Yellowstone Science

volume 15 • number 3 • 2007

A "Who's Who" of Bats

Lichens in Yellowstone National Park

Who Are Yellowstone's Backcountry Users?

Yellowstone Denied

NPS/HARLAN KREDIT

A backcountry campsite (since removed) on the southeast arm of Yellowstone Lake, 1976.

Celebrating the Less Noted

THIS ISSUE OF *YELLOWSTONE SCIENCE* highlights a few less-noted park species, visitors, and historical personalities. To enjoy such species, one needs to stay up a little later or get up a little earlier, and look a little closer. To understand the preferences of a small subset of park visitors, one must seek them out and ask a lot of questions. And to appreciate one of these eccentrics from Yellowstone's past, one needs to delve a little deeper into Yellowstone's history.

Doug Keinath's article on bats delights us with some incredible photos of these nocturnal animals. Until recently, no one really knew which species occurred in Yellowstone, but at the prompting of the National Park Service Greater Yellowstone Inventory and Monitoring Network, this comprehensive inventory was completed. Besides giving us a better understanding of species richness, abundance, and distribution in Yellowstone and Grand Teton national parks and Bighorn Canyon National Recreation Area, this study establishes a benchmark for future monitoring efforts and management actions.

Lichens are partnerships of algae and fungi, and Sharon Eversman shares results from various studies on these often overlooked organisms in her article. Besides being of interest for their symbiotic system and their many colors and shapes, their presence is an indicator of environmental condition.

Tim Oosterhous et al. surveyed those who choose a different experience than most of the park's three million annual visitors—overnight backcountry recreationists. The results of this social science study will be of interest to park managers in defining a typical backcountry user and what kind of experiences they are seeking.

Leslie Quinn invites us to explore a back corner of the park's past by reading Kim Allen Scott's book, *Yellowstone Denied: The Life of Gustavus Cheyney Doane.* Doane strove futilely throughout his life to gain the superintendency of the park and public recognition as the "discoverer" of Yellowstone. In Scott's book, Doane may finally be getting his due.

We hope you enjoy the issue.

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Submissions are welcome from all investigators conducting formal research in the Yellowstone area. To submit proposals for articles, to subscribe, or to send a letter to the editor, please write to the following address: Editor, *Yellowstone Science*, P.O. Box 168, Yellowstone National Park, WY 82190. You may also email: Tami_Blackford@nps.gov.

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on the cover:
Pallid bat (*A. pallidus*).
Photo by Douglas A. Keinath.

SHARON EVERSMAN

Peltigera aphthosa, wet on the left (green) and dry on the right (tan), is a species of lichen that lives in relatively moist habitats. Small dark spots on the top of the thallus contain cyanobacteria which fix nitrogen.

FEATURES

DEPARTMENTS

News & Notes

Do Pronghorn Eat Lichen?

During the nine winters that Yellowstone National Park volunteers Dr. Jim and Edna Caslick have been doing weekly ground surveys to map pronghorn on their winter range, they've often wondered what pronghorn could be finding to eat on the open and almost bare-ground areas where they feed. One winter, the Caslicks took a pronghorn's eye view of the ground and found that even in January and February, there's lots of bright green lichen—combinations of fungus and algae clumped together and living in harmony. Although hundreds of other kinds of lichens grow on rocks and in trees, this particular lichen grows on bare ground in loosely attached lumps that look like branched green coral, popcorn size.

Dr. Sharon Eversman of Montana State University (*see her article, page 14*) ran chemical tests on a sample and identified it as probably "X*anthoparmelia wyomingica*, (PD yellow) but very close to X. *chlorochroa."* Dr. Eversman feels that pronghorn in Yellowstone may have the digestive enzymes to handle this lichen during the winter.

PAUL SCHULLERY

After reviewing research on pronghorn in Yellowstone dating back to 1924, the Caslicks found no reference to pronghorn use of lichens. However, biologists Allan Thomas and Roger Rosentreter of the Bureau of Land Management, Idaho State Office, have reported that these vagrant (non-attached) forms of lichens are common on windswept ridges and may be an extremely important winter forage for pronghorn. They also reported that one rumen (stomach) sample of a pronghorn wintering there was 51% lichen. They further reported that wildlife biologists in the Bureau of Land Management and USDA Forest Service in Nevada and New Mexico have used the presence of *X. chlorochroa* as an indicator of excellent pronghorn range.

Please help us find out by reporting pronghorn carcasses from which we might sample the stomach contents. If you hear about or see a dead pronghorn between Mammoth and Reese Creek (just west of the park's bison management facility), please phone park wildlife biologist P. J. White at 307-344-2442.

Bison Held at and Released from Stephens Creek Facility

On June 8, Yellowstone National Park accepted 52 bison at the Interagency bison capture facility at Stephens Creek near Gardiner, Montana. The bison were captured by the Montana Department of Livestock after a mixed group of approximately 50 bison left the Cougar Meadows area and crossed the park boundary into the West Yellowstone area. They were shipped to the Stephens Creek facility, which is operated under the Interagency Bison Management Plan (IBMP). The IBMP is a cooperative plan designed to conserve a viable,

NPS/JIM PEACO

Xanthoparmelia wyomingica.

wild bison population while protecting Montana's brucellosis-free status. The five cooperating agencies operating under the IBMP are the National Park Service, the U.S. Forest Service, the Animal and Plant Health Inspection Service, the Montana Department of Livestock, and the Montana Department of Fish, Wildlife and Parks.

Among the bison captured and shipped were 24 adult cows, 16 bulls under two years old, and 12 calves. Consistent with operation of the facility and actions called for under the IBMP, juvenile bulls may be held at the capture facility when they are not considered to be a significant threat to other animals or to personnel managing the operation. At the facility, the bison were held, fed, and watered, then released on June 10. Rangers on horseback guided the herd around roadways and developed areas until they reached the Blacktail area east of Undine Falls.

On June 20, the park prepared to accept another mixed group of five bison, consisting of a young bull, three cows, and a calf, which were also outside the Yellowstone National Park boundary in the West Yellowstone area. The same transport and release strategy was used with this group.

This adaptive management strategy resulted from discussions between Yellowstone National Park and the Montana Governor's Office and was designed to address a unique set of circumstances involving bison outside the park at that time of year. Future instances will be handled case by case. YS

Yellowstone's World of Bats

Taking Inventory of Yellowstone's Night Life

Douglas A. Keinath

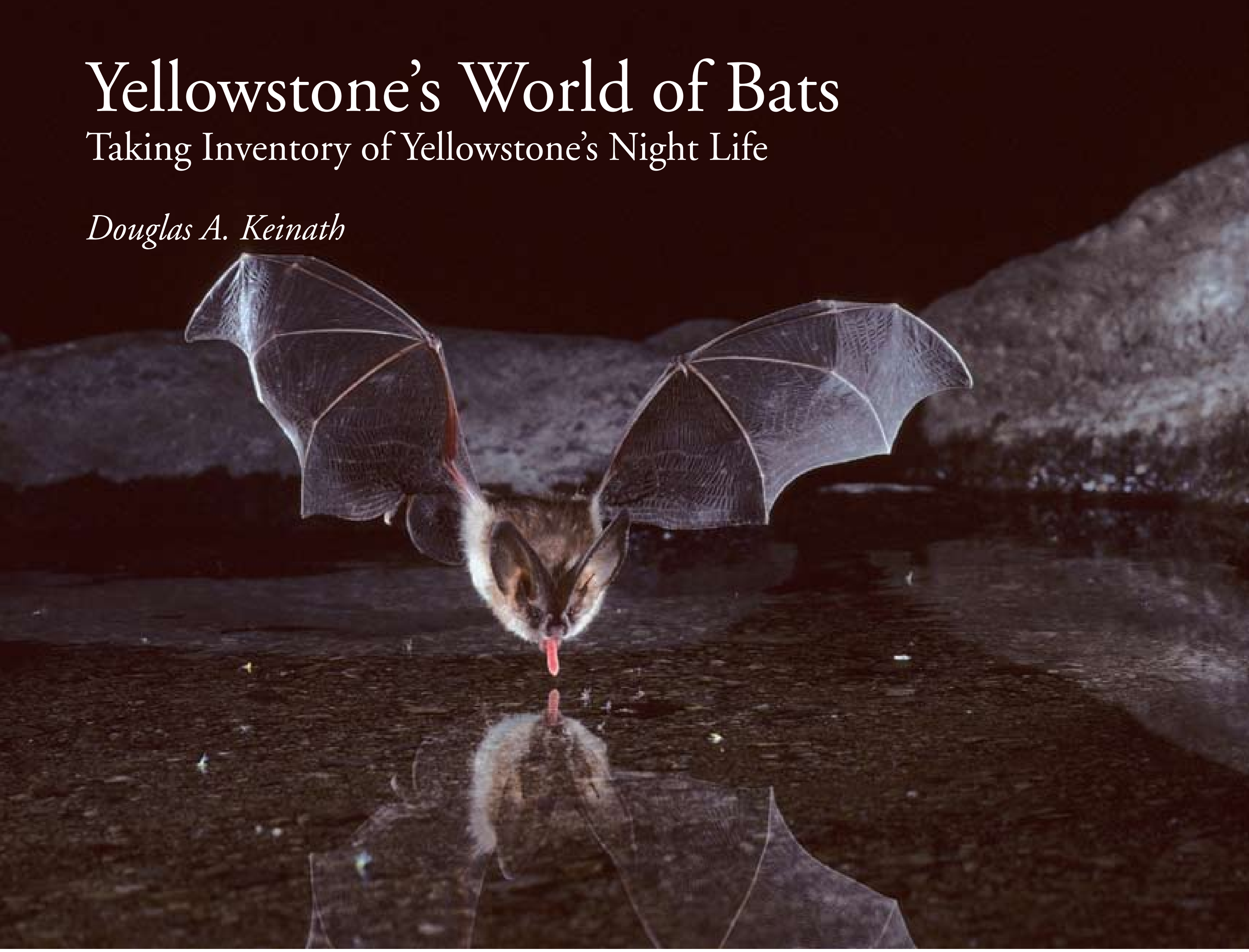

Figure 1. A Townsend's big-eared bat (*Corynorhinus townsendii*) about to drink from the surface of a small pond.

YELLOWSTONE NATIONAL PARK is known for diverse and abundant wildlife. Ask the typical visitor about Yellowstone's wildlife and you'll hear glowing stories about wolves, bear, bison, and elk, among others, but you are not likely to hear much mention of bats. If pressed, however, many visitors may recall the elusive nocturnal animals swooping around their campground, and early morning fishermen often see them skimming over the surface of Yellowstone's many waters in search of insects.

Park employees and visitors to some of Yellowstone's lodges are likely to have a few more interesting bat stories, as some of the old buildings are home to families of little brown bats (*Myotis lucifugus*) that gather in colonies to raise their young. Whereas most bats wouldn't raise their young so close to humans, little brown bats are bolder. They are among the few bats that will make their homes in structures that are actively used by people. Buildings like the Bechler and Lake Ranger Stations, which have estimated bat populations of 700 and 200 little brown bats respectively (Bogan and Geluso 1999), are some of the few places in the park where the paths of bats and humans regularly cross.

From such interactions, folks have long known that little brown bats were common in Yellowstone, but the park's other bats are generally unobtrusive and shy of humans. In fact, most bats are so elusive that until recently no one really knew which species occurred in Yellowstone and nearby national parks. Experts had ideas, but no one had taken a good, hard look at the question. This prompted scientists and managers working with the National Park Service (NPS) Greater Yellowstone Inventory and Monitoring Program to ask the question of me, which led to a three-year adventure trying to compile a "Who's Who" of bats in the Greater Yellowstone Network (GRYN). The GRYN includes Yellowstone National Park (YNP), Grand Teton National Park (GTNP), John D. Rockefeller, Jr. Memorial Parkway (administratively part of GTNP), and Bighorn Canyon National Recreation Area (BICA).

If you know where to look it is relatively easy to see bats, but it is far more difficult to systematically identify all the species present in an area, particularly in the GRYN, which is as large and diverse as bats are small and cryptic. Except for a few colonial species that roost in large, conspicuous groups, bat roosts are often very difficult to find and even more difficult to reach. The nocturnal activity of bats makes them difficult to observe in the wild except by catching brief glimpses as they fly through lighted areas or against a moonlit sky. Also, since they spend virtually all of their active hours flying and have very keen senses, they are challenging to catch. Given these difficulties, it is important to start a bat inventory by researching their ecology.

As many people know, most bats are nocturnal; they rest during the day and come out at night to forage for food and water. A less known fact is that most North American bats, and all those found in the GRYN, feed exclusively on insects. Typically, they capture these insects in flight (Figure 2), although some species also pick insects from vegetation or the ground, a type of foraging known as gleaning. To succeed in this endeavor, bats need to navigate and find prey without using the usual mammalian senses of sight and smell. They have therefore evolved highly specialized vocalizations and sensitive ears that they use to echolocate (Figure 3). Echolocation calls are quite loud and often contain a range of frequencies and harmonics (Neuweiler 2000), which essentially means that bats fly through the air screaming at the top of their lungs and listening to a complex set of echoes that reflect back to their ears. This reflected sound paints an auditory picture of their environment. Since different species of bats forage for different insects in different habitats, their echolocations sound somewhat different. Although most of these echolocations are too high in pitch for humans

Figure 2. A long-eared myotis (*Myotis evotis*) that has just captured a red moth.

Figure 3. Close-up showing the ears of a spotted bat (*Euderma maculatum*).

Figure 4. Anabat® system units (left) deployed on the rim of Bighorn Canyon (center) and at a pond in northern Yellowstone National Park (right).

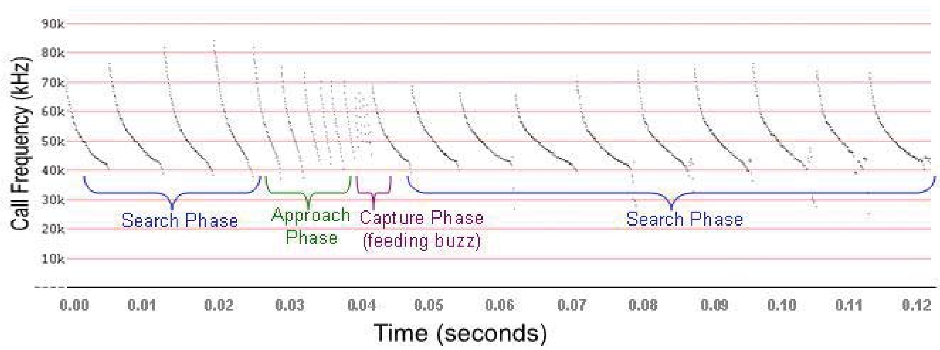

Figure 5. Example echolocation sequence from a little brown bat (*Myotis lucifugus*) recorded with an Anabat® detector while it foraged over a pond in Grand Teton National Park. Note how calls changed in shape when the bat was searching for insects (search phase), found an insect and was pinpointing its location (approach phase), and was capturing the insect (capture phase, or feeding buzz). Only search phase calls are diagnostic at the species level. *M. lucifugus* calls have a minimum frequency of about 40kHz and search phase calls have a characteristic shape, but can be confused with those of other bats having 40kHz calls, including long-legged myotis (*Myotis volans*) and small-footed myotis (*Myotis ciliolabrum*).

to hear, we can record and analyze them with the aid of computer programs (Figures 4 and 5). Some species can be confidently identified based solely on their calls, while others sound very similar and can only be differentiated by actually seeing the bat.

Another helpful bit of information is to know where bats roost during the day. Bats (especially mothers that have young) typically return to the same roost each morning, so they tend to spend more time in areas near their roosting structures. Even though it is generally difficult to find natural roosts, surveying for bats in areas with good roosting habitat increases the chances of finding bats. The bats of the GRYN roost in a variety of structures (Table 1 and Figure 6) that can be grouped into a few main categories: 1. caves and cave-like structures (e.g., abandoned mines in some NPS units); 2. rock cliffs and crevices; 3. trees (primarily cavities in trunks, under loose bark, or in foliage); and 4. human-made structures (e.g., buildings, bridges, and culverts).

A final fact that helps us find bats is that they have very restrictive resource budgets. Flying is energetically expensive, as is thermoregulation for small animals, so bats require much energy to survive (e.g., Kunz and Fenton 2003, Neuweiler

Figure 6. Some roost structures in the Greater Yellowstone Network. Clockwise from upper left: limestone cliffs and caves in Bighorn Canyon; fissure cave from thermal activity in northern Yellowstone National Park; crack in thermally heated boulder in central Yellowstone National Park; abandoned ranch building in Grand Teton National Park; hollow snag in north-central Yellowstone National Park.

Species Name	Park Occurrence and Abundance[a]	Status Notes
Little brown bat (*Myotis lucifugus*)	BICA – Very High GTNP – Very High YNP – Very High	By far the most abundant and readily observed bat in all the parks. Inhabits many old park buildings.
Big brown bat (*Eptesicus fuscus*)	BICA – High GTNP – Medium YNP – Medium	Widespread throughout the parks, but at lower abundances than *M. lucifugus*. Occasionally found roosting in buildings.
Silver-haired bat (*Lasionycteris noctivagans*)	BICA – Low GTNP – Medium/High YNP – Medium/High	Common in most mature forested areas, where it depends on the cavities and loose bark of snags for roosting.
Long-legged myotis (*Myotis volans*)	BICA – Medium GTNP – Medium GTNP – Medium	Somewhat common in most mature forested areas, where it depends on tree cavities for roosts.
Hoary bat (*Lasiurus cinereus*)	BICA – Low GTNP – Medium YNP – Low	Uncommon but widespread in GRYN in association with forests, where it roosts in foliage. It is sparsely distributed and difficult to observe.
Long-eared myotis (*Myotis evotis*)	BICA – Medium GTNP – Medium YNP – Low	Uncommon but widespread in GRYN in association with forests, where it roosts in snags or nearby cliffs.
Townsend's big-eared bat (*Corynorhinus townsendii*)	BICA – Low/Medium GTNP – Low YNP – Low	Rare and localized in GRYN with few maternity sites occurring where suitable cave roosts are present. It is noted by bat experts as being of conservation concern in much of its range.
Fringe-tailed bat (*Myotis thysanodes*)	BICA – Low GTNP – Low YNP – Low	Rare throughout the GRYN, occurring locally where dry, grass, or shrub habitat and forest coexist with roosts in either large snags or cliffs.
Yuma myotis (*Myotis yumanensis*)	BICA – Medium GTNP – Possible YNP – Low	Locally common in BICA, but rare or non-existent elsewhere in the GRYN. Can be found roosting in many structures.
Small-footed myotis (*Myotis ciliolabrum*)	BICA – Medium GTNP – Possible YNP – Likely Absent	Locally common in BICA, but rare or non-existent elsewhere in the GRYN. Often associated with dry areas and roosts in sheltered rock formations.
Spotted bat (*Euderma maculatum*)	BICA – Medium GTNP – Likely Absent YNP – Likely Absent	Within the GRYN it occurs only in BICA, where large cliffs provide roosts near water. Rare and noted by bat experts as being of conservation concern in most of its range.
Pallid bat (*Antrozous pallidus*)	BICA – Low GTNP – Likely Absent YNP – Possible	Rare in the northern Rocky Mountains, and within the GRYN probably present only in BICA. It prefers arid environments with rocky cliff roosts.
California myotis (*Myotis californicus*)	BICA – Possible GTNP – Likely Absent YNP – Likely Absent	Occurrence in the GRYN is questionable, since no definite observations were made. It possibly occurs in BICA, where suitable crevice roosts and foraging habitat are abundant.

[a] **Park units** are: Bighorn Canyon National Recreation Area (BICA), Grand Teton National Park, including John D. Rockefeller National Parkway (GTNP), Yellowstone National Park (YNP). **Abundance** is noted using a categorical scale representing the author's subjective assessment from the data collected during this inventory. Low, Medium, High, and Very High designations indicate park-wide likelihood of occurrence and do not speak to population viability or abundance outside the parks. Generally speaking, an abundance of "possible" means presence of the species was suggested by Anabat® recordings, but it has not been captured or otherwise identified in the park. Such records should be considered tentative and in need of corroboration.

Table 1. Bat species found in the Greater Yellowstone Network in roughly descending order of abundance.

2000). Therefore they minimize flight time, eat a lot, and try to conserve energy when they are not active. For example, a typical nursing female *Myotis* bat must consume more than 80% of her body weight in insects each night to prevent loss of body mass (Neuweiler 2000). Further, bats do not eat or drink when roosting so they dehydrate during the day. Once bats leave their daytime roosts, they immediately begin feeding and look for a calm body of water where they drink by skimming the surface while in flight (Figure 1). Thus, one of the best places to catch bats is a calm body of water near a roost, preferably with abundant insects. Having found such a place, researchers erect mist nets at the water's surface to catch bats as they drink and/or feed (Figure 7). Even though bats will use water bodies of all sizes, smaller ones are easier to work with and funnel bats into a more confined area, and are therefore generally more productive places to catch bats. If suitable water bodies are not available or if researchers are attempting to catch bats that don't frequent small water bodies, mist nets can be placed in "corridors" used by bats to commute from place to place (Figure 8).

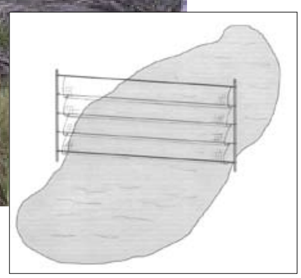

Figure 7. Photograph of researchers erecting a mist net at a large pond in Grand Teton National Park to catch bats while they are foraging for insects or drinking water. The diagram (right) illustrates such a system.

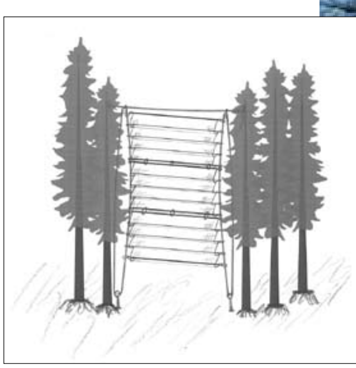

Figure 8. Photograph of researchers setting up a canopy net in a suspected flyway in northern Yellowstone National Park. The diagram (left) shows such a system consisting of three mist nets suspended above the ground between vegetation that funnels bats through a narrow corridor.

With all this ecological information in hand, I was still faced with the daunting size of the Yellowstone ecosystem; it's a very big place. To ensure that I identified as many species as possible, I needed to have sites spread around the parks in a variety of habitats. Logistic constraints precluded sampling the parks in their entirety, especially remote areas. Using a geographic information system, I developed generalized maps of habitat features important to bats, such as potential roost availability, proximity to water sources, and type of vegetation. Thus, I identified a prioritized slate of survey areas (Figure 9) where I conducted extensive field reconnaissance looking for potential roost structures, travel corridors, and/or water bodies that might attract bats. Anabat® echolocation detectors were placed at as many of these sites as practical to determine their coarse level of bat activity. If conditions were conducive to setting up mist nets, I attempted to capture bats at sites where Anabat® recordings suggested high activity, a high number of bat species, or potentially new bat species. Mist nets were set up an hour before dusk, which required two or more experienced bat biologists (depending on the complexity of the net configuration and the local abundance of bats). Biologists checked the nets about every 10 minutes until early the following morning. Captured bats were identified to species, their age, sex, and reproductive status were documented, and then they were released.

We conducted field activities over the summers of 2003 and 2004, mostly from late June to late August, resulting in more than 40 days of site evaluation (150+ sites), 63 nights of mist netting (9,500 net-area-hours of effort), nearly 80 nights of Anabat® recordings (450 recorded hours) and a dozen days of diurnal roost site investigation. Over this time we captured 527 bats of 13 species and evaluated over 10,000 individual Anabat® call files that suggested occurrences of the same 13 species (Table 1). A detailed account of the status of each species is provided in the appendix to this article, and a map of species richness across the parks is provided in Figure 10. Nine of these species were documented as occurring within the boundaries of YNP, while eight were found in GTNP and 12 were found in BICA and the associated Yellowtail Wildlife Habitat Management Area. As a whole, BICA had the highest bat abundance and the greatest number of different species, or highest species richness.

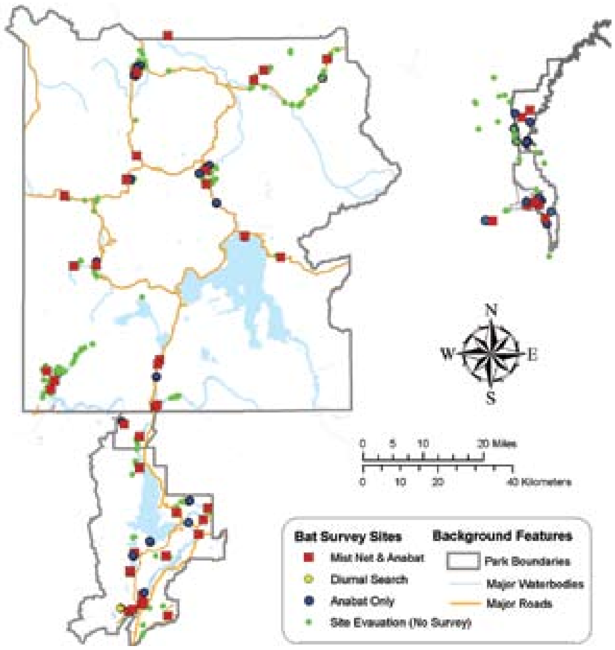

Figure 9. Map of the Greater Yellowstone Network showing approximate locations of bat survey sites.

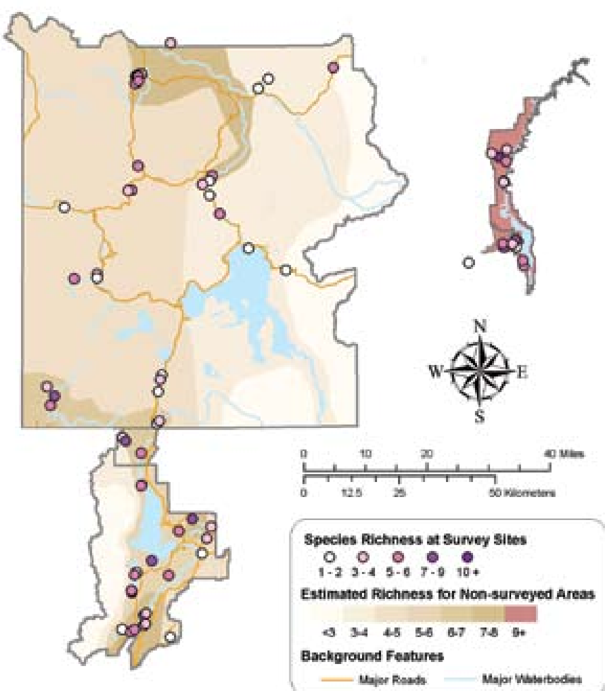

Figure 10. Map of bat species richness for the Greater Yellowstone Network. Species richness for each survey site is the number of species documented at the site and was based on a combination of records from Anabat® recordings and captures from mist nets. This information was extrapolated across the park based on coarse habitat characteristics to derive a rough estimate of species richness for non-surveyed areas; boundaries are imprecise and meant only as a general guide.

A fundamental concern with biological inventories is determining how complete they are, or how many species might have been missed with the given level of effort. Fortunately, statistical methods that use data collected during the survey are available to estimate this. To evaluate the completeness of this bat inventory I developed species accumulation curves (e.g., Soberon and Llorente 1993, Krebs 1999, Moreno and Halffter 2000, Cam et al. 2003) and used Estimate S software (V 7.5.0, © R.K. Colwell, http://viceroy.eeb.uconn.edu/estimates) and nonlinear regression algorithms in S-Plus (V 6.2, © 2003 Insightful Corp., http://www.insightful.com/) to produce bat species richness estimates for the GRYN (Figure 11). When data from all parks were combined, the accumulation curve had a clear and sharply defined plateau at 13 species for both mist net captures and Anabat® recordings, suggesting that all species present in the GRYN have been accounted for with the given level of effort. Statistical estimators supported this assessment by predicting the maximum number of species (S_{max}) to be less than 14 based on both capture data (P <0.001, N=153) and recorded calls (P < 0.001, N=371). However, similar curves constructed for each park did not reach clear plateaus with the available sampling effort, suggesting there are likely more species to be discovered in each park if more effort is expended. Individual park estimators suggest that as many as 14 species could be documented in BICA, while 10 could be found in both GTNP and YNP. I expect that with enough investigation a new species could be found in BICA, but an additional species found in GTNP or YNP would probably be one of those already on the list of 13.

Although BICA had both high bat abundance and a high number of bat species (Figure 10), it is important to note that these two factors are not always related, particularly at the scale of individual sites. The number of bats captured in mist nets at a site was not a good predictor of species richness (P = 0.919, N = 49). The number of bats recorded at a site using Anabat® was significantly but weakly related to richness (P < 0.001, R^2 = 0.24, N = 65). Moreover, there seemed to be good correlation between Anabat® call rates and species richness when richness was low, but sites with high richness had quite variable levels of activity. The take-home message is that a site with a lot of bat activity does not necessarily mean that the site has many different species 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 abundant but few other species were identified. On the other hand, BICA had one of the most productive sites in our inventory that also had the highest bat species richness. This is likely due to a unique combination of habitat features that coincide in BICA to support a diversity of bats.

Bats require three habitat features:

1. Roosts (especially maternity roosts and hibernation sites): Bats rely on roosts to rest, for security from predators,

to have pups, and to hibernate during winter. Maternity roosts and hibernacula are perhaps the most critical, because good ones are relatively scarce. If human activity increases roost availability, then bats could benefit. For example, little brown bats benefit when humans allow them to roost in buildings. However, bats often perish or leave when humans destroy or disturb their natural roosts.

2. Foraging areas: Since GRYN bats feed on insects (see Appendix for some details on specific diets), they require foraging areas where these insects are abundant. Any activities that reduce the abundance or diversity of insects, such as pesticide application or landscape conversions, are likely to alter the bat community. Such impacts can be more pronounced for specialist species like Townsend's big-eared bat than for generalists like the little brown bat.
3. Open water: Bats use open water to drink, and these same areas are often important as insect breeding locations. In order to be useful to the widest range of bats, water sources should be relatively permanent, have natural vegetation, and not be contaminated by foreign chemicals such as wastewater products, pesticides, or herbicides.

Roosts, foraging areas, and open water are each important to bats, but they are not valuable in isolation. Bats require a landscape containing all of them relatively close together, but at the same time must cover a large enough area to accommodate seasonal shifts in prey abundance. If any one element is removed or if the elements become too separated, then bats will not persist. This is probably why BICA has more abundance and diversity of bats than nearby areas. It is relatively warm, low in elevation, contains an abundance of cliff and cave roosting habitat, contains tree roosting habitat in the form of extensive cottonwood riparian areas, *and* everything is relatively close to large expanses of still water that provide abundant insect life and access to consumable water. BICA is perhaps one of the hot-spots for bats in all of the central Rocky Mountains. YNP and GTNP have much open water and probably an abundance of tree roosts, but they are generally higher and cooler than BICA with more limiting substrate roosts (i.e., caves and cliffs). YNP and GTNP therefore have decent habitat for bat species that have generalist feeding habits and either generalist roost requirements (e.g., little brown bat, big-brown bat) or roost in snags (e.g., sliver-haired bat, long-legged myotis). The presence of other bats in these parks is probably restricted by the limited location of suitable roosts and/or the distribution of moths and beetles on which more specialized bats forage.

Rabies is a frequent concern of park visitors interested in bats. The perception of bats as deadly vectors of rabies has harmed their image and resulted in public desire to exterminate them. This is an unfortunate dramatization of the facts, as the incidence of rabies in wild bats is low and poses minimal threat to humans (e.g., Constantine 1979). For most of United States history, rabies transmission to humans occurred largely from cats and dogs. Since pet vaccination programs reduced the occurrence of rabies in dogs and cats, wild animals now represent the bulk of cases, accounting for more than 90% of animal rabies cases reported to the Centers for Disease Control, the majority of which are raccoons and skunks (Krebs et al. 2001). Due to an increase in negative publicity for bats, more people have started turning dead bats in to disease professionals, but reports suggest that the prevalence of rabies in the wild population of bats is small, perhaps on order of 0.5–1.0% (Caire 1998, WC 2000, SDBWG 2004, Wilkerson 2000). Also, unlike larger animals, bats rarely transmit fatal rabies infections to humans. In fact, rabies from bats inhabiting buildings has been associated with only eight human deaths in United States history. The most common bat in the GRYN (little brown bat) has never been documented as transferring rabies to humans. People can only get rabies from bats if an infected animal bites them and breaks the skin, and most GRYN bats are so small that it is difficult for them to break the skin. Since normal, healthy bats will usually not allow themselves to be contacted by humans (unless they are in a state of torpor during roosting), virtually all risk of exposure can be eliminated by not

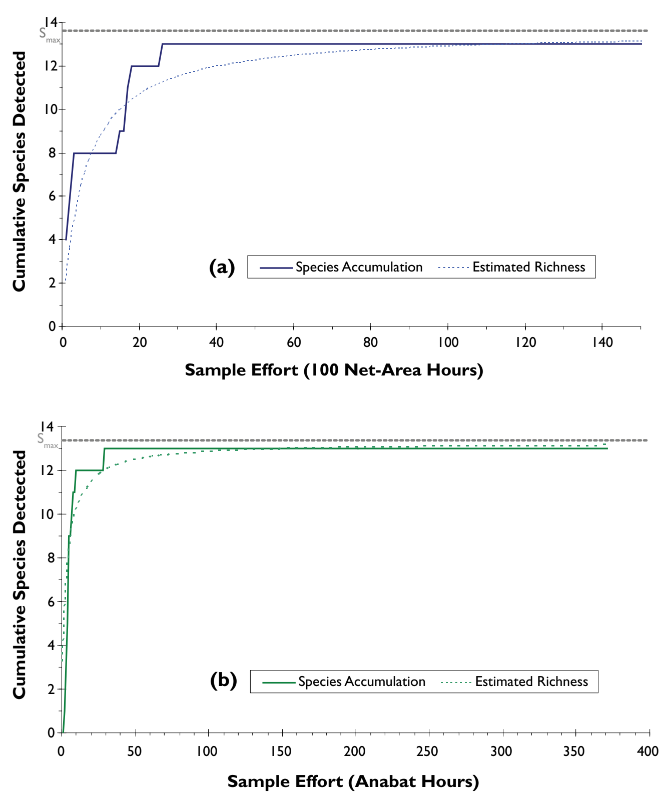

Figure 11. Species accumulation curves and richness estimators for the bat inventory of the Greater Yellowstone Network using (a) capture data from mist net activities, and (b) recorded echolocation calls from Anabat® surveys. S_{max} is the maximum predicted species richness.

handling live bats. If frequent interaction with live bats is a regular occurrence, a highly effective and painless vaccine is available that further reduces risk of transmission.

Many people are afraid of bats, dislike them, or know very little about them. People who learn a little typically begin to appreciate them, at least for the volumes of insects they consume every night. Those who make an effort to learn more about bats tend to see them as fascinating animals that have many unique qualities making them worthy of conservation. In the GRYN and elsewhere, the need for bat conservation is beginning to be recognized. Like other wildlife, bats were in the parks long before humans, and although some species can benefit from human presence, many others are disrupted by human activity. As stewards of the land, if we minimize disturbance to bats and ensure the persistence of a landscape conducive to their survival, they will continue to live peacefully with us into the foreseeable future. Readers interested in learning more about bats can consult websites such as the Lubee Bat Conservancy (http://www.lubee.org/), the Organization for Bat Conservation (http://www.batconservation.org/) and Bat Conservation International (http://www.batcon.org/). Several good books are also available, such as Fenton (2001), Adams (2003), Nowak (1994) and Tuttle (2005). More technical volumes include Kunz and Racey (1998), Kunz and Fenton (2003), Neuweiler (2000), Altringham (1996), Lacki et al. (2007), and Kunz et al. (2006).

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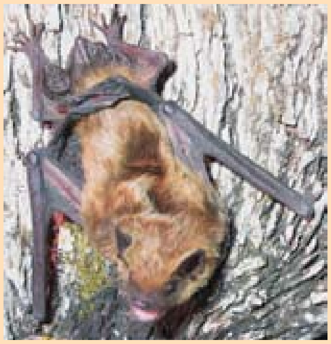
Appendix

Accounts of bat species occurring in the Greater Yellowstone Network.

Little brown bat (*Myotis lucifugus*)

M. lucifugus is by far the most abundant bat in the GRYN, being found commonly in all park units in conifer forest, streamside riparian areas, woodlots, shelterbelts, and developed areas; usually near open water. It uses a wide variety of summer roosts including buildings, trees (cavities and loose bark), bridges, rock crevices, caves, and abandoned mines. Many old buildings have colonies of little brown bats and such structures seem important to the health of their populations within the GRYN. The little brown bat begins to forage at dusk. It mainly forages over water, often within a few feet of the surface. It feeds on the wing, voraciously eating small, soft-bodied, flying insects, particularly emerging aquatic insects (e.g., caddis flies, mayflies, midges, mosquitoes). Given its habits this bat is easily surveyed by mist nets, but its recorded calls can be confused with other species.



Big brown bat (*Eptesicus fuscus*)

E. fuscus is fairly common in the GRYN and much of North America in a variety of habitats (e.g., cottonwood riparian corridors, sagebrush steppe, juniper woodland, conifer forest, and aspen woodland), but seems to be most frequent in deciduous woodlands. Big brown bats roost in buildings, often with little brown bats, and also rock crevices, caves, abandoned mines, bridges, and tree cavities. They emerge at or just before sunset to forage on a wide variety of flying insects, often well above the ground. Their calls can easily be confused with silver-haired bats and they are somewhat difficult to catch in mist nets in the GYRN, but they can be visually identified in flight.

Silver-haired bat (*Lasionycteris noctivagans*)

L. noctivagans is common in GTNP and YNP but somewhat rare in BICA, which is probably too low and arid to support a significant population of this montane forest bat. Silver-haired bats are found across North America in forested areas that have open water, but they seem to prefer late-successional forests with many snags, where they can be found roosting in cavities or under loose bark. They typically fly well after sunset and forage relatively close to the ground (i.e., <8 feet) on a variety of insects, particularly small, swarming varieties. *L. noctivagans* is one of two long-distance migrants in Wyoming (the other is the hoary bat), likely flying to southern states where it remains active during the winter. Silver-haired bats are susceptible to capture via mist nets and are easy to detect acoustically, although their calls are difficult to distinguish from those of big brown bats.

Long-legged myotis (*Myotis volans*)

M. volans seems to be common in GTNP, locally common in YNP, and somewhat common in BICA, but its abundance is unclear since it can be difficult to catch in water-based mist nets and its echolocation calls are easily confused with those of the more common little brown bat. Suitable habitat includes mature montane forest, ponderosa pine forest, and juniper woodlands, generally with wetland areas, at mid to high elevations and having many snags. Females form maternity colonies in tree cavities, buildings, rock crevices, and under loose bark. These bats emerge shortly after sunset and are active most of the night, pursuing soft-bodied insects (mainly moths) in open clearings near vegetation. They are not thought to migrate long distances, but have not been documented hibernating in Wyoming.

Hoary bat (*Lasiurus cinereus*)

L. cinereus is found throughout the GRYN, but seems to be most common in GTNP. It is one the most widespread North American bats, but occurs at generally low densities throughout its range. It roosts singly in the foliage of trees, especially conifers, making it highly associated with forested habitats that have open areas where it can forage along woodland edges. Hoary bats usually forage late in the evening, often 2 to 5 hours after sunset. They are fast rather than agile flyers and feed mostly on moths and other large-bodied insects. They are one of Wyoming's few long-distance migrants, traveling to southern states and Mexico during the winter. Hoary bats fly high and are therefore not easily surveyed via mist nets, but they have distinctive echolocation calls and can therefore be surveyed acoustically.

Long-eared myotis (*Myotis evotis*)

M. evotis occurs in low numbers throughout the GRYN and is not discernibly more abundant in any park unit. Long-eared myotis can be found in much of western North America, but can be uncommon relative to other bat species. Suitable habitat includes conifer forest, woodlands and scrubland, typically in areas close to water and near rock outcrops. Roosts are primarily in large, hollow snags and rock crevices, but sometimes in buildings, caves, or abandoned mines. Long-eared myotis is slow and maneuverable, typically foraging for moths and small beetles near vegetation and over water within forests and nearby open areas. *M. evotis* can be captured in mist nets where it is active, but can be difficult to distinguish from fringed myotis by inexperienced observers. Acoustic recordings can be useful, but care must be taken to avoid confusion with other 30kHz bats.

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

C. townsendii was found in all GRYN parks, but was rare and occurred only in areas near roost sites. Several maternity colonies exist near BICA, one is known from YNP (near Mammoth Hot Springs), and only a few bachelor males were found in GTNP. Townsend's big-eared bats occur throughout the West, but populations are small and localized because they require large cavern-like structures for roosting and maternity caves must be consistently warm. They are highly maneuverable and usually forage for moths along edge habitats (e.g., forest edges or stream corridors). *C. townsendii* is difficult to survey using standard techniques because it is wary of mist nets and emits quiet echolocation calls that are difficult to detect with Anabat® except at close range. Since this bat is sensitive to human disturbance at roosts, it is crucial that suitable caves be protected from extensive human intrusion.

Fringe-tailed bat (*Myotis thysanodes*)

M. thysanodes was most common in BICA, where abundant cliff habitat is surrounded by arid forest and grassland. It occurred at low numbers in GTNP and only rarely in YNP. Fringe-tailed bats are mostly found in dry habitats where open areas are interspersed with mature forest that has abundant large snags. They typically roost in cliff crevices or large, middle-aged snags and eat mostly beetles and moths captured on the wing or by gleaning from vegetation. *M. thysanodes* can be captured in mist nets, but since these bats forage around vegetation, methods of survey tied to water bodies can under-represent their abundance. In hand they can be mistaken for long-eared myotis (*M. evotis*) unless careful attention is given to the trailing edge of the tail membrane, which has a noticeable fringe of stiff hairs. *M. thysandoes* echolocation calls are distinctive if a good recording is obtained.

Yuma myotis (*Myotis yumanensis*)
All occurrences of *M. yumanensis* in the GRYN were peripheral or disjunct to the main range of the species. It occurred uncommonly but regularly in BICA, but occurrence in YNP and GTNP was tentative, based on a few Anabat® recordings in the Bechler Valley and John D. Rockefeller, Jr. Memorial Parkway. Further investigation is required to confirm status in these areas. Yuma myotis is found in a variety of dry, low-mid elevation habitats (e.g., deserts, woodlands, grasslands, sagebrush) where it forages over open water for small-bodied insects. Maternity colonies and day roosts may be in buildings, trees, caves, abandoned mines, bridges, or cliff crevices, but are always near water. Although its calls are somewhat distinctive, it is visually very difficult to distinguish from the little brown bat, even by experts.

Western small-footed myotis (*Myotis ciliolabrum*)
Although *M. ciliolabrum* is common in Wyoming, it appears rare in the GRYN. BICA is the only park with confirmed occurrences, all of which were in cottonwood gallery forest. YNP and GTNP are likely too high and cool for this species to occur regularly, although some Anabat® recordings in GTNP warrant further investigation. Western small-footed myotis is commonly associated with arid, rocky areas in a variety of habitats from woodlands to prairie. Day roosts tend to be rock shelters (crevices, overhangs, cliffs, under rocks) as well as caves and abandoned mines. These bats are very maneuverable and often forage along cliffs low to the ground and among vegetation on a variety of small insects, especially moths. *M. ciliolabrum* are best captured in canopy nets. Physical identification is straightforward, but its calls can be difficult to distinguish from those of other myotis species.

Spotted bat (*Euderma maculatum*)
Euderma maculatum is widespread but severely restricted in distribution and usually occurs in low numbers due to its restrictive roosting requirements and dietary specialization. BICA is one of the few places in Wyoming where they occur regularly. Neither GTNP nor YNP have suitable habitat. *E. maculatum* uses a variety of foraging habitats from desert shrub to conifer forest, but it roosts almost exclusively on extensive, large, rocky cliffs near permanent water, a situation especially prevalent in the Bighorn Basin. The spotted bat generally begins foraging for moths well after sunset along large, set routes. 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 (>10 m). 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.

Pallid bat (*Antrozous pallidus*)
Due to its roost preferences, very few areas in Wyoming are suitable for *A. pallidus*. BICA is one of the best such sites due to its warm, arid climate and abundant cliff roosts. The pallid bat probably does not occur in GTNP or YNP, although several potential pallid bat calls were recorded in the Mammoth area of YNP. Further investigation is required to determine its status outside BICA. The pallid bat usually roosts in rock crevices, and more rarely in buildings, rock piles, tree cavities, shallow caves, and mines. It generally inhabits dry shrublands and woodlands where it gleans large-bodied insects. Pallid bats are best surveyed with mist nets at ground level and are easy to identify. They can be detected with Anabat®, but recordings of them can be confused with those of other bats.

California myotis (Myotis californicus)

M. californicus was not conclusively identified in the GRYN, but there was one possible specimen from BICA and a suspicious call recorded in the Bechler Valley of YNP. It is probably only an occasional visitor to these parks, but further investigation is warranted. California myotis roosts in crevices associated with rocks, cliffs, tree snags, and buildings. It often inhabits rock-walled canyons where water is available. It is small and maneuverable, allowing it to forage on swarms of small, flying insects close to obstacles. *M. californicus* can be captured in mist nets, but its habit of foraging around vegetation causes it to be under-represented in surveys based around water bodies. In hand it can be difficult to distinguish from *M. ciliolabrum*. Similarly, it is easy to record with Anabat®, but recordings can be difficult to distinguish from those of *M. yumanensis*.

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