based upon diminishing fall capture rates coupled with increasing spring captures, it is likely that the majority of this population relies upon migration. These recent records appear to document a segment of the population remaining in the Hills throughout the winter months.

L. noctivagans is a slow flier commonly seen drinking over woodland ponds early in the evening, often prior to sunset, during periods of warm weather. In the Black Hills, roost emergence for foraging usually occurs approximately 30 minutes after sunset. Considered an opportunistic feeder, the diet is comprised of a variety of insects across its North American range (Kunz 1982, Whitaker et al. 1981*b*).

While all species of bats in the region will roost in trees, *L. noctivagans* is one of the three species of the Black Hills that roost almost exclusively in trees. Virtually all information collected on roosting preferences comes from work conducted in the southern Black Hills by Mattson (1994) using radio telemetry.

Males were found to roost solitarily beneath loose bark or within cracks or crevices on the boles of trees. They were also observed changing roost trees frequently, usually daily, and roosting at varying heights on the bole. Twenty percent roosted less than 2 m from the ground.

Females give birth to one or two pups with twins being more common (Kunz 1982). Ten maternity and nursery roosts were identified, all in Ponderosa pine snag cavities. Average height of maternity roosts was approximately 10 meters. The number of bats roosting at these sites ranged from 6 to 55 individuals.

Three of the maternity and nursery roosts identified in 1994 were monitored intermittently during the summer of 1995 with no evidence of reuse (Tigner unpublished data). The low number of observations coupled with the frequent relocation of this species does not warrant any conclusions regarding seasonal roost fidelity. Mattson (1994) found maternity roost inhabitance averaged eight days.

Though never located, a maternity and nursery roost was presumed to exist in the vicinity of the Keystone, SD sewage lagoons. On 7/14/93, shortly after sunset, approximately 11 individuals were foraging and drinking over a large pond adjacent to the lagoons. A lactating female from this group was netted.

Earliest capture of a volant juvenile was recorded on 7/11/94 near Hazelrodt Picnic Ground near Custer, SD. Thought to be newly volant, juveniles were observed flying around a snag serving as a nursery roost on 7/8/94 (Mattson 1994, Mattson 1995). Volancy in this species begins at 21 to 28 days (van Zyll de Jong 1985). This species has demonstrated considerable variability in parturition as a pregnant female was also netted earlier on 7/7/94 at Hazelrodt Picnic Ground. Post-lactating females were netted 8/12/94 and 9/6/94.

One lactating female was netted while foraging over water at Ranch A in Wyoming on 7/25/95. Priday and Luce (1995) report capturing two individuals on 6/20/94 over a stream northwest of Sundance, WY.

Mattson (1995) observed owl predation on a probable juvenile taken while resting on the bole of the roost tree. The predator was thought to be an eastern screech owl (*Otus asio*) or a northern saw-whet owl (*Aegolius acadicus*).

A difference in distribution was noted for *L. noctivagans* following comparisons between summers of 1993 and 1994 (Tigner and Aney 1994). Weather conditions between the two years were distinctly different with lower temperatures and greater rainfall characterizing the summer of 1993. Survey work conducted in 1993 in the northern Hills resulted in capture of only two individuals with six additional records based upon sightings and echolocation monitoring via ultrasonic detector. Mattson (1994), surveying in the southern Hills during the summer of 1993, frequently found this species to be the most common bat netted with 108 total captures including adult females and juveniles.

Based upon routine captures and frequent sightings of this bat in the northern Black Hills during the summers of 1994 and 1995, it is possible that unfavorable weather conditions limited the northward range of this bat during the summer of 1993.

Until recently, little was known about the natural history of this species. Difficulties in locating roosting sites have largely been overcome by the application of improved radio telemetry equipment and techniques. While definitive conclusions regarding this species' habitat requirements would be premature, several common factors have been identified.

Maternity roosts for *L. noctivagans* are located in snags, frequently old woodpecker cavities (Mattson 1994, Vonhof 1996). The snags tend to be large, with dbh 38-62 cm (Betts 1996, Mattson 1994, Vonhof 1996), which likely provides a relatively stable roost microclimate. They also typically have an unobstructed southern exposure that probably elevates roost temperatures (Betts 1996, Mattson 1994, Vonhof 1996). Communally roosting Vespertilionids typically select such warmer maternity and nursery roosts, as increased temperatures serve to shorten gestation length and promote rapid development of juveniles (Racey 1982). The selection of roost sites by bats is likely the most important factor determining juvenile survival (Tuttle and Stevenson 1982). Another common finding has been the frequent relocation of the roost generally within a localized area (Betts 1996, Mattson 1994, Vonhof 1996).

L. noctivagans is likely to be susceptible to changes in forested habitats. Reductions in snag numbers result in fewer roosting sites for this species. As such, forest management practices (e.g. timber management and firewood collection) need to maintain the availability of larger snags over time and in numbers necessary for sustaining this species.

Summer monitoring is important to assess *L. noctivagans* trends. As a seasonal migrant, summer surveys represent the only means of monitoring this bat. While additional information needs to be collected on specific habitat requirements, the role of snag management will undoubtedly serve as the basis for success of this species in the region.

Lasiurus borealis (Eastern Red Bat)

L. borealis is a medium sized bat with an average forearm length of 39.7 mm and an average weight of 12.5 gm (van Zyll de Jong 1985). It is one of the more colorful bats with reddish-orange pelage and long, pointed wings. Ears are short and rounded. The furring on this bat is long and dense and extends down onto the uropatagium (van Zyll de Jong 1985). It is easily distinguished from all other species found within the region by its coloration.

The Eastern Red Bat is the least common bat known in the Black Hills. They are fast fliers and forage in straight lines or large circular patterns feeding primarily on large moths and beetles (Shump and Shump 1982). In general, this is a solitary roosting species, though small family groups of 4 to 5 bats are not uncommon during the summer months (Shump and Shump 1982). In contrast to its solitary lifestyle, there is evidence of group migration (Shump and Shump 1982). It is thought to be a seasonal migrant arriving during the spring or summer and departing before cold weather arrives.

Considered a tree bat, this species roosts in the foliage of deciduous and coniferous trees, but generally does not rely upon cavities for protection (Barbour and Davis 1969). Multiple births of two to four pups are common and characteristic (Kunz 1982). It has been suggested the increased litter size may be in response to increased risks of predation owing to its characteristic exposed roosting posture within the branches of trees (van Zyll de Jong 1985). Common predators include blue jays (*Cyanocitta cristata*) and various raptors (Barbour and Davis 1969).

L. borealis was captured in five Black Hills locations. There are no records from the Hills in WY (Bob Luce personal communication). Based upon an earlier capture of a volant juvenile (7/29/68) and later, a lactating female, on 8/20/68, Turner (1974) surmised there were at least two families of *L. borealis* in the vicinity of Moon Campground that year. An adult male was captured at this same site on 8/8/93 (Mattson 1994). The westernmost record was an individual netted at Wildcat Peak on 8/1/93 (Mattson 1994). The third location was in the northern Black Hills near Whitewood, SD over Red Bat Pond where a non-reproductive adult female was netted on 8/12/94. She displayed slight wear of the canines.

Three individuals were captured during the summer of 1998. The first location, Alkali Creek near Sturgis, SD yielded the capture of a juvenile female (8/19/98). Two other individuals were netted at an ephemeral woodland pond (T3N R6E Sec. 32) on 8/23/98. The first of these was an adult male captured simultaneously with another that escaped the net (Tigner 1998).

Based upon the limited numbers of observations and its migratory characteristics, it is difficult to determine population characteristics within the region.

Lasiurus cinereus (Hoary Bat)

L. cinereus is the region's largest bat with an average forearm length of 52.69 mm and average weight of 27.6 gm (van Zyll de Jong 1985). It is also one of the more colorful bats with fur mixture of blacks and browns with frosted white on the tips. Ears are short and rounded with black trimming around the edges. Greater overall size distinguishes it from all other Black Hills species.

In flight, it is distinguishable by its large size, rapid speed, and forceful echolocating call which, when not foraging, is generally characterized by a slow emission of pulses at low frequency (18000 kHz). This species commonly hisses and emits a spitting sound when netted or disturbed while displaying a menacing, open-mouthed defensive posture. Such posturing is no bluff, and gloves should be worn and extra care taken if handling this species.

L. cinereus is a strong bat capable of flight from a level surface including from the surface of water. It is a fast flier that commonly feeds at treetop level above the forest canopy. The diet is comprised mainly of large moths with other insects being taken to a lesser extent (Black 1974, van Zyll de Jong 1985).

All captures in the Black Hills were over water sites with nearly all occurring well after dark, though it was observed flying high prior to sunset. Most captures begin in early June with capture rates and observations decreasing by the end of August, suggesting an early migration. Similar observations, made in Canada, noted mid-August as the beginning of migration (van Zyll de Jong 1985).

The earliest record is an adult male captured (5/27/94) at Red Bat Pond near Whitewood, SD. The latest seasonal record of capture is 8/31 (Turner 1974), though one specimen killed by a dog was turned into the veterinary office at Ellsworth Air Force Base, 13 km east of the Black Hills, on 10/14/94.

Westernmost records are from Ranch A in Wyoming. Two adult males were netted over a creek on 7/25/95. Priday and Luce (1995) reported capture of an individual over a stream northwest of Sundance, WY in the Black Hills National Forest on 6/20/94. Two other records occurred at Stots Springs in western South Dakota. An adult female was captured on 8/13/93 and an adult male on 7/27/94.

Findley and Jones (1964) described summer sexual segregation in portions of North America. In contrast, Black Hills surveys observed both sexes in the region (Mattson 1994, Turner 1974, Tigner unpublished data). Pregnant females, lactating females, and juveniles have all been captured in the Black Hills. Earliest capture of a volant juvenile was 7/18/94 (Mattson 1994), which suggests parturition before mid-June (van Zyll de Jong 1985).

Although considered migratory, one banded adult female was recaptured at the original banding site, Red Bat Pond, approximately one year after banding. Netted originally on 7/29/94, she was

parous but not lactating and exhibited no signs of pregnancy. At recapture on 6/23/95, she was obviously pregnant. Tuttle (1995) cites an example from Wisconsin of a female returning to the same tree for three consecutive years to raise young.

Not considered a colonial bat, netting surveys generally yield low numbers of captures during an evening. There were exceptions to this low capture rate in the southern Black Hills. Four such examples were noted.

On 7/7/93, 9 adult individuals, 4 male and 5 female, were netted over the sewage lagoons at Jewel Cave National Monument (Mattson 1994). The second occurrence was on 6/29/94 at Log Trough Ponds when 8 adults, 7 male and 1 female, were captured (Mattson 1994). The third survey resulting in large numbers of captures was on 7/18/94 also at Log Trough Ponds when 6 individuals were netted. This group was comprised of 3 adult males, 2 juvenile males, and 1 juvenile female (Mattson 1994). Other individuals were noted flying in the immediate vicinity but were not captured (Tigner personal observation). The final survey was conducted on 7/7/95 in the bottom of a steep-walled, narrow canyon over two small pools near Lower Woodcock Spring. During this survey, 7 individuals, 3 males and 4 females, were captured. This group was comprised entirely of adults including 3 lactating females (Paul Cryan personal communication).

MANAGEMENT RECOMMENDATIONS

Low reproductive rates, susceptibility to variations in seasonal weather conditions, narrow habitat requirements, and susceptibility to disturbance combine to highlight the need for conservation strategies for bats in the Black Hills.

Roost Protection

Whether year-round residents or seasonal migrants, all bat species found within the Black Hills are affected by the availability of suitable roosting sites. It is this aspect of their biology that is considered the most important limiting factor for distribution (Humphrey 1975).

Eight of the 11 species discussed rely on underground roosting sites at some point during the year. Dependence upon sites that provide specific microclimate conditions is probably the greatest limiting factor for species in the region. As such, it is likely the future management of natural caves and abandoned mines will play a decisive role in conservation of bat species in the Black Hills. Such management frequently requires restricting access to sites that are deemed significant during sensitive times of the year to minimize disturbance.

Site significance is often based upon a judgment of existing conditions within an area (Pierson et al.1999). Sites that contain large collectives of individual species or high species diversity are two examples of sites that should be considered significant. Another example of a significant roost would be a maternity or nursery roost for a species such as *C. townsendii,* which is known to be particularly susceptible to disturbance (Pierson et al.1999).

Bat Gates

Controlling access to significant underground roosting sites is most often achieved via installation of a specially designed bat gate. Such gates are designed to allow passage of bats in flight while restricting unauthorized human entry. In addition to these two criteria, gate design and installation must also take a variety of other circumstances into account.

Restricting existing air movement at access points of underground sites can change internal microclimates, causing abandonment (Tuttle 1977). Successful gate designs generally allow channeling of air rather than blocking air movement. Designs proven successful to a species should be given first consideration. Alternative designs should be monitored for efficacy. As this is a relatively new form of management, recent information should be obtained on current design recommendations before proceeding with gate construction.

Timing of gate installation should be adapted to minimize disturbance to the target population. If the site being protected serves as a hibernaculum, gate construction should be completed prior to the arrival of bats in the fall. Optimal gate location within the site should also be considered. Gating small access points can facilitate predation on entering or emerging bats. Placing gates in larger openings allows bats more maneuverability in navigating restrictive openings.

For a more complete discussion of gates and effective designs, see Tuttle and Taylor (1994) and Pierson et al. (1999).

Caves

Historically, caves probably met the hibernal roosting requirements for year-round resident bats. From the perspective of bats that rely upon underground roost sites, not all caves are equivalent. Numerous factors contribute to determining whether a site will be used and for what purpose (Ransome 1990). As has been commonly found in other areas, only a small percentage of total sites may provide adequate habitat for resident bat species (Tuttle and Stevenson 1978).

For a variety of reasons, many of these locations may no longer be viable roost sites. Commercial development of natural caves can be incompatible with roosting bats. Higher levels of disturbance associated with frequent visitation during the warmer seasons can prevent bats from using sites as day roosts. In attempting to protect the unique physical features found in commercially developed sites, physical barriers that restrict entry may be erected. Non-commercial wild natural caves often are damaged if unprotected.

Solid door closures restrict ingress and can alter the microclimate by preventing natural air exchange (Tuttle 1977).

Equivalent levels of protection may be achieved by installation of bat friendly designs that allow bats access and permit natural airflow. Sites developed for commercial purposes are frequently larger than many of the wild caves and, as a result, may contain a variety of microclimates if natural conditions were permitted. Such wide-ranging conditions may provide habitat to a variety of species (Tuttle and Stevenson 1978).

Cooperative partnerships between private cave owners and public agencies could minimize the costs associated with converting access points and developing appropriate management plans. Encouraging such ventures could provide a cost effective method by which new and secure bat hibernacula could be developed.

Disturbance in wild caves has reduced the suitability and number of available roosting sites. With increasing outdoor recreation demands, such disturbance is likely to increase in the future. Recreational caving can often cause unacceptable disturbance to bat roosts, which is often unintentional but no less consequential in impact. Significant disturbance can result from many factors. Body heat and non-electric light sources increase ambient temperature; noise generated by moving or talking, and close examination of hibernating bats may prove deleterious. Such disturbance may go unnoticed due to a delay in the response time required for a bat to arouse from hibernation.

Increasing interest in recreational caving underscores the important role formal caving organizations can play in educating that segment of the population that adopts this activity as a

pastime. Such caving organizations are often comprised of conservation minded individuals with an interest in protecting cave resources. Enlisting their participation in conservation strategies should be considered a priority of habitat managers.

Some people who enter caves, through either ignorance or malevolence, do not subscribe to any code of underground conservation. Examples of disturbance documented in underground sites in the Black Hills are numerous.

Some of the more disruptive and damaging activities inside caves and abandoned mines include discharging firearms and fireworks, spray-painting, campfire construction, and intentionally killing roosting bats and other wildlife. Fire building is particularly common and likely results in the greatest level of long-term disturbance. In addition to elevating interior temperatures, which are detrimental during hibernation, and accumulating smoke, deposition of soot on ceilings can eventually result in site abandonment.

Even those sites that require greater skill to enter may need restricted access to prevent multiple disturbances during sensitive times of the year. Such forms of disturbance are not limited to a particular season. Winter disturbance was documented with increasing frequency in many locations monitored since 1992.

The Black Hills contains a myriad of roads that allow access to much of the forest. This results in increased casual disturbance of roosts. Road closures may serve to reduce disturbance levels at roost sites by reducing the ease of accessibility.

Caves that are closed should be accompanied by signs explaining the reason for closure as well as times when the site is accessible for visitation. Increasing public awareness is key to developing effective bat protection strategies. Posting informational or prohibitory signs at roost locations that do not control access via gates is not recommended. Vandalism of such signs in remote locations is common. In addition, they may serve to increase the curiosity factor, which can result in increased levels of casual disturbance. Informational signs of this nature could be incorporated into more protected areas such as campgrounds and visitor centers.

One exception to this scenario would be posting educational signs at locations that are more difficult to access and would therefore have a lower visitation rate. For example, one such roost, requiring technical climbing to access, serves as a nursery roost for *C. townsendii*. Gating this location would be extremely difficult. Placement of a permanently affixed sign inside the site's access which describes its significance, times of year considered most sensitive, and appropriate responses should bats be observed, could serve to limit disturbance and increase awareness.

To date, six locations in the Black Hills, three natural caves and three abandoned mines have been gated to protect roosting bat populations. Gate design followed recommendations that met with success in other parts of the country. Site survey work was conducted for at least one year

to determine how the location was used and by which species. The three sites were used by all[1] species documented from the site after gating.

Post-gating surveys found activity levels and patterns of use to be unchanged. (See TABLE 5.) One cave, which allows public access during the summer months but was gated to control access during winter hibernation, was used by juveniles and adults as a night roost. Recaptures of banded bats entering the site or observed during hibernation indicate the site continues to serve the same purposes.

An initial increase in number of bats hibernating within one of the gated mine was observed following installation. Unfortunately, the site was vandalized shortly after this observation and construction of campfires within the location resulted in roost abandonment for the duration of that winter. At this writing, this location has remained secure for five years. Winter surveys have shown overall numbers of bats to return to previous levels with the addition of a new species, *Myotis septentrionalis.* This species was not observed at this site during pre-gating winter surveys.

Of particular concern in the Black Hills is the protection of maternity nursery roosts for *C. townsendii*, as this is the only Black Hills species thought to characteristically form such roosts underground. While no maternity or nursery roosts have been gated to date within the Black Hills, similar gate designs proved acceptable to maternity and nursery roosts of *C. townsendii* in abandoned mines in Colorado and Wyoming (K. Navo and B. Luce personal communication). Protection of such sites should be given a high priority.

It should also be noted that access to hibernation sites at Jewel Cave National Monument requires bats to fly through or over a gate placed at the historic entrance. This gate was replaced with a more bat friendly design during the fall of 2000. With the exception of *M. evotis*, all other hypogeal species of the Black Hills have been documented utilizing this site (Mattson and Bogan 1993, Worthington and Bogan 1993).

[1]One exception to this was the capture of a single *M. evotis* at one of the locations prior to gate installation. Given the low capture rate for this species, coupled with its acrobatic flying ability, it is likely its absence from post-gating surveys (at this location) reflects a lower population density rather than a rejection of gating.

Abandoned Mines

The rate of abandoned mine closure has accelerated throughout the United States in recent years (Tuttle and Taylor 1994). Such closures have largely been in response to concerns of public safety and resulting liability (Tuttle and Taylor 1994). Public land management practices have historically not considered abandoned mines as wildlife habitat (Pierson and Brown 1992), but this viewpoint is changing as documentation of the importance of abandoned mines grows. As evidence of this recognition, the U.S. Bureau of Mines included bat gates in a recent publication describing mine closure guidelines (U.S. Dept. Interior 1994).

To date, closure of abandoned mines within the Black Hills has largely been restricted to private land or active claims on public land. Most of these closures have been conducted without any assessment of use as bat habitat. In addition to intentional closure of abandoned mines, many older sites are closing from natural degradation at entrances.

For North America north of Mexico, 29 species of hypogeal bats have been documented utilizing mines as roost sites (Kunz and Pierson 1994). In the Black Hills, seven bat species were found to roost in abandoned mines. The extent to which abandoned mines sustain bat populations in the Black Hills is unknown. Based upon observations in other regions, for those Black Hills' species that roost underground, closure of unsurveyed abandoned mines should be considered a substantial threat.

Abandoned mines are most commonly used as hibernacula and night roosts. It should also be noted that in other areas of the western United States, *C. townsendii* commonly use abandoned mines as maternity and nursery roosts (Pierson et al.1999).

In the Black Hills, most bat survey work has been limited to well known mines and safely accessible adits. Mines with vertical access entry or difficult interior passages have had minimal evaluation. Such sites are likely to have less human disturbance as well as natural predators. In other areas of the country, such characteristics have been associated with larger collectives of roosting bats (Tuttle and Taylor 1994).

The importance of abandoned mines as important bat habitat is well documented. One of the best examples occurred in 1992 when a mine in northern Michigan, slated for closure the following spring, was found to contain approximately one million hibernating bats (Tuttle and Taylor 1994). The site, Millie Hill Mine, Iron Mountain, MI, represents the second largest hibernaculum ever discovered in North America. This mine has since been protected by installation of a specially designed protective cage allowing bat access and preventing unauthorized human entry.

While the above scenario represents exceptional circumstances, the implication for the practice of unsurveyed mine closure is not diminished. Given our limited knowledge, it is entirely possible that a handful of sites within the Black Hills may provide shelter to significant

populations. Loss of such sites, if they exist, would be detrimental to the bat populations of the region.

If appropriate microclimate conditions exist at such sites, it is possible they provide habitat to significant numbers of bats. For those sites that have (or are potential habitat), alternatives to complete closure have been developed and successfully employed to allow continued use by bats while restricting unauthorized human entry (Tuttle and Taylor 1994). In addition, such closures are often less costly to employ than traditional methods of closure (Tuttle and Taylor 1994). Sites requiring protection should be treated in the same manner as natural caves, including development of a comprehensive management plan. [See BAT GATES]

As with caves, not all mines meet roost habitat requirements. Temperature, humidity, physical structure, location, level of disturbance, and distance to other habitat requirements are important considerations when evaluating such locations. However, it is also important to recognize the potential variability between mines that may be in proximity to one another. As such, the significance of one location cannot be determined by survey work conducted at a separate, nearby site.

Some general mine characteristics are associated with bat roosting. Mines with multiple portals generally possess more complex airflow, which may provide for a wider range of internal temperatures and humidity (Tuttle and Taylor 1994). Such variability may provide roosting requirements to a wider variety of species.

Sites containing support timbers throughout are less likely to contain large numbers of bats. Many of the adits in the Black Hills have supporting structures located at the portals or for a short distance in less stable areas. These structural supports are frequently used by bushy-tailed wood rats (*Neotoma cinerea*) for nesting sites as well as ladders to higher levels within the mine. These mines rarely contain roosting bats. Avoiding these areas may be in response predation threats by these or other terrestrial predators. [See PREDATION]

The physical structure of the mine itself may play a role in site selection. In the Black Hills, mines with large interior chambers are likely to be used as roost sites. Such features provide bats a roosting location with minimal predation risk. Size of tailings or waste rock deposits cannot be used as a reliable determination of mine size. Such deposits, particularly at older sites, may have been altered by natural erosion or mechanical means.

Single portal mines comprised of long adits, greater than 25 m, are likely to be used by more bats than similar sites of shorter length. Such sites may contain a wider variety of roosting temperatures. Hibernating bats that roost on the rock surface were observed moving deeper into mines during periods of cold weather. Such sites may also provide more room for evading or hiding from potential predators if disturbed during summer day roosting.

Mines with portals blocked by vegetation are used less frequently than those with a clear open access, even if reduced. During road construction associated with timber sales, slash was

deposited to block access to abandoned mines (Tigner personal observation). While likely done with the best of intentions, such practices may serve to restrict access to potentially important roosts and should be prohibited.

Sites that contain natural or man-made cracks and crevices are more likely to be used by a variety of species. These features are exploited by some species as a roosting thermoregulatory behavior (Ransome 1990), while others appear to roost exclusively during hibernation in such locations. For some species, crevice roosting may render interior microclimates acceptable when surface roosting would not.

In some cases, the instability of a mine or other hazards requires that the mine be closed. The following considerations can reduce the risk of trapping substantial numbers of bats. Temporary measures to prevent bat access should be employed in the time between interior survey and permanent closure. If the entire mine has been examined and found to contain no roosting bats, inexpensive plastic sheeting can be used to block portals and prevent bats from entering until permanent closure. If the entire interior of the mine cannot be surveyed completely, such closures should still be employed, but sheeting should be removed nightly to allow trapped bats to emerge. Closures should be employed during the late summer and early fall to permit adequate time for juveniles to achieve flying ability in case the site is used as a nursery roost.

Surveys of all mines should include evaluation by individuals trained to recognize bat signs. It is important to note that such surveys are often only specific to the season of survey. For example, sites used exclusively as hibernacula may give little indication of use if surveyed during July.

With the increasing pressures on natural caves, a management plan supplemented by protecting artificial roosting sites such as abandoned mines will enable larger numbers of sites to be protected with minimal impact upon recreational interests.

For detailed descriptions of evaluation methods of abandoned mines as bat habitat see Pierson et al. (1999) and Tuttle and Taylor (1994).

Land Management Surrounding Significant Bat Roosts

Altered roost microclimates can result from changes occurring in surrounding vegetation or landscape features. Such changes can be of particular significance within smaller sites with less complex airflow (Tuttle and Stevenson 1978). For example, increases in roost temperature can occur when overstory is removed permitting the roost's access point longer exposure to sunlight. Vegetation can also shelter access points. Changes in vegetation or landscape features that result in increased air movement across the access point can cause changes in roost microclimate.

One means of limiting changes to microclimate is to establish buffer zones around significant access points. While specific conditions may affect the size of such buffers, a minimum of 150 m horizontal radius to access points for roosts containing *C. townsendii* has been recommended (Pierson et al.1999).

This method was used on the Black Hills National Forest to protect the microclimate of a cave that functions as a large hibernaculum for *C. townsendii.* Once the cave's importance was explained to the timber contractor, he agreed not to harvest within the delineated buffer. The buffer is approximately two ha in area with the access point located roughly within the center. The cave lies within a narrow drainage with adjacent ridge tops serving as two buffer boundaries. Management intent is to retain the forest structure in the future. Heavy equipment is prohibited within the boundaries to further minimize disturbance.

Sites deemed significant should have formal site-specific management plans prepared to assure continuity of protection. Such plans should be comprehensive in scope including surrounding land management recommendations, forest dynamics, potential for natural disturbance such as fire, monitoring recommendations, and methodology.

Snag Management

Three Black Hills bat species, *L. noctivagans*, *L. borealis*, and *L. cinereus*, are considered tree-roosting bats. Trees are also known to be utilized as roosts by all other resident bats found in the Black Hills with the possible exception of *Corynorhinus*.

Though individuals may roost in protected areas of healthy trees, cavities within dead and dying trees are generally associated with collective roosting. Such colonies are required for the reproductive success of several of the bat species found in the Black Hills. The species for which the greatest documentation of this behavior has been collected is *L. noctivagans* (Mattson 1994).

Several factors have combined to reduce the number of snags. These include commercial timber harvest that began before the turn of the century in the Black Hills. Management of forests for commercial harvesting is designed to improve timber production, which results in the reduction of the number and quality of snags available for wildlife. Such reductions are owing to the practice of removing diseased trees and those posing physical hazards, as well as harvesting trees

before maximum size is attained (resulting in an overall reduction in the mean size, age, and decadence of trees).

Firewood collection in forested close to urban areas has also resulted in a reduction of the number of available snags.

Bat Roosts in Buildings

Six bat species in the Black Hills are known to use buildings as maternity or nursery roosts. The extent to which other species have adopted such roosts in the Black Hills region remains unknown. In addition to collectives of bats, individuals will frequently roost on or within buildings.

As the human population increases, such roosting behavior is likely to continue and may increase. Collectives that commonly form in buildings are maternity or nursery roosts. Proper management techniques for building roosts may become an important component of future conservation strategies. Misconceptions about bats roosting in buildings are common. Public education will be an essential part of bat conservation.

Buildings offer a number of different attractive features as roost locations. The first of these is temperature. Warmer roost temperatures shorten gestation length and hasten physical development of juveniles. Attics typically have relatively warm temperatures and are frequently chosen for roosting.

An attic may provide a variety of temperatures. Such a range allows the bats to seek an area of optimal temperature without having to relocate. When roosts are located in buildings with pitched rooflines, the roosting location is frequently found at the apex during the cool evening temperatures. During the heat of the day, bats frequently move down the roofline away from the apex on the shaded side of the house. Roosts may also be located around chimneys and stone or masonry walls, which generally hold warmth longer than other materials.

A second feature of many maternity and nursery roosts identified within buildings in the Black Hills is the presence of a spacious and open attic. In addition to temperature variations, an open attic provides pups a secure area for learning to fly. Juveniles that fall to the ground can climb along unfinished wooden supports or rafters to rejoin the roost and the mother. Flying in large open areas within the confines of an attic minimizes predation risk.

Since ideal roosting sites are often accessible by only small access points, bats may exploit locations where they are less likely to confront large predators or roost competitors that may be more common in natural roosting locations.

The most effective means of ridding a building of unwanted bats is by removing the roost access (Barclay et al. 1980, Greenhall 1982). This generally requires blocking all openings. This

strategy is more effective and less disruptive if completed prior to the arrival of the bats in the spring or following their departure in the fall.

Effectively evicting bats from a building requires a series of simple steps. Failure to follow the described procedures can result in bats becoming entrapped in the structure. Bats trapped inside roosts will seek alternative exits and may end up in the interior via openings around plumbing and electrical wiring. This is generally viewed as unsatisfactory for humans and bats.

The first step in excluding bats is to identify the main roost access point usually by observations at dusk or early evening. There may be several openings, but generally, one is used more than the others are. Following the identification of this access point, all other potential entrances should be closed or filled. Closure can be achieved using a variety of materials and must be conscientiously applied to the entire structure. Leaving unblocked access points often results in a new favorite being established.

Bats are not rodents and do not create or enlarge holes in buildings. They do not build nests, chew wiring or other similar activities characteristic of rodent infestation. In light of this, plugging openings with soft material such as insulation will suffice for closing small openings. Large openings for ventilation should be covered with screen. Smaller *Myotis* species have been observed entering and exiting through a single opening within the trough of pointing between two bricks and the overlapping wooden fascia board where roof meets wall. Such small openings can make restricting access to bats difficult in many older structures.

Once all cracks and openings have been sealed, the favorite access should be covered with a piece of plastic netting or sheeting that hangs over the opening and is attached only at the top. This creates a loosely hung flap over the opening. This flap must hang flat over the surface in which the hole occurs. The opening at the bottom allows bats inside to emerge but blocks their return.

Roost openings are frequently located in corners or areas that are difficult to cover with a flat lying piece of netting. If such is the case, a funnel shaped tube constructed of sheet plastic can be attached over the access point. The large end of the funnel is sealed around the roost access opening with the small end hanging down. Again, the bats are able to emerge but unable to reenter the tube and the roost.

These devices should be left in place for four to five evenings of good weather. During this period, all bats will have the opportunity to emerge. After this time, the temporary devices can be removed and the hole filled permanently. The exclusion process should only be undertaken in early spring before females have given birth or in late summer or early fall after the juveniles are volant. If done during the nursery season, non-volant pups can be separated from mothers. Searches for access points into the roost by the adult females are likely to be more thorough if pups are trapped inside.

If the roost is located within a large open attic in a building that is difficult or too costly to seal completely, measures can be taken to make the site a less desirable roost. When bats are not in residence, fall or winter are best, the attic can be divided into separate compartments. This can be achieved by stapling inexpensive sheet plastic to rafters forming a curtain within the attic. Curtains create a physical barrier to flight. The curtain should extend the full width of the attic and should come within 30 cm of the attic floor. Slitting the plastic curtain with vertical cuts will facilitate air movement and allow easier human passage within the attic.

In larger attics, these curtains can be hung up to 3 m apart if no access points to the outside occur within the compartments. Care should be taken to center such partitions between heads of fire sprinklers to prevent blocking the water spray in the event of a fire. Creating these smaller compartments restricts the flight area within the roost and may be enough of a nuisance to cause roost abandonment. If the bats continue to use the site, it usually limits their activity to one area and often prevents them finding their way into the building's interior by restricting movement within the attic.

Other Methods of Bat Exclusion

Many traditional methods for discouraging bats from roosting in buildings are ineffective. One of the more common remedies is scattering mothballs throughout the roosting area. Numerous roost surveys have found bats and mothballs frequently occupying the same area with no apparent effect on roost use.

Electronic devices that emit ultrasonic noise to drive away roosting bats are also ineffective (Bomford and O'Brian 1990, Hurley and Fenton 1980). One maternity roost of *Eptesicus fuscus* was observed immediately above one such device mounted to a supporting column within an attic in Hot Springs, SD (Tigner personal observation).

Poisons are the least effective method of control. They do not provide a long-term solution to the problem and can frequently be more problematic. In South Dakota, the use of poisons to kill bats is illegal. Poisoned bats often become grounded, which may bring them into contact with pets and children. Poisoned bats are often able to fly some distance from the roost thereby spreading the problem to surrounding areas (Greenhall 1982). All methods of bat roost control in Wyoming are subject to approval by the Wyoming Game and Fish Department (Bob Luce personal communication).

Public Education

Public education remains one of the keys to bat survival. As the greatest source of threats to bats originates with human activities, creating an increased public awareness of their ecological importance should provide a significant contribution to protecting these animals.

Since several species have been documented roosting in man-made structures, an increased public awareness of how best to manage undesired bat roosts is needed. Nuisance roosts are often maternity roosts which, if disturbed or disrupted, may result in the loss of a complete generation of bats. Owing to their low reproductive rate, such disruptions can have significant impacts on population size for many years. Bat topics can easily be incorporated into traditional public education media. Resources to supplement such public education undertakings are available through organizations such as Bat Conservation International in Austin, Texas [www.batcon.org].

Materials describing appropriate measures for dealing with unwanted bats are a particularly effective means of public education. Materials should be made available through offices of public agencies that are most likely to receive such requests. These include county extension offices, South Dakota Game, Fish and Parks offices, Wyoming Game and Fish Department, United States Forest Service.) [See Stukel et al. (1995) for examples.]

Public Health

One of the more frequent justifications cited for persecuting bats is based upon fear of threats to human health. The following information addresses some of the more commonly asked questions and popular misconceptions about bats and their impact on public health.

Rabies is probably the best known and most feared zoonotic disease of public health significance. While misconceptions about the relationship between bats and this viral disease are numerous, recent research has demonstrated this relationship to be far less menacing than is often portrayed. As with all mammal species, bats are susceptible to contracting this disease. While some bat species seem to be more susceptible to contracting rabies, the disease in bat populations is not thought to be increasing (Brass 1993). Occurrence of the disease in bats in North America has been estimated to be less than ½ of 1 percent (Constantine 1988).

The traditional view of bats as asymptomatic carriers of rabies, immune to its progression, is now known to be untrue (Brass 1994). Another common fallacy is that bats serve as reservoirs of the virus from which the disease is spread to other species. Research has not demonstrated bats to be an important link in transmission of the disease to terrestrial mammals (Brass 1993).

One of the surest methods of avoiding a possible exposure is simply not to handle wild mammals. Not handling a possibly infected bat will reduce your risk of contracting rabies to nearly zero. When handling dead or live animals is required, always wear thick gloves. Teaching children the importance of a hands-off approach to wildlife should be one of the

primary goals of any education program. Natural inquisitiveness and innocence, coupled with anthropomorphizing common in children's media, can leave them particularly susceptible to contracting this disease. Indeed, worldwide statistics show children to be the group most frequently affected by this disease (Brass 1994).

Human exposure to rabies is far more likely to come via contact with an infected dog or cat than through contact with bats (Brass 1994). As such, vaccinating household pets against rabies is one of the most important preventive measures that can be taken against the spread of this disease (CDC 1996). Vaccinated pets that may have been exposed to an infected animal are generally prescribed a rabies booster, although a veterinarian should advise the appropriate course of action.

In the event of a possible exposure, one of the most effective means of preventing the disease is immediate and thorough washing of the infected site with soap and water. However, this is not to be considered an alternative to receiving prompt medical treatment (CDC 1991). All possible exposures should be promptly evaluated by qualified medical personnel (CDC 1991). Where possible, collection of the suspect animal for testing is recommended. Effectiveness of treatment of this disease is highest when begun soon after exposure (Berkow 1987).

The term exposure is not limited to a bite that results in rupture of the skin. Handling wildlife with cuts or scratches on hands, which become contaminated with saliva or other material of an infected animal, constitutes possible exposure. Such contamination can also occur through contact with a handler's mucous membranes (CDC 1991). These forms of potential exposure must be treated in the same manner as a bite (CDC 1991).

Incubation of the disease in a host can vary substantially from a few days to a year (Brass 1994). This finding is of particular importance to all mammalian wildlife handlers. The common belief that only healthy animals successfully hibernate through the winter is not valid, and such animals cannot be considered free of this disease (Brass 1994). In addition, handling specimens frozen for long periods may still pose a threat as freezing can preserve the virus that causes the disease (Constantine 1988).

The Center for Disease Control (CDC) recommends all individuals in high risk occupations, such as veterinarians, veterinary assistants, and wildlife handlers, receive a series of pre-exposure vaccinations to boost antibody levels in the event of an exposure (CDC 1991). The rabies pre-exposure vaccines do not provide immunity to contracting this disease. They are designed only to boost antibody titer and to improve the response to treatment that is still required following all possible exposures (CDC 1991).

For those individuals whose studies or work require handling bats and other mammalian wildlife, every effort should be taken to minimize potential exposures. These include pre-exposure vaccines followed by serology and vaccine boosters, promptly reporting and treating all potential exposures to the disease, and wearing protective gloves when handling animals. If gloves cannot be worn, animals should not be handled by people with cuts or abrasions on their hand.

For an exhaustive review of bats and rabies, see Brass (1994).

Other

Concerns about parasites are commonly expressed by many people. Nearly all parasites known to infest bats are species specific and pose little threat to pets or humans (Constantine 1988). No transmission of disease has been documented by parasites of bats to humans (Constantine 1988).

Histoplasmosis is primarily a disease of the respiratory system that manifests symptoms similar to tuberculosis (Berkow 1987). Infection comes from inhaling dust containing the fungal spores that cause the disease (Berkow 1987). The spores are commonly associated with pigeons, poultry, and bat droppings. Human exposure is generally associated with disturbing dry fecal deposits resulting in airborne dust containing the spores that is then inhaled. Individuals working in dry dusty conditions where fecal deposits may occur, particularly in confined spaces, should wear appropriate respirators. Spraying fecal deposits with water prior to disturbance will reduce dust and help minimize exposure (Benenson 1990).

FUTURE BAT RESEARCH IN THE BLACK HILLS

While much has been learned about bats in the Black Hills, many questions remain unanswered. Additional information is needed on the maternity roosting requirements of species for which there is minimal information. Further study also needs to be done on the role of abandoned mines in supporting bat populations and the identification and protection of important maternity roosts, nursery roosts, and hibernacula.

To facilitate the collection and dissemination of new information, agencies charged with the management of public lands and wildlife should develop formal relationships for the expressed purpose of maintaining monitoring and to continue habitat research. This networking would benefit those conducting research as well as the bats themselves. Alliances will provide benefits in two main areas. The first of these benefits is economic. Given the scarcity of resource agency funding, pooling resources will improve the quality and amount of work that can be conducted.

Agency participation in collaborative efforts may take a variety of forms and need not be limited to financial support. Providing vehicles, trained field personnel, researcher accommodations, and support equipment are some contributions that would be helpful.

The second benefit from collaborative ventures will be to provide a coordinated approach to future research. Cooperative ventures would prevent costly duplication of research, identify priority areas, and serve as a formal avenue of communication and dissemination of results. Consolidation of collected information into a commonly supported database would provide an effective and complete tool for future evaluation of species distribution and population trends.

Research duplication can also have a negative impact upon specific populations or roost sites. Hibernacula surveys can be a source of disturbance. Uncontrolled duplication, aside from wasting resources, can have detrimental effects on the site. Coordinated projects would reduce the possibility of excessive levels of disturbance at important roost sites. Permit applications for mist-netting, collection of specimens, and banding should include specific information as to where, how, and why the work is to be done. Such applications should be reviewed and evaluated by persons qualified to determine the applicant's ability and screened for possible duplication. This information would enable a uniform standard to be maintained in conducting future bat research.

The *Guidelines for the Protection of Bat Roosts*, as prepared and discussed by the American Society of Mammalogists (1992), could serve as the framework under which all future research would be conducted. In addition to these guidelines, the recent Idaho State Conservation Effort has additional measures specific to *C. townsendii* that should be incorporated into this framework of standards (Pierson et al.1999). Beginning in January 2001, SDGFP began requiring that applicants requesting scientific collector's permits to sample or collect bats in South Dakota provide detailed descriptions of research/monitoring plans prior to being approved for a state collector's permit [See Appendix II.]

To prevent unnecessary disturbance, specific locations of significant roosting locations, whether natural caves or abandoned mines, should be considered confidential and not for public distribution.

In Conclusion

Bat species of the Black Hills require a variety of habitat types. Changes within these habitat types will have an inevitable impact upon those species dependent upon them. Species such as *C. townsendii* or *L. noctivagans* with specific summer roosting requirements are particularly susceptible to these changes. The variation observed in hibernacula selection for year-round residents also demonstrates the diversity of required habitat. Accelerating changes resulting from increasing pressures on existing habitat likely represent the greatest threat to the survival of bat species in the region.

Given the rapid pace of change, the success of mitigation measures designed to maintain diversity could only be gauged through continued species monitoring. The importance of continued bat population monitoring in the Black Hills cannot be overemphasized. Though biological surveys are often judged to be an end in themselves, we agree with Bogan et al. (1989) in viewing them as the only reliable means to monitor population trends over time. As such, biological surveys should be viewed as an ongoing process for collecting information to assess effects of land management and help guide resource decisions.

Taken independently, much of the bat work conducted to date within the Black Hills can be considered little more than anecdotal. Lacking a historical perspective to provide points for comparison, individual point-in-time surveys only give a reflection of present conditions. Population trends are impossible to discern from such limited information. Collectively, this work, if combined with ongoing and future research, will provide a basis for understanding the complex interactions between bats and the unique habitat found within the Black Hills.

Fully understanding the complex relationship between bats and their environment must remain a goal for the future. Identifying habitat requirements is but the first step in long-term protection of these ecologically important species. Once identified, conserving these requirements becomes the challenge facing wildlife and land management agencies. Without the implementation of these identified management guidelines, future surveys will serve only to provide simple documentation of the extirpation of bats from the Black Hills.

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SPECIES BANDED	♂	♀	SPECIES TOTAL
M. ciliolabrum	55	21	76
M. evotis	05	01	06
M. lucifugus	101	74	175
M. septentrionalis	137	27	164
M. t. pahasapensis	54	21	75
M. volans	67	22	89
E. fuscus	72	90	162
C. townsendii	34	71	105
L. borealis	0	01	01
L. cinereus	18	05	23
L. noctivagans	43	18	61
SPECIES TOTALS	**586**	**351**	**937**

Table 1 Species, sex and total number of bats banded: 1992-1995.

SPECIES	♂	♀	TOTAL
M. ciliolabrum	2	1	3
M. lucifugus	2	0	2
M. septentrionalis	10	1	11
M. t. pahasapensis	5	0	5
M. volans	3	0	3
E. fuscus	3	11	14
C. townsendii	10	13	23
L. cinereus	0	1	1
L. noctivagans	1	0	1

Table 2 Banding recaptures by species: 9/92-12/02.

No records of recaptures have been noted for *M. evotis* or *L. borealis*.

Tables 3 and 4 provide common measurements collected from bats in the Black Hills (Tigner unpublished data).

SPECIES	♂ FA [mm] (n)	♀ FA [mm] (n)	FA average for species (n)	FA range for species (mm)
M. ciliolabrum	31.16 (76)	31.53 (32)	**31.27** (108)	29-34
M. evotis	37.80 (5)	40.00 (1)	**38.17** (6)	37-40
M. lucifugus	37.37 (108)	37.66 (73)	**37.49** (181)	32-41
M. septentrionalis	36.03 (141)	36.29 (28)	**36.07** (169)	32-43
M. t. pahasapensis	40.50 (54)	41.70 (20)	**40.82** (74)	37-44
M. volans	37.79 (72)	38.35 (23)	**37.93** (95)	35-41
E. fuscus	45.18 (73)	46.14 (96)	**45.72** (169)	41-51
L. borealis	**	42.00 (1)	**39.7**[1] (8)	36-42[2]
L. cinereus	52.35 (20)	53.83 (6)	**52.69** (26)	50-55
L. noctivagans	41.09 (45)	41.73 (22)	**41.3** (67)	39-44
C. townsendii	43.18 (34)	44.85 (72)	**44.31** (106)	40-47

Table 3 Forearm (FA) measurements by sex and species.

[1, 2] from van Zyll de Jong 1985

Weights are shown to provide a comparison between species only. In calculating the mean weights, no adjustments were made for variables such as pregnancy[1] or recent foraging activity[2].

SPECIES	♂ weight [gm] (n)	♀ weight [gm] (n)	mean weight for species [gm] (n)	weight range for species [gm]
M. ciliolabrum	5.72 (62)	5.71 (28)	**5.72** (90)	4.0-9.5
M. evotis	7.50 (2)	7.50 (1)	**7.50** (3)	7.5
M. lucifugus	8.23 (96)	8.64 (29)	**8.33** (125)	5.0-11.5
M. septentrionalis	7.14 (113)	7.09 (22)	**7.13** (135)	4.5-11.0
M. t. pahasapensis	7.70 (45)	8.11 (14)	**7.80** (59)	6.0-10.5
M. volans	7.73 (56)	8.18 (17)	**7.84** (73)	5.0-11.5
E. fuscus	17.18 (68)	17.88 (72)	**17.54** (140)	11.0-26.5
L. borealis[3]	**	20.00 (1)	**12.5**[4] (4)	10.0-17.44[4]
L. cinereus	23.58 (20)	20.50 (2)	**27.6**[4] (22)	25.4-30.3[4]
C. townsendii	11.04 (27)	12.21 (24)	**11.59** (51)	9.0-19.0

Table 4 Weight by sex and species.

[1] Kurta and Kunz (1987) in surveying published literature, found the mean weight of bat pups at birth to be 22.3 percent of the mother's post-partum body weight.

[2] One adult female *C. townsendii* banded emerging from a cave was recaptured 2.5 hours later reentering the cave. At emergence, she weighed 11.5 gm and at recapture (with bulging stomach) 16 gm, a gain of 4.5 gm or nearly 40% of its body weight (Tigner unpublished data).

[3] No males were netted; only one female was recorded.

[4] from van Zyll de Jong 1985.

SPECIES	NIGHT ROOST	DAY ROOST	HIBERNACULUM

	BEFORE➔AFTER	BEFORE➔AFTER	BEFORE➔AFTER
M. ciliolabrum	♂♀ ➔ ♂♀	♂✓ ➔ ♂✓	✓ ➔ ✓
*M. evotis**	♂ ➔ X		
M. lucifugus	♂♀ ➔♂♀	♂♀ ➔ ♂♀	
M. septentrionalis	♂ ➔ ♂	♂ ➔ ♂	
M. t. pahasapensis	♂♀ ➔ ♂♀	✓ ➔ ✓	✓ ➔ ✓
M. volans	♂♀ ➔ ♂♀		
C. townsendii	♂♀ ➔ ♂♀	♂♀ ➔ ♂♀	♂♀ ➔ ♂♀
E. fuscus	♂♀ ➔ ♂♀	♂✓ ➔ ♂✓	✓ ➔ ✓

***** Represents a single capture at only one of the 3 gated locations; ✓=unknown sex; X=no captures

Table 5 Roost usage at gated sites.

APPENDIX I BATS OF THE BLACK HILLS - BRIEF DESCRIPTIONS

The following is a brief description of the eleven bat species known from the Black Hills. Included are behavioral and physical observations.

Distinguishing among *Myotis* species can be frustrating at times and nearly impossible if the bat is hibernating since hibernating bats should not be disturbed. Pelage color alone is not a reliable identifying characteristic as significant variations occur within species.

Myotis ciliolabrum (Western Small-footed Myotis) - Forearm is 29-34 mm. *M. ciliolabrum* is the smallest bat found in the Black Hills. Its skull gives a flattened appearance, and bat has characteristic black mask and ears that often contrast with pale brown fur. Calcar is keeled. *M. ciliolabrum* is a year-round resident that hibernates in caves and mines in crevices and rock surfaces and generally prefers cooler hibernacula. No maternity roosts have been identified in the Black Hills.

Myotis evotis (Long-eared Bat) - Forearm is 36-41 mm. Ears very long, 22-25mm in length, extending 5 mm or more beyond nose tip when pressed forward. Ear length is more than ½ length of forearm. Fur is long with color varying in shades of brown. Ears and membranes are very dark to black, and there is often an inconspicuous fringe of minute hairs along edge of uropatagium.

Myotis lucifugus (Little Brown Myotis) - Forearm is 34-41 mm. Blunt tragus is approximately ½ length of ear. Fur varies in shades of brown often with a sheen. Membranes and ears dark brown. Calcar is absent or weak. *M. lucifugus* commonly feeds very low over water surface. Maternity roosts are common in buildings during summer. It is a year-round resident that hibernates in caves and mines with high levels of humidity and is found in crevices and roosting on rock surfaces.

Myotis septentrionalis (Northern Myotis) - Forearm is 32-39 mm. Size is similar to *M. lucifugus* but has longer ears, 17-19 mm, with long, pointed tragus. Calcar is not keeled, and fur is dull, not glossy. Membranes and ears medium brown. Face is often more bald than other *Myotis* species. A very vocal bat when disturbed. It is a year-round resident that hibernates in caves and mines and is found in crevices.

Myotis thysanodes pahasapensis (Fringed Myotis) - Forearm is 39-44 mm. Ears are long, 16-20 mm, and generally very dark to black as is the mask. A distinct fringe of small stiff hairs is found along the edge of uropatagium. Subspecies found only in the Black Hills region. *M. t. pahasapensis* is a year-round resident that hibernates in caves and mines and roosts in crevices and on rock surfaces.

Myotis volans (Long-legged Myotis) - Forearm is 35-41 mm. It often displays a characteristic furring from elbow to knee on underside of wing membrane and a well-developed keel to the calcar. *M. volans* generally has darker brown membranes. A shorter rostrum gives head a

smaller appearance than *M. lucifugus*. This species is a year-round resident that hibernates in caves and mines and is found on rock surfaces and in crevices. Maternity and nursery roosts have been found in a building and a snag.

Corynorhinus townsendii (Townsend's Big-eared Bat) Forearm is 41-47 mm. Ears are very long, >25 mm, with two lumps near the end of the snout. This species is often misidentified as the ears are commonly folded back and adjacent to folded wings while roosting or hibernating. Tragus does not fold back with ear and are often mistaken for *Myotis* ear tips. It is dependent upon caves and mines. *C. townsendii* roosts in the open on rock surfaces often near the openings of caves and mines. Echolocation is very soft and can be difficult to detect in the field. A very acrobatic flier, this species is known to utilize feeding perches during foraging. *C. townsendii* is a year-round resident with the largest known hibernating population in the Black Hills located at Jewel Cave.

Eptesicus fuscus (Big Brown Bat) - Forearm is 41-51 mm. *E. fuscus* is generally larger than *Myotis* species with a broad head and snout. Ears are short with rounded tragus. Calcar is keeled. It commonly roosts in buildings during the summer months. *E. fuscus* is a year-round resident that hibernates in caves and mines roosting in crevices and on rock surfaces.

Lasionycteris noctivagans (Silver-haired Bat) Forearm is 37-44 mm. Fur is dark, usually black, and silver-tipped. Ears are short and rounded. Rarely found underground, this bat usually roosts on tree trunks in crevices or beneath loose bark. Maternity roosts are located in tree cavities. This species is a slow flier and feeds over woodland ponds and streams. Although a few winter records exist, *L. noctivagans* is considered a migratory species in SD.

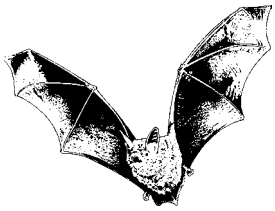
Lasiurus borealis (Eastern Red Bat) - Forearm is 36-42 mm. Fur is reddish, and wings are long and pointed. Ears are short and rounded. Interfemoral membrane is heavily furred. *L. borealis* routinely gives birth to more than one pup. Twins, triplets and quadruplets are not uncommon. This species roosts almost exclusively in the branches of trees and is generally a high-flying bat. There are few records of *L. borealis* in the Black Hills. It is considered migratory.

Lasiurus cinereus (Hoary Bat) - Forearm is 48-58 mm. *L. cinereus* is the largest bat in the Black Hills. Fur is multicolored and heavy. Ears are short and rounded edged in black. Many hairs tipped in white give the appearance of being frosted. It is not a colonial bat and is generally a high, fast flier. *L. cinereus* is a summer resident that migrates southward by the end of August.

APPENDIX II

BAT SAMPLING AND COLLECTION PROTOCOL GUIDELINES AND REQUIREMENTS (Effective 1 January 2001)

SOUTH DAKOTA DEPARTMENT OF GAME, FISH AND PARKS
523 E. Capitol, Pierre, SD, 57501



The Black Hills of South Dakota and Wyoming have historically been of interest to bat researchers and specimen collectors. Many specimens have been collected for a variety of purposes, and these specimens are housed in museum and university collections throughout the country. In recent years, natural and intentional mine closures combined with the continued interest in research on Black Hills bat populations have caused concern about impacts of sampling and collection on local bat populations. This document presents specific guidelines and requirements for bat sampling and collection related to monitoring and research activities throughout South Dakota. This document is not intended to provide recommendations on study or sampling design, which can be obtained from other sources (ex: *Inventory Methods for Bats – Standards for components of British Columbia's Biodiversity No. 20*. 1998. Resources Inventory Committee, British Columbia).

The overriding intent of this document is to provide for the safety of individual bats and for the long-term stability of bat populations in South Dakota. State Scientific Collector's Permits will be issued only for research and monitoring activities that are compatible with this overriding intent.

Components of this document are arranged as guidelines or requirements. The permittee should assume that deviations from requirements will not be approved unless justified to the satisfaction of the SD Department of Game, Fish and Parks.

This document is a supplement to the *South Dakota Department of Game, Fish and Parks Free Scientific Collector's Permit Application*. Legal authorities: SDCL 41-6-32 (scientific collector's license) and SDCL 41-1-2 (state authority for wildlife protection).

REQUIREMENTS:

1. Applicants must provide evidence that they are familiar with the desired sampling techniques and with identification of bat species likely to be found in the study area. This requirement applies to all parties that will operate under the Scientific Collector's Permit. The Scientific Collector's Permit cannot be transferred or delegated to individuals not covered under the Permit.
2. In addition to completing the *South Dakota Department of Game, Fish and Parks Free Scientific Collector's Permit Application*, applicants must submit a copy of their study or monitoring plan. At a minimum, the plan should include species of concern, number of individuals to be collected or handled, study area and duration, techniques, personnel, and eventual location of specimens or tissues.
3. Mist nets must be attended at all times. Harp traps must be checked frequently to minimize effects of predation, weather, absence of mother from pup, etc.
4. No collection or handling of bats will be allowed at hibernacula. Surveys or other activities at hibernacula will be reviewed on a case-by-case basis.
5. Live bats may not be held overnight without permission of SDGFP.
6. No surveys will be allowed for western big-eared bats (*Corynorhinus townsendii*) at known maternity/nursery roosts. If a researcher suspects that western big-eared bats are using a site as a maternity/nursery roost, surveys must end immediately, and SDGFP must be notified. In general, surveys of maternity/nursery roosts of all bat species are discouraged.
7. Applicants desiring to handle bats must submit proof of pre-exposure vaccinations for rabies.
8. Applicants desiring to band bats must comply with established South Dakota protocol for band type, placement, color, and numbering system.
9. In general, no collection of specimens or body tissue will be allowed of bat species monitored by the SD Natural Heritage Program. A current list of monitored species can be viewed at: http://www.state.sd.us/gfp/Diversity/index.htm. If individuals of monitored species are captured, they will be released immediately at the point of capture. Any unintentional collection of individuals of monitored species will be reported to SDGFP within 72 hours and surrendered to SDGFP.
10. Collection of any bat species must be approved by SDGFP. Collection of more than two specimens of nonmonitored species must be justified within the context of a study or monitoring plan. This plan should include a description of the method of killing and a description of availability of tissue or specimens for examination by other researchers.
11. Bat survey or monitoring activities should not alter or damage natural or artificial sites.
12. Only personal, battery-powered or non-heat-generating light sources will be used within roosts. No open-flame torches, smoke-producing instruments, photography equipment, carbide lamps, or toxicants will be taken into roost sites.
13. Permit holders will notify SDGFP of the location of any maternity roosts discovered during study or monitoring activities.

GUIDELINES:

1. Applicants should be familiar with humane methods of removing other nocturnal animals likely to be captured in bat sampling equipment.
2. Applicants should be familiar with property boundaries in their selected study area and should seek permission from the appropriate public or private landowner.
3. Applicant should notify public or private landowner when survey activities will be conducted.

GLOSSARY OF SELECTED TERMS

adit - horizontal underground mine passage that connects to the outside

calcar (keeled calcar) - a piece of cartilage attached to the heel of the foot that extends along the free-edge of the tail membrane; "keeled calcar" refers to a small portion (flap) of the membrane that extends beyond the edge of the calcar

cave - naturally formed underground cavity

day roost - general term for a roosting location used by bats during the active season (may include maternity and nursery roosts)

drift - horizontal underground mine passage that follows a vein or layer of rock

echolocation - a highly advanced "sonar" system used by bats to orient themselves and locate food

hibernaculum - location used for overwintering; usually characterized by cooler (above freezing) stable temperatures

hibernation - energy conserving behavior used during longer cold weather periods when food is scarce; characterized by lower metabolic rate and body temperature

hypogeal - occurring beneath the surface

insectivorous - feeding on insects (all SD and WY bats are insectivorous)

maternity roost - roost location used by a group of reproductive adult females

mine - man-made underground cavity

night roost - location used between bouts of foraging for resting, ingesting larger prey, and socializing

nulliparous – never given birth

nursery roost - roost location used by adult reproductive adult females and their offspring

parous - having given birth

pelage - fur

portal - access point or opening at a horizontal mine entrance

shaft - vertical opening/passage into a mine

thermoregulation - controlling body temperature to achieve optimal use of stored energy reserves

torpor - a short-term adaptive behavior for conserving energy characterized by lowered body temperature and metabolic rate

tragus - small, erect piece of cartilage attached at the base of and located in front of the ear

Harp trap (a.k.a. Tuttle trap) - portable capture device used primarily at roost access points or within restricted flyways; comprised of a frame of two vertical banks of filament (each strung in harp-like fashion) divided by a narrow space with a collection bag hung below this gap. Bats generally fold their wings to pass through the first bank of strings and become blocked by the second bank whereupon they drop down into the holding bag. The remaining area of the cave/mine opening not covered by the trap is blocked with plastic sheeting. (See Tuttle 1974)

ultrasonic echolocation detector - in its simplest form, an electronic bat survey instrument that receives the echolocation pulses, which are generally above the range of human hearing, that are emitted by bats and lowers them into the range audible to humans.

uropatagium - membrane of skin that extends between the legs (a.k.a. tail membrane)

volant - able to fly