# BAT INVENTORY of the GREATER YELLOWSTONE NETWORK

# FINAL REPORT

by

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# CONTENTS

BACKGROUND AND INTRODUCTION ..... 2

METHODS ..... 2

RESULTS AND DISCUSSION ..... 4
*Species Composition and Abundance* ..... *4*
*Inventory Completeness* ..... *5*
*Additional Survey and Biological Results* ..... *6*
*Next Steps* ..... *7*

REFERENCES ..... 8

TABLES AND FIGURES ..... 11
Table 1: Bat species list by Park Unit in the Greater Yellowstone Network. ..... 12
Table 2: Summary of bat captures in the Greater Yellowstone Network. ..... 13
Table 3: Bat inventory completeness summary for the Greater Yellowstone Network. ..... 14
Figure 1: Diagram of habitat suitability algorithm ..... 15
Figure 2: Final bat capture suitability model for Yellowstone National Park ..... 16
Figure 3: Final bat capture suitability model for Grand Teton National Park ..... 17
Figure 4: Priority bat survey sites in Bighorn Canyon National Recreation Area ..... 18
Figure 5: Bat inventory site distribution throughout the Greater Yellowstone Network ..... 19
Figure 6: Species accumulation curves and richness estimators for the Greater Yellowstone Network ..... 20
Figure 7: Species accumulation curves and richness estimators for each park unit GRYN. ..... 21
Figure 8: Summary of bat occurrences. ..... 22
Figure 9: Bat captures as a function of time of day. ..... 23
Figure 10: Captures of reproductively active adult bats and juveniles by time of year ..... 24

APPENDICES ..... 25
*Appendix 1: Species Accounts.* ..... *26*
Pallid bat (*Antrozous pallidus*, ANPA) ..... 27
Townsend's big-eared bat (*Corynorhinus townsendii*, COTO) ..... 28
Big brown bat (*Eptesicus fuscus*, EPFU) ..... 29
Spotted bat (*Euderma maculatum*, EUMA) ..... 30
Hoary bat (*Lasiurus cinereus*, LACI) ..... 31
Silver-haired bat (*Lasionycteris noctivagans*, LANO) ..... 32
California myotis (*Myotis californicus*, MYCA) ..... 33
Western small-footed myotis (*Myotis ciliolabrum*, MYCI) ..... 34
Long-eared myotis (*Myotis evotis*, MYEV) ..... 35
Little brown bat (*Myotis lucifugus*. MYLU) ..... 36
Fringe-tailed bat (*Myotis thysanodes*, MYTH) ..... 37
Long-legged myotis (*Myotis volans*, MYVO) ..... 38
Yuma myotis (*Myotis yumanensis*, MYYU) ..... 39
*Appendix 2: Geographic Information System (GIS) Data* ..... *40*
*Appendix 3: Preliminary Bat Surveys of White Grass and Bar B C Ranches, Grand Teton National Park* ..... *43*
Contents ..... 43
Background and Introduction ..... 43
Summary Results ..... 43
Building Accounts: Bar B C Ranch ..... 44
Building Accounts: White Grass Ranch ..... 59
*Appendix 4: Keys to the bats of the Greater Yellowstone Network* ..... *66*
Dichotomous Key to the Bats of the Greater Yellowstone Network ..... 67
Draft Key to ANABAT® Echolocation Call Recordings for Bats of the Greater Yellowstone Network ..... 69

# BACKGROUND AND INTRODUCTION

The National Park Service (NPS) is undertaking a nationwide effort to inventory and monitor the biological resources within its management areas. Recognizing the need for a cross-boundary, ecosystem approach to natural resource management, the system of national parks has been grouped into Cooperative Ecosystem Units to facilitate inventory, monitoring, and subsequent management decisions in ecologically meaningful areas. The Greater Yellowstone Network (GRYN) includes Yellowstone and Grand Teton National Parks (YNP and GTNP) and Bighorn Canyon National Recreation Area (BICA). A combined effort of biologists from these parks and regional wildlife experts resulted in the recent release of a study plan for the GRYN inventory and monitoring efforts (NPS, 2000). This document identified significant gaps in information on the species richness, abundance, and distribution of bat species within all GRYN parks and terrestrial mammals in BICA. They have therefore proposed that the NPS conduct a comprehensive inventory of bats throughout GRYN and terrestrial mammals in BICA to establish a benchmark for future monitoring efforts and management actions. The specific goals of these inventory efforts, as stated in the GRYN Study Plan (NPS, 2000), are as follows:

1. To document, through existing, verifiable data and targeted field investigations, the occurrence of at least 90 percent of the species of vertebrates and vascular plants currently expected to occur in Bighorn Canyon National Recreation Area, Grand Teton National Park, and Yellowstone National Park.
2. To describe the distribution and relative abundance of species of special concern, such as threatened and endangered species, non-native species, and other species of special management interest occurring within park boundaries.
3. To provide the baseline information needed to develop a general monitoring strategy and design that can be implemented by parks once inventories have been completed, tailored to specific park threats and resource issues.
4. To make information easily available to park managers, resource managers, scientists, and the public.

With these goals in mind, it is valuable to briefly discuss the effort represented by this inventory in terms of what is reasonable to expect from such an effort. This inventory was designed to generate comprehensive documentation of the bat fauna of the GRYN, with a target, as noted above, of documenting 90 percent of the species that actually occur in these parks. Attainment of this somewhat arbitrary objective is largely dependent upon survey effort expended and is therefore directly related to the amount of time and money spent. With a fixed budget there are many species that are easy to document (e.g., little brown bats) and several, generally rare species, that are difficult to document (e.g., spotted bats). Therefore, (as a hypothetical example) documenting the first 80 percent of species may be fairly straight-forward, while the remaining 20 percent could be fare more difficult. Further, we do not have *a priori* knowledge of which species are present, so we must estimate at which point we have achieved the 90 percent goal. Estimation of completeness is compounded by the fact that there is a fine line defining when a species is rare versus so unlikely to occur that it is not worth the effort to document. As an extreme example, one could spend a lifetime trying to document fruit bats in Bighorn Canyon, which (exceedingly unlikely though it may be) could result in the capture of an errant migrant from southern Texas. Such a finding would not, under reasonable scrutiny, represent a meaningful addition to the fauna of BICA. We believe that this report strikes the appropriate balance between effort expended and inventory completeness.

# METHODS

We first identified and compiled all geographically referenced electronic data on features that might be useful in identifying important areas of bat use within and near the parks. We used this data to construct habitat suitability models identifying critical bat habitat for GTNP and YNP (priority areas were already identified for BICA and therefore no model was developed for the recreation area; Keinath 2001). These models incorporated wetland distribution, vegetative landcover, bedrock geology, elevation, and topographic relieve (slope and aspect), as

outlined in Figure 1. Models were generated as raster coverages in a Geographic Information System (GIS) with 100 meter resolution. Six coverages were generated, one for each of the main components noted above. Each 100 meter cell in the park units was scored for each of these coverages and then a final habitat score was calculated for each cell by additively combining the six components (Figure 1).

For instance, one of the 6 coverages was based on wetlands as classified by the National Wetlands Inventory (NWI). Each wetland type was given a "type score" of 0 – 3 based on its suitability for use by bats as foraging and drinking habitat, where a score of 0 meant it was never used and a score of 3 meant it was preferred. A given cell was assigned a type score based on the wetland that it contained. Since proximity of a cell to other wetland areas also increases suitability, the same cell was also given a distance score, where low, unsuitable values (e.g. 0) represented long distances to other wetlands, and high, suitable scores (e.g., 3) represented proximity to other wetlands. The type and distance score for each cell was then weighted and combined into a single NWI coverage whose total range of scores was still 0 – 3 (e.g., NWI score = 0.7*type score + 0.3*distance score). A similar process was followed for each of the other main components, resulting in five additional values for the given cell (i.e., HAB, GEO, ELV, CLF, and ASP), each having a score of 0 – 3. The six values of each cell were added, weighting the most important components (wetlands and landcover) slightly more than the rest. This resulted in a final coverage in which each cell had a cumulative value of 0 – 22.5, where higher valued cells were relatively more suitable for finding bats via mist netting and acoustic monitoring activities than lower valued cells.

This information was be used in concert with input from park biologists and to identify specific inventory sites. Sites were be prioritized based on several factors including: 1. their likelihood of being used by bats, 2. the relative diversity of species likely to be present, 3. accessibility issues, and 4. their contribution to achieving a geographically inclusive sample from each park. Our goal was to make the most of our limited time in the parks, so we wanted to insure that sufficiently diverse habitat was sampled to capture all suspected species of bats. The ultimate goal of this phase was to generate an inventory site list to be surveyed repeatedly over the following two summers using the field methods noted below.

Habitat models (for GTNP and YNP) are displayed in Figures 2 and 3, in which the most suitable cells are shaded maroon and red and progressively less suitable cells are green, gray, and white. Focal areas for survey, in order of decreasing priority, are as follows:

1. areas of high maroon and red concentrations,
2. areas of high green concentrations with some red,
3. areas of high green concentration,
4. under-represented habitat features or geographic areas that don't appear in the model.

The initial list of focal areas for which we conducted field visits was as follows:

BICA: Layout Creek (especially ponds by Ewing-Snell Ranch); BICA land near Yellowtail Wildlife Habitat Management Area (YWHMA); Hillsboro Ranch and beaver ponds; Lockhart Ranch and beaver ponds; Caves that on or near BICA (usually on BLM land, but whose bat population likely forages on the recreation area); Cliffs along the walls of Bighorn Canyon and Devils Canyon.

GTNP: Snake River South (including Blacktail Ponds and Moose-Wilson Ponds); Snake River North (including Glade Creek in JDRMP); Snake River Central (including Oxbow bend and Willow Flats); Foothills Lakes (including Moose Ponds and Lupine Meadows, String Lake, and some parts of western Jackson Lake and Leigh Lake); Pilgrim and Pacific Creeks; Northwestern GTNP (including Moose, Berry, and Owl Creeks).

YNP: Bechler area (including Bechcler Canyon, Bechler Meadows and Falls River Basin); Lamar Valley area (including Lamar River, Slough Creek and Soda Butte Creek); Madison Junction area (including Madison River and Gibbon Basin); Grand Canyon area (including Yellowstone River and wetlands south of the canyon); Gardner's Hole area (including Gardner River, Africa Lakes and nearby wetlands); South Central Yellowstone (including Snake River and Lewis River south of Lewis Lake); Old Faithful area (including portions of the Firehole River).

Field technicians searched each of these broad focal areas to identify specific sites that were suitable for conducting mist net and acoustic monitoring activities. Depending on the nature of each site and the bat species expected, we used a variety of survey methods including, actively and passively operated acoustic bat detectors, mist nets, and harp traps. Bat detectors were be used to determine the relative level of bat activity at each site and to preliminarily identify species based on characteristic vocalizations. We then employed mist nets and harp traps at potential roosting, foraging, and transit areas to capture, identify, and photograph the various bat species.

All survey sites were located via GPS, bats were identified to species, their age and sex were determined, photographs were taken to document species occurrence, and the number of individuals captured was documented. No additional data was required by park service staff.

# RESULTS AND DISCUSSION

This section provides a brief summary what the inventory process revealed. Most useful data is presented and interpreted in the tables, figures and appendices at the end of this report. A thorough investigation of these items will provide the reader with many insights on the chiroptofauna of the Greater Yellowstone Network. In many ways, this relatively brief section should be read as the preamble to the wealth of information presented therein. Specifically, park biologists may regularly refer to the following items:

- Table 1: The "final" list of bat species in each park unit
- Figure 7: Map-based summary of bat occurrences in the GRYN
- Appendix 1: Species Accounts
- Appendix 2: Geographic Information System data
- Appendix 4: Identification keys to the bats of the GRYN

## *Species Composition and Abundance*

The list of species for each park unit is presented in Table 1, summary capture statistics are presented in Table 2, and geographic representations are presented in Figure 7. Further, occurrence information on a species-specific basis is provided in Appendix 1.

In total, we identified 13 species of bats that occur in the Greater Yellowstone Network, although a few designations are tentative (see Table 1). Each park within the GRYN contains a subset of these 13 species; 8-10 occurring in GTNP, 9-10 occurring in YNP, and all 13 potentially occurring in BICA. Despite representing less than two percent of the area of the GRYN, BICA clearly has the richest and most concentrated bat fauna of the three park units. In general, GTNP and YNP were similar in the apparent composition of their bat fauna and collectively they had a less diversity and relative abundance than BICA. Further, although localized areas in the other parks showed high bat activity and/or abundance, the whole of BICA experiences substantial and diverse bat use. This is due to the fact that, when compared with nearby areas in Wyoming, Montana and Idaho, BICA and the adjacent federal lands (primarily owned by the Bureau of Land Management and the State of Wyoming) are relatively arid, warm, low in elevation, contain an abundance of cliff and cave roosting habitat, contain tree roosting habitat in the form of extensive cottonwood riparian areas, and have all roosting habitat relatively proximate to large expanses of still-water that provides abundant insect life and access to consumable water. BICA is indeed one of the hot-spots for bats in all of Wyoming and perhaps all of the northern Rocky Mountain states.

BICA has high bat abundance and diversity, but managers should note that high bat abundance does not necessarily suggest high species richness, particularly at the scale of individual sites (e.g., Figure 8). More specifically, there seemed to be good correlation between ANABAT® call rates and species richness when richness was low, but high richness sites in our study had quite variable levels of activity. There are many possible explanations for this that could be investigated with more effort, but the take-home message for managers in the GRYN is that just because you get a lot of bat activity does not mean you have a diversity of bats. Sites with high activity could be dominated by one or two common species and actually have lower richness than other, less-active

sites. We found this to be the case at numerous sites in YNP and some in GTNP where little brown bats were highly abundant, but few other species were identified. On the other hand, one of the most productive sites in our inventory was also the site with the highest bat species richness; you simply cannot tell based on activity alone.

It is hard to evaluate or rank individual sites using this broad-based inventory. However, a few areas are worth noting:

- Layout Creek (BICA): Layout Creek, and in particular the small pond next to the Ewing-Snell Ranch, was by far the richest location in the study, with all 13 of the GRYN species being documented there. Due to its unique mix of habitat features, it stands out as a pre-eminent batting location in the GRYN.
- Yellowtail Wildlife Habitat Management Area (YWHMA, in BICA): YWHMA is a relatively large area of ideal foraging habitat for many bats of different species. In shear abundance of bats seen foraging, it is probably the most productive area in the GRYN. Along with an apparent abundance of insect life, it has an extensive mosaic of chiropteran foraging habitat from open-water habitat, open grassland and shrubland, cottonwood gallery forest, and extensive edges where these components mingle. This abundance of bats, however, is dependent on the surrounding wealth of roosting habitat (e.g., cliffs, caves, abandoned buildings and mines). Not only the insect diversity and composition of the foraging habitat should be conserved, but the relationship of roost features to YWHMA should be maintained in order to insure bat access to these areas.
- Mammoth (YNP): The active and inactive terraces around Mammoth Hot Springs in YNP seems to support an isolated collection of bat species approaching that of BICA, although on a much smaller scale. In this area thermally heated caves provide maternity colonies for common and rare species (e.g., Townsend's big-eared bat); inactive caves and sink-holes provide non-maternity day roosts and possibly hibernacula for a variety of species; and mature, open forests near varied shrubland provide foraging and roosting opportunities for tree-roosting species.
- Thermal Features (YNP): Bat use of thermal features in the park is unique and poorly documented. There are scattered reports of bats roosting at ground level in thermally heated stumps. We found a sizable maternity colony in a ground-level bolder in Gibbon Geyser basin and documented use of several sink-holes and fishers in the Mammoth area. The extent to which bats use these features and, moreover, to which such use allows a more abundant or diverse community of bats to exist within the park, is intriguing and worth future study.
- Northern GTNP: Portions of north GTNP, including the Two Oceans Lake area and John D. Rockefeller Parkway along Glade Creek, seem to have an unexpectedly large diversity of bats, including some that don't seem typical of the area (notably fringe-tailed myotis). Further investigation of the area to verify this diversity and determine why/how these bats are found there is an interesting question; although one that may not have immediate ramifications to species conservation.
- Southern GTNP: The lowland area of southern GTNP, particularly Blacktail ponds, the Moose-Wilson Road beaver ponds, Blacktail Butte, and White Grass Ranch, supports a variety of habitats that collectively have a high diversity of species. Also, they contain the only records of Townsend's big-eared bat in the park, which further investigation will hopefully confirm as being part of a local breeding population.

## *Inventory Completeness*

Evaluation of capture statistics and ANABAT® recordings was combined to generate a final species list for each park unit in the Greater Yellowstone Network (Table 1). This table represents the condensed result of over 40 days of site evaluation (150+ sites), 63 nights of mist netting (9,500 net-area-hours of effort), nearly 80 nights of passive acoustic monitoring (450 recorded hours), and a dozen days of diurnal roost site investigation (e.g., Figure 5). As much as possible, we let the modeling data (Figures 2 - 4) drive site selection, which resulted in numerous backcountry locations. Over this time we captured 527 bats of 13 species (Table 2) and evaluated over 10,000 individual ANABAT® call files that suggested occurrences of the same 13 species.

Qualitatively, the above-noted level of effort seems sufficient to document all species occurring in the parks. However, a quantitative estimate of progress can be roughly approximated using rarefaction or species accumulation curves (e.g., Soberon and Llorente 1993, Krebs 1999, Moreno and Halffter 2000, Cam et al. 2003, Gotelli and Graves 1996, Chao 1984, Colwell and Coddington 1994). I developed species accumulation curves for GRYN and each park unit therein (Figure 6) and used the EstimateS software package (V 7.5.0, © R. K. Colwell, http://viceroy.eeb.uconn.edu/estimates) to produce species richness estimates using the Chaoe-1 and ACE estimators. All models used the Michaelis-Menten equation for fitting predicted values of the appropriate indicator output to sample effort (i.e., Captures/Hour, Capture/Net-Hour, or Calls/Hour):

$$SpNum = (SpMax * Effort) / (k + Effort)$$

where *SpNum* = number of species predicted for a given level of sampling effort, *Effort* = sampling effort in hours or net-hours, *SpMax* = estimate of the maximum number of species likely to be present, and *k* = approximate level of sampling effort corresponding to half of *SpMax*. *SpMax* and *k* are estimates used to guide the nonlinear regression algorithms, which were implemented in S-Plus (V 6.2, © 2003 Insightful Corp., http://www.insightful.com/).

As shown in Figure 6, the sample-site accumulation curve for the network as a whole has a clear and sharply defined asymptote at 13 species for both captures and Anabat® recordings. This suggests we have accounted for all species present in the GRYN based on our given level of effort. The estimator of species richness generates a smooth curve very similar in form to the true plot of species accumulation and predicts an asymptote of less than 14 species based on capture data (*Smax* = 13.6 ± 0.02 species) and based on call recordings (*Smax* = 13.2 ± 0.01 species). This further indicates a complete inventory, with over 96% of the estimated bat species accounted for (Table 3).

As in most inventories, as you subdivide your study area (e.g., from the whole GRYN to the individual park units), your sampling effort decreases and the results become more variable. This can be seen in Figure 7, where the park-specific capture and Anabat® curves do not all seem to reach clear asymptotes with the available sampling effort. This suggests that although the inventory as a whole has identified virtually all species present, there are likely more species to be discovered in each park unit. Table 3 summarizes these estimates, wherein we can see that we have accounted for between 68% and 88% of the estimated bat species richness in the individual units. Not surprisingly, YNP is fairly low, despite having the largest sampling effort, which is probably due to its large geographic area and commensurately diverse (and difficult to survey) habitat. GTNP exhibits a wide range, since the estimator based on Anabat® varied substantially from that based on mist net captures. We believe this, in part, reflects the difficulty of catching bats in GTNP due to the abundance of water sources. It should be noted, however, that we believe the remaining "undiscovered" species in each of these park units is likely to be encompassed in those identified elsewhere in the inventory. The possible exception to this could be BICA, which may have new species, due to its concentration of unusually good bat habitat.

In conclusion, I am confident that well over 90% of the species occurring in the GRYN have been identified and that something less than, but approaching, 90% of the species in each park unit has been identified. However, I fully expect that the list for each park is not complete. In order to solidify the park-specific lists (Table 1), further effort targeted toward the questionable species must be spent in each park. Such follow-up surveys would use techniques tailored to specific species in specific areas, rather than using the broad-based inventory approach used in this study. Such efforts would aim to conclusively document the questionable species in each park by tailoring mist net activities or *active* ANABAT® surveys to their particular foraging styles and to areas in the parks where they are most likely to occur. See *Next Steps* for how to proceed with these supplemental surveys.

## *Additional Survey and Biological Results*

Considering the number of bats captured, the most productive period to survey for bats is the first 2 hours after sunset (Figure 9). However, as suggested in the species accounts (Appendix 2) and in our capture records, bat species fly during different times of night, so surveying only in the early evening might result in a restricted species list. This inventory thus conducted all mist netting until at least 1:00 AM in the morning, often longer. This means that netting occurred until at least 4 - 5 hours after sunset depending on the date, by which time captures for most species diminished (Figure 9). Passive ANABAT units, however, were regularly left active throughout the night to

document later bat activity. With this combination of effort, it seems that we collected an adequate temporal sample to capture all species present in the parks.

Most bats in the GRYN hibernate after migrating short distances to suitable hibernacula within, or near, the parks. A few bats (e.g., hoary bats and silver-haired bats) migrate longer distances and likely winter outside the GRYN. In either case, when trying to document resident, and hopefully breeding, bats, it is important to time surveys appropriately. Although there are undoubtedly species differences, it seems that juvenile bats in the GRYN become volant in mid July, as evidenced by their increasing representation in mist net captures at that point (Figure 10). Given a time from parturition to flight on the order of 3 - 4 weeks (depending on species and climate), this means young in the GRYN are being born in mid-June. Further, for most vespertilionid bats gestation begins as they arouse from hibernation and lasts on the order of 70 days (e.g., Barclay and Harder 2003), suggesting that the bulk of GRYN bats emerge from hibernation in mid-April and arrive on their "summering grounds" shortly thereafter, perhaps in early May. Surveys can thus be conducted as early as mid May, but are best later in the season when temperatures are warmer and bats are more active.

Timing of roost surveys should be more restricted, particularly if maternity colonies are being observed. A few things to consider: 1) even though bats may be present in the GRYN in May, it is not clear when they actually begin roosting at maternity sites; 2) bats are most sensitive to roost disturbance at the time of parturition (mid-June), so roost should not be entered at this time; 3) when young of most bats begin flying (3-4 weeks after birth), they are virtually indistinguishable from adults without examining joint development. Thus, roost surveys aimed at evaluating reproduction should occur after young are born, but before they are difficult to tell from adults (i.e., roughly late June - mid July). Young are not fully weaned until several weeks after they are able to fly, so maternity roost surveys can be conducted into mid-August if estimating the number of young is not critical. It is possible that the whole cycle occurs earlier in BICA than the higher, cooler regions of GTNP and YNP (Figure 10). Although bats can likely be found active in the GRYN until October, I suspect that bats in the GRYN, or at least in GTNP and YNP, begin aggregating for departure to hibernacula in late August, so surveys should be conducted before then to insure that "resident" bats are being surveyed, not migratory individuals.

These findings also have implications for the timing of bat exclusion activities in buildings within the parks; such activities should be completed between late-October and mid-April (e.g., November 1 - April 1) in order to have the least impact on roosting bats.

## *Next Steps*

As noted above (see also Table 1 and Appendix 1), a couple species in each park have only been tentatively identified and further verification of their presence is needed before concluding that they regularly occur in the parks. To "complete" the species list for each park, the following targeted surveys are recommended.

1. BICA: Silver-haired bats (tree-roosting; target mature forested canyons and marshes in central BICA and YWHMA using mist nets and active ANABAT® recording with visual observation)
2. BICA: California myotis (forage around vegetation; target brushy canyon country in central BICA using primarily active ANABAT® recording and targeted canopy netting)
3. GTNP: Western small-footed myotis (forage around vegetation; target vegetated flyways and water bodies in northeast GTNP using canopy netting)
4. GTNP: Yuma myotis (forage over open water; target large ponds and roost structures in JDRNP using active ANABAT® recording with visual observation and netting where possible)
5. YNP: Yuma myotis (forage over open water; target large ponds and roost structures in Bechler area using active ANABAT® recording with visual observation and netting where possible)
6. YNP: Pallid bat (forage around vegetation by arid cliffs; target open forest and vegetated edges in the vicinity of the Mammoth terraces and possibly the Grand Canyon using primarily active ANABAT® recording with visual observation and mist netting over calm bodies of water)

There are three particular cases where further knowledge regarding the occurrence and ecology of known species within the parks would be important to conservation of those species. These are summarized briefly as follows:

1. Townsend's big-eared bat in GTNP: In this study, we documented male Townsend's big-eared bats (*Corynorhinus [= Plecotus] townsendii*) roosting in abandoned buildings in two former ranches within GTNP (White Grass Ranch and Bar B C Ranch). Use of these buildings by *C. townsendii* appears to be a regular and long-term occurrence, since anecdotal investigations 20 years ago also found them (Susan Wolff pers. comm.). The bat diversity around these ranches seems substantial, but Townsend's big-eared bat in particular is a sensitive species throughout the western United States (Western Bat Working Group 1998, Gruver and Keinath 2004). They require particular cave characteristics for maternity colonies that are sparse on the western landscape, which drastically limits the habitat capable of supporting them and makes every maternity colony an important focus of conservation effort (Pierson et al. 1999). Male *C. townsendii* do not generally roost in the maternity colonies, but they only migrate locally and congregate with females in the spring and fall, which suggests that a maternity colony may exist within GTNP. Documenting such a colony, which would be the only one found in the park, and insuring its continued protection is therefore an important conservation goal.
2. Townsend's big-eared bat in YNP: In this study, we documented a maternity roost of Townsend's big-eared bats (*Corynorhinus [= Plecotus] townsendii*) in Devil's Kitchen on the Mammoth Terrace and witnessed additional use of caves on the upper terrace. The possibility exists for *C. townsendii* to be using similar caves as maternity and bachelor roosts. It is important for the park to know which structures are being used so that future activity (either by park staff or visitors) can be viewed in light of potential impacts.
3. Roosting habitat investigations for the fringe-tailed bat: The fringe-tailed bat (*Myotis thysanodes*) is recognized by several federal and state agencies as a sensitive species that is apparently rare and at risk, based on scant knowledge of local, regional, and national populations (Keinath 2004). Suitable roosting sites are a critical habitat component, the availability of which can determine population sizes and distributions (e.g., Humphrey 1975, Kunz 1982). Despite variable range-wide roost use, *M. thysanodes* seems to be locally restricted to only a few roost types, cliff crevasse and snags being those likely in the GRYN (e.g., Weller and Zabel 2001, Cryan 1997). Which roosts are being used in YNP and GTNP, and moreover the character of those roosts, could suggest the nature of the GRYN population and help the parks identify actions that are likely to cause adverse impacts. A roosting study of *M .thysanodes* in these areas is therefore recommended.

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# TABLES AND FIGURES

# Table 1: Bat species list by Park Unit in the Greater Yellowstone Network.

Table 1a. Bighorn Canyon National Recreation Area.

| Species Code | Species Name | Abundance [a] | Status Notes [b] |
|---|---|---|---|
| ANPA | Pallid bat (*Antrozous pallidus*) | Low | localized |
| COTO | Townsend's big-eared bat (*Corynorhinus townsendii*) | Low-Medium | localized |
| EPFU | Big brown bat (*Eptesicus fuscus*) | High | widespread |
| EUMA | Spotted bat (*Euderma maculatum*) | Medium | localized |
| LACI | Hoary bat (*Lasiurus cinereus*) | Low | sparse but widespread |
| LANO [b] | Silver-haired bat (*Lasionycteris noctivagans*) | Uncertain | questionable occurrence |
| MYCA [b] | California myotis (*Myotis californicus*) | Uncertain | questionable occurrence |
| MYCI | Small-footed myotis (*Myotis ciliolabrum*) | Medium | |
| MYEV | Long-eared myotis (*Myotis evotis*) | Medium | |
| MYLU | Little brown bat (*Myotis lucifugus*) | Very High | common and widespread |
| MYTH | Fringe-tailed bat (*Myotis thysanodes*) | Low | localized |
| MYVO | Long-legged myotis (*Myotis volans*) | Medium | |
| MYYU | Yuma myotis (*Myotis yumanensis*) | Medium | |
| Total Species Richness for BICA | | 11-13 | |

Table 1b. Grand Teton National Park (including John D. Rockefeller Memorial Parkway).

| Species Code | Species Name | Abundance [a] | Status Notes [b] |
|---|---|---|---|
| COTO | Townsend's big-eared bat (*Corynorhinus townsendii*) | Low | bachelors only |
| EPFU | Big brown bat (*Eptesicus fuscus*) | Medium | widespread |
| LACI | Hoary bat (*Lasiurus cinereus*) | Medium | sparse but widespread |
| LANO | Silver-haired bat (*Lasionycteris noctivagans*) | Medium-High | widespread |
| MYCI [b] | Small-footed myotis (*Myotis ciliolabrum*) | Uncertain | questionable occurrence |
| MYEV | Long-eared myotis (*Myotis evotis*) | Medium | |
| MYLU | Little brown bat (*Myotis lucifugus*) | Very High | common and widespread |
| MYTH | Fringe-tailed bat (*Myotis thysanodes*) | Low | localized |
| MYVO | Long-legged myotis (*Myotis volans*) | Medium | |
| MYYU [b] | Yuma myotis (*Myotis yumanensis*) | Uncertain | questionable occurrence |
| Total Species Richness for GTNP and JDRNP | | 8-10 | |

Table 1c. Yellowstone National Park.

| Species Code | Species Name | Abundance [a] | Status Notes [b] |
|---|---|---|---|
| ANPA [b] | Pallid bat (*Antrozous pallidus*) | Uncertain | questionable occurrence |
| COTO | Townsend's big-eared bat (*Corynorhinus townsendii*) | Low | localized, sensitive |
| EPFU | Big brown bat (*Eptesicus fuscus*) | Medium | |
| LACI | Hoary bat (*Lasiurus cinereus*) | Low | sparse but widespread |
| LANO | Silver-haired bat (*Lasionycteris noctivagans*) | Medium-High | widespread |
| MYEV | Long-eared myotis (*Myotis evotis*) | Low | |
| MYLU | Little brown bat (*Myotis lucifugus*) | Very High | common and widespread |
| MYTH | Fringe-tailed bat (*Myotis thysanodes*) | Low | localized |
| MYVO | Long-legged myotis (*Myotis volans*) | Medium | |
| MYYU | Yuma myotis (*Myotis yumanensis*) | Low | localized; accidental? |
| Total Species Richness for YNP | | 9-10 | |

**a** Abundance is noted using a categorical scale representing the author's subjective assessment from the data collected during this inventory. Low, Medium, High, Very High, and Uncertain designations indicate unit-wide likelihood of occurrence and do not speak to population viability or relevance to broader distributions.

**b** Generally speaking, questionable, or uncertain, species have been identified only by passively collected ANABAT® recordings, but have not been captured or otherwise identified in the park. These records should be considered tentative and in need of corroboration. The *Myotis californicus* in BICA was captured, but not conclusively identified (final determination will be made by museum experts).

# Table 2: Summary of bat captures in the Greater Yellowstone Network.

Table 2a. Bighorn Canyon National Recreation Area. Capture effort in BICA was approximately 2,843 NAH [a].

| Species Code | Species Name | Number Captured | Captures Per 100 Net Area Hours [a] |
|---|---|---|---|
| ANPA | Pallid bat (*Antrozous pallidus*) | 2 | 0.070 |
| COTO | Townsend's big-eared bat (*Corynorhinus townsendii*) | 5 | 0.176 |
| EPFU | Big brown bat (*Eptesicus fuscus*) | 59 | 2.075 |
| EUMA | Spotted bat (*Euderma maculatum*) | 20[b] | 0.704 |
| LACI | Hoary bat (*Lasiurus cinereus*) | 1 | 0.035 |
| MYCA | California myotis (*Myotis californicus*) | 1 | 0.035 |
| MYCI | Small-footed myotis (*Myotis ciliolabrum*) | 22 | 0.774 |
| MYEV | Long-eared myotis (*Myotis evotis*) | 9 | 0.317 |
| MYLU | Little brown bat (*Myotis lucifugus*) | 101 | 3.553 |
| MYTH | Fringe-tailed bat (*Myotis thysanodes*) | 2 | 0.070 |
| MYVO | Long-legged myotis (*Myotis volans*) | 29 | 1.020 |
| MYYU | Yuma myotis (*Myotis yumanensis*) | 3 | 0.106 |
| Total | | 253 | 8.900 |
| Richness | | 12 | 0.387 |

Table 2b. Grand Teton National Park (including John D. Rockefeller Memorial Parkway).
Capture effort in GTNP and JDRMP was approximately 6,629 NAH [a].

| Species Code | Species Name | Number Captured | Captures Per 100 Net Area Hours [a] |
|---|---|---|---|
| EPFU | Big brown bat (*Eptesicus fuscus*) | 4 | 0.060 |
| LACI | Hoary bat (*Lasiurus cinereus*) | 15 | 0.226 |
| LANO | Silver-haired bat (*Lasionycteris noctivagans*) | 23 | 0.347 |
| MYEV | Long-eared myotis (*Myotis evotis*) | 6 | 0.091 |
| MYLU | Little brown bat (*Myotis lucifugus*) | 188 | 2.836 |
| MYTH | Fringe-tailed bat (*Myotis thysanodes*) | 1 | 0.015 |
| MYVO | Long-legged myotis (*Myotis volans*) | 7 | 0.106 |
| Total | | 244 | 3.681 |
| Richness | | 7 | 0.106 |

Table 2c. Yellowstone National Park. Capture effort in YNP was approximately 7,931 NAH [a].

| Species Code | Species Name | Number Captured | Captures Per 100 Net Area Hours [a] |
|---|---|---|---|
| COTO | Townsend's big-eared bat (*Corynorhinus townsendii*) | 1 | 0.013 |
| EPFU | Big brown bat (*Eptesicus fuscus*) | 4 | 0.050 |
| LACI | Hoary bat (*Lasiurus cinereus*) | 2 | 0.025 |
| LANO | Silver-haired bat (*Lasionycteris noctivagans*) | 18 | 0.227 |
| MYEV | Long-eared myotis (*Myotis evotis*) | 1 | 0.013 |
| MYLU | Little brown bat (*Myotis lucifugus*) | 312 | 3.934 |
| MYTH | Fringe-tailed bat (*Myotis thysanodes*) | 1 | 0.013 |
| MYVO | Long-legged myotis (*Myotis volans*) | 1 | 0.013 |
| Total | | 340 | 4.287 |
| Richness | | 8 | 0.101 |

**a** Net Area Hours (NAH) is a measure of sampling effort for mist netting activities; calculated as the time in hours during which nets are deployed multiplied by the surface area of those nets. For example one 9 m X 2.6 m net deployed for 5 hours results in 117 NAH reported as "square meter hours".

**b** EUMA were not actually captured, but audibly or visually encountered at net sites during netting activities.

**Table 3: Bat inventory completeness summary for the Greater Yellowstone Network; richness curves and summaries of individual estimators are presented in Figures 6 and 7.**

| Park Unit | Inventory Richness | Estimated Richness (Captures) | Estimated Richness (Anabat®) | Estimated Inventory Completeness |
|---|---|---|---|---|
| **All GRYN** | **13** | **13.6** | **13.2** | **96% - 98%** |
| BICA | 12 | 14.9 | 13.7 | 81% - 88% |
| GTNP | 7 | 8.4 | 10.3 | 68% - 83% |
| YNP | 8 | 10.4 | 10.3 | 77% - 78% |

# Figure 1: Diagram of habitat suitability algorithm

**1. Score individual habitat features (Type and Distance Components)** → **2. Apply weighting factors and structure modifiers** → **3. Combine each habitat value via modeling formula**

General Type Score (tsi)

0 Avoided or Never Used
1 Possible Use
2 Used as Available
3 Preferred Habitat

Distance from Roost Score (dsi)

| | Clutter Adapted | Open Adapted |
|---|---|---|
| 0 | >10km | >40km |
| 1 | 5-10km | 20-40km |
| 2 | 2.5-5km | 10-20km |
| 3 | <2.5km | <10km |

Distance from water score (dsi for NWI)

0 >3km
1 2-3km
2 1-2km
3 <1km

Elevation Score (tsi)

0 >10000ft or 3050m (Ice in Caves, No insects)
1 Mid Elevation
2 <7000ft or 2100m (Vally level, Lowands)

Aspect Score (tsi)

0 North (0-45,315-360)
1 Slight North (45-90,270-315)
2 Slight South (90-135,225-270)
3 South (135-225)

Cliff Modifier Score (smi)

0 not a cliff (<50% slope)
1 cliff (>50% slope)

Geology Modifier Score (smi)

0 bedrock below surface
1 bedrock at surface

Wetlands Score

NWI = wi * (dsi + tsi)

Landcover Score

For GTNP: HAB = wi * (tsi)
For YNP: HAB = wi * (Habitat tsi + Cover tsi)

Geology Score

GEO = wi * (smi * tsi + dsi)

Topography Score

ELV = wi * tsi
CLF = wi * dsi
ASP = wi * tsi

**FINAL SCORE = NWI + HAB + GEO + ELV + CLF + ASP**

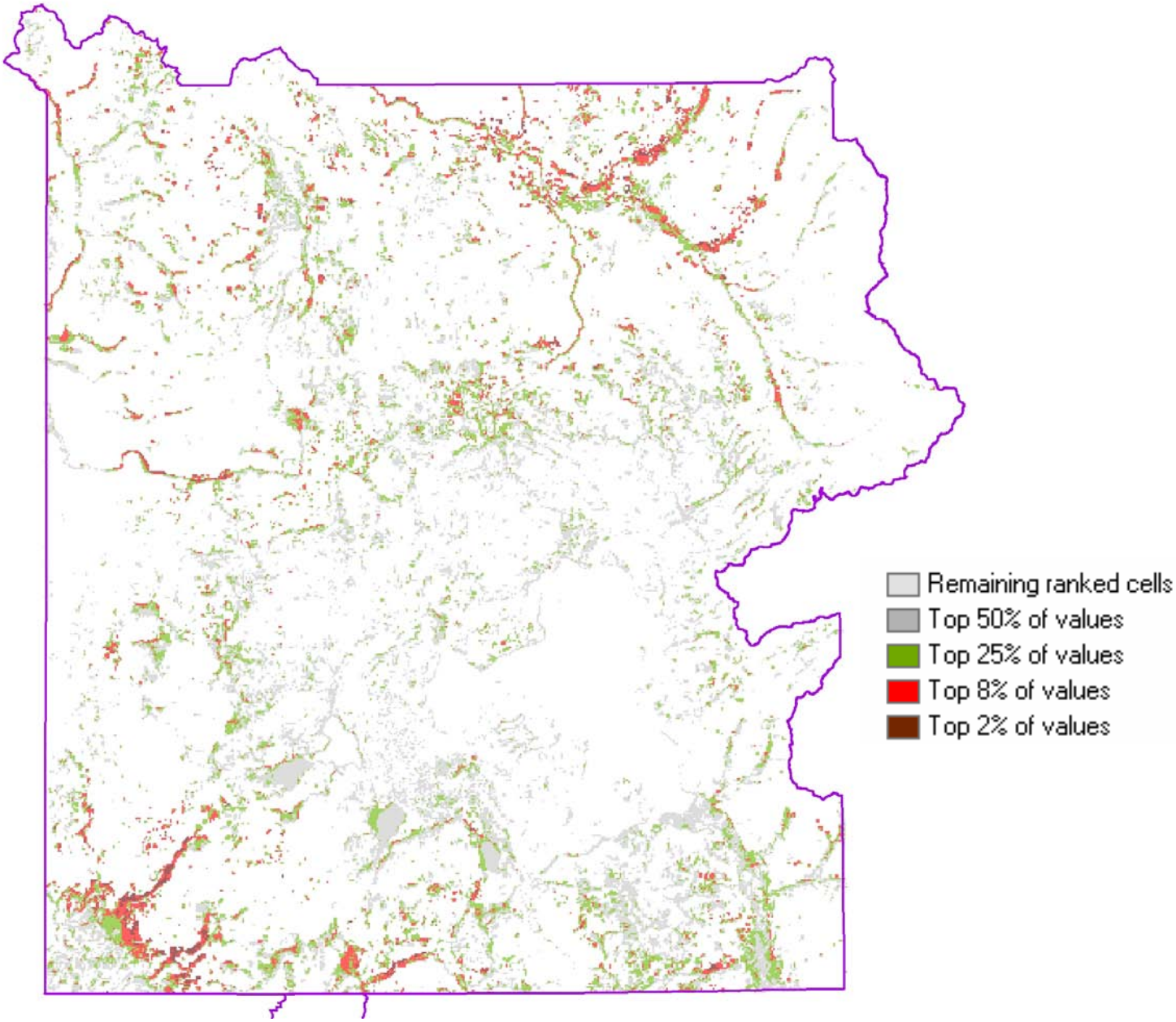
Feature Weight (wi)

0 not applicable
0.5
1
1.5
2 very important

| Theme | Code | Feature weight (wi) | Type score (tsi) | Distance score (dsi) | structure modifier (smi) |
|---|---|---|---|---|---|
| National Wetlands Inventory | NWI | 2 | 0.7*(0-3) | 0.3*(0-3) | - |
| Landcover (habitat) | HAB | 1.5 | 0-3 | - | inc in type |
| Geology (caves) | GEO | 1 | 0.4*(0-3) | 0.6*(0-3) | 0 or 1 |
| Elevation (temp) | ELV | 1 | 1.5*(0-2) | | |
| Slope (cliffs) | CLF | 1 | - | 0-3 | 0 or 1 |
| Aspect (thermal heating) | ASP | 1 | 0-3 | - | - |

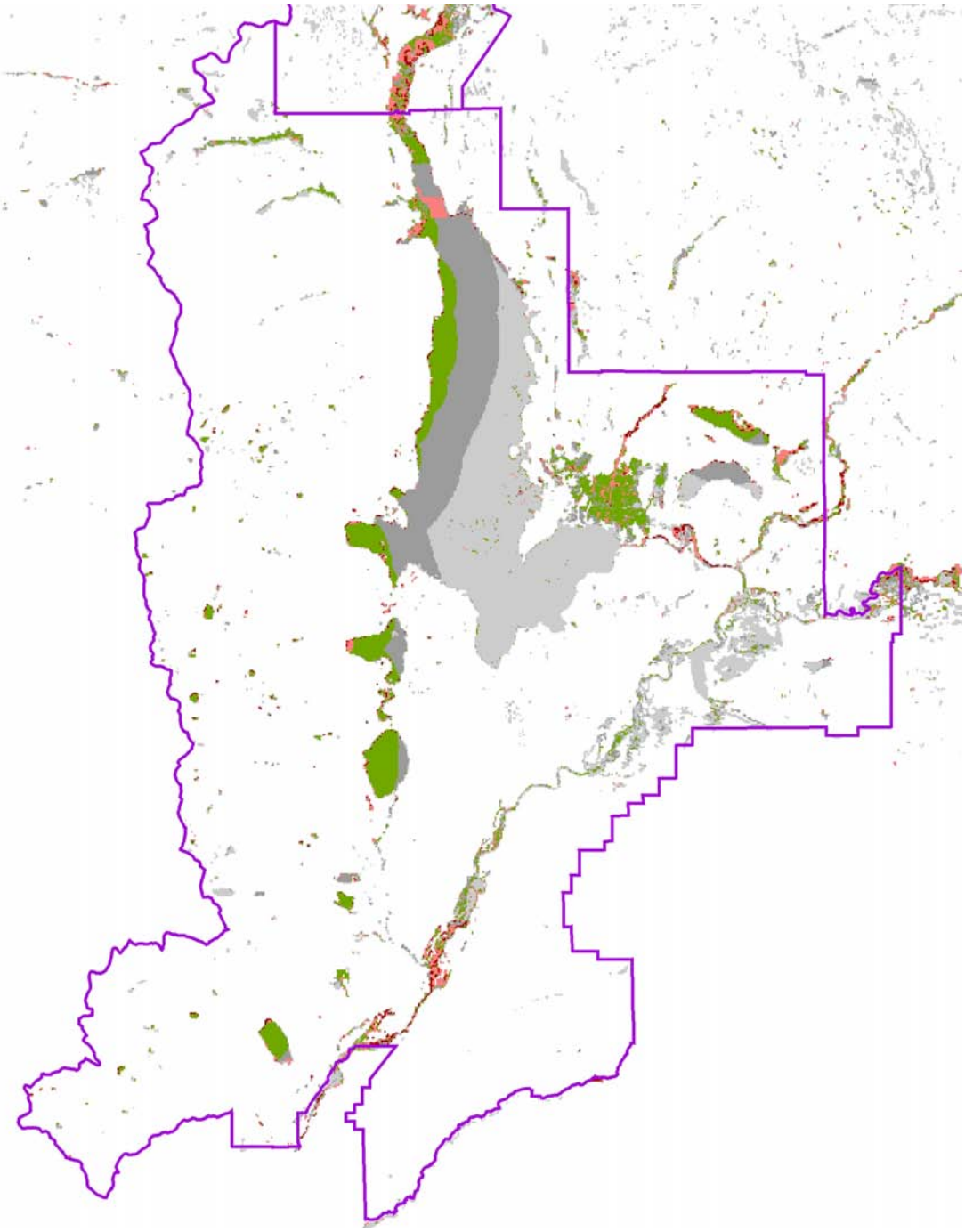
## Figure 2: Final bat capture suitability model for Yellowstone National Park

Areas deemed suitable for netting the greatest diversity of bat species within Yellowstone National Park are highlighted in maroon (top 2% of modeled area) and red (top 8% of modeled area). Focal areas for survey, in order of decreasing priority, were 1. areas of high maroon and red concentrations, 2. areas of high green concentrations with some red, 3. areas of high green concentration, 4. under-represented habitat features or geographic areas.

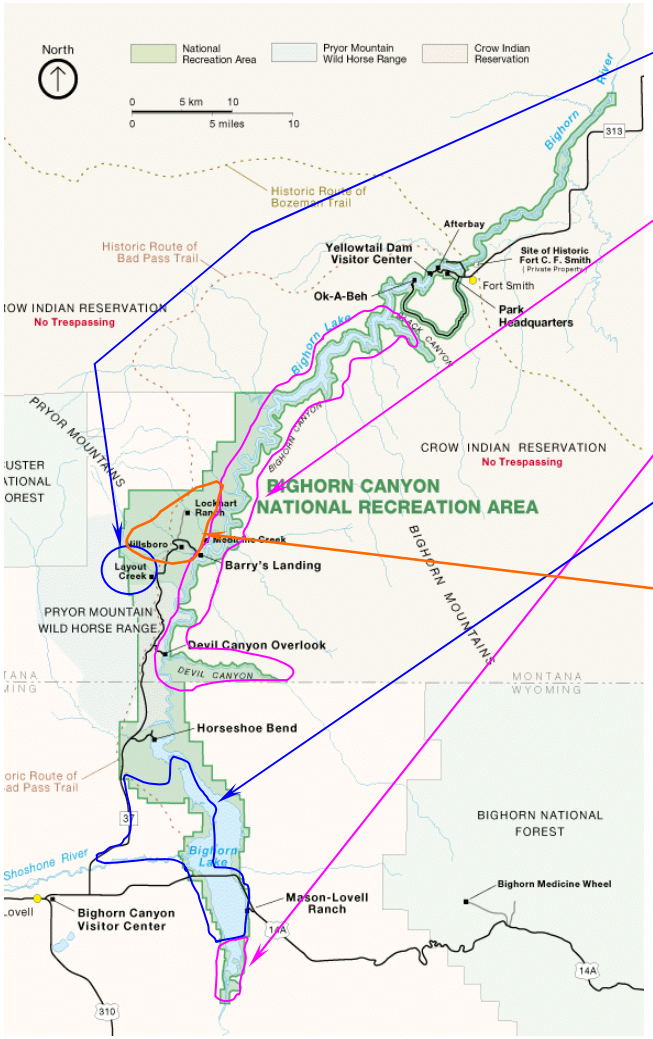


## Figure 3: Final bat capture suitability model for Grand Teton National Park

Areas deemed suitable for netting the greatest diversity of bat species within Yellowstone National Park are highlighted in maroon (top 2% of modeled area) and red (top 8% of modeled area). Focal areas for survey, in order of decreasing priority, were 1. areas of high maroon and red concentrations, 2. areas of high green concentrations with some red, 3. areas of high green concentration, 4. under-represented habitat features or geographic areas.



# Figure 4: Priority bat survey sites in Bighorn Canyon National Recreation Area




Detailed map reproduced from National Park Service Homepage (http://www.aqd.nps.gov/grd/parks/bica/maps.htm).

| Site | Rationale |
|---|---|
| Layout Creek and nearby tributaries | Layout creek has at least one still pond and lies within the high probability area delineated by the Townsend's big-eared bat model. It is also just below much cliff roosting habitat and contains the only documented occurrence of spotted bat activity in the recreation area. |
| Cliffs along the walls of Bighorn Canyon and Devils Canyon. | The canyon walls represent the most extensive complex of spotted bat rooting habitat in the area and there are anecdotal reports of spotted bat calls along the rim of Devil's Canyon. |
| Yellowtail Wildlife Habitat Management Area (YWHMA), specifically:<br><br>a. Ponds at the southernmost extent of YWHMA.<br><br>b. Known and potential roost buildings anywhere in the management area and small ponds anywhere in YWHMA. | YWHMA contains a wealth of bat foraging and roosting habitat. Areas for survey are highlighted because:<br><br>a. The Kane Caves, just south of YWHMA are known bat roosts, including Townsend's big-eared bats.<br><br>b. At least one building in YWHMA has very high bat activity, and others in the vicinity are also likely to receive some use. Bats forage over the extensive wetlands in YWHMA. The most likely place to capture them is over small bodies of flat water over which they would feed and drink. |
| Hillsboro Ranch and beaver ponds and Lockhart Ranch and beaver ponds. | These ranches consist of several uninhabited structures along drainages containing numerous beaver ponds in otherwise dry country. They are therefore likely to concentrate bats foraging in the drainages and there is evidence that at least some of the buildings serve as night roosts. |
| Caves that are just off BCNRA, usually on BLM land, but whose bat population likely forages on the recreation area. | These caves include Horse Thief Cave, Bighorn Caverns, Natural Trap Cave, Mystery Cave, and numerous others to the east of the recreation area. |
| Other habitats, such as cottonwood riparian corridors and edges in conifer forest. | As time and budget permit, other habitats might be sampled to increase the diversity of sites. |

**Figure 5: Bat inventory site distribution throughout the Greater Yellowstone Network (parks are not to scale)**

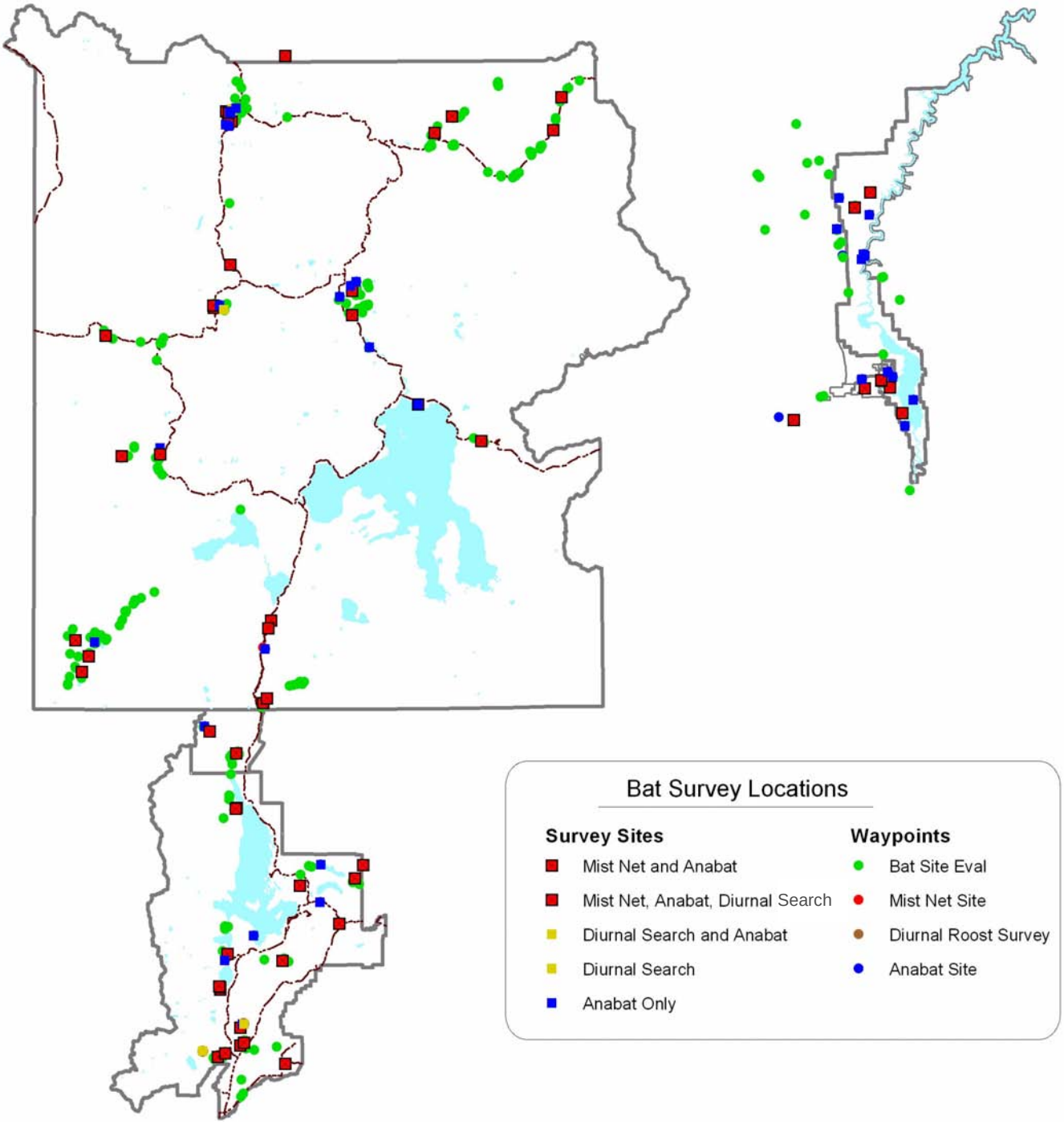
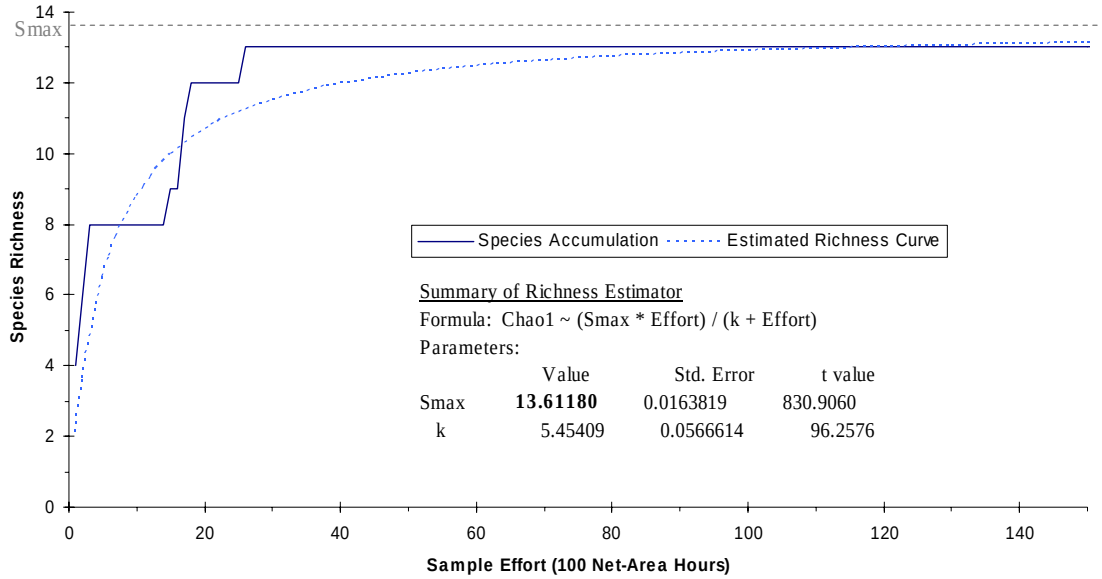


**Figure 6: Species accumulation curves and richness estimators for the Greater Yellowstone Network using: a) capture data from mist netting activities and b) recorded echolocation calls from Anabat® surveys.**

**(a)**




**(b)**

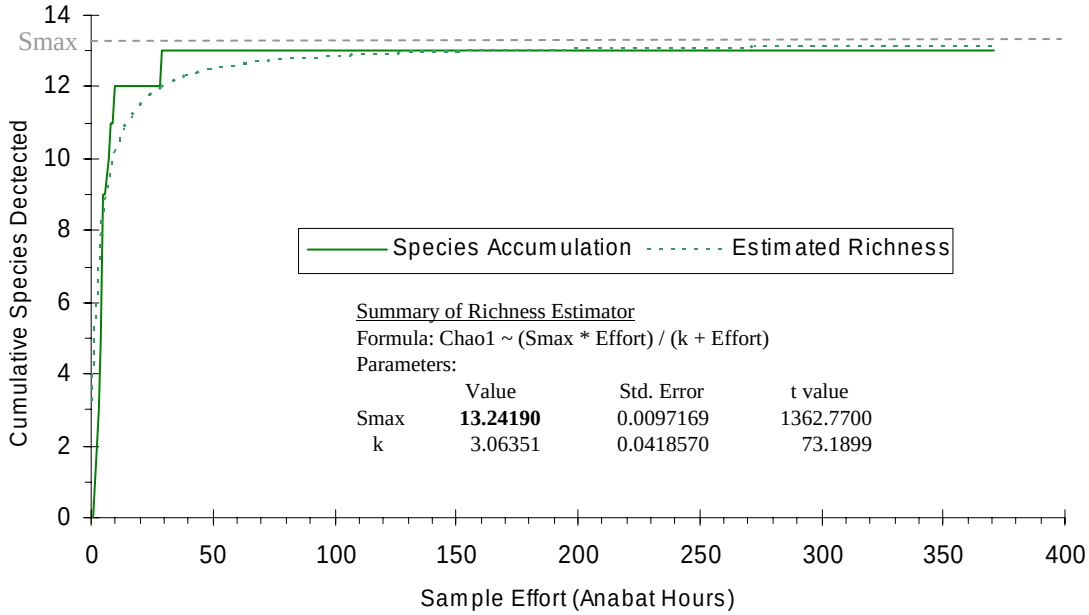
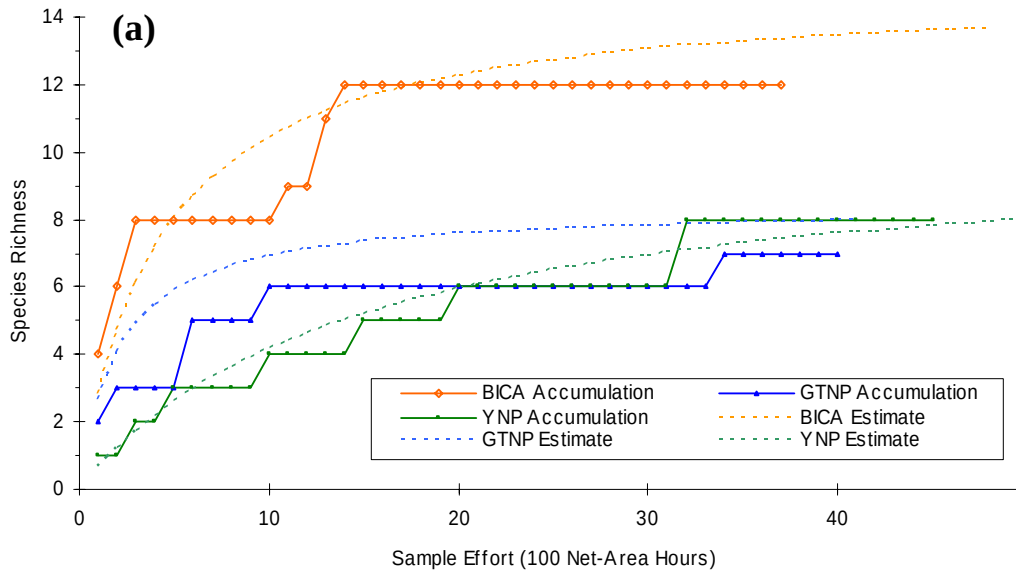


**Figure 7: Species accumulation curves and richness estimators for each park unit in the Greater Yellowstone Network using: a) capture data from mist netting activities and b) recorded echolocation calls from Anabat® surveys.**




Estimator for BICA
Formula: Chao1 ~ (Smax * Effort)/(k + Effort)
Parameters:

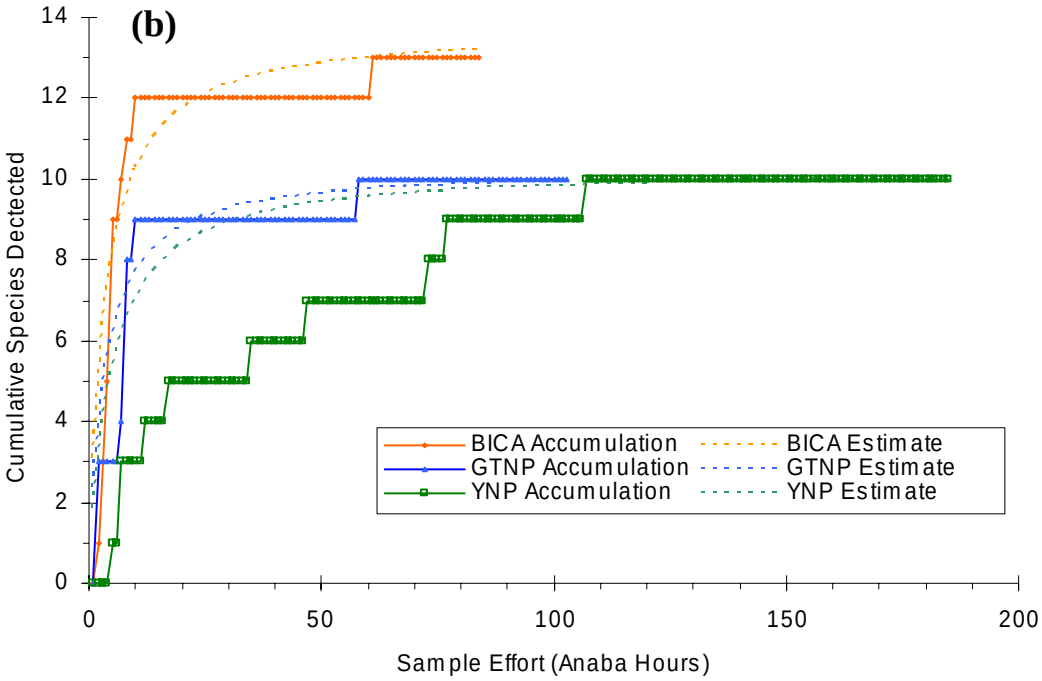
| | Value | Std. Error | t value |
|---|---|---|---|
| Smax | **14.88520** | 0.153025 | 97.2731 |
| k | 4.25426 | 0.231969 | 18.3398 |

Estimator for GTNP
Formula: Chao1 ~ (Smax * Effort)/(k + Effort)
Parameters:

| | Value | Std. Error | t value |
|---|---|---|---|
| Smax | **8.36783** | 0.0386934 | 216.2600 |
| k | 2.10481 | 0.0695252 | 30.2741 |

Estimator for YNP
Formula: Sobs ~ (Smax * Effort)/(k + Effort)
Parameters:

| | Value | Std. Error | t value |
|---|---|---|---|
| Smax | **10.3921** | 0.256363 | 40.5365 |
| k | 14.9147 | 1.156200 | 12.8997 |




Estimator for BICA
Formula: Chao1 ~ (Smax * Effort)/(k + Effort)
Parameters:

| | Value | Std. Error | t value |
|---|---|---|---|
| Smax | **13.74190** | 0.0420474 | 326.8190 |
| k | 3.38373 | 0.0838500 | 40.3546 |

Estimator for GTNP
Formula: Chao1 ~ (Smax * Effort)/(k + Effort)
Parameters:

| | Value | Std. Error | t value |
|---|---|---|---|
| Smax | **10.29540** | 0.0237806 | 432.9310 |
| k | 3.32927 | 0.0700298 | 47.5407 |

Estimator for YNP
Formula: Chao1 ~ (Smax * Effort)/(k + Effort)
Parameters:

| | Value | Std. Error | t value |
|---|---|---|---|
| Smax | **10.29110** | 0.0113985 | 902.8470 |
| k | 4.54544 | 0.0529804 | 85.7949 |

**Figure 8: Summary of bat occurrences; (a) estimated bat species richness, (b) ANABAT® records per hour, and (c) bat captures per net-area-hour by site in the Greater Yellowstone Park Network.**

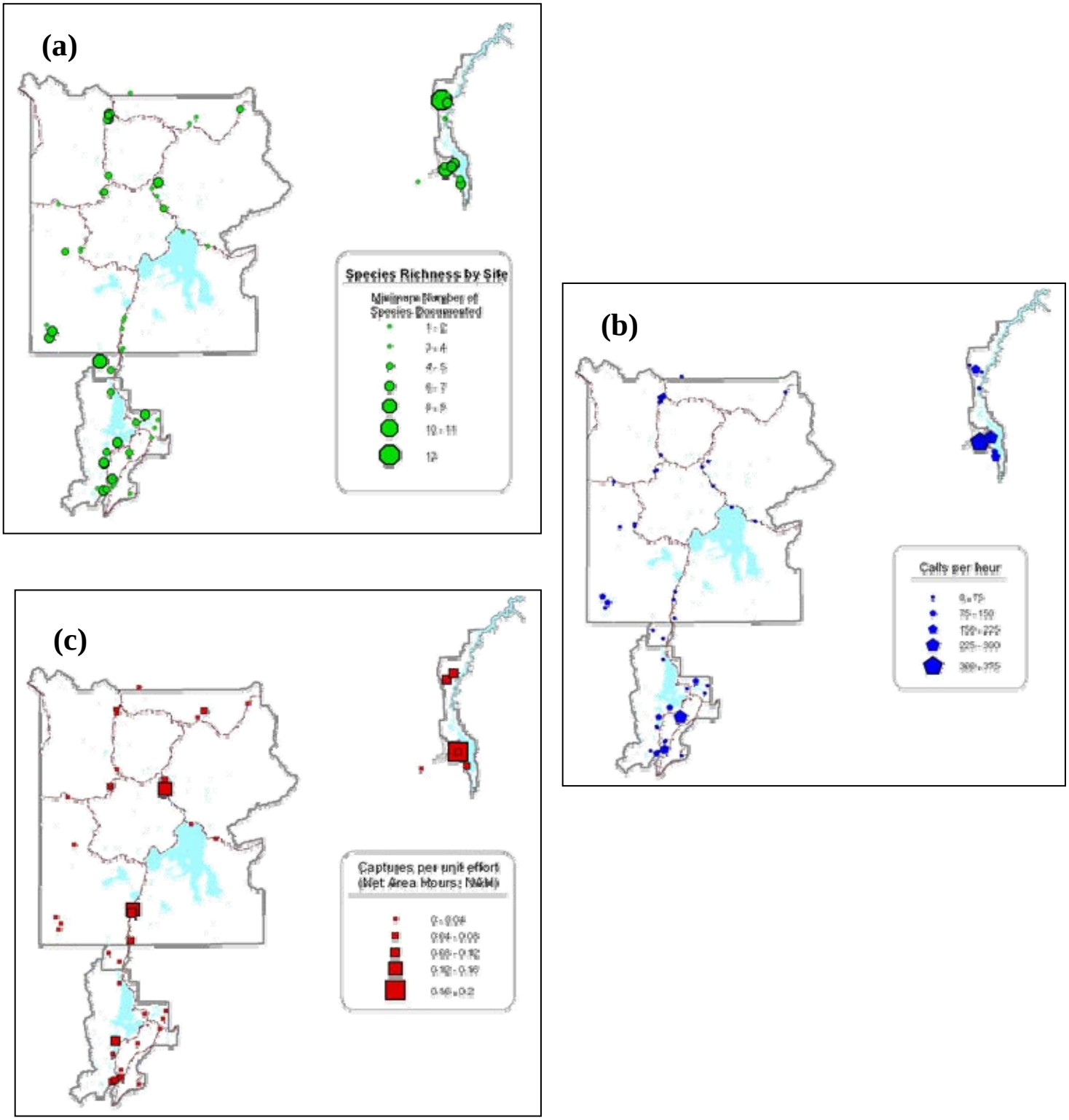


**Figure 9: Bat captures as a function of time of day as (a) frequency of all captures combined and (b) ranges for individual species.**

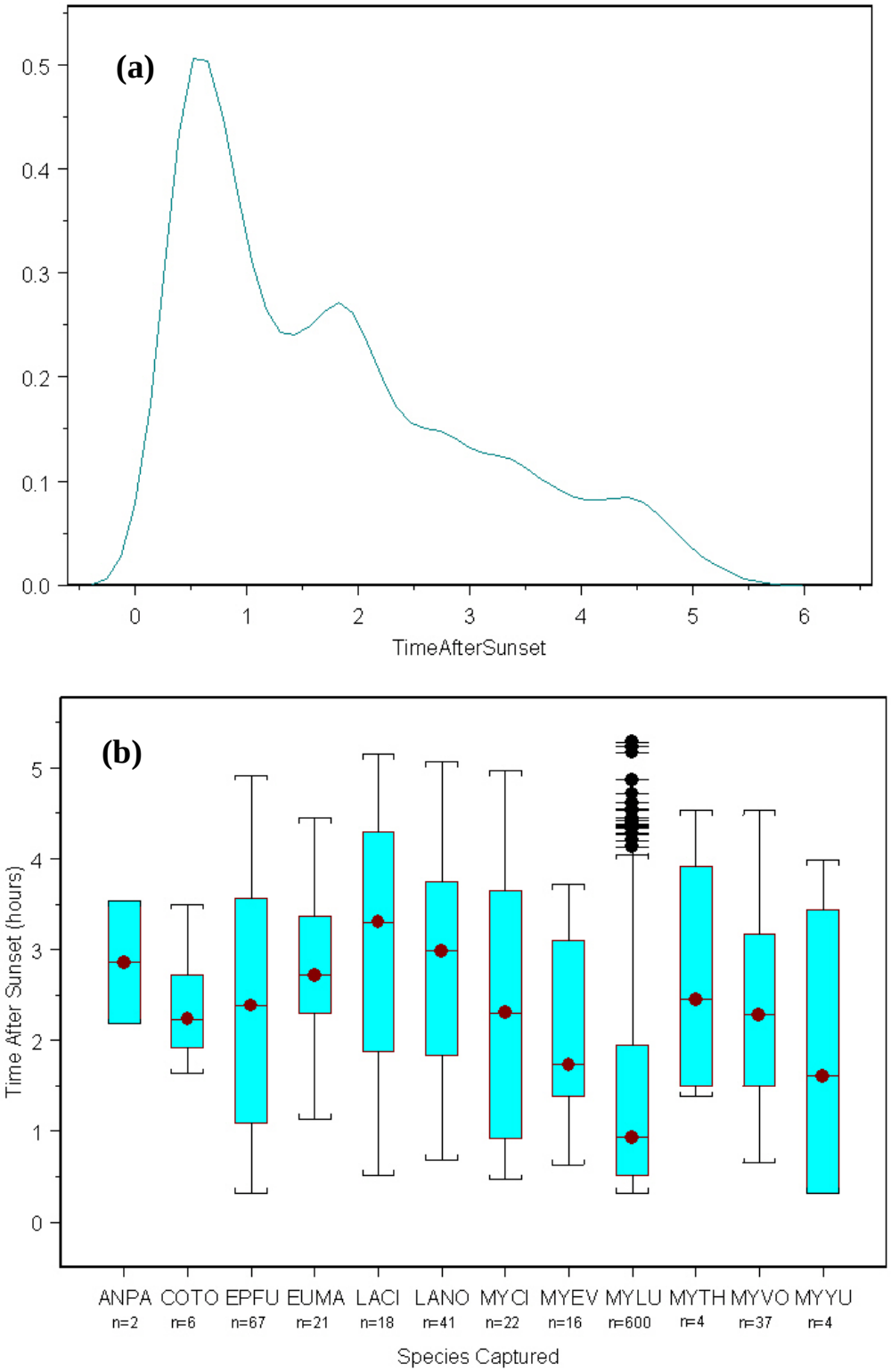
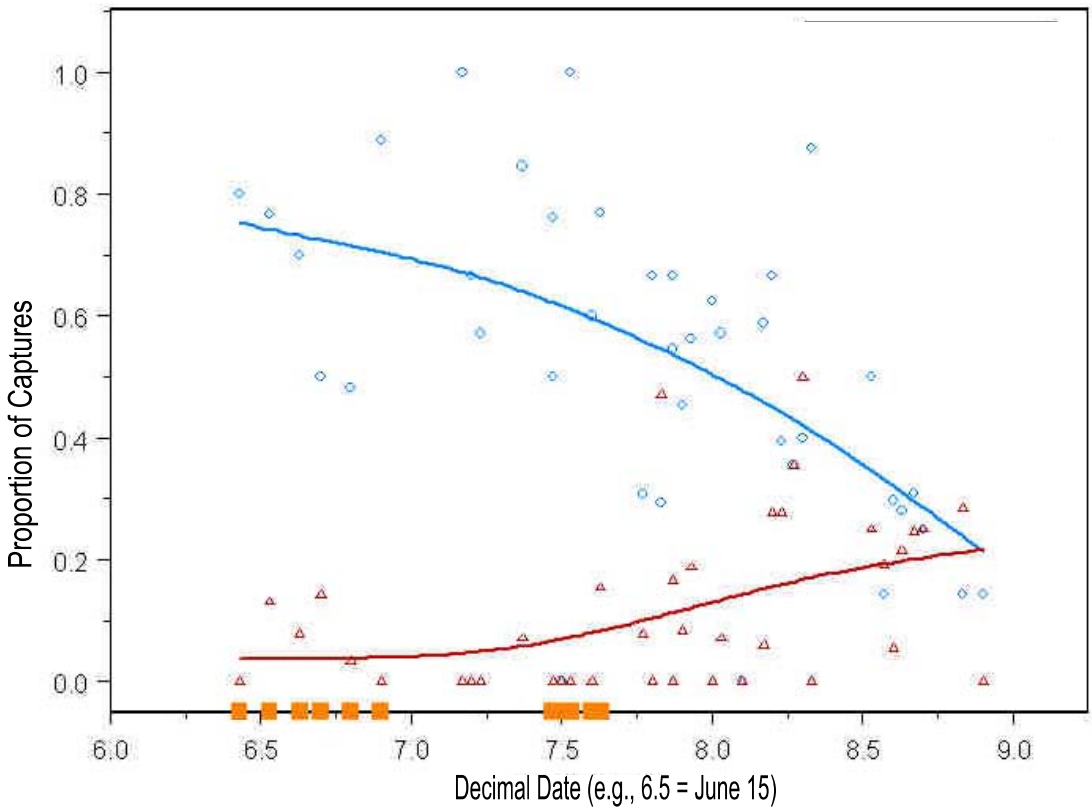


**Figure 10: Captures of reproductively active adult bats and juveniles by time of year (summer months only) for the Greater Yellowstone Ecosystem.**




Proportion of captures that were reproductively active adults (Females: pregnant, lactating, post-lactating; Males: tentacles descended). Line represents the cubic smoothing spline of the data.

Proportion of captures that were juveniles. Line represents the cubic smoothing spline of the data.

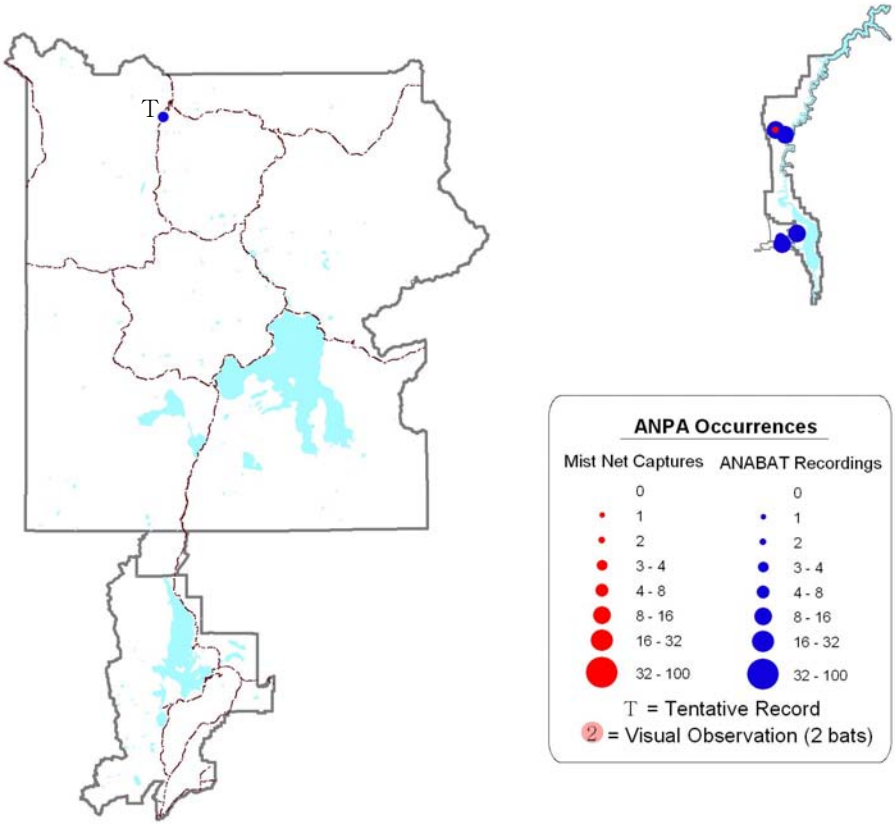
Dates during which capture activities occurred at Bighorn Canyon, where temperatures are warmer and parturition likely occurs earlier.

# APPENDICES

## *Appendix 1: Species Accounts*

Pallid bat (*Antrozous pallidus*, ANPA)....27
Townsend's big-eared bat (*Corynorhinus townsendii*, COTO)....28
Big brown bat (*Eptesicus fuscus*, EPFU)....29
Spotted bat (*Euderma maculatum*, EUMA)....30
Hoary bat (*Lasiurus cinereus*, LACI)....31
Silver-haired bat (*Lasionicteris noctivagans*, LANO)....32
California myotis (*Myotis californicus*, MYCA)....31
Western small-footed myotis (*Myotis ciliolabrum*, MYCI)....32
Long-eared myotis (*Myotis evotis*, MYEV)....33
Little brown bat (*Myotis lucifugus*. MYLU)....34
Fringe-tailed bat (*Myotis thysanodes*, MYTH)....35
Long-legged myotis (*Myotis volans*, MYVO)....36
Yuma myotis (*Myotis yumanensis*, MYYU)....37

# Pallid bat (*Antrozous pallidus*, ANPA)




**Species Ecology**

The pallid bat inhabits low desert shrublands, juniper woodlands, grasslands, and nearby cottonwood-riparian zones. It is most common in low, arid regions with rocky outcrops. Roost structures are usually rock crevices and buildings, but also rock piles, tree cavities, shallow caves, and abandoned mines. It likely hibernates in narrow crevices within caves and abandoned mines.

The pallid bat emerges about 1 hour after sunset to forage. It primarily gleans large insect prey from the ground and vegetation, but also forages in flight within about 3 m (10 ft) of the ground.

**Status in GYN**

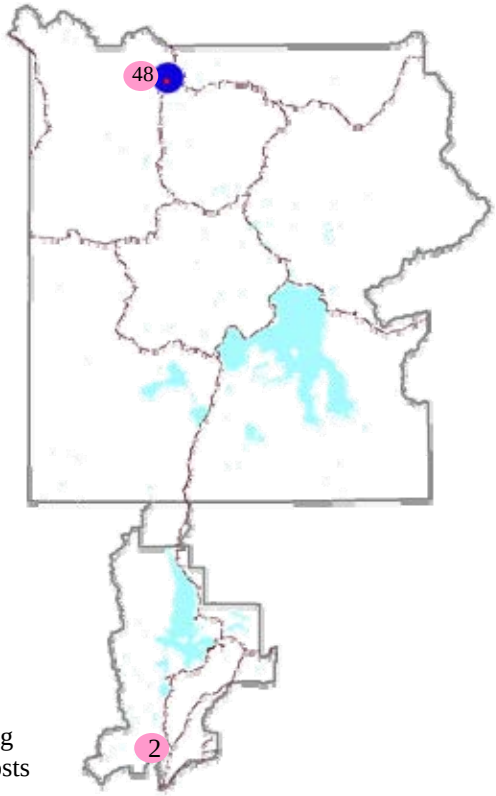
Due to its roost preferences, very few areas in Wyoming are suitable for the pallid bat. Statewide surveys in the 1990s found this species roosting in only 5 sites. **BICA:** Bighorn Canyon is one of the best such sites due to its warm, arid climate and abundant cliff roosting habitat. The BICA population should be considered permanent and a major contribution to this bats persistence in the state.

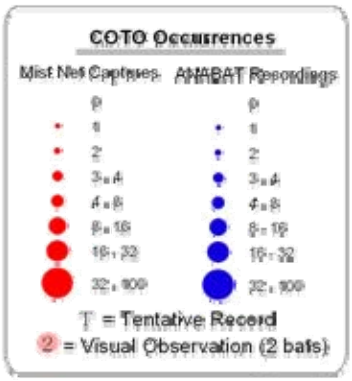
**YNP:** Several potential Pallid bat calls were recorded in the Mammoth area of YNP, but none were captured. The habitat there seems suitable, but if they occur there the population is likely small and may not be permanent. Further investigation is required to determine their status in YNP.

**Survey Notes**

Pallid bats are best surveyed with mist nets at ground level. They are easy to identify in-hand based on size, pelage color, and facial morphology. They can be detected with ANABAT®, but recordings can be confused with other 30k bats. Guano accumulation in night roosts is a useful survey tool when many are present.

# Townsend's big-eared bat (*Corynorhinus townsendii*, COTO)






**Species Ecology**

The most critical and restrictive feature of Townsend's big-eared bat ecology is the requirement for large cavern-like structures for roosting during all stages of its life-cycle. Maternity roosts are even more limiting, as they must be consistently warm throughout the breeding season. This results in a general preference for warm, low-mid elevation habitats. Otherwise, habitat use is fairly general and driven by prey availability. Townsend's big-eared bat forages primarily along edge habitats (e.g., forest edges, intermittent streams), but also in forests and along vegetated stream corridors. All reports indicate that it is an agile flier specializing on moths, which it captures on the wing. It occurs in Wyoming year-round, migrating short distances to hibernate in thermally stable caves.

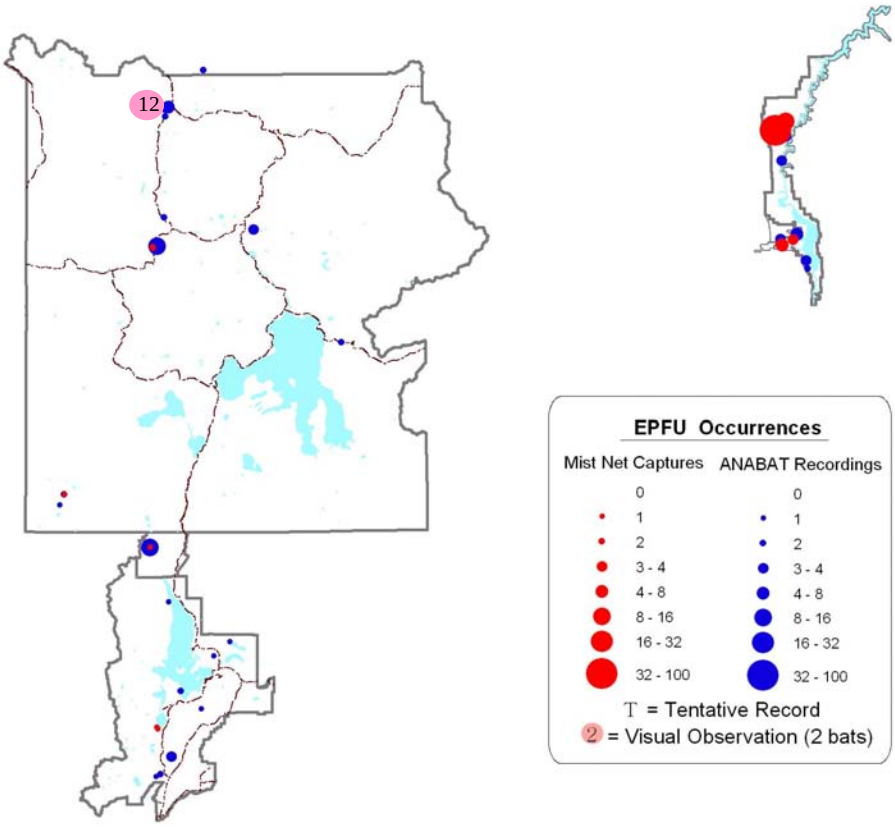
**Status in GYN**

Townsend's big-eared bats occur throughout the west, but populations are small and localized due to restrictive roost requirements, particularly for maternity colonies. It is crucial that suitable caves be protected from extensive human intrusion, as these bats are sensitive to disturbance. **BICA** and nearby BLM and Reservation land contain geological features ideal for the formation of roost caves. There are several known maternity colonies in the vicinity of Bighorn Canyon and it is likely that smaller ones exist that have not yet been identified. In **YNP**, the Mammoth Terraces hold an isolated, but regularly breeding, population of Townsend's due to the thermal caves in the area. Devil's Kitchen is the only documented maternity colony, but other fishers and sink-holes in the area have similar potential. Further, the cooler caves of the upper terraces are likely the summer home of bachelor male bats. Bachelor males have been documented in abandoned ranch buildings in the south of **GTNP**, but no females have been found. *Further research is required* to determine if a maternity colony is associated with these bachelors.

**Survey Notes**

Townsend's can be difficult to survey using standard techniques. They emit very "quiet" echolocation calls that are difficult to detect with ANABAT® except at close range. Once recorded, calls are easy to identify. They are also wary of mist nets, but those that are captured are easy to identify based on facial morphology. The best way to identify presence of these bats is to seek out suitable roosting structures and use ANABAT® where the bats are likely to emerge, or along restricted flyways nearby. Within the roost they are usually in the open, so visual searches during the day are also possible if proper care is taken to minimize disturbance.

# Big brown bat (*Eptesicus fuscus*, EPFU)




**Species Ecology**

The big brown bat is found in most of North America and is a year-round resident throughout Wyoming. It occupies a variety of habitats, including cottonwood riparian woodlands, sagebrush steppe, juniper woodlands, conifer forests, aspen woodlands, and can often be found in urban areas and around manmade structures. It may be more abundant in deciduous forests and woodlands than coniferous areas (Kurta and Baker 1990), which is born out by our surveys in GYN. Big brown bats are known for their tendency to roost in buildings, but they also use rock crevices, caves, abandoned mines, bridges, and tree cavities.

The big brown bat emerges at or just before sunset and forages most intensely for the first 2 hours after emergence. The big brown bat is a generalist forager, often feeding over meadows, pastures, and tree canopies; around ranch buildings; along tree-lined streets and riparian areas; and under streetlights.

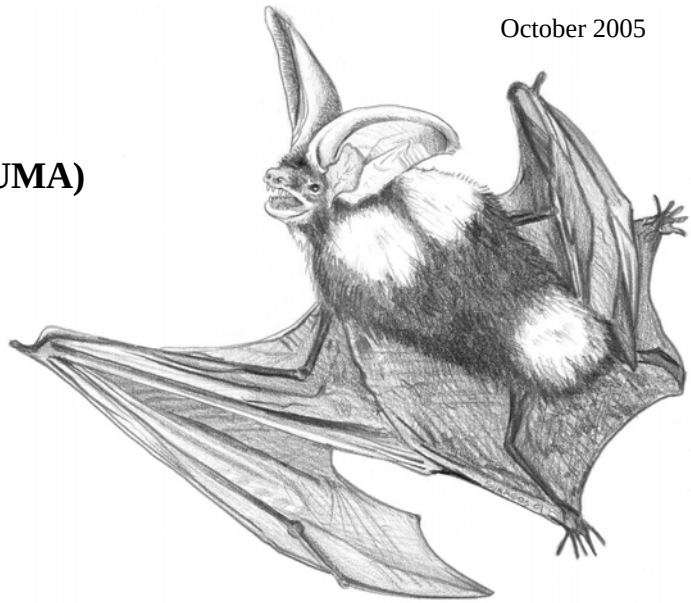
**Status in GYN**

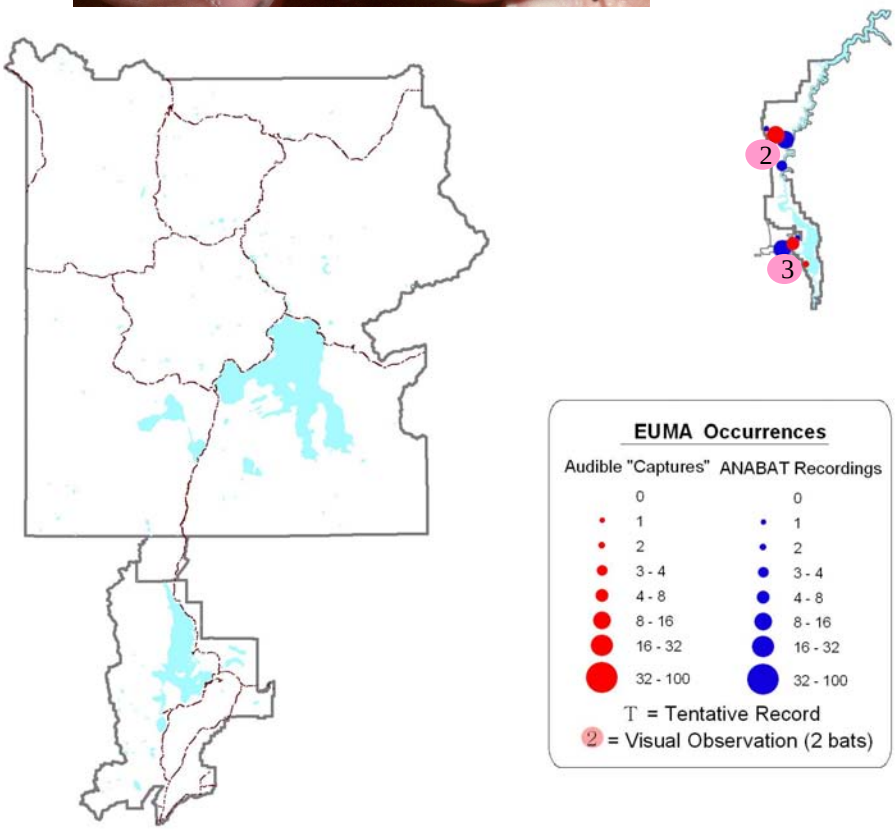
Big brown bats are found at varying abundance throughout GYN. They seem to be somewhat more abundant in **BICA** than in the other park units. Although frequently detected via ANABAT® in **YNP** and **GTNP**, they were rarely captured in those areas and one wonders if some purported occurrences were not in fact the calls of silver-haired bats. Earlier surveys of bats roosting in buildings found them to regularly occur in park structures (Bogen and Geluso 1999).

**Survey Notes**

Big brown bats are wary of mist nets and can be hard to catch for this reason. They are often detected, visually and with ANABAT®, flying around nets shortly after sunset. Given their generalist foraging strategy, nets are best placed over water where bats are likely to drink after emergence from day roosts. Experienced bat researchers find them easy to identify in-hand, due to their large size, facial morphology, and dentition. Their calls are easy to detect with ANABAT®, but can easily be confused with those of the silver-haired bat, making further confirmation important.

# Spotted bat (*Euderma maculatum*, EUMA)






**Species Ecology**

Throughout its wide range, the spotted bat uses a variety of habitats from desert shrub to coniferous forest, but roosting habitat is almost exclusively rocky cliffs on or near substantial cliff features. Suitable habitat in Wyoming is associated with rocky cliffs and karst formation near permanent water, a situation especially prevalent in the Bighorn Basin.

The spotted bat generally begins foraging well after dark along large, set routes. It forages primarily for moths while flying high (> 10 m) above the ground, usually above canopy height near forest openings. Foraging has been observed in black oak, ponderosa pine, pinyon-juniper, moderate to large riparian habitat (often in canyons), wetlands, meadows, and old agricultural fields.

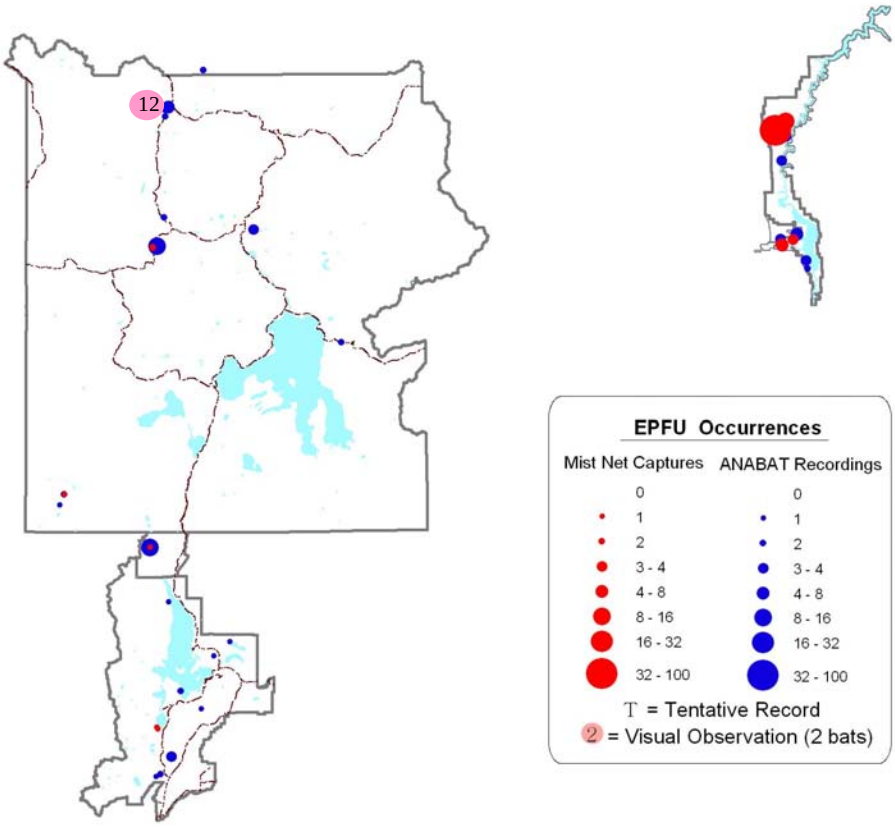
**Status in GYN**

The spotted bat is a widespread species, but is severely restricted in distribution and usually occurs in low numbers due to its restrictive roosting requirements and specialization on capturing high-flying moths. **BICA** is one of the few places in Wyoming where they regularly occur. Together with Tent Sleep Canyon it can be considered the most important location in the state for this species. Neither **GTNP** nor **YNP** have suitable habitat for the spotted bat.

**Survey Notes**

Spotted bats are extremely difficult to capture via mist nets and somewhat difficult to record with ANABAT® because they roost exclusively on tall cliffs and forage over large areas high above the ground. However, their calls are loud and sufficiently low in frequency that people with good high-frequency hearing can detect them with the un-aided ear. Thus, simple auditory surveys, often accompanied by spotlighting, are the best way to search for spotted bats.

# Big brown bat (*Eptesicus fuscus*, EPFU)




**Species Ecology**

The big brown bat is found in most of North America and is a year-round resident throughout Wyoming. It occupies a variety of habitats, including cottonwood riparian woodlands, sagebrush steppe, juniper woodlands, conifer forests, aspen woodlands, and can often be found in urban areas and around manmade structures. It may be more abundant in deciduous forests and woodlands than coniferous areas (Kurta and Baker 1990), which is born out by our surveys in GYN. Big brown bats are known for their tendency to roost in buildings, but they also use rock crevices, caves, abandoned mines, bridges, and tree cavities.

The big brown bat emerges at or just before sunset and forages most intensely for the first 2 hours after emergence. The big brown bat is a generalist forager, often feeding over meadows, pastures, and tree canopies; around ranch buildings; along tree-lined streets and riparian areas; and under streetlights.

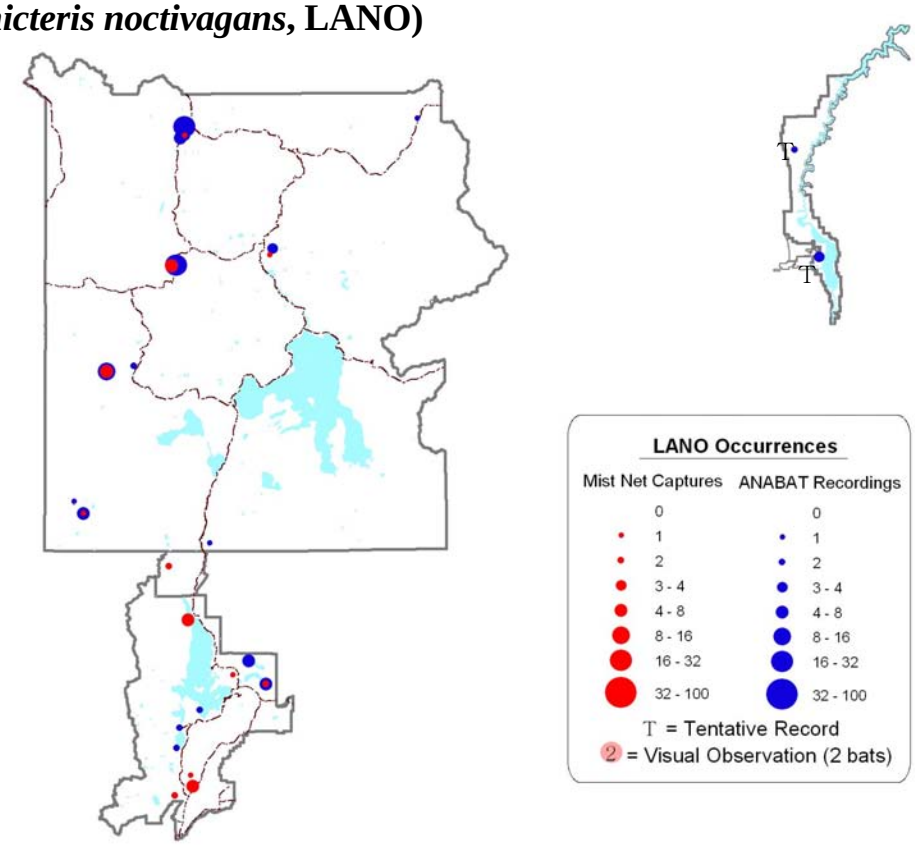
**Status in GYN**

Big brown bats are found at varying abundance throughout GYN. They seem to be somewhat more abundant in **BICA** than in the other park units. Although frequently detected via ANABAT® in **YNP** and **GTNP**, they were rarely captured in those areas and one wonders if some purported occurrences were not in fact the calls of silver-haired bats. Earlier surveys of bats roosting in buildings found them to regularly occur in park structures (Bogen and Geluso 1999).

**Survey Notes**

Big brown bats are wary of mist nets and can be hard to catch for this reason. They are often detected, visually and with ANABAT®, flying around nets shortly after sunset. Given their generalist foraging strategy, nets are best placed over water where bats are likely to drink after emergence from day roosts. Experienced bat researchers find them easy to identify in-hand, due to their large size, facial morphology, and dentition. Their calls are easy to detect with ANABAT®, but can easily be confused with those of the silver-haired bat, making further confirmation important.

## Silver-haired bat (*Lasionicteris noctivagans*, LANO)




**Species Ecology**

The silver-haired bat is found in most of North America at varying abundance. It is commonly associated with montane forest that has open water (e.g., lakes, ponds, streams) and occurs most frequently in late-successional forest with high snag densities. Forest types include conifer, mixed deciduous-conifer, juniper, aspen, cottonwood, and willow. The silver-haired bat roosts almost exclusively in trees. 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 flies later in the evening, often foraging 2 to 4 hours after sunset and again 6 to 8 hours after sunset. 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. It is one of two long-distance migrants in Wyoming (the other being the hoary bat), likely flying to southern states for winter.

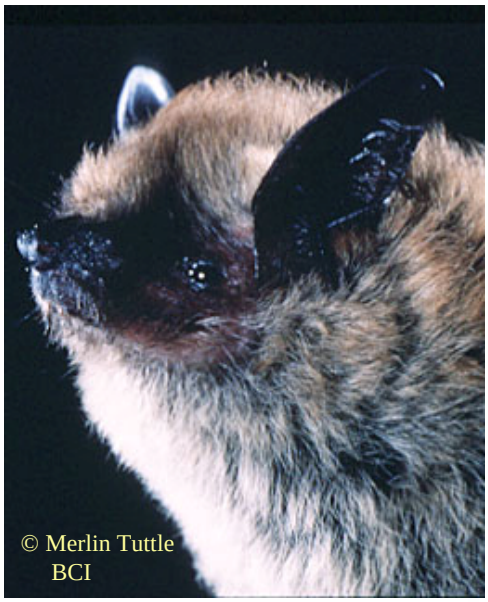
**Status in GYN**

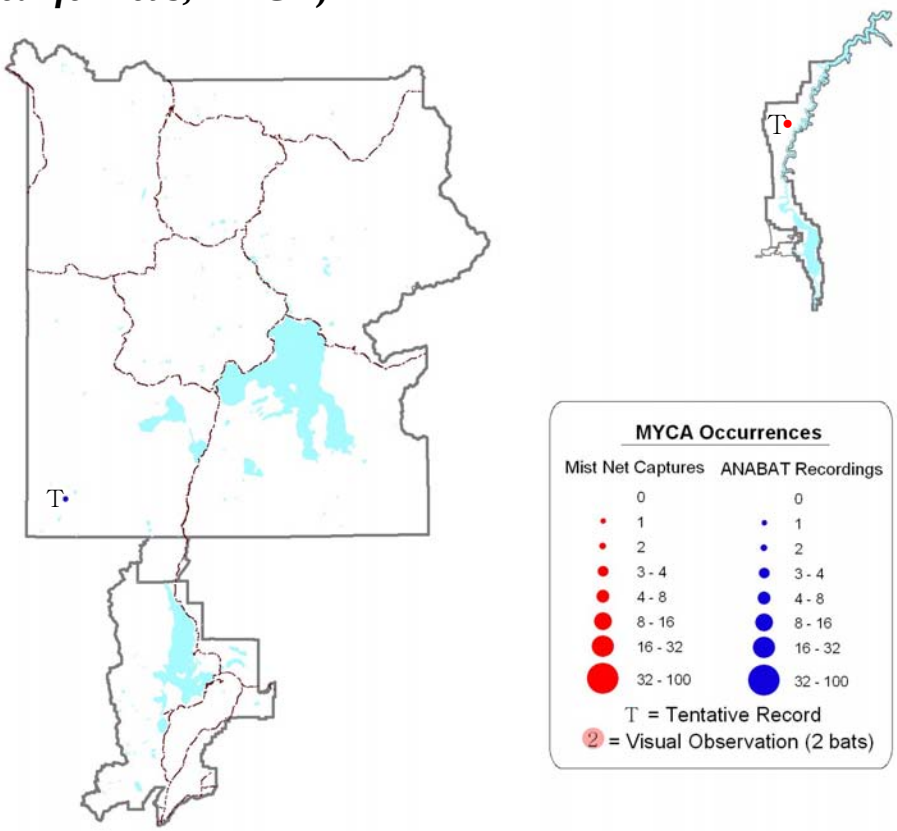
Like the other tree roosting species of the GYN (i.e., hoary bat), the silver-haired bat is found in much of the GYN but seems to occur most regularly in **GTNP**. Unlike the hoar bat, however, it is fairly common in **YNP** and was only found in **BICA** based on a few questionable records from ANABAT®. Being largely a montane forest bat, BICA may be too low and arid to support a population of silver-haired bats, although they are likely to occur in the highlands to either side of the canyon (e.g, the Pryor Mountains and Bighorn Mountains).

**Survey Notes**

The silver-haired bat is susceptible to capture via mist nets, depending on habitat, and particularly over water sources. It is easy to detect acoustically, but its calls are difficult to distinguish from those of big brown bats and Brazilian free-tailed bats (where they occur). However, experienced observers can distinguish these three species in flight, so combining active acoustic surveys with visual observation using spotlights can be effective.

# California myotis (*Myotis californicus*, MYCA)




**Species Ecology**

The california myotis is found typically in deserts, grasslands, juniper woodlands, and arid interior basins, but it can also occur in forested and montane regions. It often inhabits rock-walled canyons where water is available and where it can forage among trees, such as cottonwood and willow. In summer, the California myotis typically roosts in crevices associated with rocks, cliffs, trees (snags), and/or buildings.

The California myotis emerges shortly after sunset, after which it is most active, with another peak of activity possible after midnight. It is small, slow, and highly maneuverable, allowing it to forage close to obstacles such as vegetation and rock surfaces. Thus, it seems to forage along margins of tree clumps, around the edge of the tree canopy, but can less frequently be found feeding over water and in open country. It often feeds on swarms of small, flying insects using a very erratic flight pattern within about 3 m (10 ft) of the ground.

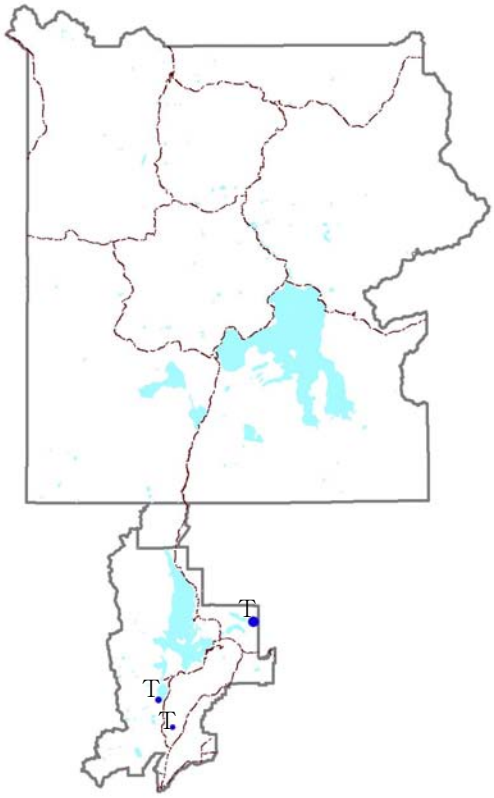
**Status in GYN**

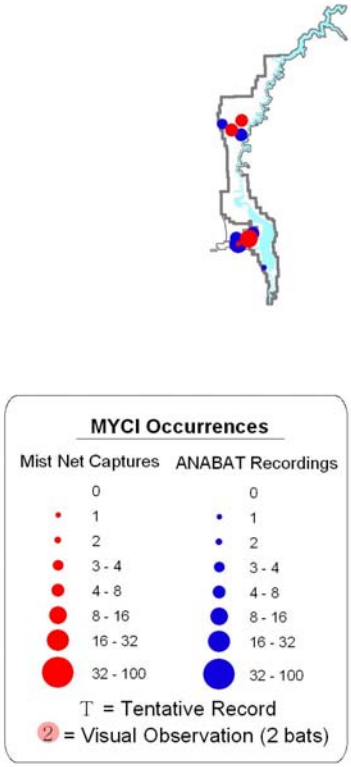
We documented no definite occurrences of California myotis in GYN, but captured one possible specimen in **BICA** and recorded a suspicious call in the Bechler Valley of **YNP**. We suspect its occurrence in both parks to be occasional, given that it occurs regularly in southwestern Wyoming and north central Idaho and the GYN lies roughly between these areas. We documented no occurrence of this species in **GTNP**. Further investigation is warranted.

**Survey Notes**

The California myotis can be captured in mist nets, but its habit of foraging around vegetation rather than water makes it more difficult to catch. Further, in-hand it can be extremely difficult to distinguish from the western small-footed myotis (where they co-occur). California myotis is easy to detect acoustically, but ANABAT® recordings of its calls can be difficult to distinguish from those of Yuma myotis. Experienced observers can distinguish its flight behavior from that of Yuma myotis, so combining active acoustic recording with visual observation can be an effective survey tool.

# Western small-footed myotis (*Myotis ciliolabrum*, MYCI)




**Species Ecology**

The western small-footed myotis 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). 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 when California myotis are not present. It begins foraging at or shortly after sunset, but activity may not peak until later (e.g., 10 - 11 PM and 1 - 2 AM). 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.

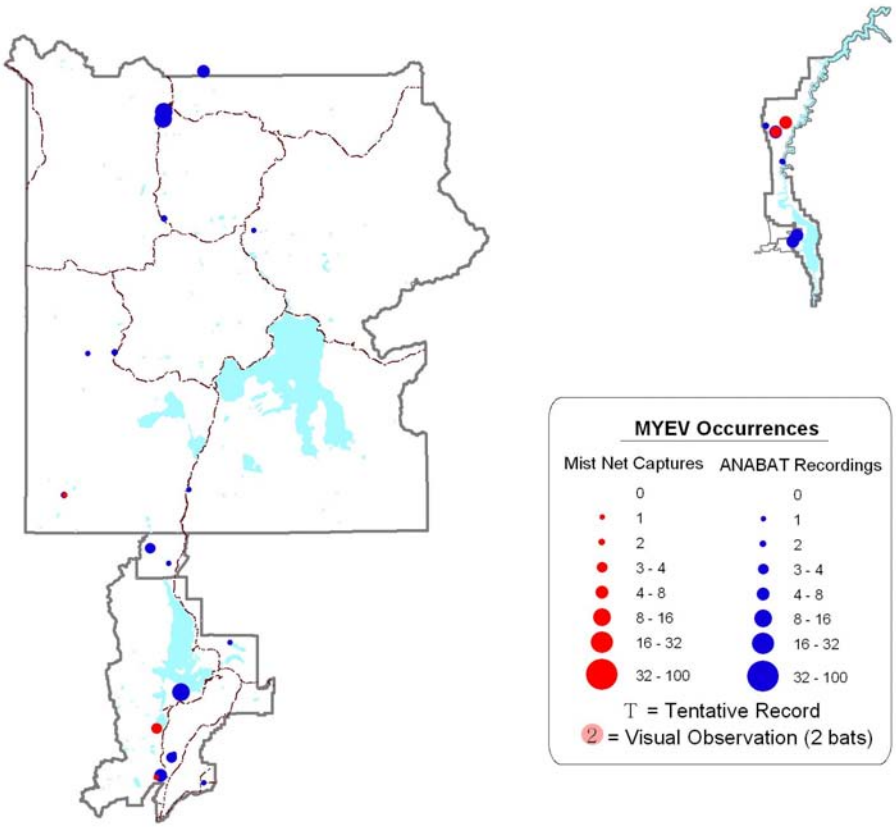
**Status in GYN**

Although widely distributed in the western United States the western small-footed myotis is not considered abundant. It seems to be common in Wyoming based on surveys of abandoned mines, but appears relatively sparse in the GYN. **BICA** is the only park unit with confirmed occurrences, all of which were in cottonwood gallery forest. They seem to be common in some localized areas of Yellowtail Wildlife Habitat Management Area near the south end Bighorn Canyon. **YNP** is likely too high and cool for small-footed myotis. Some echolocation recordings in **GTNP** looked suspiciously like this species, but they were few and no captures were made. Given its habitat characteristics, GTNP likely does not support a viable population of small-footed myotis. Further investigation is warranted.

**Survey Notes**

In general the small-footed myotis can be captured in mist nets, particularly if nets are placed in flyways among vegetation (e.g., cottonwood gallery forest in BICA). Once in hand, identification is straightforward based on pelage and membrane characteristics, as long as the surveyor is experienced in distinguishing among myotis species. Small-footed myotis are easy to detect acoustically, but ANABAT® recordings are difficult to distinguishable from other 40 kHz myotis and visual identification in flight is difficult without substantial experience.

# Long-eared myotis (*Myotis evotis*, MYEV)




**Species Ecology**

The long-eared myotis inhabits most of western North America including Wyoming, where it is uncommon relative to other species. Common habitat of long-eared myotis is coniferous forest and woodland (e.g., juniper, ponderosa pine, subalpine spruce-fir). It is more likely in areas close to a water source and near rock outcrops. Roosts are primarily in large snags, but can sometimes be in buildings, rock crevices, caves, and abandoned mines. Very few maternity colonies have been located in Wyoming.

Foraging times are variable. The long-eared myotis is slow and maneuverable, typically foraging near vegetation and over rivers, streams, and ponds within forest, but also over other open areas (e.g., camp-grounds, forest openings). It can catch insects both by aerial pursuit, hovering and gleaning. 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.

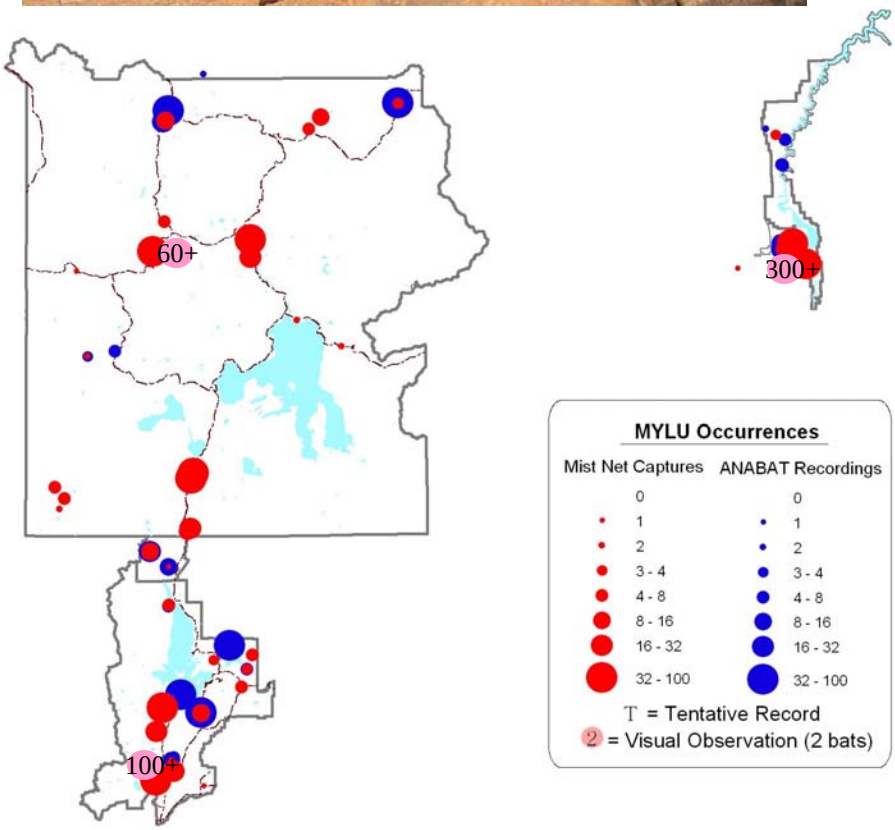
**Status in GYN**

The long-eared myotis occurs in low numbers throughout the GYN and is not discernibly more abundant in any particular park unit, although fewer were captured in **YNP** than either BICA or GTNP. ANABAT® recordings were made at entrances to abandoned ranch buildings in **GTNP**, suggesting possible night use of those structures.

**Survey Notes**

The long-eared myotis is readily captured in mist nets at both aquatic and terrestrial sites, particularly along roads and cut lines through trees. However, in-hand it can be difficult to distinguish from fringed myotis by those without such experience. It is easy to detect acoustically, but only a subset of passively collected ANABAT® calls are diagnostic, the rest being easily confused with other 30 kHz bats, notably fringed myotis.

# Little brown bat (*Myotis lucifugus*. MYLU)




**Species Ecology**

In Wyoming, the little brown myotis is most common in conifer forest, streamside riparian areas, woodlots, shelterbelts, 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.

The little brown bat begins to forage at dusk. It is small, slow, and highly maneuverable, allowing it to forage close to obstacles and pursue insects over short distances. 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 feeds mainly on small, soft-bodied, flying insects, particularly emerging aquatic insects (e.g., caddis flies, mayflies, midges, mosquitoes).

**Status in GYN**

The little brown bat inhabits is a year-round resident throughout Wyoming. It is by far the most common bat in the GYN, occurring at high abundance relative to other bats at most survey sites. Many buildings in **YNP**, **GTNP**, and a few in **BICA** have large roosting colonies of little brown bats (see also Bogen and Geluso 1999). In fact, such structures seem important to the health of its populations within the GYN. It is a voracious feeder on common pest insects (e.g., mosquitoes), making these building-centered populations an asset to visitors.

**Survey Notes**

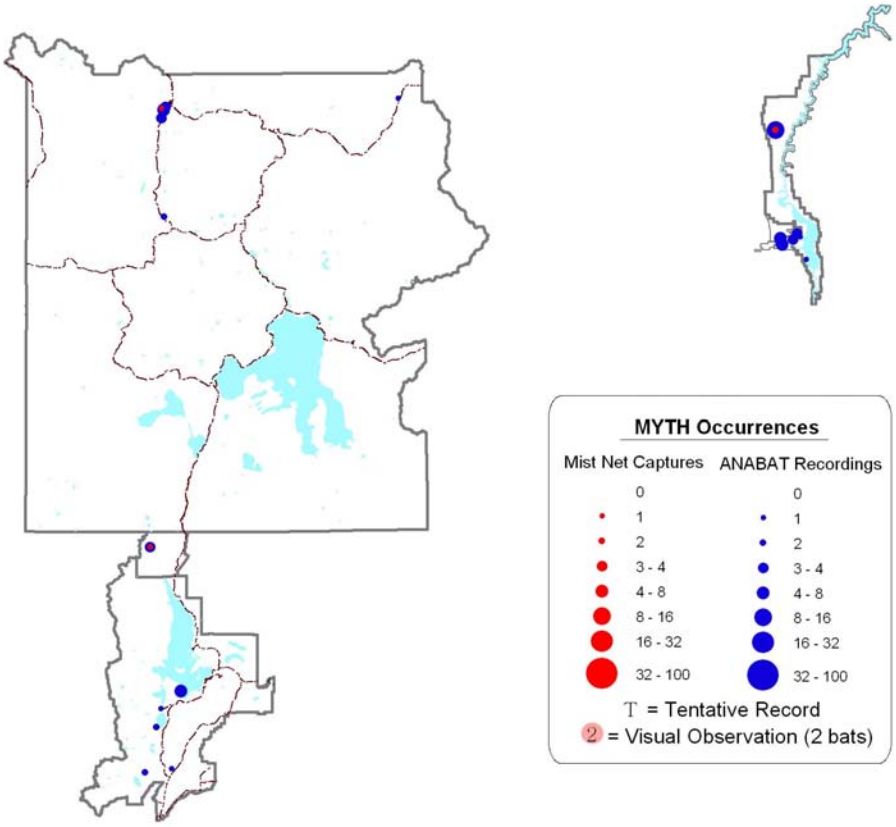
Given their habit of feeding at the surface of calm water, little brown bats are easily surveyed with mist nets placed over water bodies. In-hand, they are very difficult to distinguish from Yuma myotis, although they are much more common. Using ANABAT®, its calls are easy to distinguish from Yuma's, making the combination of mist nets and ANABAT® effective. Using ANABAT® alone, little brown bat calls are easily confused with other 40 kHz myotis in Wyoming, namely small-footed myotis and long-legged myotis, but a subset can be distinguished by experts.

# Fringe-tailed bat (*Myotis thysanodes*, MYTH)

**Species Ecology**

When trying generalize published information on the fringe-tailed bat, they are mostly found in dry habitats where open areas (e.g., grasslands and deserts) are interspersed with mature forests (usually ponderosa pine, pinyon-juniper, or oak), creating complex mosaics with ample edges and abundant snags. It seems that this type of habitat usually occurs at mid-elevations in the Rocky Mountains and that ideal sites are near water and have abundant roosts. Fringed-myotis in Wyoming seem to roost predominantly in crevices of cliff or in large, middle-aged snags in mature conifer forest.

The fringed-tailed bat likely eats mostly beetle and moths, which it can capture on the wing or by gleaning from vegetation. They are adapted to fly in vegetatively cluttered environments, which means they probably forage in interior forest and/or along forest edges.



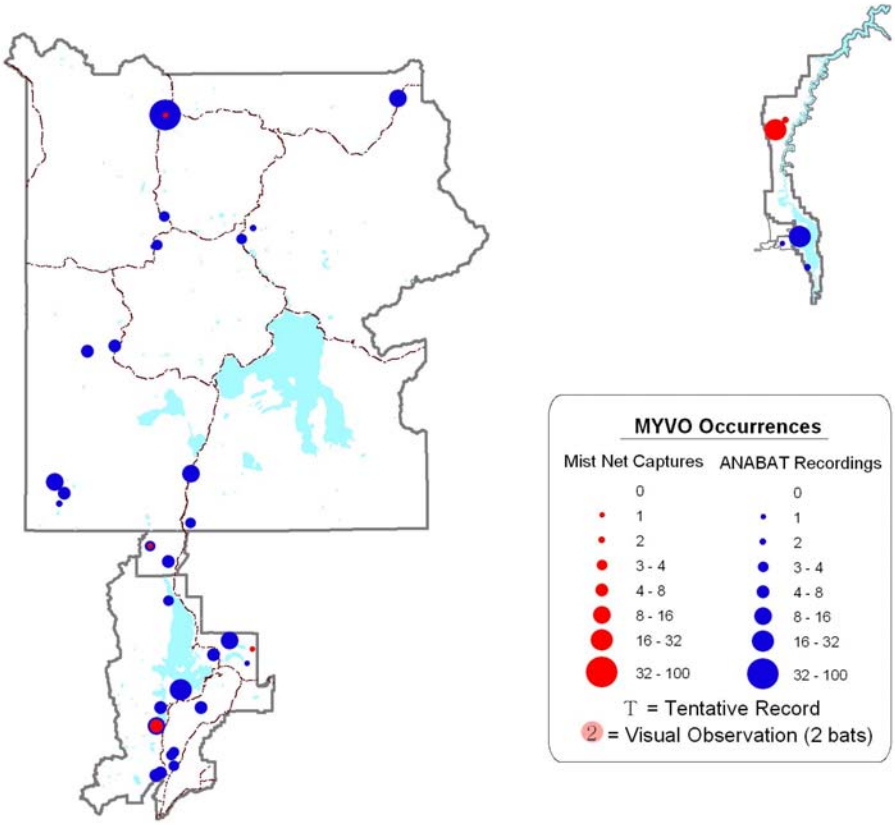

**Status in GYN**

Fringed myotis occurred in all three park units of the GYN, with BICA containing the greatest relative abundance. It seemed regular, if not truly common, in **BICA**, where abundant cliff habitat exists for roosting surrounded by a patchwork of arid forest and grassland. It seemed to occur at low numbers in much of **GTNP**, presumably roosting in snags, as no evident cliff habitat seemed to drive distribution. In **YNP**, fringed myotis turned up a few times, primarily in the vicinity of Mammoth, which is much like BICA in its mixture of cliffs and dry forest habitat. Further investigation of the roost use of this species in each park is merited.

**Survey Notes**

Fringed-tailed bats can be captured in mist nets, but since they forage around vegetation, typically near forested areas, methods of survey not tied to water bodies (e.g., canopy netting) will likely be most productive. In-hand they can be mistaken for long-eared myotis (*M. evotis*) if careful attention is not given to evaluating the trailing edge of the tail membrane. Their echolocation calls are distinctive if a good recording is obtained, which is difficult to do with a stationary ANABAT9® unit. Conducting active acoustic surveys along forest edges and netting openings along those edges where calls are detected seems to be a valid survey strategy for this species.

# Long-legged myotis (*Myotis volans*, MYVO)




**Species Ecology**

Suitable habitat for long-legged myotis in Wyoming includes mature montane forest, ponderosa pine and juniper woodlands, and montane shrubs and willows near forested areas; primarily at mid to high elevations with many snags. During summer, females form maternity colonies in tree cavities, buildings, rock crevices, and under loose bark. Most roosts are in large-diameter snags with loose bark, near forest openings, and near permanent water. Males will roost more broadly. Migration is unclear, as it has not been documented hibernating in Wyoming.

The long-legged myotis emerges in early evening and is active most of the night; activity may peak 3 - 4 hours after sunset. It is a rapid, direct flier that pursues prey in open areas (e.g., camp-grounds, small clearings), vegetated riparian areas, and around forest canopy. Although feeding on a variety of soft-bodied insects, it mainly eats moths.

**Status in GYN**

The long-legged myotis occurs throughout Wyoming *where suitable habitat exists*. Portions of all GYN parks appear to contain suitable habitat, as defined above. It is difficult to get a sense of abundance, because *M. volans* is difficult to catch in nets and its echolocation calls can easily be confused with the more common little brown bat. We estimate that it is common in **GTNP**, locally common in **YNP**, and somewhat common in **BICA**. Like other tree-roosting bats, its fate in these areas depends largely on the state of mature forests.

**Survey Notes**

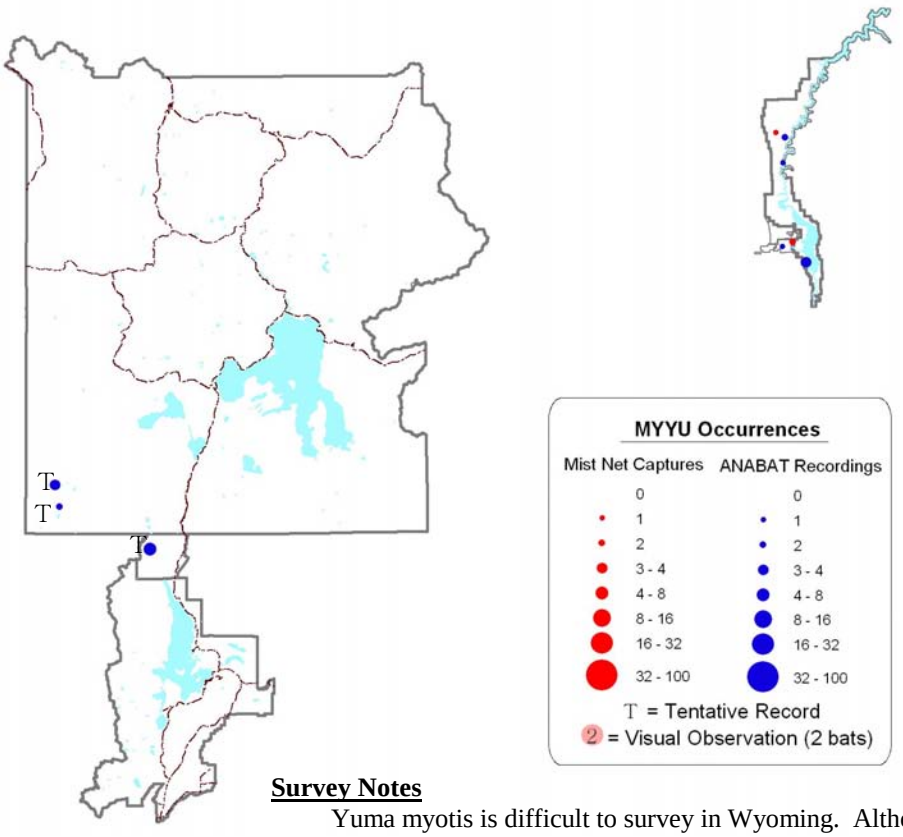
Since long-legged myotis forage around vegetation, it occurs in water-based mist nets below its proportion in the local chiroptofauna (only one was captured in all YNP, despite many suspected ANABAT® recordings). It is easy to detect acoustically, but its calls are easy to confuse with other 40 kHz myotis, particularly little brown bats flying in cluttered areas. Its long tail membrane may be distinguishable in flight to experienced observers, so visual observation combined with active ANABAT® recording is likely an effective survey option.

# Yuma myotis (*Myotis yumanensis*, MYYU)

**Species Ecology**

The Yuma myotis is found mostly in low-mid elevation arid areas, but in a variety of habitats including deserts, woodlands, grasslands, sagebrush steppe, and riparian corridors. Despite occurring in arid areas, it is closely associated with water features, and usually occurs near permanent sources of water. Maternity colonies and day roosts may be in buildings, trees, caves, abandoned mines, bridges, or cliff crevices, always close to water.

The Yuma myotis emerges just after sunset to begin foraging. It forages almost exclusively over water features (often a few centimeters above the surface), but may in open habitats when prey is abundant. Like the little brown bat, it feeds opportunistically on a variety of insects, primarily aquatic and soft-bodied insects (e.g., caddis flies, mayflies, flies, moths, small beetles).




**Status in GYN**

All occurrences in GYN may be disjunct from the main range of Yuma myotis. The best GYN habitat for them occurs in **BICA**, where a relatively arid landscape and suitable roost sites occur in proximity to large, open bodies of water. It occurred uncommonly but regularly in BICA during this survey, and one confirmed maternity roost was found in Yellowtail Wildlife Habitat Management Area. Occurrence of Yuma myotis in **YNP** and **GTNP** is more tentative, based on several localized sets of ANABAT® recordings in the Bechler Valley and John D. Rockefeller Parkway. These habitats are not ideal for the species and likely do not support reliable populations. However, Yuma myotis occurs just west of YNP in Idaho, so there is the possibility of a stable, albeit peripheral, population; *further investigation is required*.

**Survey Notes**

Yuma myotis is difficult to survey in Wyoming. Although its water-skimming foraging strategy makes it vulnerable to capture in mist nets, in the GYN it seems to forage over large bodies of water that are extremely difficult to net. In-hand it is very difficult to distinguish from the little brown bat, even by experts. Further, although it is easy to detect acoustically, its calls can be difficult to distinguish from California myotis. The foraging behavior of these two species is markedly different, so active recording combined with visual observation by experienced bat biologists may be an efficient survey method.

**Note**: The CD-ROM containing GIS data was not distributed with this reproduction of the report. If you require access to this data, please submit a request to the Wyoming Natural Diversity Database:

Attention: Data Manager
Wyoming Natural Diversity Database
University of Wyoming, Dept. 3381
Laramie, Wyoming 82071
307-766-3023

## *Appendix 2: Geographic Information System (GIS) Data*

The CD-ROM found in the back cover of this report contains a folder labeled "bat_inv." All information in this folder can be easily accessed if it is copied to a hard drive in the following folder: C:\ArcWork\. The folder contains the following items:

| Name | Size | Type | Date Modified |
|---|---|---|---|
| BackgroundFiles | | File Folder | 10/28/2005 3:26 PM |
| DataFiles | | File Folder | 10/28/2005 3:26 PM |
| info | | File Folder | 10/28/2005 11:22 AM |
| Bat Inventory Data.mxd | 129 KB | ESRI ArcMap Document | 10/28/2005 3:27 PM |

1. **BackgroundFiles** contains several GIS shapefiles with basic park data (i.e., roads, water bodies, unit boundaries), for use as coarse spatial references when viewing the data on-screen.
2. **DataFiles** contains a shapefile, a metadata file, and a Microsoft Excel workbook containing summary information of the data collected during this bat inventory (see below). Each column of information presented in the survey data shapefile and workbook are described in the metadata document.

| Name | Size | Type | Date Modified |
|---|---|---|---|
| Metadata for surveydata1283.htm | 26 KB | HTML Document | 10/28/2005 3:21 PM |
| surveydata1283.dbf | 48 KB | DBF File | 10/28/2005 1:45 PM |
| surveydata1283.prj | 1 KB | PRJ File | 10/28/2005 1:48 PM |
| surveydata1283.sbn | 5 KB | SBN File | 10/28/2005 1:45 PM |
| surveydata1283.sbx | 1 KB | SBX File | 10/28/2005 1:45 PM |
| surveydata1283.shp | 3 KB | SHP File | 10/28/2005 1:48 PM |
| surveydata1283.shp.xml | 27 KB | XML Document | 10/28/2005 3:24 PM |
| surveydata1283.shx | 1 KB | SHX File | 10/28/2005 1:48 PM |
| SurveyData.xls | 50 KB | Microsoft Excel Worksheet | 10/28/2005 1:34 PM |

3. **info** contains information essential to ArcMap for reading the rest of this data. It should not be modified or removed.
4. **Bat Inventory Data.mxd** is an ArcMap project that references all the above noted data files and provides symbology useful for viewing the data.

*Note: As stated in "Metadata for surveydata1283.htm," all shapefiles are projected using the Universal Transverse Mercatur projection based on the 1983 North American Datum (NAD1983). The definitions of each field in "surveydata1283" and "SurveyData.xls" are listed in the section on "Entity and Attribute Information" of the same metadata file and reprinted in the following table.*

**Table A2-1. Field Definitions for "surveydata1283.shp" and "SurveyData.xls," as reported in the html file "Metadata for surveydata1283.htm." Row colors have the following meanings: Yellow = general site information, Pink = information from mist net activities, Blue = information from Anabat® activities, Green = summary information on species diversity.**

| Field Label | Field Definition |
|---|---|
| SITE | Survey Site: Code used to define a given survey site during inventory activities. |
| PARKUNIT | Park Unit: The park unit (BICA, GTNP, or YNP) in which this survey site occurs. |
| SUBUNIT | Sub-unit: Coarse geographic reference for the location of the survey site within the Greatery Yellowstone Network |
| LOCATION | Survey Site Location: Textual discription of where the survey site is located. |
| EASTING | UTM Easting: X-coordinate for survey site in UTM Zone 12, NAD 1983. |
| NORTHING | UTM Northing: Y-coordinate for survey site in UTM Zone 12, NAD 1983. |
| DATUM | Datum in which the point was recorded ... should be NAD1983 for all sites. |
| SURVEY | Survey Activity: Categorical definition of the type of survey performed at each site. |
| TOTCAP | Total Captures: Total number of bats captued at a given survey site. Values only for those sites were mistnetting activities occured. |
| ANPA | Number of pallid bats captued at a given survey site. Values only for those sites were mistnetting activities occured. |
| COTO | Number of Townsend'd big-eared bats captued at a given survey site. Values only for those sites were mistnetting activities occured. |
| EPFU | Number of big brown bats captued at a given survey site. Values only for those sites were mistnetting activities occured. |
| EUMA | Number of spotted bats documented at a given survey site. Values only for those sites were mistnetting activities occured. |
| LACI | Number of hoary bats captued at a given survey site. Values only for those sites were mistnetting activities occured. |
| LANO | Number of silver-haired bats captued at a given survey site. Values only for those sites were mistnetting activities occured. |
| MYCA | Number of california myotis captued at a given survey site. Values only for those sites were mistnetting activities occured. |
| MYCI | Number of myotis cilliolabrum captued at a given survey site. Values only for those sites were mistnetting activities occured. |
| MYEV | Number of long-earred myotis captued at a given survey site. Values only for those sites were mistnetting activities occured. |
| MYLU | Number of little brown bats captued at a given survey site. Values only for those sites were mistnetting activities occured. |
| MYTH | Number of fringed-tailed bats captued at a given survey site. Values only for those sites were mistnetting activities occured. |
| MYVO | Number of long-legged myotis captued at a given survey site. Values only for those sites were mistnetting activities occured. |
| MYYU | Number of Yuma myotis captued at a given survey site. Values only for those sites were mistnetting activities occured. |
| EFFORT CAP | Capture Effort: The mist net sampling effort expended at a given survey site, reported in net area hours (NAH). NAH is the area of nets operated on a site (in square meters) multiplied by the length of time (in hours) that those nets were active. |
| CAP PER EF | Captures per Effort: The number of bats captured at a given survey site per unit of sampling effort at that site. Reported as bats per NAH. |
| CAP RICH | Capture Richness: the number of different species identified at a given site as a result of mist net activities. |
| SPECPEREFF | Species Per Effort: The number of different bat species documented at a given site per unit of sampling effort at that site. Reported as number of species per NAH. |
| TOTCALL | Total Calls: Total number of unique bat calls recorded at a given survey site. Reported only for sites where echolocaiton calls were recorded with Anabat equipment. |
| UNKNBAT | Unkown Bat Call: The number of calls recorded at a given survey site that could not be distinguished to the species level. Reported only for sites where echolocaiton calls were recorded with Anabat equipment. |
| MULTICALL | Multiple Calls: The number of Anabat files at a given site that contained calls of more than one bat. |

| Field Label | Field Definition |
|---|---|
| AB25K | Number of unique bat calls identifiable as a 25 kilohertz bat, but not identifiable to the species level. Reported only for sites where echolocaiton calls were recorded with Anabat equipment. |
| AB30K | Number of unique bat calls identifiable as a 30 kilohertz bat, but not identifiable to the species level. Reported only for sites where echolocaiton calls were recorded with Anabat equipment. |
| AM40K | Number of unique bat calls identifiable as a 40 kilohertz bat, but not identifiable to the species level. Reported only for sites where echolocaiton calls were recorded with Anabat equipment. |
| AM50K | Number of unique bat calls identifiable as a 50 kilohertz bat, but not identifiable to the species level. Reported only for sites where echolocaiton calls were recorded with Anabat equipment. |
| AANPA | Number of unique bat calls identifiable as coming from a palid bat. Reported only for sites where echolocaiton calls were recorded with Anabat equipment. |
| ACOTO | Number of unique bat calls identifiable as coming from a Townsend's big-eared bat. Reported only for sites where echolocaiton calls were recorded with Anabat equipment. |
| AEPFU | Number of unique bat calls identifiable as coming from a big brown bat. Reported only for sites where echolocaiton calls were recorded with Anabat equipment. |
| AEUMA | Number of unique bat calls identifiable as coming from a spotted bat. Reported only for sites where echolocaiton calls were recorded with Anabat equipment. |
| ALACI | Number of unique bat calls identifiable as coming from a hoary bat. Reported only for sites where echolocaiton calls were recorded with Anabat equipment. |
| ALANO | Number of unique bat calls identifiable as coming from a silver-haired bat. Reported only for sites where echolocaiton calls were recorded with Anabat equipment. |
| AMYCA | Number of unique bat calls identifiable as coming from a california myotis. Reported only for sites where echolocaiton calls were recorded with Anabat equipment. |
| AMYCI | Number of unique bat calls identifiable as coming from a western small-footed myotis. Reported only for sites where echolocaiton calls were recorded with Anabat equipment. |
| AMYEV | Number of unique bat calls identifiable as coming from a long-eared myotis. Reported only for sites where echolocaiton calls were recorded with Anabat equipment. |
| AMYLU | Number of unique bat calls identifiable as coming from a little brown bat. Reported only for sites where echolocaiton calls were recorded with Anabat equipment. |
| AMYTH | Number of unique bat calls identifiable as coming from a fringe-tailed bat. Reported only for sites where echolocaiton calls were recorded with Anabat equipment. |
| AMYVO | Number of unique bat calls identifiable as coming from a long-legged myotis. Reported only for sites where echolocaiton calls were recorded with Anabat equipment. |
| AMYYU | Number of unique bat calls identifiable as coming from a Yuma myotis. Reported only for sites where echolocaiton calls were recorded with Anabat equipment. |
| HRS CAL | Hours Call: The sampling effort at a given survey site where echolocation calls were recorded. Reported as Anabat hours (i.e., the number of hours an Anabat unit was recording at the site). |
| CAL PER HR | Calls per Hour: The number of unique echolocation calls recorded at a given survey site per hour of Anabat operation. |
| CAL RICH | Call Richness: The number of different species of bats whose echolocation calls were recorded at a given site. |
| SPECPERHR | Species per Hour: The average number of different species recorded per hour of Anabat operation at a given site. |
| RICHNESS | Richness: The total number of species "conclusively" recorded at a given site using both Anabat recordings and mist net captures. |
| SPEC LIST | Species List: The list of species documented at a given site based on both mist net captures and Anabat recordings. Those documented only through recordings are preceeded by the leter "a" (e.g., aCOTO). |
| POSSIBLESP | Possible Species: A list of species for which only vague Anabat were the only evidence that they occured at the site. Thus, the could possibly occur there, but we do not have conclusive evidence to that effect. |

# *Appendix 3: Preliminary Bat Surveys of White Grass and Bar B C Ranches, Grand Teton National Park*

by
Douglas A. Keinath
Senior Zoologist, Wyoming Natural Diversity Database

May 2005

## Contents

Background and Introduction .....39
Summary Results .....39
Building Accounts: Bar B C Ranch .....40
Building Accounts: White Grass Ranch.....55

## Background and Introduction

In 2003 the Wyoming Natural Diversity Database (WYNDD) began a two-year inventory of the bat fauna of the Greater Yellowstone Network (GYN) as part of the National Park Service Inventory and Monitoring Program (NPS IM). During the summer 2004 field season, biologists in Grand Teton National Park (GTNP) noted the need to specifically investigate two abandoned ranches located in the park (White Grass Ranch and Bar B C Ranch) that are being considered for building modifications (i.e., renovation and/or destruction). Based ad hoc investigations in the past there was reason to believe that at least some structures on these ranches might serve as bat roosts, but there was no information available to confirm current use. WYNDD personnel visited Bar B C on 4 August 2004 and White Grass Ranch on 8 August 2004, at which times we conducted thorough searches of each building to document the presence and level-of-use by bats.

## Summary Results

The bat activity of each building was documented and is noted in the following building accounts, along with photographs, basic building descriptions, and GPS coordinates. This information is provided for reference only and it is the opinion of the author that follow-up study should be conducted, as suggesting in the building accounts, before management decisions are made regarding these ranches and particular buildings therein.

Those buildings with bat activity have been given a priority score base on the author's estimation of their importance to the local bat fauna; buildings with no bat use are not given a score. For quick reference, the rough priority score of each building (i.e., High, Medium, Low) is noted in upper left corner of each building account and is color-coded for ease of use (Red = High priority, Orange = Medium and Low priority). Specific information regarding bat activity and recommendations for follow-up activities are provided in the last two cells of each account. Bat activity at the ranches can be summarized as follows:

- **Bar B C**: 28 buildings were surveyed. Of these, 13 buildings (46% of existing structures) showed evidence of use by bats. Four buildings are of high priority due to a combination of high use levels and presence of sensitive species, three are of medium priority, and six are of low priority. Of the high priority buildings, one is a substantial maternity colony, another is a day roost for Townsend's big-eared bat, and two have generally high use.
- **White Grass**: On the whole, White Grass Ranch exhibited a high level of bat activity and may be important to the local bat fauna of Grand Teton National Park. Of the 13 buildings surveyed, 11 buildings (85% of existing structures) showed evidence of bat use. Five buildings are of high priority due to a combination of high use levels and presence of sensitive species, three are of medium priority, and three are of low priority. Of the high priority buildings, 4 showed high bat activity. Further, two were used by Townsend's big-eared bats and one was a sizable maternity colony for little brown bats.

## Building Accounts: Bar B C Ranch

| | **Building ID**: BBC-a | **GPS Location** (E, N): | 0524625 4838068 | **Location Error**: 12 m |
|---|---|---|---|---|

**Description**:

Sheet shingle roof log cabin with chinking. Small porch on west side. Screened porch n south.

Beam and plank ceiling. Two rooms. Contains old shelves, table, lumber, and sheet insulation.

Bat habitat Notes: Many possible entrance holes for bats.

**Bat Use**: None.

**Recommendations**: No follow-up necessary.

| L | **Building ID**: BBC-b | **GPS Location** (E, N): | 0524589 4838070 | **Location Error**: 6 m |
|---|---|---|---|---|

**Description**:

Small (4m X 4m) long cabin with chinking. Sheet-shingle roof. One door on west and one window.

Beam and plank ceiling. One room. Contains: shelves, extra doors. Several yellow-jacket nests (ouch!).

Bat habitat Notes: Main bat entry points is gap in roof planks in southwest corner.

**Bat Use**: Low bat use based on scatter guano. Possible night roost or sparsely-used day roost.

**Recommendations**: Could conduct ANABAT® survey of main emergence point, but follow-up not critical.

| M | **Building ID**: BBC-c | **GPS Location** (E, N): | 0524600 4838122 | **Location Error**: 3 m |
|---|---|---|---|---|

**Description**:

Small cabin (5m X 12m). Two entry doors with porch on west side. Sheet-shingle roof and chinked logs.

Beam and plank ceiling. Two rooms. Spare lumber, table, and shelves.

Bat habitat Notes: Many possible entrance holes; main one being on the northeast corner of the cabin.

**Bat Use**: Moderate level of bat use based on scattered guano. Likely a night roost, but possibly a day roost during other times of the season.

**Recommendations**: Conduct ANABAT® survey of main emergence point on the NE corner of the cabin.

| M | **Building ID**: BBC-d | **GPS Location** (E, N): | 0524588 4838053 | **Location Error**: 11 m |
|---|---|---|---|---|

**Description**:

"Cabin 5." Small (4m X 7m) log cabin with chinking. Tin roof. One door on south and four windows.

Beam and plank ceiling with a large board nailed to center beam forming an 'attic' space. Two rooms.

Bat habitat Notes: Large gap on base of south wall and possible entry point at roof joint on southwest wall.

**Bat Use**: Moderate bat activity based on guano accumulations. Likely a night roost or day roost earlier in the season, since no bats were seen during inspection.

**Recommendations**: Conduct follow-up survey with ANABAT® to determine level and timing of bat activity, as well as species composition.

| | | | | |
|---|---|---|---|---|
| | **Building ID**: BBC-e | **GPS Location** (E, N): | 0524649 4838058 | **Location Error**: 1 m |

**Description**:

Mid-sized (7m X 16m) log cabin. Sheet-shingle roof with chimney on north side. Entrances on west and east sides.

Beam and plank ceiling. One room. Contains lumber, tables, bench, dressers, and spare doors.

Bat habitat Notes: Bat entrances through many holes near floor level plus an open chimney.

**Bat Use**: None.

**Recommendations**: No follow-up necessary.

| | | | | |
|---|---|---|---|---|
| | **Building ID**: BBC-f | **GPS Location** (E, N): | 0524584 4837996 | **Location Error**: 8 m |

**Description**:

Mid-sized (4m X 12m) log cabin with chinking. Two entry doors, both on north side with porch. Four windows. Sheet-shingle roof.

Beam and plank ceiling with stovepipe hole in the southeast. Two rooms.

Bat habitat Notes: Bat emergence point likely through stovepipe hole.

**Bat Use**: None.

**Recommendations**: None.

| M | **Building ID**: BBC-g | **GPS Location** (E, N): | 0524649 4838059 | **Location Error**: 2 m |
|---|---|---|---|---|

**Description**:

Small (4m X10m) log cabin. Sheet-shingle roof with stone chimney on north side. Two entrance doors with porch on the west. 4 windows.

Beam and plank ceiling. Two rooms. Contains shelves.

Bat habitat Notes: Openings in northeast corner, south west corner, and through the chimney.

**Bat Use**: Moderate bat use based on guano accumulations, mainly near chimney. Likely a night roost, but possibly a day roost during other times of year.

**Recommendations**: Conduct ANABAT® surveys of the chimney emergence point.

| | **Building ID**: BBC-h | **GPS Location** (E, N): | 0524603 4838164 | **Location Error**: 8 m |
|---|---|---|---|---|

**Description**:

"Cabin 1." Small (4m X 4m) log cabin. One door on south, with porch. Two windows. Sheet-shingle roof.

Beam and plank ceiling. One room.

Bat habitat Notes: None.

**Bat Use**: None.

**Recommendations**: None.

| | | | | |
|---|---|---|---|---|
| | **Building ID**: BBC-i | **GPS Location** (E, N): | 0524588 4838005 | **Location Error**: 1 m |

**Description**:

Small (4m X 5m) log cabin with most chinking in tact. Two entrance doors, with a porch on the north side. Two windows. Sheet-shingle roof.

Beam and plank ceiling. One room. Contains an old stove and broken shelves.

Bat habitat Notes: Some possible entrance holes along the floor and around the south door.

**Bat Use**: None.

**Recommendations**: No follow-up necessary.

| | | | | |
|---|---|---|---|---|
| | **Building ID**: BBC-j | **GPS Location** (E, N): | 0524535 4838181 | **Location Error**: 6 m |

**Description**:

Small (4m X 9m), collapsed log cabin. One door, 5 windows, many holes. Wood plank roof.

Beam and plank ceiling. Two rooms. Unstable!

Bat habitat Notes: None.

**Bat Use**: None.

**Recommendations**: None.

| | | | | |
|---|---|---|---|---|
| | **Building ID**: BBC-k | **GPS Location** (E, N): | 0524651 4838179 | **Location Error**: 4 m |

**Description**:

Small (5m X 9m) log cabin with most chinking in tact. Barn-style double doors on north and another door on south. 5 windows. Wood-slat roof with no shingles.

Beam and plank ceiling. Much "junk"; looks like old tack shed. Windows and doors open.

Bat habitat Notes: Many large openings.

**Bat Use**: None.

**Recommendations**: No follow-up necessary.

| | | | | |
|---|---|---|---|---|
| | **Building ID**: BBC-l | **GPS Location** (E, N): | 0524408 4838092 | **Location Error**: 6 m |

**Description**:

Small (4m X 5m) log cabin with chinking. One door and two windows. Unshingled roof.

Beam and plank ceiling. One room.

Bat habitat Notes: Possible bat entry holes through deteriorating roof.

**Bat Use**: None.

**Recommendations**: None.

| | | | | |
|---|---|---|---|---|
| | **Building ID**: BBC-m | **GPS Location** (E, N): | 0000000 0000000 | **Location Error**: 00 m |

**Description**:

Mid-sized log cabin. Sheet-shingle roof. Door on north and window on east. Half of building is open and contains saddle rests.

Beam and plank ceiling. One inside room, one open room with saddle bars. Contains some shelves.

Bat habitat Notes: Entrance points above door on north wall and on top of south wall.

**Bat Use**: None.

**Recommendations**: No follow-up necessary.

| | | | | |
|---|---|---|---|---|
| L | **Building ID**: BBC-n | **GPS Location** (E, N): | 0524431 4838046 | **Location Error**: 6 m |

**Description**:

Small (4m X 8m) log cabin. Sheet-shingle roof with chimney. Somewhat unstable.

Beam and plank ceiling. Two rooms. One fireplace with blocked chimney.

Bat habitat Notes: Possible bat entrance through stovepile hole and upper corners of walls.

**Bat Use**: Low bat use based on some guano. Likely a night use for a small number of bats.

**Recommendations**: Possible ANABAT® to determine level of use and species of bats present, but follow-up not critical.

| | **Building ID**: BBC-o | **GPS Location** (E, N): | 0524468 4838124 | **Location Error**: 4 m |
|---|---|---|---|---|

**Description**:

"Cabin 17" Small log cabin with worn chinking. Crumbling plank roof with shingles. Door on southeast (kicked in) and window on southeast.

Beam and plank ceiling. One room. Contains a table and shelves.

Bat habitat Notes: Small holes in ceiling and on upper southeast wall could provide entrance points.

**Bat Use**: None.

**Recommendations**: No follow-up necessary.

| H | **Building ID**: BBC-p | **GPS Location** (E, N): | 0524440 4837927 | **Location Error**: 6 m |
|---|---|---|---|---|

**Description**:

Large (8m X 12m) log cabin with an L-shaped layout. Sheet shingle roof with two chimneys.

Beam and plank ceiling. About 9 rooms and a cellar. Two fireplaces.

Bat habitat Notes: Many emergence holes throughout building, plus a even-temperature, cave-like cellar.

**Bat Use**: Moderate bat use based on scattered guano throughout house. Roosting male Townsend's big-eared bat (*Corynorhinus townsendii*) found in southeast room (see photo).

**Recommendations**: Definitely conduct active ANABAT® surveys at several points in the season to determine level of use and species composition. *C. townsendii* often difficult to record, so also conduct low-disturbance diurnal roost survey early and late in the season. Consider preserving this building as bat habitat.

| H | **Building ID**: BBC-q | **GPS Location** (E, N): | 0000000 0000000 | **Location Error**: 00 m |
|---|---|---|---|---|

**Description**:

Small (4m X 8m) log cabin with chinking. Worn shingled roof. Two entrance doors facing east with collapsed roof. Two windows.

Beam and plank ceiling. Two rooms.

Bat habitat Notes: Building interior noticeable warmer than others. Main entrance points are the window on the northeast side and an old chimney hole in the ceiling of the south east room.

**Bat Use**: High bat activity based on large amount of guano. One *Myotis lucifugus* seen roosting by the ceiling peak on the southeast wall. Definitely a day roost and possibly night roost as well.

**Recommendations**: Conduct ANABAT® survey of main emergence points and possibly harp-trap the entrance and/or do an emergence count to determine abundance of bats.

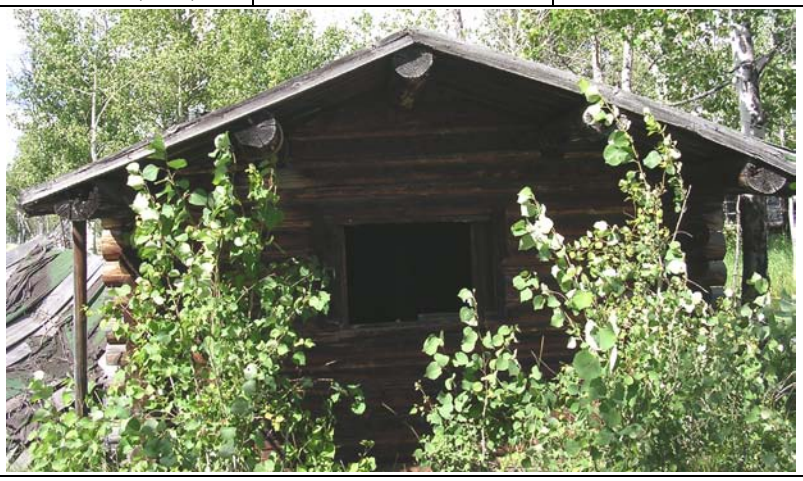
| L | **Building ID**: BBC-r | **GPS Location** (E, N): | 0524409 4837915 | **Location Error**: 10 m |
|---|---|---|---|---|

**Description**:

Small (4m X 4m) log cabin. wood roof. One door and one window.

Beam and plank ceiling. one room.

Bat habitat Notes: Possible bat entrance through south-facing window.



**Bat Use**: Low bat use based on some guano. Likely a night use for a small number of bats.

**Recommendations**: Possible ANABAT® to determine level of use and species of bats present, but follow-up not critical.

| L | **Building ID**: BBC-s | **GPS Location** (E, N): | 0524487 4838001 | **Location Error**: 3 m |
|---|---|---|---|---|

**Description**:

Small (4m X 5m) log cabin with chinking. One door with porch on the east. Two windows. Close to BBC-u on the west. Worn shingled roof.

Beam and plank ceiling. Blocked chimney on east side of building.

Bat habitat Notes: Emergence points through crack in east wall and by the south window.

**Bat Use**: Low bat use based on scattered guano by west window. Size of guano suggests use by *Eptesicus fuscus*. Age of guano suggests no recent activity.

**Recommendations**: No follow-up necessary.

| | **Building ID**: BBC-t | **GPS Location** (E, N): | 0524408 4837869 | **Location Error**: 7 m |
|---|---|---|---|---|

**Description**:

Old wood and log building with north side collapsed. Wooden roof that's half missing.

One partially remaining room with piles of wood.

Bat habitat Notes: Entrances everywhere, but no decent roosting space.

**Bat Use**: None.

**Recommendations**: None.

| H | **Building ID**: BBC-u | **GPS Location** (E, N): | 0524491 4838008 | **Location Error**: 4 m |
|---|---|---|---|---|

**Description**:

Small (4m X 5m) log cabin with chinking. Entrance door with porch on east side. Chimney used to be on the north. Two windows. Crumbling sod roof.

Beam and plank ceiling. One room. Door is wide open.

Bat habitat Notes: Large openings through door and windows. Sod roof likely regulates temperature of building.

**Bat Use**: High level of bat use based on guano accumulation. Size of guano suggests use by *Eptesicus fuscus*. Likely an active night roost.

**Recommendations**: Conduct ANABAT® survey with visual observation at entrances. Possibly mist net nearby.

| | **Building ID**: BBC-v | **GPS Location** (E, N): | 0524405 4837886 | **Location Error**: 5 m |
|---|---|---|---|---|

**Description**:

Wooden barn with east side collapsed.

One partially remaining room.

Bat habitat Notes: Entrances everywhere, but no decent roosting space.

**Bat Use**: None.

**Recommendations**: None.

| L | **Building ID**: BBC-w | **GPS Location** (E, N): | 0524490 4837971 | **Location Error**: 1 m |
|---|---|---|---|---|

**Description**:

Small (5m X 9m) log cabin with chinking. Plank and tarp roof with remnants of sod. Two doors (east and north, with porch). Four windows.

Two doors enter separate and unconnected rooms.

Bat habitat Notes: Main entrance point would be a large hole over the north door.

**Bat Use**: Low bat use based on scattered guano. No bats seen, so likely used as a night roost.

**Recommendations**: Could ANABAT® the main emergence point, but follow-up not critical.

| | **Building ID**: BBC-x | **GPS Location** (E, N): | 0524514 4838045 | **Location Error**: 6 m |
|---|---|---|---|---|

**Description**:

Small (4m X 5m) log cabin. One door and one window. Sheet-shingled roof with chimney.

Beam and plank ceiling. One room.

Bat habitat Notes: Possible bat entrance through chimney.

**Bat Use**: None.

**Recommendations**: None.

| H | **Building ID**: BBC-y | **GPS Location** (E, N): | 0524531 4838031 | **Location Error**: 1 m |
|---|---|---|---|---|

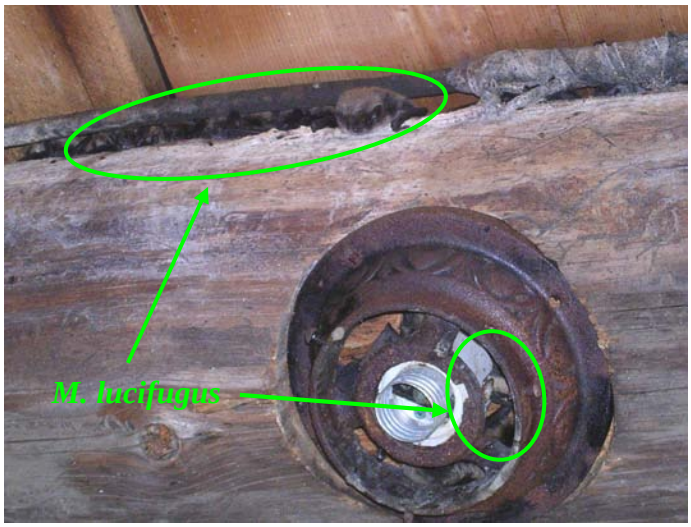
**Description**:

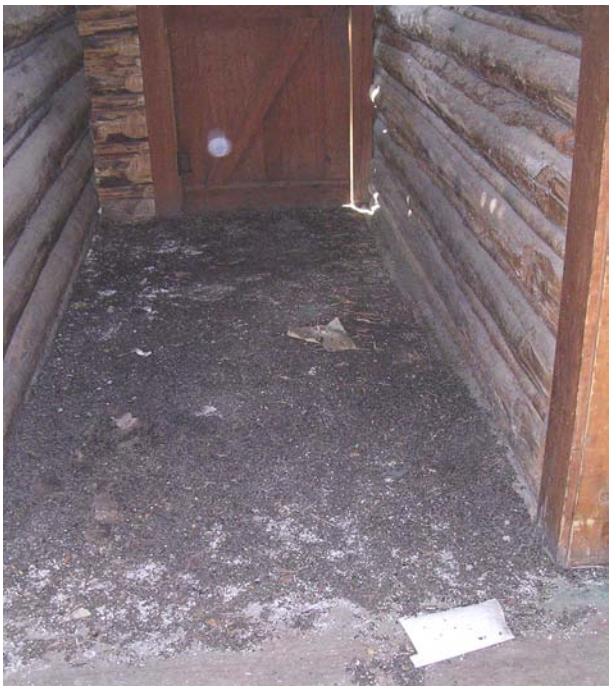
Large (roughly 25m X 37m) log building with worn chinking. Deteriorating, sheet-shingle roof. Several doors (one on north with porch). Many windows. Collapsed chimney on north side and boarded-up chimney on south side.

Beam and plank ceiling, collapsed in places. 8+ rooms.

Bat habitat Notes: Many emergence points through roof, doors and walls.

**Bat Use**: High bat use based on guano accumulation and visual and audible confirmation of at least 21 roosting little brown bats. Definitely used as a day-time roost and probably a maternity roost.



**Recommendations**: It would be hard to conduct a comprehensive ANABAT® survey, since there are many possible emergence points. However, active acoustic survey of several emergence points might document use by additional species. Also, an internal count early in the breeding season might yield a count of pups and confirm its status as a maternity colony. Consider preserving this building in its current state as a bat roost.

| | | | | |
|---|---|---|---|---|
| | **Building ID**: BBC-z | **GPS Location** (E, N): | 0524510 4838056 | **Location Error**: 13 m |

**Description**:

Small (4m X 5m) log cabin with chinking. Tin roof with chimney. One door and two windows.

Beam and plank ceiling. One room.

Bat habitat Notes: Possible bat entrance through chimney.

**Bat Use**: None.

**Recommendations**: None.

| | | | | |
|---|---|---|---|---|
| | **Building ID**: BBC-aa | **GPS Location** (E, N): | 0524503 4838046 | **Location Error**: 3 m |

**Description**:

"Cabin 9." Small log cabin with chinking. One door with porch on south side. Two windows. Sheet-shingle roof with stone chimney on east side.

Beam and plank ceiling. One room with closed chimney. Contains: old shelves. Large bird nest.

Bat habitat Notes: Some open entry points.

**Bat Use**: None.

**Recommendations**: None.

| L | **Building ID**: BBC-bb | **GPS Location** (E, N): | 0524516 4838076 | **Location Error**: 7 m |
|---|---|---|---|---|

**Description**:

Small log cabin. One door and 3 windows. Sheet-shingle roof with chimney.

Beam and plank ceiling. Stovepipe hole in ceiling. Chimney open.

Bat habitat Notes: Possible entrance points through the stovepipe hole and chimney.

**Bat Use**: Low bat activity based on scatter guano. Likely a night roost or day roost for a few bats during other parts of the season.

**Recommendations**: Conduct active ANABAT® recordings to document level of use and species composition, but follow-up not critical.

# Building Accounts: White Grass Ranch

| H | **Building ID**: WGa | **GPS Location** (E, N): | 0518226 4833773 | **Location Error**: 6 m |
|---|---|---|---|---|

**Description**:

Large (main?) cabin. Chinked log construction. Plastic over wood-shingled roof. Chimneys on north and west. Porches on east.

Beam and plank A-frame ceiling. 7 rooms.

Bat habitat Notes: Many internal hiding spaces for bats. Many exit points through holes in roof. Difficult to passively ANABAT due to number of exit points.

**Bat Use**: Light to moderate use based on guano accumulation. However, a bachelor *Corynorhinus townsendii* was observed day-roosting on the ceiling in the large northern room (see photo), making it an important building for local bats.

**Recommendations**: This building should be left intact and undisturbed. *C. townsendii* is recognized as a sensitive species by most state and federal agencies in Wyoming (e.g., BLM, USFS, WYNDD, WYGFD). They require large, open roosting structures and are sensitive to disturbance.

| L | **Building ID**: WGb | **GPS Location** (E, N): | 0518252 4833826 | **Location Error**: 5 m |
|---|---|---|---|---|

**Description**:

Small (3m X 15m ) cabin. Chinked log construction. Plastic sheet over wood-plank roof. Main entrance faces south.

Beam and plank A-frame ceiling. Two rooms and collapsed bathroom.

Bat habitat Notes: Main emergence point through gap over north door.

**Bat Use**: Light use based on scattered guano. No visual or audible identification of bats. Probably a night roost for foraging bats. Not likely a critical roost building.

**Recommendations**: None.

| H | **Building ID**: WGc | **GPS Location** (E, N): | 0518301 4833847 | **Location Error**: 7 m |
|---|---|---|---|---|

**Description**:

Large cabin. Chinked log construction. Plastic sheet over wood-shingled roof. Chimneys on north and west. Insulation in one room.

6+ rooms. Beam and plank A-frame ceiling.

Bat habitat Notes: Many roosting places and emergence points. Warm interior. Hard to ANABAT due to numerous openings.

**Bat Use**: High bat use based on substantial guano accumulation and numerous bats seen flying and roosting along ceiling beams and walls (see photo), which appeared to be *Myotis lucifugus*.. Based on its warm temperature and the number of bats seen, it is likely maternity colony for over 100 bats.

**Recommendations**: This seems to be a substantial maternity colony and therefore worth preserving. Emergence counts may be valuable to determine number of bats present, but difficult due to the number of emergence points. Other bats can cohabitate with *M. lucifugus*, so follow-up surveys with ANABAT® should be done to determine species composition.

| M | **Building ID**: WGd | **GPS Location** (E, N): | 0518266 4833829 | **Location Error**: 5 m |
|---|---|---|---|---|

**Description**:

Small (4m X 7m ) cabin. Log construction. Plastic sheet over wood-plank roof. Main entrance faces southeast.

Beam and plank A-frame ceiling. Two rooms. Wood stove.

Bat habitat Notes: Two main emergence points; above the front door and in the wall where the bathroom addition joins the main room.

**Bat Use**: Moderate bat use based on scattered guano with one area of accumulation underneath the main roof beam. However, no bats were seen or heard. It could be a day roost that was recently vacated, or it could be a night roost.

**Recommendations**: Maybe valuable to search again to determine day-night use and conduct acoustic monitoring to determine species composition.

| M | **Building ID**: WGe | **GPS Location** (E, N): | 0518290 4833870 | **Location Error**: 8 m |
|---|---|---|---|---|

**Description**:

Small (4m X 6m) cabin. Chinked log construction. Plastic sheet over wood-plank roof.

Beam and plank A-frame ceiling. Two rooms.

Bat habitat Notes: There are several emergence points; stovepipe hole in roof and cracks in the ceiling.

**Bat Use**: Light to moderate bat use based on guano accumulation. A few bats seen; most likely *Myotis lucifugus*, making it a day roost but not necessarily a maternity roost.

**Recommendations**: Maybe valuable to search again earlier in the season (e.g., early July) to determine whether it is a maternity colony. Other bats may cohabitate with *M. lucifugus*, so follow-up surveys could be done to determine if sensitive species are present. An emergence count could be done to estimate the number of bats roosting in the building.

| L | **Building ID**: WGf | **GPS Location** (E, N): | 0518271 483380 | **Location Error**: 6 m |
|---|---|---|---|---|

**Description**:

Small (7m X 9m ) duplex cabin. Chinked log construction. Asphalt sheet roof with 3 stovepipes. Main entrance faces southwest.

Beam and plank A-frame ceiling. Ceiling in bathroom partially collapsed.

Bat habitat Notes: Main emergence point is likely the stovepipe in the south room.

**Bat Use**: Low level of bat use based on scattered guano and insect parts in south room. Most likely a night roost where bats stop to digest food. Based on size of guano, the bats could be *Eptesicus fuscus*.

**Recommendations**: Likely not a major roost. Maybe valuable to use acoustic monitoring to determine species composition.

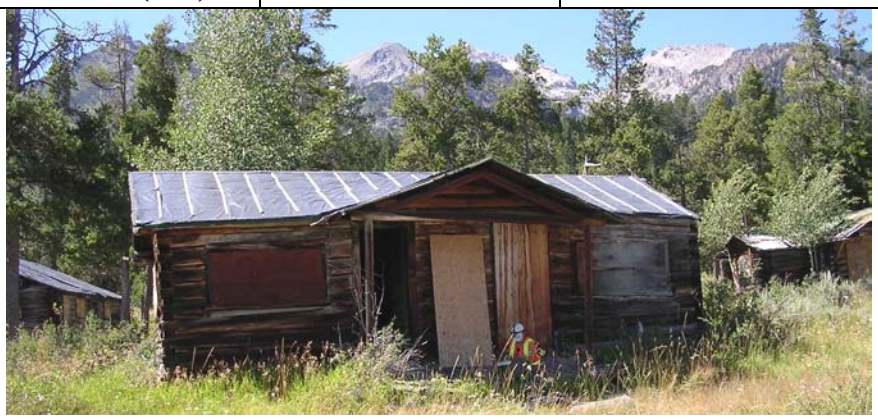
| | **Building ID**: WGg | **GPS Location** (E, N): | 0518298 4833904 | **Location Error**: 10 m |
|---|---|---|---|---|

**Description**:

Small (4m X 8m ) duplex cabin. Log construction. Plastic sheet over plywood roof.

Beam and plank A-frame ceiling. Two rooms and a bathroom.

Bat habitat Notes: The main emergence point is a hole hear the ceiling beam in the north room.



**Bat Use**: No evidence of bat use.

**Recommendations**: None.

| H | **Building ID**: WGh | **GPS Location** (E, N): | 0518263 4833905 | **Location Error**: 2 m |
|---|---|---|---|---|

**Description**:

Larger building, possibly the main showers. Chinked log construction. with 4 doors. Plastic sheet over plank roof.

Various ceiling structures with attic space. Many rooms; boiler room, shower stalls, laundry facilities.

Bat habitat Notes: Many emergence points, but largest two are an open door on the east and a broken wall on the south. Attic is hot (good for maternity roost) but does not have much guano. Possibly difficult to ANABAT due to many holes.

**Bat Use**: Moderate to high bat use based on scattered guano throughout the building. Visual observations were made of two *Myotis lucifugus* and one *Corynorhinus townsendii* (see photo). *M. lucifugus* were seen the attic and the main shower rooms, while *C. townsendii* was seen roosting in a large, open "closet" off the "linen room" in the west side of the building.

**Recommendations**: *C. townsendii* is recognized as a sensitive species by most state and federal agencies in Wyoming (e.g., BLM, USFS, WYNDD, WYGFD). They require large, open roosting structures and are sensitive to disturbance. Also, it seems to be a fairly consistent day and/or night roost for other species. Try to conduct acoustic monitoring at the western door and/or re-survey earlier in the season to determine species composition. Consider leaving this building intact and undisturbed.

| | **Building ID**: WGi | **GPS Location** (E, N): | 0518277 4833923 | **Location Error**: 8 m |
|---|---|---|---|---|

**Description**:

Small (3m X 6m ) cabin. Log construction. Plank roof with chimney.

Beam and plank A-frame ceiling. One room and a bathroom.

Bat habitat Notes: Many possible emergence holes.

**Bat Use**: None.

**Recommendations**: None.

| H | **Building ID**: WGj | **GPS Location** (E, N): | 0518291 4833944 | **Location Error**: 2 m |
|---|---|---|---|---|

**Description**:

Medium-sized cabin. Log construction. Asphalt sheet roof with 2 stovepipes. Porch and 3 exterior doors, with the main entrance facing east.

Beam and plank A-frame ceiling. 3 rooms and a bathroom.

Bat habitat Notes: Roosts mainly along center ceiling beams, but guano scattered everywhere. Emergence points are likely thorugh 2 un-capped stovepipe holes.

**Bat Use**: High bat use based on guano piles (see photo) and scattered guano throughout the building. No visual or audible observations. Probably a long-term night roost, but could easily be a day roost that was used earlier in the summer. Some guano is large, suggesting *Eptesicus fuscus*. ANABAT® recordings were attempted on 10 Aug 2004, but equipment malfunction resulted in only a few calls early in the evening, which included *M. lucifugus*, *E. fuscus*, and *M. thysanodes*.

**Recommendations**: This roost structure should be kept intact. It seems to be a significant roost and one of the few that receive regular *E. fuscus* use. For further information, one might consider unobtrusively visiting it earlier in the season to confirm night versus day use and conducting emergence counts to determine the number of bats currently using it.

| L | **Building ID**: WGk | **GPS Location** (E, N): | 0518242 4833911 | **Location Error**: 9 m |
|---|---|---|---|---|

**Description**:

Small (4m X 7m ) duplex cabin. Chinked log construction. Asphalt sheet roofing with one stovepipe.

Beam and plank A-frame ceiling with some insulation. Two rooms and a bathroom.

Bat habitat Notes: The un-capped stovepipe represents the main emergence point.

**Bat Use**: Low bat use based on some guano. Not likely a valuable roost structure.

**Recommendations**: None.

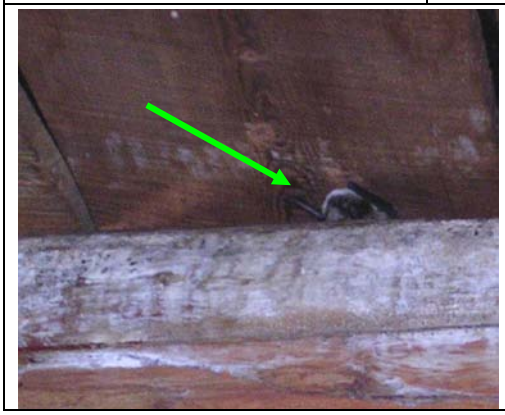
| M | **Building ID**: WGl | **GPS Location** (E, N): | 0518223 4833881 | **Location Error**: 1 m |
|---|---|---|---|---|

**Description**:

Small cabin with large east-facing front porch. Chinked log construction. Asphalt sheet roofing.

Beam and plank A-frame ceiling with some insulation. One room and a bathroom.

Bat habitat Notes: Stovepipe holes and holes in the bathroom are likely the main emergence points.



**Bat Use**: Moderate bat use as a day roost based on scattered guano and visual identification of three *Myotis lucifugus* roosting along the man ceiling beam (see photo). There is, however, much old staining on the ceiling beams suggesting it may have been more heavily used in the past.

**Recommendations**: Conduct acoustic monitoring and or another site visit early in the summer to determine level of current use and species composition.

| H | **Building ID**: WGm | **GPS Location** (E, N): | 0518237 4833900 | **Location Error**: 10 m |
|---|---|---|---|---|

**Description**:

Small (4m X 8m ) duplex cabin. Chinked log construction. Asphalt sheet roofing with 4 stovepipes.

Beam and plank A-frame ceiling with some insulation. Two rooms and a bathroom.

Bat habitat Notes: The un-capped stovepipes and a hole do to collapsing ceiling represent the main emergence points.

**Bat Use**: Moderate to High bat activity based on much guano accumulation and direct observations of at least 10 *Myotis lucifugus* (see photo).

**Recommendations**: Maybe valuable to search again earlier in the season (e.g., early July) to determine whether it is a maternity colony. Other bats may cohabitate with *M. lucifugus*, so follow-up surveys could be done to determine if sensitive species are present. An emergence count could be done to estimate the number of bats roosting in the building.

## *Appendix 4: Keys to the bats of the Greater Yellowstone Network*

# Dichotomous Key to the Bats of the Greater Yellowstone Network

Doug Keinath, WYNDD, dkeinath@uwyo.edu

| # | 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 | Tragus short, blunt, and club-shaped. Small-bodied. Body fur medium to pale brown in contrast to jet black face and ears. Forearm 27-33mm. | Pipistrellus Hesperus |
| 9b | Tragus longer and pointed | 10 |

| | | |
|---|---|---|
| 10a | Large, medium to dark brown bat with keeled calcar. First upper premolar at least ½ as long as canine (see diagram below). Forearm 42-51mm (wingspan 325-350mm). Tragus rounded. | Eptesicus fuscus |
| 10b | Smallish bat. First upper premolar less than ¼ as tall as canine (see diagram below). | 11 |

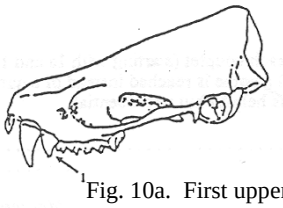


Fig. 10a. First upper premolar ½ as tall as canine (*Eptesicus fuscus*)

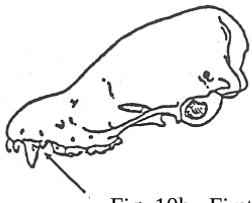


Fig. 10b. First upper premolar < ¼ as tall as canine (Myotis spp.)

# ***Myotis species***

| # | If this is true … | … then go to … |
|---|---|---|
| 11a | Calcar keeled. (Fig. 11a) | 12 |
| 11b | Calcar not keeled. (Fig. 11b) | 14 |

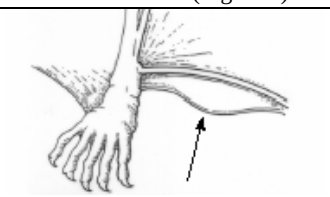


Fig. 11a. Keeled calcar (go to 12)

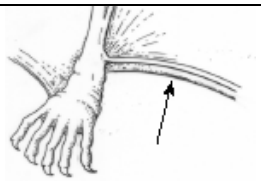


Fig. 11b. Keel absent (go to 14)

| | | |
|---|---|---|
| 12a | Body fur uniformly dark brown or grayish brown with no distinctively darker face mask. Forearm 38-42mm (wingspan 250-270mm). [Underside of wing furred from side to elbow.] | Myotis volans |
| 12b | Body fur medium to very light tan or reddish brown with clearly darker face mask. Forearm 29-36mm. [Underside of wing not furred from side to elbow.] | 13 |

| | | |
|---|---|---|
| 13a | Tail does NOT extend beyond uropatagium. Thumb length < 4.2mm. Braincase has an abruptly rising profile (convex forehead). Length of bare snout ≈ width across nostrils. Dorsal fur dull, pale colored, with dark-brown face mask distinctive but less contrasting with fir. (Fig. 13a) | Myotis californicus |
| 13b | Tail often extends slightly beyond uropatagium. Thumb length > 4.2mm. 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. 13b) | Myotis ciliolabrum |

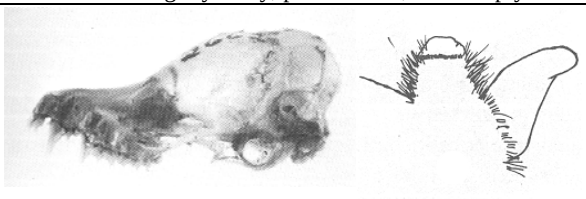


Fig. 13a. *M. californicus:* Rising braincase. Length of bare snout ≈ width across nostrils.

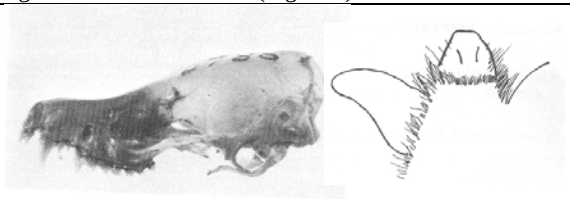


Fig 13b. *M.ciliolabrum*: Shallow braincase. Length across snout ≈ 1.5 times width across nostrils

| | | |
|---|---|---|
| 14a | Distinct fringe of hair extending 1.0-1.5mm be nd edge of uropatagium (picture). Ears darkly pigmented and 16-20mm long. Belly fur light. Forearm 39-46mm. | Myotis thysanodes |
| 14b | Fringe absent (no more than scattered hairs on edge of uropatagium). | 15 |

| | | |
|---|---|---|
| 15a | Ear length ≥17mm. | 16 |
| 15b | Ear length ≤ 16mm. | 17 |

| | | |
|---|---|---|
| 16a | Ears, wings, and uropatagium are blackish and opaque. Ear length 19-24mm. [May have an inconspicuous fringe of hairs on the posterior uropatagium.] | Myotis evotis |
| 16b | Ears, wings, and uropatagium are brownish and translucent. Ear length 17-19mm. | Myotis septentrionalis |

| | | |
|---|---|---|
| 17a | 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. 17a), skull usually greater than 14mm. Ventral fur light-tipped but never white. Foot hairs extend beyond toes. | Myotis lucifugus |
| 17b | 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. 17b), skull usually less than 14mm. Ventral fur with whitish tips. | Myotis yumanensis |

Fig. 17a. *M. lucifugus*: Forehead with gradual slope

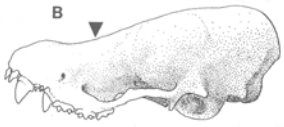
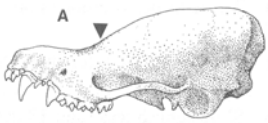



Fig. 17b. *M. yumanensis*: Forehead with steep slope



# Anabat® Call Key for the Greater Yellowstone Ecosystem

Developed by

*Douglas A. Keinath*
Wyoming Natural Diversity Database
University of Wyoming
Laramie, Wyoming

## DISCLAIMER

***This is not a definitive classification key.***

Anabat® is a system designed to help users find and identify echolocating bats by digitally recording those calls and plotting them on a computer screen (please see the following web site for more information: http://users.lmi.net/corben/anabat.htm#Anabat%20Contents ). With the appropriate software, the resulting calls can be visually analyzed to determine what type of bat made each call. However, these echolocation calls are notoriously hard to distinguish at the species level, due to the wide variation in recording quality, intra-species call morphology, and environmentally induced frequency shifts. Correct analysis depends heavily on the accumulated experience of the analyst.

Some bats (e.g., hoary bats, spotted bats) can readily be identified by new users, but other species (e.g., myotis volans and myotis ciliolabrum) are very difficult to distinguish, even by experts. This key is meant to provide a starting point for biologists wishing to analyze bat calls recorded in Wyoming, particularly in the northwestern corner of the state, in the vicinity of Yellowstone National Park, Grand Teton National Park and Bighorn Canyon National Recreation Area. Even with this information, many calls cannot be identified at the species level.

Before employing this key, users should be familiar with the general principals of call analysis (e.g., see http://users.lmi.net/corben/glossary.htm #Glossary). With such background information, this key can be used to roughly classify calls and perhaps (given well-recorded calls) identify the particular species making those calls. Questionable calls, calls of difficult to distinguish species, or those 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: 307-766-3013, dkeinath@uwyo.edu) or the Wyoming Game and Fish Department (Martin Grenier: *****).

Analyzing bat calls can be very challenging and frustrating, but with patience and experience it provides a fascinating look at our bat communities. Please let me if you found this document useful or if you have suggestions for improving it.

Good luck!

Sincerely,

Doug Keinath

# GRYN ANABAT® Call Key

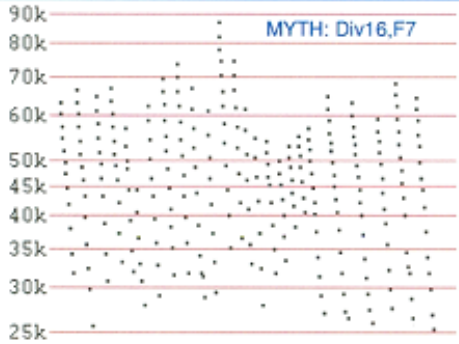
© Doug Keinath
University of Wyoming, WYNDD
307-766-3013

## $F_{min}$ (kHz)

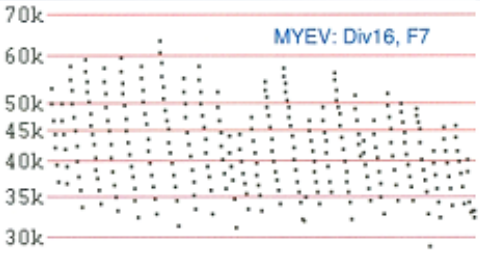
- **<10** — Yes → **EUMA** Calls steep and sparse. Usually beginning above 10 and ending below 8.
- No → **16 - 20** — Yes → **LACI** Calls usually low slope and can be hook-shaped. Calls tend to jump around in Fmin, but typically 17-18k. Often give several calls at a higher freq, but with same shape.
- No → **~25** — Yes → **25k Bats** (EPFU or LANO) … Next Page
- No → **25 - 35** — Yes → **~30k Bats** (MYTH, MYEV, COTO, or ANPA) …. See Below
  *Note: If sequences are not long and clean, many of these can be difficult to tell apart and must then be reported simply as "**aB30k**".*
- No → **~40** — Yes → **40k Myotis** (MYLU, MYVO, MACI) … Next Page
- No → **45 - 50** — Yes → **50k Bats** (PIHE, MYYU, MYCA) …. Next Page

## 30k Bats (steep calls)

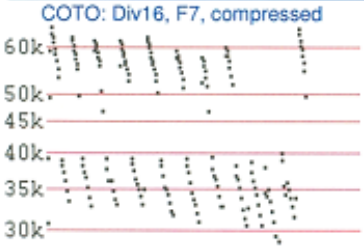
**MYTH** Calls very steep (Δslope ≥ 100) with huge freq. range (up to 20-100 in same call) and no tail. Variable $F_{min}$ with some calls usu. dropping to or below 25. Freq range usu ≥50.

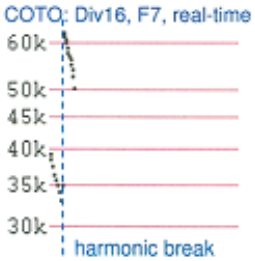



**MYEV** Calls very steep ($\Delta_{slope}$ usu > 150; often 300) and very sparse, with no tail. $F_{min}$ usu ~35, but varies within sequence, seldom dropping below 30. Freq range usu ~30.

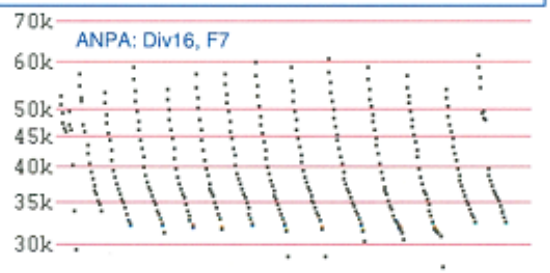



**COTO** Calls steep, weak, have two harmonics. $F_{min}$ usu ~30, but can be ≤25. Harmonic-break often between 40-50. Sometimes only one harmonic captured: Upper can look like 50k myotis; Lower can look like steep 25k getting thinner at tail.



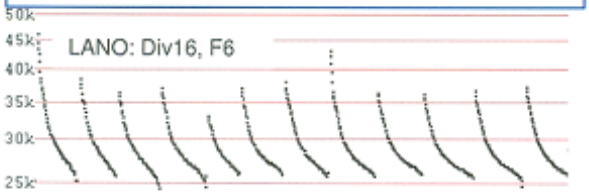

**ANPA** Calls steep, but often slightly more curved than MYTH or MYEV and somewhat "thicker". Very little tail, but sometime "dribbling off" in a "lazy S" shape. Fmin ~30k and Fmax ≥50. Can also be difficult to tell from EPFU in clutter, which will usu. have time between calls of <100ms.



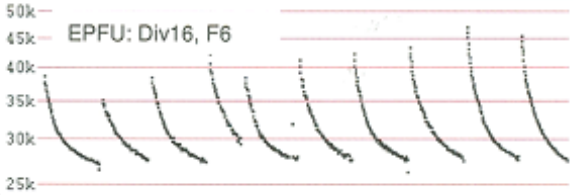
## 25k Bats (tailed calls)

*Note: LANO and EPFU are difficult to distinguish from each other, especially in clutter. Many call files must be reported simply as "**aB25k**".*

**LANO** 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").



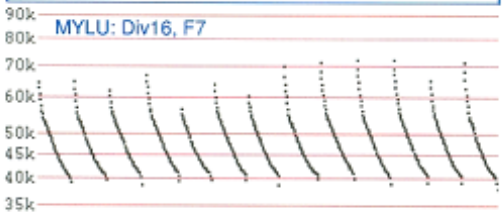

**EPFU** Calls are more curvilinear than LANO, but can be more bilinear when they are short in sweep (i.e., ~25-40). Slope of tail is very consistent. On flat calls, Δslope plots may show many calls with "fish-hook" ends. Fmin often not uniform, with some calls falling below 25k. Calls sometimes irregularly spaced ("heart beat").



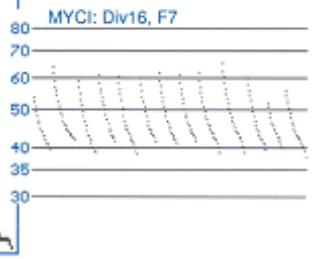

## 40k Myotis

*Note: 40k myotis are very difficult to distinguish from each other, especially in clutter. Many call files must be reported simply as "**aM40k**".*

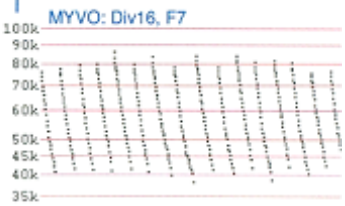
**MYLU** Gentlly curved slope throughout call (but often get more bilinear in clutter and may "dribble off" at the end). Clean calls often sweep from ~100 to just over 40. On clean calls, $\Delta slope_{min}$ can be as low as 40, but usually higher. Sometimes alternate curved call with a more linear one.
*Behavior*: MYLU classically feed over water, which can result in "wobbly" calls."




**MYCI** 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 $\Delta slope_{min}$ 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.




**MYVO** 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.



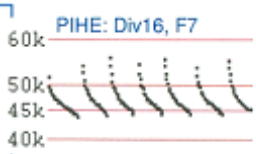

## 50k Bats

*Steep Calls*

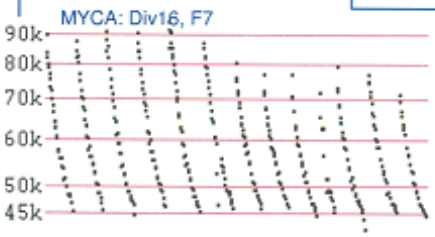
Steeper than PIHE and usu. Fmin at or just below 50k. Single calls can drop to 40k, but not whole series (consistently above 43k). Difficult to distinguish from each other, especially in clutter, and many must be reported simply as "**aM50k**".

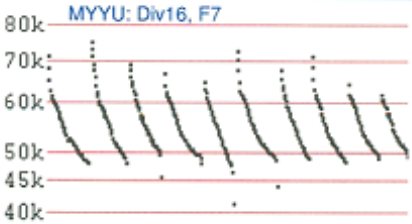
*Flat / tailed calls*

**PIHE** Usually starting around 50 and often ending below (~45). Thick calls with flat tails often with a drooping tail. Duration>5.0ms.




**MYCA** 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.




**MYYU** 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.