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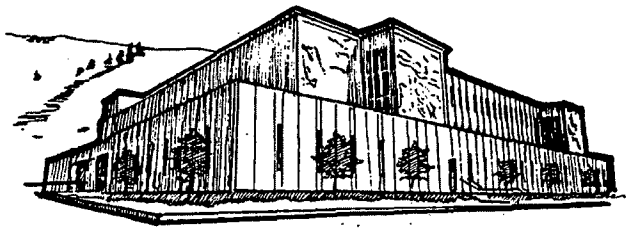

Abundance, Distribution, and Sexual Segregation of Bats in the Pryor Mountains of South Central Montana

By

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Abundance and Distribution of Bats in the Pryor Mountains of South Central Montana (41 pp.)

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Bat occurrence in the Pryor Mountains of south central Montana was examined between June and September in 1989 and 1990. A total of 1,319 individuals representing 10 species were captured. Bats were captured at ponds, springs, and at the entrance of five caves. Numbers of bats captured were generally greater at the caves. Capture success was considerably lower at water sources, but a greater diversity of species was noted at these sites. While several of the species captured occurred throughout the area, the spotted bat, *Euderma maculatum*, the pallid bat, *Antrozous pallidus*, and the silver-haired bat, *Lasionycteris noctivagans*, were more restricted in distribution. Two specimens of the spotted bat, *Euderma maculatum*, were captured, representing the first spotted bats captured in Montana since 1949. Spotted bats were observed throughout the eastern portion of the study area. Townsend's Big-eared bat, *Plecotus townsendii*, was previously known only from winter records in the Pryor Mountains; 9 individuals were observed during this study. Twenty-four individuals of *Antrozous pallidus* were captured, the first specimens observed since the species was first documented in Montana in 1979. Several of the species of bats found in the Pryor Mountains were captured in numbers significantly different from an expected 1:1 sex ratio. This was especially true at the caves, where males of most species greatly out numbered females, suggesting that males and females may be differentially utilizing habitat. The generally low temperatures of the caves investigated in this study may preclude their summer use by many female bats, especially pregnant or lactating individuals, which require higher roost temperatures to maintain the higher metabolic rate necessary for raising young. Bat activity at the caves, especially Mystery Cave, indicated that these caves provide important summer roosting habitat. Additionally, these caves possess characteristics which may make them important as hibernacula.

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INTRODUCTION

Males and females may segregate in many species of bats during the summer (Racey and Swift, 1985; Swift and Racey, 1983; Humphrey et al., 1977; Humphrey and Kunz, 1976). In the hoary bat, *Lasiurus cinereus*, roosts may be separated by several hundred miles, making the sexes of this species effectively allopatric through much of the year (Jones et al., 1983; Findley and Jones, 1964). Frequently, males and females of many species may occupy different roosting sites, but forage together in the same area (Humphrey et al., 1977; Humphrey and Kunz, 1976). Intersexual differences in foraging patterns are known to exist in birds (Holmes, 1986; Morse, 1968), but these studies have dealt with birds foraging together in the same habitat, rather than being sexually segregated. And while several studies discuss differential interspecific habitat use by bats, they do not discuss the sex of bats observed (Crome and Richards, 1988; McKenzie and Rolfe 1986; Warner, 1985; Bell, 1980). Fenton et al. (1983) conducted a thorough study of the distribution of bats in three national parks of Canada, but his methodology did not allow determination of the sex of bats captured during the course of the study. Humphrey et al. (1977), however, found that extremely few males occurred in the foraging area of a nursery population of the Indiana

bat, *Myotis sodalis*. Similarly, on two nights during the summer of 1987 when approximately 40 bats were netted over a pond in Dinosaur National Monument, Colorado, eight species were taken, and all specimens were males (per. obs.). M.A. Bogan (per. comm.) suggested that such apparent segregation of males and females may be related to energy demands during pregnancy and lactation, and that males and females may be foraging in different areas.

Even where males and females do forage together, differences in foraging behavior have been documented. Kunz (1974) found that female cave bats, *Myotis velifer*, returned to their roost before males, and he suggested that such foraging differences may serve to reduce competition for available resources. Specifically he stated that a reduction in the number of males foraging near females may allow pregnant and lactating females to forage closer to their roost, thus reducing energy costs. Tuttle (1976a, 1976b) found that young, newly volant gray bats (*Myotis grisescens*) exhibited decreased growth rates and increased mortality as the distance from their roosts to their feeding area increased.

Humphrey (1975) suggests that roosting sites may be the most important limiting factor in female bat distribution. Females require suitable roosts to reproduce successfully, and must return to the roosts regularly during lactation to feed young (Kunz, 1982). Anthony et al. (1981) found that

maternity colonies of *M. lucifugus* occurred in roosts with temperatures above 0° C. Thus, even though caves are common in the Pryor Mountain area, they may not be adequate for use as maternity roosts. Tuttle and Stevenson (1978) suggest that those caves that possess structural and elevational complexity and a wide thermal range provide the greatest diversity of roosting sites. Tuttle (1979) found that of 1635 known caves in Alabama, only 2.4% were used by gray bats (*Myotis grisescens*) in summer, and only 0.1% were used in winter. Larger, more complex caves may provide suitable roosting habitat for a diversity of species (Dalquest and Walton, 1970) and may provide sites for larger aggregations of these species (Kunz, 1982). While caves are numerous in the Pryor Mountains, most are small and horizontal (Cambell, 1978). The few large caves found in the area may be of primary importance to bats, and were a primary focus of this study.

Ten species of bats are known to inhabit the Pryor Mountain area (Hall, 1981; Shryer and Flath 1980; Hoffmann and Pattie, 1968; Table 1). A specimen of the California myotis (*Myotis californicus*; University of Wyoming #5569), collected in the study area (Patterson 1985) was recently re-examined, and is referable to *Myotis ciliolabrum* (M.A. Bogan, per. comm.). Two species, the spotted bat (*Euderma maculatum*) and Townsend's big-eared bat (*Plecotus townsendii*), are listed under category 2 as candidates for

TABLE 1.--*Bats Occurring in the Pryor Mountains*. From Hall, 1981; Shryer and Flath 1980; and Hoffmann and Pattie, 1968.

Myotis lucifugus	little brown myotis
Myotis ciliolabrum	western small-footed myotis
Myotis evotis	long-eared myotis
Myotis volans	long-legged myotis
Eptesicus fuscus	big brown bat
Antrozous pallidus	pallid bat
Lasiurus cinereus	hoary bat
Lasionycteris noctivagans	silver-haired bat
Plecotus townsendii	Townsend's big-eared bat
Euderma maculatum	spotted bat

listing under the Endangered Species Act (Federal Register, 1987). *Plecotus townsendii* and *E. maculatum* are listed as sensitive species by the Forest Service (USFS) in Region 1. The pallid bat, *Antrozous pallidus*, together with the previous two species, is listed as a species of special concern by the Montana Natural Heritage Program (MTNHP, 1990). The first specimen of *A. pallidus* from Montana was collected in the Pryor Mountains by Shryer and Flath (1980). *Plecotus townsendii* has been found in hibernacula during winter in the study area (D. Genter, per. comm.). Two specimens of *E. maculatum* are known from the eastern edge of the Pryor Mountains in the Bighorn Canyon NRA (T. Peters, per. comm.), and the only live specimen previously known was collected in Billings in 1949 (Nicholson, 1950).

The purpose of this study was twofold. One objective was to determine if patterns of sexual segregation were evident in three of the most abundant species of bats, *M. evotis*, *M. volans*, and *M. lucifugus*, and to determine if any such patterns varied among species and/or sites, or varied through time. Secondly, this study was conducted to expand the base of information available on the species of bats occurring in the Pryor Mountains. The large number of caves in the area, combined with a diversity of habitats, together with information gathered from previous work conducted in the area, suggests that the Pryor Mountain area could support a large diversity of bat species. Included among

these are several species, discussed above, that are potentially rare. Data gathered in this study provides additional information regarding the distribution, abundance, and ecology of these species. Such information is useful both from a scientific perspective, as ecological information is often lacking for the species considered in this study, as well as from a management perspective. The Federal Cave Resources Protection Act of 1988 mandates that federal agencies identify significant caves and manage for their protection. The caves discussed in this report may warrant such management. The two candidate species discussed previously, together with *Antrozous pallidus*, as well as the more abundant species, may require special management consideration. The information gathered from this study will assist the federal agencies involved in management of the Pryor Mountain area in making management decisions for bats as well as for caves and their additional biological resources.

STUDY AREA

This study was conducted in the Pryor Mountains, approximately 72 km south of Billings, Montana (Figure 1). The area is primarily federal in ownership, and is administered by the Bureau of Land Management, the Custer National Forest, and the National Park Service. The Crow Indian Reservation borders the northern portion of the region, and small portions of private land are dispersed throughout the area. The area ranges in elevation from approximately 1100 m to over 2600 m, and encompasses approximately 500 sq. km. Nine terrestrial 'ecosystems' have been described in the Pryor Mountains (South, 1980; Table 2), ranging from low elevation red desert salt shrub to subalpine plateau found at the higher elevations.

Figure 1.-- Location of the study area: The Pryor Mountains of South Central Montana.

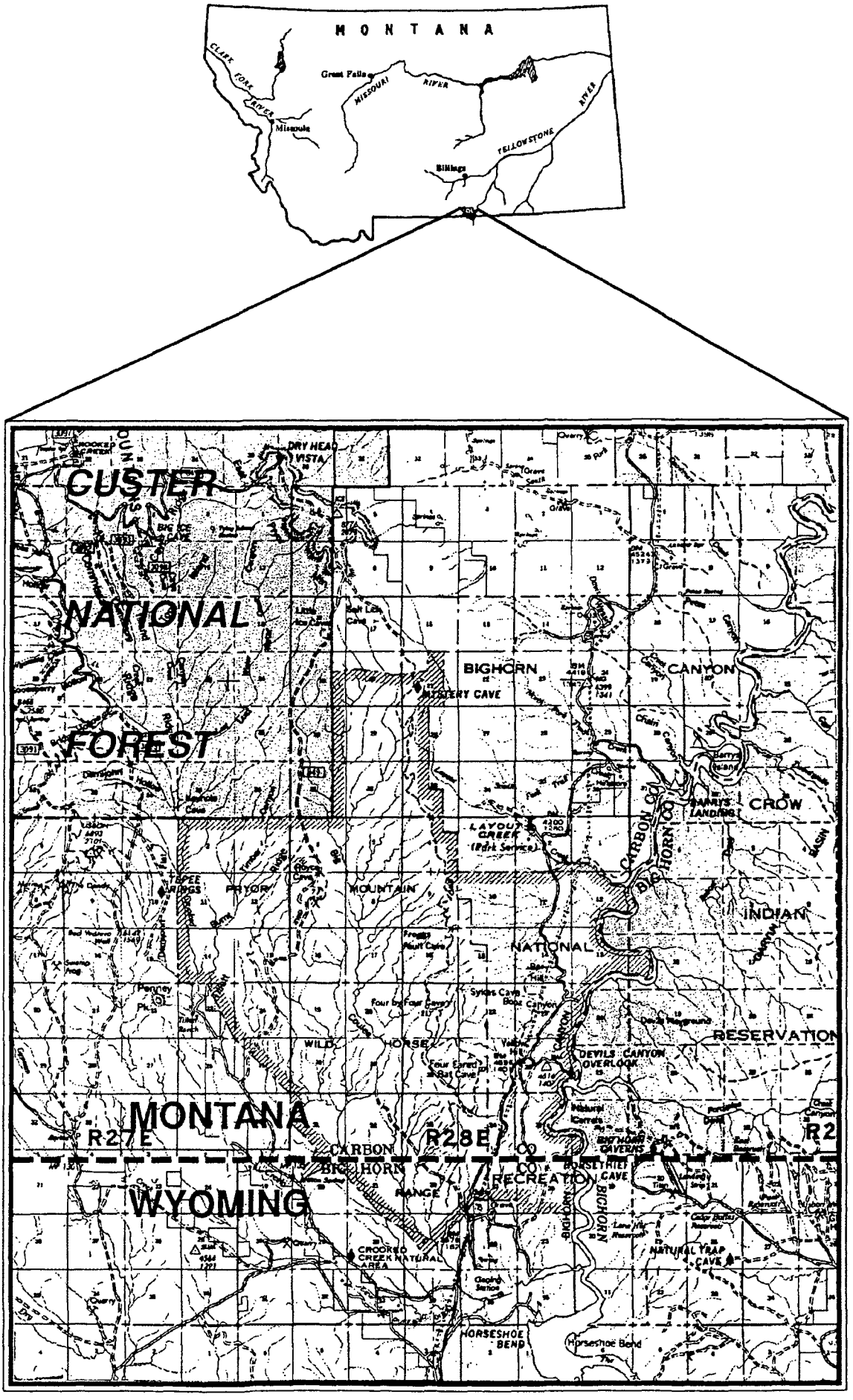
MONTANA
Great Falls
Missoula
Billings
CUSTER
NATIONAL
FOREST
DRY HEAD VISTA
BIGHORN
CANYON
MYSTERY CAVE
CROW
INDIAN
RESERVATION
PRYOR
MOUNTAIN
WILD
HORSE
DEVILS CANYON OVERLOOK
MONTANA
WYOMING
R27E
R28E
R2
CARBON CO
BIG HORN
RANGE
RECREATION
CROOKED CREEK NATURAL AREA
HORSESHOE BEND
NATURAL TRAP CAVE

TABLE 2.-- *Terrestrial Ecosystems of the Pryor Mountains.* From South, 1980.

1) Subalpine Plateau
2) Subalpine Forest and Meadow
3) Douglas-fir
4) Rock Outcrop
5) Mountain Grassland
6) Streamside Hardwood
7) Utah Juniper-Blacksage
8) Sagebrush-Grasslands
9) Red Desert Salt Shrub

METHODS

Capture Methods.-- Bats are most successfully captured over calm water sources (Kunz and Kurta, 1988; von Frenckell and Barclay, 1987), especially over ponds, or near the entrance of caves or mines used as roosting sites (Griffith and Gates, 1985). Water sources, caves, and mines were located using US Geological Service (USGS) topographic maps, ground searches, and *Caves of Montana* (Cambell, 1978). Bats were captured at water sources and caves using one or more 36-mm mesh-mist nets 5.5, 9, or 13 m long. Additionally, a Tuttle trap (Tuttle, 1974; Kunz and Kurta, 1988) was frequently employed at the caves. Since bats may become more effective at avoiding nets on subsequent nights of trapping (Kunz, 1973; Laval, 1970; Kunz and Kurta, 1988), an attempt was made to avoid netting at the same site on two or more successive nights in 1989. In 1990, there were usually at least four days between subsequent visits to a site.

Mist nets and/or the Tuttle trap were deployed shortly after sunset when bat activity commenced, and were left deployed through the night until dawn. Seven caves and two water sources were investigated for bat activity in 1989, and five caves and four water sources were investigated in 1990. In 1989, bats were captured on 40 nights between 15 June and 10 September. In 1990, the sites were visited on 50 nights between 22 June and 11 September. In 1989, more

effort was placed on capturing bats at water sources with 37 of the 40 trap nights taking place at a water source. During 1990, 20 trap nights were spent at water sources, while 30 were spent at caves. Of the sites investigated in 1990, four caves and two water sources were netted at least seven times.

Species, Sex, and Age Determination.-- All captured bats were identified to species, and sex was determined by examination of external genitalia. Reproductive condition was assessed by external examination of the testes in males and visual examination of the mammary glands in females (Racey, 1988), although pregnancy was not determined. Adult females that possessed mammary glands that were swollen or from which milk could be exuded were considered lactating. Adult females that possessed mammary glands around which hair was lacking but that were not swollen were considered post-lactating, and females that possessed mammary glands around which hair was present were considered non-lactating. Bats captured in 1990 were classified as adults or juveniles based upon the degree of epiphyseal-diaphyseal fusion of wing bones (Anthony, 1988). A bat was considered to be a juvenile if the epiphyseal-diaphyseal fusion of the bat's back-lit wing appeared to be incomplete. Age was not determined in bats captured in 1989. Body mass was determined by weighing bats in a small plastic bag using a

50-gm Pesola scale. Most bats were marked using A. C. Hughes size XF or XCS color and number coded split-plastic wingbands (Barclay and Bell, 1988) to facilitate identification upon recapture and to document movements between trapping locations.

Site Characteristics.-- Caves at which bats were captured were entered to locate roosting bats, record temperature and humidity, and to provide a gross description of structural characteristics. While vegetation analysis was conducted at neither the caves nor the water sources, the general habitat in which the site occurred was determined using South's (1980) ecosystem descriptions. Elevation at each site was also recorded.

Candidate Species.-- Special efforts were placed on locating *Euderma maculatum* and *Plecotus townsendii*. In 1990, trapping continued at three sites where capture success was otherwise low in an attempt to capture these species. In addition to trapping efforts, aural monitoring was conducted to locate *Euderma maculatum*. This is the only species of bat in the study area that possesses an echolocation call audible to the unaided ear (sensu Fenton et al., 1984) and was easily identifiable. Monitoring for *Euderma maculatum* was conducted primarily within the Bighorn Canyon NRA.

Analysis.-- Sex ratios at each site were analyzed using a Chi-square test to estimate if proportions of males and females differed from a 1:1 ratio. Differences in sex ratios over time (i.e. differences between visits) were also assessed using the Chi-square statistic. Differences in species composition were examined using Chi-square and loglinear analysis.

Differences between 1989 and 1990.-- Because the 1989 field season was used primarily to become familiar with the area and to develop a study plan, time spent at sites varied considerably, with some sites visited just once or twice while a few sites were visited eight or more times. Additionally, the sites were visited in no particular order, and no attempt was made to visit the sites on a regular schedule throughout the summer, as was done in 1990. Also, some of the sites visited in 1990 were not investigated in 1989, and vise versa. Finally, juveniles were not identified during 1989. Juvenile bats represent an unknown portion of the total number of bats captured in that year. Thus, while useful in providing information on total number and species of bats captured throughout the study, the data from 1989 are difficult to combine or compare with those of 1990. Therefore, in discussion of species occurrence, relative abundance, and sex ratios, I have excluded bats captured in 1989 from any comparative analysis or

discussion, except where specifically noted. Additionally, I focus primarily on the sites that were visited seven or more times in 1990.

RESULTS

Species Composition and Relative Abundance.-- A total of 1,319 bats were captured -- 319 in 1989 (Table 3), and 1,000 in 1990 (Table 4), representing ten species. In 1990, three species, *Myotis lucifugus, M. volans*, and *M. evotis* represented 87 percent of all bats captured. Trapping success was generally greater at the caves, where 900 (90%) bats were captured in 30 nights of trapping. Considerably fewer bats were captured at water sources: 100 (10%) in 20 nights of trapping. Little Ice Cave, Royce Cave, and Four-eared bat Cave were investigated seven times, while Mystery Cave was visited on eight occasions. Eight hundred ninety-four bats were captured at these three caves. Only two water sources were investigated regularly in 1990: Gyp Spring and Layout Creek. Each was netted seven times, and a total of 38 and 24 bats were captured, respectively.

Species composition differed significantly among those sites visited 7 or more times ($\chi^2 = 1340.2$, $P < .001$). Three species of the genus *Myotis* accounted for most of the bats captured at the caves, but relative proportions of these species differed among caves ($\chi^2 = 234.9$, $P < .001$). At both Mystery Cave and Little Ice Cave, where 797 (80%) bats were captured, only species of the genus *Myotis* were captured (with the exception of one *Plecotus townsendii* captured at Mystery Cave).

TABLE 3.-- *Number of bats captured at each of 9 study sites visited in 1989.*

Species	Mystery Cave	Little-Ice Cave	Gyp Spring	Indian Spring	Crooked Creek	Sage Creek Work Station	Bain-bridge Spring	Twin Hills Guzzler	Sage Creek Camp ground	Total
Myotis lucifugus	69	17	3						15	104
Myotis volans	27	24	2							53
Myotis evotis	24	26	3			5	1		1	60
Myotis ciliolabrum	1		26	2				9	4	42
Eptesicus fuscus			6	4					22	32
Antrozous pallidus			8							8
Lasiurus cinereus			6	2	1				9	18
Lasionycteris noctivagans									2	3
Total	121	67	54	9	1	5	1	9	53	319
No. visits	2	1	9	2	1	5	1	3	12	

TABLE 4.-- *Number of bats captured at each of 9 study sites visited in 1990.*

Species	Mystery Cave	Little-Ice Cave	Royce Cave	Four-eared bat Cave	Syke's Cave	Gyp Spring	Layout Creek	Horse-shoe Bend	Kruger Pond	Total
Myotis lucifugus	426	84	1		1		3	11		526
Myotis volans	136	43	3			2	1		2	187
Myotis evotis	75	26	50		1		1		2	155
Myotis ciliolabrum	5	1	6	7	4	25	4	1	3	66
Antrozous pallidus						8	4	4		16
Plecotus townsendii	1		5	3						9
Euderma maculatum							2			2
Eptesicus fuscus			1	11		1	9	4	6	32
Lasiurus cinereus						2		2		4
Lasionycteris noctivagans								3		3
Total	643	154	66	31	6	38	24	25	13	1000
No. visits	8	7	7	7	1	7	7	3	1	

Species composition at Mystery Cave and Little Ice Cave was very similar (χ^2= 6.5, P>.05), with *M. lucifugus* being the most abundant at both caves (66.3% and 54.5% at Mystery Cave and Little Ice Cave, respectively). *Myotis volans* was the second most abundant species (21.1% and 27.9%), followed by *M. evotis* (12% and 17%). *Myotis ciliolabrum* represented less than one percent of the bats captured at either cave. Species composition was significantly different at Royce Cave compared to the previous two caves (χ^2= 273.6, P<.001). *Myotis evotis* was the most common species there, comprising 75.8% of all bats captured, followed by *M. ciliolabrum* (9.1%), *P. townsendii* (7.5%), *M. volans* (4.5%), and *E. fuscus* and *M. lucifugus* with 1.5% each. Thus, *M. lucifugus* and *M. volans*, which were the most common species at Mystery Cave and Little Ice Cave, were the least abundant at Royce Cave. Total numbers, however, were much lower at this cave, with 66 bats captured. Four-eared bat Cave was the only other cave investigated regularly in 1990. *Myotis ciliolabrum*, which was among the least common bats observed at the previous three caves, was the most abundant species here, comprising 54.8% of all bats. *Eptesicus fuscus* represented 35.5% of the total, while *P. townsendii* represented 9.7%. Thirty-one bats were captured at this site.

While trapping success was low at both Gyp Spring and Layout Creek, several species that occurred at these sites

did not occur at the caves. *Euderma maculatum*, *A. pallidus*, and *L. cinereus* occurred at at least one of these two water sources. Conversely, *P. townsendii* was the only species captured at the caves that did not occur at either Gyp Spring or Layout Creek. *Myotis ciliolabrum* was the most abundant species captured at Gyp Spring (65.8%) followed by *A. pallidus* (20.5%), with *E. fuscus*, *M. volans*, and *L. cinereus* combined representing less than 13% of the total. Thirty-eight individuals were captured at this site. Only 25 bats were captured at Layout Creek. So, although *E. fuscus* represented 37.5% and *A. pallidus* 16.7% of the total, actual numbers of these bats were low. The remaining species captured here included all four species of *Myotis* (four or fewer of each species) as well as the only two specimens of *E. maculatum* taken during the study.

Site characteristics.-- Both Mystery Cave and Little Ice Cave occurred in Douglas-fir forest at a similar, high elevation: 2,384 m and 2,494 m. The caves possessed the same temperature (3.3° C) and humidities (100%). Structurally, however, these caves are very different. Mystery Cave consists of several large, interconnected domed chambers extending inward approximately 200 m. The chambers vary in size, from a few meters in diameter to more than 10 m in diameter and up to 10 m in height. Standing water is present throughout the cave, in the form of small, shallow

pools. Little Ice Cave extends inward a similar distance, and consists of several levels, but the cave lacks the large, domed rooms characteristic of Mystery Cave. The cave lacks standing water, but as the name suggests, ice is present in the cave throughout the year. Royce Cave is lower in elevation (1878 m) than either Mystery Cave or Little Ice Cave, and occurs in more xeric habitat than those two caves (rock outcrop forest). The cave is less complex than Little Ice Cave, consisting of a single large domed chamber similar to those found in Mystery Cave, but is much smaller in size. Humidity was 100%, but Royce Cave is warmer, 8.9° C. Four-eared bat Cave is somewhat similar in structure to Mystery Cave and Royce Cave, consisting of several connected chambers, though the cambers are not as highly domed as in those caves. This is a moderately warm and dry cave (8.8° C, 73% humidity) and is located on an arid ridge of Utah juniper-blacksage.

Both Gyp Spring and the pond at the Layout Creek Ranger Station occur in Utah-juniper blacksage, and were the lowest sites investigated: 1400 m and 1300 m, respectively. The area immediately surrounding Gyp Spring is characterized by 10-m high red-sandstone outcrops, forming a narrow canyon through which a shallow (<10-cm) spring-fed stream flowed. The Layout Creek Ranger Station occurs in similar habitat, though it lacks any outcroppings. Bats were netted at this site over an approximately .5-ha pond.

Banding results.-- Of 1,079 bats marked (273 in 1989, 806 in 1990), 86 individual bats were recaptured, representing 98 total recaptures. Of the total, 38 (39%) recaptures represented bats marked in 1989, the remaining 60 (61%) were marked during 1990. All of the recaptures occurred at one of four caves: Mystery, Little Ice, Royce, and Four-eared, with the exception of one pallid bat recaptured at Gyp Spring. Only one recapture represented a bat that had moved between caves, a male *Myotis evotis*, that was captured at Little Ice Cave in 1989 and recaptured twice in 1990 at Royce Cave.

Candidate Species and Antrozous pallidus.-- Two spotted bats, one lactating female and one juvenile female, were netted, and individuals were heard on 9 nights at 4 different locations: Horseshoe Bend, Four-eared bat Cave, Layout Creek, and the Big Horn River near Deadman's Creek. On several occasions, bats passed over more than once, but it was not possible to determine if this represented more than one bat or a single individual passing through the area more than once. The exception to this was when two bats were observed simultaneously at the Horseshoe Bend campground sewage lagoon on 29 June 1990.

In addition to the specimens of *P. townsendii* discussed above, an adult male Townsend's big-eared bat was located

roosting in an abandoned building on private land just west of Horseshoe Bend Campground.

Eight pallid bats were captured in 1989, 16 in 1990. These specimens included both lactating females and juveniles.

Sex Ratios.-- Juveniles of all species were captured in 1990, but are not considered in the discussion of sex ratios. Young of the year generally do not become volant until mid- to late-July (Kunz, 1982), and so were not catchable throughout the entire season. In almost all of the species, and at all of the sites visited regularly, adult males outnumbered adult females, often by ratios of 4:1 or greater (Table 5). This trend was most evident at Mystery Cave and Little Ice Cave, and especially in the genus *Myotis* (Table 5). At all of the sites where numbers of bats captured were large enough to compare, adult males of *Myotis lucifugus*, and *M. volans*, outnumbered females. This trend was also apparent in *E. fuscus* and *M. ciliolabrum*, although capture numbers for these two species were much smaller. The pattern was evident for *E. fuscus* only at Four-eared bat Cave, and only at Gyp Spring for *M. ciliolabrum* (Table 5). While male *M. evotis* occurred in larger numbers than females at Mystery Cave, numbers of males and females were not significantly different at Royce Cave (χ^2=.083, P>.05). At Gyp Spring, seven female pallid

TABLE 5.-- *Numbers of adult males and females captured at 6 sites in 1990. Asterisks represent a significant deviation from a 1:1 sex ratio (P<.05).*

	Myotis lucifugus		*Myotis volans*		*Myotis evotis*		*Myotis ciliolabrum*		*Eptesicus fuscus*		*Antrozous pallidus*	
Site	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀
Mystery Cave	419	32*	120	10*	60	17*	5	0				
Little Ice Cave	86	3*	45	1*	16	10*	1	0				
Royce Cave	2	0	3	0	27	29	6	0	1	0		
4-eared bat Cave							14	2*	11	0*		
Gyp Spring			2	0			18	7*	1	0	0	8
Layout Creek	1	0	2	2	0	1			9	0	4	0
Totals	508	35	172	13	103	57	44	9	22	0	4	8

bats were captured together with four males, and four males were captured at the sewage lagoon at Horseshoe Bend Campground. Thus, across both of these sites, which were the only places where this species was captured, the sex ratio was nearly 1:1. Adults of *L. cinereus* (3 males, 1 female), *L. noctivagans* (3 males, no females) and *E. maculatum* (one female) were not captured in numbers large enough to assess sex ratios. Sex ratios for each species did not vary significantly with visit, i.e. through the summer, at any of the sites (all χ^2's > 234.6, P<.001).

DISCUSSION

Species Composition and Relative Abundance.-- The observed variation in species composition and/or abundance at the caves may be attributable to either differences in site characteristics (e.g. elevation, habitat), cave characteristics (e.g. size, structure, temperature, or humidity), or by a combination of these and other factors.

Combining sites based upon similarities in temperature, structure, or habitat, and comparing sites differing in these characteristics yielded significant differences in species composition: large (cold) caves vs. small (warm) caves, $\chi^2 = 432.2$, $P<.001$; timbered sites vs. open sites, $\chi^2 = 692.4$, $P<.001$. Additionally, a loglinear analysis suggests that the habitat in which a cave occurs may be more important than its structure. Habitat alone is a good predictor of species composition ($G^2 = 0.00$, $P=1.0$), while cave structure alone is not ($G^2 = 51.5$, $P=0.0$). Habitat and structure together provide no more predictive information than habitat alone ($G^2 = 0.00$, $P=1.0$). The only two sites that did not exhibit significant differences between species composition were Mystery Cave and Little Ice Cave. That these caves occurred in the same habitat further suggests that the habitat in which a cave occurs may be an important factor in determining species composition. This contention is supported by Fenton and Barclay (1980), Warner and

Czaplewski (1984), and Van zyll de Jong (1985), who summarizes the habitat with which several species of bats are most frequently associated. The habitat of sites where a particular species of bat was most frequently encountered in this study generally corresponds with the habitat associations identified by van Zyll de Jong (1985; Table 6).

Euderma maculatum and *A. pallidus*, together with *L. cinereus* and *L. noctivagans*, were never observed at the caves, but these species are not known to be cavernicolus (Hermanson and O'shea, 1983; Shump and Shump, 1982; Kunz, 1982; Watkins, 1977). *Plecotus townsendii* was found, in small numbers, at caves in a variety of habitats. Such a distribution is typical of this species, which occupies a wide range of habitats, from humid coastal forest to arid scrub and pine forest (Kunz and Martin, 1982; van Zyll de Jong, 1985).

The structure of a cave can influence its internal temperature, humidity, and airflow (Tuttle and Stevenson, 1978). Additionally, these parameters may change with season. While temperature and humidity of the caves examined in this study appeared to be constant between June and September, this may not be the case year-round, and may differ among caves. Also, temperature and humidity recordings were taken only in portions of the caves that were readily accessible. Temperatures and humidities in other portions of these caves, e.g. at the top of a dome or

TABLE 6.-- *Habitat associations of bats known to occur in the Pryor Mountains (from Van Zyll de Jong, 1985).*

Species	Characteristic habitat
Myotis lucifugus	timbered, near water
Myotis volans	forested, mountain regions
Myotis evotis	rocky outcrops in conif. forest
Myotis ciliolabrum	arid, rocky
Eptesicus fuscus	wooded to semi-open, often urban
Antrozous pallidus	arid
Lasiurus cinereus	forested, near openings
Lasionycteris noctivagans	forested, near water
Plecotus townsendii	various: coastal forest to arid
Euderma maculatum	arid

in a narrow crevice, may differ from these readings. I recorded ambient temperature, but surface temperatures may differ. It is surface temperature that some authors suggest may be important in roost selection for bats (Raesly and Gates, 1987; Mcnab,1974). Bats may be sensitive to slight variations in temperature and humidity associated with different regions of a cave, but such variations were not identifiable in this study.

Distance to foraging areas may act also to restrict roosting habitat for bats. Tuttle (1974) found that mortality in young bats increased as travel distance to foraging site increased. Four-eared bat Cave and Royce Cave occurred in very arid habitat, and there does not appear to be any permanent water sources within several miles of these caves. Thus, it is possible that even if these caves offer suitable roosting sites in terms of temperature, humidity, etc., lack of suitable foraging habitat could be responsible for the relatively low numbers of bats found there.

Trapping at caves can yield large numbers, in part, because it is possible to effectively block the entire entrance of a cave, forcing bats to attempt to pass through traps in order to exit the cave. At water sources, it was not possible to set nets in such a way to guarantee that a bat entering the area would encounter a net. Layout Creek was too large and too deep to net anywhere but along the

edges, and the stream at Gyp Spring extended for several km, while nets were placed over a length of less than 100 m. While it is likely that relatively few bats were captured at Royce Cave and Four-eared bat Cave because few bats were present, it is less certain that this was the case at Gyp Spring and Layout Creek. Thus comparing abundance at caves vs. water sources may be of limited value.

Sex Ratios.-- The preponderance of males at the caves may be best explained by cave temperature. Males often occupy colder caves with higher humidity. Such conditions are optimum for entering daily torpor (Twente, 1955), but may preclude their use by females. Pregnant and lactating females must maintain a high metabolic rate for development and nursing of young, and maintaining such high rates is costly in a cold environment (Racey, 1982). Thus in temperate regions, where caves are usually cold, bats rarely use caves as maternity roosts (Kunz, 1982). Few of the females captured at caves were found to be lactating: 4 of 59 at Mystery Cave, none at Little Ice Cave, 5 of 29 at Royce Cave, and none at Four-eared bat Cave. The females most often encountered at the caves may represent barren females, lactating females who recently lost young, or, later in the season, females who had weaned young. At Mystery Cave, for example, 16 of the 18 adult female *M. lucifugus* captured during the last three visits were post-

lactating. Even if some of the lactating individuals could have been using the caves as maternity roosts, it seems unlikely that these few individuals could represent the entire breeding population of females associated with the males in a given cave. It seems more likely that the majority of females were roosting elsewhere. It is possible that suitable maternity roost habitat is not available in the Pryors, and that the majority of females reproduce outside the area. However, juvenile bats were captured at the sites beginning in late July, which corresponds with the time that bats of these species are weaned and become volant (van zyll De Jong, 1985). If females were reproducing in the area, it is not necessarily surprising that they were not observed more frequently at either the ponds or caves investigated. Tuttle (1974) found that survivorship of young decreases with foraging distance from the maternity roost. Additionally, Racey and Swift (1985) found that the distance females travelled from their roost decreased during lactation, and that females often feed and drink within a small radius of their roost. Thus, if a maternity colony in the study area was even a few kilometers from one of the sites investigated, it is not certain that females would be found at that distance from their roost.

Obviously, females must come into contact with males in order to mate. In vespertilionids, this generally occurs in late summer and into fall, when males and females enter

hibernacula. Sex ratios did not change significantly through the season at any of the sites, but it is possible that females migrate to the caves later in the fall (October and November), either from areas in the Pryor Mountains or from more distant areas. Breeding would occur at this time, and both males and females may remain for hibernation. However, in both *M. lucifugus* and *M. volans*, two of the species that exhibited skewed sex ratios in this study, males have often been found to outnumber females in hibernacula (Fenton, 1970; van zyll de Jong, 1985). These studies suggest that the high costs associated with reproduction may increase mortality in females, and account for such observations. A similar pattern was observed in *E. fuscus* (Kurta and Matson, 1980), but the authors suggested that the sexual disparity was due to different hibernation behavior between the sexes, rather than actual population number differences between males and females. To further confuse this issue, in an extensive survey of *M. grisescens*, differential survival between males and females was not detected (Stevenson and Tuttle, 1981).

Banding information.-- That only one marked specimen was observed to move between sites suggests high roost fidelity. The greatest number of bats marked were captured at Mystery Cave and Little Ice Cave, which are approximately 3 km apart, yet no bats were found to move between these two

roosting sites, either during 1990 or between 1989 and 1990. It therefore appears that in this study, bats maintained seasonally distinct roosts. Bats captured at one cave in 1989 were not found at the other in 1990, although it is not certain that this separation is maintained year round. Nonetheless, it is possible that the populations at each of these caves may be reproductively isolated. Further investigation with banded individuals will be necessary to address this possibility.

Status of the Candidate Species, and Management Implications.-- The capture of both a lactating female and a juvenile spotted bat in mid-July suggests that this species probably breeds in the area. Spotted bats were observed throughout the southern portion of the Bighorn Canyon NRA, suggesting that they may be fairly widespread in this region.

Unlike the spotted bat, the Townsend's big-eared bat's call is inaudible to the unaided human ear, and it is not easily distinguishable from other bats with electronic bat detectors. Also, the energy level of this bat's call is relatively low. Thus aural monitoring was not practical for this species. However the observation of 11 individuals in 1990 confirms the summer occurrence of this species in the study area. One of the specimens captured was a juvenile, again suggesting that this species breeds in the area.

During the summer, this species may roost in a variety of locations, ranging from abandoned buildings to caves or abandoned mines (Kunz and Martin, 1982). Thus, individuals may be dispersed, and it may be difficult to locate a significant number to determine abundance, especially if population numbers are small. This species tends to favor roosting near the entrances of mines and caves for hibernation (Humphrey and Kunz, 1976; per. obs.) and tends to remain in the same area throughout the year (Kunz and Martin, 1982). Therefore examination of potential hibernation sites may be an effective means of determining the abundance of this species in the area.

The capture of 24 pallid bats, including several lactating females and juveniles, strongly suggests that breeding occurs in the area. This species was encountered frequently at the sites where it was captured, and it seems likely that it may be locally common in the area.

It would be particularly desirable to continue work on the two candidate species under consideration for listing by the U.S. Fish and Wildlife Service, *Euderma maculatum* and *Plecotus townsendii*. In the case of the spotted bat, additional work could take several directions. Wai-Ping and Fenton (1989) have successfully radio-tagged individuals of this species in order to obtain information on foraging and roosting areas and habits. Such a program could be undertaken in the Bighorn Canyon NRA and surrounding area in

order to identify significant areas of use by this species. However, such research would be labor intensive and costly. A more immediate concern should probably be the identification of the distribution pattern of this species. An examination by boat of the Bighorn Canyon between Barry's Landing and Big Elk Creek to the north revealed potential spotted bat habitat. The area is characterized by high (300 m) cliffs and is similar to spotted bat habitat in Dinosaur National Monument (per. obs), as well as that described by Woodsworth et al., (1981) and Watkins (1977). Monitoring throughout the area, including spending a significant amount of time in the canyon, would likely provide significant information on this species' distribution and habitat use throughout the area.

Mystery Cave has been gated in order to prevent unauthorized access. The U.S. Forest Service and the Bureau of Land Management may wish to consider gating other caves occurring on their lands. This is particularly important in light of efforts by these agencies to increase access and visitation to the area by the public. Gating would assist in preserving the biological, archaeological, and geological integrity of the caves in the Pryor Mountains. It may be especially important for caves occupied by the Townsend's big-eared bat, (e.g. Four-eared Bat Cave and Royce Cave). This species, which generally roosts in the open and is particularly susceptible to disturbance (Humphrey and Kunz,

1976; Kunz and Martin, 1982; Genter, 1986; 1989), may abandon roosts when disturbed.

The caves investigated in this study appear to be important summer habitat for bats. It should be determined if use of these caves by bats is continuous or seasonal. It would therefore be desirable to visit these caves during the winter to determine whether or not the caves are used as hibernacula. Very little is known about the wintering habits of bats in Montana, and nothing is known about the hibernating habits of *Myotis evotis* throughout its range (Manning and Jones, 1989). All of the caves investigated possess characteristics of hibernacula, including numerous crevices and fractures where bats may roost, as well as cold temperature and high humidity (Raesly and Gates, 1987; Tuttle and Stevenson, 1978). Of these, Mystery Cave and Little Ice Cave may have the greatest potential. These two caves are large and complex, and possess high humidity and cold temperatures, making them potentially ideal hibernacula.

The Pryor Mountain area contains considerably more caves than were investigated in this study. Frogg's Fault Cave, for example, is a very extensive cavern, but is vertical in nature and requires technical equipment to enter. Several caves in the western portion of the area were not investigated, and may also represent important bat habitat.

Insofar as this study has resulted in the compilation of a list of species of bats occurring in the Pryor Mountain area, it provides useful information. Bogan et al. (1988) point out that *"Such lists are not trivial exercises because they are the raw materials for making land management decisions.....We believe that biological surveys resulting in verified records....are the only reliable means to determine the presence of a species and to monitor population trends over time."* This is especially true, given that bats, as nongame species, have generally been overlooked by land managers in favor of game species (Szaro, 1988; Gibbons, 1988).

While not entirely complete in its inventory of potential cave habitat in the Pryor Mountains, this study does indicate that the area is inhabited by a bat fauna of significant diversity (10 of the 13 species known to occur in Montana are represented) and suggests that cave management in the Pryor Mountains could have a significant impact on these species. Conservation of these caves is likely to be extremely important in maintaining both the numbers and species diversity of bats in this region of Montana and Wyoming.

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