INVENTORYAND STATUS OF BATS AT DEVILS TOWER NATIONAL MONUMENT

FINAL REPORT 2011

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INTRODUCTION

Until now, very little information about the status and distribution of bats at Devil's Tower National Monument (DTNM) has been available. This has hampered the Monument's ability to protect bat habitat and promote public awareness of bats and their conservation. DTNM has the potential to support large numbers of bats representing many species due to its diversity of vegetation, many rock formations, and free-standing water. The Wyoming Natural Diversity Database (WYNDD) is charged with tracking rare species across the state, and has expertise in conducting bat inventories (Keinath 2005). To our knowledge, few systematic bat surveys have been conducted in northeastern Wyoming resulting in limitations in our understanding of bat distribution in the Black Hills Foothills Ecoregion (Chapman et al. 2004). Recognizing that a comprehensive survey would benefit both agencies, the USDI National Park Service (NPS) provided the resources needed by WYNDD to conduct an inventory of bats at DTNM in 2010 & 2011.

The primary objectives of the study were to determine what species inhabit the park, estimate their relative abundance, determine the resources they use, and ascertain their general health. This information will help resource managers take measures to protect bats, and it will allow for the development of interpretive materials to teach visitors about the diverse species that use the park, and the role that the Tower and other features play in bat conservation. A secondary objective of the study was to assess park buildings and structures as potential bat roost sites, evaluate the hazard for zoonotic disease transmission, and suggest exclosure measures to prevent contact with humans.

The timing of these surveys is important with regards to White-nose Syndrome; a disease that has devastated entire populations of cave-roosting bats in the eastern United States since 2006. Although not present in Wyoming yet, White-nose Syndrome has spread westward and was documented in Oklahoma in 2010 (BCI 2010). Although the causes of the Syndrome are complex and poorly understood, populations of bats that hibernate in large caves are most susceptible to infection. The surveys described in this report represent an important baseline inventory of bat health and abundance in DTNM and lay the groundwork for future bat monitoring by park staff or the Northern Great Plains Inventory and Monitoring Network

(NGPI&M). Ongoing monitoring of bats is certainly recommended in order to measure the potential impacts of White-nose Syndrome and other potential stressors in the coming years.

METHODS

We used mist nets and acoustic recorders to survey for bats in DTNM. Capturing live bats with mist nets allowed us to inspect individuals for disease, verify species presence, and collect demographic and physical data. Acoustic recorders were efficient tools for collecting species presence data from a wide variety of sites throughout the park. When choosing survey sites, we attempted to get as much spatial coverage of the park as possible while sampling all types of available habitat. Permission was sought and granted to survey private land just south of the Monument in order to access the Belle Fourche River. Surveys took place in early and late summer in 2010 and late summer in 2011 in order to capture female reproduction and juvenile emergence.

Mist Net Surveys

Figure 1: Mist netting along the Belle Fourche River

Because all Wyoming bats require flat water from which to drink, mist nets are most effectively placed above free-standing water. When bats descend to drink or feed, they are caught in the net, and can be removed, identified and released. In areas without suitable water bodies, nets can also be placed across features that naturally 'funnel' bats, such as draws or breaks in the forest canopy. At our sites, 2-4 mist nets[1] were suspended between aluminum poles above or near water (e.g., Figure 1) in single or double-high arrangements. We opened nets at dusk and closed them at 1am. Nets were closed earlier in the event of inclement weather that limited bat activity, including high wind or persistent rain. We checked the nets every 15 minutes and carefully removed and processed bats within 30 minutes of capture. Species, sex, age, reproductive status, and any signs of disease, wing damage, or fungal growth were recorded. All

[1] Avinet.com: bat -specific mist nets: 38mm mesh, black polyester, USA made.

sites were mist netted for one night only. Appendix B displays the key we used to identify species with taxonomy from Adams (2003).

Acoustic Surveys

We deployed two kinds of acoustic recorders to capture bat echolocations for species identification; Anabat[2] and Song Meter[3]. Although comparable in effectiveness, the time processing calls is thought to be less with Song Meters through the use of Sonobat[4] software. Recorders were placed in a variety of habitats throughout DTNM and positioned to maximize exposure to foraging bats (Figure 2). Units were generally deployed for one night per site and retrieved the next day, after which recordings were downloaded to a computer. Later, we compiled all recordings by site and analyzed them on a computer using frequency, slope, sweep, amplitude, harmonics and call density metrics. Species presence and the number of calls per species per night were recorded for each site. Trained technicians reviewed and identified all Anabat files using AnalookW software (Corben 2011). Appendix C displays the key used. Song Meter recordings were analyzed by automated Sonobat software (Szewczak 2011) after which questionable calls were reviewed by a trained technician.

Figure 2: Anabat unit set at the base of Devil's Tower

Park Buildings

In order to determine which buildings should be searched for bat activity, we asked facilities management personnel to identify structures at DTNM with a history of bat roosting. The Visitor Center/Bookstore and Climbing Permit buildings near the Tower were identified. We gained access into the working quarters and attics of these older buildings in June of 2010 and searched with flashlights for roosting bats and bat guano indicating current or past use by bats.

[2] Anabat SD1 Bat Detector. Columbia, MO www.titley-scientific.com
[3] Song Meter SM2Bat. Ultrasonic monitoring. Concord, MA www.wildlifeacoustics.com
[4] SonoBat 3. Software for bat call analysis. Arcata, CA. www.sonobat.com

RESULTS

Mist Net and Acoustic Surveys

A total of 10 sites were mist netted and 25 sites acoustically surveyed in 2010 and 2011. Half of the mist net sites were along the Belle Fourche River, and the rest were at freshwater springs and forest locations where heavy bat activity had been previously recorded (Figure 3). Acoustic survey sites were scattered throughout the park in open grassland, burned and live ponderosa pine forest, closed canopy deciduous forest, sandstone outcrops, exposed badland formations, and the base of Devil's Tower (Figure 3). We surveyed during three periods; June 21-27, 2010, August 8-14, 2010, and August 14-19, 2011.

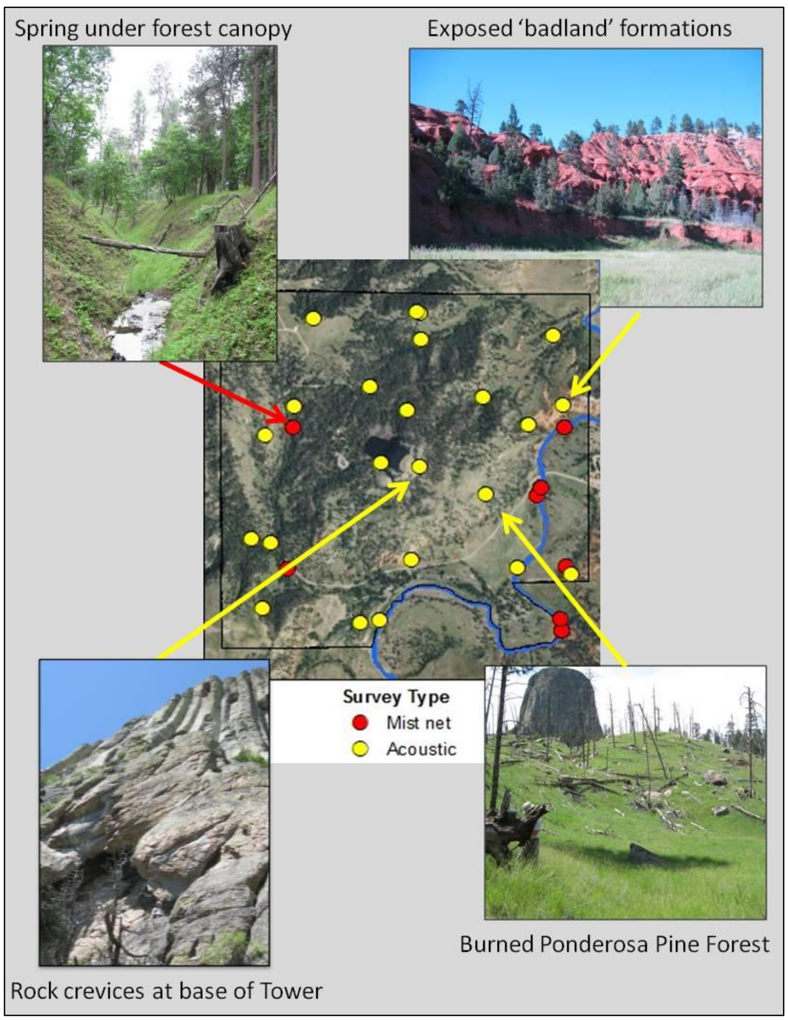

Figure 3. Mist net and acoustic survey sites placed in a variety of habitats at DTNM.

We captured a total of 72 bats while mist netting. No evidence of White-nose Syndrome or other infections or disease was detected on captured bats. The majority of captures were little brown myotis and fringed myotis (Table 1). A handful of captures were made of hoary bat, big brown bat, northern long-eared myotis, western long-eared myotis, and eastern red bat. Three additional species were detected by acoustic recordings only, namely silver-haired bat, western small-footed myotis, and long-legged myotis. Although not captured by us, the silver-haired bat has been captured in DTNM previously (Schmidt et al. 2004.). The remaining two species; western small-footed myotis and long-legged myotis, could not be physically confirmed, however over thirty recordings of each species were identified across several sites indicating that both species are likely to occur in DTNM. Nevertheless, because there is some overlap between their acoustic signatures and those of other confirmed species, we cannot be entirely certain that they reside in the park. Because most species were found in a variety of habitats, all should be considered widespread in DTNM. Based on the number of physical captures and recordings, all species are somewhat common except the silver-haired bat, western small-footed myotis, and long-legged myotis (Table 1). Reasons for their apparent low densities are discussed in Appendix A.

The list of ten species (Table 1) detected in DTNM encompasses all but one species thought to inhabit northeastern Wyoming, suggesting that although DTNM is small, it contains habitat needed to support all species in the region. The only species occurring in the vicinity but not found in DTNM was Townsend's big-eared bat (*Corynorhinus townsendii*), which is restricted to areas with large, cavern-like structures not thought to occur in the area.

Three of the ten species detected migrate long distances to spend their summers in DTNM. The eastern red bat, hoary bat, and silver-haired bat all spend winters in the southern and southeastern U.S. and summers across North America. All three species roost in the foliage of trees, and it is thought that they must migrate to warmer climates in order to survive winters away from the protection of caves. Although the rest of the species we detected are considered year-round residents of the Black Hills, they probably migrate outside DTNM to hibernate in thermally-protected caves during the winter. Hibernation is covered in more detail in the Discussion below.

At least one juvenile of each captured species was identified, confirming successful reproduction of little brown myotis, fringed myotis, hoary bat, big brown bat, northern long-eared myotis, western long-eared myotis, and eastern red bat (Table 2). Unfortunately, captures were not numerous enough to calculate reliable sex and age ratios, but males and females of most species were captured. This is significant because habitat segregation between males and females of the same species can occur during summer months, where areas of optimal habitat are allocated for females and their young. Although separation between maternity colonies and bachelor roosts is likely at DTNM, it appears that overall sex segregation does not occur. Literature and anecdotal evidence from captures indicate that most bat species in DTNM give birth to young between late-June and early-July. Young emerge from maternity roosts by early August. Males and females breed sometime between August and October and enter hibernation by early-November. Female bats delay egg implantation until April or May when they emerge from hibernation.

Park Buildings

We found no evidence of present or past bat activity in the Climbing Permit building at the base of the Tower. The Visitor Center/Bookstore building had a small amount of bat guano which appeared to be between 6 months and 2 years old. It is possible that small numbers of bats may have used the attic of that building for roosting or hibernating in the past. Neither building seemed suitable for supporting large numbers of roosting bats.

DISCUSSION

A key characteristic of DTNM that allows it to support so many bat species is its habitat heterogeneity. The geological complexity of the park is largely responsible for this variation by providing everything from exposed vertical rock to the flat river bottom of the Belle Fourche. There are additional features on which bats are particularly dependent which managers should strive to maintain or improve in order to aid bat conservation.

When comparing the level of recorded bat activity across different habitat types, forested areas were generally the most active. Many species that we detected in DTNM (Appendix A) are known to roost under the bark of snags and in the foliage of trees. In a conservation assessment of fringed myotis, Keinath (2004) discusses the importance of medium to large conifer snags (>30 in. DBH), specifically those that have been dead for several years, are still standing, and set in open stands with ample sun exposure. The fires that have swept through DTNM in the last 20 years have promoted this kind of forest structure which may help explain the high density of fringed and northern long-eared myotis captured at several forested sites. Continued forest management activities such as prescribed fire which maintain and promote crops of these medium to large ponderosa pine snags will help ensure the ongoing availability of this important roosting habitat for many species of bats.

The igneous rock formation of Devil's Tower itself and the sandstone outcrops which encircle the Tower provide some additional roosting habitat. During the day, bats will crawl into very small cracks and crevices in the rock to sleep and will often use the same roost day after day. Several nights of visual and acoustic monitoring around the base of the tower did not reveal evidence of large communal roosts (i.e. hundreds of bats). Visual inspection of a number of small caves and depressions in the aforementioned sandstone layer yielded similar results. Given that DTNM is not known to support large caves or suitable roosting buildings, our assessment is that bats roost (and possibly hibernate) in a relatively dispersed fashion within DTNM. Frequently used climbing routes along the Tower may have a small impact on bats by making specific cracks unsuitable for roosting due to continual human disturbance.

The degree to which bats are using rock features at DTNM for hibernation is unknown. Studies have shown that the characteristics of hibernacula (particularly of *Myotis spp.*) are quite specific in order to support bats during the long winter. Usually they are caves or abandoned mines that are deep underground and thermally protected with a constant temperature of about 40ºF. Humidity levels need to be almost 100% and a small amount of outside ventilation is needed to carry away carbon dioxide from the hibernation area (Adams 2003). Because cave formations are not known to exist in the park, and we found no evidence of large hibernacula, we suspect that most year-round residents are migrating in August or September to sites within about 50 miles of DTNM in order to hibernate.

Reliable water sources are also important features supporting bats in the park. We recorded many bats drinking water and feeding on emerged aquatic invertebrates above the Belle Fourche River, which underlines the importance of good water quality and quantity in the river. Similarly, the few small seeps and springs in the park that provided even small puddles of stagnant water appear to be heavily used by bats. For example, we caught 18 bats in as many minutes a one such spring (UTM: 521885, 4937732), which was the most activity detected anywhere in the park. The pond formed by this spring seems to be a particularly important landscape feature to tree-roosting bats (notably fringed myotis) in the otherwise dry landscape of DTNM. Other perennial springs throughout the park should also be targeted for conservation as they are undoubtedly important to bats. It is our understanding that some of these small springs are currently covered by human structures and DTNM is considering some level of natural restoration. If restoration is anticipated to result in the increased availability of surface water, we believe this will benefit bats.

The primarily disease of concern with regards to bats roosting in human structures is rabies. The disease can be transmitted if a rabid bat bites a human but not from humans inhaling guano. Although less than half of 1% of bats carry the disease, steps should always be taken to prevent bats from entering or roosting in the living or working quarters of occupied buildings. Based on the searches we conducted at buildings near the Tower, we found no evidence of bats in working quarters, but some past bat activity in a sealed-off attic. We do not think bats pose any human health risk at DTNM now or in the foreseeable future.

If bats are seen in living quarters, they should be caught and released humanely while using personal protection (bat fecal material looks like hard rodent pellets, but when crushed, it disintegrates and shiny insect parts are visible). The next step in excluding future bat entry is to find where the bat entered the living/working quarters and seal off the opening. Entry locations can be as small as one half inch. Outside entry locations should be sealed off from bat entry too, these locations are more common in old building and often occur where walls meet eaves, siding meets windows, or at the entrances of doors and chimneys. One-way exclusion devices are a humane way of allowing roosting bats to escape buildings while not allowing them back in. More information about bat removal and exclusion can be found on Bat Conservation International's website (BCI 2011).

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TABLES

Table 1. **Summary of mist net and acoustic survey results from bat surveys at DTNM**

Common Name	Scientific Name	Abundance	Number of captures	Number of recordings	Season of Residency in NE WY	Previously documented in DTNM[5]
Little Brown Myotis	Myotis lucifugus	common	28	>100	year-round	yes-captured
Fringed Myotis	Myotis thysanodes	common	28	70	year-round in NE WY	yes-captured
Hoary Bat	Lasiurus cinereus	common	5	>100	summer only	no
Big Brown Bat	Eptesicus fuscus	common	4	>100	year-round in NE WY	yes-recorded
Northern Long-eared Myotis	Myotis septentrionalis	common	4	>100	year-round in NE WY	yes-captured
Western Long-eared Myotis	Myotis evotis	common	2	>100	year-round in NE WY	yes-captured
Eastern Red Bat	Lasiurus borealis	uncommon	1	8	summer only	yes-recorded
Western Small-footed Myotis	Myotis ciliolabrum	apparently uncommon	0	65	year-round in NE WY	no
Silver-haired Bat	Lasionycteris noctivagans	apparently uncommon	0	35	summer only	yes-recorded
Long-legged Myotis	Myotis volans	apparently uncommon	0	30	year-round in NE WY	no

Table 2. **Sex and age information of captured bats in DTNM**

Common Name	Scientific Name	Females (Repro[6])	Males (Repro)	Juveniles [7]	Adults
Little Brown Myotis	Myotis lucifugus	17 (3)	11 (1)	7	16
Fringed Myotis	Myotis thysanodes	13 (2)	15 (0)	6	22
Hoary Bat	Lasiurus cinereus	2 (0)	3 (0)	1	4
Big Brown Bat	Eptesicus fuscus	0	4 (0)	1	3
Northern Long-eared Myotis	Myotis septentrionalis	1 (0)	3 (0)	3	1
Western Long-eared Myotis	Myotis evotis	2 (1)	0	1	1
Eastern Red Bat	Lasiurus borealis	1 (0)	0	1	0
Totals		36	36	20	47

[5] Schmidt et al .2004.
[6] Repro = Number of captured adults that were in reproductive condition. This mainly includes pregnant, lactating and post-lactating females, but also one male with descended testicles.
[7] Juvenile and adult data excluded June 2010 captures (before juvenile emergence).

ACKNOWLEDGEMENTS

We appreciate the efforts of Mark Biel and Angela Wetz, Resource Managers at DTNM for securing funds and helping coordinate this project. Shirley Cummings, private land owner kindly granted permission to conduct surveys on her land. We also appreciate the field surveys performed by Paula O'Briant and Ken Brown.

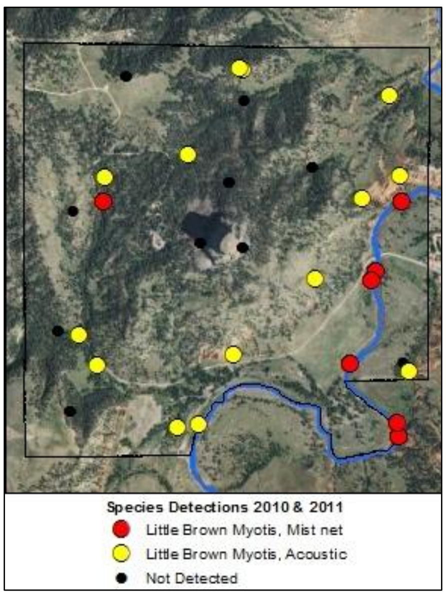
APPENDICES

APPENDIX A: Species Accounts

Little Brown Myotis *(Myotis lucifugus)*

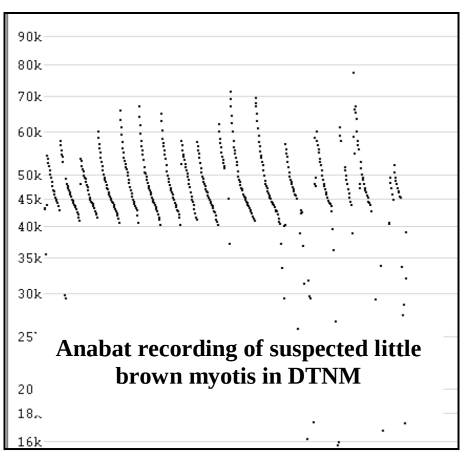
Species Ecology

Because of its behavioral and ecological versatility, the little brown myotis ranges widely across North America and Wyoming. It is a year-round resident, although females are thought to migrate as far as several hundred kilometers between summer maternity and winter hibernating roosts (Adams 2003). The little brown myotis is most common in conifer forest, streamside riparian and urban areas; usually found near open water and absent from hot, arid lowlands. During summer, the little brown bat uses a wide variety of roosts including buildings, trees (cavities and loose bark), bridges, rock crevices, caves, and abandoned mines. It is one of the most common species in Wyoming's buildings. It mainly forages over water, often within a few feet of the surface, but also in open woodlands and forest openings. Although an opportunistic feeder, it mainly eats small, soft-bodied, flying insects, particularly emerging aquatic insects (e.g., caddisflies, mayflies, midges, mosquitoes).



DTNM Notes

Little brown myotis is very common in DTNM. It was most frequently recorded and captured above the Belle Fourche River, where it forages just above the water surface. A few captured females were lactating or had recently weaned pups in August, and half the individuals captured at the same time were juveniles. This, along with a female-biased sex ratio (Table 2) indicates that there may be one or more maternity roosts in or near DTNM. Within the park, such roosts could occur in large snags that receive suitably high solar warming. Due to an apparent lack of large caves in the area, these maternity roosts probably support dozens of individuals, instead of hundreds. Little brown myotis tend to hibernate in large caves and are one of the most susceptible species to infection by White-nose Syndrome.

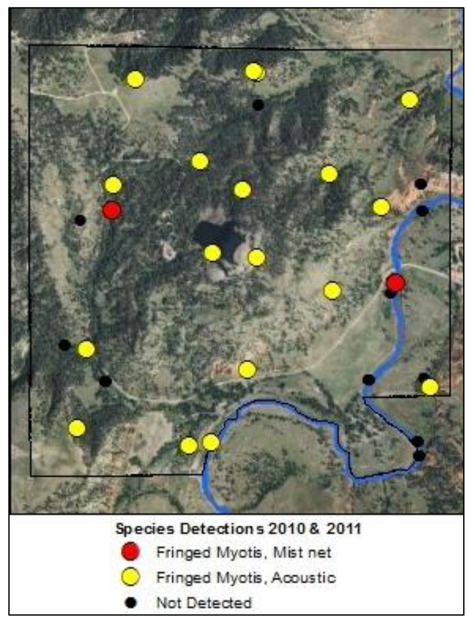


Anabat recording of suspected little brown myotis in DTNM

Fringed Myotis *(Myotis thysanodes)*

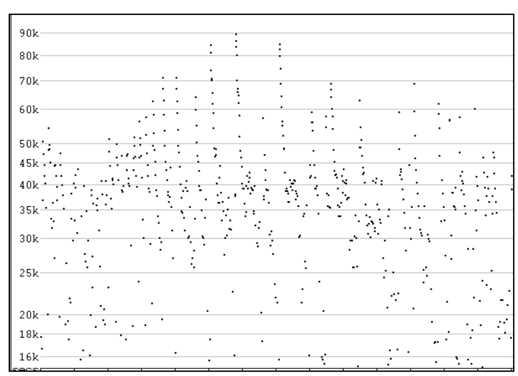
Species Ecology

The fringed myotis ranges across most of western North America preferring dry woodlands at mid-elevations. In Wyoming, the species occurs primarily in the sagebrush steppe and open forests of the mountain foothills (Keinath et al., 2010). Fringed myotis are thought to migrate intermediate distances between summer roosts and winter hibernacula, but very little information is available about its migration habits (Adams 2003). It has been documented roosting in rock crevices, caves, mines, and buildings, but it was also found throughout Grand Teton National Park in the apparent absence of such features, leading Keinath (2005) to assume that snags were also used as roosts. Fringed myotis primarily eat beetles and moths which they catch within the forest canopy or along forest edges.



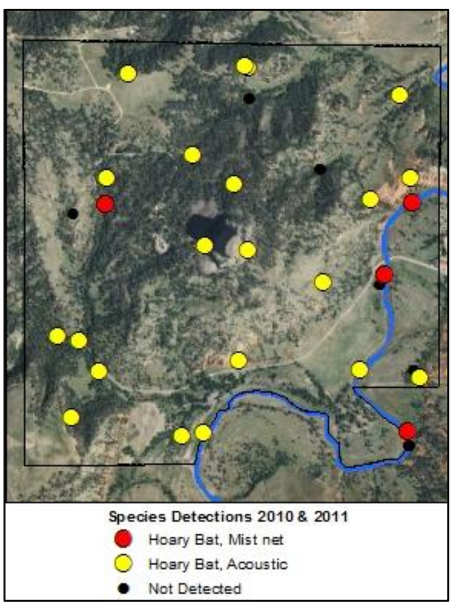
DTNM Notes

The apparently distinct subspecies *Myotis thysanodes pahasapensis* occurs in DTNM (Adams 2003). Fringed myotis are very common in DTNM and were caught in large numbers at a small spring west of the Tower. Preferring to forage within the forest, the species is likely to depend heavily on these small water bodies instead of venturing out into the open Belle Fourche River. The wealth of suitable roost sites, namely rock crevices and snags might explain the high numbers in DTNM. Maternity colonies probably exist within or near DTNM as 20% of the individuals captured in August were juveniles. Generally, maternity colonies of fringed myotis have 30-35 females and are particularly susceptible to disturbance from humans (Adams 2003). It is unclear whether fringed myotis that spend the summer in DTNM also hibernate there. The limited extent of this subspecies and its vulnerability to White-nose Syndrome make it a high priority for conservation.



Anabat recording of suspected fringed myotis in DTNM

Hoary Bat *(Lasiurus cinereus)*

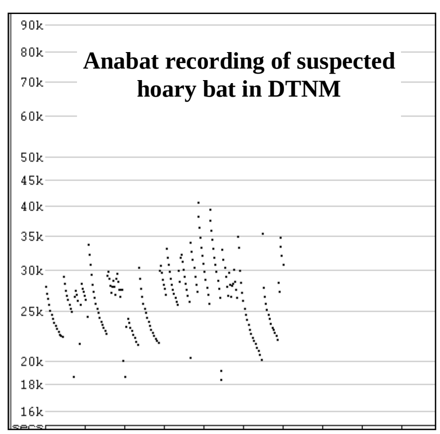


Species Ecology

The hoary bat ranges throughout North America and is considered widespread throughout Wyoming. It is one of Wyoming's few long-distance migrants, spending its winters in the southern and southeastern United States. Hoary bats are large and fast, preferring to forage in open areas where they hunt moths and other large-bodied insects. They usually forage late in the evening, 2 to 5 hours after sunset. They are solitary and roost in the foliage of deciduous and coniferous trees rather than communally in geologic or human structures. Ideal habitat consists of a mixture of trees and open areas because they often roost and forage along forest edges.

DTNM Notes

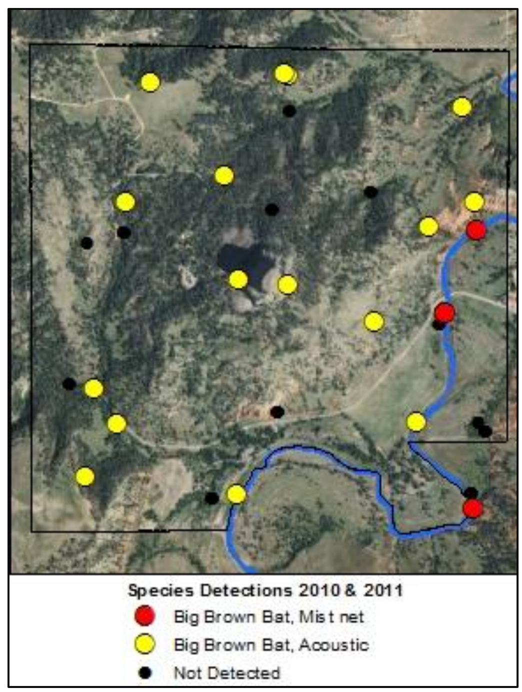
Hoary bats are widespread in DTNM. Five individuals were captured and numerous calls recorded in both open and forested habitats suggesting that they are somewhat common in the park, though they are solitary rooters and thus occur at lower densities than other species. This is an exciting discovery because hoary bats have been difficult to catch and few documented in Wyoming. Compared with year-round residents, hoary bats are less susceptible to White-nose Syndrome because they hibernate outside and in isolation. Hoary bats are, however, susceptible to human impacts such as habitat destruction and mortality from wind turbines.



Big Brown Bat *(Eptesicus fuscus)*

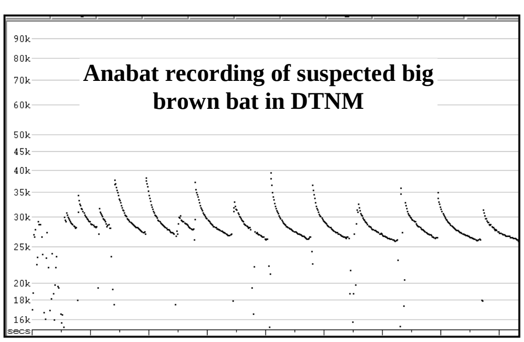
Species Ecology

The big brown bat is found across most of North America. Although it has been documented in sagebrush, it is most often associated with forested habitats and ranges from low-elevation riparian to high-elevation conifer habitats in Wyoming. They are beetle-eating specialists, but will also take other winged insects. Big brown bats are year-round residents and hibernate alone or in small groups in caves, abandoned mines, or human structures. They are known for their tendency to roost in buildings, but they also use rock crevices, caves, abandoned mines, bridges, and tree cavities. Females form large maternity colonies in the summer which disband in August or September when they join up with the males, mate, and find hibernacula.



DTNM Notes

Big brown bats tend to forage soon after sunset and their relatively large body size, propensity to forage in open areas, and characteristic figure-eight flight pattern make them easy to see above the Belle Fourche River and around the base of the Tower during summer months. They are wide-spread and common in DTNM although more so in open habitats rather than dense trees. The risk of White-nose Syndrome infection in big brown bats at DTNM is thought to be medium because it hibernates in smaller groups than many *Myotis* species that occur in the park.



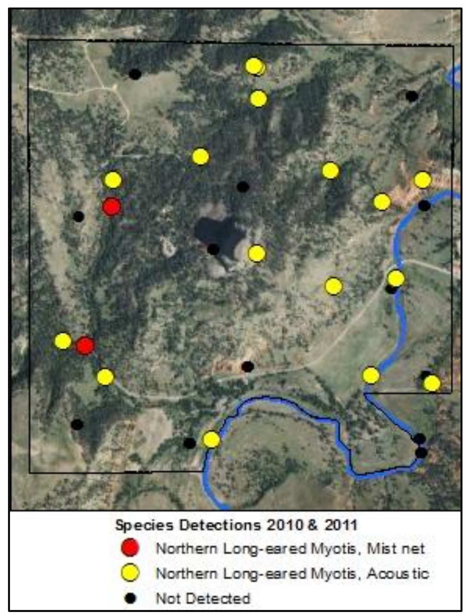
Anabat recording of suspected big brown bat in DTNM

Northern Long-eared Myotis *(Myotis septentrionalis)*

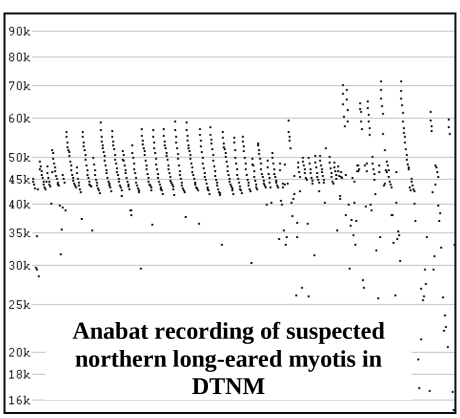
Species Ecology

Northern long-eared myotis range from southern Canada through central and eastern United States. They barely extend in to Wyoming, only occurring in the Black Hills where relatively few specimens have been documented. They tend to occur in forested areas, are agile fliers, and glean insects from leaves, branches and the ground. They are year-round residents, presumably hibernating in moist caves or mines for up to 9 months with as many as 100 other individuals. In the summer, they tend to roost or in small groups in rock crevices or in foliage (Adams 2003).

DTNM Notes



Although northern long-eared myotis were recorded throughout the park, they were much more abundant at forested sites and were only captured in mist nets placed between the forest canopy and surface water. Like the fringed myotis, they seem to keep primarily to the forest to roost and forage. For this reason, maintaining small springs with canopy cover will be important for their conservation. Small maternity colonies probably exist in DTNM as several juveniles were captured in late summer. Northern long-eared myotis in DTNM probably hibernate in caves or abandoned mines in the Black Hills and are vulnerable to infection from White-nose Syndrome.

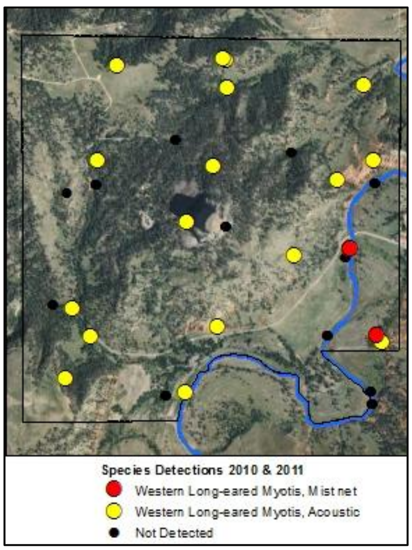


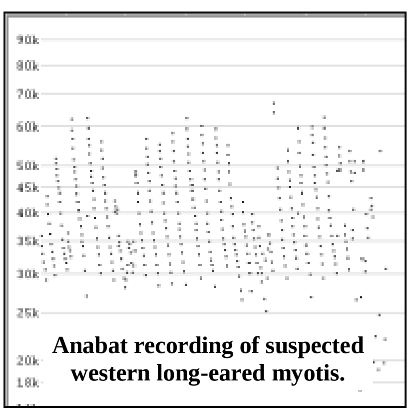
Anabat recording of suspected northern long-eared myotis in DTNM

Western Long-eared Myotis *(Myotis evotis)*

Species Ecology

Western long-eared myotis looks similar to the northern long-eared myotis but has even longer ears and opaque skin on its tail. It ranges throughout temperate western North America. In Wyoming, the species does not occur in dry basins, but is most common at intermediate elevations and foothills (Keinath et al. 2010). It is primarily a foliage gleaner, capturing insects on bark and leaves by listening to the flutter of their wings. For this reason, it prospers in vegetatively complex environments ranging from sagebrush shrubland to thick conifer forests (Adams 2003). It roosts in small groups under the bark or in the hollows of snags, in caves, or human structures. Primary food sources are moths and small beetles. Long-eared myotis are colonial and after feeding they often gather in night roosts that are near, but separate from, day roosts. Little is known about the hibernation habits of western long-eared myotis, but it is assumed that they hibernate in relatively small groups in caves or mines (Adams 2003).





Anabat recording of suspected western long-eared myotis.

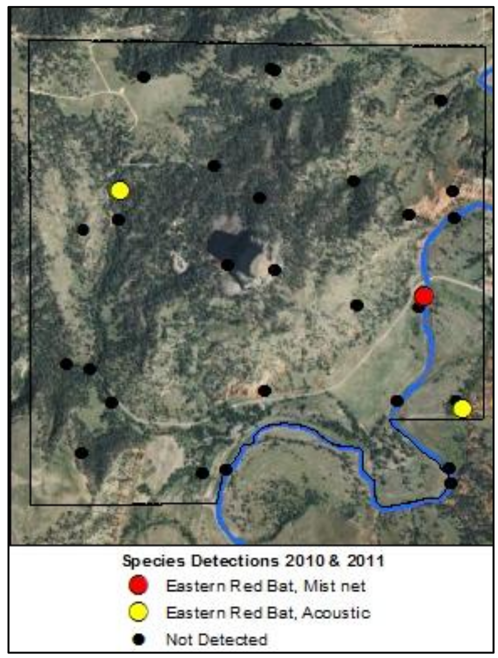
DTNM Notes

Western long-eared myotis are widely distributed in DTNM but were not abundant at any one site. Only two individuals were caught during mist netting and we were not entirely sure of correct identification in both cases. Fortunately, the species' echolocation signature is not easily confused with other species. One of the supposed individuals caught was a lactating female and the other a juvenile female lending credence to the existence of maternity colonies within the park. The risk of White-nose Syndrome is substantial due to its presumed habit of hibernating in groups.

Eastern Red Bat *(Lasiurus borealis)*

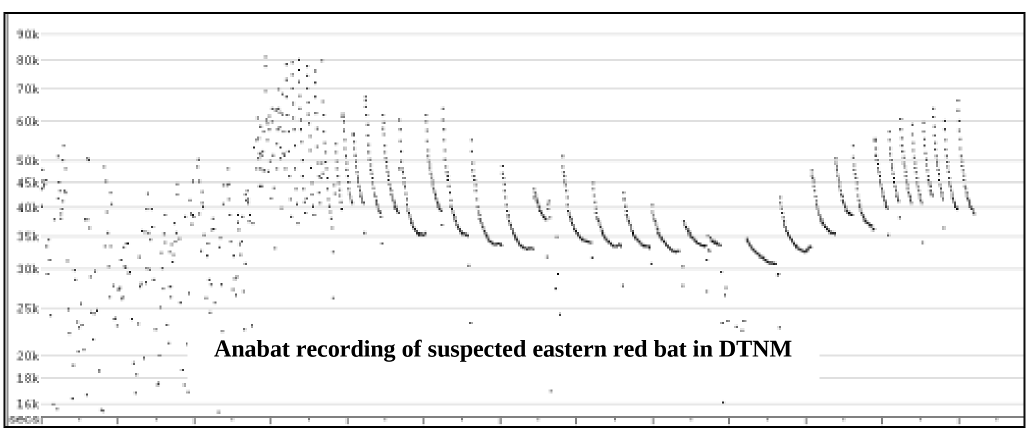
Species Ecology

The eastern red bat has a wide range across central and eastern North America and only occurs in far eastern Wyoming. It is one of three species that migrates from the southern and eastern United States to spend its summers in Wyoming. The red bat primarily roosts in the foliage of deciduous trees, hanging upside down, apparently imitating a dried leaf. It is generally solitary, except during fall migration. In Wyoming, most records are from riparian areas near perennial water where it preys by aerial pursuit on moths and other insects.



DTNM Notes

One adult female was captured in DTNM along the Belle Fourche River in June 2010. Red bats were also detected at two Anabat sites in the park. All three detections were in habitat dominated by deciduous trees (cottonwoods and oaks) which leads us to believe that this might be the preferred habitat of the species in DTNM. Based on these limited detections, our assessment is that the species is uncommon in DTNM as is probably the case in the broader region. Red bat vulnerability to White-nose Syndrome is considered low because it hibernates outside and in isolation.

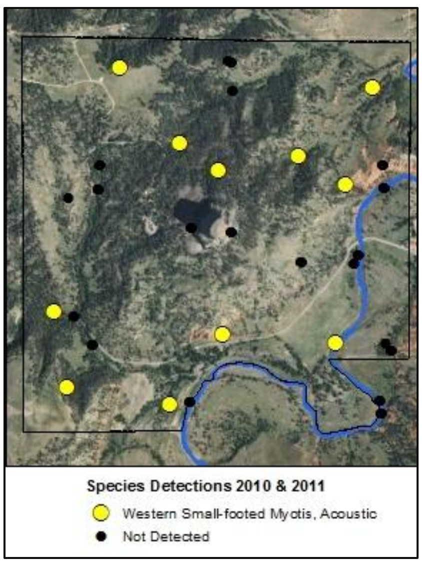


Anabat recording of suspected eastern red bat in DTNM

Western Small-footed Myotis *(Myotis ciliolabrum)*

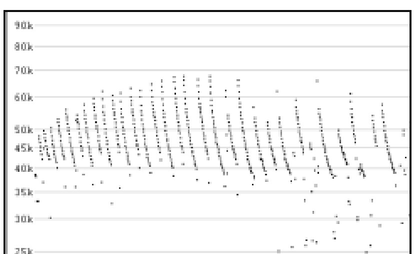
Species Ecology

The western small-footed myotis has a range encompassing southern Canada and extending through the Rocky Mountain states to Arizona and New Mexico. It is found throughout most of Wyoming, but is excluded from high mountains and most of northeastern Wyoming (Keinath et al. 2010). It is commonly associated with middle and low-elevation arid, rocky areas (such as canyons, cliffs, rock outcrops, and badlands) within a variety of habitats (e.g., montane forest, juniper woodlands, sagebrush steppe, shortgrass prairie). It is a year-round resident, known to hibernate is small colonies, a few of which have been identified in north-central and southwestern Wyoming (Adams 2003). Diurnal roosts are varied, but tend to be rock shelters (crevices, overhangs, cliffs, and under rocks), caves, and abandoned mines. Unlike many other species, it will roost at ground level. Small-footed myotis typically forages along cliffs and rocky slopes in dry areas, but can forages over water. It is highly maneuverable, often foraging low to the ground (i.e., <10 ft) among boulders, shrubs, and trees, feeding on a variety of small, soft-bodied insects, especially moths.



DTNM Notes

The western small-footed myotis was recorded at 11 sites throughout DTNM, but none were captured in mist nets. Because the species' echolocation calls can be confused with other species, we cannot be completely certain that it is a resident although ample habitat exists in the form of cliffs, boulder fields, gullies, and badland formations. Relatively few recordings were made leading us to believe that the species is somewhat uncommon in the park. White-nose Syndrome vulnerability is considered high in this communally-hibernating species.

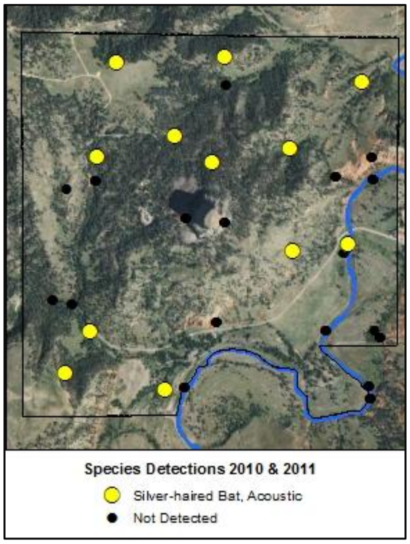


Anabat recording of a suspected western small-footed myotis

Silver-haired Bat *(Lasionycteris noctivagans)*

Species Ecology

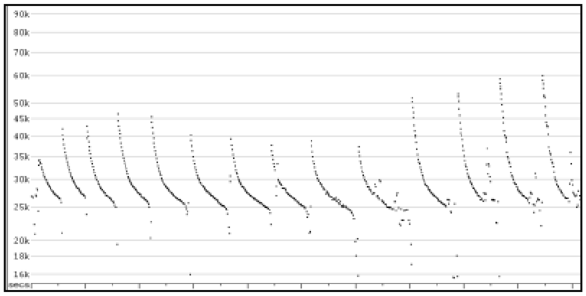
The silver-haired bat is found in most of North America at varying abundance. The silver-haired bat roosts almost exclusively in trees. In Wyoming it occurs state-wide but usually in association with late-successional montane forest. High snag density and the availability of open water are other important habitat characteristics. Like the hoary and eastern red bat, it migrates hundreds of miles from southeastern United States to spend its summers in Wyoming. Reproductive females normally roost in small colonies within tree cavities, while males and non-reproductive females roost singly under loose bark or within cracks and crevices. The silver-haired bat usually forages close to the ground (i.e., < 8ft). Although a somewhat generalist feeder, it is a slow and agile flier, making it good at pursuing small, swarming insects at short distances.



DTNM Notes

The silver-haired bat was not captured during our mist netting efforts, although it was recorded at 12 sites throughout DTNM. It was captured by Schmidt et al. (2004) during a bat survey in 2003 which serves to confirm its residency in the park. Based on the relatively few recordings we picked up, we assume that the species is somewhat uncommon in DTNM.

This might be because the available habitat is slight more xeric than is ideal for this montane species. Silver-haired bat vulnerability to White-nose Syndrome is considered low because it hibernates outside and in isolation.

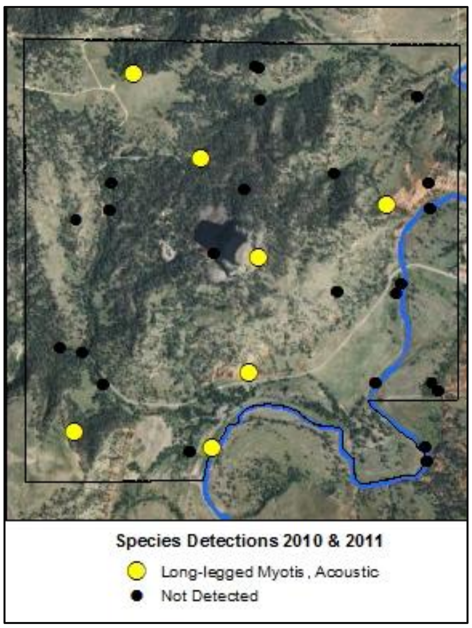


Anabat recording of suspected silver-haired bat in DTNM.

Long-legged Myotis *(Myotis volans)*

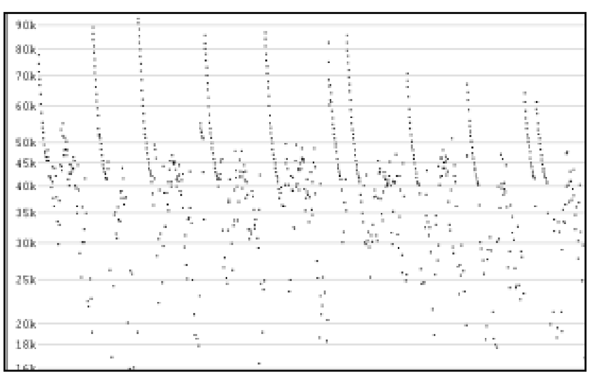
Species Ecology

Long-legged myotis occurs throughout western North America from Alaska to northern Mexico. In Wyoming, it is limited to mid and high elevation forests with many snags. During summer, females form maternity colonies in tree cavities, loose bark, buildings, and rock crevices. Most roosts are in large-diameter snags with loose bark, near forest openings, and near permanent water. Males will roost more broadly. It is considered a year-round resident and hibernates in caves and mines. The long-legged myotis is a rapid, direct flier that pursues moths and other insects in forest openings.



DTNM Notes

The long-legged myotis was recorded at 7 sites throughout DTNM, but none were captured in mist nets. Because the species' echolocation calls can be confused with other species, we cannot be completely certain that it is a resident. Relatively few recordings were made, leading us to believe that the species is somewhat uncommon in the park.



Anabat recording of suspected long-legged myotis in DTNM

Habitat may not be ideal for the species as it tends to occur in dense forests at higher elevations. White-nose Syndrome vulnerability is considered high in this communally-hibernating species.

APPENDIX B: Wyoming Species Identification Key

Key to the Bats of Wyoming

Doug Keinath, WYNDD Zoologist

#	If this is true …	… then go to …
1a	Tail extends 1/3 or more beyond rear edge of uropatagium.	2
1b	Tail does not extend more than barely beyond rear edge of uropatagium	3
2a	Forearm > 50mm. [Large bat. Ears join at forehead. Pale-brown to black fur.]	Nyctinomops macrotus
2b	Forearm < 50mm. [Smallish bat. Ears almost joined at forehead. Gray-brown fur.]	Tadarida brasiliensis
3a	Conspicuous pair of white spots on shoulders and one on rump contrast with black dorsal fur. Pink ears.	Euderma maculatum
3b	Lacks white dorsal spots.	4
4a	At least anterior half of dorsal surface of uropatagium heavily furred.	5
4b	Dorsal surface of uropatagium mostly naked or scantily furred.	7
5a	Distinct white patches of fur at dorsal bases of thumbs and often on shoulders. Dorsal surface of uropatagium fully furred.	6
5b	No white patches of fur at dorsal bases of thumbs or on shoulders. Dorsal surface of uropatagium ranging from half to fully furred. Black dorsal fur with silver tips. Black face and uropatagium.	Lasionycteris noctivagans
6a	Light colored ear distinctively edged in black. Dorsal hairs dark gray and tipped with a broad band of white giving a hoary colored appearance. Forearm 46-58mm.	Lasiurus cinereus
6b	Light colored ear never edged in black. Fur bright reddish-orange to yellow in males and tending toward light brownish – grayish in females. Dorsal hairs never dark gray and tipped with white, though possibly frosted. Forearm 35-45mm.	Lasiurus borealis
7a	Dorsal fur lighter at base (pale yellow-blond) than tips (brown). Pale translucent ears 25-33mm long. Forearm 50-55mm. Blunt snout.	Antrozous pallidus
7b	Dorsal fur darker at base than tips. Fur color, ear and forearm lengths highly variable.	8
8a	Prominent pair of lumps above nose on each side of muzzle (see picture). Ear length 30-39mm. Slate-gray fur.	Corynorhinus townsendii
8b	No lumps on nose.	9
9a	Very small bat (mass ≤ 6g; forearm usu. < 33mm). Tragus relatively short and not sharply pointed.	10
9b	Larger (mass > 6g; forearm usu. > 33mm). Tragus longer and somewhat pointed.	11
10a	Small-bodied (3-6g). Tragus short (<5mm), blunt, and club-shaped. Body fur medium to pale brown in contrast to jet black face and ears. Tail membrane sparsely furred on anterior third of dorsal surface. Forearm 27-33mm.	Pipistrellus Hesperus
10b	Hair distinctively tricolored (dark base / light middle / dark tip). Lighter ears and no distinct face mask. Leading edge of wing noticeably paler than rest of membrane. Forearm 30-35mm.	Pipistrellus subflavus
11a	Large, medium to dark brown with keeled calcar. First upper premolar ≥ ½ canine length (see Fig. 11a). Forearm 42-51mm (wingspan 325-350mm). Tragus rounded.	Eptesicus fuscus
11b	Smallish bat. First upper premolar less than ¼ as tall as canine (see Fig. 11b).	12 (myotis spp.)

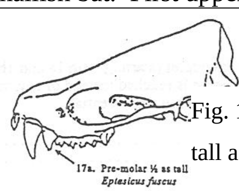


Fig. 11a. First upper premolar ½ as tall as canine (*Eptesicus fuscus*)

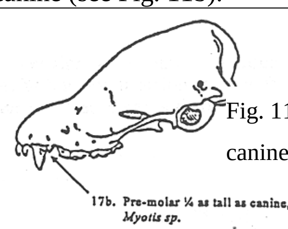


Fig. 11b. First upper premolar < ¼ as tall as canine (*Myotis spp.*)

Myotis species

#	**If this is true …**	**… then go to …**
12a	Calcar keeled. (see Fig. 12a)	13
12b	Calcar NOT keeled. (see Fig. 12b)	15

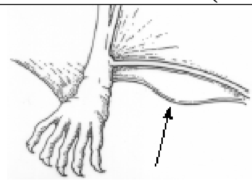


Fig. 12a. Keeled calcar (go to 12)

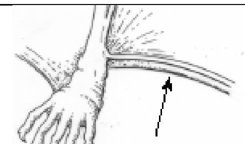


Fig. 12b. Keel absent (go to 14)

Keeled calcar

13a	Forearm 38-42mm (wingspan 250-270mm). Body fur uniformly dark brown or grayish brown with no distinctively darker face mask. [Underside of wing furred from side to elbow.]	Myotis volans
13b	Forearm 29-36mm. Body fur medium to very light tan or reddish brown with clearly darker face mask. [Underside of wing not furred from side to elbow.]	14

14a	Thumb length < 4.2mm. Tail does NOT extend beyond uropatagium. Braincase has an abruptly rising profile (convex forehead). Length of bare snout ≈ width across nostrils. Dorsal fur dull, pale colored, with slightly-contrasting dark brown face mask.(Fig. 14a)	Myotis californicus
14b	Thumb length > 4.2mm. Tail often extends slightly beyond uropatagium. No distinct rise in braincase profile (sloping forehead). Length across snout ≈ 1.5 times width across nostrils. Dorsal fur slightly shiny, pale colored, and sharply contrasting with black face mask. (Fig. 14b)	Myotis ciliolabrum

Fig. 14a. *M. californicus:* Rising braincase. Length of bare snout ≈ width across nostrils.

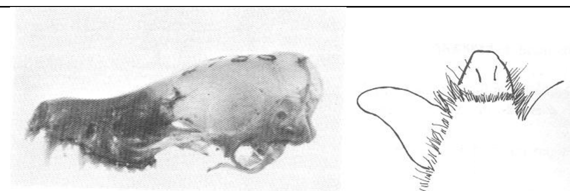


Fig 14b. *M.ciliolabrum*: Shallow braincase. Length across snout ≈ 1.5 times width across nostrils

Long Ears

15a	Distinct fringe of hair extending 1.0-1.5mm beyond edge of uropatagium (picture). Ears darkly pigmented and 16-20mm long. Belly fur light. Forearm 39-46mm.	Myotis thysanodes
15b	Fringe absent (no more than scattered hairs on edge of uropatagium).	16

16a	Ear length ≥17mm.	17
16b	Ear length ≤ 16mm.	18

17a	Ears, wings, and uropatagium are blackish and opaque. Ear length 17-24mm (WY: 17-23mm, but usu. ~20mm). Ears extend past end of nose when laid down. Fur light brown with hairs black at base. [May have an inconspicuous fringe of hairs on the posterior uropatagium.]	Myotis evotis
17b	Ears, wings, and uropatagium are brownish and translucent. Ear length 15-19mm (WY: 15-16mm).	Myotis septentrionalis

18a	Dorsal body fur brown to reddish-brown, long and glossy. Forearm usually 36.5-40.5mm (BC Range: 33.0-40.3mm). Ears dark, 14-16mm long, with short tragus. Forehead with a gradual slope (Fig. 18a), skull usually greater than 14mm. Ventral fur light-tipped but never white. Many foot hairs extend beyond toes.	Myotis lucifugus
18b	Dorsal body fur brown to reddish-brown, short and dull. Forearm usually 32-36mm (BC Range: 30.0-38.0mm). Ears paler, 12-14mm long. Forehead with steep slope (Fig. 18b), skull usually less than 14mm. Ventral fur with whitish tips.	Myotis yumanensis

Fig. 18a. *M. lucifugus*: Forehead with gradual slope

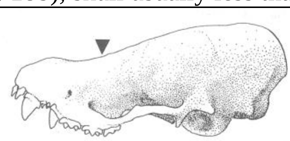
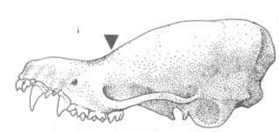
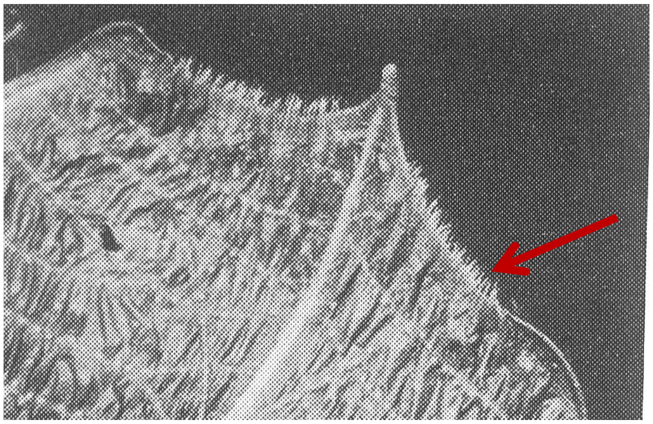


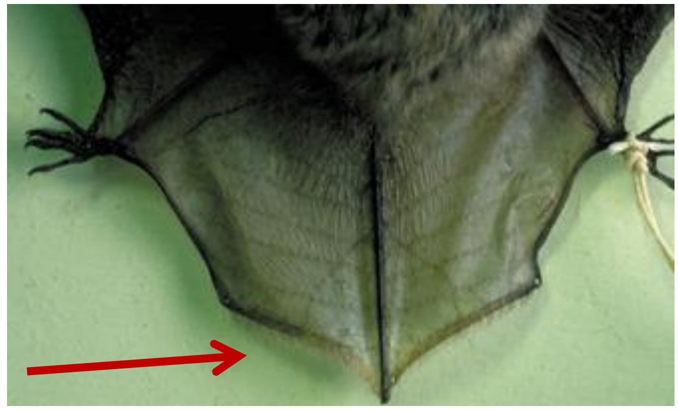
Fig. 18b. *M. yumanensis*: Forehead with steep slope



Supplementary Images for the Wyoming Bat Key

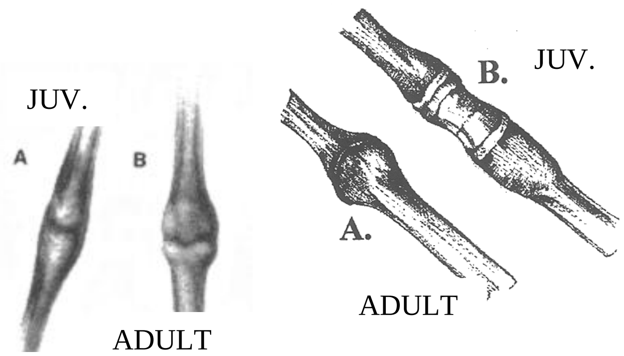


Uropatagial fringe of *Myotis thysanodes*

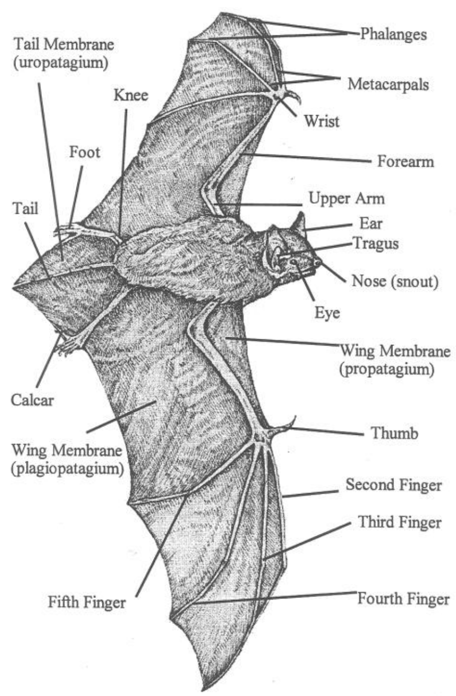


Face and tragus of *P. hesperus*

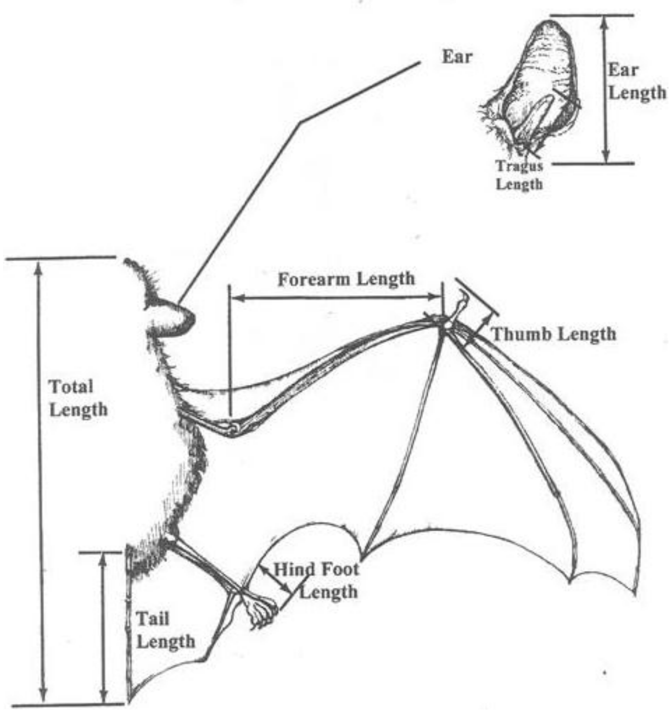
Nose folds of *C. townsendii*



Finger joint of juvenile (tapered, epiphesial plates visible) and adult (nobby and opaque) finger joints, as seen by illuminating the wing from behind (From Nagorsen and Brigham, 1993)



Bat Anatomy (from AZ bat conservation workshop)



Standard Bat Measurements (from The Bats of Texas)

APPENDIX C: Wyoming Anabat Call Key

Wyoming ANABAT Call Key (2011 DRAFT)

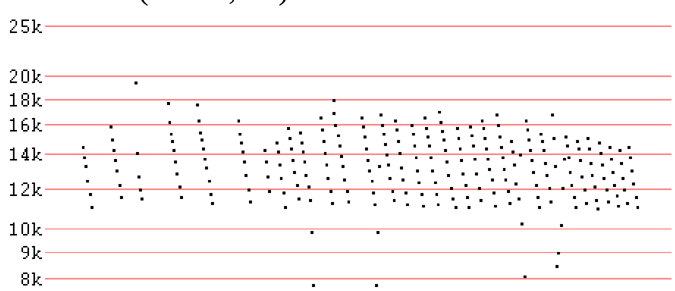
Developed by *Douglas A. Keinath*

Wyoming Natural Diversity Database, Laramie, Wyoming

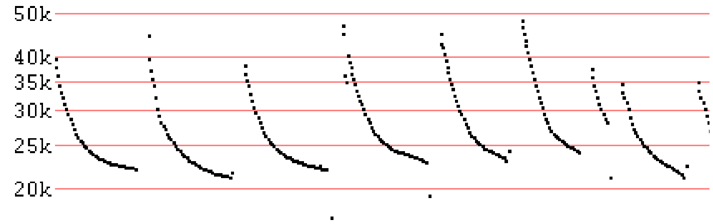
NOTE: Anabat® is a system designed to help users find and identify echolocating bats by digitally recording those calls and plotting them on a computer (for more information see: http://users.lmi.net/corben/anabat.htm #Anabat%20Contents). Before employing this key, users should be familiar with general principals of call analysis (e.g., http://users.lmi.net/corben/glossary.htm #Glossary). With such background information, this key can be used to roughly classify calls. Questionable calls, calls of difficult to distinguish species, or calls that represent new occurrences in an area should always be viewed by local Anabat® experts. In Wyoming, people should contact the Wyoming Natural Diversity Database (Doug Keinath) or the Wyoming Game and Fish Department (Martin Grenier).

Fmin (kHz)	Description	ID
< 10	1. Calls steep and sparse. Usually beginning above 10 and ending below 8. Calls can be heard audibly with unaided ear; sounds like two pebbles being struck together.	EUMA
16 – 20	2. Calls usually low slope & can be hook-shaped. Calls tend to jump around in Fmin, but typically ~20k or lower. Calls tend to vary in curvature throughout the sequence. Often give several calls at a higher freq, but with same shape.	LACI
~ 25	Fmin ~25 and with distinct tail. Two possibilities (LANO or EPFU), which are difficult to distinguish from each other, especially in clutter. Many call files must be reported simply as "**aB25k**"	a25k
	3. Calls are more bilinear than EPFU. Slope of tail is more variable than EPFU. Min Δslope often ~10 and Δslope plots usually "dribble off" rather than forming "fish-hook" ends. Calls rarely fall below 25k. Calls very regularly spaced ("metronome").	LANO
	4. Calls are more curvilinear than LANO, but can be more bilinear when they are short in sweep (i.e., ~25-40). Slope of tail is very consistent. On flat calls, Δslope plots may show many calls with "fish-hook" ends. Fmin often not uniform, with some calls falling below 25k. Calls sometimes irregularly spaced ("heart beat").	EPFU

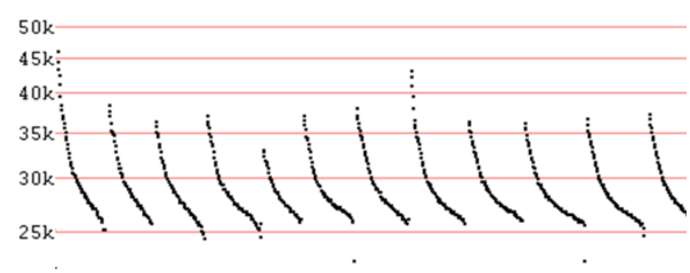
1. EUMA (Div16, F7)



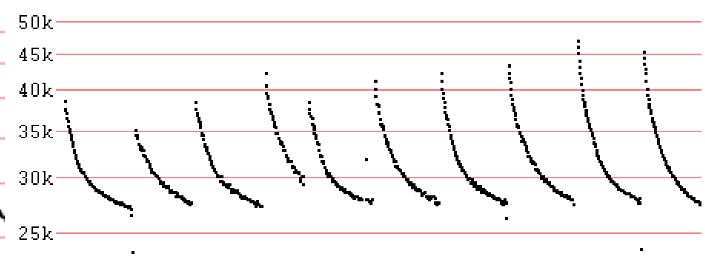
2. LACI (Div16, F7; stock file)



3. LANO (Div16, F6)

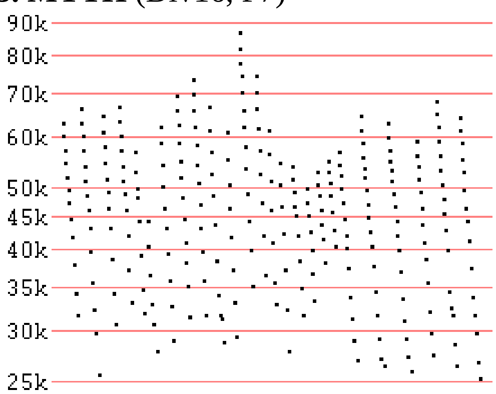


4. EPFU (Div16, F6)

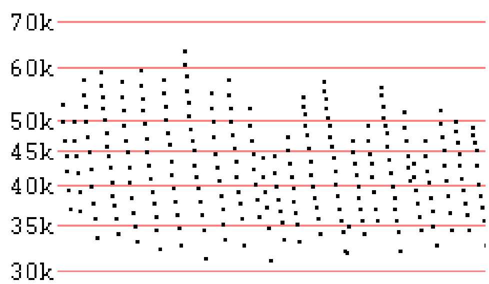


Fmin (kHz)	Description	ID
~ 25 - 30	F-min 25 – 30 and calls very steep with little tail. Four possibilities (MYTH, MYEV, COTO, ANPA). If sequences are not long and clean, many of these can be difficult to tell apart and must then be reported simply as "**aB30k**".	aB30k
	5. Calls very steep (Δslope ≥ 100) with huge freq. range (usu. > 50 and up to 20-100 in same call) and no tail. Variable Fmin with some calls usu. dropping to or below 25.	MYTH
	6. Calls very steep (Δslope usu > 150; often 300) and very sparse, with no tail. Fmin usu ~35, but varies within sequence, seldom dropping below 30. Freq range usu ~30.	MYEV
	7. Calls steep, but often slightly more curved than MYTH or MYEV and somewhat "thicker". Very little tail, but sometime "dribbling off" in a "lazy S" shape. Fmin ~30k and Fmax ≥50. Can also be difficult to tell from EPFU in clutter, which will usu. have time between calls of <100ms	ANPA
	8. Calls steep, weak, have ***two harmonics***. Fmin usu ~30, but can be ≤25. Harmonic-break often bet. 40-50. Sometimes only one harmonic captured: Upper can look like 50k myotis; lower can look like steep 25k getting thinner at tail	COTO
	9. Unique in its variability; calls vary between flat to steep in same sequence. Flat calls usually sweep 28-25 kHz, while steep usually sweep 60-27kHz. <u>Behavior</u>: open habitat, flying straight for moths and large insects.	TABR

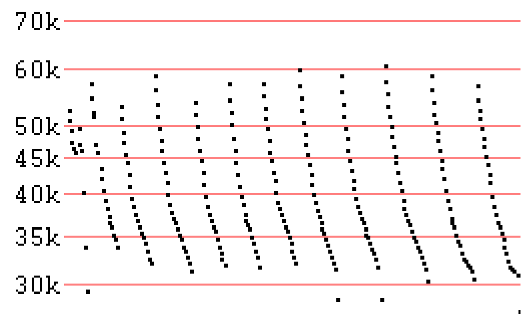
5. MYTH (Div16, F7)



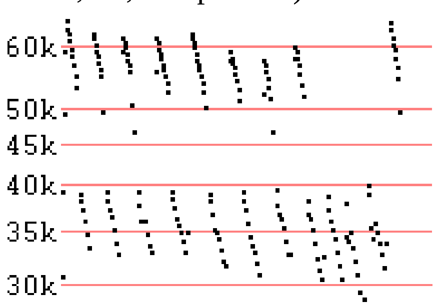
6. MYEV (Div16, F7)



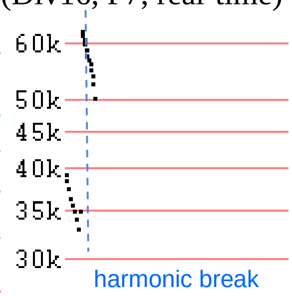
7. ANPA (Div16, F7)



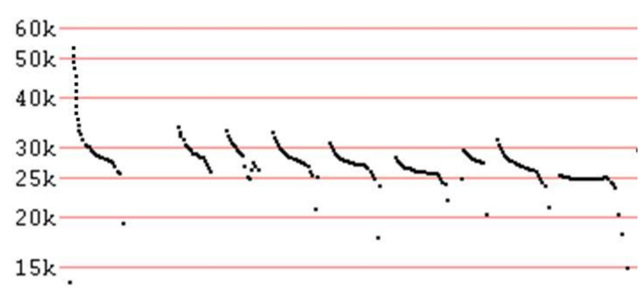
8a. COTO
(Div16, F7, compressed)

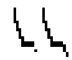


8b. COTO
(Div16, F7, real-time)

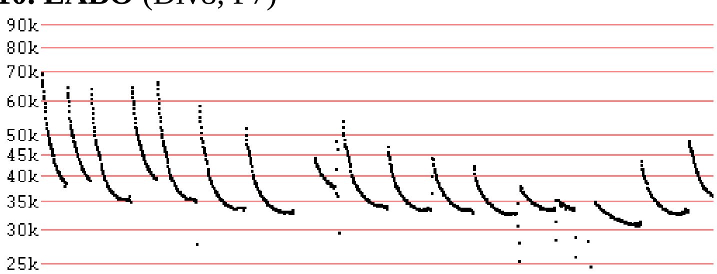


9. TABR
(Div16, F7, stock file)

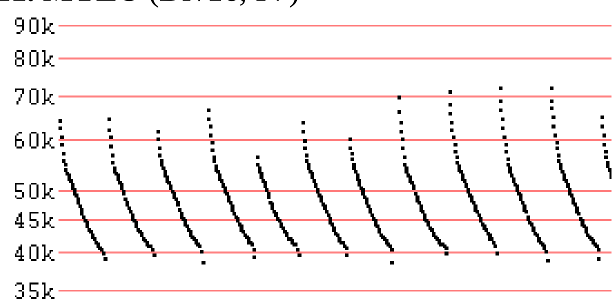


Fmin (kHz)	Description	ID
~ 27 - 35	10. Calls increases in frequency at end, creating a slight hook shape (like hoary bat). Calls sweep steeply from over 50k to just below 40k, with numerous calls often shifted downward so Fmin can be as low as 27k.	LABO
~ 40	Fmin usually at 40k, with some potentially falling above or below. Four possibilities (MYLU, MYCI, MYSE, MYVO). 40k myotis are very difficult to distinguish from each other, especially in clutter. Many call files must be reported simply as "**aM40k**".	aM40k
	11. Gently curved slope throughout call (but often get more bilinear in clutter and may "dribble off" at the end). Clean calls often sweep from ~100 to just over 40. On clean calls, Δslopemin can be as low as 40, but usually higher. Sometimes alternate curved call with a more linear one. Behavior: MYLU classically feed over water, which can result in "wobbly" calls."	MYLU
	12. Calls steep and regularly have a small "toe" at or just before the end, resulting in a "golfclub" or "S" shaped call. Even with a toe, calls usually have Δslopemin near 80. Clean calls usually straighter than MYLU, but can be more curvilinear than MYVO. Calls can have a wobble in the middle of the call (usually ≤50k). Behavior: MYCI feed around vegetation, like MYCA.	MYCI 
	13. Calls look similar to MYEV, but lower frequency limit is roughly 40kHz. Calls typically sweep from 80kHz to just over 40kHz. Clean calls are straighter than MYLU and MYCI and less vertical than MYVO. Behavior: MYSE feed around vegetation, often forests, gleaning and aerially pursuing insects.	MYSE
	14. Calls steep often with "wiggly look"; like MYLU in clutter, but greater call spacing. Calls tend to be more linear (or bilinear) than MYLU and have less "toe" than MYCI. Calls can have a wobble high in the sweep (usually ≥50k). Δslope is usually high (~100) but can drop to ~60. Difficult to distinguish from other 40k myotis	MYVO

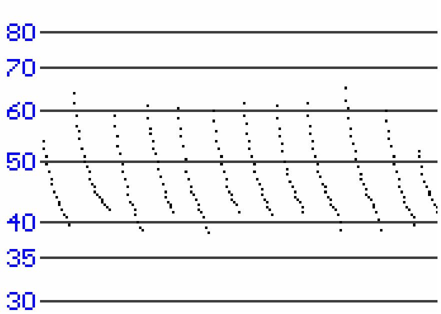
10. LABO (Div8, F7)



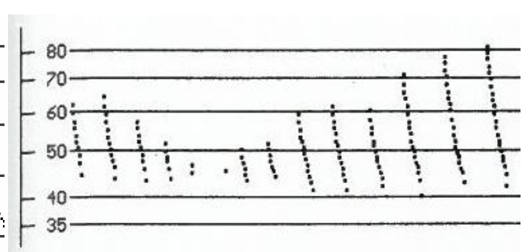
11. MYLU (Div16, F7)



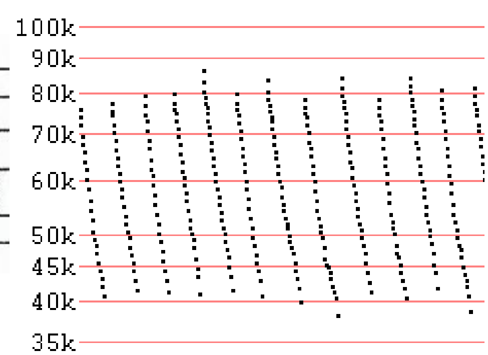
12. MYCI (Div16, F7)



13. MYSE (from Adams 2003)

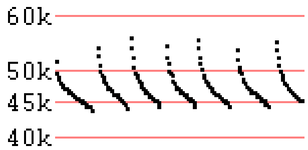


14. MYVO (Div 16, F7)

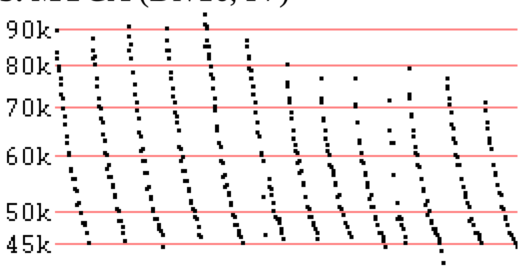


Fmin (kHz)	Description	ID
~50	15. Usually starting around 50 and often ending below (~45). Thick calls with flat tails often with a drooping tail. Duration>5.0ms.	PEHE
~ 50	Steeper than PIHE and usu. Fmin at or just below 50k. Single calls can drop to 40k, but not whole series (consistently above 43k). Difficult to distinguish from each other, especially in clutter, and many must be reported simply as "**aM50k**".	aM50k
	16. Often show calls dropping below 50k (~45k). Call shape similar to MYLU, but thicker tail. Calls often "dribble-off", rather than having constant toes. Dribble calls can have Δslope down to 40. In a series, there is often one call that is flatter than the rest. *Behavior*: MYYU often feed over water.	MYYU
	17. Calls frequently have a flat "toe" at the end, rather than dribbling off. Toed calls usually have Min. Δslope of 30ish. "Dribbling calls" usually have Min. Δslope greater than MYYU (i.e., above 40). Behavior: MYCA typically feed by hugging vegetation.	MYCA

14. PEHE (Div16, F7)



15. MYCA (Div16, F7)



16. MYYU (Div 16, F7)