# SPECIES ASSESSMENT FOR WESTERN LONG-EARED MYOTIS (*MYOTIS EVOTIS*) IN WYOMING

prepared by

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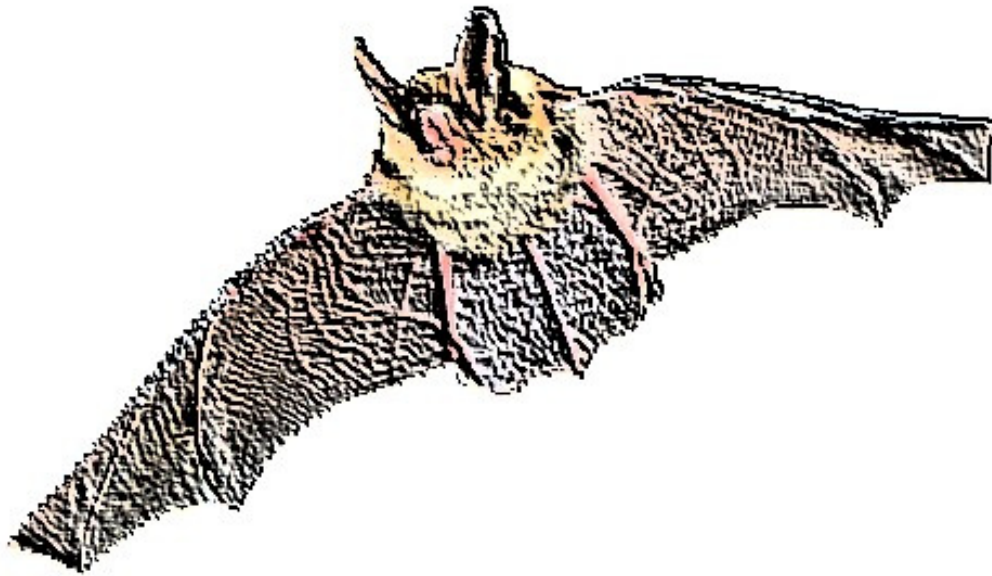
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Summary

Myotis evotis (long-eared myotis), a former Category 2 Candidate, is currently recognized by several federal and state agencies as a sensitive species, in part because very little information exists to provide evaluations on population status and viability locally or rangewide.

Primary threats to *M. evotis* are roost disturbance (especially that leading to loss or destruction of roosting structures), habitat alteration, and toxic chemicals. Roost disturbance (especially of maternity roosts and hibernacula) can take the form of direct human contact or alternation of the roost environment. Habitat alteration refers to modification of any component of the required habitat mosaic, (e.g., presence and quality of open water, roost structures, and coniferous forest stands) that might directly decrease suitability for bats or indirectly affect bats by altering prey availability or modifying how those components relate to each other spatially. Chemicals refer primarily to pesticides and toxic impoundments from resource extraction, which can cause direct bat mortality and reduce populations of insect prey.

It is important to determine presence and abundance of *M. evotis* within Wyoming, and then determine habitat associations in order to apply proper conservation management for this species. Continual and consistent monitoring of known populations will help define local populations and establish habitat-use. Once these specific habitat features are determined, management directions should insure that key life history stages are not disturbed, the habitat mosaic is preserved for persistence of these populations, and exposure to potentially detrimental chemicals is eliminated. More specific issues of conservation concern are discussed in greater detail later in this assessment. Fulfilling the information needs listed at the end of this document will clarify population status and contribute to refining these conservation goals.

Introduction

This assessment addresses the biology, ecology, and conservation status of long-eared myotis throughout its current range, with particular attention given to that portion occurring within and near Wyoming. Our goal is to provide a summary of published information and expert interpretation of this information that can be used by the Bureau of Land Management (BLM) to develop management plans. *M. evotis* was selected for assessment because it occurs on the Wyoming BLM sensitive species list due to the lack of biological and ecological information known about the species as a whole.

Relatively little is known about most *M. evotis* populations and very few records of this species are available for Wyoming. Therefore, this assessment attempts to summarize information documented throughout its North American range, and provide an objective and informed overview in order to relate this information to *M. evotis* in Wyoming. Primary literature was the main source used, supplemented by various agency reports.

As with all pieces of literature synthesized from disparate data, this assessment has some limitations. Since most data presented comes from specific studies with restricted research areas, interpolation and extrapolation of this data must be done with caution. It seems that aspects of *M. evotis* biology, ecology, and conservation vary over the geographic extent of its range. Therefore, the information in this assessment should not be taken as definitive of *M. evotis* in any particular area. Rather, it should be used as a guide to the range of biological parameters and behaviors possible for *M. evotis*, which can then help direct specific investigation to clarify the status of local populations in Wyoming as a prelude to major management action.

Natural History

Morphological Description

Indicative of its name, M. *evotis* (long-eared myotis or western long-eared myotis; figure 3) has the longest ears of any North American *Myotis* species, which measure greater than 21 mm (Adams 2003). The ears have a long, slender tragus, and when the ears are laid forward they extend at least 5 mm beyond the end of the nose (Manning and Jones 1989; Whitaker 1996). The ears and membranes are black, creating a striking contrast against the long and glossy, dull or palish brown to straw-colored pelage (Manning and Jones 1989; Whitaker 1996; Adams 2003). Darkish brown shoulder spots visible against the duller pelage can be used to distinguish it from other similar *Myotis* species (Van Zyll De Jong 1979). Individual hairs are dark basally (Manning 1993; Adams 2003). Before juveniles obtain adult pelage in mid-to-late summer, they have a shorter, more "woolly" pelage with individual hairs more uniformly gray, resulting in less contrast between the base and tip (Manning 1993). Dorsal overhair has been used to distinguish *M. evotis* from other Chiropteran species (figure 4; Amman et al. 2002). The posterior border of the uropatagium lacks conspicuous fringe and encloses the majority of the tail with no more than a few millimeters free (Manning and Jones 1989; Manning 1993; uwadmnweb.uwyo.edu/wyndd). The calcar has little to no keel (Manning 1993). *Myotis evotis* is one of the largest of the American long-eared myotis group, both externally and cranially (Manning and Jones 1989). Recorded morphometric measurements are given in Table 1. Sexes can be determined by examining external features. There is slight sexual dimorphism, with females having longer forearms both in measurement and in proportion to body size than males (Williams and Findley 1979). Males possess a broad, hourglass-shaped baculum that is 1.5mm long with a forked, laterally upturned, and flattened distal tip (Manning and Jones 1989). In addition, there is

evidence of geographic variation, with specimens having larger skulls in southwestern Canada than in the States (Van Zyll De Jong and Nagorsen 1994).

Other adaptive morphology that assists foraging in habitats with dense vegetation, although not diagnostic, is the shape and size of its wings. *Myotis evotis* have short, wide wings, creating a low aspect ratio (wing span^2/wing area) allowing slower, more maneuverable flight. In addition, a low wing loading (body mass/wing surface area) increases the capacity for slow flight (Feldhamer et al. 2004).

Myotis evotis can be difficult to differentiate from *M. thysanodes* (fringed myotis), *M. keenii* (Keen's myotis), *M. septentrionalis* (northern long-eared myotis), and *M. auriculus* (southwestern myotis) where they co-occur (Manning and Jones 1989; Manning 1993; Van Zyll De Jong and Nagorsen 1994; Arizona Game and Fish 2003). The most distinguishable characteristic when identifying *M. evotis* from *M. thysanodes* is the conspicuous fringe that *M. thysanodes* possesses on the posterior edge of the uropatagium (Manning and Jones 1989; Manning 1993). Longer tooth rows and darker ears help distinguish *M. evotis* from *M. auriculus, M. keenii,* and *M. septentrionalis* (Barbour and Davis 1969; Van Zyll De Jong and Nagorsen 1994). Subspecies of *M. evotis* are more difficult to distinguish where they co-occur. *Myotis e. pacificus* is relatively smaller and darker than the other subspecies, and therefore lack the noticeable contrast between pelage and membranes, and makes it much more similar to *M. keenii*. However, work done by Van Zyll De Jong and Nagorsen (1994) determined that the apparent distribution of *M. e. pacficus* and *M. keenii* are different, with *M. keenii* predominately restricted to a narrow coastal strip. Otherwise, differences between the three paler subspecies, *M. e. evotis*, *M. e. chrysonotus*, and *M. e. jonesorum*, can be identified through cranial and external measurements (see Manning 1993).

Voice

Bats can often be identified by examining spectrographs of their echolocation calls recorded with sonar devices. *Myotis evotis* has one of the lowest, least intense frequency calls of the *Myotis* species (Barclay 1991; Adams 2003). Vocalizations are highly broken and staccato throughout, beginning around 80-97 kHz and sweeping smoothly down to 40-54 kHz (figure 5; Barclay 1991; Adams 2003). This pattern seems to hold those M. evotis recorded in Wyoming (Doug Keinath, unpublished data). Each search call lasts a maximum of three milliseconds. This echolocation is adaptive for gleaning insects and moving through cluttered habitat (Adams 2003).

Taxonomy and Distribution

Taxonomy

Myotis evotis is a member of the largest family in the order Chiroptera, Vespertilionidae - the evening bats (Feldhamer et al. 2004). Within this family, it belongs to a long-eared group of American myotis (*M. auriculus, M. keenii, M. milleri, M. septentironalis, and M. thysanodes*; Manning and Jones 1989). This grouping of bats is based on morphologic, chromosomal, and electrophoretic data, which separates them from other North American verspertilionids (Bickham 1979; Manning 1993).

Four subspecies of *M. evotis* are recognized in western North America based on morphology: *M. e. evotis*, *M. e. pacificus*, *M. e. chrysonotus*, and *M. e. jonesorum* (figure 2; Manning 1993). Two additional subspecies have been suggested, but are not commonly recognized as valid. Based on morphological characteristics Manning (1993) suggested the *M. e. micronyx* subspecies, but this has only been documented from a single specimen in Baja California. It has also been suggested that *M. milleri*, a bat usually thought of as a closely-related, but separate species, is a subspecies of *M. evotis* (*M. e. milleri*) based on morphological and kayrotypic data (Manning

1993). Little effort has been spent to verify the validity of *M. e. micronyx* or *M. e. milleri*, and we do not expect this to occur in the near future.

Distribution and Abundance

Range

Myotis evotis occurs across most of western North America, extending as far north as central British Columbia, southern Alberta, and the southwestern corner of Saskatchewan in Canada (Fig. 2). It also inhabits States south of Canada along the Pacific Coast to Baja California (Washington, Oregon, and California), as well as suitable habitat in Montana, Idaho, western portions of the Dakotas, Utah, Wyoming, Nevada, Colorado, New Mexico, and Arizona. *Myotis evotis* has been documented at altitudes that include mountain ranges of 2,830m in Wyoming to near sea level on the Pacific coast (Manning and Jones 1989).

One subspecies, *M. e. chrysonotus,* has been documented in Wyoming (Fig. 2). It also occurs throughout the northern and interior parts of western U.S., including parts of southeastern Oregon, inland areas of northern and central California (Sierra Nevada), southern Idaho, Nevada, Utah, central and eastern Montana, extreme North and South Dakota, Colorado, north central New Mexico, and in adjacent Canadian provinces of Alberta, British Columbia, and Saskatchewan. Other subspecies do not occur in Wyoming: *M. e. evotis* is found from the San Francisco Bay area southward through the coastal range of southern California to San Diego County; *M. e. pacificus* occurs in southern and western British Columbia, Washington, western and northern Oregon, coastal areas of northwestern California, northern Idaho, and northwestern Montana; and, *M. e. jonesorum* occurs in the Kaibab Plateau of northern Arizona and Mogollon Rim (Colorado Plateau) of northeastern Arizona and western New Mexico (figures 1 and 2; Manning 1993).

Clark and Stromberg (1987) report that *M. evotis* occur in suitable habitat throughout Wyoming; however, the majority of the records are from the western half of the state, from lower elevations consisting of ponderosa pine forests, to higher elevations with spruce-fir forests (Fig. 6).

Abundance

Myotis evotis has a relatively broad geographical distribution throughout the temperate west of North America and can be fairly common if suitable roosting and foraging habitat is present (Pierson 1998). Throughout its range *M. evotis* seems to be well represented, comprising about 13.9% (range: 0.4% - 53.0%) identified bats in published survey efforts (Table 2). The high end of this range was an outlier that occurred in Alberta, Canada (Barclay 1991). Without this outlier, the mean frequency of occurrence decreases to about 9.0 % (range: 0.4% - 16.1%), with the highest densities in Arizona, northern California, and British Columbia (Rabe 1995; Vonhof and Barclay 1996; Rabe et al. 1998; Grindal et al. 1999; Seidman and Zabel 2001). Other studies have reported fairly common captures of this species, based on ranks. In Alberta, *M. evotis* was the second most abundant bat species making up 30% of captures along the river (Holloway and Barclay 2000). Various studies in Utah have reported it as the 4th most common bat captured (see Oliver 2000), and Humes et al. (1999) reported that *M. evotis* was one of four species that were recorded frequently enough in the Oregon Coast Range to warrant statistical analysis. Very little is known about the abundance of *M. evotis* in Wyoming. In 1954, Findley (1954) found *M. evotis* to be the third most identified *Myotis* species in Teton County, Wyoming, and in 2003, Keinath (2004a) listed this species as the fourth most frequently captured in the Greater Yellowstone Area.

Population Trend

Assessments of population trends are critical in determining a species' status; however, with species that do not aggregate at readily accessible traditional roost sites, (e.g., *M. evotis*),

population trends are more difficult to evaluate (Pierson 1998). No monitoring efforts have

targeted *M. evotis* in Wyoming or throughout its range; therefore, no information exists on

population trends of *M. evotis* or its subspecies. USFWS (1994) listed the population trend for

this species as unknown. State-level reports are inconsistent. For example, Arizona lists *M. evotis*

populations as stable (Hinman and Snow 2003), South Dakota as critical (SDBWG 2004), and

Nevada as "not well understood" (Altenbach et al. 2002).

Habitat Requirements

General

Habitat types

Myotis evotis are found in a wide variety of habitats, from grasslands and conifer forests, to

humid coastal and montane forests (Manning and Jones 1989). Habitat type of *M. evotis* has been

established through capture, echolocation, radio-telemetry studies, and observations conducted in

the evening (foraging sites) when bats are most active, as well as during the day when they are

resting (roost sites). It has been suggested that bats choose roosting and foraging sites that are in

close proximity to each other in order to minimize energy costs (Tuttle 1976; Waldien and Hayes

2001). Therefore both areas should be considered for habitat requirements. Most studies have

associated *M. evotis* with coniferous montane forests and wooded riparian areas. Some specific

studies have indicated the following:

- Clark and Stromberg (1987) report that in Wyoming, *M. evotis* are common in ponderosa
  pine (*Pinus ponderosa*) and occasionally have been captured in spruce-fir (*Picea - Abies*)
  forests at higher elevations. *M. evotis* were also captured in drier habitats along sand dunes
  and bluffs, containing various forbs and shrubs (e.g., sage, rushes, greasewood, and
  juniper).

- In British Columbia, Fenton et al. (1980) captured or located *M. evotis* at various sites
  (abandoned mine, fast flowing creek, and over a pond) within ponderosa pine forests. Also

in British Columbia, *M. evotis* were captured in heavy vegetation within 500m of water (Brigham 1993).

- Female *M. evotis* were captured in mist-nets in the badlands of the South Saskatchewan River valley, Alberta, Canada, which is bordered by steep sandstone cliffs where they are known to roost (Chruszcz and Barclay 2003). Holloway and Barclay (2000) detected that these individuals in the South Saskatchewan River valley forage in and around clusters of cottonwoods (*Populus deltoids*) located at the edge of the river. This habitat use was also noted in Oregon by Waldien and Hayes (2001) who observed female *M. evotis* via radio-telemetry frequently using terrestrial habitats or riparian areas immediately adjacent to water on the western slope of the Cascade Mountains.

- Vonhof and Barclay (1997) reported that *M. evotis* roosted in the bark of ponderosa pine and lodgepole pine (*Pinus contorta*) clear-cut stumps more often than their availability in the Redfish Creek watershed and West Arm Demonstration Forest located in British Columbia. Swystun et al. (2001) detected high number of bats (including *M. evotis*) using edges of remnant patches in lodgepole-dominated clear-cuts in British Columbia.

- In Alberta, Canada, Barclay (1991) captured *M. evotis* most often over land as opposed to over water, primarily along paths and roads predominated by lodgepole pine. If *M. evotis* was captured over water (5 of 221 captures), it was within 2m of the shore.

- In the Washington Cascade Mountains and Oregon Coast Range, *M. evotis* were detected foraging in old-growth stands of Douglas-fir – western hemlock (*Pseudotsuga menziesii – Tsuga heterophylla*) using ultrasonic detectors (Thomas 1988). Humes et al. (1999) also detected *M. evotis* in western hemlock old-growth stands of the Oregon Coast Range, as well as managed stands (thinned and unthinned) dominated by Douglas-fir.

- Kuenzi et al. (1999) reported mist-netting *M. evotis* in pinyon-juniper woodlands and in riparian stream corridors of central Nevada.

- Near Flagstaff, Arizona, *M. evotis* were captured more often over water in ponderosa pine dominated forests than ponderosa pine – Gamble oak forests (Rabe 1995; Rabe et al. 1998).

Elevation

 Myotis evotis has been documented at elevations up to 2,830m in the mountain ranges of

Wyoming to near sea level on the Pacific coast (Manning and Jones 1989). In Colorado, *M. evotis*

has been recorded from about 1,829m in the foothills west of Boulder to about 2,591m in the

Rockies (Armstrong et al. 1994; Adams 2003). In Utah, this species ranges from 1,430m –

2,895m (Mollhagen and Bogan 1997). In Idaho, it has been reported that *M. evotis* occurs on the

summit of Smith Mountain (2,286m; Davis 1939). In Arizona, *M. evotis* was captured in

elevations ranging from 2,015m – 2,621m (Rabe 1995; Rabe et al. 1998). In Oregon, Waldien and

Hayes (2001) captured female *M. evotis* from 350m – 700m. In Canada, *M. evotis* seem to be

located at lower elevations than the rest of their range, perhaps reflecting the cooler temperatures,

thus less insect activity at higher latitudes.

 Research conducted in Canada has reported different ranges for reproductive females and

males. For example, in British Columbia, reproductive females were recorded at 780m and males

at 1,250m (Vonhof and Barclay 1997). This trend in British Columbia was also observed in

research conducted by Grindal et al. (1999): pregnant females were captured at lower elevations

(540-1,000m) than males (1,000-1,400m). Chuszcz and Barclay (2002) captured female *M. evotis*

at about 700m in Alberta, Canada, within the range recorded in British Columbia. This difference

observed is likely related to the energetic advantages gained by raising young in relatively warmer

and insect-rich lowland environments (Cryan et al. 2000).

Water Resources

 All mammals lose water during obligate physiological functions, such as fat metabolism and

breathing. However, bats are even more susceptible to water loss because of their small body size

and large wing membranes which act as effective evaporative surfaces (Adams 2003; Feldhamer

et al. 2004). Physiological adaptations (e.g., thermoregulation), roost site/hibernacula selection

(e.g., high humidity and warm/cool ambient temperatures), and foraging behavior help minimize water loss. In addition, research has shown that bats living in arid environments have kidneys with more prominent medullae, creating greater urine concentration, and therefore less water loss (Geluso 1980; Adams 2003; Feldhamer et al. 2004). Bats can replenish their water supply by visiting water holes, gaining water from their food, and producing metabolic water (a cellular byproduct of metabolizing fat and carbohydrates; Adams 2003; Feldhamer et al. 2004).

It is often assumed that bodies of open water and riparian areas serve as foraging and drinking sites for bats (Grindal et al. 1999; Seidman and Zabel 2001), and thus would be located close to day-time roost sites in order to conserve energy (e.g., Tuttle 1976). In the case of *M. evotis*, most research suggests that *M. evotis* at least forage in the vicinity of water. Waldien and Hayes (2001) determined that riparian areas and water sites constitute important activity sites for female *M. evotis* and probably relate to foraging efficiency and access to water for drinking. In northwestern California, *M. evotis* was one of the most common species detected over streams in riparian areas (Seidman and Zabel 2001). It was noted by Adams (2003) that small bats outside of Boulder, Colorado, including *M. evotis*, visited watering holes shortly (within an hour) after emergence. Most captures documented within Wyoming have been located over water (Clark and Stromberg 1987). However, it must be noted that captures over water might only reflect *M. evotis* coming to drink as opposed to using these sites to roost or forage (Brigham 1993). As for selection of roost sites in proximity to water sources, Waldien et al. (2000) determined that roosts were most likely not selected for their proximity to water sources.

Roosts

Little is known about the roosting ecology of *M. evotis,* but it appears that the variety of roosts used by *M. evotis* is greater than that of several other species (see Waldien et al. 2000). Most reports provide details about roost characteristics specific to that study, or address a collection of

Myotis species, rather than *M. evotis*, specifically (Schmidt 2003). Such studies show that roost

sites play a prominent role in the success of most bats, providing sites for mating, hibernation, and

rearing young, as well as protection from adverse weather and predators (Kunz 1982). Therefore,

maternity roosts, diurnal roosts, nocturnal roosts, and winter hibernacula must all be considered.

Bats roost in a variety of structures, including caves, manmade structures, rock crevices, cracks in

the ground, mines, loose bark, tree cavities, and tree stumps in clear cuts (Kunz 1982; Manning

and Jones 1989; Vonhof and Barclay 1996). Microclimate of a roost is important in roost site

selection (see Chruszcz and Barclay 2002). Roost sites with high humidity are often selected

(Barbour and Davis 1969), probably to mitigate or reduce water evaporation while at rest.

In general, selection of summer, day-time roost sites is important, since temperate bats will

spend over half of each day in a roost site (Vonhof and Barclay 1996). For most bats, males and

nonreproductive females are often solitary and select different sites than reproductive females,

which are more commonly in groups. For example, they may select cooler sites in order to enter

torpor easily and minimize energy expenditure (e.g., Hamilton and Barclay 1994), whereas

reproductive females select roost sites with increased temperatures, allowing thermoregulatory

costs to be reduced, and the rate of fetal development to increase (Vonhof and Barclay 1997;

Chruszcz and Barclay 2002). However, this separation of roost site selection may not be concrete,

since Waldien et al. (2000) determined that reproductive and nonreproductive female *M. evotis*

used the same day-time roost sites. The following roost sites used by *M. evotis* have been

documented: loose bark in tall, open-canopied snags (Vonhof and Barclay 1996); pine stumps in

south-facing clear-cuts with minimal vegetation overgrowth in younger forests, and conifer snags

in older forests (Vonhof and Barclay 1997; Rabe et al. 1998); rock crevices (Chruszcz and Barclay

2002); caves (Barbour and Davis 1969); abandoned mines (Hendricks 1998; Altenbach et al.

2002; Hinman and Snow 2003; Ellison et al. 2004); and bridges (Keely 1998). Selection of

stumps and snags appeared to have the following characteristics: 1) moderate stages of decay, and therefore more potential for roost sites due to the sloughing of bark, 2) larger in diameter, providing thicker bark for more insulation (e.g., ponderosa pine), 3) taller than surrounding trees and/or vegetation (e.g., roost selection increased with the height of the stump), and 4) in open canopies providing easier access and more direct sunlight (Knight 1994; Vonhof and Barclay 1996, 1997; Rabe et al. 1998; Waldien et al. 2000). Suitable bridge roosts were characterized by a concrete bridge containing a 3/4 to 1-inch wide crevices at least 6 to 12-inches deep, located 10 feet or greater above the ground, sealed from rain water at the top, and receiving full sun for the majority of the day (Keely 1998).

In addition to the studies outlined above, some research has reported specific day-roost selection for reproductive female *M. evotis.* For example, Chruszcz and Barclay (2002) observed female *M. evotis* in two reproductive stages, gestation and lactation, using crevices in sandstone boulders as roost sites in the South Saskatchewan River Valley in Alberta. They noted that pregnant females used crevices that were closer and parallel to the ground. These roost sites were cooler at night, but warmed quickly during the day, assisting rewarming from torpor. On the other hand, lactating females used crevices that had vertical crevices which stayed warm at night. This roost selection minimized thermoregulatory costs to the young when the adult was foraging at night. Nursery roost sites have been documented in buildings (Barbour and Davis 1969; Manning and Jones 1989; Tigner and Stukel 2003). It has been speculated that these structures may allow more female adults and pups to roost together to increase body heat and decrease energy costs of thermoregulation. Also, reproductive females may select roost sites in lower elevations more than males and nonreproductive females, in order to utilize warmer ambient temperatures of roost sites (e.g., to facilitate fetus and pup development), as well as be closer to more abundant prey (as a result of increased temperatures) to decrease energy expenditure (Cryan et al. 2000).

Night roosts serve as resting, eating, digesting, and communicating sites (Fenton 1985). Little data is available on structures that are used as night roosts by *M. evotis*. This lack of information could possibly be a result of *M. evotis* only spending a small portion of the night roosting (Chruszcz and Barclay 2003).   Barbour and Davis (1969) and Manning and Jones (1989) suggest that *M. evotis* use caves and mines as night roosts. Adam and Hayes (2000) captured 10 *M. evotis* using cast-in-place concrete bridges during the night. They suggested these bridges retained heat longer than other bridges, especially in the end chambers near the ground, allowing the bats to maintain higher body temperatures with less energy expenditure. Most likely various structures in the vicinity of the foraging areas are used as resting spots for *M. evotis*, since commutes back to day-roosts could be costly, and they are only there for a small portion of the night (Kunz 1982; Chruszcz and Barclay 2003).

Hibernacula

A major force behind hibernation and/or migration in bats is the loss of a food supply. Most temperate bats are known to hibernate, and in the case of *M. evotis,* hibernation is speculated since an enormous amount of energy would be required to migrate to climates that would provide an adequate food source. Navo et al. (2002) reported swarming activity of *M. evotis* at a cave in Colorado (the first documentation of this behavior for this species), which suggested that they hibernated in that cave or one nearby. Another report found two *M. evotis* hibernating in a mine in Montana (Foresman 2001 in Schmidt 2003). Overall, little information is known about the winter activities or range of *M. evotis.* Hibernacula that have been documented for other bat species are usually in caves or mines (as is suspected with *M. evotis*) with temperatures that do not fluctuate or drop below 0°C, to prevent freezing (Tuttle and Taylor 1998).

<u>Roost fidelity</u>

Several researchers have reported frequent roost-switching for both male and female *M. evotis* (Vonhof and Barclay 1996, 1997; Chruszcz and Barclay 2002, 2003), suggesting that summer day-time roost fidelity is low. For example, Vonhof and Barclay (1996) documented a mean of 2 ± 1.4 days of residency at a particular roost site for *M. evotis* in British Columbia. On the other hand, fidelity for winter hibernacula sites is probably high. Navo et al. (2002) recaptured "swarming" male *M. evotis* at the same site in Colorado over a period of 16 years.

Seasonal and Life History Shifts

No data is available on the winter range of *M. evotis,* and only a couple of reports have documented potential hibernacula sites for this species (see Hibernacula). Therefore, it can be speculated that in temperate portions of its range, *M. evotis* migrate short distances to winter hibernacula that are lower in elevation and/or more southern than summer roosts (Pierson 1998). In southern desert areas, *M. evotis* might actually move to higher elevations in search of cooler temperatures to facilitate hibernation.

Area Requirements

Very little data is available on the home range requirements for insectivorous bats, including *M. evotis*. Nightly activity areas for individual *M. evotis* were reported as approximately 38.3ha (SE = 7.3ha; n = 11 nights) based on radio-telemetry in late summer (Waldien and Hayes 2001), and Pierson (1998) has reported a 0.6km, one-way travel distance from roost to foraging area. Caution must be used when making management decisions based on these reported numbers however, since home range can vary due to a variety of environmental factors, such as proximity of day-roosts to water sources and prey distribution and abundance. For example, Waldien and Hayes (2001) reported centers of *M. evotis* activity averaging <100m from available water sources, yet over 500m from day-roost sites, and de Jong (1994) showed that *Eptesicus nilssoni*

"home range" increased substantially (from ~ 12 ha to over 700 ha) as insect abundance decreased over the course of a summer.

Landscape Context

Like other bats, ideal areas for *M. evotis* will contain a mosaic of foraging habitat, water sources, and roost structures that are proximate to each other (Pierson 1998). However, based on the small reported nightly activity areas for *M. evotis* (see above), it may have more restrictive landscape requirements than other bats; i.e., *M. evotis* may require the major habitat components to be in very close proximity. The reasons why *M. evotis* may be more sensitive to landscape variation are unclear, since although the biological importance of the spatial relationship of foraging, night-roosting, and day-roosting sites is generally recognized, the optimal configuration for particular species is poorly understood. For bats in general, roost sites are near, but geographically separate from foraging sites (Waldien and Hayes 2001), because these two areas are selected for different qualities. Roost sites are chosen for thermal regime, accessibility, and predator avoidance, whereas foraging areas are chosen for insect abundance, vegetative structure, and access to drinking water. The extent to which roosting and foraging areas are geographically proximate contributes to the quality of those sites for supporting viable bat populations, because the delicate energy balance of bats is impacted most significantly by time spent in flight, which is directly related to time spent foraging and commuting to foraging areas (Studier and O'Farrell 1980). Thus, the farther apart roosting and foraging areas become, the more energy bats must spend commuting, and the less suitable such environments are for supporting healthy populations.

Movement and Activity Patterns

Seasonal Movements

Information documented on the location of *M. evotis* throughout the year is restricted to its

summer range. There are no reports of the winter range of *M. evotis*, but they must either migrate

seasonally to warmer climates (southern range) or hibernate during the winter when insects are

generally unavailable (Martin et al. 2001). It is believed that they only migrate short distances

from summer to winter range, using caves or abandoned mines for hibernation (Manning and

Jones 1989; Adams 2003) where ambient temperatures remain above freezing and fluctuate

slightly (Feldhamer et al. 2004). Navo et al. (2002) documented swarming behavior of male *M.

evotis* at a cave entrance in Colorado, which is indicative of potential hibernacula-use of that cave

or a near-by cave. Therefore, it can be speculated that *M. evotis* reside in Wyoming year-round,

utilizing suitable hibernacula during the winter months.

In Alberta, Canada, reproductive female *M. evotis* change day-roosts during gestation (May

through June) versus lactation (July through early August). Relatively low (spatially), horizontal

rock crevices are used during gestation, and deeper, vertical rock crevices are used during lactating

months (Chruszcz and Barclay 2002). This allows the roost environment to be compatible with

the energy demands of the female and fetus/neonate requirements during each reproductive stage.

Daily Activity and Energy Budgets

Bats that feed entirely on flying insects are almost strictly active at night and demonstrate a

bimodal activity pattern. For example, bats will forage in the evening and again before dawn

(Barbour and Davis 1969; Kunz 1974; Erkert 1982) when ambient temperatures are conducive for

insect activity (Hamilton and Barclay 1998; Chruszcz and Barclay 2003). However, this is not the

case with *M. evotis*, which has the ability to "hawk" insects out of the air and "glean" insects from

surfaces (Faure and Barclay 1994). This dual method of foraging allows *M. evotis* to emerge later

in the evenings (about one hour after dark) and forage throughout the night (Manning and Jones 1989; Chruszcz and Barclay 2003). Individuals only spend a small proportion of the night resting. Chruszcz and Barclay (2003) reported that female *M. evotis* stopped flying about five times per night (5.1+/-0.8 times/night) resulting in a total of approximately one-half hour (32.3+/-4.8 minutes) of inactivity each night. This is considerably less time spent resting at night than other insectivorous bats. During daytime hours *M. evotis* remain primarily in roost sites in a state of torpor (Chruszcz and Barclay 2003).

Two major factors determine the energy requirements of mammals: the physical environment and their daily activities. Bats use physiological and behavioral adaptations to help regulate these energy demands, which can be particularly high in insectivorous bats living in temperate regions (Feldhamer et al. 2004). Although no formal research has specifically investigated the energy requirements of *M. evotis,* thermoregulatory behavior, roost site selection, and foraging behavior suggest that they "exist on a tight energy budget" (Chruszcz and Barclay 2002, 2003).

Maintaining internally regulated body temperature is costly, especially in bats that have large surface-area-to-mass ratios and readily lose heat to the environment. During the evening when temperatures generally are cooler, bats are active and can easily maintain higher body temperatures. However, during the day when bats are resting, it requires more energy to maintain high body temperatures. Therefore *M. evotis* practice daily torpor by lowering body temperature to approach ambient temperatures in the day-time roost (usually not below 15°C). Torpor not only reduces the body temperature of a bat, but also breathing, and heart rate. This allows tremendous savings of metabolic energy (McNab 1982; Chruszcz and Barclay 2002; Adams 2003; Feldhamer et al. 2004). One of the highest energy demands during this cycle, however, is raising torpor body temperature to levels that will maintain a metabolic rate sufficient for flight. *Myotis evotis* reduces

energy costs during this stage by selecting a day-time roost site that is exposed to early morning sun. This allows the roost to "heat" up and makes the process of getting out of torpor less demanding (Chruszcz and Barclay 2002). Although maintaining body temperature uses quite a bit of energy, it is the slow, maneuverable flight of *M. evotis* during foraging bouts that uses a large proportion of the daily energy budget (Kurta et al. 1989). Day-time roost site selection relatively close to foraging habitat may function to reduce the amount of energy expended getting to-and-from roost and forage sites (Tuttle 1976). For example, Waldien and Hayes (2001) reported that the furthest *M. evotis* was detected from a day-roost in western Oregon was 2.4km, whereas Pierson (1998) reported a maximum distance of 0.6km. In addition, it has been speculated that foraging techniques (see below; Faure and Barclay 1994) and the elasticity of the wings (Norberg 1998) help reduce energy expenditure.

Bats in temperate regions either migrate to warmer climates or hibernate near roosting/forage sites during winter months. Both of these require large amounts of energy. Little documentation of hibernacula and no documentation of migration for *M. evotis* are available; however, it is thought that this species most likely hibernates rather than migrates (Manning and Jones 1989). Hibernation is a period of deep torpor, where body temperatures are reduced to about 2–5°C for periods of weeks during the winter (Adams 2003; Feldhamer et al. 2004). It requires a large amount of energy to maintain such low body temperatures and is equally expensive to rewarm the body out of hibernation. Therefore, in preparation for hibernation, bats will increase white body fat reserves to equal a third of their body mass, and that reserve will be used to maintain basic metabolic functions during hibernation (Barbour and Davis 1969; Feldhamer et al. 2004). In addition, bats possess interscapular brown fat that permits rewarming of blood to the heart and brain to occur rapidly after hibernation (and daily torpor) with minimal heat loss, therefore conserving energy (Adams 2003; Feldhamer et al. 2004).

Reproduction and Survivorship

Breeding Phenology

Most mammals, including bats, adjust their reproductive cycles opportunistically so that the

young are born during periods of food abundance (Oxberry 1979; Racey 1982; Findley 1993). For

insectivorous bats, the period of peak insect activity is during the warm summer months (Taylor

1963), and this reflects the breeding cycle of *M. evotis.* Male hibernating bats begin

spermatogenesis in the summer and mate in the fall (August or September) prior to migration or

hibernation (Racey 1979; Clark and Stromberg 1987; Feldhamer et al. 2004). Spermatozoa are

stored in the female reproductive tract, with fertilization, ovulation, and implantation occurring in

the spring when the reproductive females arouse from hibernation (Racey 1979, 1982). Gestation

lasts for 50 to 60 days (Manning and Jones 1989) and has been documented in *M. evotis* as early

as May 13 in New Mexico and as late as July 26 in Oregon (Manning 1993). Lactating females

have been documented as early as June 28 in New Mexico and as late as September 9 in Oregon

(Manning 1993), and therefore parturition must occur from late spring to early summer (May

through June; Manning and Jones 1989; Whitaker 1996). *Myotis evotis* are iteroparous and

produce a single litter per year with one offspring (Racey 1982; Manning and Jones 1989;

Feldhamer et al. 2004). Very little is known of *M. evotis* growth rate, development, and weaning.

In New Mexico, Findley et al. (1975) documented the capture of juveniles in late July. Juveniles

obtain adult pelage in mid- to late summer (Manning 1993).

Mating occurs when food availability is low, which is not conducive to the high energetic

requirements of gestation and lactation. The majority of bats have adapted to this inconvenience,

by undergoing several months of delayed ovulation, fertilization, and/or implantation (Racey

1979). Although this breeding cycle has not specifically been documented in *M. evotis,* it is

assumed it occurs. Bats also have the ability to delay development of a fetus when resources are

inadequate and temperatures are colder (Racey and Swift 1981) by reducing body temperature and

slowing the rate of cell division for embryonic growth (Bradshaw 1962). Reproductive female *M.*

evotis use daily torpor throughout pregnancy and lactation, directing energy expenditure toward

the growth of the fetus and balancing daily water budgets (Chruszcz and Barclay 2003). This is

not surprising since this is a period of high energy demand, and females are only feeding at night.

Latitudinal variation among bat species has been noted during the breeding period, with more

succinct parturition occurring later at higher latitudes. This trend is probably a consequence of

later ovulations associated with later arousal from hibernation at higher latitudes and colder

temperatures (Barclay et al. 2004).

Breeding Behavior

No specific reports of *M. evotis* mating behavior have been reported. Males and

nonreproductive females are usually solitary, but reproductive female *M. evotis* and pups form

small maternity or nursing colonies (usually in buildings) of up to 30 individuals in the summer

(Barbour and Davis 1969; Manning and Jones 1989; Whitaker 1996; Tigner and Stukel 2003).

Groups of 12-30 individuals were discovered roosting in buildings in British Columbia (Cowan

and Guiguet 1965 in Barbour and Davis 1969), a group of adults and young were found in a

deserted ranch house in Colorado (Allen 1928 in Barbour and Davis 1969), and 20-25 individuals

were located in the attic of a two-story brick building in Sturgis, South Dakota (Tigner and Stukel

2003). It is thought that groups are formed in order to generate more body heat without expending

as much energy (see VonHof and Barclay 1996), and this behavior is also beneficial to juvenile

development.

Prior to parturition, however, females roost alone, and only occasionally in small groups (2-3

individuals; Chruszcz and Barclay 2002). Maintaining individual body temperature, as well as

acquiring the energy needed for gestation and lactation, requires females to increase insect

consumption (Kunz 1974). In order to meet these energy requirements, females often move to

lower elevations where insect activity is higher and roost sites are warmer (Cryan et al. 2000).

Reproductive female *M. evotis* also adjust to high energy demands by modifying their

thermoregulatory and roosting behavior (Hamilton and Barclay 1994; Chruszcz and Barclay

2002). In Alberta it was noted that pregnant female *M. evotis* select roost sites in horizontal rock

crevices which are closer to the surface. These sites warm more rapidly and have a higher mean

daytime temperature, allowing the pregnant female to maintain body temperature closer to

ambient temperatures during the day without expending as much energy. After foraging

throughout the night, these females return to the cooler roost site and go into a deep torpor,

conserving energy for fetal development. It was noted that these females switched roost sites

almost daily in order to prevent scent build-up and reduce predatory detection.   After parturition,

females selected for roost sites that were in a vertical plane relative to the ground, which

maintained a higher overall temperature. This warmer temperature enabled juveniles to maintain

high body temperatures while the mother foraged. Lactating females also entered a daily torpor to

conserve energy, but not as deep as pregnant females (Chruszcz and Barclay 2002).

Fecundity and Survivorship

    Chiropteran life histories are unusual in that they have one small litter per year, usually one

pup that grows and matures slowly, and a long reproductive lifespan – opposite of what is seen in

most other small mammals (Feldhamer et al. 2004). This holds true for *M. evotis*: reproductive

output is limited to one offspring per year (Barbour and Davis 1969; Manning and Jones 1989)

and lifespan is quite long, with a record longevity of 22 years reported for a free-ranging male

(Tuttle and Stevenson 1982), although the average is probably lower. Navo et al. (2002)

recaptured two male *M. evotis* from 1981 through 1997, suggesting a lifespan of at least 16 years.

Females most likely begin reproducing their second year, since first year females often enter

hibernation with lower fat reserves than older females, which would prevent successful

reproduction the following spring (Tuttle and Stevenson 1982; Kunz et al. 1998; Barclay et al.

2004). Once sexual maturity is reached, females will reproduce annually if conditions are

favorable, fat storage for hibernation is adequate, and resources are sufficient. If these

reproductive requirements are unfavorable, the female will forgo reproduction for that year in

order to increase the probability of future, successful reproduction (Barclay et al. 2004). For

example in Alberta, only 55.3% (21/38) of female *M. evotis* captured in July and August wre

reproductive (pregnant or lactating; Barclay 1991). It is important to note that reproductive rates

may decrease with increasing latitude because of shorter breeding and feeding seasons due to the

climate (Barclay et al. 2004). However, this may not be the case with *M. evotis*, since research has

documented reproductive female *M. evotis* foraging in areas of reduced aerial insect activity that

are not commonly used by other reproductive bat species (Barclay 1991), most likely a result of

the dual foraging methods, roost site selection, and thermoregulatory behavior of *M. evotis*.

Mortality rates are unknown, but probably low due to their ability to fly and escape predation

(Pomeroy 1990).

Population Demographics

Spatial Characteristics and Genetic Concerns

Increasing genetic studies will help direct management actions and better quantify goals for

conservation of *M. evotis*. To date, no studies have been conducted regarding the metapopulation

dynamics or genetic differentiation among *M. evotis*. This would pose an interesting question for

future research, since although bats are highly mobile, they are also closely tied to roosting and

foraging areas, thus limiting potential distribution and dispersal. For instance, the relative level of

sympatry between the four recognized subspecies, *M. e. evotis*, *M. e. pacificus*, *M. e. chrysonotus*,

and *M. e. jonesorum*, and thus the extent and validity of each subspecies, is largely unknown.

Currently research is investigating inter- and intraspecific variation in mitochondrial DNA for five

species of *Myotis*, including *M. evotis*, but does not have results at this time (Dewey 2000;

SDBWG 2004).

Food Habits

Diet

   Myotis evotis is an insectivore with its diet consisting mainly of moths (Lepidoptera) and

beetles (Coleoptera), but they will also consume five other orders of insects, including flies

(Diptera) and spiders (Arachnida) (Black 1974; Whitaker et al. 1977; Whitaker et al. 1981;

Barclay 1991; Whitaker 1996). Research that analyzed stomach contents in Oregon (Whitaker et

al. 1977, 1981) and Alberta, Canada (Barclay 1991), determined that Lepidoptera were the most

frequent insect eaten, whereas scat analysis conducted in New Mexico (Black 1974) suggested

Coleoptera were the most frequent insect eaten. Other research has determined that males capture

more Lepidoptera and females capture more Coleoptera (Husar 1976; Adams 2003). This perhaps

could be a difference in energy expenditure for capturing each of these prey items (aerial hawking

vs. gleaning). Freeman (1981) suggests that *M. evotis* is adapted morphologically to eat harder

prey, such as Coleoptera, more than its congeners. Moreover it is likely that *M. evotis* generally

feeds preferentially on moths and beetles, but that the predominance of either in its diet varies

geographically, seasonally, and in concert with local prey availability.

Foraging

   Myotis evotis typically forage in terrestrial habitats (Manning and Jones 1989), using low

frequency echolocation calls to guide itself through its habitat and locate prey at short distances

(Neuweiler 1989). These low frequency calls are undetectable by tympanate moths and other

nocturnal insects, increasing the susceptibility of these species to predation (Faure et al. 1990; Greenfield and Baker 2003). Also *M. evotis* can use echolocation to locate prey on an object, then cease calls and use the noise generated from the prey to guide the attack (Barclay 1991; Faure and Barclay 1994). The ability to adjust echolocation to each foraging situation assists *M. evotis* in the successful capture of prey through aerial-hawking or substrate-gleaning methods (Faure and Barclay 1994). For example, Barclay (1991) noted that *M. evotis* was able to catch flying insects, as well as "glean" fluttering moths off aspen (*Populus tremuloides*) leaves. This flexible foraging style most likely minimizes competition for *M. evotis* in popular aerial hunting grounds over water, and allows it to take advantage of a more stable insect population in terrestrial, forested habitats (Lewis 1970; Barclay 1991). In Alberta, foraging *M. evotis* were captured more often (216 of 221 captures) on paths and roads in forests adjacent to water than over water (Barclay 1991), suggesting greater foraging success and less competition within the forest.

Unlike most insectivorous bats, *M. evotis* has been noted to emerge later in the evening and forage efficiently throughout the night (Manning and Jones 1989; Chruszcz and Barclay 2002), optimizing the peak period of insect activity (just after sunset; Taylor 1963), and then feeding on substrate-borne insects as temperatures become cooler and aerial insect activity decreases. Ingles (1949) noted that *M. evotis* foraged around 12m above the ground just after dusk, but foraged closer to the ground when temperatures dropped, most likely searching for insects to glean off of surfaces. In British Columbia, Fenton et al. (1980) reported *M. evotis* emerging from its roost between 21:35 and 21:45 and flying through a valley gleaning insects from foliage or catching them close to foliage. Barclay (1991) also reported *M. evotis* commonly flying about 1m above the ground. Times reported for the emergence of *M. evotis* in the evening vary. It has been reported that they emerge from day-roosts before dark (Hoffmeister 1970), shortly after dark (Whitaker et al. 1977), and later in the evening (Fenton et al. 1980; Manning and Jones 1989).

This witnessed fluctuation is probably related to foraging methods and temperature, since *M. evotis*, including reproductive females, forage efficiently at high elevations which have lower ambient temperatures (Arizona Game and Fish 2003), and can glean insects. Jones (1965 in Manning and Jones 1989) noted that *M. evotis* foraged more often when temperatures were cooler. Time spent foraging increases as the summer progresses to maximize food consumption when insect abundance is lower, in order to acquire enough energy for molting and hibernation preparation. This foraging time increase is also witnessed in females during reproductive months (Kunz 1974; Barclay 1989).

Water

Throughout the day and night insectivorous bats use large amounts of water to maintain metabolic function and compensate for high protein diets (McNab 1982; Feldhamer et al. 2004). As a result, most insectivorous bats need open, still bodies of water to replenish this loss upon leaving the roost. This is accomplished while skimming over bodies of water and using their lower jaw to "scoop" up the water (Barbour and Davis 1969). Since *M. evotis* have wing structure that allows them to be more maneuverable, in fact "hover" for several seconds (Barclay 1991), they should be able to utilize very small watering holes, just a few centimeters in diameter (Cross 1986; Seidman and Zabel 2001). It has been documented that shortly after leaving the roost, *M. evotis* visit water holes to drink (Adams 2003). Although research has suggested that *M. evotis* do not select day-roost sites that are associated with water (Waldien et al. 2000) and do not readily forage over water (Barclay 1991), they probably establish themselves close to water for drinking purposes, if available. However, it must be noted that *M. evotis* have several physiological adaptations (e.g., regular use of torpor, specialized kidneys) that reduce the loss of water, and therefore water sources may not be critical (Waldien and Hayes 2001). This certainly must be the

case when *M. evotis* are located in more xeric habitats, obtaining water through diet and metabolic

functions (Feldhamer et al. 2004).

Community Ecology

Studies that have looked at the insect consumption rate of free-ranging bats, have observed

rapid consumption of insects (e.g., Kunz 1982; Long 1996), with some bats consuming half their

body weight in insects each night (Whitaker 1988). Therefore, bats may represent major predators

of nocturnal insects and could play an important role in "pest" control (Long 1996; Martin et al.

2001; Feldhamer et al. 2004). In addition, it has been speculated that bats may positively

contribute to forested ecosystems, by depositing nitrogen-rich feces at roosting sites after a night

of foraging (Grindal 1995; Rainey et al. 1992). However, this may only be the case with bats that

are known to roost in large numbers, unlike *M. evotis*.

Predators and Competitors

Studies that have used telemetry, echolocation, and mist-nets to identify bat species using

roosting and foraging sites have shown that *M. evotis* coexists with a wide variety of other bat

species including: *M. occultus* (Arizona occult bat)*, M. auriculus* (southwestern myotis)*, M.

californicus* (California bat)*, M. ciliolabrum* (western small-footed bat)*, M. lucifugus* (little brown

bat)*, M. septentrionalis* (northern long-eared bat)*, M. thysanodes* (fringed bat)*, M. volans* (long-

legged bat)*, M. yumanensis* (Yuma bat)*, Antrozous pallidus* (pallid bat)*, Eptesicus fuscus* (big

brown bat)*, Idionycteris phyllotis* (Allen's lappet-browed bat)*, Lasionycteris noctivagans* (silver-

haired bat)*, Plecotus townsendii* (Townsend's big-eared bat), and *Lasiurus cinereus* (hoary bat;

Thomas 1988; Vonhof and Barclay 1996; Rabe et al. 1998; Humes et al. 1999; Cryan et al. 2000;

Seidman and Zabel 2001). This list may partially reflect the wide distribution and habitat

selection of *M. evotis*. It appears that competition with these species is minimized in part through

niche partitioning in which *M. evotis* forages in cluttered areas and gleans insects from vegetation in addition to capturing insects in the air (e.g., Findley and Wilson 1982; Faure and Barclay 1994). The most foraging competition *M. evotis* may encounter is with its conspecifics and other gleaning foragers (Perkins 1996 in Schmidt 2003). Barclay (1991) noted this foraging difference (gleaning) between *M. evotis* and *M. lucifugus*, as well as researchers (Black 1974; Husar 1976) who noted that when *M. auriculus* and *M. evotis* lived within the same range, *M. evotis* ate more Lepidoptera and *M. auriculus* ate more Coleoptera. Nonselective roost site selection of *M. evotis* may be another factor that minimizes competition. *Myotis evotis* has been documented to use a variety of structures, both natural and manmade as daytime roosts (see Roosts).

Although a variety of animals can prey upon bats, bats do not appear to be a focal prey item for any carnivore group, so it is unlikely that predation is a significant mortality factor in many areas. The only report of predation on *M. evotis* came from British Columbia. McIntosh and Gregory (1976) reported a yellow-bellied racer preying upon *M. evotis* as it emerged to forage from its day-roost located in a rocky ridge. Other possible predators could be chipmunks, bears, and avian predators. However, researchers have suggested that *M. evotis* strategically select roost sites that will protect them from predators, and switch roosts often to prevent scent build-up and minimize predation risk (Vonhof and Barclay 1996, 1997; Chruszcz and Barclay 2002). Water sources are probably not a source of competition (Findley 1993).

Parasites and Disease

Ectoparasites that have been found on *M. evotis* include chiggers (*Leptotrombidium myotis*) found on the ears and two mites (*Macronyssys crosbyi* and *Spinturnix americanus*). No internal parasites have been documented for this species.

Myotis evotis is also a known carrier of rabies (see Manning and Jones 1989), but as with other bats, the incidence of this is likely very low and poses minimal threat to humans (Constantine 1979, Constantine et al. 1979) and no threat to the persistence of the species. However, the perception of bats as deadly vectors of rabies has greatly harmed their image and resulted in public desire to exterminate bats. Bat Conservation International (BCI), provides a concise account of the bat-rabies connection on its website (http://www.batcon.org/), from which much of the following information was derived. Historically, most rabies transmission to humans occurred in domestic animals (e.g., cats and dogs), but following widespread pet vaccination programs, wild animals now represent the bulk of animal rabies cases. Wild animals accounted for about 93% of animal rabies cases reported to the Centers for Disease Control in 2001, of which 37.2% were raccoons, 30.7% skunks, 17.2 bats, 5.9% foxes, and 0.7% other wild animals (Krebs et al 2001), but neither the total number and type of animals turned in nor the methods for their collection were reported . The apparently large proportion of bats in this list may be partially due to an increase in the prevalence of bats being turned in to disease professionals (WC 2000). Some state-level reports suggest that bats turned into health departments have a lower incidence of rabies infection (often < 10% of cases), suggesting that the prevalence among the entire wild population is smaller still, perhaps on order of 0.5-1.0% (e.g., Caire 1998, WC 2000, SDBWG 2004). Further, bats rarely transmit fatal rabies infections to humans, as evidenced by the fact that rabies viruses attributed to bats that commonly live in buildings have only been associated with eight human fatalities in all of U.S. history, and the most common bat in Wyoming (little brown bat, *M. lucifugus*) has never been documented transferring rabies to humans. Only a bite from an infected bat that breaks the skin can transmit the rabies virus; the virus has not been isolated from bat blood, urine or feces, and there is no evidence of air-borne transmission in buildings. Thus, the only way for someone to get rabies from a bat is to disturb an evidently sick bat to the point that it

inflicts a severe bite, and even then only a small portion of noticeably sick bats actually have

rabies. Since normal, healthy bats will usually not allow themselves to be contacted by humans

(unless they are in a state of torpor during roosting), virtually all risk of exposure can be

eliminated by not handling live bats that allow such contact. If frequent interaction with live bats

is a regular occurrence, a highly effective and painless vaccine is available that further reduces risk

of transmission. Primary care doctors or public health officials can usually order and administer

this vaccine.

Symbiotic and Mutualistic Interactions

There are no documented symbiotic or mutalistic interactions between *M. evotis* and other

Chiropteran or non-Chiropteran species. Many bats have a commensal relationship with beaver,

since beaver create small bodies of open water from which bats can drink. Further, beaver ponds

promote vegetative growth around their edges and may enhance local insect abundance.

Conservation

Conservation Status

Federal Endangered Species Act

Myotis evotis (including all subspecies) was formerly listed as a Category 2 (C2) Candidate

Species prior to modifications of the United States Endangered Species Act (ESA) in 1996. The

modifications redefined the candidate list to include only species for which the U.S. Fish and

Wildlife Service (USFWS) had sufficient information to support listing, or Category 1 Candidate

Species (USFWS 1996). Candidate 2 species, or those for which the USFWS had some

information indicating that the species may be in trouble but not enough to warrant listing, where

dropped from the revised list (16 U.S.C. §§ 1531-1533; USFWS 1996). However, until 2003 *M.*

evotis was still classified as a Federal Species of Concern (USFWS 2003). *M. evotis* and its

associates are no longer listed, being considered for listing, or being watched under the ESA.

Bureau of Land Management

The Wyoming Bureau of Land Management (BLM) lists former ESA Candidate 2 species,

including *M. evotis,* as a sensitive species. According to the BLM Manual 6840, this designation

is meant to provide protection of *M. evotis* and the habitat on which they depend. Therefore the

BLM is responsible for reviewing programs and activities on BLM land to determine their

potential effect on *M. evotis* (USDI BLM Wyoming 2002). Other State Offices of the BLM

(Nevada, California, Arizona, New Mexcio, Montana, Idaho, Oregon, and Washington) also

include *M. evotis* on their sensitive species lists.

Forest Service

The range of *M. evotis* encompasses portions of 6 forest service regions, including the western

half of The Northern Region (R1), the western half of The Rocky Mountain Region (R2), the

western half of The Southwestern Region (R3), The Intermountain Region (R6), The Pacific

Southwest Region (R5), and the Pacific Northwest Region (R6). Currently these regions do not

include *M. evotis* on their sensitive species list.

State Wildlife Agencies

Myotis evotis is recognized as a special management concern by some state wildlife agencies,

including the Wyoming Game and Fish Department (WGFD), which assigns *M. evotis* a special

concern rank of NSS2 (Native Species Status 2). The NSS2 rank is based on WGFD estimates

that *M. evotis* populations in Wyoming are restricted in numbers and experiencing ongoing

significant loss of habitat, although extirpation is not deemed imminent (Oakleaf et al. 2002).

WGFD ranks native species on a scale of NSS1 to NSS7, with NSS1 representing critically

imperiled species [e.g., Townsend's big-eared bat (*Plecotus townsendii*)] and NSS7 representing

stable or increasing species. These ranks are assigned by WGFD biologists as a way to roughly

prioritize wildlife concerns in the state, but they carry no legal, regulatory, or management weight.

Natural Heritage Ranks

The Natural Heritage Network assigns range-wide and state-level ranks to species based on

established evaluation criteria. *Myotis evotis* merits a global rank of G5, which means that

rangewide it is deemed by Heritage scientists to be Apparently Secure. This is based on a

synthesis of state ranks and biological evidence that suggests it is "widespread in western North

America [with] well over 100 occurrences; abundance is apparently low; protected at a minimum

of three locations; appears to be moderately threatened" (NatureServe Explorer 2001).

Sixteen western states and provinces have assigned a State Rank to *M. evotis* and three of these

states rank it as S2 (imperiled) or S1 (critically imperiled). In general, state ranks are assigned

based on the assessed risk of extinction within a state, where S1 species are deemed critically

imperiled and S5 species are deemed demonstrably secure. These assessments are based on

biological information on population status, natural history, and threats at the state level. Specific

State Ranks are as follows: Arizona (S4), California (S3S4), Colorado (S4), Idaho (S3?), Montana

(S4), Nevada (S4B), New Mexico (S4), North Dakota (SU), Oregon (S3S4), South Dakota (S1),

Utah (S3S4), Washington (S3), Wyoming (S1B,S1?N), Alberta (S2), and British Columbia

(S4S5). Question marks indicate that the rank is uncertain, generally due to lack of information on

population status. SU indicates that the species is sensitive, but the status has not yet been

determined. SB and SN designations refer to breeding and nonbreeding status population,

respectively, and are generally used for species whose conservation concerns vary with season

(e.g., migratory animals). SU indicates that the population is sensitive, but the status is undetermined.

Western Bat Working Group

The Western Bat Working Group (1998) ranked *M. evotis* as medium conservation concern in 6 of 10 ecoregions in which it occurs, and as low priority in the other 4 regions (figure 1). The Intermountain Semi-Desert Province ecoregion, given a medium rank, encompasses approximately half of Wyoming.

Biological Conservation Issues

Extrinsic Threats

It is thought that habitat loss, modification, and fragmentation affecting summer and winter roost sites, as well as roost disturbance, pesticide use, and misperceptions of bats by people, have caused declines in bat populations throughout the U.S. Two things make bats particularly vulnerable to population decline or extinction: 1) they tend to congregate in suitable habitats and 2) they have low reproductive rates preventing a quick recovery if populations decline (Cross 1986). This assessment has attempted to identify important roosting and foraging habitats as documented in published literature, as well as other factors that may influence the survival of *M. evotis*. The next section will address possible threats to the survival and success of *M. evotis* populations throughout its range, and management actions that can be taken to mitigate these threats.

Roost Disturbance

Bats spend over half of their lives at roost sites (Vonhof and Barclay 1996), and therefore disturbances of these sites could have significant ramifications. Roost disturbance can encompass acts that completely destroy entire roosts, or simply cause a bat to relocate to a potentially less

desirable site. Disturbances can be human-caused or produced by natural events (e.g., wildfires,

floods, windstorms). Most often disturbances occur during critical stages in a bat's lifecycle (e.g.,

reproduction and hibernation), dramatically affecting the success of the population disturbed

(SDBWG 2004). In addition, slight disturbances to roost sites could change the qualities of why a

roost was selected (e.g., suitable microclimate, protection from predation and adverse weather;

Kunz 1982).

    Myotis evotis are known to utilize caves, mines, and crevices in rocks as roost and hibernacula

sites (Manning and Jones 1989; Tuttle and Taylor 1998. Chruszcz and Barclay 2002; Hinman and

Snow 2003; Ellison et al. 2004). In summer day-time roosts, *M. evotis* are in a state of torpor, and

in winter roosts, they are in a deeper state of torpor – hibernation. Disturbance at this time,

whether intentional or unintentional, will cause them to arouse, and expend an enormous amount

of energy, which could result in roost abandonment or death during the winter (Adams 2003).

Recreationists and tourists in and around caves unintentionally disturb roosting bats by arousing

them with increased noise levels and/or changing microclimates with increased ambient

temperature and decreased air flow. Roost disturbance in caves and mines could also be

intentional – people antagonizing the bats or vandalism to the structures (Tuttle and Taylor 1998;

Altenbach et al. 2002; Hinman and Snow 2003; Ellison et al. 2004; SDBWG 2004). Complete

closures or improper gate use on abandoned mines could eliminate potential roost sites or

unfavorably change the climate within the mine (Tuttle and Taylor 1998). Use of rock crevices as

roost sites presents the possibility of sharing hand-holds with rock-climbers who could

unintentionally disturb *M. evotis* (Kunz 1982; Hinman and Snow 2003; Ellison et al. 2004;

SBDWG 2004).

In Arizona (Rabe et al. 1998), Oregon (Waldien et al. 2000), and British Columbia (Vonhof and Barclay 1996, 1997), *M. evotis* are known to use large diameter clear-cut stumps and snags in diverse, mixed-coniferous forests, switching roost sites often during the summer months. Certain silvicultural practices that lead to monotypic stands and removal of large, old trees and snags could adversely affect the quality and availability of roost sites for *M. evotis* (Kunz 1982; Knight 1994; Hinman and Snow 2003; SBDWG 2004). In addition, exclusion of fires has created dense thickets that prevent sunlight from entering potential roost sites, altering the microclimate of roosts and limiting easy access (Knight 1994; Mannan et al. 1996; Vonhof and Barclay 1997). On the other hand, prescribed burns and/or wildfires can change vegetative structure and composition within forest ecosystems, altering roost habitat (e.g., removal of loose exfoliating bark, opening up canopy; Knight 1994; Mannan et al. 1996). However, fires often assist in snag recruitment (Knight 1994), thus potentially providing more roost sites. Bears can also disturb roost sites by stripping bark off of snags and stumps (Vonhof and Barclay 1997).

Other roosts used by *M. evotis* are manmade structures, such as buildings and bridges. Inhabiting areas with higher human contact increases the possibilities of roost disturbance. Bats using roosts under bridges are in danger of being spotted easily from passer-bys, or losing their roost site as a result of bridge construction or excavation. Buildings, both abandoned and inhabited, often provide large spaces for maternity colonies to form over the summer (Barbour and Davis 1969; Manning and Jones 1989; Tigner and Stukel 2003), but their presence can be a nuisance (noise) and/or destructive (guano build-up). As a result, roost sites are often blocked or bat colonies exterminated from these sites (Adams 2003).

Non-roost Disturbance

In addition to roost sites, *M. evotis* select areas to forage and obtain water. Often these areas are in close vicinity of each other in order to reduce energy expenditure when traveling between

sites (see Landscape Context). Habitat selection is thought to be influenced largely by insect

availability (Whitaker et al. 2000; Fenton 1990), which is most abundant and diverse around water

sources, tree-tops, and forested edges (Thomas 1988; Barclay 1991; SDBWG 2004). If these

structures are disturbed and/or altered, insect populations may decrease, since insects depend on

both aquatic and terrestrial vegetation for breeding grounds and food sources. The use of

pesticides may also negatively influence insect abundance. The actual affect a decreased insect

population would have on bats is unknown, yet it has been speculated that it may cause a bat to

relocate to another, less desirable foraging area, and as a result, expend more energy (Adams

2003). However, this may not be the case for *M. evotis,* since they are known to forage throughout

the night, even though aerial insect densities are low at that time (see Foraging Behavior; Chruszcz

and Barclay 2002, 2003).

   Wetlands are important for bat populations, and probably support a disproportionate number of

bats than upland habitats (Ohmart and Anderson 1986), since they supply abundant insect

populations for efficient bat foraging and provide an adequate source for drinking water.

However, wetlands are becoming scarce. It has been estimated that more than 90% of

cottonwood-willow riparian areas in the Rocky Mountains have been lost (Johnson and Carothers

1981 in Ohmart and Anderson 1986). The diverse vegetation associated with wetlands could be

destroyed and negatively alter bat foraging and drinking areas through 1) poorly managed

livestock grazing; 2) mining activities that result in complete sterility of the riparian system or

channel cutting, reduced water quality, and flooding; 3) recreational activity; 4) impoundment

construction by beavers or humans; 5) logging and associated road building; and, 6) riparian

ground-water withdrawal (Ohmart and Anderson 1986; Ellison et al. 2004; SDBWG 2004). Other

foraging areas that *M. evotis* have been associated with are along forest edges (which also supply

an abundant source of prey) and within dense vegetation or forests. *Myotis evotis* are able to

exploit these areas in addition to wetlands because of their maneuverable flight and flexible

echolocation calls. Alteration of these foraging areas may occur as a result of forest management

practices such as thinning and fuel reduction, and fire suppression or prescribed burning.

However, alteration of these habitats may not hinder *M. evotis* populations directly, but rather alter

the prey base and possibly indirectly affect *M. evotis* populations (Fenton 1990).

Chemicals

Pesticides and herbicides used in agricultural and forest management practices, as well as

toxins associated with mining operations, can lead to direct poisoning of bats, either by drinking

spoiled water sources or through consumption of affected insects (Adams 2003; Ellison et al.

2004). These chemical pollutants could be responsible for bat declines in some areas.

Pesticide and herbicide use impacts bats by significantly reducing the abundance of bat prey

and/or by accumulating in the surviving prey and eventually becoming concentrated in bat tissues

once the invertebrates are consumed. The chemicals are accumulated in stored fat that is used

during migration, hibernation, and lactation (Barbour and Davis 1969), potentially resulting in

reduced fecundity and exposure of young to large doses of pesticides (Keinath 2004b). Some

studies have shown that bats accumulate very high concentrations of organochlorines (e.g., DDT,

DDE) and other contaminants in their tissues (Jefferies 1972; O'Shea, et al. 2001; Keinath 2004b).

However, Henny et al. (1982) reported that *M. evotis* did not show significant change in pesticide

levels when DDT was used to control Douglas-fir tussock moths in forests in northeastern Oregon.

So, pesticide and herbicide use may not negatively affect *M. evotis* populations.

Toxins associated with mining operations also have potential to negatively affect bat

populations through drinking polluted water or consumption of insects that forage on

contaminated plants or have nymph stages in the polluted waters. For example, the water in

cyanide-laced ponds (linked with gold mining) can cause rapid asphyxiation if ingested. In Nevada it was reported that 158 bats were found dead in cyanide-solution ponds over a three year period (Adams 2003). No specific reports of *M. evotis* fatalities from cyanide leach fields have been documented.

Wind Energy

Initially, concern for wildlife collisions with wind-energy turbines focused on bird fatalities, especially raptors. However, as more turbines were constructed and studied, research demonstrated that bat mortality due to collision with turbine blades was much more prevalent than birds (Osborn et al. 1998; Johnson et al. 2003; Tuttle et al. 2004). A variety of species have been found killed at these turbines, but most cases are the tree-roosting, migratory species (e.g., hoary bats and red bats), which sometimes represent more than 70% of recorded mortalities (Johnson et al. 2003; Tuttle et al. 2004; Williams 2004). Over the past two years, however, as research has become more rigid and therefore more successful at locating inconspicuous bats, an increasing number of cave-dwelling bats have been found, suggesting that not only migratory bats are being killed by the turbine blades. It is speculated that insect aggregations near turbine blades may be contributing to bat mortalities (Tuttle et al. 2004). To date, *M. evotis* mortality has not been confirmed. This is most likely a result of *M. evotis* not using open areas to forage (where most wind-farms are located) and not being migratory.

Tuttle et al. (2004) reported that a national Bats and Wind Power Cooperative has been organized by Bat Conservation International, the U.S. Fish and Wildlife Service, the National Renewable Energy Lab, and the American Wind Energy Association in order to set priorities and conduct the research required to assess and remedy threats to bats.

Abundance and Abundance Trends

As discussed in the Biology and Ecology section, *M. evotis* appears to be widely distributed across its range, and rather well represented in capture activities occurring in suitable habitats (see Table 3), although the percentage of *M. evotis* captured in relation to other bats is, perhaps, on the low side (~14% of total captures). However, great caution should be used when interpreting capture information for bats, because there are potentially huge variations within and across studies due things like survey design, net placement, timing of surveys, weather events, local insect abundance, and moon phase. Also, bat surveys are often conducted to capture the greatest variety of bats, which may or may not result in representative captures of any one species.

Overall, there is insufficient data to estimate abundance trends for *M. evotis* throughout its range due to inconsistent and intermittent monitoring and survey efforts in documented *M. evotis* habitat (Oliver 2000; Ellison et al. 2004). For example, there has been only one long-term study published that captured *M. evotis* at a cave entrance in Colorado on five different occasions, from 1981 to 1997, that indicated a variable trend (possibly increasing) for *M. evotis* abundance [08/1981(8), 07/1982(4), 09/1993(3), 07/1997(4), 09/1997(13); Navo et al. 2002]. This inconsistency could be a result of time of the year surveys were conducted, development of better capture techniques and experience in species identification, or use of general methods not specifically targeting *M. evotis*, but rather a variety of bat species. For these reasons and those listed in the preceding paragraph, it is not appropriate to extrapolate this estimate beyond the particular locality in Colorado, no is it appropriate to estimate trends based on captures of *M. evotis* across studies.

Distribution Trends

Bats have received increased attention over the last decade, which has resulted in increased surveys with better equipment. As a result, formerly unidentified ranges of *M. evotis* have been

discovered, potentially increasing the previously recognized range, as published by various

authors (e.g., Barbour and Davis 1969; Manning and Jones 1989; Manning 1993). However, this

does not mean that the distribution of *M. evotis* is increasing; it just is evidence of newly

recognized areas where the species has historically resided. Due to inconsistent and varied

surveying and monitoring efforts throughout *M. evotis* range, assessing distribution trends with

available data (both historical and current) would not be accurate.

Habitat Trends

Information on bat habitat trends, including roosting habitat, foraging habitat, and water

sources, is not readily available. Therefore, the following information has been extrapolated from

general habitats in order to address possible trends in habitat specific to *M. evotis*.

Trends in forest roosting habitat are unclear. *Myotis evotis* seem to utilize the bark on large

snags and fallen logs, as well as clear-cut stumps for day-time roost sites. This variability

suggests that *M. evotis* may adapt well to a variety of forest management activities, and therefore

forest roosting habitat could be fairly stable. However, if the currently proposed Healthy Forest

Initiative (President of the United States 2002) is widely adopted and implemented, there will be a

major emphasis on reducing fuel loads (e.g., dead snags and fallen logs) in older stands, and could

result in a decrease of available roost sites.

Myotis evotis also roost in crevices of rocks and cliffs, which can be destroyed by dam

construction in canyons and/or impacted by rock climbing and tourist activities. However it is

unclear how these activities affect these roost sites. For example, the foraging habitat around

these areas can be negatively affected by recreational development and/or enhanced by reservoir

establishment (e.g., more diverse vegetation resulting in more insects). In any case, relative to

other roost structures, cliff roosting habitat has probably not experienced great declines in abundance and availability.

The extent that *M. evotis* use caves and abandoned mines is not well documented; however, it can be assumed that they are used readily as hibernacula sites because of appropriate microclimates. Suitable cave roosting habitat is structurally limited in Wyoming and has likely decreased over the last century due to human disturbance of cave systems (SDBWG 2004). Large cave complexes are particularly vulnerable to such disturbance because they attract tourists and have often been established as part of national or state parks. In recent decades, however, awareness of the importance of caves to bats has increased and actions, such as seasonally limiting access to caves, are slowly being taken to protect key cave complexes from disturbance. If this trend continues and is supported by land management agencies, the downward trend in cave roosting habitat should be expected to stabilize in the next decade. Additionally, the availability of abandoned underground mines may somewhat mitigate the loss of cave habitat. It has been estimated that 80% of abandoned mines may be used by bats, with 10% receiving substantial use. However recently, abandoned mines have been permanently closed to prevent human injuries and casualties, eliminating potential roost and hibernacula sites. Also, renewed mining activity at abandoned mines (e.g., surface mining) has destroyed potential roosting sites. The closures and renewed mining activity could result in decreased availability of roosting and hibernacula sites (Tuttle and Taylor 1998; Keinath 2004b).

Trends in available foraging and water habitat are much harder to estimate than trends in roost sites, since the foraging habits of most bats are not as well understood. It can be assumed that foraging habitat is becoming limited, however, since wetlands are decreasing at alarming rates

(Ohmart and Anderson 1986), and these habitats provide breeding and feeding grounds for insects, a factor that appears to dictate bat use.

Intrinsic Vulnerability

Small mammals are usually depicted as r-selected species: short-lived and rapidly reproducing organisms exhibiting pronounced population fluctuations. However, bats seem to contradict this, demonstrating the characteristics of k-selected species: relatively constant population size, slower reproduction, and, greater longevity (Findley 1993). This second factor, slow reproduction, in combination with naturally low abundance, could potentially cause *M. evotis* to go locally extinct with stochastic environmental variation (Keinath 2001, unpublished data).

Reproductive female *M. evotis* use daily torpor to conserve energy for fetal development and milk production (Chruszcz and Barclay 2002). Disturbance of day-time roost sites could result in arousal from torpor, causing energy reserved for reproduction to be used, and possibly result in relinquishment of successful reproduction for that year (Bradshaw 1962; Racey and Swift 1981). Without annual recruitment, populations could decline.

In addition, hibernation is important for bats to survive throughout the winter season when little to no food is available. *Myotis evotis* may favor hibernacula sites year-after-year (Navo et al. 2002), and removal or closure of potential sites (e.g., caves and mines), may also result in population decline.

Conservation Action

Existing or Future Conservation Plans

To date, there has been only one conservation assessment completed for the Forest Service on *M. evotis*, with management focus on the Black Hills National Forest in South Dakota and Wyoming (Schmidt 2003). Some western states have recently completed bat conservation plans

to provide guidance for the numerous bat species within their boundaries, with particular focus on

federally listed species. The following are completed bat conservation plans: Nevada Bat

Conservation Plan (Altenbach et al. 2002), Arizona Bat Conservation Strategic Plan (Hinman and

Snow 2003), Colorado Bat Conservation Plan (Ellison et al. 2004), and South Dakota Bat

Management Plan (SDBWG 2004). Plans for Utah, Washington, and Wyoming are in production

(Keinath 2004b). The completed plans differ greatly in their level of detail and the strength of

their management recommendations, but most provide general guidance and also offer

recommendations pertaining to specific species relevant to their habitat use. These plans contain

substantial guidance that is directly applicable to *M. evotis*. However, they are guidance

documents and carry little, if any, legal weight. As such, they will only be effective if state and

federal agencies rigorously apply their recommendations.

Conservation Elements

There has been no study explicitly investigating implications of environmental change on *M.

evotis.* However, there have been studies that provide information on structures and habitat types

used by *M. evotis*, and management strategies to preserve these sites. Five main conservation

elements should be addressed for *M. evotis* conservation management. Specific approaches that

have been proposed to address these conservation elements are provided in the following section

on Tools and Practices.

1. **Protection of roost sites** – Throughout its range, it has been documented that *M. evotis*
    uses various structures for roost sites (e.g., mines, caves, tree bark, snags, rock crevices,
    buildings, bridges, etc.). Any disturbance to these sites could be critical to the future of
    this species. Maternity roosts should be protected to assure that viable offspring are being
    produced annually. Also, hibernacula (e.g., mines and caves) need to be protected, since
    the appropriate microclimate could be rare and is important in the survival of this species
    through the winter. Several studies have determined that *M. evotis* readily use snags and

stumps as roost sites. Therefore, when planning forest management projects, the current and future abundance and distribution of these elements on the landscape should be considered.

2. **Protection of foraging areas** – It appears that *M. evotis* forage primarily in riparian areas with high insect abundance and mixed-coniferous forests, dominated by pines (e.g., ponderosa pine, lodgepole pine, and whitebark pine). However, they have also been captured in high alpine forests, pinyon-juniper woodlands, sagebrush steppe, and in riparian desert scrub habitats. Given the range of habitat types used by *M. evotis,* it is most likely the availability of appropriate roost sites, water sources, and insect populations that influence foraging areas used rather than vegetative species (Waldien and Hayes 2001; Hinman and Snow 2003). It can be assumed, however, that insect abundances correlate with vegetative structure, and if a decrease in any of these habitat types results in a decrease of insect abundance, *M. evotis* can be negatively affected. Although, the "critical level" of insect abundance for *M. evotis* resilience is unknown. Similarly, a certain amount of cover is needed for predator protection and shelter from inclement weather for foraging bats, but the optimal percentage of cover is unknown

3. **Protection of water sources** – Still, open water sources are important breeding grounds for insects, and provide a source of drinking water for *M. evotis*. The modification or removal of wetlands (riparian areas) could negatively affect water quality and plant diversity, directly affecting prey abundance, and indirectly affecting bat populations. The absence of reliable, accessible, and uncontaminated water sources could directly affect *M. evotis* populations, as well (Hinman and Snow 2003; Ellison et al. 2004; SDBWG 2004).

4. **Maintenance of a landscape mosaic** – *M. evotis* select roost sites that are in close proximity to foraging areas and water sources (Waldien and Hayes 2001), most likely to conserve energy. It is important to protect each of these elements together, because change in one of these required elements could aversely affect *M.* evotis (Pierson 1998).

5. **Elimination of exposure to toxic chemicals** – Artificial water sources provide drinking sites for bats in the arid West, however some of these water sources may be toxic to bats, such as oil-field waste pits, cyanide ponds, and wastewater facilities (Adams 2003). Preventative actions should be taken to reduce the accessibility of these hazardous sites. In

addition, consumption of insects that have been sprayed with pesticides can directly poison bats. Timing and use of such pesticides should be considered to reduce bat poisoning.

Tools and Practices

Acting on Conservation Elements

A few states have drafted conservation plans (e.g., Nevada, Arizona, Colorado, South Dakota) that provide general suggestions of management practices for *M. evotis* and other bats. In addition, research that focused specifically on *M. evotis,* or included *M. evotis* with a group of other *Myotis* species, has also provided management suggestions that may provide the best opportunity to conserve suitable roosting and foraging habitat. It is important that these management suggestions are scrutinized, because they are based on specific habitats found in other areas of *M. evotis* range, and do not necessarily relate directly to situations in Wyoming.

1. **Protection of roost sites: General** – Bats primary activities, such as roosting, feeding, and drinking are closely tied to specific habitat features. Any geographic area that seems to contain potential roosting sites for *M. evotis* should be thoroughly searched. These potential sites could include coniferous forest, wooded riparian areas, rocky outcroppings, caves, bridges, mines, buildings, etc. (see roosting). Before management action occurs in areas of potential *M. evotis* habitat, (e.g., prescribed burning, thinning, harvesting, mine closures, renewed mine activity, etc.), monitoring and surveys should be conducted to determine presence of *M. evotis* and any other bat species. Protecting habitat for reproductive females should be the highest priority. Chruszcz and Barclay (2002) determined that reproductive females roosted alone and selected different roosts during each stage (gestation or lactation) to help facilitate easy entry into torpor, easy arousal from torpor, conservation of energy and water, and reduction of predation risk.

    Tree Roosts: Day-time roost sites used by *M. evotis* include exfoliating bark on old-growth snags, fallen logs, and clear-cut stumps (commonly pines) that are situated higher on slopes, in late decay stages, and in open canopies. These sites are created by: 1) frequent surface fires (including prescribed burns) that control tree density, curtail vegetative undergrowth, and maintain older trees (Knight 1994); 2) forest management

practices that retain clusters of mature green trees of various sizes for future snag recruitment (Rabe et al. 1998; Waldien et al. 2000; SDBWG 2004); and, 3) tree harvesting methods that provide taller stumps with larger diameters, (extending the use of the stumps before vegetation overgrows them), as well as maintains snags (Vonhof and Barclay 1997). Since *M. evotis* have been shown to switch roosts often, most likely to reduce predation risk, stumps and snags should be maintained in spacious clusters (~ 61m ± 17.7m between possible roosts; Vonhof and Barclay 1996), and managed aggressively when in proximity of water sources (0.5km – 1.0km; Waldien and Hayes 2001). Forest management techniques that suppress fires may contribute to the decline of roosting sites by facilitating dense forests (e.g., not enough radiant energy or easy access to roosts), and in turn, providing fuel for intense crown fires that are capable of burning young trees, old trees, and snags (i.e., no roost sites). In addition, any policies or logging practices that removes coarse woody debris and dead and dying trees (e.g., Healthy Forest Initiative, President of the United States 2002), may be detrimental to possible *M. evotis* roost sites.

Caves, Mines, Manmade structures: Other roost sites that are commonly used by *M. evotis* include mines, caves, rock crevices, and manmade structures (e.g., buildings and bridges). Specific management actions can be taken to protect these structures, especially during critical periods (e.g., reproduction and hibernation).

Inactive mines that are used as roosting sites (determined by surveys and monitoring), should be protected by installing "bat-friendly" steel gates that maintain proper airflow and microclimate, allow free access to bats, and provide no access to humans (Tuttle and Taylor 1998; Hinman and Snow 2003; Ellison et al. 2004). In addition to gate installation, clearly visible interpretive signs that do not block air flow can be placed nearby to educate the public of the reasons for the action and hopefully avoid vandalism by uninformed parties. If renewed mining is scheduled, and bats are known to occupy these mines sometime throughout the year, exclusion should occur before operations commence. If a mine is used year-round, exclusion in the spring or fall is best. Bats should not be excluded during the winter or inclement weather (Tuttle and Taylor 1998). Artificial underground roosts that maintain microclimatic needs of targeted bat species can be constructed to replace mines that are renewed for mining activity (see Tuttle and Taylor 1998).

Caves, mines, and abandoned or historic buildings that are known to contain hibernacula, should be closed to public access between November 1 and April 1 each year, and structures known to harbor maternity colonies should be closed from at least April 1 to October 1, in order to minimize lethal disturbances (e.g., Altenbach et al. 2002). When closure of occupied buildings is not an option, construction of nearby bat-houses may promote bat use and therefore serve as a substitution for occupied buildings and reduce potential disturbances. All forest management activities should be conducted when roosts are unoccupied and not within a 0.25 mile buffer of the roost (Pierson et al. 1999).

2. **Protection of foraging areas** – The foraging methods (glean and hawk), flexible echolocation calls, and low wing aspect ratio and wing loading of *M. evotis*, allow it to forage successfully in a variety of habitats. Maintenance of forest edges and wetlands occurring within the scale of bat home ranges (e.g., within 40 ha and no more than 1-4 km apart from each other or roost sites) will provide important components for good foraging habitat (Grindal and Brigham 1998; Altenbach et al. 2002). Also, retention of residual tree patches when conducting clear-cuts may provide additional foraging habitat (as well as potential roost sites) along the edge of both the clear-cut and residual patches (Grindal and Brigham 1998; Swystun et al. 2001). Opening canopies through thinning, forest harvesting, or road construction may create flyways that assist in efficient and successful foraging (Grindal and Brigham 1998; Humes et al. 1999). Insuring a natural mix of native vegetation at *M. evotis* foraging sites will help maintain native insect fauna, thereby maintaining the bats' prey base. Thus, managers should pay close attention to how land use practices such as grazing, fire, timber harvest, and resource extraction impact vegetation communities and strive to maintain a natural mosaic.

3. **Protection of water sources** – Water sources are important to bats for supporting abundant, diverse insect populations, as well as supplying drinking water. Practices that degrade stream water quality and alter riparian vegetation are therefore likely to negatively impact *M. evotis*. Arid environments in the West do not generally have abundant water sources, so management and conservation of existing water sources is important. Riparian areas should be managed to maintain woody vegetation along streams and lakes to provide diverse, native vegetation that promotes insect diversity and abundance. Ponds can be created to improve the foraging quality and suitability around potential roost sites

(Waldien and Hayes 2001). Permanent streams with channel widths of at least 1.8m are suggested as having higher bat activity, and therefore should be preferentially maintained (Seidman and Zabel 2001).

4. **Maintenance of a landscape mosaic** – The spatial arrangement of foraging and roosting sites, as well as their connectivity with suitable commuting habitat, need to be carefully considered (e.g., Pierson 1998). Maintaining remnant patches of diverse, older forests with large snags in watersheds could provide all elements required for successful *M. evotis* populations. Snag densities over 8 per hectare may be required based on recommendations for similar bats such as *M. thysanodes* (e.g., Keinath 2004). These densities are higher than existing guidelines for cavity-nesting birds and areas of high snag density must be close (< ~1 km) to forest openings and water bodies, so that the habitat mosaic provides potential roost sites, drinking-water sources, and edges for foraging (Grindal and Brigham 1998; Vonhof and Barclay 1997; Waldien et al. 2000). No research has looked specifically at what promotes day-use of snags by bats in remnant patches, but it can be assumed that in order to facilitate use, remnant patches should be fairly close enough to existing, occupied forest.

5. **Elimination of exposure to toxic chemicals** - Where bats may be exposed to toxic surface impoundments, such as cyanide ponds from mining activities, those ponds should be netted or otherwise restricted to prevent bats from drinking from them. Colorado requires this to be done when ponds contain more than 40 parts per million cyanide (Ellison et al. 2004). Pesticide use should be minimized and targeted to reduce spray block size, non-target insect mortality, and the potential for spray drift (Ellison et al. 2004). Any intensive spray area should be searched for roosts prior to spraying and a 2-mile, no-spray buffer should be left around roost sites (Ellison et al. 2004) to eliminate the chance of direct impacts on bats. Further, aerial application should be timed so that it does not directly contaminate foraging bats (i.e., not during the early evening, night, or before sunrise).

Survey, Inventory, Monitoring

Little is known about bats compared to other animals because they are nocturnal, highly maneuverable, silent to human ears, and inconspicuous. There have been numerous studies that have looked at the presence of bats in a variety of habitats to determine where species forage and

roost, as well as particular habitat features that may be required for the maintenance of various bat populations. A handful of studies have looked at *M. evotis* specifically; however, most studies have just included *M. evotis* with a cluster of other *Myotis* species when captured, detected, and reported. It is difficult to determine specific habitat requirements, abundance, and population trends of *M. evotis* from such generalized reports. Below are some suggestions that may assist in the surveying and monitoring of *M. evotis*. In order to obtain the most information on this species, it is recommended to use as many techniques as possible (Cross 1986; Altenbach et al. 2002).

Multiple site and site types – Oftentimes a definition of bat habitat only includes a single location in time and space (e.g., day-time roost site, foraging site, watering hole). However, monitoring plans should include all habitats in order to determine abundance and distribution, (including daily and seasonal movements), to effectively manage for *M. evotis* (Zimmerman and Glanz 2000; Ball 2002). These habitats include roosting (day, night, maternity, and hibernacula), foraging (riparian, open water, forest edges, coniferous forests, and woodlands), and water sites (reservoirs, ponds, guzzlers, etc). Selecting multiple sites similar in area, elevation, and vegetative type and structure will assist researchers in determining habitat associations. Nevada (Altenbach et al. 2002) recommends employing a 100km grid system to select at least 60 wetland habitat sites throughout the state for annual monitoring.

Multiple visits – Multiple sampling throughout the year(s) is important to understand the habitat associations, seasonal movements, and fidelity of *M. evotis*. At minimum, a known site with *M. evotis* activity should be examined at least once during a season – therefore, at least four times in a year (winter, spring, summer, and fall; Altenbach et al. 2002), maintaining consistency in survey dates over time. Also, since evidence suggests that roost site selection (e.g., roost switching), and nightly foraging strategies can change on a day-to-day basis, a minimum sampling

period of three consecutive nights/days should be conducted for each location (Altenbach et al. 2002). This sampling method should increase potential to recapture/resight specific individuals and increase knowledge on habitat associations, seasonal movement patterns, and site fidelity (Nietfeld et al. 1996) to be used for conservation management strategies.

Acoustic monitoring – Acoustic surveys provide powerful tools to determine the level of bat activity within a particular habitat, and provide researchers an idea of bat abundance (Cross 1986; Altenbach et al. 2002). Acoustic surveys can be both passive and/or active and conducted at fixed points, providing information about bat use of a particular feature (e.g., cave entrance), or they can be mobile to capture use throughout a selected habitat. Placement of acoustic devices is important to capture clear echolocation calls and reduce interference from clutter (e.g., rocks and vegetation; Altenbach et al. 2002). One of the most common systems for collecting echolocation calls is ANABAT® (http://users.lmi.net/corben/ anabat.htm#Anabat%20Contents; http://www.titley.com.au/tanabat.htm). Interpreting data collected from this device can be difficult, and requires bat experts who are experienced at reading spectrographs from various bat species.

Bat detectors work by relying on bats to actively echolocate. Since *M. evotis* sometimes do not echolocate while passively foraging for prey, and also have low-intensity calls that are usually undetectable by these systems, echolocation surveys may not be the most reliable tool to detect the presence of *M. evotis* (e.g., Barclay 1991; Tuttle and Taylor 1998; O'Farrel and Gannon 1999; Altenbach et al. 2002). Also, echolocation surveys cannot be used to determine bat density, only levels of activity, because individual bats are unidentifiable. Altenbach et al. (2002, Appendix A) offer a great "at a glance" tool for comparing echolocation calls from species often found in the same collecting sites. However, expert advice should be acquired when identifying *M. evotis* from

call signatures, because *M. evotis* uses a variety of calls that have different functions and therefore different signatures (e.g., foraging vs. gleaning calls; Faure and Barclay 1994).

Capturing bats – Positive identification of bats and analyses of population demographics requires that the animals be captured and visually examined. In fact, capture techniques may be the best method to use regardless, when determining the presence of *M. evotis*, since capture techniques yield better results for detecting *M. evotis* than acoustic detection (Tuttle and Taylor 1998; O'Farrel and Gannon 1999). All capture methods cause stress to bats, but location, timing, and method of capture could minimize stress induced on individuals (Cross 1986; Ellison et al. 2004).

- **Location**: In order to minimize disturbance at roost sites, which may cause bats to switch to lower quality roosts, the best place to capture bats is in foraging areas and at watering sites (Ellison et al. 2004). Focusing capture efforts at flyways along forest edges and paths, as well as over any body of water (regardless of size) in close vicinity (0.5km – 1.0km) of known *M. evotis* roost sites (or potential sites), may be most beneficial (Cross 1986; Waldien and Hayes 2001). When targeting reproductive females, efforts should be focused at lower elevations where insect activity is greatest and foraging for the female most efficient. However, it should be noted that in the case of *M. evotis*, the use of lower elevation foraging areas may not be as pronounced as species that only rely on aerial prey (Chruszcz and Barclay 2003).

- **Capture methods**: Two methods have been commonly used to capture bats: mist-nets and harp traps. Mist-netting is an efficient and versatile method of capturing bats, and is most successful when placed in potential foraging areas with sufficient space for bats to forage, which also allows enough space to set-up the net. However, mist-nets should not be used in areas of high bat concentrations, since bats cannot be untangled quickly and injury may occur. Also, successful bat capture with mist-nets may decrease in wind and rain, and therefore should not be used (Cross 1986; Schemnitz 1996). More "bat-friendly" capture devices are harp traps. These traps can be used in areas with high bat density since removal from the trap is easier, and bats can be left in the trap for longer periods of time,

without incurring injury (Cross 1986). Bats can also be captured by hand, but this is usually only possible when bats are in a torpid state. Caution must be exercised when handling torpid bats, because arousal from torpor will cause a serious depletion of stored energy, and could also cause the bat to abandon a preferred roost site (Cross 1986). If using traps to monitor use of mines and caves as summer roost sites or potential hibernacula, mist-nets and traps should only be used over horizontal entrances. If entrances are vertical, determine the flight pattern of bats out of the mine or cave, and then set up the traps and/or nets along the flight path (Tuttle and Taylor 1998).

- **Timing** – *Myotis evotis* have been reported to forage throughout the night, taking advantage of peak insect periods at dusk and just before sunrise, as well as gleaning insects from surfaces of foliage during off-peak periods. Therefore, capture methods could be used throughout the night; however, nets should never be left unattended (Racey 1982; Cross 1986; Chruszcz and Barclay 2003). Capture efforts seeking to monitor breeding bat populations should occur from mid-June through August, and efforts monitoring potential use of mines or caves as hibernacula should occur during August and September (Tuttle and Taylor 1998).

Exogenous factors – Bat activity may vary with precipitation, temperature, wind, phase of the moon, and cloud cover, so survey efforts must take these factors into account. The effects of each of these factors are uncertain, but rough ideas are presented in Table 3. In addition to affects on bat activity, wind and rain can make mist-nets more detectable and perhaps be less efficient at capture (Cross 1986). These facts should be considered when planning survey activities.

Monitoring roosts – Techniques discussed above have provided a variety of tools and

suggestions to effectively monitor *M. evotis* populations throughout its habitat. Monitoring of

roost sites require more caution in order to keep disturbance levels down to a minimum, especially

in energy demanding seasons, such as the summer breeding season (reproductive females) and

winter hibernating season. The following are suggestions on how to minimize disturbance of

potential *M. evotis* roost sites when monitoring.

- Chruszcz and Barclay (2003) determined that reproductive female *M. evotis* emerge from
  day-time roosts nightly to forage. Therefore, to minimize disturbance and maximize
  monitoring efforts, reproductive females should be monitored in mid-June to early August
  at day-roost "exits", beginning at dusk, and continuing two hours after dark (Tuttle and
  Taylor 1998; Ellison et al. 2004).

- Monitoring for hibernacula in caves and mines is most efficient through internal surveys of
  the structure(s) during the winter, every two – three years, if the structure is safe
  (Hendricks 1998; Tuttle and Taylor 1998; Ellison et al. 2004). To minimize disturbance
  and bat arousal from hibernation, red lights should be used only if necessary, noise should
  be kept to a minimum (e.g., only two surveyors), and researchers should stay close and low
  to the sides of the cave or mine. (At this time, documentation of large guano piles can be
  useful indicators of summer roost sites, since surveying in the summer is not recommended
  since it could result in roost abandonment). If a possible hibernacula site is unsafe for
  internal surveys, external monitoring of the entrances of potential mines and caves in
  August and September could detect hibernating individuals. In addition, "swarming"
  behavior (believed to be related to breeding behavior and hibernation site selection)
  detected at mine or cave entrances may be indicative of hibernacula sites. However
  detection of swarming behavior in Wyoming could be difficult with the numerous mines
  and caves available for hibernacula, reducing the number of individuals using a particular
  site (Tuttle and Taylor 1998; Navo et al. 2002).

- Radio-telemetry can be a useful tool to monitor roost site selection. Bats could be
  captured, identified, and supplied with a radio transmitter while foraging, and receivers can
  be used during the day and night (for the life of the transmitter) to detect various roost

sites. Adhering to suggestions by Aldridge and Brigham (1988) that transmitters not be greater than 5% of an individual's body mass, activity and behavior should not be affected (e.g., Chruszcz and Barclay 2003).

- Mark and recapture/resight techniques could be used to determine roost fidelity in individuals from year-to-year. For example, color-coded aluminum bands (recommended for bats <10g) can be attached to the forearms of the bat (Bonaccorso et al. 1976; Cross 1986; Neitfeld et al. 1996), with a color representing a particular year and/or particular habitat. However, caution must be used since banding of temperate bats during hibernation has been identified as one of the major causes for population decline in several countries (see Neitfeld et al. 1996). Another method used to mark bats for short term studies (<5 months) is punch-marking (see figure 7; Bonaccorso and Smythe 1972; Bonaccorso et al. 1976; Cross 1986). Nocturnal tracking lights can be used for short periods of time to locate night roosts (Nietfeld et al. 1996).

Captive Propagation and Reintroduction

No captive propagation or reintroduction of *M. evotis* is currently happening. Due to the lack of information on its lifecycle and habitat requirements, such action is not recommended. Conservation efforts for known habitat used by *M. evotis* would be much more beneficial, since *M. evotis* does not appear to be in danger of extirpation throughout its range.

Information Needs

Relatively little is known about several aspects of *M. evotis* biology and ecology that are relevant to the management of this species. The following is a list of information needs that are deemed important in order to establish effective conservation strategies for this species.

1. **Distribution and Abundance** – Reports of *M. evotis* in Wyoming are few. Intensive surveying for this species throughout potential habitat in Wyoming (see figure 6) is necessary if future management actions are to consider this species. Pierson (1998) noted that in previously unstudied areas, new records of *M. evotis* emerge. Documentation of *M. evotis* throughout the State can then be used to estimate local abundance.

2. **Population trend** – Annual monitoring of marked individual *M. evotis* is needed to determine if the populations in Wyoming are increasing, decreasing, or remaining stable. This trend data can then be used to help determine the status of *M. evotis* in Wyoming and direct conservation management decisions.

3. **Local roosting habits and roost and habitat suitability** – A variety of summer roosting structures have been reported throughout *M. evotis* range, however no specifics for Wyoming. Therefore, knowledge on seasonal roosting requirements is needed. Once these requirements have been determined, characteristics of selected sites should be documented, and then similar sites investigated as potential roost sites.

4. **Foraging requirements** – More information is required on vegetative type and structure selected as foraging habitat, what constitutes an adequate prey supply, and the dependence of water sources for *M. evotis*. Efforts should be focused on sites specifically used by reproductive females, in order to conserve those areas.

5. **Management impacts** – Several studies have looked at roost and habitat selection by a collection of temperate, insectivorous bats (including *M. evotis*) in the West (e.g., Thomas 1988; Vonhof and Barclay 1997; Rabe et al. 1998; Humes et al. 1999; Jung et al. 1999), documenting habitat and structure use within old-growth and managed forests. However, affects of timber management practices on the activity of specific species has not been conducted. One study in British Columbia (Grindal and Brigham 1998) addressed short-term effects of small-scale cut-blocks on bat activity, but the results of this study cannot be extrapolated to long-term, large-scale projects or to specific species. In order to effectively conserve *M. evotis,* more information is needed on the short- and long-term effects of timber management practices (e.g., clearcut, salvage logging, snag recruitment, forest thinning, and fire management) of known *M. evotis* populations.

6. **Winter range** – No information of the winter roosting requirements or winter movement patterns in Wyoming, as well as throughout its North American range, have been documented. This information is necessary to protect potential hibernacula sites.

Tables and Figures

Table 1: Reported morphometric measurements for *Myotis evotis*.

Source [(Location)]	Forearm Length (mm)	Hindfoot Length (mm)	Ear Length (mm) [a]	Tail Length (mm)	Total Length (mm)	Weight (g)	Pelage
[b] Hoffmeister 1986 (Arizona)	36.9-39.8	8-10	20-24	36-45	82-94	-	-
[b] Armstrong 1972 (Colorado)	37.8-39.2	8-10	22-23	44-46	89-94	-	-
[b] Durrant 1952 (Utah)	38	9	19	40	85	-	-
Long 1965 (Wyoming)	-	9-11	17-23	39-43	87-96	-	"Upper parts Saccardo Brown to bright Buckthorn Brown; underparts creamy Pinkish Buff to Cinnamon-Buff"
Clark and Stromberg 1987 (Wyoming)	36-41	9-11	17-25	39-43	87-96	-	black, opaque ears; fur is long, glossy; brown above, paler below
[b] Davis 1939 (Idaho)	-	9	22	40	87	-	-
[b] Foresman 2001 (Montana)	-	8.3-9.4	18.3-18.8	42-46.4	82.3-89.2	-	-
Whitaker 1996	35-41	7-10	18-22 (7)	36-46	75-97	5-8	"Long, glossy fur, light brown to brown. Ears dark, usually black."
Barbour and Davis 1969	36-41	-	22-25	-	-	-	Fur is long and glossy – brown, buffy below; ears and membranes black; wingspan: 275mm.
Manning 1993	34.7-40.2	8.1-10.2	19-23.2 (5)	37.6-42.6	84.6-94.5	-	heavily pigmented ears; long and glossy fur with individual hairs of dorsum dark basaly

[a] Lengths in parenthesis refer to how far, in millimeters, the ear extends beyond the snout when laid forward.

[b] Citations in Adams (2003).

Table 2: Selected occurrence reports of *M. evotis* across its range. This table reports only the results of surveys that identified *M. evotis*, so it reflects relative abundance in currently occupied habitat. There have been many other surveys within *M. evotis* range that have not reported individuals of this species.

Source	MYEV Encounters			Species Identified	Rank[a]	Location	Collection Dates and Habitat Information
	M/F	% of Total	Hourly Rate[b]				
Barclay 1991	91/133	53.0	nr	nr	1?	Kananaskis Valley, Alberta, Canada	Dates: 1985-1988. Habitat: Coniferous forest, lodgepole pine dominant near water. Elevation: 1,350 m – 2,150 m.
Grindal et al. 1999	26	11.5	1.9	9	4	Southern British Columbia	Dates: 1993 – 1995. Habitat: Mixed conifer. Western red cedar, western hemlock, Engelmann spruce, subalpine fir. Elevation: 540 m – 1,800 m.
Keinath 2004a[c]	8	8.6	0.7	12	4	BICA	Dates: 2003. Habitat: Juniper, lodgepole pine, mixed conifer; mostly along riparian areas. Elevation: 1,100 m - 2,500 m.
	6	3.7	0.2	6	4	GTNP	
	1	0.4	0.03	5	4	YNP	
Rabe 1995	153/116	16.1	nr	15	3	Northern Arizona	Dates: 1993 – 1995. Habitat: Mixed pine dominated by ponderosa pine.. Elevation: 2,015 m – 2,620 m.
Seidman and Zabel 2001	24/6	14.5	nr	7	2	Pilot Creek watershed, northwestern California	Dates: 1996 – 1997. Habitat: Late-successional forest, Douglas-fir dominant.. Elevation: 1,100 m – 1,320 m.
Thomas 1988	6/2	2.7	nr	12	7	Southern Washington Cascade Mountains and Oregon Coast Range	Dates: 1984-1985. Habitat: Douglas-fir – western hemlock sere. Elevation: 300 m – 700 m.
Vonhof and Barclay 1996	3/0	14.3	nr	~5	3	West Arm Demonstration Forest, British Columbia	Dates: 1993-1994. Habitat: Mixed coniferous, western red-cedar, Engelmann spruce and subalpine fir.. Elevation: 650 m – 1,800 m.

nr = not reported

[a] "Rank" represents the ordinal abundance rank of *M. evotis* among the species captured in a given survey. For instance, a rank of 5 indicates that *M. evotis* was the 5th most abundant species of bat captured.

[b] Hourly encounter rate given as number of *M. evotis* per 100 net-hours.

[c] Surveys were gathered at Bighorn Canyon National Recreational Area (BICA), Grand Teton National Park (GTNP), and Yellowstone National Park (YNP) during summer 2003.

Table 3: Potential effects of exogenous factors on activity of free-ranging bats. This information
was taken from Keinath et al. (2004), which was extracted largely from discussions presented
by Ekert (1982), Kunz (1982), and Grindal (1995).

Factor	Suggested Effects	Possible Mechanisms
Cloud Cover (Light)	Heavy cloud cover that noticeably darkens the sky can cause early emergence from day roosts.	Light-mediated inhibition of locomotor activity. Predator (owl) avoidance.
Phase and rising of moon (Light)	Activity is generally reduced as the moon becomes fuller and during those periods of the night when the moon is in the sky.	Light-mediated inhibition of locomotor activity. Predator (e.g., owl) avoidance.
Temperature	Decreasing temperature results in decreased bat activity.	Lower temperatures result in increased metabolic demands of activity. Insect activity decreases with decreasing temperature (e.g., Grindal 1995).
Precipitation	Activity response varies with intensity of precipitation. Light rain probably has no impact. Heavy rain can prevent flight entirely. Moderate rain can reduce or alter patterns of activity.	Precipitation can interfere with echolocation, flight, and thermoregulation. Precipitation can also decrease insect activity. Effectiveness of mist-nets is decreased with increasing precipitation.
Wind	Activity response varies with strength of wind. Light or moderate wind probably has little impact. Strong or gusty wind can prevent flight entirely.	Wind can interfere with prey capture, flight, and thermoregulation. Wind can also decrease insect activity.
Food Supply	Abundant recourses can result in reduced foraging time and consequently more strongly bimodal peaks of activity related to peaks in insect abundance that often occur in twilight periods.	Like most animals, bats forage until energy demands are met, and then rest.
Reproductive Phase	Pregnant and lactating females often are very active because they have high energy demands. However, pregnant bats can become less active the closer they are to parturition.	Wing loading becomes higher with more advanced pregnancy, thus making foraging more difficult and energy intensive.
Elevation	Given the same habitat types, activity can be greater at lower elevations (e.g., Grindal 1995).	Temperature and insect abundance decrease with increasing elevation.

Fig. 1: Photographs of *M. evotis* showing general appearance and the sharp contrast of black, long ears and membranes against the pale brown pelage (A & B: © Merlin Tuttle, Bat Conservation International, Austin, Texas; C: © Bat Photography llc, by J. Scott Altenbach).

A)

B)
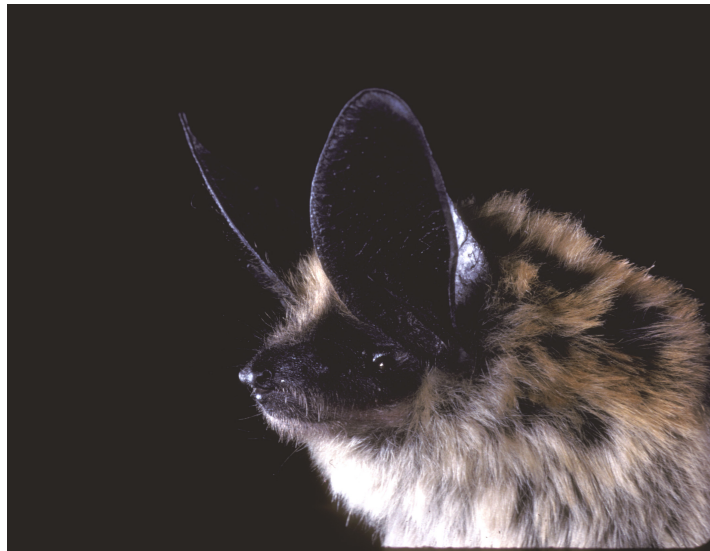
C)

Fig. 2: Electron micrograph (1320 X) of distal portion of dorsal overhair from *Myotis evotis*
    (Amman et al. 2002).

Fig. 3: Example of a *Myotis evotis* echolocation call from Sweetwater County, Wyoming. The
         vertical axis is frequency in kHz. Spectrograph was provided from the following web address
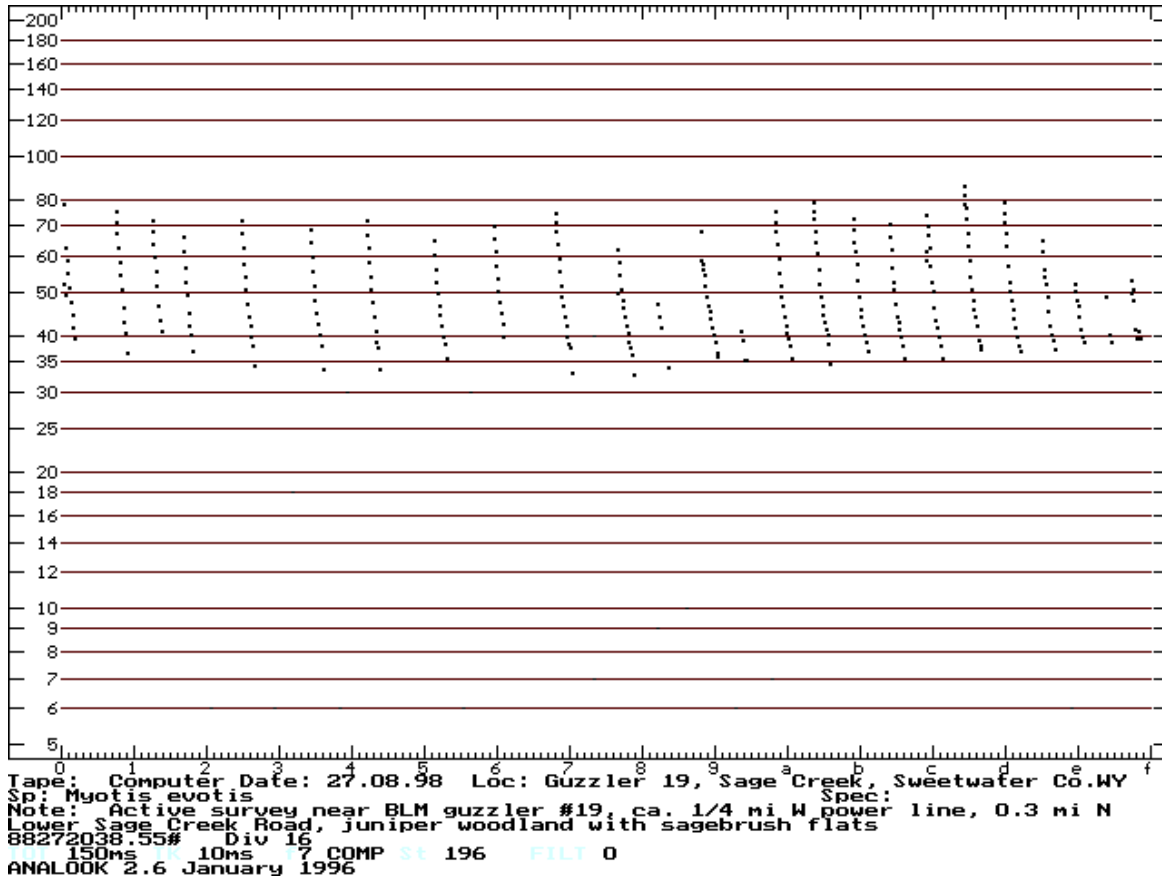   by M. J. O'Farrell: http://www.msb.unm.edu/mammals/batcall/accounts/
         accountsbase/myoevo.html.

Fig. 4: North American range of Myotis evotis adapted from range maps compiled by Bat
    Conservation International, Austin, Texas and Manning (1993). Current estimated year-round
    range is shaded in blue. The blue star indicates a possible isolated population in North Dakota.
    Approximate subspecies locations are in green. The fourth subspecies, M. e. chrysonotus is
    found throughout the rest of the range (blue stripes) in North America. Only a few M. evotis
    have been identified in Baja California and have been speculated to be two "other" subspecies
    of M. evotis: M. e. milleri and M. e. micronyx (see Manning 1993).
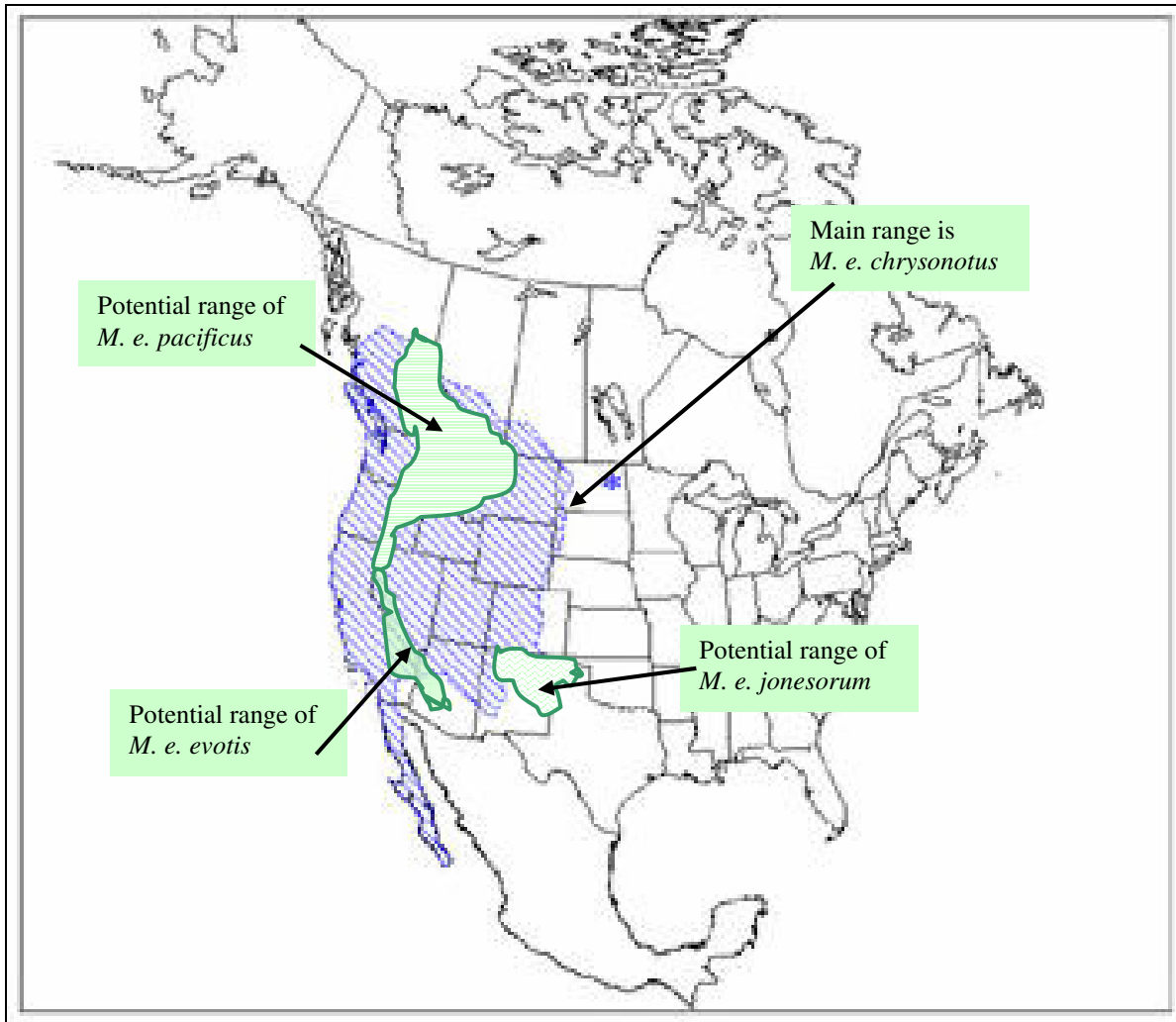
Fig. 5: Regional Conservation Priority of *Myotis evotis* throughout its range as defined by the
Western Bat Working group. Image adapted from Western Bat Working Group (1998).
Approximate range of *M. evotis* outlined in blue is taken from range maps compiled by Bat
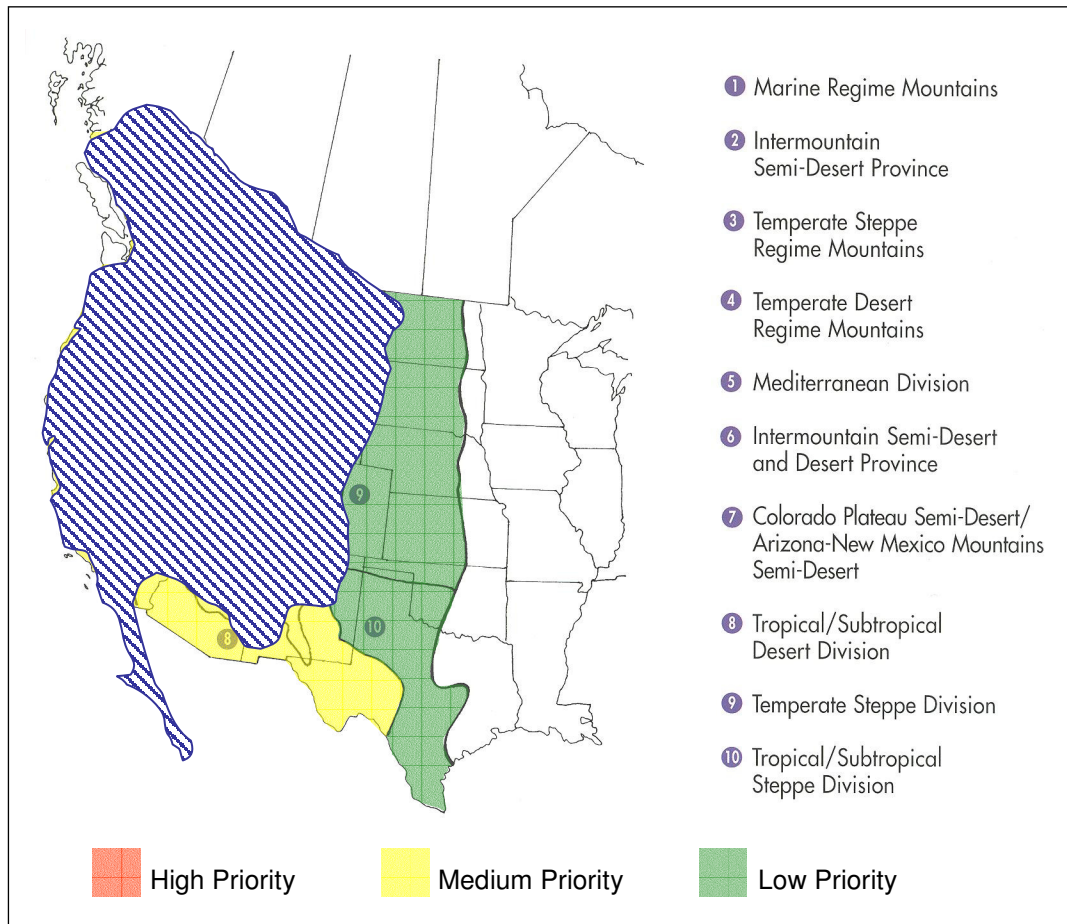Conservation International, Austin, Texas (see figure 2).

Fig. 6: A) Map of GAP analysis delineating potential primary and secondary habitat of *M. Evotis* in Wyoming based on all habitats that have been documented for this species throughout its range. B) To assist in detection and monitoring efforts of *M. evotis* in Wyoming, a map was constructed to include alpine coniferous forests throughout the state, specifically highlighting ponderosa pine, where most captures and detection of *M. evotis* have been documented. Targeting these habitats at elevations between 1,500m and 2,500m may make survey efforts for *M. evotis* more efficient.
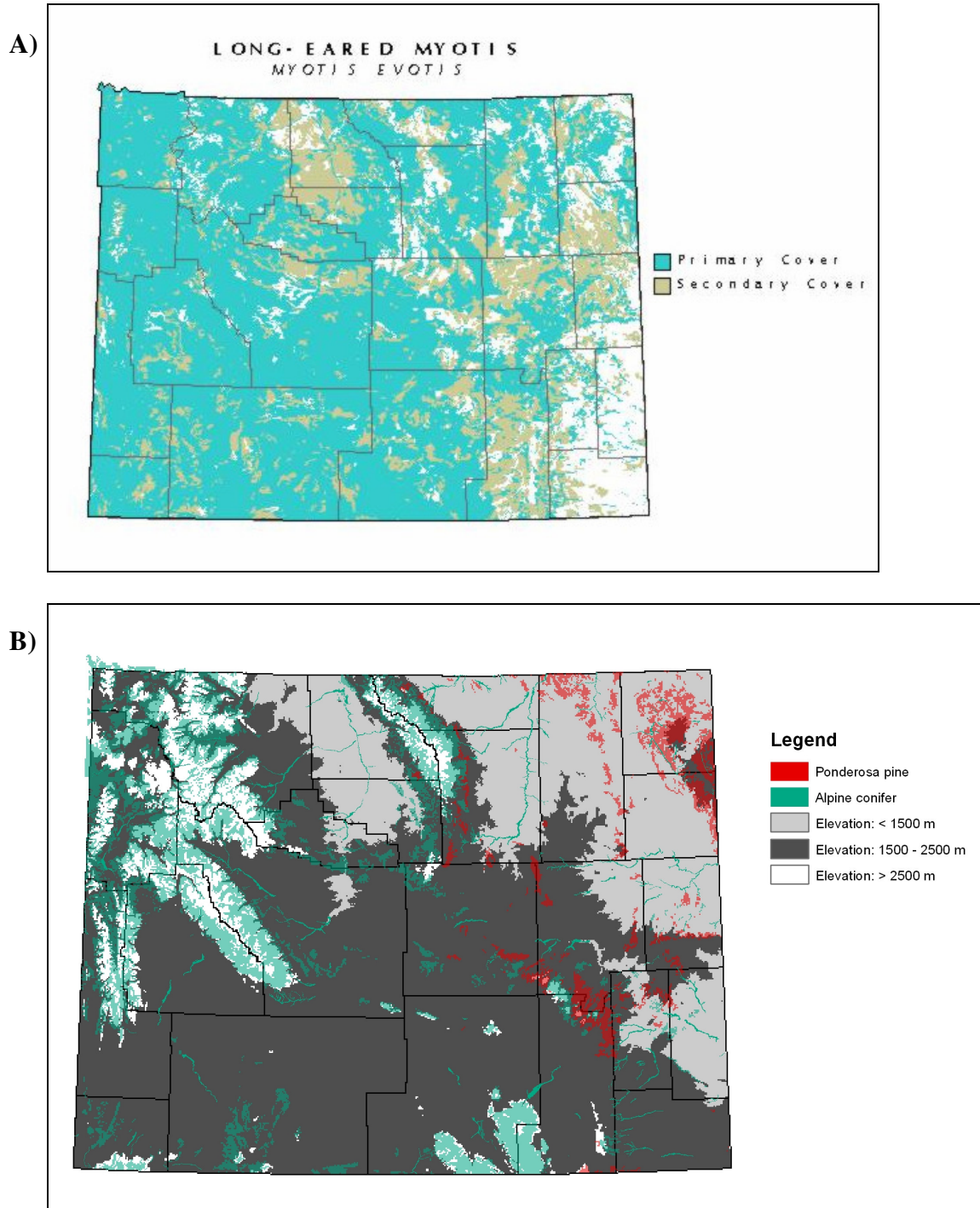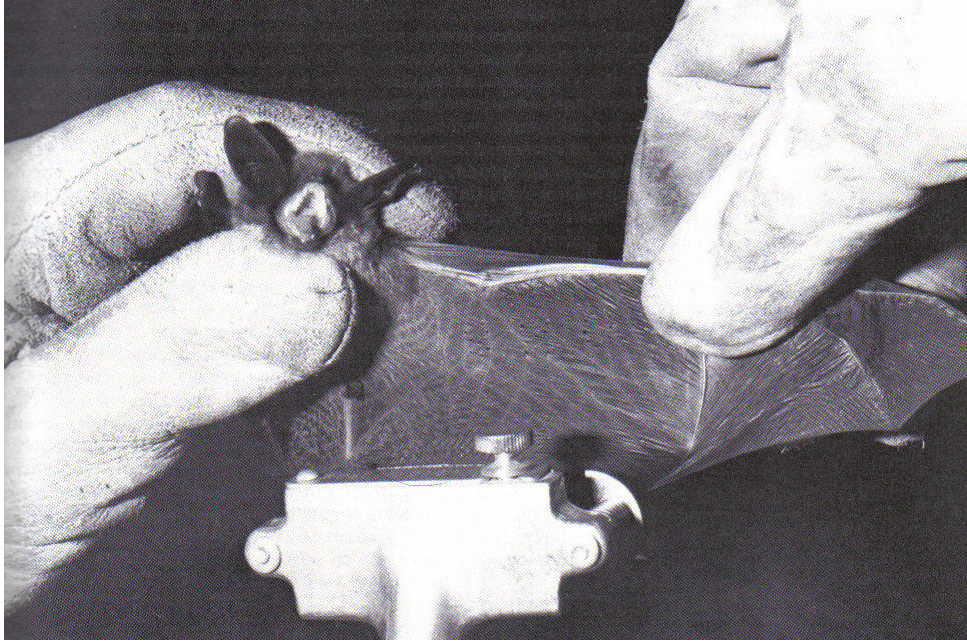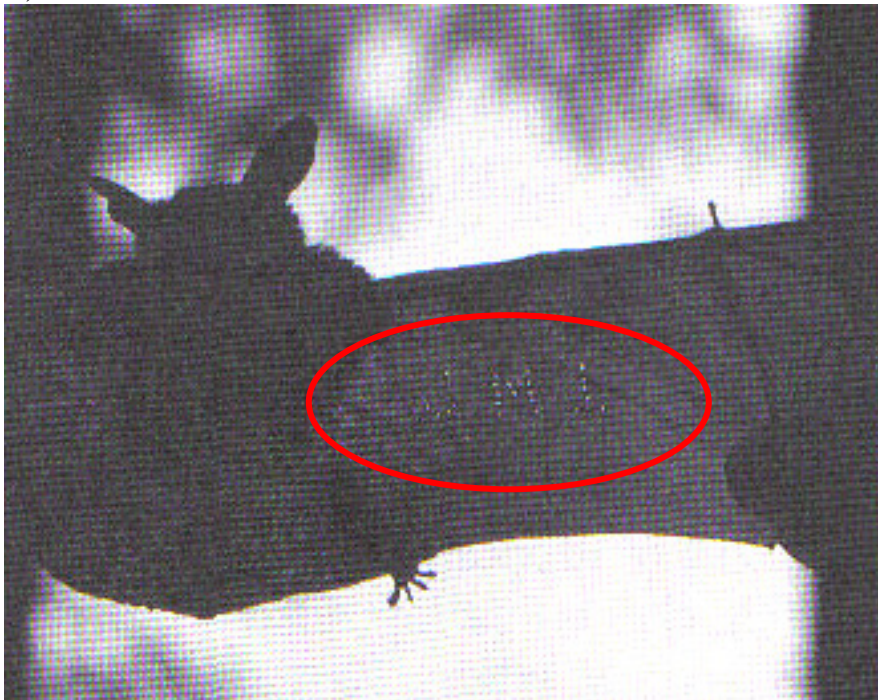
Fig. 7: A) Punch marks on an M. evotis wing resulting from the large animal tattoo device (pictured below the wing). B) Punch marks (YM1) back-lit on the wing of a M. yumanensis. (Cross 1986; 508, 509).

A)

B)

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