

**MAMMALS OF GREAT BASIN NATIONAL PARK
Final report**

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EXECUTIVE SUMMARY

In this report we summarize data on the non-volant mammals in Great Basin National Park (GRBA) obtained from inventories conducted within and around the Park before 2000 and from field investigations targeting small mammals and small predators conducted during 2000, 2002, and 2003. The primary scope of work included the following tasks:

1. Establishing a comprehensive list of expected mammal species within the Park,
2. Conducting inventories of the small mammals and small predators within GRBA with the ultimate goal of documenting the occurrence of 90% of small mammals by random and directed sampling in identified priority locations and through opportunistic data collection,
3. Obtaining voucher specimens for each species,
4. Identifying sensitive species that are federally or state-listed, rare, or worthy of special consideration,
5. Establishing a core of randomly located permanent sampling grid sites (and associated protocol) for future monitoring of mammal communities by the Park. The ultimate aim of this effort is to aid the National Park Service in their broader initiative to “lay the groundwork necessary for park managers to develop effective monitoring programs and formulate effective management strategies for resource management and protection (NPS 1999:2)”.

This report documents our effort in accomplishing these objectives as follows:

1. We conducted literature and museum searches to compile historic records and conducted field surveys in priority locations in order to document at least 90% of the small mammals within the Park. The field surveys were designed to fill gaps in existing data, collect voucher specimens that unequivocally document occurrences and provide a basis for future research activities, and identify sensitive species or those that are worthy of special management consideration,
2. We compiled a revised, comprehensive list of mammals occurring in the Park, including those with potential occurrence,
3. From our search and survey efforts a total of 46 mammal species are documented to occur within GRBA and estimate at least 90% inventory completeness for mammals (other than bats) within the Park.
4. We entered the data for records within GRBA boundaries into NPSpecies,
5. We established six randomly-located permanent sampling grid sites and associated sampling protocol for future monitoring of mammal communities by the Park personnel,
6. We provide a brief review of prehistoric (late Quaternary) records of mammals from the region to provide a deeper temporal context for understanding the current Park fauna,
7. We compare the historic and contemporary mammal inventory data to assess long-term trends in the Park region over the past 70 years in order to lay the ground work for the development of GRBA management strategies,
8. We compile a list of mammal species that are sensitive or of special management concern,
9. Based on our results and observations, we make some general recommendations regarding future monitoring and management of the mammal fauna within the Park,
10. Finally, we present a revised version of the comprehensive list of mammals for the Park region.

INTRODUCTION

In 1992, the National Park Service (NPS) established a Service wide Inventory and Management (I&M) Program to obtain credible and organized information on the natural and cultural resources within National Parks to fulfill the mandates within the congressional National Parks Omnibus Management Act (NPS 1999). In 2002, Mojave Network I&M program managers (NPS 2001) identified the inventory of small mammals and small predators of Great Basin National Park a high priority and retained the services of Dr. Eric Rickart, Curator of Vertebrates at the Utah Museum of Natural History and Adjunct Assistant Professor of Biology at the University of Utah, to act as Principle Investigator for this task.

Prior to this task agreement (during the summer of 2000), the PI and colleagues from the Field Museum, Chicago, conducted initial surveys along an elevation gradient of the south Snake Range that included the east-central portion of the Park along the Lehman and Baker creek drainages.

STUDY AREA

Great Basin National Park (GRBA), established as a National Park in 1987, encompasses most of the southern portion of the bifurcated Snake Range and is located midway along the eastern border of Nevada. The majority of the Park's 77,082 acres incorporates mid- and high-elevation mountain habitat with only 80 acres of low elevation basin habitat. The southern Snake Range is distinctly geographically separated from the northern range by Sacramento Pass (see Fig. 1). GRBA is unique in that it is the only National Park wholly within the physiographic Great Basin and contains the most dramatic elevational range and the largest expanse of high-elevation, boreal habitat (over 7,000 acres above 10,000 feet) within the Basin and Range region. Elevation within the Park ranges from 5,800 feet on the eastern margin to 13,063 feet at the summit of Wheeler Peak, the second highest peak in Nevada (NPS 2001). GRBA is located within a cold desert climate zone and experiences dramatic ranges in annual temperature and precipitation. Temperatures at GRBA vary from -10 to 40+ degrees F during the winter (Lehman Cave, 6,825 feet elevation) to 85-95+ degrees F in the valleys and 55-65+ degrees F along the mountain ridges in the summer. Average annual rainfall is about 6 inches in the valleys to over 30 inches along the mountain ridges (NPS 2001).

Plant communities at GRBA vary with elevational gradients grading from sagebrush grassland to piñon-juniper woodland to mixed aspen-conifer forest to mixed conifer forest to unique subalpine and alpine communities dominated by low-growing herbaceous and woody perennials. Over 700 plant species have been documented within the Park boundaries so far, many of which are endemic. There are ten perennial stream systems and alpine lakes within GRBA and low elevation arid desert basins surround the Park. The reliable water sources and broad elevational gradient of GRBA create an oasis habitat for natural communities. Within the Basin and Range, mountains have acted as islands throughout the Holocene, sustaining plant and animal populations that are isolated from each other by intervening arid lowlands. As a result, the plants and animals in a given mountain range within the basin may be quite unique from a nearby neighboring range. This appears to be true for the non-volant mammal fauna within GRBA (to establish the validity of this impression, regional comparisons are reviewed later in this report).

Although this area is remote, it has nevertheless experienced significant mining, farming, and grazing impacts since the late 19th century when the varied natural resources within the Park region attracted human exploitation. The effects of disturbance on the local ecology by humans and domesticated animals over the past century can still be seen and felt today.

METHODS

Historical records

Assembling historical inventory data is essential for resource management and the design of research agendas (NPS 1999). With the assistance of GRBA staff, we compiled historical records for mammals other than bats through a review of the published literature, survey of museum collection records, and from other unpublished sources. In addition to records of actual occurrence within the GRBA boundaries we also compiled records from the "Park region" to create a list of the species that potentially occur within the Park but have not been documented. We defined the "Park region" as the southern Snake Range south of Sacramento Pass and portions of the adjacent Snake and Spring valleys due east and west of the Park. In some instances, we also refer to records from the northern Snake Range (north of

Sacramento Pass) when we felt they were relevant examples. For purposes of analysis and discussion, we have ranked species into 3 size categories that reflect survey methodology: 1) small (<500 g) includes species that are readily sampled through trapping; 2) medium (500 g - 5 kg) includes species that require larger traps or visible survey; and 3) large (> 5 kg) species that require visual survey.

Georeference data for localities, expressed as latitude-longitude in decimal degrees and using the NAD 1927 horizontal datum, were obtained directly from the original sources and verified by the authors, or were generated by the authors, using the GNIS gazetteer (USGS 2004) and the MaNIS georeference protocols (MaNIS 2004). The location accuracy of historical records and records from other collections were verified by us using the same protocol. We inspected specimens from the Utah Museum of Natural History collections and verified their species identifications. We did not physically examine the specimens from other institutions, but because they are from well-curated collections with high standards for data quality we assume these species identifications to be reliable.

We use units of feet rather than meters to describe elevation above sea level since this follows both historical locality data and the most detailed USGS topographic maps. For purposes of data analysis, we recognize four general elevation zones that roughly correspond to major plant community groupings in the Park region:

1. low elevation (below 6,500 ft) - principally desert shrub communities
2. mid-elevation (6,000 - 8,000 ft) - desert shrub and piñon-juniper or mountain mahogany woodland
3. high elevation (8,000 - 10,500 ft) - subalpine forest and meadow communities
4. alpine (> 10,500 ft) - krumholtz communities and areas above treeline

For historical museum records we report the following information for each specimen: museum collection acronym for where the specimen is held, the specimen catalog number, scientific name (genus and species), common name, original collector, collector's field number, sex of the specimen, preparation type, description of the collecting locality, occurrence within Park boundaries, the year, month, and day of collection, locality georeference coordinates (in decimal degrees), horizontal datum, and locality elevation (in feet). Data for specimens collected within the Park boundaries were entered into the NPSpecies database. Scientific names are from Wilson and Reader (1993) the most recent comprehensive source for nomenclature. Common names are those used most frequently.

Review of published records

The foundation for our list came from an existing mammal species list compiled by GRBA (Pfaff 1999). To verify and supplement this list, we searched the literature using academic search engines and library holdings at the University of Utah for early mammal records from GRBA. We relied heavily on Hall (1946) who assembled an exhaustive and comprehensive faunal report on the mammals of Nevada that includes a detailed accounting of all known vouchered and sighted records within the GRBA region before 1945. Hall was well respected as a thorough and meticulous scholar who set many of the standards for field surveys and faunal reports. We feel confident in the reliability of his voucher data, although we question a few records of sightings that we consider equivocal. A previous review of GRBA mammal records by Baggs (1993) was based entirely on Hall (1946) and earlier versions of the GRBA species list compiled by Park personnel and provided no additional information on Park records for mammals other than bats.

Review of museum collections

Museum records were searched to locate all the voucher specimens taken from GRBA that are held in museum collections. Records were accessed through the MaNIS network system of distributed databases (MaNIS 2004). This network includes collection information from 17 institutions in North America including the primary collection repositories for specimens from the Park region, most notable among these is the Museum of Vertebrate Zoology at the University of California, Berkeley (MVZ) which holds more than 900 mammal specimens from the Snake Range. Other collections within the MaNIS network with mammal records from the Park region include the Burke Museum at the University of Washington, Seattle (UWBM), Bell Museum of Natural History at the University of Minnesota, Minneapolis (MMNH), Museum of Southwestern

Biology at the University of New Mexico, Albuquerque (MSB), Nevada State Museum, Carson City (NSMC), and Utah Museum of Natural History at the University of Utah (UMNH). Using the MaNIS search engine, we queried the network for all records from White Pine County, Nevada, and by inspection selected those that fell within the Park region (the Snake Range and surrounding valleys). To account for any records that might not include county of origin, we ran additional queries for Nevada records containing various key words in the specific locality based on place names within the Park and surrounding region (e.g., Baker, Lehman, Snake, Pole, Strawberry, Wheeler, etc.). This second search failed to reveal any additional records from the region. In addition to MaNIS institutions, we solicited information directly from the Nevada State Museum collection (NSMC) and the Monte L. Bean Museum at Brigham Young University (BYU).

Review of unpublished sources

A few unpublished records of mammals from within the Park region were obtained from GRBA staff. These consist of early records of visual sightings or physical specimens retained by the GRBA resource Management office.

Review of prehistoric (Quaternary) records

In addition to searching the published literature for historic records of occurrence, we also searched for paleofaunal records in the Park region to establish when and what local extinctions may have occurred. Regional prehistoric data were assembled from published reports on excavated cave deposits within GRBA (Lehman Cave, Snake Creek Cave), north Snake Range (Smith Creek Cave), and the Snake Valley (Crystal Ball Cave, Gatecliff Shelter). Although we did not verify specimen identifications, most of the important prehistoric records have been extensively reviewed by Donald Grayson (1987, 1993), a recognized expert on Great Basin faunal history. We do not include paleofaunal records for extinct species. For records of extant species that are no longer present in the region we report the following information: the scientific name (genus and species), common name, regional site localities, source citation, and specific comments.

Field surveys for small and medium-sized mammals (excluding bats)

Inventory techniques and equipment

The most effective means of determining the presence and quantifying the abundance, of mammal species is by physical capture (Resources Inventory Committee 1998). There are many different ways to capture mammals and the appropriate methodology is primarily determined by a project's research goals, species being targeted, the staff and time available for collecting data (feasibility), and methods of data analysis. Although randomized sampling allows for rigorous statistical control, directed trapping is a preferred method for rapid assessment of local species diversity (Wilson et al. 1996). This approach, which utilizes a variety of traps and techniques to target specific taxa and microhabitats with the aim of maximizing trap success, has proved to be very effective in adding important new records in regional mammal studies (Grayson and Livingston 1993, Lawlor 1998, Rickart and Heaney 2001, Rickart et al. 2004).

Mammal surveys require specialized trapping and animal handling equipment (Wilson et al. 1996; Resources Inventory Committee 1998). Our surveys employ three basic trap types: live traps, pitfall traps, and snap traps. The most common live trap used by researchers is the collapsible aluminum Sherman trap (H.B. Sherman Traps, Tallahassee, Florida) available in a variety of sizes (the most popular being 13 x 13 x 38cm and 7.5 x 9 x 22cm). These traps are set by catching the door onto a pressure sensitive treadle-trigger, and they must be set on a firm, flat surface to be effective. Sherman traps target smaller species (i.e., those weighing less than 500 g), and they are particularly effective for capturing smaller rodents. However, Sherman traps are less effective with other groups (such as shrews) or for trapping in many microhabitats (e.g., steep rocky slopes or very wet riparian areas). For much of our trapping, we employed break-back snap traps that are designed to quickly and humanely kill small mammals. These traps are relatively small and can be set in a wide variety of sites where live traps cannot be used. We used two sizes of snap traps to target small to medium-sized rodents; the Museum Special (7 x 14 cm) and the Victor Rat Trap (9 x 18 cm) both manufactured by Woodstream Corp., Lititz, Pennsylvania. Pitfall traps, constructed from containers that are placed in the ground with the open top

flush to the surface, are particularly effective for shrews (genus *Sorex*) that are generally difficult to capture with standard small mammal traps (Rickart and Heaney 2001). Although pitfalls are often set in uniform arrays connected by drift fences, we utilized simple versions constructed from 12 oz (355 ml) beverage cans set individually without drift fences. For larger mammals, we set Tomahawk Traps (13 x 13 x 40 cm) manufactured by the Tomahawk Live Trap Co., Tomahawk, WI, or Havahart Traps (18 x 18 x 60 cm) manufactured by Woodstream Corp. At a few sites, McAbee Gopher Traps (Woodstream Corp.) were used for collecting pocket gophers.

Additional information on Park mammals was obtained through visual observations, opportunistic collection of salvaged specimens, collection of scat samples, and records of tracks and other sign. Park visitors and staff reported much of this information. We also include some records of carnivores obtained by Park personnel through the use of automated camera stations, records of directed surveys for marmot, and general results of small mammal grid trapping conducted independently by Park personnel in 2004.

Survey localities were photographed with film or digital cameras. The following locality information was documented for each site: written locality description, horizontal georeference coordinates, elevation (in feet), and basic habitat description. Georeference coordinates were determined using a Garmin handheld GPS unit utilizing a minimum of four satellite contacts. Georeference data were recorded in two formats: as Universal Transverse Mercator (UTM) coordinates utilizing the NAD 1983 datum (the required NPS format), and as decimal-degree latitude and longitude utilizing the NAD 1927 horizontal datum (format for the MaNIS database). Data were recorded in the field on standardized, data sheets. For live-trapped individuals that were marked and released we recorded species identity, sex, and age. For voucher specimens we recorded species identity, age, sex, and basic reproductive condition, as well as external measurements of total length, length of tail vertebrae, length of hind foot including claws, length of ear from notch (all in mm), and body mass (in grams).

Specimens retained as vouchers were preserved whole in formalin (later transferred to 70% ethyl alcohol) or prepared as complete skeletons. For nearly all voucher specimens, samples of skeletal muscle tissue for future genetic analyses were preserved in 95% ethanol and stored under refrigeration at UMNH. We present the following data for voucher specimens obtained during 2000-2004 surveys: museum acronym, specimen catalog number, scientific name (genus and species), common name, description of the collecting locality, occurrence within Park boundaries, the year, month, and day of collection, locality georeference coordinates (in decimal degrees), horizontal datum, and locality elevation (in feet). Voucher specimens from the 2000 field survey were deposited in the collections of the Field Museum (FMNH) and the Utah Museum of Natural History (UMNH). Specimens from 2002-2004 were deposited in the UMNH mammal collection as GRBA accession number GRB-308, and are retained there under a loan agreement with the Park. Original written field data are filed at the Utah Museum of Natural History (UMNH), and also were scanned and delivered to GRBA as an electronic file. Field data were transcribed into Excel spreadsheet files and subsequently entered in the NPSpecies and the UMNH collection databases.

2000 Preliminary Survey

Information on contemporary distribution and relative abundance of mammals in the Park region was collected through field surveys. We include data from an initial survey conducted in July 2000, prior to the award of this contract, in our analysis. That work, done in collaboration with colleagues from the Field Museum (FMNH), involved resurveying sites in the most accessible east-central portion of the Park along the Lehman and Baker Creek drainages worked by field crews of the Museum of Vertebrate Zoology, University of California (MVZ) between 1929 and 1938.

2002-2003 Surveys

Fieldwork conducted by the authors in 2002 and 2003 was done under contract with the National Park Service and Great Basin National Park. That work involved surveys of areas that had been poorly sampled or had not been sampled previously mainly in the northern, southern, and western portions of the Park. Low and high elevation habitats within the Park that were less intensively sampled historically were specifically targeted. Our 2002-2003 surveys involved two principal approaches:

Grid trapping

In 2002 we sampled small mammals using 30 m x 30 m trapping grids at 11 sites within Snake Creek and Strawberry Creek canyons. Accessible sites were chosen from a list of randomly generated points provided by GRBA in predefined low and mid-elevation vegetation communities (see plant community definitions below). At each chosen site, we established a 30 x 30 meter grid centered on the coordinate resulting in 9 trap stations placed at 10 m intervals. At each station we placed one Sherman live trap and one Museum Special snap trap set within 1 m of each grid coordinate (total of 18 traps per grid). Each grid was sampled for at least 3 nights (54 trap-nights).

Six of these 11 grids were established as permanent sites that could be revisited and expanded by GRBA management for future monitoring of small mammal communities. When possible, we co-located our mammal grids with the permanent herpetology grids. In each canyon, permanent sites were chosen that were representative of first three of the following four defined vegetative communities identified by Eddleman and Jaindl (1994) where vegetation type was uniform across the extent of the grid:

1. Combined desert and mountain shrub vegetation – low to mid-elevation communities dominated by *Artemesia nova* and *A. tridentata*.
2. Combined evergreen shrub and piñon-juniper woodland vegetation – mid-elevation communities dominated by *Juniperus*, *Pinus monophylla*, and *Cercocarpus ledifolius*.
3. Mid-elevation forest vegetation – mid-elevation communities dominated by *Abies concolor*, *Populus tremuloides*, and mixed aspen/conifer.
4. High elevation forest vegetation – high-elevation communities dominated by *Picea englemanni*, *Pinus flexilis*, and *Pinus longaeva*.

Traps were checked in the morning. Animals captured in Sherman live traps were identified species and released after marking their fur mid-dorsally with a permanent ink pen. Animals caught in snap traps were processed as voucher specimens in the field. All grid traps were left unset during the daytime, then rebaited and reset in the late afternoon.

With approval from Kristina Heister, Park project coordinator, we made several amendments to the task agreement in 2002 regarding permanent grid sampling in order to maximize our survey efficiency. First, we chose not to establish permanent grids in the 'high elevation forest vegetation' stratum because this zone is known to be depauperate due to historical biogeography. The common high elevation species that are characteristic of such habitat (e.g. *Zapus* and *Clethrionomys*) are known to be absent from the Snake Range. Previous work in high elevation forest had already established a reliable species list and voucher specimens for the Park (Hall 1946, Rickart and Heaney 2000) and we felt establishing a permanent grid in this habitat would result in redundant effort. Second, trapping stations within grids were spaced 10 meters (instead of 15 meters) apart to maintain site control in difficult terrain (e.g., steep, rocky slopes). Our third amendment was to sample each permanent grid only once for at least three consecutive nights. Because of the relatively poor success rate of grid sampling, we chose to abandon this method and redirect our remaining effort to directed trapping in order to best meet our specific project objective (documenting at least 90% of the GRBA mammal species). While grid trapping was not effective for achieving our primary sampling goal, it did meet an ancillary objective of the task agreement to set-up a sampling procedure that could be used in future routine monitoring by the Park staff. In 2004, Park staff did initiate grid trapping at sites along Lehman Creek (the general results of which are reported below).

Directed trapping

The targeted objective of our task was best achieved using directed trapping techniques. This approach, which is standard for museum surveys, involves trapping in a range of local microhabitats with several types of traps in order to maximize the rate of species detection. Many of the animals captured are retained as voucher specimens for positive identification and further study. Directed trapping is subjective in that it involves investigator bias toward placing traps in what are assumed to be productive sites, and it employs a mixed strategy for purposefully targeting different species. We considered directed trapping the best approach for accomplishing

our primary project goal of documenting at least 90% of the Park mammal species. Directed trapping is also effective in assessing patterns of local diversity and relative abundance of different species, and in providing general information on habitat preferences of different species (Wilson et al. 1996). Furthermore, it had the added advantage of being the same general approach used in early surveys. Because of this consistency in methodology, survey data could be compared longitudinally and regionally with high confidence.

We used a mixture of Museum Special snap traps and Sherman live traps to capture small rodents and small pitfall traps to capture shrews. On occasion, we set Victor rat traps and Tomahawk or Havahart live traps to target larger rodents and small carnivores, and McAbee traps for pocket gophers. Separate trap transects were set in lines of between 5 to 50 traps in areas of relatively uniform habitat and were operated for 3 to 5 consecutive nights. Relative trapping effort was measured in trap-nights (1 trap-night = 1 trap set for 24h). Traps were set in runways, beside fallen logs, by burrow openings, or in other locations with signs of small mammal activity. Traps set for rodents were baited with a mixture of oatmeal and peanut butter (snap traps) or mixed bird seed (live traps). Traps set for carnivores were baited with canned cat food or tuna. Pitfall traps were left unbaited. All traps were checked in the morning and rebaited in the late afternoon. Live-trapped animals were marked and released at the point of capture after positive species identification. Snap-trapped animals were retained as voucher specimens.

Opportunistic data collection

This category encompasses all information collected through non-targeted, opportunistic means, including salvaged dead animals, visual observations, and collection of diagnostic species sign (scats, skeletons, etc.). We include information gathered by us during our field surveys, as well as records obtained from GRBA staff. When reliable, these records are useful in establishing presence/absence of certain species within the Park (particularly larger species and elusive species poorly documented through trapping). We ranked the reliability of records as follows (ranging from most to least credible): actual specimens with locality data, photographic evidence with locality data, unambiguous secondary sign (scat or track), first-hand visual observations, and second-hand reports of visual observations. For observations, we give the most credence to reports from trained professionals and for cases involving repeated observation of unambiguously identifiable species (i.e., those not easily confused with others).

RESULTS AND DISCUSSION

Results of search for historical records

We located 526 historical specimen records from the Park region representing 33 species of mammals other than bats (Appendix 1). Of these, 383 specimens (72.8%) representing 31 species are clearly from within the Park boundaries. The majority of these records (481) are from the MVZ collections and most of these (468 specimens; 88.5% of the total) were collected between 1929 and 1938 (primarily from localities within the Park along the Baker and Lehman creek drainages).

Results of 2000, 2002-2004 field surveys

Summary of field effort

Fieldwork conducted in July 2000 involved trapping at 12 general localities within the Snake Creek and Baker Creek drainages, and 2 localities east of the Park boundary (Fig. 1). Most of these sites were in areas intensively worked by MVZ field crews 65 to 70 years earlier. In 2002 we surveyed multiple sites at 4 general localities in Snake Creek and Strawberry Creek canyons and in 2003 we worked at sites in Big Wash, near Pyramid Peak, and the Mount Washington-Lincoln Peak area (Fig. 1). Collectively, these recent surveys covered the broadest possible elevation range in the Park and included a broad spectrum of habitats (Appendix 2).

Cumulatively, more than 1,000 person-hours of fieldwork and 4,379 trap-nights yielded 642 small mammal captures. Roughly half of this effort (2,019 trap-nights and 330 captures) was expended during the 2002-2003 fieldwork conducted under this contract. From all recent surveys, a total of 520 voucher specimens were prepared (including those obtained through salvage), representing a total of 26 species (Appendix 3).

Comparison of grid trapping and directed trapping

In June-August 2002, we conducted grid trapping at 8 sites in the lower and upper Snake Creek drainage and at 3 sites in the Strawberry Creek drainage in communities dominated by sagebrush, piñon-juniper, and Englemann spruce. In a total of 630 trap-nights we captured 50 individuals representing 6 species (Appendix 4).

In July and August 2004, Bryan Hamilton and GRBA staff conducted grid trapping at 10 sites in the Lehman Flat area north and east of the Lehman Caves visitor's center (ca. 6800-7000 ft). A total of 1,929 trap-nights yielded 299 total captures (116 individuals) representing 7 identified species (Appendix 5). Voucher specimens were not retained.

Altogether, 2,559 trap-nights of grid trapping captured 166 individuals (6.5% trap success overall, not including recaptures) and documented a total of 8 species. A roughly comparable amount of directed trapping within the Park (3,172 trap-nights) yielded 557 individuals (17.6% trap success overall) representing a total of 20 species (Table 1). Overall capture success of directed trapping was more than twice that of grid trapping. More importantly, directed trapping was more effective than grid trapping in determining species richness, yielding 2.5 times as many species. Although directed trapping was conducted over a broader elevation range, this did not contribute to the disparity in either trap success or species detection. The differences reflect the fact that directed trapping utilizes a mixture of traps set in a broader range microhabitats and targets species such as shrews and pocket gophers that are not captured in live-trap grids.

Patterns of relative abundance and species richness

Recent surveys have significantly extended the geographic coverage of occurrence records within the Park (Fig. 1) and provided new information on the elevational distributions of individual species (Table 2). These records allow us to examine patterns of species richness across the full elevation gradient in the Park region. Combined historical and recent occurrence records for 36 small and medium-sized mammals are shown in Figure 2, with records grouped by 500 feet elevation intervals. Species in the large category were excluded because they potentially occur over the entire elevation gradient and would therefore add little to the analysis. Species richness of 24 species within the mid-elevation zone (mixed desert shrub and piñon-juniper woodland), attenuated slightly to 21 species in both low elevation (desert shrub) and high elevation (subalpine forest and meadow) zones, and drops dramatically to 11 species in the alpine zone. A mid-elevation peak in abundance is common in small mammal assemblages. However, because the Snake Range is a biogeographic isolate it lacks many of the species that inhabit higher elevations elsewhere in the mountain west. As a result, the peak in species richness occurs at a lower mid-elevation than in, for example, the Uinta (Rickart 2000).

The assemblage of Park mammals includes some species that have relatively narrower elevation ranges (e.g., *Tamias dorsalis*, *Peromyscus crinitus*, and most of the heteromyid rodents). These tend to be species that are restricted to areas with particular substrate or plant assemblages. Several Park species have broad elevation ranges (e.g. *Sorex vagrans*, *Tamias umbrinus*, *Peromyscus maniculatus*, *Microtus longicaudus*). Most of these are ecological generalists that inhabit a wide variety of microhabitats. As discussed below, some of these species have expanded their local distributions upward into higher elevation habitat in the absence of more specialized high elevation species.

The directed trapping conducted for our primary inventory surveys does not provide direct information about population densities. However, this method does provide information on relative abundance of different species. The number of specimens documented from historical sources (largely obtained through similar directed trapping programs) can be used as a general indication of relative abundance. For a subgroup of 24 species of shrews and rodents in the small and medium sized categories (i.e., those that are readily surveyed through trapping), the number of voucher specimens from recent and historical surveys are shown in Figure 3, with records grouped by 500 feet elevation intervals. The interval totals are highly variable indicating unevenness in the amount of investigator effort at each gradient interval. In particular, there has

been much less relative trapping effort at the highest elevations in the Park. Despite this difference, the data are sufficient to determine the basic pattern of relative abundance across elevation. One species, the deer mouse, (*Peromyscus maniculatus*) stands out as abundant over most of its elevation range, accounting for between 12.5 and 74% of the total captures within each elevation zone. Several other species are moderately common across much of their distributions (e.g. *Sorex vagrans*, *Tamias umbrinus*, and *Perognathus parvus*). At the opposite extreme are apparently rare species represented by fewer than 10 specimens or captures (e.g. *Sorex palustris*, *Sorex tenellus*, and *Lemmys curtatus*). In general, there appears to be a direct relationship between relative abundance and elevation range of species.

Results of opportunistic data collection

A total of 23 specimens representing 11 species were obtained through salvage of dead animals or through incidental capture in reptile pitfall arrays. All were prepared as voucher specimens and are included in Appendix 3 where they are noted as opportunistic. Included among these specimens are the only Park vouchers for three species: gray fox (*Urocyon cinereoargenteus*), yellow-bellied marmot (*Marmota flaviventris*), and northern grasshopper mouse (*Onychomys leucogaster*).

Records of visual observations, tracks, scat, and other diagnostic sign, were obtained for 30 species (Appendix 6). These records include general results of targeted surveys by GRBA staff (for predators and marmots), as well as second-hand reports from staff and visitors compiled by Allan (2004).

Inventory Completeness of Mammals other than bats

For mammals other than bats, a total of 46 species have been recorded within the Park (Table 3). Of these 37 are documented by voucher specimens and 9 are based on diagnostic sign, unambiguous (but unvouchered) trapping record, or multiple sightings. An additional 10 species potentially occur in the Park with varying probabilities (Table 4). Only these, only 1 species (*Sorex merriami*) has a high probability of present occurrence, while 4 others (*Brachylagus idahoensis*, *Sylvilagus auduboni*, *Chaetodipus formosus*, and *Perognathus longimembris*) have low to moderate probabilities based on records from the region and the availability of suitable habitat within the Park. The remaining 5 species have very low probability of occurrence but are included on the basis of regional records or possibility that they have some potential to move into the region in the future. In addition, there are 9 species of Recent (living) mammals that have been reported from local prehistoric sites are now extinct in the Park region (Table 5). Detailed information on all species is presented in the form of a synopsis (Appendix 7).

From these data, we estimate that between 47 and 51 species of non-volant mammals currently occur within the Park. Of these, 46 (90-98%) have been documented. This includes 26 (90-97%) of the 27 to 29 species in the small (i.e., "trappable") size category, and 20 (91-100%) of the 20 to 22 medium-sized and large species. On the basis of these calculations, our inventory meets the predetermined goal of documenting 90% of the non-volant species in the Park.

Adequacy of sampling and limitations of data analysis

Although we did not search some major collections for historical records (most notably the Smithsonian Institution), we believe there are few, if any, missing records from this report. Prior to our 2000, 2002, and 2003 surveys, the only major fieldwork in the Park region had been conducted by the MVZ in the 1920's and 30's and all of the specimen records from that work were accessible to us through MaNIS (2004). Earlier records of importance (including any housed at the Smithsonian) were reported by Hall (1946). Furthermore, it is likely that any additional historic records would simply duplicate those from the MVZ.

Museum records are invaluable resources for investigating changes in population and community structure. However, there are limitations to how these data can be utilized and interpreted. Fortunately, most of the historic records from the Park region (more than 90%) are from one source, the MVZ, and most of these stem from surveys conducted over a ten year period (1929-1938). This is advantageous for several reasons. First, most of the locality information is accurate and relatively detailed so that previously sampled sites can be relocated with some precision. Second, the general survey methods used by MVZ field zoologists are well known (Hall 1946, 1981) and comparable to those used in recent

surveys. Finally, and most importantly, the records are from a relatively narrow time period and therefore can be treated as a homogeneous temporal sample.

Vouchered museum records are unimpeachable factual evidence of occurrence. Moreover, voucher records for different species can be assembled for particular sites to provide information on community composition. Although we do not have direct information on sampling effort (i.e., actual number of trap-nights) or actual trapping results (capture frequencies) for the MVZ surveys, numbers of specimens do provide some estimate of relative abundance. MVZ field crews sampled the entire community spectrum and were interested in obtaining representative specimens and information on all species (Hall 1946). Specimen preparation is laborious and time-consuming, and was particularly so in the days of the MVZ surveys when virtually all specimens were prepared as study skins. It is safe to assume that uncommon or rare animals were saved whenever and wherever they were collected and, therefore, voucher records accurately reflect survey results for these species. For common species (e.g., *Peromyscus maniculatus*), perhaps only a subset of each day's catch would have been prepared, but in most instances they would be represented by larger relative numbers. Although we lack direct information on habitat conditions 65-70 years ago, it is possible to make some general inferences based on the reconstructed historical assemblages and our understanding of the habitat preferences of the various species

Biogeography and community structure

Although a relatively large number of species have been documented in the Park and surrounding areas (Tables 3 & 4), there are fewer species of mammals occupying the southern Snake Range that would be expected based on current habitat diversity (Appendix 2) and the pool of potential species occurring within the broader intermountain region. In particular, many species that could occur at higher elevations are not present. This pattern, which is generally reflected among the isolated mountain ranges of the Great Basin, was the primary empirical basis for the theory of faunal relaxation (Brown 1971, 1978). Faunal relaxation is an area-dependent phenomenon that, in the present context, involves selective extinction of high elevation montane (or "boreal") species that require wet habitats. Theoretically, the shift toward warmer and drier conditions following the Wisconsin glaciation (approximately 30-20,000 years ago, Grayson 1993) first reduced and then eliminated dispersal corridors, isolating local populations. Ultimately, areas of suitable habitat for mesic species were reduced to a point during the mid-Holocene altithermal (approximately 15-10,000 years ago, Grayson 1993) that viable populations could not be sustained. The prehistoric record indicates that small mammal species diversity within the Park region has indeed been reduced since the end of the Pleistocene (Table 5). However, we now understand that Brown's (1971, 1978) model was an over-simplification. While there have been repeated cycles of extinction for some montane species, there have also been cases of subsequent recolonization of isolated montane systems (Grayson 1993, Grayson and Madsen 2000, Lawlor 1998).

Furthermore, there are several montane mammals (e.g. *Tamiasciurus hudsonicus*, *Glaucomys sabrinus*, *Microtus richardsoni*, *Clethrionomys gapperi*, *Zapus princeps*) that are not found in the Park despite the fact that suitable habitat is plentiful. Although some may have been present in the past but have yet to be documented from prehistoric sites, these species appear to have failed to colonize the Snake Range during the late Pleistocene when conditions would have been the most favorable for immigration across intervening lowlands (Rickart 2001).

Despite the fact that the Park is depauperate with respect to boreal mammals, the high elevation communities are hardly barren. In addition to species that normally have very broad habitat tolerances and elevation ranges, a number of others that are normally restricted to low or mid-elevations in mountains with "saturated" local faunas have expanded upward in the absence of their better-adapted montane relatives (Rickart 2001). Within the Park, this phenomenon species such as *Sorex vagrans*, *Lepus californicus*, *Spermophilus variegatus*, and *Thomomys talpoides*, illustrate this phenomenon (Fig. 2).

The mammal fauna of the Park is highly dynamic and has been shaped by ongoing colonization, selective extinction, and shifting local community structure. In the future, these processes will continue to influence the Park's biota, especially with the important addition of human activities.

Recent faunal change

The first humans may have arrived in the Park region as early as 10,000 years ago (GRBA website), and prehistoric people undoubtedly had a major impact on natural communities. Some species of late Pleistocene - early Holocene megafauna formerly present in the region (e.g., horses, camels, bison; Jefferson et al., 2004) may have become extinct through human agency (Grayson, 1993). There is evidence of ancient fires throughout the Park and anecdotal ethnographic accounts that local people used fire to modify habitat for hunting or agriculture (J. Sirotnak, personal communication, 2000). The arrival of European-American settlers in the mid-19th century led to hunting with firearms, logging, mining, modification of watersheds, introduction of livestock and exotic plants, and active suppression of natural fires. Such activities had both direct and indirect impact on wildlife. By the early 20th century several large mammals had disappeared from the Park region. All but one of these (the gray wolf) have since been reintroduced or have recolonized without human assistance.

The rich historical data on the mammals of the Park region provide a rare opportunity to examine potential changes in community structure during the past century. We are fortunate to have fairly precise information during a relatively brief time period from long enough ago (65-70 years) to make some informative comparisons with the present. We examined groups of local sampling sites located within each of the three elevation zones that we defined based on general vegetation type (see Study Area section). These included: 1) a group of low elevation sites (5300-6000 ft.) encompassing valley floor and bajada desert shrub communities immediately east of the Park, 2) a group of mid-elevation collecting sites located along Baker Creek between 6500 and 7500 ft., and 3) a group of high elevation localities from the upper portions of Lehman Creek to its headwaters in the vicinity of Stella Lake (8200-10500 ft.). Assembling records by zone allowed us to compare our survey results with the historic community compositions we reconstructed from the MVZ records. We limit our comparisons to species in the "small" body size category (< 500 g) inventoried both historically and recently with standard small mammal traps. We excluded shrews captured through pitfall sampling since that technique was unknown to early collectors. Our general interpretation of differences in the historic and current assemblages is based on presence or absence of species and rough estimates of relative abundance.

Comparison of the low elevation data suggests that changes in community composition have occurred over the past 70+ years (Table 6). For many species, numbers of specimens are small so some apparent temporal differences are almost certainly due to sample size. The presence of the montane vole (*Microtus montanus*) in the historical sample suggests that MVZ crews did some trapping in riparian habitat (which we did not sample in this zone). The chisel-toothed kangaroo rat (*Dipodomys microps*), by far the most abundant species in 1929, is still among the most common species today. Surprisingly, the Great Basin pocket mouse (*Perognathus parvus*), the most abundant species in our recent surveys, was not recorded in this zone in 1929, nor was Ord's kangaroo rat (*Dipodomys ordii*) or the deer mouse (*Peromyscus maniculatus*). The latter's complete absence from the early sampling is unlikely since it was so abundant elsewhere, and specimens may have been discarded. The presence of a few least chipmunks (*Tamias minimus*) in 1929, a species not recorded recently, is perhaps meaningful when considered along with the mid-elevation comparison. We believe these differences may reflect subtle shifts in plant community composition within this zone.

The mid-elevation comparison shows a dramatic shift in community composition (Table 6). Four of the five most abundant species in 1929, the least chipmunk (*Tamias minimus*), Great Basin pocket mouse (*Perognathus parvus*), bushy-tailed woodrat (*Neotoma cinerea*), and desert woodrat (*Neotoma lepida*), were not recorded in 2000. Two species present in the recent survey, the Uintah chipmunk (*Tamias umbrinus*) and piñon mouse (*Peromyscus truei*), were not recorded in 1929 despite what appears to be greater relative effort in the early survey (based on total sample sizes). We believe that most of these compositional differences reflect a shift from open habitat dominated by sagebrush (preferred by *Tamias minimus* and *Perognathus parvus*) to piñon-juniper woodland (preferred by *Tamias umbrinus* and *Peromyscus truei*). However, because woodrats are habitat generalists their dramatic disappearance is unlikely due to habitat change (see following section).

In contrast to the low and mid-elevation groups, the high elevation comparison shows that the small mammal community has been relatively stable over the 65-70 year interval between survey efforts (Table

6). There appears to have been a decline in the number of golden-mantled ground squirrel (see below). Other differences are most likely due to low overall sample sizes and perhaps a bias against saving specimens of common species in the historical survey.

Mammal species requiring special consideration

Our data indicate that particular species have experienced major declines during the past 70 years. The disappearance of woodrats at mid-elevations is particularly puzzling. Although we have no direct evidence, disease of some sort may be responsible for this. Another species of woodrat, *Neotoma magister*, has experienced a dramatic decline due to infestation by a macroparasitic roundworm (Logiudice 2003). The relative scarcity of golden-mantled ground squirrels, particularly at mid-elevations, may reflect increasing forest density due to fire suppression (Yensen and Sherman 2003). Porcupines appear to have undergone a dramatic reduction, and may now be absent from the. This is particularly notable since it reflects what may be a broad regional decline for this species. The specific factors responsible for these changes are unknown and certainly warrant future investigation.

We have compiled a list of mammal species that we believe are worthy of special consideration (Table 7). In addition to species that have clearly declined historically, it includes important ecological keystone species that influence the structure of local communities, and others that are specialized or ecologically sensitive and are therefore potential indicators of habitat health or change. The list includes some species that are currently subjects of Park monitoring and management programs and others that we believe are logical candidates for such activities (as elaborated in the following section). Further details are presented in the synopsis species accounts (Appendix 7).

RECOMMENDATIONS FOR FUTURE MONITORING AND MANAGEMENT

This project has provided much information that we believe is directly relevant to resource management within the Park. We present the following points as a series of general recommendations.

Riparian management

The reappearance of beaver in the Park region is a major event with respect to natural resource management and one that we believe will result in profound improvements to the general health of riparian communities. Although they may cause management problems in some areas (due to flooding), beaver are invaluable agents for reinvigorating entire watersheds, greatly increasing local habitat diversity and species richness, and generally improving stream hydrology by moderating seasonal cycles of flow to reduce the severity of seasonal flooding and drought. We recommend that reestablishment of beaver in watersheds where they formerly occurred should be made a very high management priority.

Mid-elevation communities

Our comparisons of historical and current survey data (Table 6) support the view that open shrub communities at low to mid-elevations are being replaced by piñon-juniper and mountain mahogany woodland. Management efforts aimed at reversing this trend (either through removal, prescribed burns, or management of natural fires) and encouraging the reestablishment of brush and grassland habitat would benefit a number of mammal and bird species that have apparently declined in recent decades.

Exotic plants

We suspect that the invasion and spread of exotic plants, particularly cheat grass and other weedy annuals, will have an increasingly negative impact on diversity and abundance of small mammals. Exotic annuals alter the fuel base, increasing the frequency and intensity of fires that may impact natural communities throughout the Park. Locally, an increase in exotic annuals is expected to depress certain species, particularly heteromyid rodents (*Perognathus* spp. and *Dipodomys* spp.) while promoting the spread of some grass-loving species (e.g., *Microtus longicaudus* and *Reithrodontomys megalotis*).

Monitoring and management of keystone species

Current efforts by Park staff to monitor carnivores, ungulates, and marmots are important activities that should continue, because such species are ecological "keystones" that influence the broader structure of natural communities. We recommend extending these efforts to include beaver (as discussed above) and possibly porcupine. The potential role of the porcupine in the local dynamics of mid-elevation woodland and alpine forest communities may be worthy of investigation.

Management in the broader context

Animal-oriented management programs usually focus on particular species, for example marmots, bighorn, and sage grouse (GRBA 2003). While it is logical to target particular keystone species in this manner, management programs that integrate activities within particular ecological communities are likely to be more successful and have wider impact (for example, an integrative riparian management program involving beaver, Bonneville cut-throat, and riparian plants). Furthermore, management activities need to extend beyond Park boundaries to account for the full range of regional habitats and natural processes (such as vertical and regional animal migration). This requires inter-agency cooperation, and if possible, eventual extension of Park boundaries to encompass important low elevation habitat.

REVISED PARK MAMMAL LIST

We have compiled a revised comprehensive list of 73 species of mammals, including bats, from the Great Basin National Park region (Appendix 8). This includes 53 species recorded from within the Park and documented either through voucher specimens (as indicated) or through reliable, multiple sightings. The list also includes 20 species (including 10 bats) that have yet to be recorded in the Park but have some probability of occurrence either now or in the near future.

We have dropped the following 11 species that appeared on previous lists (Pfaff, K. 1999; GRBA undated):

1. *Myotis leibii* (taxonomic change, species now recognized as *M. ciliolabrum*)
2. *Ochotona princeps* (prehistorically extinct in Snake Range, no evidence of historic occurrence)
3. *Lepus townsendii* (historically absent, no evidence of former occurrence in Snake Range)
4. *Thomomys talpoides* (historically absent, no evidence of former occurrence in Snake Range)
5. *Phenacomys intermedius* (prehistorically extinct, no evidence of historic occurrence)
6. *Spermophilus beldingi* (historically absent, no evidence of former occurrence in Snake Range)
7. *Spermophilus richardsoni* (historically absent, no evidence of former occurrence in Snake Range)
8. *Zapus princeps* (historically absent, no evidence of former occurrence in Snake Range)
9. *Vulpes macrotis* (taxonomic change, now considered a synonym for *V. velox*)
10. *Gulo luscus* (prehistorically extinct in Snake Range, no credible evidence of historic occurrence)
11. *Martes americana* (historically absent, no evidence of historic occurrence in Snake Range)

We have added the following species: Inyo shrew, *Sorex tenellus* (documented in 2000)

During the course of this project, voucher specimens have been obtained for the following species (previously undocumented by Park vouchers):

1. Inyo shrew (*Sorex tenellus*)
2. Gray fox (*Urocyon cinereoargenteus*)
3. Yellow-bellied marmot (*Marmota flaviventris*)
4. Chisel-toothed kangaroo rat (*Dipodomys microps*)
5. Northern grasshopper mouse (*Onychomys leucogaster*).

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Figure 1. Map of Great Basin National Park. Closed black circles represent historic survey sites and open circles represent locations surveyed between 2000-2003.

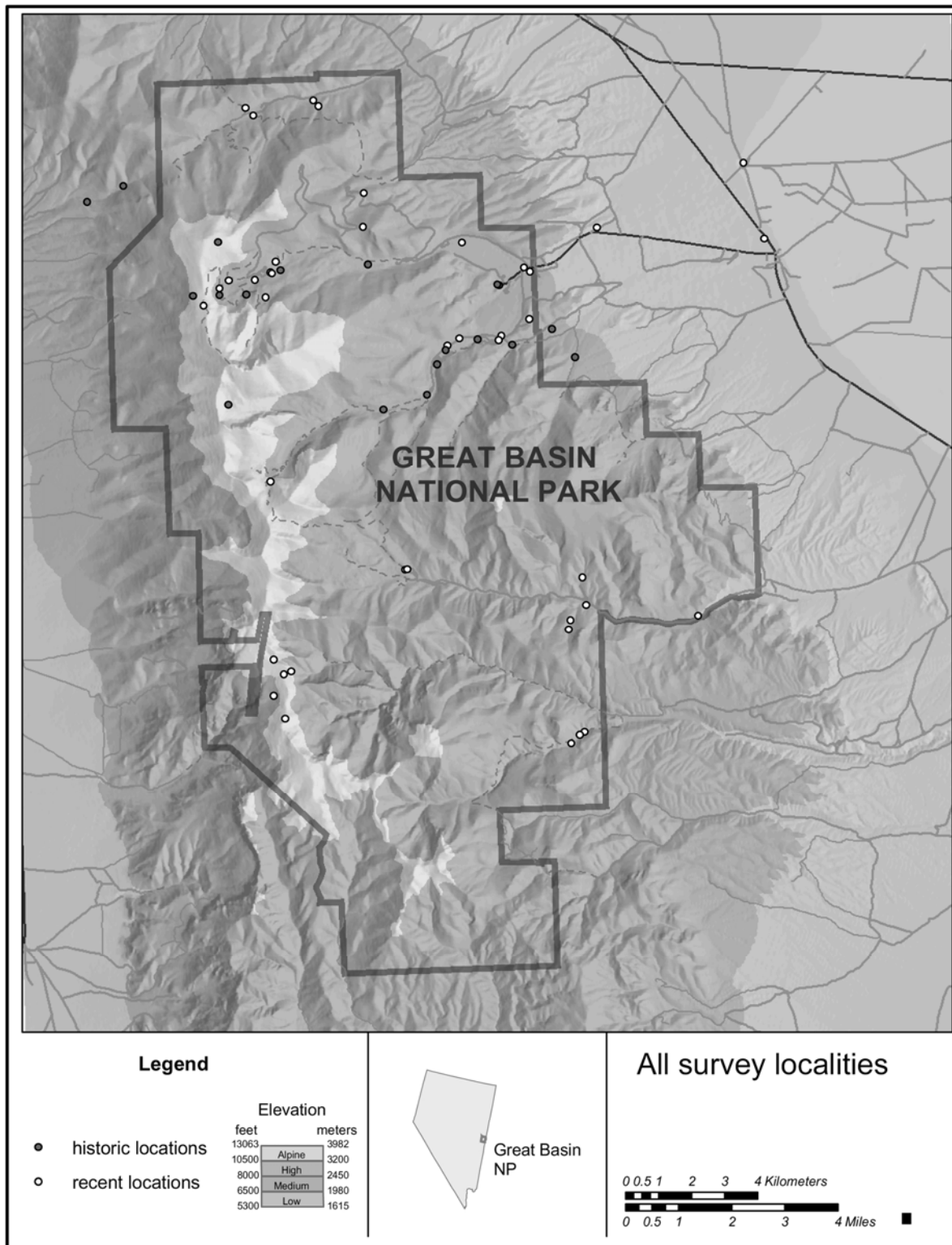


Figure 2. Elevational distribution of small and medium-sized mammals (other than bats) in the Great Basin National Park region. Numbers in bold are captures from recent surveys (2000-2004), numbers in normal type are specimens from historical sources.

Species	Common name	Size group	Low elevation				Mid-elevation				High elevation				Alpine				
			5001-5500	5501-6000	6001-6500	6501-7000	7001-7500	7501-8000	8001-8500	8501-9000	9001-9500	9501-10000	10001-10500	10501-11000	11001-11500	11501-12000	12001-12500	12501-13060	
<i>Sorex merriami</i>	Merriam's shrew	small	X									X							
<i>Sorex palustris</i>	Water shrew	small											X						
<i>Sorex tenellus</i>	Inyo shrew	small										X							
<i>Sorex vagrans</i>	Vagrant shrew	small				X, X	X					X, X				X			
<i>Bassariscus astutus</i>	Ringtail	medium				X													
<i>Mephitis mephitis</i>	Striped skunk	medium																	
<i>Spilogale putorius</i>	Spotted skunk	medium		X															
<i>Mustela frenata</i>	Long-tailed weasel	small																	
<i>Mustela erminea</i>	Ermine	small																	
<i>Sylvilagus nuttallii</i>	Mountain cottontail	medium	X																
<i>Lepus californicus</i>	Black-tailed jackrabbit	medium			X	X	X												
<i>Tamias dorsalis</i>	Cliff chipmunk	small				X, X													
<i>Tamias minimus</i>	Least chipmunk	small	X		X	X	X					X, X							
<i>Tamias umbrinus</i>	Uinta chipmunk	small	X		X	X	X					X, X							
<i>Ammospermophilus leucurus</i>	Antelope ground squirrel	small	X		X														
<i>Spermophilus lateralis</i>	Golden-mantled ground squirrel	small	X																
<i>Spermophilus mollis</i>	Piute ground squirrel	small																	
<i>Spermophilus variegatus</i>	Rock squirrel	medium																	
<i>Marmota flaviventris</i>	Yellow-bellied marmot	medium																	
<i>Perognathus longimembris</i>	Little pocket mouse	small	X																
<i>Perognathus parvus</i>	Great basin pocket mouse	small	X		X, X	X, X	X, X												
<i>Dipodomys microps</i>	Chisel-toothed kangaroo rat	small	X, X	X	X														
<i>Dipodomys ordii</i>	Ord's kangaroo rat	small	X																
<i>Thomomys bottae</i>	Valley pocket gopher	small																	
<i>Reithrodontomys megalotis</i>	Western harvest mouse	small	X		X	X, X	X, X												
<i>Peromyscus crinitus</i>	Canyon mouse	small			X, X	X, X	X, X												
<i>Peromyscus maniculatus</i>	Deer mouse	small	X		X	X, X	X, X												
<i>Peromyscus truei</i>	Piñon mouse	small	X		X, X	X, X	X, X												
<i>Onychomys leucogaster</i>	Northern grasshopper mouse	small	X, X																
<i>Neotoma cinerea</i>	Bushy tailed woodrat	small																	
<i>Neotoma lepida</i>	Desert woodrat	small			X	X	X, X												
<i>Microtus longicaudus</i>	Long-tailed vole	small			X	X	X												
<i>Microtus montanus</i>	Montane vole	small			X	X	X, X												
<i>Lemmiscus curtatus</i>	Sagebrush vole	small					X, X												
<i>Ondatra zibethicus</i>	Muskrat	medium			X														
<i>Mus musculus</i>	House mouse	small																	
Total number of species (in 500 foot interval)			16	11	10	20	19	13	17	11	5	9	7	7	7	1	1	1	
Total number of species (by elevation zone)			21				24				21				11				

Figure 3. Numbers of specimens or captures of small mammals (rodents and shrews) from the Great Basin National Park region by elevation¹. Numbers in bold are captures from recent surveys (2000-2004), numbers in normal type are specimens from historical sources.

Species	Common name	Low elevation			Mid-elevation			High elevation						Alpine				Totals			
		5501-5500	5501-6000	6001-6500	6501-7000	7001-7500	7501-8000	8001-8500	8501-9000	9001-9500	9501-10000	10001-10500	10501-11000	11001-11500	11501-12000	12001-12500	12500-13060				
<i>Sorex merriami</i>	Merriam's shrew	1						1			1			3				1			
<i>Sorex palustris</i>	Water shrew										1							5			
<i>Sorex tenellus</i>	Inyo shrew										1							1			
<i>Sorex vagrans</i>	Vagrant shrew				1, 2	5	2	5	2, 7		1, 21	3		4				19			
<i>Tamias dorsalis</i>	Cliff chipmunk				2, 3	5, 1	1											1			
<i>Tamias minimus</i>	Least chipmunk	2	3	10	6	9	2	2, 3	4	1			15	1				37			
<i>Tamias umbrinus</i>	Uinta chipmunk			2	1	7	4, 6	6, 3	13	1, 12	1, 10	13, 18						39			
<i>Ammospermophilus leucurus</i>	Antelope ground squirrel	2		1	3			5	5			4, 1	7, 2	1				6			
<i>Spermophilus lateralis</i>	Golden-mantled gnd squirrel																	11			
<i>Perognathus longimembris</i>	Little pocket mouse	1	2	3, 13	4, 2	16, 1	5, 2	1										3			
<i>Perognathus parvus</i>	Great basin pocket mouse	1	1	4														3			
<i>Dipodomys microps</i>	Chisel-toothed kangaroo rat	1, 8	15															19			
<i>Dipodomys ordii</i>	Ord's kangaroo rat	4		2	1													5			
<i>Reithrodontomys megalotis</i>	Western harvest mouse	1	4	2	2, 7	6, 3	1, 2											7			
<i>Peromyscus crinitus</i>	Canyon mouse			2, 2	2, 2	4, 2	1											1			
<i>Peromyscus maniculatus</i>	Deer mouse	3		6	20, 10	17, 50	9, 23	4, 24	21	19	1, 41	5, 27	6, 60	1, 3	1			50			
<i>Peromyscus truei</i>	Piñon mouse	2			3, 1	3, 17	2	1					2					7			
<i>Onychomys leucogaster</i>	Northern grasshopper mouse	6, 2	6															6			
<i>Neotoma cinerea</i>	Bushy tailed woodrat					20	2		11	1			1					35			
<i>Neotoma lepida</i>	Desert woodrat			2	4	20, 1			1									8			
<i>Microtus longicaudus</i>	Long-tailed vole		1		5	1	4, 4	2	3		2, 6	1, 6	2, 4	4				15			
<i>Microtus montanus</i>	Montane vole	2	3		8	2	1, 2	3			2	1						21			
<i>Lemmings curtatus</i>	Sagebrush vole	2				2												4			
<i>Mus musculus</i>	House mouse		3		1													4			
Total number of specimens (in 500 foot interval)		14, 24	38	15, 28	57, 33	109, 83	29, 44	21, 39	60, 7	1, 33	7, 80	23, 56	16, 83	14, 3	1	0	0				
Total number of specimens (in elevation zone)		67, 52						195, 160						112, 215						31, 87	
Total number of species (in elevation zone)		16						17						13						8	

¹ Includes those species that are captured by standard snap and pitfall traps. Excludes four small mammal species from Figure 2: *Mustela frenata*, *Mustela erminea*, *Spermophilus mollis*, and *Thomomys bottae*.

Table 1. Comparison of results from grid and directed trapping in Great Basin National Park during 2000-2004.

Grid trapping (sorted by site number)					
	Elevation (feet)	Trap-nights	Number of individuals	Number of species	Overall trap success (%)
2002 grid sites					
0001 (Snake)	7260	72	1	1	1.4
0002 (Snake)	7478	72	2	1	2.8
0003 (Snake)	8350	54	7	3	13.0
0004 (Snake)	7697	54	3	3	5.6
0005 (Snake)	6305	54	3	1	5.6
1001 (Snake)	6889	54	1	1	1.9
1002 (Snake)	7451	54	5	3	9.3
1003 (Snake)	8350	54	7	2	13.0
1004 (Strawberry)	7496	54	5	2	9.3
1005 (Strawberry)	7775	54	8	1	14.8
1006 (Strawberry)	7920	54	8	2	14.8
2002 subtotals		630	50	6	7.9
2004 Lehman Flat grids	6800-7200	1929	116	7	6.0
Total grid trapping		2559	166	8	6.5

Directed trapping (sorted by elevation)					
	Elevation (feet)	Trap-nights	Number of individuals	Number of species	Overall trap success (%)
2002-2003 surveys					
Administrative Site (2002)	5344	39	1	1	2.6
Lehman Creek pitfalls (2002)	6575	62	1	1	1.6
Lower Snake Creek (2002)	7150-7600	202	10	1	5.0
Upper Strawberry Creek (2002)	7966	122	10	6	8.2
Upper Snake Creek (2002)	8350-8525	252	30	7	11.9
Big Wash (2003)	6838-7075	212	54	7	25.5
Pyramid Peak (2003)	10660	112	36	4	32.1
Washington-Lincoln peaks (2003)	10225-11226	388	138	3	35.6
2002-2003 subtotals		1389	280	14	20.2
2000 (within Park only)	6580-11100	1783	277	15	15.5
Total directed trapping		3172	557	20	17.6

Table 2. Elevation range records of mammals (excluding bats) from the Great Basin National Park. Significant range extensions from recent surveys are indicated in bold.

Species	Common name	Elevation records (in feet)		
		pre-2000 records	2000 survey	2002-2004 surveys
<i>Sorex palustris</i>	Water shrew	8400, 11100	9750	none
<i>Sorex tenellus</i>	Inyo shrew	none	9900	none
<i>Sorex vagrans</i>	Vagrant shrew	6600-11100	7450-10350	6575-8525
<i>Canis latrans</i>	Coyote	8000	none	7260*-11400*
<i>Urocyon cinereoargenteus</i>	Gray fox	6700	7100*	10533
<i>Vulpes velox</i>	Kit fox	none	none	(park sightings)*
<i>Bassariscus astutus</i>	Ringtail	none	6850*	7500*
<i>Mephitis mephitis</i>	Striped skunk	none	9850*	(park sightings)*
<i>Mustela erminea</i>	Ermine	8675, 11100	none	11220*
<i>Mustela frenata</i>	Long-tailed weasel	6600-8500	none	(park sightings)*
<i>Spilogale putorius</i>	spotted skunk	8000	none	(park sightings)*
<i>Taxidea taxus</i>	Badger	8100	6150*	5340*
<i>Lynx rufus</i>	Bobcat	8000	7500*	(park sightings)*
<i>Puma concolor</i>	Mountain lion	none	7080*	(park sightings)*
<i>Sylvilagus nuttallii</i>	Mountain cottontail	7200-8675	8500	5430
<i>Lepus californicus</i>	Black-tailed jackrabbit	none	6150*-8500*	10600*
<i>Tamias dorsalis</i>	Cliff chipmunk	6700-7500	7080*	6600- 7697
<i>Tamias minimus</i>	Least chipmunk	5800-8675	9200	8365
<i>Tamias umbrinus</i>	Uinta chipmunk	6200-11100	7550-11000	7775-10817
<i>Ammospermophilus leucurus</i>	Antelope ground squirrel	6900-7000	5275, 6150	none
<i>Spermophilus lateralis</i>	Golden-mantled ground squirrel	8200-11200	10200- 13063*	10200*
<i>Spermophilus mollis</i>	Piute ground squirrel	5800	5275*	5345*
<i>Spermophilus variegatus</i>	Rock squirrel	7300-8450	7080- 9200*	7600-7800*
<i>Marmota flaviventris</i>	Yellow-bellied marmot	12200*	7500*	7000-8500*
<i>Perognathus parvus</i>	Great basin pocket mouse	5800-8300	5275, 6580	6305-7950
<i>Dipodomys microps</i>	Chisel-toothed kangaroo rat	5220-5300	5275, 6150	5340
<i>Dipodomys ordii</i>	Ord's kangaroo rat	6850	5275	none
<i>Thomomys bottae</i>	Valley pocket gopher	6600-10500	8500*, 9850*	8350
<i>Castor canadensis</i>	Beaver	none	(7000* old sign)	6850*
<i>Reithrodontomys megalotis</i>	Western harvest mouse	5800-7700	6150-7450	5340-7950
<i>Peromyscus crinitus</i>	Canyon mouse	6700-7700	none	6850-7450
<i>Peromyscus maniculatus</i>	Deer mouse	6600-11500	5275-11000	5340-11226
<i>Peromyscus truei</i>	Piñon mouse	6700-7500	6700-7000	5340-10700
<i>Onychomys leucogaster</i>	Northern grasshopper mouse	5220-5800	none	5340
<i>Neotoma cinerea</i>	Bushy-tailed woodrat	7200-10800	9200	none
<i>Neotoma lepida</i>	Desert woodrat	5800-8675	6150	7010
<i>Microtus longicaudus</i>	Long-tailed vole	8000-11100	6580-11100	7010-10660
<i>Microtus montanus</i>	Montane vole	5800-9650	7160-10200	7950-8365
<i>Lemmys curtatus</i>	Sagebrush vole	5500, 7200	none	none
<i>Ondatra zibethicus</i>	Muskrat	none	none	(park sightings)*
<i>Mus musculus</i>	House mouse	5300	none	ca. 6800*
<i>Erethizon dorsatum</i>	Porcupine	7300-10600	none	Snake Valley*
<i>Cervus elaphus</i>	Wapiti	none	none	(park sightings)*
<i>Odocoileus hemionus</i>	Mule deer	8800, 9000	(park sightings)*	6150*-12000*
<i>Antilocapra americana</i>	Pronghorn	sightings	(park sightings)*	(park sightings)*
<i>Ovis canadensis</i>	Bighorn sheep	9000 ^S , 12000 ^S	none	(park sightings)*

* sight or sign record

^S old salvaged specimen

Table 3. Mammal species (other than bats) documented from within Great Basin National Park boundaries.

Species	Common name	Size group ¹	Documentation	Elev. range ²	Source(s)	Comments
<i>Sorex palustris</i>	Water shrew	small	voucher specimens	low-high	MVZ & FMNH collections	uncommon, restricted to riparian habitat
<i>Sorex tenellus</i>	Inyo shrew	small	voucher specimen	mid-high	UMNH collection	uncommon or rare, possibly restricted to rocky habitat
<i>Sorex vagrans</i>	Vagrant shrew	small	voucher specimens	low-high	MVZ & UMNH collections	widespread and locally common
<i>Canis latrans</i>	Coyote	large	voucher specimen; sign	low-high	MVZ collection; this report	probably common
<i>Urocyon cinereoargenteus</i>	Gray fox	large	voucher specimens	low-high	MVZ & UMNH collections	common at low elevations
<i>Vulpes velox</i>	Kit fox	large	multiple sightings	low-mid	GRBA staff	probably common at low elevations
<i>Bassariscus astutus</i>	Ringtail	medium	voucher specimen	low-mid	GRBA collection	probably common at low elevations
<i>Mephitis mephitis</i>	Striped skunk	medium	multiple sightings	low-high	Rickart & Heaney 2000	probably common at low elevations
<i>Mustela erminea</i>	Ermine	small	voucher specimens	mid-high	MVZ collection	most common at mid-high elevations
<i>Mustela frenata</i>	Long-tailed weasel	small	voucher specimens	low-high	MVZ	most common at low elevations
<i>Spilogale putorius</i>	spotted skunk	medium	published records, sightings	low-mid	Hall 1946; GRBA staff	probably common at low elevations
<i>Taxidea taxus</i>	Badger	large	voucher specimen	low-high	MVZ	most common at low elevations
<i>Lynx rufus</i>	Bobcat	large	voucher specimens	low-high	MVZ	probably moderately common
<i>Puma concolor</i>	Mountain lion	large	voucher specimens	low-high	MVZ collection; GRBA staff	probably moderately common
<i>Sylvilagus nuttallii</i>	Mountain cottontail	medium	voucher specimens	low-high	MVZ & UMNH collections	common
<i>Lepus californicus</i>	Black-tailed jackrabbit	medium	voucher specimens	low-high	MVZ & UMNH collections	most common at low elevations
<i>Tamias dorsalis</i>	Cliff chipmunk	medium	sightings	low-high	Rickart & Heaney 2000; this report	common
<i>Tamias minimus</i>	Least chipmunk	small	voucher specimens	low-mid	MVZ & UMNH collections	uncommon
<i>Tamias umbrinus</i>	Uinta chipmunk	small	voucher specimens	low-high	MVZ & UMNH collections	uncommon, primarily sagebrush. Formerly more common
<i>Ammospermophilus leucurus</i>	White-tailed antelope squirrel	small	voucher specimens	low-high	MVZ & UMNH collections	abundant in virtually all habitats
<i>Spermophilus lateralis</i>	Golden-mantled ground squirrel	small	voucher specimens	low	MVZ & UMNH collections	uncommon at low elevations
<i>Spermophilus mollis</i>	Plute ground squirrel	small	voucher specimens	mid-high	MVZ & UMNH collections	common at high elevations, uncommon elsewhere
<i>Spermophilus variegatus</i>	Rock squirrel	medium	voucher specimens	low	this report; MVZ collection	common at low to mid elevations
<i>Marmota flaviventris</i>	Yellow-bellied marmot	medium	voucher specimens	mid-high	MVZ & UMNH collections	common locally at mid elevations
<i>Perognathus parvus</i>	Great basin pocket mouse	small	voucher specimens	low-mid	MVZ & UMNH collections	common at low to mid elevations
<i>Dipodomys microps</i>	Chisel-toothed kangaroo rat	small	voucher specimens	low	MVZ & UMNH collections	common locally at mid elevations
<i>Dipodomys ordii</i>	Ord's kangaroo rat	small	voucher specimens	low	MVZ & UMNH collections	uncommon, lowest elevation
<i>Thomomys bottae</i>	Valley pocket gopher	small	voucher specimens	low-high	MVZ & UMNH collections	most common at low elevations
<i>Castor canadensis</i>	Beaver	large	sighting	mid	GRBA staff	historically extinct, reestablished
<i>Reithrodontomys megalotis</i>	Western harvest mouse	small	voucher specimens	low-mid	MVZ & UMNH collections	locally common, grassy habitat
<i>Peromyscus crinitus</i>	Canyon mouse	small	voucher specimens	low-mid	MVZ & UMNH collections	uncommon, rocky habitat
<i>Peromyscus maniculatus</i>	Deer mouse	small	voucher specimens	low-high	MVZ & UMNH collections	abundant in virtually all habitats
<i>Peromyscus truei</i>	Piñon mouse	small	voucher specimens	low-high	MVZ & UMNH collections	locally common in piñon juniper, rare at high elevations
<i>Onychomys leucogaster</i>	Northern grasshopper mouse	small	voucher specimens	low	MVZ & UMNH collections	uncommon or rare at low elevations
<i>Neotoma cinerea</i>	Bushy-tailed woodrat	small	voucher specimens	mid-high	MVZ & UMNH collections	locally uncommon, formerly more common
<i>Neotoma lepida</i>	Desert woodrat	small	voucher specimens	low-mid	MVZ & UMNH collections	common at low elevations, formerly more common
<i>Microtus longicaudus</i>	Long-tailed vole	small	voucher specimens	low-mid	MVZ & UMNH collections	common in grassy areas, less common elsewhere
<i>Microtus montanus</i>	Montane vole	small	voucher specimens	low-high	MVZ & UMNH collections	uncommon to common, restricted to riparian areas
<i>Lemmys curtatus</i>	Sagebrush vole	small	voucher specimens	low-high	MVZ & UMNH collections	uncommon or rare, restricted to sagebrush
<i>Ondatra zibethicus</i>	Muskrat	medium	voucher specimens	low	MVZ collection	locally restricted to aquatic habitats
<i>Mus musculus</i>	House mouse	medium	sighting	low	GRBA staff	probably restricted to buildings and nearby disturbed habitat
<i>Erethizon dorsatum</i>	Porcupine	small	unvouchered trap record	low	GRBA staff	formerly common, now rare or possibly extinct in Park
<i>Cervus elaphus</i>	Wapiti	large	voucher specimens	low-high	MVZ collection	historically extinct, reestablished
<i>Odocoileus hemionus</i>	Mule deer	large	sightings	low-high	Hall 1946; this report	common, widespread
<i>Antilocapra americana</i>	Pronghorn	large	voucher specimens	low	this report	common at low elevations, occasional occurrence in Park
<i>Ovis canadensis</i>	Bighorn sheep	large	sightings	high	Hall 1946; this report	historically extinct, reestablished and rare

¹ small (< 500 g); medium (500 g - 5 kg); large (> 5 kg)

² low (< 6000 ft); mid (6000 - 8000); high (> 8000)

Table 4. Mammal species (other than bats) that potentially occur within Great Basin National Park.

Species	Common name	Size group ¹	Documentation	Source(s)	Probability of occurrence	Comments
<i>Sorex merriami</i>	Merriam's shrew	small	regional record (near Baker)	MVZ collection	high	Probably rare in low-mid elevation sagebrush habitat in Park
<i>Canis lupus</i>	Gray wolf	large	historical record from E Nevada	MVZ collection	low	Historically extinct, very low probability of recolonization
<i>Vulpes vulpes</i>	Red fox	large	regional sightings (Snake Valley)	GRBA staff	low	Report sightings may be other species, may be introduced
<i>Procyon lotor</i>	Raccoon	large	records from E Nevada, W Utah	Hall 1946, 1981; MVZ & UMNH	low	Not present, but future occurrence very probable
<i>Mustela vison</i>	Mink	medium	records from E Nevada	Hall 1946, 1981; MVZ collection	low	Not present, future occurrence possible but unlikely
<i>Brachylagus idahoensis</i>	Pygmy rabbit	medium	regional record (Spring Valley)	Hall 1946; MVZ collection	low-moderate	Possibly rare in low elevation sagebrush habitat in Park
<i>Sylvilagus auduboni</i>	Desert cottontail	medium	regional records (N Snake Valley)	Hall 1946; MVZ collection	low-moderate	Unlikely at lowest elevations in Park
<i>Chaetodipus formosus</i>	Long-tailed pocket mouse	small	regional records (N Snake Range)	MVZ collection	low-moderate	Possibly in rocky habitat at low elevations in Park
<i>Perognathus longimembris</i>	Little pocket mouse	small	regional records (Snake valley)	FMNH & NSMC collections	low-moderate	Unlikely at lowest elevations in Park
<i>Microdipodops megacephalus</i>	Dark kangaroo mouse	small	regional record (Spring Valley)	MVZ collection	low	Very unlikely at lowest elevations in Park

¹ small (< 500 g); medium (500 g - 5 kg); large (> 5 kg)

Table 5. Recent mammal species of prehistoric (late Quaternary) occurrence no longer present in the Park region.

Species	Common name	Records	Within GRBA?	Source(s)	Comments
<i>Gulo luscus</i>	Wolverine	Snake Creek Burial Cave	yes	Barker & Best 1976	
<i>Martes americana</i>	Marten	Lehman Cave	yes	Zielger 1964	may represent the extinct <i>Martes nobilis</i> (Grayson 1993)
		Crystal Ball Cave	no	Heaton 1990	may represent the extinct <i>Martes nobilis</i> (Grayson 1993)
<i>Mustela vison</i>	Mink	Crystal Ball Cave	no	Heaton 1990	
<i>Lepus cf. americana</i>	Snowshoe hare	Crystal Ball Cave	no	Heaton 1990	
<i>Lepus cf. townsendii</i>	White-tailed jackrabbit	Gatecliff Shelter	no	Grayson 1983	species identification uncertain (may be <i>L. californicus</i>)
		Crystal Ball Cave	no	Heaton 1990	
<i>Ochotona princeps</i>	Pika	Smith Creek Cave	no	Thompson & Mead 1982	
		Crystal Ball Cave	no	Heaton 1990	
<i>Thomomys cf. talpoides</i>	Northern pocket gopher	Lehman Cave	yes	Zielger 1964	questionable species identification (probably <i>T. bottae</i>)
<i>Phenacomys intermedius</i>	Heather vole	Smith Creek Cave	no	Miller 1979	questionable species identification (probably <i>T. bottae</i>)
		Gatecliff Shelter	no	Grayson 1981	
<i>Synaptomys borealis</i>	Northern bog-lemming	Smith Creek Cave	no	Thompson & Mead 1982	
		Smith Creek Cave	no	Mead et al. 1992	

Table 6. Comparison of small mammal surveys at locations within GRBA sampled historically and re-sampled recently.

Species	Common name	Historical records (1929-1930)		Recent records (2000 - 2003)	
Low elevation -- vicinity of Baker (5,300 - 6,000 ft).		Presence/ absence	Number of vouchers	Presence/ absence	Number of vouchers
<i>Tamias minimus</i>	Least chipmunk	1	4	0	0
<i>Ammospermophilus leucurus</i>	Antelope ground squirrel	0	0	1	3
<i>Spermophilus mollis</i>	Piute ground squirrel	1	1	1	(sign)
<i>Dipodomys microps</i>	Chisel-toothed kangaroo rat	1	15	0	10
<i>Dipodomys ordii</i>	Ord's kangaroo rat	0	0	1	4
<i>Perognathus longimembris</i>	Little pocket mouse	0	0	1	1
<i>Perognathus parvus</i>	Great Basin pocket mouse	0	0	1	13
<i>Reithrodontomys megalotis</i>	Western harvest mouse	1	4	1	3
<i>Peromyscus maniculatus</i>	Deer mouse	0	0	1	8
<i>Peromyscus truei</i>	Piñon mouse	0	0	1	2
<i>Onychomys leucogaster</i>	Northern grasshopper mouse	1	6	1	2
<i>Neotoma lepida</i>	Desert woodrat	1	1	1	2
<i>Microtus montanus</i>	Montane vole	1	3	0	0
Number of species		7		10	
Mid-elevation -- Baker Creek drainage (6,500 - 7,500 ft).					
<i>Sorex vagrans</i>	Vagrant shrew	1	1	1	1
<i>Tamias dorsalis</i>	Cliff chipmunk	1	1	1	sighting
<i>Tamias minimus</i>	Least chipmunk	1	15	0	0
<i>Tamias umbrinus</i>	Uinta chipmunk	0	0	1	4
<i>Ammospermophilus leucurus</i>	Antelope ground squirrel	1	2	0	0
<i>Spermophilus variegatus</i>	Rock squirrel	1	2	1	1
<i>Perognathus parvus</i>	Great Basin pocket mouse	1	10	0	0
<i>Reithrodontomys megalotis</i>	Western harvest mouse	1	6	1	3
<i>Peromyscus crinitus</i>	Canyon mouse	1	4	0	0
<i>Peromyscus maniculatus</i>	Deer mouse	1	15	1	35
<i>Peromyscus truei</i>	Piñon mouse	0	0	1	8
<i>Neotoma cinerea</i>	Bushy-tailed woodrat	1	15	0	0
<i>Neotoma lepida</i>	Desert woodrat	1	21	0	0
<i>Lemmys curtatus</i>	Sagebrush vole	1	2	0	0
<i>Microtus longicaudus</i>	Long-tailed vole	0	0	1	3
<i>Microtus montanus</i>	Montane vole	1	8	1	1
Number of species		13		9	
High elevation -- upper Lehman Creek and Stella Lake areas (8,200 - 10,500 ft)					
<i>Sorex palustris</i>	Water shrew	1	1	1	1
<i>Sorex vagrans</i>	Vagrant shrew	0	0	1	2
<i>Tamias minimus</i>	Least chipmunk	1	1	0	0
<i>Tamias umbrinus</i>	Uinta chipmunk	1	10	1	10
<i>Spermophilus lateralis</i>	Golden-mantled ground squirrel	1	7	1	1
<i>Peromyscus maniculatus</i>	Deer mouse	1	8	1	43
<i>Microtus longicaudus</i>	Long-tailed vole	1	3	1	13
<i>Microtus montanus</i>	Montane vole	0	0	1	1
Number of species		6		7	

* excluding pitfall trapping

Table 7. Mammal species (other than bats) in Great Basin National Park of special concern.

Species	Common name	Current status	Comments
<i>Sorex palustris</i>	Water shrew	rare habitat specialist	key indicator species for riparian communities
<i>Puma concolor</i>	Mountain lion	apparently common	requires monitoring as a key predator of large ungulates
<i>Marmota flaviventris</i>	Yellow-bellied marmot	uncommon	requires monitoring as an important species in alpine habitats
<i>Spermophilus lateralis</i>	Golden-mantled ground squirrel	locally common	potential indicator species for alpine forest communities
<i>Castor canadensis</i>	Beaver	recolonizing	critical species for reestablishing riparian communities
<i>Neotoma cinerea</i>	Bushy tailed woodrat	uncommon, historical decline	requires monitoring as important species in rocky habitat
<i>Lagurus curtatus</i>	Sagebrush vole	rare habitat specialist	key indicator species for sagebrush communities
<i>Erethizon dorsatum</i>	Porcupine	rare, historical decline	potential indicator species for alpine forest communities
<i>Ovis canadensis</i>	Bighorn sheep	reestablished, but uncommon	requires monitoring an important large ungulate