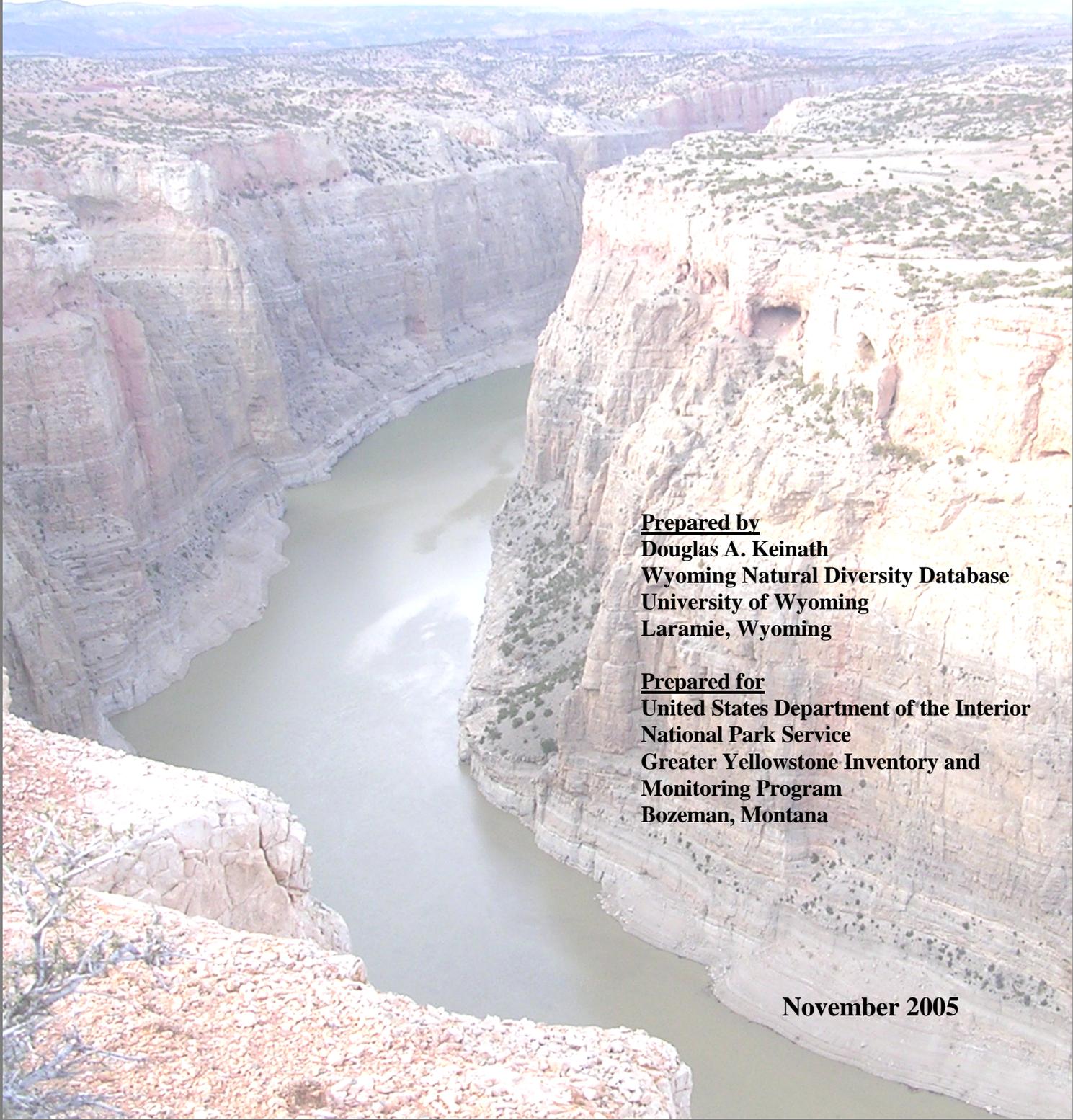


Supplementary Mammal Inventory of Bighorn Canyon National Recreation Area

FINAL REPORT



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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 gaps in information regarding terrestrial mammals in BICA and therefore proposed that the NPS conduct a supplementary inventory of mammals in BICA to establish a benchmark for future monitoring efforts and management actions. The general goals of the GRYN Inventory and Monitoring Program, 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.

The main objective for this study, as suggested above, is to insure that 90 percent of the mammalian species in BICA have been accounted for, cumulatively considering all past efforts. Attainment of this objective is largely a

result of the survey effort expended on each species. Many common species are easy to document with very little effort, (e.g., deer mice). However, the rarer a species is, the harder it becomes to document. Therefore, (as a hypothetical example) documenting the first 70 percent of species in a park is usually fairly straight forward, while the remaining 20 percent is often *far* more difficult and time consuming. Further, there is a fine line defining when a species is rare versus so unlikely to occur in the area that it is not worth surveying (e.g., lynx in BICA). The efforts discussed in this document are designed to support previously developed lists of mammals in BICA (i.e., Patton 1885, Cameron 2002) by focusing additional survey effort for those species with little or no documented occurrence in BICA (Table 1). In other words, this supplementary inventory focuses effort those species that have already proven difficult to document.

METHODS

Not only have the species listed in Table 1 proven difficult to document in standard surveys (see discussion above), but they are also very disparate in ecology, thus requiring a wide variety of specialized survey methods. Where feasible, standard references on field methodology were used to design surveys (e.g., Krebs 1999, MELP 1998, Sutherland 1996), but modifications were frequently made based on expert opinion and local constraints. A brief description of specific methods is noted in the following paragraphs. Survey sites for these taxa were distributed roughly as shown in Figure 1.

Small Mammals: Small mammals herein are defined as those likely to be captured via Sherman live traps (H.B. Sherman Company; <http://www.shermantraps.com>. Folding Trap-LFATDG-P, Dimensions: 3x3.5x9"). Roughly speaking, this included all rodents (mice, voles, rats) and small ground squirrels that were not tied to burrow systems (e.g., chipmunks). Habitat was stratified such that survey effort focused on those habitats likely to contain additional species noted in Table 1. Thus, trapping was targeted toward the following areas:

1. Grassy riparian areas to find meadow voles (*Microtus pennsylvanicus*);
2. Wooded riparian corridors to find white-footed mice (*Peromyscus leucopus*);
3. Mesic conifer forest to find red-backed voles (*Clethrionomys gapperi*);
4. Conifer stream sides to find water voles (*Microtus richardsonii*).
5. Dense sagebrush shrubland to find sagebrush voles (*Lemmiscus curtatus*).

Transects consisting of at least 50 trap stations placed 10 meters apart in an approximately linear fashion were established in each habitat. Each trap station consisted of one Sherman live trap (see above) and one snap trap (Kness Manufacturing; <http://www.kness.com/Snap-E.html>). Traps were baited with a mixture of 3-way horse feed and peanut butter. Each transect was operated for 4-5 days, during which time traps were set between 5 PM and dusk, and checked before 10 AM each morning.

Squirrels: There were 4 categories of squirrels on our target list (Table 1): ground squirrels (prairie dogs and thirteen-lined ground squirrels), tree squirrels (fox squirrels), flying squirrels (northern flying squirrel), and marmots.

1. Ground Squirrels: To locate ground squirrels, we conducted extensive visual surveys looking for burrows by driving and hiking through suitable habitat. If burrows were found, we planned to conduct intensive observation of the area in an attempt to visually identify the type of ground squirrels present. If such observation yielded no results, we then planned to trap burrow entrances using large Sherman live traps (H.B. Sherman Company, <http://www.shermantraps.com>. Folding Trap-XLF15, Dimensions: 4x4.5x15") until occupation was confirmed.
2. Tree Squirrels: Visual surveys were conducted for fox squirrels by walking cottonwood gallery forests, primarily in YWHMA and southern BICA. Visual identification was made with 10X binoculars and documented photographically where possible.
3. Flying Squirrels: Since flying squirrels are largely nocturnal and therefore difficult to survey, we took a two-pronged approach to maximize our limited resources. First, when conducting snow track surveys for carnivores in subalpine conifer habitat (see below) we hung 6 nest boxes with the hope that the cavity-

nesting squirrels would take residence in them over the course of our study. These boxes were checked for occupation in the spring of 2003 and 2004. Second, when conducting small mammal trapping in mesic conifer forest, we placed large Sherman live traps on the lower branches of large trees (~ 1.5 meters above ground) that occurred near our transect (similar to Carey et al. 1991). These traps were baited with 3-way horse feed, peanut butter, and/or mushrooms and monitored in concert with the small mammal traps.

4. Marmots: We searched for yellow-bellied marmots by conducting vehicle and foot-based visual surveys in suitable habitat, generally in mid-morning, when marmots are most likely to be exposed, sunning themselves.

Moose: We interviewed the interpretive staff of the park to learn of any past sightings and conducted ad hoc searches for moose while conducting other inventory activities (primarily small mammal trapping). Searches consisted of walking likely habitat and visually searching for signs of moose, such as tracks, scat, and bed sites.

Meso-Carnivores: Medium sized carnivores fell into 3 survey groups: boreo-alpine species (lynx, marten), lower elevation species (swift fox, ermine, skunk), and river otter. Remote cameras were used extensively for meso carnivore surveys and were generally set as noted in Figures 2 and 3.

1. Marten and Lynx: Very little mesic conifer forest exists within BICA to support boreo-alpine species. This forest occurs only in higher elevation drainages on the western border of the park and is minimally contiguous with larger expanses of similar habitat outside the park. Although it is remotely possible (though unlikely) that marten could be in BICA, it is highly unlikely that lynx occur there except as rare dispersers from northwestern Wyoming. Thus, we did not expend much effort looking for these species. We made a snow tracking excursion into the Upper Layout Creek area in the winter of 2002-2003. In the summers of 2003 and 2004 we also placed baited remote camera stations designed to attract marten. In addition to food-based bait of meat byproducts, we used a commercial lure (<http://www.nwtrappers.com>) formulated to attract marten. Cameras were left operational for 5 - 14 days and checked every few days depending on accessibility and weather.
2. Fox, Ermine and Skunk: Lower elevation carnivores on our list included swift fox, ermine, and spotted skunks. Due to budgetary constraints, the specialized trapping required to target ermine was impractical and we chose to forgo the effort. We surveyed for swift fox by first identifying suitable habitat (short, flat grassland), in which we conducted visual surveys for sign, often including nocturnal spotlight surveys. Few suitable areas were found, most being small, relatively barren or having a substantial shrub component. In some of these locations we established remote camera stations and/or baited tomahawk live traps (<http://www.livetraps.com/>), both of which used meat byproducts and/or commercial canid bait (<http://www.nwtrappers.com>) to attract fox. As above, cameras were operated in one location for 5-14 days, while trap lines were run for about 5 days, being left open continually and checked every morning. Spotted skunks were also surveyed using remote cameras and live traps, but these were placed near riparian areas on shrub habitat. Skunk traps were baited with meat byproducts, boiled potatoes and eggs, the latter two items being recommended by a local trapper for capturing skunks.
3. River Otter: River otter required specific visual surveys conducted via boat and foot. On two occasions in the summer of 2003 we slowly floated the main channel of the Bighorn River and several of its tributaries including Big Bull Elk Creek, Hoodoo Creek, Dry Head Creek, Deadman's Creek, Gyp Creek, Davis Creek, and Layout Creek. The shore was carefully scanned for slides and latrine sites indicative of regular otter use. Further, foot-based searches for otter scat were conducted along the banks of several stretches of these water bodies.

Shrews: Shrews can be captured in Sherman live traps and snap-traps, so the above-noted surveys for small mammals can be considered part of our shrew efforts. However, pitfall traps are more effective at capturing shrews and were used to supplement the standard small mammal trapping at several locations. Pitfall arrays consisted of five 9" deep coffee cans arranged such that one can was central and connected to each of the remaining 4 cans via drift fences constructed of 12" tall aluminum flashing (e.g., Handley and Merrill 1994). Cans were either filled 2" deep with water and a thin layer of mineral oil to reduce evaporation, or they were fitted with metallic funnels so animals slid into the cans but could not escape once inside. Pitfalls were not baited, left in place for 1-2 weeks and checked every day for captured animals.

RESULTS AND DISCUSSION

This section provides a brief summary of what the inventory process revealed. Most useful data is presented and interpreted in the tables and figures. Readers should pay particular attention to:

- Table 2: Small mammal capture summary for Bighorn Canyon Recreation Area during the summers of 2003 and 2004.
- Table 3: Updated mammal list for Bighorn Canyon National Recreation Area.
- Table 4: GPS coordinates for new species observations.
- Figure 4: Additions to the mammal list of mammals in Bighorn Canyon National Recreation Area with geographically referenced observation data.

Also, readers should note the discussion in the last paragraph of the *Background and Introduction* section. The efforts discussed in this document were meant to focus additional survey effort on those species with little or no documented occurrence in BICA (i.e., those species that have already proven difficult to document). As such, results in the form of additions to the fauna list for BICA are sparse, despite concerted efforts. Further, because methods were necessarily diverse in order to sufficiently target the ecologically disparate species of interest, effort is not comparable between species. Thus, the following discussion is necessarily of a qualitative nature.

Small Mammals: Small mammal capture data are presented in Table 2. Two new species were added to the list of BICA fauna as a result of these trapping efforts: white-footed mouse and house mouse. House mice were abundant, but it is unclear how prevalent white-footed mice were, since they are very difficult to distinguish from deer mice. Most captures were thus recorded only as "*Peromyscus*," but voucher specimens were more carefully examined to determine species. Using the classification key in Clark and Stromberg (1987) we analyzed 113 specimens based on their morphometric characteristics (primarily tail length, hind foot length, and tail morphology). Of these, 5 were white-footed mice, 43 were deer mice, and 65 could not be distinguished to the species level. Thus, roughly 10% of identifiable *Peromyscus* specimens (4% of all *Peromyscus* specimens) were white-footed mice. This suggests that white-footed mice are less abundant than either deer mice or house mice. All other small mammals captured were less common, but expected based on our prior knowledge of the area.

Squirrels: No evidence of prairie dog activity was found within BICA or YWHMA. Visual surveys revealed no evidence of burrow complexes, much less actual sightings of animals. Moreover, much of the park has hard, rocky soil and shrub vegetation not suitable for occupation by prairie dogs, so it is unlikely that they occur there. Fox squirrels, on the other hand, were seen at several locations along the Shoshone River outside BICA and at one location within YWHMA (e.g., Figures 4 and 5). Fox squirrels are common in the eastern United States, but reach their western-most limit of distribution in Wyoming. They depend on deciduous trees, primarily cottonwoods in Wyoming, and are frequently found in relation to humans. For example, they are common in parks of larger cities such as Cheyenne and Laramie. They can be found in areas of Lovell and Byron, Wyoming, from which they have likely spread up the Shoshone River to BICA. No evidence of flying squirrels was found. Flying squirrels are typical of boreal-type conifer forest, which generally occurs in higher elevation sites in Wyoming. There are only a few places in BICA where they could occur, notably portions of Upper Layout Creek, Spring Creek and Trail Creek at the western-most boundary of the park. These patches of mesic conifer habitat are relatively small and restricted to drainage bottoms, becoming more xeric on the hillsides and often bordered by shrublands. It is highly unlikely that flying squirrels would occur in any of these areas. Yellow-bellied marmots are present in low but regularly occurring numbers in the grass and talus slopes near the Yellowtail Dam Visitor Center (e.g. Figure 5), where they are, in fact, a focal point of visitors coming to see the Dam. Given their occurrence on BLM and Forest Service lands around the park, it is distinctly possible that they could occur at other, restricted locations in the northern portion of BICA.

Moose: No sign of moose was found during any of our survey efforts. However, we recorded one opportunistic observation of a moose during our two summers in BICA (an errant male seen in the bottom of the canyon by river marker 42) and noted one historic report of a cow and calf in YWHMA several years ago (see Figure 4). Being such a large and charismatic animal, moose sightings are likely to be reported by park visitors, so the fact that only one sighting was reported in the last decade suggests they are regularly found in BICA. Further, the contiguous willow riparian habitat preferred by moose is lacking in BICA, making it unlikely that the park would support a permanent

population. Thus, I conclude that BICA does not likely support a regular moose population, rather occasionally harboring dispersing individuals from nearby areas such as the Bighorn National Forest.

Meso-Carnivores: None of the carnivores on our list (Table 1) were documented as occurring in BICA. Like flying squirrels, discussed above, lynx and marten depend on mesic conifer habitat that is very scarce in BICA. Lynx further require such a large area of good habitat that even places in northwestern Wyoming that have large expanses of suitable forest see only occasional use by less than a dozen lynx. Neither of these animals is thus likely to occur within the BICA. No swift fox were found in BICA or YWHMA. Although known from the eastern plains of Wyoming and Montana, swift fox have never been documented in the Bighorn Basin and are not likely to be found in the broken grass-shrub habitats of the park. Spotted skunk, on the other hand, could easily occur in BICA, as suitable habitat (riparian areas and/or human habitation in dry grass or shrubland) is present in many areas of the park. The eastern spotted skunk has been previously documented in the park (Patton 1985) and range maps suggest that the western spotted skunk could be sympatric in BICA (e.g., Clark and Stromberg 1987). However, although several striped skunks were found, no spotted skunks were documented in this study. Further, the only report we have of anyone seeing a spotted skunk in the area was from a local trapper who could not provide accurate location details, much less an accurate species identification. The current opinion of the author is that spotted skunks are rare, perhaps even accidental, to BICA and that until additional information is available, we should assume that they are of the eastern variety. River Otter can occur in most any riverine ecosystem that has an intact population of native fish and low levels of disturbance, but they were extirpated from many such areas in the late 1800's and early 1900's, primarily by fur trapping activities and dam-building projects. Fortunately, it is fairly straight forward to survey for their presence, as they leave evident sign in the form of latrine sites and characteristic scat piles along river banks. None of our searches turned up any evidence of river otter in BICA, from which I conclude that they are currently absent from the park. Further, although re-population is possible, the barren conditions in the canyon and the presence of Yellowtail Dam do not seem likely to attract otters.

Shrews: We had very low success capturing shrews at any location in BICA, despite using proven techniques. It is possible that shrew populations were down in the summers of 2003 and 2004, possibly because of a long term drought in the area that could have forced a reduction in the abundance of their insect prey. It is also possible that shrew populations are historically low in the area, although this doesn't completely concur with earlier studies (e.g., Patton 1985). This is just speculation, however. The end result is that I can provide little comment on what shrews likely occur in the park, other than water shrews being extremely unlikely due to their propensity to inhabit clear, cold streams adjacent to lush, moist meadows; a habitat type which is virtually absent from BICA. For lack of better information, I recommend that the list of possible shrews remain as shown in Table 3, until further study can be done to determine which, if any, can be removed from the list.

Inventory Completeness: It is extremely difficult to quantitatively estimate the completeness of the entire mammal list for BICA (Table 3), due to the wide variety of species present that require vastly different survey effort and techniques to study. Based on published literature on habitat associations, accounts of known distributions, and past survey efforts, it seems that this list is at least 90% complete. Moreover, we conducted approximately 8000 trap nights of small mammal trapping, 500 array days of pitfall trapping, 200 camera days with remote camera stations, 200 trap nights of Tomahawk trapping, and 1700 hours of visual searches. When added to previous efforts (Patton 1985), it is my opinion that the park has been adequately sampled (with the possible exception of additional effort targeted specifically toward shrews and ermine).

Beyond this educated guess, we can attempt to estimate the level of completeness for the small mammal portion of our inventory, because we used the same methods to survey small mammals throughout the park. This assessment is supported by a quantitative estimate of completeness made using rarefaction, or species accumulation, curves (e.g., Soberon and Llorente 1993, Krebs 1999, Moreno and Halffter 2000, Cam et al 2002). I developed species accumulation curves for the small mammal trapping effort in BICA (Figure 6a), which shows an asymptote at just under 14 species. We documented 11 species, or 79% of the predicted maximum, which suggests that further sampling could have turned up additional species, probably at much greater effort. However, one must consider this in light of the fact that this study is just a supplementary inventory, meant to document a narrowly defined list of species (Table 1), so a species accumulation analysis is not technically appropriate in this instance. Further, there are several extenuating factors, which I have summarized in Figure 6b. Notably, 3 of the 19 small mammal species in Table 3 likely don't occur in BICA, since they have not been documented there during any study, and the 3 shrew species are not readily sampled with small mammal traps, so they are perhaps not appropriate to include in a

rarefaction analysis based on those traps. Eliminating these species from the possible list brings the total we could have found from 19 down to 13 or 14, which is exactly in line with the prediction in Figure 6a. This suggests that, although our efforts alone were not enough to document all small mammal species in the park, when combined with information collected from earlier surveys, we probably have a very good idea of the small mammal species richness in BICA.

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TABLES AND FIGURES

Table 1: Target mammal list and summary results for supplementary inventory; highlighted species were documented in this inventory.

Species ¹	Pre-Inventory Expectation ²	Post-Inventory Classification	
		Presence ³	Inventory Notes
Black-tailed prairie dog (<i>Cynomys ludovicianus</i>)	Possible	Absent	No sign of prairie dogs seen during visual survey of suitable habitat in this or earlier studies.
White-tailed prairie dog (<i>Cynomys leucurus</i>)	Possible	Absent	No sign of prairie dogs seen during visual survey of suitable habitat in this or earlier studies.
Thirteen-lined ground squirrel (<i>Spermophilus tridecemlineatus</i>)	Possible	Unlikely	Not likely present based on visual survey for burrows and small mammal traps set in suspected habitat.
Northern flying squirrel (<i>Glaucomys sabrinus</i>)	Unlikely	Absent	No evidence from nest boxes or trapping efforts. Not likely present since there is very little suitable habitat in BICA and lack of connectivity to other areas.
Fox squirrel (<i>Sciurus niger</i>)	Possible	Present	Present in restricted, but likely expanding, areas. See Figure 2.
Yellow-bellied marmot (<i>Marmota flaviventris</i>)	Possible	Present	Present at one location in the north of the recreation area. See Figure 2.
Southern red-backed vole (<i>Clethrionomys gapperi</i>)	Unlikely	Absent	None captured in this inventory, despite trapping efforts in the best available habitat. Suitable habitat very limited in BICA.
Water vole (<i>Microtus richardsonii</i>)	Unlikely	Absent	None captured in this inventory. Suitable habitat limited in BICA.
White-footed mouse (<i>Peromyscus leucopus</i>)	Possible	Present	Present in moderate numbers in southern BICA. See Figure 2.
House mouse (<i>Mus musculus</i>)	Possible	Present	Common in southern BICA. See Figure 2.
Meadow vole (<i>Microtus pennsylvanicus</i>)	Possible	Unlikely	None captured in this inventory, despite trapping efforts in suitable habitat.
Sagebrush vole (<i>Lemmys curtatus</i>)	Possible	Absent	None captured in this inventory, despite trapping efforts in best available habitat. Also, no burrows seen during visual surveys of sagebrush habitat.
Moose (<i>Alces alces</i>)	Accidental	Occasional	Not regularly occurring in BICA, but rather occasional dispersers from neighboring areas. See Figure 2.
Swift fox (<i>Vulpes velox</i>)	Unlikely	Absent	No evidence found via remote cameras or trapping. Not likely present in BICA due to lack of good habitat.
Lynx (<i>Lynx canadensis</i>)	Accidental	Absent	Low survey effort in this inventory, but no evidence documented on remote cameras or during snow tracking. There is little or no suitable habitat in BICA.
American marten (<i>Martes americana</i>)	Unlikely	Absent	Low survey effort in this inventory, but none were documented via remote cameras or snow tracking. Very little suitable habitat occurs in BICA.
Ermine (<i>Mustella ermina</i>)	Unlikely	Unlikely	Not surveyed in this inventory due to the effort required.
River otter (<i>Lutra Canadensis</i>)	Unlikely	Absent	No evidence of otter presence based on in-stream surveys for otter sign.
Western spotted skunk (<i>Spilogale gracilis</i>)	Possible	Unlikely	No spotted skunks found using visual surveys, tomahawk traps, or baited camera stations. Suitable habitat exists, but appears to be dominated by striped skunks.
Northern water shrew (<i>Sorex palustris</i>)	Possible	Absent	None captured in this inventory, despite riparian trapping efforts. There appears to be little suitable habitat in BICA.
Dusky shrew (<i>Sorex monticolus</i>)	Possible	Unlikely	None captured in this inventory, despite trapping efforts. However, very few shrews were captured, so sample size was small.
Dwarf shrew (<i>Sorex nanus</i>)	Possible	Unlikely	None captured in this inventory, despite trapping efforts. However, very few shrews were captured, so sample size was small.

1. Mammals on this list were not documented in BICA prior to this inventory, but had the potential to occur there based on range maps, habitat relationships, and existing observations. The preliminary list of target species for this inventory also included yellow pine chipmunk and vagrant shrew, which were since eliminated based on documentation found in Patterson (1985).
2. Pre-Inventory Expectation of presence in BICA and YWHMA was derived largely from information presented by Anderson et al. (1984), Patterson (1985), and Clark and Stromburg (1987).
3. Post-Inventory Presence in the park (i.e., BICA and YWHMA) is estimated based on the results of this study, which are noted briefly under Inventory Notes. Classifications use the following definitions: *Present*: The species occurs regularly in the park. *Occasional*: The species was documented in the park, but depends mostly on habitat outside the park and is therefore not likely a regular resident. *Unlikely*: The species was not documented in this or previous inventories, but it is possible that it could occur in the park at least occasionally based on apparent habitat suitability. *Absent*: The species probably does not occur in either BICA or YWHMA on a regular or even occasional basis.

Table 2: Small mammal capture summary for Bighorn Canyon Recreation Area during the summers of 2003 and 2004.

Species	Habitat Category						Total	Capture Success (Cap/100TN)
	Conifer	Juniper	Riparian	Riparian- Human	Sagebrush	Shrub- Grass		
Ord's kangaroo rat (<i>Dipodomys ordii</i>)			4	13	14		31	0.6
Long-tailed vole (<i>Microtus longicaudus</i>)	1					1	2	0.1
Prairie vole (<i>Microtus ochrogaster</i>)	4		13	18		1	36	0.6
House mouse (<i>Mus musculus</i>)	3	7	73	40	3		126	1.7
Bushy-tailed wood rat (<i>Neotoma cinerea</i>)	4	6		10			20	0.5
<i>Peromyscus</i> spp. (White-footed mouse - <i>Peromyscus leucopus</i> and Deer Mouse - <i>Peromyscus maniculatus</i>)	190	138	404	184	90	60	1066	13.7
Western harvest mouse (<i>Reithrodontomys megalotis</i>)	2		30	4	1	1	38	0.6
Masked shrew (<i>Sorex cinereus</i>)			1			1	2	0.1
Least chipmunk (<i>Tamias minimus</i>)		7	2			8	17	0.4
Western jumping mouse (<i>Zapus princeps</i>)						1	1	0.2
Total Captures	204	158	527	269	108	73	1339	17.2
Approximate Trap Effort (TN)	1400	1000	2900	1600	400	500	7800	
Capture Success (Cap/100TN)	14.6	15.8	18.2	16.8	27.0	14.6	17.2	

Table 3. Updated mammal list for Bighorn Canyon National Recreation Area. See footnotes and text for explanation of terms.

Group ¹	Common Name	Scientific Name	Park Status ²	Source Notes ³	Abundance ⁴	
Shrews	masked shrew	<i>Sorex cinereus</i>	Present	P	Common	
	vagrant shrew	<i>Sorex vagrans</i>	Present	P	Uncommon	
	dwarf shrew	<i>Sorex nanus</i>	Unconfirmed	-	NA	
	water shrew	<i>Sorex palustris</i>	Encroaching	Minimal habitat (see K2)	NA	
	Merriam's shrew	<i>Sorex merriami</i>	Present	P	Rare	
Bats	little brown bat	<i>Myotis lucifugus</i>	Present	K1, P, W	Common	
	long-eared myotis	<i>Myotis evotis</i>	Present	K1, P, W	Uncommon	
	long-legged myotis	<i>Myotis volans</i>	Present	K1, W	Uncommon	
	California myotis	<i>Myotis californicus</i>	Present	K1, P	Rare	
	small-footed myotis	<i>Myotis ciliolabrum</i>	Present	K1, P, W	Uncommon	
	silver-haired bat	<i>Lasionycteris noctivagans</i>	Present	K1, W	Rare	
	big brown bat	<i>Eptesicus fuscus</i>	Present	K1, P, W	Common	
	hoary bat	<i>Lasiurus cinereus</i>	Present	K1, W	Rare	
	spotted bat	<i>Euderma maculatum</i>	Present	K1, W	Uncommon	
	Townsend's big-eared bat	<i>Corynorhinus townsendii</i>	Present	K1	Rare	
	pallid bat	<i>Antrozous pallidus</i>	Present	K1, W	Rare	
	Small Mammals (Pocket Mice, Kangaroo Rats, New World Mice, Old World Mice, Jumping Mice, Pocket Gophers)	northern pocket gopher	<i>Thomomys talpoides</i>	Present	P	Uncommon
		olive-backed pocket mouse	<i>Perognathus fasciatus</i>	Present	P	Rare
		Ord's kangaroo rat	<i>Dipodomys ordii</i>	Present	P	Uncommon
western harvest mouse		<i>Reithrodontomys megalotis</i>	Present	P	Uncommon	
deer mouse		<i>Peromyscus maniculatus</i>	Present	P	Abundant	
northern grasshopper mouse		<i>Onychomys leucogaster</i>	Present	P	Rare	
bushy-tailed wood rat		<i>Neotoma cinerea</i>	Present	P	Common	
southern red-backed vole		<i>Clethrionomys gapperi</i>	Encroaching	Minimal habitat (see K2)	NA	
meadow vole		<i>Microtus pennsylvanicus</i>	Unconfirmed	-	NA	
montane vole		<i>Microtus montanus</i>	Present	P	Uncommon	
long-tailed vole		<i>Microtus longicaudus</i>	Present	P	Common	
prairie vole		<i>Microtus ochrogaster</i>	Present	P	Common	
water vole		<i>Microtus richardsoni</i>	Encroaching	Minimal habitat	NA	
muskrat		<i>Ondatra zibethicus</i>	Present	P	Common	
house mouse		<i>Mus musculus</i>	Present	K2	Abundant	
western jumping mouse		<i>Zapus princeps</i>	Present	P	Uncommon	
Squirrels		least chipmunk	<i>Tamias minimus</i>	Present	P	Abundant
		yellow pine chipmunk	<i>Tamias amoenus</i>	Present	P	Common
	yellow-bellied marmot	<i>Marmota flaviventris</i>	Present	P, K2	Rare	
	thirteen-lined ground squirrel	<i>Spermophilus tridecemlineatus</i>	Encroaching	-	NA	
	black-tailed prairie dog	<i>Cynomys ludovicianus</i>	Absent	see K2	NA	
	white-tailed prairie dog	<i>Cynomys leucurus</i>	Absent	see K2	NA	
	fox squirrel	<i>Sciurus niger</i>	Present	K2	Rare	
	red squirrel	<i>Tamiasciurus hudsonicus</i>	Present	P	Common	
	northern flying squirrel	<i>Glaucomys sabrinus</i>	Encroaching	Minimal habitat (see K2)	NA	

Table 3 continued.

Group ¹	Common Name	Scientific Name	Park Status ²	Source Notes ³	Abundance ⁴
Medium Mammals (Rabbits, Beaver, Porcupine)	Nuttall's cottontail	<i>Sylvilagus nuttallii</i>	Present	P	Common
	desert cottontail	<i>Sylvilagus audubonii</i>	Present	P	Common
	white-tailed jackrabbit	<i>Lepus townsendii</i>	Present	P	Uncommon
	beaver	<i>Castor canadensis</i>	Present	P	Uncommon
	porcupine	<i>Erethizon dorsatum</i>	Present	P	Uncommon
Small and Medium Carnivores	coyote	<i>Canis latrans</i>	Present	P	Common
	red fox	<i>Vulpes vulpes</i>	Present	P	Uncommon
	swift fox	<i>Vulpes velox</i>	Absent	Minimal habitat (see K2)	NA
	raccoon	<i>Procyon lotor</i>	Present	P	Abundant
	American marten	<i>Martes americana</i>	Encroaching	Minimal habitat (see K2)	NA
	ermine	<i>Mustela erminea</i>	Unconfirmed	-	NA
	long-tailed weasel	<i>Mustela frenata</i>	Present	P	Uncommon
	mink	<i>Mustela vison</i>	Present	P	Uncommon
	badger	<i>Taxidea taxus</i>	Present	P	Common
	eastern spotted skunk	<i>Spilogale putorius</i>	Present	P	Occasional
	western potted skunk	<i>Spilogale gracilis</i>	Unconfirmed	see K2	NA
	striped skunk	<i>Mephitis mephitis</i>	Present	P	Common
	river otter	<i>Lontra canadensis</i>	Absent	see K2	NA
	lynx	<i>Lynx canadensis</i>	Absent	Minimal habitat (see K2)	NA
bobcat	<i>Lynx rufus</i>	Present	P	Rare	
Large Carnivores	black bear	<i>Ursus americanus</i>	Present	P	Uncommon
	grizzly bear	<i>Ursus arctos</i>	Absent	-	NA
	mountain lion	<i>Felis concolor</i>	Present	P	Uncommon
Hoofed Mammals (Deer, Pronghorn, Bovids, and Equines)	elk	<i>Cervus elaphus</i>	Present	P	Uncommon
	mule deer	<i>Odocoileus hemionus</i>	Present	P	Abundant
	white-tailed deer	<i>Odocoileus virginianus</i>	Present	P	Common
	moose	<i>Alces alces</i>	Present	K2	Occasional
	pronghorn	<i>Antilocapra americana</i>	Present	P	Common
	bison	<i>Bison bison</i>	Absent	-	NA
	mountain goat	<i>Oreamnos americanus</i>	Unconfirmed	-	NA
	bighorn sheep	<i>Ovis canadensis</i>	Present	P	Common
wild horse	<i>Equus caballus</i>	Present	-	Abundant	

See next page for footnotes.

Footnotes for Table 3

1. **Groups** presented are meant to make the table more user-friendly. They are artificial collections of animals based on gross morphology, not ecology or accepted taxonomy.
2. **Park Status** records the author's estimation of whether each species occurs within the boundaries of Bighorn Canyon National Recreation Area (BICA) and/or Yellowtail Wildlife Habitat Management Area (YWHMA). Categories used reflect those defined by the National Park Service in its NPSpecies database and are as follows:
 - Present*: Species occurrence in park is documented and assumed to be extant.
 - Probable*: BICA is within the species range and contains appropriate habitat, but no documentation on presence in the park currently exists. However, documented occurrences of the species in adjoining areas give reason to suspect that it probably occurs within the park. This represents very high confidence that the organism is currently in the park.
 - Unconfirmed*: Species is included on the BICA list based on weak ("unconfirmed record") or no evidence, giving minimal indication of its occurrence in the park. Confidence is usually low (but can be high) that the organism is currently in the park.
 - Encroaching*: The species is not documented in the park, but is documented as being adjacent to the park and has potential to occur in the park. However, Confidence is extremely low that the organism is currently in the park on a regular basis.
 - Absent*: The species is included on this list because it was previously reported to occur within the park, but current evidence indicates that the report was based on a misidentification, a taxonomic concept no longer accepted, or some other similar problem of interpretation. This represents extremely low confidence that the organism is currently in the park.
3. **Source Notes** lists formal studies that have documented species occurring in BICA and/or YWHMA. For undocumented species, a note on reasons why it has not been found is sometimes made. Codes are as follows:
 - K1: Keinath, D.A. 2005. Bat Inventory of the Greater Yellowstone Network: Final Report. Prepared by the Wyoming Natural Diversity Database, University of Wyoming, Laramie, Wyoming. Prepared for the Greater Yellowstone Network Inventory and Monitoring Program, Bozeman, Montana.
 - K2: Keinath, D.A. 2005. Supplementary Mammal Inventory Bighorn Canyon National Recreation Area: Final Report. Prepared by the Wyoming Natural Diversity Database, University of Wyoming, Laramie, Wyoming. Prepared for the Greater Yellowstone Network Inventory and Monitoring Program, Bozeman, Montana.
 - P: Patterson, C.T. 1985. Bird and Mammal Inventory for the Bighorn Canyon National Recreation Area. NPSpecies Bibliographic ID: NATUREBIB-164122. Prepared by the Wyoming Cooperative Fish and Wildlife Research Unit, Laramie, Wyoming. (Note: This is the original report that resulted in the subsequent publication by Anderson, et al. (1987), which was therefore not included in this list.)
 - W: Worthington, D.J. 1991. Abundance and Distribution of Bats in the Pryor Mountains of South Central Montana and North Eastern Wyoming. NPSpecies Bibliographic ID: NATUREBIB-164123. Prepared by the University of Montana, Missoula Montana. Prepared for the Montana Natural Heritage Program, USDA Bureau of Land Management - Billings Resource Area, and Custer National Forest.
4. **Abundance** notes the coarse level of occurrence of each species within BICA and YWHMA. These estimates are made by the author based on a synthesis of information presented in this report, information presented in the above listed reports (footnote 3), information presented in the NPSpecies database, and the author's knowledge of the area from other studies. These designations should be considered educated guesses, since most species on the list have not been surveyed to develop actual abundance estimates. The codes used are a modification of those defined in the NPSpecies database and are as follows:
 - Abundant*: May be seen daily, in suitable habitat and season, and counted in relatively large numbers.
 - Common*: May be seen daily, in suitable habitat and season, but not in large numbers.
 - Uncommon*: Likely to be seen monthly in appropriate season/habitat. May be locally common.
 - Rare*: Present in the park, but usually seen only a few times each year.
 - Occasional*: Occurs in the park at least once every few years, but not necessarily every year.
 - Unknown*: Abundance unknown. There is insufficient information to even coarsely estimate abundance.
 - NA*: Not Applicable. This refers to species listed that have not been documented in BICA or YWHMA, so abundance estimation is not appropriate.

Table 4. Global positioning system coordinates for new species documented in this study given in Universal Transverse Mercature (UTM) coordinates in Zone 12 using the North American Datum of 1983. These points are presented in Figure 2.

Species	Description	UTM Easting	UTM Northing	Approx. Dates of Observation
Fox squirrel (<i>Sciurus niger</i>)	Observation of one fox squirrel during visual survey in cottonwood gallery forest along the Shoshone River.	718799	4973117	25 Jun 04
Yellow-bellied marmot (<i>Marmota flaviventris</i>)	Observation of yellow-bellied marmots (family group of two adults and 3 young) on talus pile and grassy slope just outside the Yellowtail Dam Visitor Center.	738550	5021485	12 Jun 04
White-footed mouse (<i>Peromyscus leucopus</i>)	Positive identification of white-footed mice at two trapping locations: 1. upper layout creek and 2. dry draw in juniper shrubland just south of the Montana border.	1. 716064 2. 712566	1. 4985702 2. 4997460	1. 12 Jun 04 2. 16 May 04
House mouse (<i>Mus musculus</i>)	House mice were captured at several locations in southern BICA.	716467 720834 716584 720053 715864 716764 716004 715838 716141 715807 713266	4982215 4971759 4982255 4971665 4982055 4984992 4983115 4982269 4982479 4981920 4996750	25-Jun-03 17-Jun-03 25-Jun-03 15-May-04 28-May-04 16-May-04 28-May-04 29-May-04 1-Jun-04 1-Jun-04 12-Jun-04
Moose (<i>Alces alces</i>)	Two recorded moose observations: 1. single moose sighted at river marker 42, and 2. mother and calf moose seen in late 1990s near convergence with Shoshone River.	1. 717600 2. 718690	1. 4992700 2. 4972200	1. 20 Jun 04 2. Uncertain

Figure 1: Mammal survey sites in and near Bighorn Canyon National Recreation Area during May and June of 2003 and 2004. (Notes: Sites noted are not comprehensive; points are generally midpoints of transects or trap arrays; boundary of parkland north of Yellowtail Dam is not shown.)

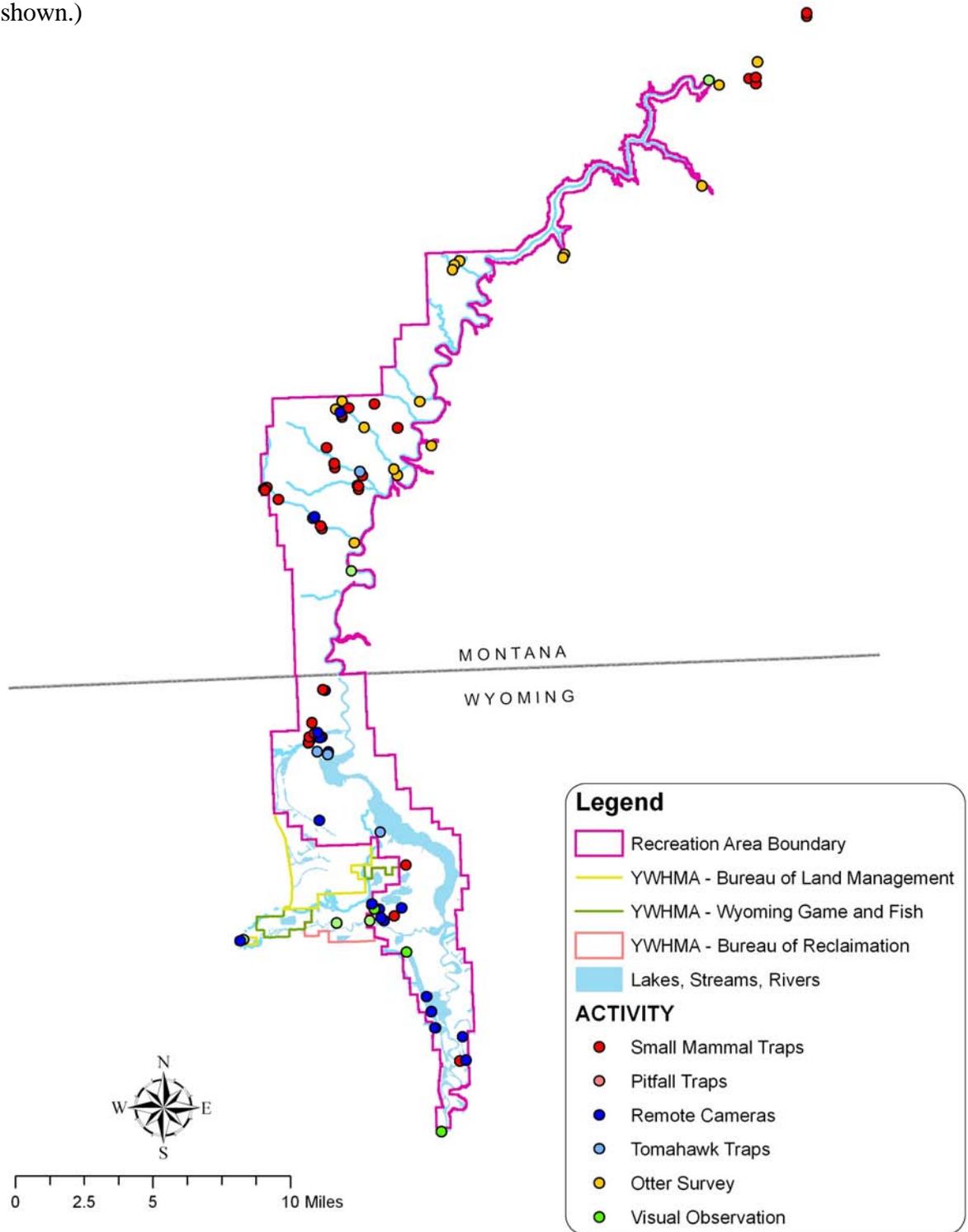


Figure 2: Generic setup used for remote camera stations showing relative positions of a) heat and motion activated camera; b) funneling feature such as a fence line, game trail, or creek bed; c) bait pit; d) visual attractant and call lure; e) track plate coated in talc; and f) focal range of camera. This system was modified slightly depending on the habitat and target animal.

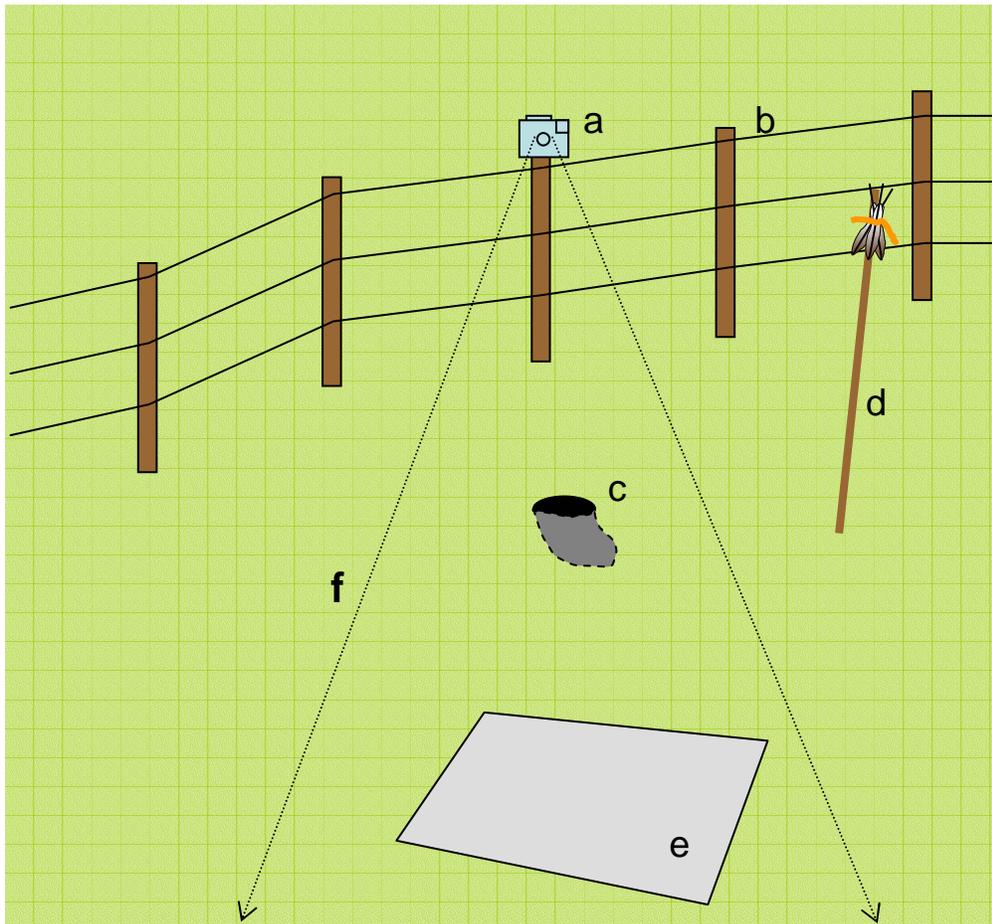


Figure 3: Examples of remote camera setups on a) side channel of Shoshone River, b) cottonwood riparian corridor in Yellowtail Wildlife Habitat Management Area, and c). dry streambed near Horseshoe Bend.



Figure 4: Additions to the list of mammals in Bighorn Canyon National Recreation Area with geographically referenced observation data. (Notes: House mouse locations were coincident with *Peromyscus* locations, but points on the map have been displaced slightly south and east for display purposes).

Species	Status and Comments
Fox squirrel (<i>Sciurus niger</i>)	Fox squirrels were documented along the Shoshone River in YWHMA based on visual surveys of riparian corridors. Fox squirrels, which are typically abundant in human-dominated landscapes, were also documented in nearby municipal areas. They are likely "invading" BICA along major riparian corridors such as the Shoshone.
Yellow-bellied marmot (<i>Marmota flaviventris</i>)	Marmots were documented on rocky slopes near the Yellowtail Dam Visitor Center based on visual surveys of upland habitat. There appears to be a few resident family groups occupying the sparse upland habitat in this area. Reports from park staff indicate this is a permanent population; existing for at least the last 5 years.
White-footed mouse (<i>Peromyscus leucopus</i>)	Several white footed mice were captured at scattered locations in the southern two-thirds of BICA. They are common in the east, but tend to be restricted to riparian areas in portions of eastern Wyoming and Montana.
House mouse (<i>Mus musculus</i>)	House mice were captured at numerous survey sites in the southern half of BICA. They were common at these sites, second only to <i>Peromyscus</i> species in number of animals captured. They are "old world" mice, typically associated with disturbed landscapes following European settlement.
Moose (<i>Alces alces</i>)	We recorded one visual observation of a moose during our two summers in BICA (an errant male seen in the bottom of the canyon by river marker 42) and also noted one historic report of a cow and calf in YWHMA several years ago. BICA does not likely support a regular moose population, rather occasionally harboring dispersing individuals from nearby areas such as the Bighorn National Forest.

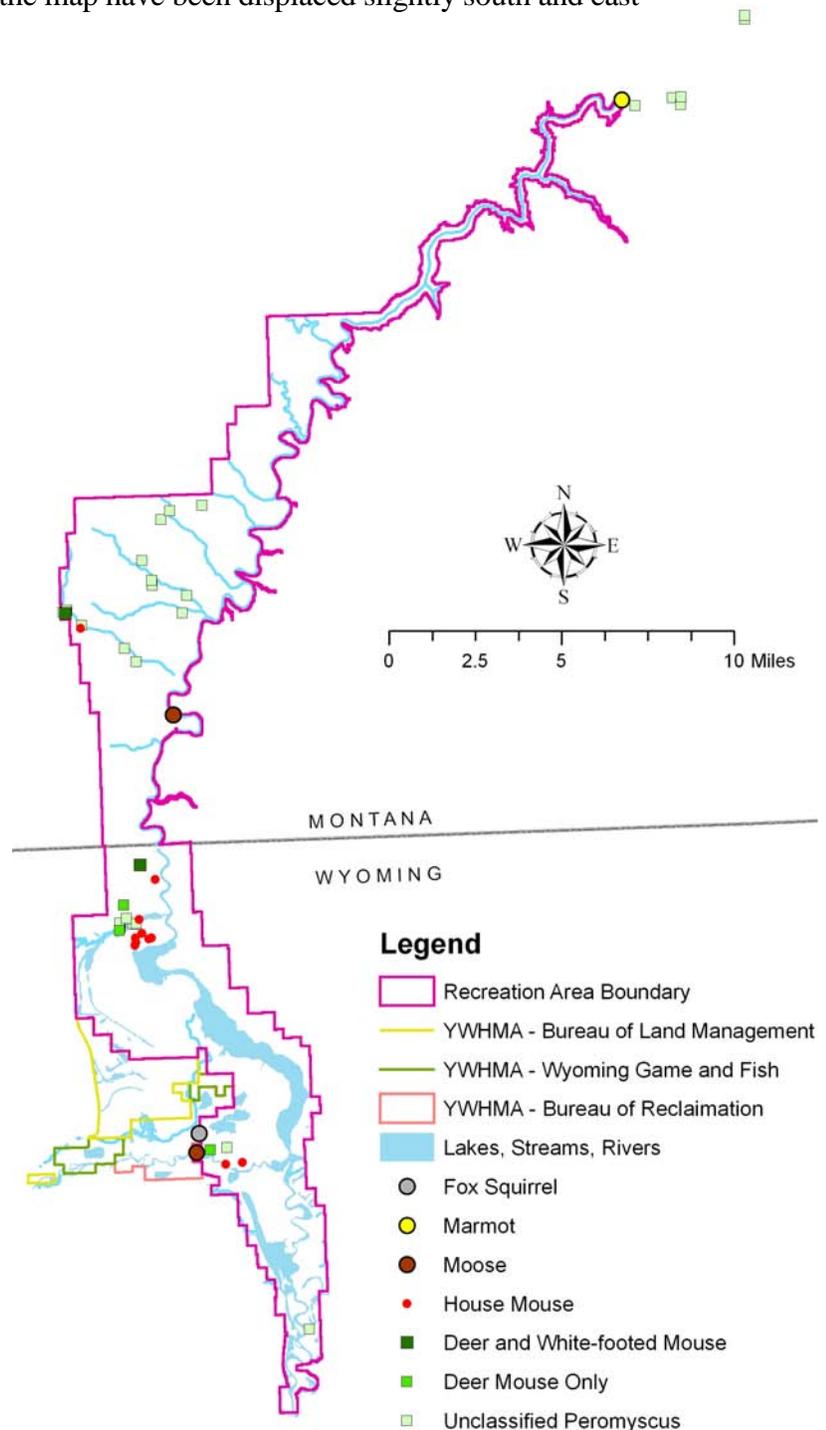


Figure 5: Photos of selected animals documented in this study; a) fox squirrel in cottonwoods along Shoshone River, b) yellow-bellied marmot in talus near Yellowtail Dam Visitor Center, c) saw-whet owl using nest box erected for flying squirrels on Upper Layout Creek.



Figure 6a: Small-mammal species accumulation curve for this study based on Sherman and snap trap transects, and the species richness estimate derived from this data.

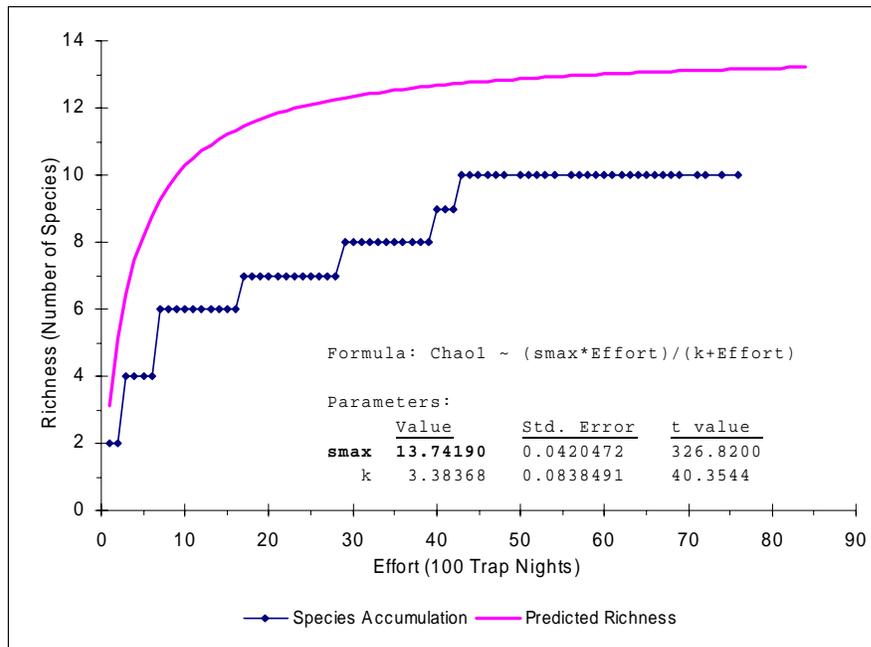


Figure 6b: Only a subset of mammals surveyed in this inventory are adequately surveyed by the Sherman live traps and snap traps upon which Figure 3a is based. Considering the list in Table 3, 19 species could feasibly be captured near BICA with these methods (see List 1, below). Of these, 3 are highly unlikely to occur in the area, reducing the maximum number likely captured to 16 (see List 2, below). Further, capture success of shrews in Sherman traps and snap traps is notoriously poor, so it is likely that shrews were under-sampled with these methods, further reducing the maximum number of species likely captured to 13 or 14 (see List 3, below). Considering these variables, the Smax of 13.7 species predicted in Figure 3a is a reasonable estimate and suggests a fairly complete inventory.

List 1: All Potential Species

1. olive-backed pocket mouse
2. Ord's kangaroo rat
3. western harvest mouse
4. deer mouse
5. northern grasshopper mouse
6. bushy-tailed wood rat
7. southern red-backed vole
8. meadow vole
9. montane vole
10. long-tailed vole
11. prairie vole
12. water vole
13. house mouse
14. western jumping mouse
15. least chipmunk
16. yellow pine chipmunk
17. masked shrew
18. merriam's shrew
19. vagrant shrew

List 2: Possible Species in Area

1. olive-backed pocket mouse
2. Ord's kangaroo rat
3. western harvest mouse
4. deer mouse
5. northern grasshopper mouse
6. bushy-tailed wood rat
7. montane vole
8. long-tailed vole
9. prairie vole
10. house mouse
11. western jumping mouse
12. least chipmunk
13. yellow pine chipmunk
14. masked shrew
15. merriam's shrew
16. vagrant shrew

List 3: Adequately Sampled Species

1. olive-backed pocket mouse
2. Ord's kangaroo rat
3. western harvest mouse
4. deer mouse
5. northern grasshopper mouse
6. bushy-tailed wood rat
7. montane vole
8. long-tailed vole
9. prairie vole
10. house mouse
11. western jumping mouse
12. least chipmunk
13. yellow pine chipmunk