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Conservation Assessment for the Townsend's Big Eared Bat in the Black Hills National Forest South Dakota and Wyoming

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Conservation Assessment

for the

Townsend's Big-Eared Bat

in the

Black Hills National Forest,

South Dakota and Wyoming

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

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INTRODUCTION

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

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

CURRENT MANAGEMENT SITUATION

Management Status

Corynorhinus townsendii ranges across most of the western United States, extending northward into central British Columbia, southward into central Mexico, and eastward along a narrow band that stretches from western Oklahoma and Kansas through Missouri and to Virginia. Populations in the eastern arm of the range are mostly isolated and have decreased dramatically in the last several decades. While western populations tend to be larger and more frequent, they too have shown declines. Closing of mines in many areas for purposes of risk abatement has been suggested to contribute to this species' decline as these bats frequently use abandoned mines as roost sites. The two eastern subspecies, *C. t. virginianus* and *C. t. ingens* are listed as Endangered by the US Fish and Wildlife Service. Townsend's big-eared bat in the western United States is considered a sensitive species by the US Forest Service and as a species of concern by various state agencies such as the South Dakota, Utah, and Wyoming Natural Heritage Programs.

Existing Management Plans, Assessments, Or Conservation Strategies

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Bain, J.R. 1988. Management recommendations for a nursery colony of Townsend's big-eared bat, *Plecotus* townsendii, in the Last Chance Mine, Horseshoe Mesa, Grand Canyon National Park Arizona. Report to National Park Service, Grand Canyon National Park, and Arizona Game and Fish, Phoenix, Arizona.

Hensley, S. and C. Scott. 1993. Ozark big-eared bat, *Plecotus townsendii ingens* (Handley), revised recovery plan. US Fish and Wildlife Service Region 2, Albuquerque, New Mexico.

Perkins, J. and T. Schommer. 1991. Survey protocol and interim species strategy for *Plecotus townsendii* in the Blue Mountains of Oregon and Washington. Unpublished report, Wallawa-Whitman National Forest, Baker, Oregon.

Pierson, E. and G. Fellers. 1996. The distribution, status and management of Townsend's big-eard bat (Corynorhinus townsendii) in California. California Department of Fish and Game, Bird and Mammal Conservation Program Report 96-7, Sacramento, California.

REVIEW OF TECHNICAL KNOWLEDGE

Systematics

Corynorhinus townsendii, a member of the microchiropteran family Vespertilionidae, was first described as *Plecotus townsendii* by Cooper in 1837 (Kunz and Martin 1982). While some early authorities treated *Corynorhinus* as a separate genus (Nowak 1994), the majority of the literature referred to this species as *Plecotus townsendii* through the mid-1990s. In 1992, Tumlinson and Douglas reported a phenetic study based on morphological characters which clearly separated nearctic *Corynorhinus* from palearctic *Plecotus*. Subsequent authors (Qumsiyeh and Bickham 1993; Volleth and Heller 1994), based primarily on chromosomal evidence, debated the results of Tumlinson and Douglas (1992). Bogdanowicz et al. (1998) reanalyzed both morphological and chromosomal data, and concluded that *Corynorhinus* was a valid genus and restricted *Plecotus* to the Palearctic forms. While it took some time for this change to be reflected in the literature, *Corynorhinus* is now accepted as the genus for those New World species formerly assigned to *Plecotus* (i.e. *Plecotus townsendii, P. mexicanus* and *P. rafinesquii* are now in the genus *Corynorhinus*). *C. townsendii* is commonly referred to as Townsend's Big-eared bat. Other vernacular names used for this species are western long-nosed bat, western lump-nosed bat, and western big-eared bat (Barbour and Davis 1969; Jones et al. 1979). The name 'lump-nosed' bat is reflective of two large glandular masses which appear on the dorso-lateral surface of the muzzle between the eye and nostril (Barbour and Davis 1969).

Corynorhinus townsendii is a medium-sized bat with large ears which are greater than one inch in length (Barbour and Davis 1969). External measurements are: total length 90-112mm; length of tail 35-54mm; length of foot 9-13mm; length of ear 30-39mm; and length of forearm 39.2 - 47.6mm (Kunz and Martin 1982). The ventral coloration is brownish or buff, while the tips of the dorsal hairs range from pale cinnamon brown to blackish brown (Kunz and Martin 1982). *Corynorhinus townsendii* is distinguished from the only other species of lump-nosed bat in the

United States (*C. rafinesquii*) by having ventral pelage washed with tan to pale bluff instead of white as in *C. rafinesquii*. Furthermore, the dorsal pelage of *C. townsendii* grades gradually from brown at the tip to slate at the base, whereas *C. rafinesquii* has distinctly bicolored hairs with grey tips. The ranges of these two species are largely disjunct. *C. townsendii* is easily distinguished from *Antrozous pallidus* (another species of big-eared bat) in areas where their ranges overlap in that *Antrozous* lacks the large glandular masses (lumps) on the muzzle. The subspecies occupying the Black Hills region is *C. townsendii pallescens* (Hall 1981). It is distinguished from *C. t. townsendii,* which occupies areas of the Pacific northwest, by a paler pelage (Barbour and Davis 1969).

Distribution And Abundance

Distribution Recognized In Primary Literature

Overall Range

The main portion of the species range for *Corynorhinus townsendii* occupies the western half of the United States, extending northward across the Canadian border into central British Columbia, and southward into western and central Mexico (Nagorsen and Brigham 1995; Kunz and Martin 1982; Hall 1981). In the United States, the range extends from the west coast to a line running NW to SE across Montana and extending into South Dakota to include the Black Hills region. The border of the range then swings westward into eastern Colorado before swinging east a last time to include the panhandle region of Oklahoma and then south through approximately the center of Texas (Kunz and Martin 1982). Isolated, apparently relictual, populations are known from a band of areas extending from northeastern Texas and eastern Oklahoma and Kansas through Missouri to Virginia and West Virginia (Barbour and Davis 1969; Schwartz and Schwartz 1981).

Local Distribution

Townsend's big-eared bat has been recorded from all South Dakota counties of the Black Hills (Jones and Genoways 1967; Turner and Jones 1968; Turner 1974) and reported to be the most numerous bat in Crook Co. Wyoming (USDA Forest Service 1974). This bat is recorded from the Black Hills for both summer and winter (Winter and Hawks 1972; above references). Adams (1997) reported capture of *C. townsendii* at Ft. Laramie National Historic Site in eastern Wyoming.

Additional Information From Federal, State, And Other Records

Corynorhinus townsendii is a US Forest Service Region 2 and Region 4 Sensitive Species. The Wyoming Natural Heritage Database (online 2002) lists *Corynorhinus townsendii* as a species of concern in Wyoming (global/state rank G4/S1B,S2N) as does the Wyoming Game and Fish Department (state rank SSC2). The G4 ranking indicates that rangewide the species is apparently secure although it may be quite rare in some parts of its range, particularly at the periphery (which, for *C. townsendii* would include the populations in western South Dakota). A G4 rank implies a cause for long term concern. The S1B and S2N refer to rankings during Breeding and Non-breeding seasons, respectively. A state rank of S1 describes the species as critically imperiled because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extinction. A state rank of S2 indicates the species is considered imperiled because of rarity (6-20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extinction throughout its range. South Dakota Game Fish and Parks and the South Dakota Natural Heritage Program (SDNHP) rank Townsend's big-eared bat as G4/S2S3 with G4 and S2 as indicated above, and S3 indicating the species is very rare and local throughout its range (occurrences in the range of 21-100), or vulnerable to extinction throughout its range because of other factors (SD NHP Rare Mammals website; SDNHP Report 2002).

Estimates Of Local Abundance

Estimates of local abundance are usually expressed in qualitative terms such as 'common' and 'scarce.' Across the range of *C. townsendii*, the species is considered most abundant along the west coast region and in the southwest and most scarce in the eastern half of the United States. In Oklahoma, estimates of summer populations at known maternity sites, made annually from 1983 to 1995, produced estimates ranging from a low of 215 in 1983 to a high of 852 in 1990 (Clark et al. 1997). In western Oklahoma and Kansas, Humphrey and Kunz (1976) characterized *C. townsendii* as locally abundant in karst regions, but low in density, with estimated summer roost-related abundances of 4.4-7.5 bats per available roost site, 5.8-9.9 bats per inhabited roost, and 44.0-74.5 bats per inhabited nursery. The state rankings given this species by the Natural Heritage Programs of both South Dakota and Wyoming (above) provide some measure of local abundance relative to the Black Hills region. Townsend's big-eared bat was reported by Martin and Hawks (1972) to be the most commonly encountered bat hibernating in caverniculous structures in the Black Hills. Mattson and Bogan (1993) reported that in 1992, there were 1200 *C. townsendii* hibernating in Jewel Cave; comprising the largest known hibernating colony of this species in the western United States. Arita (1993) reported that cave-roosting Mexican populations of this species occurred in low to moderate population sizes (<100 – 10,000 individuals).

Habitat Associations

Townsend's big-eared bat occupies a variety of habitats across its range. In the desert southwest it is associated with desert scrub, pinon-juniper, and pine forest (Barbour and Davis 1969; Jones 1965). Most accounts of this species' habitat focus on the requirement of suitable roosts including caves, mines, and rocky ledges and overhangs (e.g. Nagorsen and Brigham 1995; Turner 1974; Jones et al. 1983). Gellman and Zielinski (1996) and Fellers and Pierson (2002) reported use of basal hollows in old-growth redwoods as roosting sites, as well as strict use of anthropogenic structures for maternity colonies along the California coast. Arita (1993) classified Mexican populations of *C. townsendii* as using primarily caves for roosting, selecting caves which were occupied by only a few bat species (segregationists). Humphrey and Kunz (1976) reported that in Oklahoma and Kansas this species appears to be restricted to riparian communities with gypsum caves nearby. Throughout much of its range, *C. townsendii* is common in mesic habitats with coniferous and deciduous forests (Jones 1965). Holroyd et al. (1994) found Townsend's big-eared bat associated with wet habitats in areas of interior British Columbia that were classified as Bunchgrass (hot and dry, with bunchgrass, sagebrush, and dry ponderosa pine forest) and Interior Douglas-fir biogeoclimatic zones.

Roosting Ecology

Maternity Roosts

One of the most recent and complete studies of roosting affinities of *C. townsendii* is that by Sherwin et al. (2000) in northern Utah. The remainder of this paragraph summarizes the findings of Sherwin et al. (2000). They conducted their surveys during four periods for each year: winter hibernation, spring migratory, summer maternity, and autumn migration; for two years (1996-1998). Although this species has been reported to roost in a variety of settings, from abandoned buildings, bridges, and culverts to caves and abandoned mines, their survey of 105 bridges on Federal and State lands in northern Utah found no bats of this species utilizing those bridges as day roosts. The survey of 676 mines and 39 caves on these same lands found 196 sites which were used as day roosts by *C. townsendii*. Of these, only 13 were maternity roosts. The mean size for maternity colonies was128.9 mature females (range of 15 to 550). The majority of the caves used as maternity roosts for which internal inspection was possible (9/12) had multiple levels and multiple openings. This contrasts with bachelor roosts (see below). In northern Utah, roost use was associated with the following habitat characters: lower elevation (<2000m), sagebrush grassland, juniper woodland, and mountain brush. Caves were more likely to be used as maternity colonies than were mines, and cave-based maternity colonies were stable while mine-based maternity colonies moved among several mines throughout the maternity period.

Humphrey and Kunz (1976), working in the karst regions of western Oklahoma and Kansas, found an average maternity colony size of 26 adult females (range of 17 to 54). The maternity colonies occurred in relatively warm domes or on large, flat ceilings of caves (Humphrey and Kunz 1976). Each maternity population roosted as a tight, rounded cluster and no other species were in or near these clusters (Humphrey and Kunz 1976). In California, 6 maternity colonies of *C. townsendii* were found in buildings, 3 in mines or caves, and one alternated at times between two mines and a cave (Pearson et al. 1952). Pearson et al. (1952) also reported that the bats ordinarily returned to the same sites year after year. Fellers and Pierson (2002) reported on maternity colonies located in old buildings and indicated that all currently known maternity roosts along the California coast occur in anthropogenic structures. Clark et al. (1997) reported on numbers of bats at maternity roosts, but did not study the characteristics of the roosts themselves.

In South Dakota, the location of maternity roosts, particularly in proximity to Jewel Cave in the southern Black Hills (which serves as a major hibernaculum for this species) has been difficult. Extensive surveys by Mattson and Bogan (1993) found no maternity colonies in this area, although maternity colonies of this species were found by J. Tigner in the northern Black Hills, at distances far greater than reported hibernaculum-to-summer roost movements elsewhere (Mattson and Bogan 1993). Cryan et al. (2000) reported location of five maternity colonies in the southern Black Hills and suggested that females move from hibernacula to lower elevations than males to form nursery colonies in response to physiological demands of lactation and neonatal development, and warmer temperatures at lower elevations. Reproductive females were mistnetted over water sources at a mean elevation of 1405m (Cryan et al. 2000).

Hibernacula

Physical Characteristics

Pearson et al. (1952) described conditions in two caves (both lava tubes) and one set of mine tunnels utilized by Townsend's big-eared bats as hibernacula. Temperatures proximal to clusters of hibernating bats varied throughout the study, with the range in the cave with the largest colony being -1.9°C – 7.8°C (28.5°F-46°F) and that in the cave with the smaller hibernating colony being 0°C-10°C (32°F-50°F; Pearson et al. 1952). They also surveyed a number of other lava tubes which were slightly warmer in winter, but found only scattered hibernating bats. This, combined with the fact that there were warmer parts of the two utilized caves available to the bats, but unused, suggests that the bats selected caves, and sites within those caves, which provided cooler temperatures for hibernating. The same trend held true for the set of 3 mine tunnels used by these bats, in that other, warmer tunnels which were nearby were not used by *C. townsendii*. Winter temperature in the three utilized tunnels ranged from 0.6°C-16.7°C (33°F-52°F). The behavior of the mine-hibernating bats differed from that of the cave-hibernators in that the mine-hibernators moved frequently throughout the winter among the three tunnels and they did not form hibernating clusters as did the bats in the caves (Pearson et al. 1952).

Sherwin et al. (2000) reported that in northern Utah, caves not only were more likely to be used as hibernacula than were mines, but that they were more likely to be used as both summer and hibernation roosts. As hibernacula, these caves were occupied by a range of 1-58 individuals, with an average of 7.2 bats; which did not differ from the hibernating occupancy of mines (Sherwin et al. 2000). Kuenzi et al. (1999) conducted one-pass surveys of 70 inactive mines in west central Nevada from December 1994 through February 1995. *Corynorhinus townsendii* was the most common hibernating species, occurring in 16 of the 19 mines that had hibernating bats (Kuenzi et al. 1999). *C. townsendii* was found hibernating at sites with air temperatures of 0.0-17.0°C (32.0-62.6°F) and relative humidity of 21.0-66.0% (Kuenzi et al. 1999). Humphrey and Kunz (1976) also noted that this species appears to require relatively cold temperatures for hibernation.

Behavior In Hibernacula

In the Black Hills of South Dakota, *Corynorhinus townsendii* was the most commonly recorded bat hibernating in caverniculous structures, having been found hibernating in 5 mines and 10 caves, all at elevations between 1140m and 1887m (3800-6290ft) in elevation (Martin and Hawks 1972). Martin and Hawks (1972) observed, as did the above authors, that *C. townsendii* appears to be quite tolerant of irregular temperature fluctuations, and to prefer cooler microclimates within hibernacula relative to other bats hibernating in the same structures. Townsend's big-eared bats found hibernating in the Black Hills occurred singly and in clusters, with cluster size being apparently correlated with the size of the hibernaculum and its population of these bats, and the largest clusters being composed entirely of females (Martin and Hawks 1972).

In contrast, Humphrey and Kunz (1976) reported that larger clusters in western Oklahoma and Kansas tended to have more equal representation of the two sexes. Humphrey and Kunz (1976) also reported that this species will move during the hibernation period, presumably as response to thermoregulatory requirements relative to changing temperatures over the winter. These bats will roost singly, close to entrances of hibernacula during the beginning of hibernation, but may move further into the cave and form clusters during the colder part of the season (Humphrey and

Kunz 1976).

In California, *C. townsendii* began to arrive at the hibernacula late in October; the hibernating colony peaked by January; and the majority of the wintering colony had left each hibernaculum by April (Pearson et al. 1952). Females arrived earlier and stayed later than males; and males were more active during the winter than females (Pearson et al. 1952). Humphrey and Kunz (1976) reported similar activity patterns for hibernating *C. townsendii* in the southern Great Plains. Their report added that bats of both sexes lost over half their body weight before spring. This, combined with susceptibility to predation during hibernation, and late winter foraging efforts prompted Humphrey and Kunz (1976) to propose substantial winter mortality as a major limiting factor.

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

The mean size of bachelor roosts (adult males and nonporous females) in northern Utah was 1.5 individuals per site (Sherwin et al. 2000). All roosts were located within 2 km of water (Sherwin et al. 2000).

In western Oklahoma and Kansas, male *C. townsendii* roosted short distances inside cave entrances and man-made structures (Humphrey and Kunz 1976). Although more than one bat occupied some of the roost sites (range of 1-6 bats; average of 2), the bats roosted singly, and these bachelor roosts never occupied the same site as a *C. townsendii* maternity colony (Humphrey and Kunz 1976).

Fellers and Pierson (2002), working in coastal California, located 7 day roosts of solitary males in basal hollows of redwoods with dbh measures ranging from 115-194cm.

Night Roosts

Adam and Hayes (2000) examined the use of different types of bridges as night roosts by bats in the Oregon Coast Range. Although *C. townsendii* was caught only incidentally during this study, the results are included here in view of the relative dearth of information about night roosts. Of the bridge types examined (concrete cast-in-place with chambers on underside, concrete flat-bottom, I-beam with concrete or steel girders, and wooden), bats primarily used the concrete cast-in-place bridges as night roosts, probably because the chamber walls restricted airflow thereby conserving heat (Adam and Hayes 2000). Bat use of these bridges as night roosts peaked between 0300 and 0430h, with bats generally departing before 0600h, indicating that they were not used as day roosts (Adam and Hayes 2000). Pearson et al. (1952) reported that night roosts used by *C. townsendii* in California were similar in characteristics to day roosts, but may not be used as day roosts.

Interim Roosts

Relatively little research has focused on roosts used by bats between the winter hibernating and summer maternity periods. Dobkin et al. (1995) radiotracked five female and one male *C. townsendii* from their hibernacula in central Oregon and determined that the females did not proceed directly to maternity colonies, but instead roosted at a number of interim sites over a period of up to two months. Neither males nor females appeared to express fidelity to interim roost sites and Dobkin et al. (1995) suggested that interim roost use is dictated by spatial and temporal variation in prey availability.

Wethington et al. (1996) examined prehibernation habitat use by *C. t. ingens* in eastern Oklahoma. Although their study focused on foraging, they did document that adult females traveled no more than 5km from cave roosts to forage during the August to October time period.

Foraging Habits

Seidman and Zabel (2001) examined bat use of intermittent stream habitat in northwestern California. They reported that *C. townsendii* was captured more frequently along large (mean channel width of 7.0 ± 1.2m) and medium (mean channel width of 1.9 ± 0.0m) intermittent streams, than along smaller intermittent streams or in proximal upland habitats (Seidman and Zabel 2001). Fellers and Pierson (2002) light-tagged and radio-tracked *C. townsendii* after the nursery period in coastal California. The remainder of this paragraph summarizes their findings. Females traveled greater distances (mean of 3.2km ± 0.5km) than males (mean of 1.3 ± 0.2km) to forage during this period. Bats foraged primarily along edges of riparian vegetation, and flew close to vegetation when foraging and when transiting an area. Individuals traveled less than 10.5km from the day roost, and returned to the same areas to forage each night. Bats foraged at heights 10-30m off the ground, between mid-canopy and the top of the canopy.

Humphrey and Kunz (1976) studied populations of *C. townsendii* in western Oklahoma and Kansas. Based on a number of assumptions including ones about habitat use and distance traveled from roost to foraging area, Humphrey and Kunz (1976) estimated foraging habitats of 4.7ha per bat in early summer, 3.5ha per bat in midsummer, and 6.6ha per adult female.

In Kentucky, Burford and Lacki (1995) reported that *C. townsendii virginianus* was significantly more active in foraging over old fields than in stands of timber greater than 30 years of age, stands of timber less than 30 years of age, and above and below cliffs. Clark et al. (1993) reported that Townsend's big-eared bats in Oklahoma used from one to four foraging sites, with edge habitats associated with intermittent streams and mountain slopes being preferred foraging areas.

Prey Species

Corynorhinus townsendii is considered a moth (Lepidoptera) specialist (Schwartz and Schwartz 1981), with both macrolepidopterans (Sample and Whitmore 1993) and microlepidopterans (Whitaker et al. 1977) consumed. Whitaker et al. (1977) reported that 15 of 16 stomachs analyzed from this species in western Oregon contained only Lepidoptera. The remaining stomach contained 95% Lepidoptera and 5% Hemiptera (Whitaker et al. 1977). In eastern Oregon (Whitaker et al. 1981) concluded that *C. townsendii* consumed moths exclusively, as did *Lasiurus cinereus*. Burford and Lacki (1998) identified 45 species of moths consumed by *C. townsendii* based on moth forewings collected at feeding roosts. Although six families were represented, the majority of forewings were from Noctuidae, Sphingidae, and Geometridae, in descending order. Sample and Whitmore (1993) reported that while analysis of guano and culled insect parts from three maternity colonies in eastern West Virginia indicated that Coleoptera, Diptera and Hymenoptera were consumed in addition to Lepidoptera, bats selectively consumed Lepidoptera and avoided Coleoptera.

Characteristics Of Prey Species

Burford and Lacki (1998) indicated that over 75% of the moths eaten by *C. townsendii* are dependent on forest plants. Forewings collected ranged from 1.3-4.1cm in length, and Burford and Lacki (1998) suggested that smaller moths may be eaten in-flight and so not appear in their data. Sample and Whitmore (1993) also indicated that while previous studies had reported consumption of prey items ranging from 3-10mm in size, their study of culled forewings collected at maternity caves indicated consumption of much larger prey and suggested that smaller food items are consumed in-flight. Freeman (1981) conducted principal components analysis of 14 cranial measurements of 41 species of vespertilionid bats and then regressed the PC loadings against a prey hardness scale. The first principal components axis related to robustness of the skull, with bats on the negative end having more robust skulls, and bats on the positive end having more "gracile skulls" (Freeman 1981). *Corynorhinus townsendii* fell out on the first principal components axis at a value of about +0.25-0.3 indicating a mildly to moderately gracile skull. Freeman (1981) also ranked the hardness of the prey items for these 41 bat species on a scale of 1 (softest; e.g. Neuroptera and Diptera) to 5 (hardest; Coleoptera), and calculated a weighted average of the food habits for each species. According to this scheme, *C. townsendii* prey items had a weighted average of 2.08, reflecting the preponderance of Lepidoptera in its diet (Freeman 1981).

Reproduction And Development

Life History Characteristics

Townsend's big-eared bats are relatively k-selected, with only one offspring per successful reproductive effort (Kunz and Martin 1982). Pearson et al. (1952) conducted the most in-depth study of reproduction in *C. townsendii* to date, and the remainder of this paragraph summarizes their findings from California, unless otherwise cited. While some male young-of-the-year were capable of producing very low numbers of mature sperm, the low numbers combined with small size of accessory glands prevented them from being able to breed their first fall. Female young-of-the-year, on the other hand, were capable of becoming pregnant during their first year. Copulation began in autumn, with some females apparently mating before reaching the hibernacula, and peaked at the hibernacula in November through February. No copulatory plug was observed in females and males were observed mating with torpid females. Turner (1974) however, did report the presence of vaginal plugs in many females observed in Jewel Cave during the winter of 1967. Sperm were stored in the female reproductive tract until spring when ovulation, fertilization and gestation occurred. Gestation lasted from 56 to 100 days, with young born over a 3-5 week period beginning in late May, and adult females typically delivering before yearling females. Neonates ranged from 2.1-2.7g (average of 2.4g) in weight and had forearm lengths of 16-18mm (average of 16.6mm).

Survival And Reproduction

Pearson et al. (1952) estimated about 50% survivorship of young from year of birth to the next, and about 80% year to year survivorship for adults. Estimates of natality are comparable throughout the species range, varying from 90-100% (Kunz and Martin 1982). Mortality between birth and weaning was 5% in South Dakota (Turner and Jones 1968) and 4% in Oklahoma and Kansas (Humphrey and Kunz 1976). Pearson et al. (1952) suggested that most mortality of young of the year occurred before hibernation.

Local Density Estimates

Humphrey and Kunz (1976) calculated that density of *C. townsendii* for the entire Cimarron tract in western Oklahoma (46.6km^2) ranged from 0.013-0.025 bats per hectare (one bat to 40-76ha). Pearson et al. (1952) reported densities of 0.008bats/ha (one bat per 124ha [310 acres]) in California.

Limiting Factors

Pearson et al. (1952) suggested that, in California, the number of suitable roosting sites surrounded by adequate food supplies limited the population of *C. townsendii*; instead of predation, disease, or size of winter or summer roosting sites. Humphrey and Kunz (1976) postulated that in the southern Great Plains the limiting factor was high winter mortality due to the lack of hibernating sites that provided thermally stable conditions throughout the winter and the resulting energy expenditures associated with movement within the hibernaculum over the winter.

Patterns Of Dispersal

No studies were found which dealt specifically with patterns of dispersal. This bat is recognized for its apparent site fidelity (returning yearly to the same maternity roost) and lack of long-distance migration (Pearson et al. 1952; Humphrey and Kunz 1976; Barbour and Davis 1969).

Metapopulation Structure

No studies were found which dealt with the metapopulation structure of *Corynorhinus townsendii*. However, given its apparent site fidelity (see 5. above), it is predicted that there would be strong metapopulational structure for this species, with limited gene flow among disjunct subpopulations within the species' range.

Community Ecology

Predators

Although Pearson et al. (1952) concluded that the impact of predation on this species is probably minimal, Fellers (2000) reported what appeared to be substantial predation by *Rattus rattus* on a colony of *C. townsendii* located in an old building. As reproductive failure of that colony in 1993 was attributed to the presence of *R. rattus*, Fellers (2000) suggested that old buildings may function as population sinks for bats, undermining their conservation value. Humphrey and Kunz (1976) suggested that a disturbed maternity colony which had subsequently moved to a lower part of a cave where it was vulnerable to raccoons, may have suffered predation but they did not document any such events. Altenbach (1994) reported that ringtails (*Bassariscus astutus*) preyed on *C. townsendii* as they flew through a small opening at the Mariscal Mercury Mine in Big Bend National Park, Texas.

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

The movement patterns that *C. townsendii* expresses during hibernation relative to thermoregulation, its selection of open ceilings for roosting and avoidance of crevices and cracks utilized by most other caverniculous species, and its prevalent use of areas close to caves entrances (i.e. in the "twilight zone"), greatly reduces the likelihood of competition from other bats for roosting sites. While it may be tempting to attribute these characteristics to 'ghosts of competitions past,' Humphrey and Kunz (1976) suggest that these behaviors are the result of preadaptations and conditions across the species' range at the end of the Pleistocene.

Based on skull morphology and dietary scaling based on prey "hardness" (Freeman 1981), C. *townsendii* would be predicted to have the greatest dietary overlap, and thus the greatest potential for food competition, with *Euderma maculatum* (the spotted bat).

Parasites, Disease

Corynorhinus townsendii is the typical host for a winged bat fly, *Trichobius corynorhinus* (Bradshaw and Ross 1961). This bat fly commonly occurs on the membranes (e.g. wings) of the host in the roost and leaves the host before the bat takes flight (Kunz 1976). Levels of infestation by this species appear to be dependent on host density (Kunz 1976). Other ectoparasites include the wingless bat fly *Basilia corynorhini* (Nycteribiidae; Bradshaw and Ross 1961), three species of ticks in the genus *Ornithodoros* (Bradshaw and Ross 1967; Jameson 1959), macronyssid mites (Kunz and Martin 1982; Turner 1974), the sarcoptid mite *Sarcoptes lasionycteris* (Turner 1974), and a chigger *Leptotrombidium myotis* (Turner 1974).

Endoparasites have not been as well documented as ectoparasites, but records of two nematodes, a cestode, and a trypanosome do exist (Kunz and Martin 1982). Constantine (1967) reported that rabies virus was isolated from less than 1% of asymptomatic bats taken in New Mexico.

Other Complex Interactions. Include Interactions With Other Bat Species

A number of species of bats, particularly in the genus *Myotis*, have been found associated with *C. townsendii* in all roost types. *Myotis californicus*, *M. lucifigus, M. subulatus* [now *ciliolabrum*]*, M. thysanodes, M. volans*, and *M. yumanensis* have been found sharing night roosts with *C. townsendii* (Pearson et al. 1952). Day roosts have been shared with *M. lucifugus, M. thysanodes, M. yumanensis*, and *Macrotus californicus* (Pearson et al. 1952). *Eptesicus fuscus* and *Myotis californicus* have been found hibernating in tunnels with *C. townsendii*, and *M. ciliolabrum* has been found within a cluster of hibernating *C. townsendii* (Pearson et al. 1952). Szewczak et al. (1998) also reported *Myotis ciliolabrum* hibernating in close proximity (within 40cm) of *C. townsendii* in mines of the White and Inyo mountains of California and Nevada. Martin and Hawks (1972) noted that in Jewel Cave (Black Hills of South Dakota), where numerous species were found hibernating, *C. townsendii* predominated in the zone within 200 ft of the entrance to cave passages and as the passages descended and *C. townsendii* diminished in numbers, *Myotis ciliolabrum* began appearing. The only species documented to co-occur in a nursery colony with *C. townsendii* is *Macrotus californicus* (Pearson et al. 1952). The tendency of *C. townsendii* to roost on open domes and similar structures of caves as opposed to roosting in tight spots such as cracks like many of the above species utilize, and their unique thermal regime over the course of hibernation, would seem to ameliorate much of the potential for competition for roost sites with the species listed above.

As Pearson et al. (1952) suggested, a limiting factor for *C. townsendii* in many areas may be the number of suitable roosting sites surrounded by suitable foraging areas with an ample food supply. As the studies of Bruford and Lacki (1995, 1998) and others indicate, this bat displays considerable plasticity in the habitats used for foraging. These studies also indicate that, in forested areas, the majority of the moths upon which this moth specialist feeds, have larval stages which are dependent upon forest vegetation.

Roost Site Vulnerability

While roost sites of this bat do not appear to typically be vulnerable to many of the usual hazards such as predation, *Corynorhinus townsendii* is extremely sensitive to anthropogenic roost disturbance, not only in maternity roosts, but also in hibernacula (Pearson et al. 1952; Barbour and Davis 1969; Humphrey and Kunz 1976).

Risk Factors

In the Black Hills, the sensitivity of this species to anthropogenic disturbance of roost sites, combined with mine closings, may present the greatest risk factors for *C. townsendii*.

Response To Habitat Changes

Management Activities

Timber Harvest

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

The Land and Resource Management Plan ROD 3/97 (LRMP-ROD 3/97) did address the need to protect caves for bats (page II-43) with Standard 3102 requiring protection of roosting caves and their microclimates during the design of timber harvest activities. Additional guidance in the LRMP on cave management, contained in Guideline 1401 (Page II-13) stated "Avoid ground disturbance within 100 feet of an opening of a natural cave." This distance was increased to 500 feet in the Phase I Amendment (US Forest Service 2001) to be consistent with Pierson et al. (1999), and is to be treated as a standard.

Recreation

The increased interest in spelunking in the United States has the potential to negatively impact *C. townsendii* populations as these bats are very sensitive to disturbance and their low reproductive output requires considerable time for a population to rebound from a drop in numbers. Members of the National Speleological Society, and comparable local groups such as the Paha Sapa Grotto, are typically very supportive of cave conservation and, as such, are important resources for management agencies. Unfortunately, some individuals who are not members of such conservation-minded organizations, explore and abuse cave habitats. Direct impact on the caves themselves, however, is not the only threat. As previously mentioned, these bats are extremely sensitive to disturbances in the vicinity of their roosts, including loud noises such as those produced by motorized off-road vehicles, discharging of firearms, and other such activities.

Livestock Grazing

No studies were found which addressed the impact of livestock grazing on Townsend's big-eared bat populations. One could predict, however, that this activity would negatively impact this species only if livestock grazing and associated activities were allowed to degrade water sources, or to convert mesic riparian habitats to more xeric upland habitats. Livestock grazing may indirectly benefit bat species through the construction of additional water sources (Chung-MacCoubrey 1996).

Mining

Abandoned mines obviously provide alternative roosting sites for *C. townsendii*. Recent increased efforts to close entrances to mines deemed unsafe, to prevent human injury and lawsuit, may negatively impact populations of this species in some areas. Mining activities themselves, if they occur in the vicinity of roosts, could potentially have a negative impact on those populations because of disturbance to the roosts.

Prescribed Fire

No studies were found which specifically addressed the impact of prescribed burns on Townsend's big-eared bat. In as much as *C. townsendii* has long been an inhabitant of the western region of the United States, across much of which fire was historically an important component, it would seem that prescribed fire that emulates natural fire regimes would not negatively impact this species. Burns need to be planned (temporally and spatially) such that known roosts are not disturbed directly or indirectly (e.g. by heavy smoke). Consideration should be given to the impact of prescribed fire on the prey base for this species.

Fire Suppression

As with prescribed fire, in the absence of studies specifically addressing the impact of fire suppression on this species, examination of the historical (natural) fire regimes of an area probably provide the best indicator for the impact of fire suppression on native wildlife populations. Fire suppression leading to loss of edge habitat and increased density of forest interiors, both of which serves as foraging habitat for *C. townsendii* in many areas, could negatively impact this species. Further, for those systems in which fire was a natural component, suppression of fire could alter the native plant diversity, thereby impacting the prey base for this bat.

Non-Native Plant Establishment And Control

Corynorhinus townsendii is a moth-specialist, the majority of whose diet is composed of moth species dependent on forest plant species for larval development. Diversity of moths taken would suggest the need for a diverse forest flora. Non-native plant establishment tends to reduce native plant diversity and could thus negatively impact the prey base for this bat.

Pesticide Application

Sample and Whitmore (1993) examined the diet *of C. t. virginianus* in order to assess potential impact of gypsy moth infestation and control efforts on the prey base for this species. They concluded that both gypsy moth infestation and the most common control efforts (Dimilin and *Bacillus thuringiensis*, both of which substantially impact non-target lepidopterans) could reduce the prey base for *C. t. virginianus*; the former through reduction of foliage available to larvae of prey species, and the latter through direct reduction in lepidopteran diversity and numbers (Sample and Whitmore 1993). These authors recommended the use of highly selective viral and fungal pathogens for control of gypsy moths (Sample and Whitmore 1993).

Fuelwood Harvest

No studies elucidating the impact of fuelwood harvest on populations of *C. townsendii* were found.

Natural Disturbance

Insect Epidemics

Insect epidemics would have the potential to negatively impact the food source of *C. townsendii* in two direct ways. First, through decimation of plant species upon which the larval stages of this bat's prey species are dependent. Second, as summarized above under Pesticide Application, is through the use of pesticides which are not target-specific for the culprit species, thereby reducing the prey base for *C. townsendii*. In addition to these direct impacts on the prey base*, C. townsendii* may also be at risk of poisoning from the insecticides through bioaccumulation and bioamplification (Clark 1988).

Wildfire

No studies were found which specifically addressed the impact of wildfires on populations of *C. townsendii*. However, as they are specialists on a specific group of insects, the larval forms of which are dependent upon native forest plant species, intense fires at the wrong time of the year and surrounding maternity roosts could impact the reproductive effort of this species by forcing lactating females to fly farther to forage. On the reverse, for those systems in which fire was a natural component, suppression of fire could alter the native plant diversity, thereby impacting the prey base for this bat.

Wind Events

Although no studies have directly addressed the impact of wind events on *C. townsendii*, it is not anticipated that such events would have much impact on this species in areas where caverniculous roosting sites are available.

Flooding

As *C. townsendii* does use a variety of caverniculous structures, flooding could present a hazard to colonies using structures with the potential to be inundated. No documentation as to the frequency of such impact was located.

Other Events

Open pit mining, often occurring in areas of historical hard rock mining, has the potential to destroy underground structures (shafts, adits, etc.) that may be used by *C. townsendii* as roosting sites.

SUMMARY

Corynorhinus townsendii is most abundant in the western portion of its range which includes the central portion of southern British Columbia, the western United States, and south to western and central Mexico. This species becomes reduced in numbers along its eastern periphery, including the Black Hills region and a band extending across Oklahoma and Missouri to Virginia. In the Great Plains region, where winters can be quite severe, the relatively unique hibernating strategy of this species may limit its ability to attain high population numbers (Humphrey and Kunz 1976). This species is primarily dependent upon caverniculous structures for roosts throughout the year, although buildings and similar structures are also used as day and night roosts during the summer. Males and females will share hibernacula during the winter. Females form maternity colonies during the summer, while males are solitary during this time. As such, this species is very sensitive to activities such as recreational caving, mine closings for risk abatement, and open-pit mining activities in regions of old underground mines which destroy roosting structures.

This species forages in a variety of habitats including old fields, along edge habitats, along intermittent streams, and along mountain slopes. It is a moth-specialist, feeding primarily on moth species whose life cycles are dependent upon native forest plants. Whereas a number of hibernacula are documented for this species in the Black Hills region, little is known of its foraging habits or its diet in this region.

REVIEW OF CONSERVATION PRACTICES

Management Practices

While a number of states have implemented management practices for *C. townsendii* in the western United States, hard data on the performance of these practices is not readily available. Certainly, it can be predicted that these practices, designed specifically to facilitate populations of this bat, have not negatively impacted it. However, the efficacy of these practices relative to the population as whole, within the matrix of private land management which may or may not consider the needs of this species, is not known. Typical management practices, exemplified by the Idaho Conservation Effort (Pierson et al. 1999) for this species, include the following components:

-Management of abandoned mines to conserve both current and potential roosting sites.

-Management of caves to:

1) Conserve current, historical, and potential roost sites.

2) Limit visitor use to periods of minimal impact to roosting populations.

3) Restrict human visitation/vandalism by gates, education, law enforcement, road

restrictions, etc.

-Evaluate historical mining sites prior to renewed mining to protect existing bat roosts and associated habitats.

-Pesticide spraying should be prohibited within a 2 mile radius of known roosting sites, and be applied in 0.25 mile strips beyond this buffer zone to a 10-mile radius.

-Use silvicultural strategies to reduce the amount of susceptible hosts, reducing the need for pesticide spraying.

-Maintain or improve riparian and wetland habitats near roosts.

-Stagger burning within a given radius (e.g. 0.5-1.5mi) of roosts, such that no more than half the area is burned per decade. Burning should only occur when the roost is unoccupied.

-Manage timber harvest on a seasonal basis to avoid disturbance to hibernacula and maternity roosts. Maintain a buffer zone of at least 500 feet around roost entrances and construct roads in such a way as to maintain obscurity of such entrances.

-Establish permitting requirements for all investigators working with bats.

-Develop research and monitoring activities which will elucidate gaps in our knowledge of the requirements for *C. townsendii* while minimally impacting this disturbance-sensitive species.

Models

Review of the literature produced no models specific to this species.

Inventory Methods

Inventory methods for bats traditionally included mist-netting over water sources, and more recently, the use of ultrasonic bat detectors. Mist-netting is limited in its effectiveness for most species by appropriate weather conditions and relative availability of water. Wind and rain make nets more visible to bats and reduce the ability to capture bats in the nets. In areas where numerous water sources are available, numbers of bats caught at any one water source can drop. For *C. townsendii*, mist-netting is even more limited by this bat's superior ability to detect and avoid mist nets (Jones et al. 1983).

Acoustic inventory of bats provides advantages over mist-netting in that echolocating bats can be detected regardless of wind or rain. However, identification of echolocating bats to species requires the development of echolocation libraries for signal comparison, and the development of expertise on the part of the researcher in distinguishing among the echolocation sequences of the species in a given area. Incomplete call sequences can lead to erroneous species identification.

For *C. townsendii*, as a caverniculous rooster, direct examination of mines and caves is an important inventory method. Advances in molecular genetics are currently being implemented to facilitate determination of presence/absence based on assignment of fecal pellets from bridges and comparable roosts to species (Ormsbee et al. 2002).

Monitoring Methods

Evening exit counts of maternity roosts during the 2-3 weeks prior to parturition provide the most reliable estimates of the number of adult females in a nursery colony (Pierson et al. 1999). Entering into maternity roosts should be avoided if at all possible, and involve no more than two people when absolutely necessary (Pierson et al. 1999).

Hibernacula monitoring should be minimized, occurring not more than once every two years, being conducted as quickly and quietly as possible, and involving the minimum number of people possible, to reduce the impact of these surveys (Pierson et al. 1999).

ADDITIONAL INFORMATION NEEDS

Distribution

Hibernacula utilized by *C. townsendii* have been documented in the Black Hills, with Jewel Cave serving as hibernaculum for the greatest number of this species (Martin and Hawk 1972; Mattson and Bogan 1993). Although the limited movement of *C. townsendii* from hibernacula to summer/maternity roosts across its range would suggest that *C. townsendii* hibernating in Jewel cave would remain in the southern Black Hills for the summer, extensive surveys by Mattson and Bogan (1993) found no maternity colonies in this area. Maternity colonies of this species were found by J. Tigner in the northern Black Hills, at distances far greater than reported hibernaculum-to-summer roost movements elsewhere (Mattson and Bogan 1993). It is not known, however, whether or not the females comprising these maternity roosts hibernated in Jewel Cave, or elsewhere in the Black Hills. Cryan et al. (2000) reported location of five maternity colonies at lower elevations in the southern Black Hills. Determining seasonal distribution of resident populations of this species is an area in need of research.

Species Response To Stand Level Changes

As *C. townsendii* roosts in caverniculous structures, any response to stand level changes would probably be based on changes to foraging habitat, prey availability, and/or changes to microclimatic conditions of the roosts. Research on the impacts of stand level changes on each of these components is needed.

Roosting Habitat Adaptability

The Black Hills is replete with potential roost sites for Townsend's big-eared bats, ranging from caves and abandoned mines to various types of buildings. As mentioned above, a number of hibernacula and their characteristics have been documented, and the work by Fellers and Pierson (2002) suggests that *C. townsendii* does exhibit a fair amount of plasticity in roost utilization. Identification and monitoring of roosts currently and potentially used by *C. townsendii* is an ongoing research need.

Movement Patterns

Determining the *movement* of individuals from the various hibernacula to summer grounds, including interim and maternity roosts, is needed to understand the distribution and habitat requirements of this species in the Black Hills. With radio transmitters weighing <1g now available, this information may best be acquired through extensive radiotracking efforts.

Foraging Behavior

Relatively little is known about the foraging habitat and behavior of Townsend's big-eared bats in the Black Hills. As habitat used for foraging has shown variation across the range of this species, its determination in the Black Hills is important for developing conservation strategies for this species in the Black Hills. Bat foraging studies available in the literature often fail to collect and analyze data about insect diversity and availability in conjunction with the bat diet studies. This information is needed to elucidate not only dietary preference, but also many other aspects of foraging ecology such as seasonal variation, differences between reproductive classes of individuals, and the potential for competition within and among bat species, and with other insectivores such as crepuscular birds.

Demography

Growth rates of young have been documented. However, elucidation of the age structure of populations of *C. townsendii* remains to be achieved. Given the sensitivity of this species to disturbance, this may be an area which cannot currently be addressed without the risk of negatively impacting the populations.

Table 1. Priorities and cost categories of research needs.

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

*Low: would refine or improve management strategies; Intermediate: is required to develop comprehensive management strategies; High: is required to develop minimal science-based management strategies.

**Low: estimated cost $5,000-$25,000; Moderate: estimated cost $25,000-$100,000; High: estimated cost >$100,000.

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