Final Report for 2003 and 2004 Mammal Inventories on Selected National Park Service Southern Colorado Plateau Network Parks:

Navajo National Monument

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ABSTRACT

Holistic Wildlife Services NM was contracted by the Navajo Nation Department of Fish and Wildlife to conduct biological inventories for mammals at Navajo National Monument (NAVA) as part of the National Park Service Inventory and Monitoring Program. The goals of this study were to document at least 90% of the mammals using verifiable documentation and taxa-specific field surveys, provide distributional information, estimates of species richness, and relative abundance of mammals, and provide baseline information and make recommendations to develop future management and monitoring schemes of zoological resources. There had been no baseline mammal work conducted at NAVA prior to these surveys. A total of 26 mammal species were estimated to inhabit the park based on species-area models; however we estimated 51 species for NAVA based on known specific ranges and available museum records. Field inventories extended from 29 June to 29 September 2003, and 16 May to 5 July 2004. We used a variety of survey methods including live-trapping, mist netting and acoustic surveys for bats, track-scat surveys, and opportunistic observations. We documented a total of 41 species (Chiroptera, 12 species; Lagomorpha, 2 species; Rodentia, 18 species; Carnivora, 8 species; and Artiodactyla, 1 species). Our survey efforts documented 80% of the 51 species we considered potential to occur, and we documented an additional 58% compared to the 26 species predicted by species-area models. The deer mouse was the most abundant species of mammal at NAVA during both field seasons, accounting for 66.5% and 38.9% of all captures in 2003 and 2004, respectively. One Navajo Tribal-listed endangered species, Townsend's big-eared bat, was documented during this study.

Key Words: Navajo National Monument, inventory, Inventory and Monitoring Program, mammal, National Park Service.

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INTRODUCTION

The Colorado Plateau of the southwestern United States is a topographically diverse region that accommodates the highest native mammalian species richness in the country (Mac et al. 1998). In particular, Arizona's landscape of pine forests, cactus deserts, high plateaus, and deep canyons has resulted in the presence of more than 140 mammalian species (Hoffmeister 1986). With such a large number of species, this area became the focus of many biological studies. Dr. C.B.R. Kennerly collected specimens and recorded observations in 1853 and 1854 as part of a survey team seeking railroad routes to the Pacific Coast. Dr. Samuel Woodhouse was a naturalist and part of an expedition to study the Colorado and Little Colorado rivers in 1851. Many naturalists were also associated with military outposts in Arizona during the mid 1800's. Dr. Elliot Coues collected mammals around Fort Whipple and wrote the first published account of the mammals of Arizona in 1867. When the United States Biological Survey was established in the late 1800's, mammal collecting intensified and many biologists were sent to Arizona, intending to prepare a report on the mammals of Arizona. Vernon Bailey, C. Hart Merriam, and E. A. Goldman were just a few of the federal mammalogists that spent many years collecting in the state.

Interest in the biological resources of Arizona has continued to the present day with many persons and institutions conducting scientific research and making collections in the region. Despite nearly two hundred years of scientific interest in Arizona, some areas remain relatively unstudied. As part of the National Park Service Inventory and Monitoring (NPS I&M) program Navajo National Monument (NAVA), part of the Southern Colorado Plateau Network (SCPN), was identified as having significant natural resources that were not well documented. No baseline mammal work had been conducted there and estimated completeness was 25% for

NAVA (Stuart 2000) prior to this work. This park needed full, directed surveys conducted by experienced investigators. This report provides a description of the results of biological inventories for mammals conducted on NAVA during 2003 and 2004.

Objectives

The overall goal of the inventory phase of the NPS I&M program was to provide park resource managers with systematically rigorous baseline information that could be used in the development of a monitoring strategy. Considering that goal, there were several objectives of the mammal inventory including:

1. Document at least 90% of the mammals using verifiable documentation and taxa-specific field surveys with methods consistent with other NPS units in the SCPN.
2. Provide distributional information, as well as estimates of species richness and relative abundance.
3. Provide baseline information and make recommendations to develop future management and monitoring schemes of zoological resources.

STUDY AREA

The Colorado Plateau is a geologically and topographically distinct region. It is situated between the arid Great Basin to the west and the lush forests of the Rocky Mountains to the east, covering approximately 130,000 mi^2 from southeastern Utah and western Colorado, to northern Arizona and northwestern New Mexico (Wheeler 1990). The region lies in the zone of arid-temperate climates in North America. This type of climate is characterized by periods of drought and irregular precipitation, relatively warm to hot growing seasons, and long winters with

sustained periods of freezing temperatures. Winters are dominated by Pacific region storm patterns, while summers (on the southern portions of the Plateau) are dominated by monsoonal moisture from the Gulf of Mexico. Low, open woodlands of drought-adapted conifers at higher elevations and extensive areas of drought-tolerant shrubs and grasses at lower elevations characterize the vegetation.

Navajo National Monument encompasses 145.8 ha (360 ac) of sandstone canyons and is situated about 22.5 km (14 mi) west of Kayenta, in Coconino and Navajo Counties, Arizona. It includes three discrete sites, each containing 13th century cliff dwellings: Betatakin, Keet Seel, and Inscription House (including Owl House and Snake House). Each site is located on federal lands surrounded by those owned by the Navajo Nation. This inventory also included an additional 97.2 ha (240 ac) of land, leased under agreement with the Navajo Nation, where park headquarters, a visitor center, and campgrounds are located. Betatakin is comprised of 64.8 ha (160 ac) adjacent to the headquarters and is the primary visitor area. Elevation ranges from 1790 m to 2210 m (5870 ft to 7250 ft). The Keet Seel site includes 64.8 ha, located in Keet Seel Canyon, 10 km (6 mi) northeast of headquarters. Elevation ranges from 2050 m to 2280 m (6730 ft to 7480 ft). The Inscription House site includes 16.2 ha (40 ac) and is located more than 50 km (31 mi) by road from headquarters near the mouth of Nitsin Canyon. Access to all sites requires travel through Navajo Nation lands.

The vegetation of NAVA is generally characterized as Great Basin desert scrub on the valley floors and juniper-piñon (*Juniperus* sp.-*Pinus edulis)* woodlands at higher elevations (Hoffmeister 1986). Sagebrush (*Artemisa* spp.) and grasses dominate the floor of Betatakin Canyon, while the north facing slopes near the head of the canyon include relictual Douglas fir (*Pseudotsuga menziesii*) and quaking aspen (*Populus tremuloides*) forest with a secondary story

of scrub oak (*Quercus gambellii*). The south facing slopes are dominated by juniper-piñon woodlands and associated ground cover (primarily bunch grasses). Abundant sand, exposed sandstone, shear cliffs and rocky outcrops are located throughout the area. The top of the mesa above Betatakin Canyon is characterized as juniper-piñon woodland. The Keet Seel site is characterized by scrub oak and juniper-piñon woodlands at higher elevations, while cottonwoods (*Populus fremontii*), box elder (*Acer negundo*), and sagebrush grow along the riverbanks. Inscription House is located in cliffs above a perennial stream. The riparian area has been severely eroded, and riparian vegetation is dominated by saltcedar (*Tamarix ramosissima*), however some cottonwoods persist in the river bottom. Vegetation on the valley floor (located roughly 30 feet above the level of the river) includes sagebrush, snakeweed (*Gutierezzia sarothrae*), and cheat grass (*Bromus tectorum*), and appears to be heavily modified by grazing. A small area located immediately below Inscription House ruins is protected from livestock and contains vegetation that is likely a remnant of the community that dominated the valley floor prior to grazing. This community includes a variety of cactus, bunch grasses, and shrubs, which were not observed in any areas accessible to grazing animals.

METHODS

In order to meet our objectives, we implemented the following methods:

Objective 1

The NPS Inventorying and Monitoring Planning Team (NPSIMPT; see Stuart 2000) used species-area models to predict the number of mammalian species that would inhabit each park. They predicted that 26 species would likely occur in NAVA. We compiled an additional list of

species likely to occur in the park based on known specific ranges and available museum records. This list was developed by studying known ranges and habitat associations of mammals in Arizona, and through consulting museum records and other accessible databases that might include more recent information. Through these efforts, we produced a potential species pool of 51 species for NAVA.

We used these lists to calculate percent documentation and assess inventory completeness. Field surveys for specific groups of mammals were conducted in a manner consistent with other SCPN parks as follows:

Small terrestrial mammal inventories

Inventories for rodents and other small mammals were conducted using Sherman live traps arranged in traplines (Wilson et al. 1996). Traplines generally consisted of 20 paired trap stations placed at 15 m (15 ft) intervals for a minimum distance of 300 m (984 ft). Traps were baited with dry oatmeal and left open overnight, and sometimes during diurnal hours.

Trapping areas were selected so that each major type of habitat within a given park was sampled. Traplines were stratified by habitat with randomly selected starting points and, where feasible, extend through only one habitat (Stuart 2000). Effort is reported as number of trap-nights (total number of traps multiplied by number of days).

Bat inventories

Bats were inventoried using mist nets and acoustic surveys. Mist nets were strung across and around bodies of water in order to capture bats coming in to drink or feed on insects flying over the water (Kunz 1988). Size of nets ranged from 6-20 m (18-60 ft) and number of nets

varied depending on the area of the body of water. Mist nets were set up shortly before sunset and tended for several hours or until sunrise. This method is especially effective when sources of water in the landscape are limited, as this causes bats to be concentrated in a relatively small area allowing them to be more easily captured.

Acoustic surveys entailed the use of a bat detector and zero-crossing analysis interface module (ZCAIM; Anabat II hardware, Anabat software version 6.3f; Titley Electronics, Ballina, New South Wales, Australia) with a laptop computer, which recorded echolocation calls. A bat detector produces audible output from the ultrasonic calls emitted by echolocating bats. The ZCAIM interfaces the audio-frequency signal from the detector to a computer. Analyses were performed using Analook software (version 4.8n, Titley Electronics, Ballina, New South Wales, Australia). The frequency-time display generated by the software from detected echolocation call sequences was used to identify species based on qualitative analysis of call parameters compared to reference calls from known individuals (Fenton and Bell 1981; O'Farrell et. al. 1999). This method is useful when no water is available over which to net or when water is too ample to effectively concentrate bats over a small enough area for capture. Acoustic surveys are also useful for detecting species that are not easily captured in mist nets.

Effort was recorded as net-nights (number of mist nets multiplied by number of nights) and acoustic hours (total number of hours spent recording echolocation calls).

Carnivore inventories

Carnivores were documented primarily through track and scat surveys. Track and scat surveys entailed area searches on foot in locales likely to attract animals and show evidence of animals, such as around water sources, in canyon bottoms, in sandy soils, and around areas

where humans leave refuse (e.g. campgrounds and housing areas). Effort for carnivore inventories was quantified as estimated distance surveyed (km).

Opportunistic observations

Anytime a species or sign of a species (e.g. tracks, scat, middens) was observed that was not documented by trapping or other means, it was noted. Location was recorded for all opportunistic observations, and when possible a voucher photograph was obtained. Opportunistic observations are the predominant means of documenting ungulates, but many other species are also documented in this manner.

We also confirmed the presence of some species using reliable park observation files and by talking to knowledgeable park staff and local residents.

Objective 2

Species richness (number of species documented) and relative abundance of species (percent of all individuals detected) was calculated for NAVA. We also provided summaries of effort including person-days, trap-nights, mist net-nights, acoustic hours and survey distance, as appropriate. We also updated the mammal species list based on captures, observations, and historical records.

Objective 3

Data for NAVA was analyzed and summarized for this report to the Navajo Natural Heritage Program (NNHP) following the completion of two seasons of fieldwork. Data from field studies was provided to the NNHP in requested formats. Then, we made management and

monitoring recommendations pertaining to any species of concern or interest documented during this study.

RESULTS

Objective 1

Following two years of mammal inventories at NAVA, we calculated that we documented 80% (41 species) of the 51 mammal species that potentially occur on the park (Tables 3 and 4).

We documented 75% of the number of bat species likely to occur at NAVA (12 species), 100% of the lagomorphs (2 species), 90% of the rodents (18 species), 67% of the carnivores (8 species), and 100% of the ungulates (1 species).

Copies of all data sheets, photographs, and field journals were provided to Navajo Nation Department of Fish and Wildlife. Voucher specimens were deposited in the U.S. Geological Survey mammal collection at the Museum of Southwestern Biology, University of New Mexico.

Objective 2

Efforts at NAVA yielded 59 person days, 3,581trap nights, 24 mist net nights, 32.8 hours of acoustic surveys, and 260.4 km of track and scat surveys (Tables 1 and 2). Live trapping success rate was approximately 20.0% in 2003 and 14.7 % in 2004. Current level of species richness at NAVA is 41 species. The National Park Service Inventory and Monitoring Planning Team estimated that 26 species of mammals likely occur at NAVA (Stuart 2000).

The deer mouse was the most abundant species of mammal at NAVA during the 2003

field season. Deer mice accounted for 66.5% of all captures, far exceeding the relative abundance of the next most common species (the canyon mouse and brush mouse which each accounted for 5.5% of all captures (Table 5).

During 2004, deer mice were again the most abundant species, comprising 38.9% of the species documented. The brush mouse was the next most abundant species, accounting for 32.1% of the species documented (Table 5).

Objective 3

Several Species of Concern (as listed by the Arizona Natural Heritage Data Management System, January 2003) were documented at NAVA: western small footed myotis, long-eared myotis, long-legged myotis, Yuma myotis, Townsend's big-eared bat, Allen's big-eared bat, and spotted bat. Townsend's big-eared bat is also listed as a Group 4 (G4) species by the Navajo Nation Department of Fish and Wildlife. A G4 species is defined as any species for which there is currently insufficient information for a higher listing (i.e. Group 2 or Group 3), but there is reason to consider them.

DISCUSSION AND RECOMMENDATIONS

The overall goal of the inventory phase of the NPS Inventory and Monitoring Program was to provide park resource managers with systematically rigorous baseline information that may result in the development of a monitoring strategy. Considering that goal, there were several objectives for the mammal inventories conducted at NAVA. These were to, 1) document at least 90% of the mammals using verifiable documentation and taxa-specific field surveys with

methods consistent with other NPS units in the SCPN, 2) provide distributional information, as well as estimates of species richness and relative abundance using field surveys with methods consistent with other NPS units in the SCPN, 3) provide baseline information and make recommendations to develop future management and monitoring schemes of zoological resources. We were also expected to document presence of species using the best means possible (specimens, photographs, or other forms of evidence) and complete and transfer zoological specimens and required data in hard-copy and digital formats usable by the NPS.

Objective 1 *- document at least 90% of the mammals using verifiable documentation and taxa-specific field surveys with methods consistent with other NPS units in the SCPN.*

Interestingly, we confirmed more species than was predicted by the NPSIMPT. The 41 confirmed species at NAVA exceeds the NPSIMPT prediction (26) by 58%. The NPSIMPT used species-area models alone to predict the number of mammalian species that would inhabit each park. This application invokes principles of island biogeography through which park (island) area is used to predict species diversity. The NPSIMPT estimates of mammalian diversity assume that either landscape heterogeneity plays no role in species diversity, or that there is always a positive correlation between park size and habitat diversity. By using this model they seemed to assume that parks represent insular units, surrounded by landscapes of unusable habitat, whereby park area alone determines species diversity. These assumptions have been controversial since the first publication of "The Theory of Island Biogeography" by MacArthur and Wilson (1963), and it has since been determined that species area relationships lose sensitivity at small spatial scales (for example, see Simberloff, 1982). Additionally, the NPSIMPT estimates are ambiguous as they fail to discern residents from vagrants or clearly

define species presence (i.e., breeding populations). Regardless, the fact that we confirmed higher mammalian diversity than predicted by the NPSIMPT clearly indicates that, at least for these parks, species-area models alone underestimated mammalian diversity. Alternatively, the broad approach of the sampling design may not have accounted for conditions of individual parks nor taken advantage of investigators' specialized knowledge of species or habitats in predicting species richness.

Had we merely accepted the NPSIMPT estimates, we would have conducted far less intensive monitoring and subsequently underestimated the mammal diversity of each park. By creating our own lists of potential species we were prompted to conduct more intensive sampling than that recommended by the NPSIMPT. We documented 41 species at NAVA (80% of species of the 51 on our list). Percentages of documentation varied by mammalian order, with highest levels of documentation occurring in groups that occupy lower trophic levels (primary consumers), as they tend to occur in high local densities relative to organisms higher up the food web. Within the primary consumers, we found highest levels of documentation among species that are easily observed such as large bodied, ungulates (100%), and lagomorphs (100%). High levels of documentation were also found in primary consumers with small home ranges and limited capability for dispersal such as rodents (90%). Lowest levels of detection were found in species that represent secondary and tertiary consumers (predators). We documented 67% of carnivores from our species list at NAVA. Similarly, we confirmed 63% of bats at NAVA. Both carnivores and bats live predatory lifestyles and are dependent on primary consumers as prey items.

Because energy is lost between each trophic level, the total biomass (i.e., number of individuals) decreases by between 84-96% for each step up the food web. Therefore, by

definition, fewer predators will be found per unit area relative to primary consumers, and individuals will likely have much larger home ranges than will prey species. An inverse relationship generally exists between species abundance and detectability, and between home range size and detectability. Because predators are both less abundant and function over larger spatial scales than prey items, it is likely that some undetected species of carnivores and bats from our species pool use NAVA but their presence was masked by low densities, or they may use the park occasionally, and in a transitory fashion, and were simply not present during the period of this study.

Objective 2 *- provide distributional information, as well as estimates of species richness and relative abundance using field surveys with methods consistent with other NPS units in the SCPN.*

As a result of these surveys we were able to document species richness at NAVA as 41 species. Patterns of abundance and distribution of mammal species varied between years included in this study. The deer mouse was the most abundant species of mammal at NAVA during both the 2003 and 2004 field seasons, followed by the canyon mouse and brush mouse in 2003 (each of which accounted for 5.5% of all captures), and the brush mouse in 2004 (32.1% of total captures). Temporal variation in relative abundance of rodent species is not uncommon as populations of rodents are sensitive to local food abundance (i.e., seed production), have high reproductive output and are profoundly impacted by density-dependent pressures. As a result, many species of rodents can explode in numbers during some years, and be virtually absent during others.

While some species were found to be ubiquitous throughout NAVA (i.e., deer mouse, red

fox, coyote), others appear more limited in their distribution. For example, heteromyids (kangaroo rat burrows and pocket mice) were limited to sandy areas of valley bottoms at Keet Seel and Inscription House. The brush mouse was most commonly found in and around scrub oak and was most commonly captured in Betatakin Canyon. Piñon mice were always captured in areas dominated by juniper-piñon woodlands, and were largely excluded from valley floors. Canyon mice were generally captured in and amongst rocky outcrops, with most captures of this species being in Betatakin Canyon. The only capture of a grasshopper mouse was amongst bunch grasses and cactus in Betatakin Canyon. Additionally, Hopi chipmunks and white-footed woodrats were most commonly observed in Betatakin Canyon. The strong association of these species with the Betatakin site is not surprising in that this area contains the largest elevational relief and most diverse vegetative communities of all of the sites sampled at NAVA.

Objective 3 *- provide baseline information and make recommendations to develop future management and monitoring schemes of zoological resources.*

Baseline information for NAVA is included in the results section and associated tables and figures. Based on the information collected during these surveys we strongly recommend that this park prioritize, maintain, and promote vegetative diversity within their park boundaries. The fact that NAVA has higher levels of species richness than would be expected based on park size is likely, at least in part, due to the habitat diversity within there, and the incredible diversity of the landscapes in which it is situated. Additionally, the dynamic nature of mammal communities observed in these surveys (variation in trapping success, relative abundance of species, and detectability) illustrates the importance of multi-year sampling for establishing baseline data. We recommend that any future monitoring at this park be established over the

long-term so that natural variation in community dynamics does not become confused with population trends (declines or increases) at either park.

Much of the diversity at NAVA was associated with the diverse habitat and elevational relief in the park. Betatakin Canyon and the associated mesa tops include dramatic examples of habitat diversity (vegetative communities ranging from great basin desert scrub to aspen and coniferous forest) compressed into a small geographic area. As a result, desert and montane species exist in sympatry. The high mammalian richness in Betatakin Canyon is also a likely reflection of its diverse elevational and vegetational offerings. Despite the fact that diversity in this area is high, we know little about how individual species interact, and what the background community dynamics are. It is possible that such the small area included in the park experiences regular species turnover, such that patterns of species occurrence and relative abundance vary across temporal scales. In order to document community stability, we recommend that permanent sampling grids be established in Betatakin Canyon that include trap stations as described by Wilson et al. (1996). Capture/recapture techniques should then be used to investigate community dynamics of small terrestrial mammals through time.

Additionally, all of the Arizona Natural Heritage Species of Concern found at NAVA were bats (see results), and one (Townsend's big-eared bat) is also listed as a Group 4 (G4) species by the Navajo Nation Department of Fish and Wildlife. Therefore, it is critical that data regarding use of habitat throughout NAVA be collected. This could be achieved through the establishment of permanent acoustic stations throughout NAVA, including two in Betatakin Canyon, one at Inscription House and one at Keet Seel. These stations would collect echolocation calls from flying bats, and these data would ultimately provide valuable information regarding both annual and seasonal use of NAVA by bats.

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Table 1. Field schedule for 2003 Navajo National Monument (NAVA) mammal inventories, in chronological order, indicating dates, parks visited, observers, effort and sampling methods.

			Effort					
Date(s)	Park visited	Observer(s)	Person days	Trap nights	Net nights	Acoustic hours	Track/scat survey distance (km)	Sampling method(s)
29 June-01 July	NAVA	S. Haymond, R. Sherwin	4	160		1.8	7.2	Sherman live traps, acoustic surveys, track/scat surveys, opportunistic observations
14-22 August	NAVA	R. Sherwin, J. Goheen	13	909		6.0	164.1	Sherman live traps, acoustic surveys, track/scat surveys, opportunistic observations
21-29 September	NAVA	R. Sherwin, J. Goheen, A. Lopez	12	790	15	15.0	61.1	Sherman live traps, mist nets, acoustic surveys, track/scat surveys, opportunistic observations
		Total	41	2621	23	43.0	245.8	

Table 2. Field schedule for 2004 Navajo National Monument (NAVA) mammal inventories, in chronological order, indicating dates, parks visited, observers, effort and sampling methods.

			Effort					
Date(s)	Park visited	Observer(s)	Person days	Trap nights	Net nights	Acoustic hours	Track/scat survey distance (km)	Sampling method(s)
16-20 May	NAVA	T. Orr, R. Sherwin, D. Tinnin	12	600	2	2.0	0.4	Sherman live traps, acoustic surveys, track/scat surveys, opportunistic observations
1-4 June	NAVA	T. Orr, R. Sherwin, D. Tinnin	9	604	2	2.5	19.1	Sherman live traps, acoustic surveys, track/scat surveys, opportunistic observations
2-5 July	NAVA	T. Orr, R. Sherwin, D. Tinnin	9	518	5	5.5	8.5	Sherman live traps, mist nets, acoustic surveys, track-scat surveys, opportunistic observations
		Total	39	2416	15	21.7	42.0	

Table 3. Level of documentation for major groups of mammals on Navajo National Monument and overall level of documentation for all mammals.

Order	Number of species likely	Number of confirmed species	Percent of possible species
Chiroptera	16	12	75
Lagomorpha	2	2	100
Rodentia	20	18	90
Carnivora	12	8	67
Artiodactyla	1	1	100
Total	51	41	80%

Table 4. Mammals of Navajo National Monument, including currently known park status.

Common Name	Park Status	Reference/Observation
California myotis	Present	This inventory, 2004 (Table 5); voucher
Western small-footed myotis	Present	This inventory, 2003 (Table 5); acoustic
Little brown bat	Present	This inventory, 2003 (Table 5); acoustic
Long-eared myotis	Present	This inventory, 2004 (Table 5); voucher
Fringed myotis	Probable	Hoffmeister 1986
Long-legged myotis	Present	Drost 2000; acoustic
Yuma myotis	Present	This inventory, 2004 (Table 5); voucher
Western pipistrelle	Present	This inventory, 2003 (Table 5); acoustic
Townsend's big-eared bat	Present	This inventory, 2004 (Table 5); acoustic
Allen's big-eared bat	Present	This inventory, 2004 (Table 5); observed animals
Big brown bat	Present	This inventory, 2004 (Table 5); voucher
Pallid bat	Probable	Hoffmeister 1986
Hoary bat	Probable	Unconfirmed park record
Silver-haired bat	Probable	Unconfirmed park record
Spotted bat	Present	Drost 2000; acoustic
Brazilian free-tailed bat	Present	This inventory, 2004 (Table 5); acoustic
Desert cottontail	Present	This inventory, 2003 (Table 5); observed animal
Black-tailed jack rabbit	Present	This inventory, 2003 (Table 5); observed animal
Hopi chipmunk	Present	This inventory, 2003 (Table 5); voucher
White-tailed antelope squirrel	Present	This inventory, 2003 (Table 5); observed animal
Rock squirrel	Present	This inventory, 2003 (Table 5); observed animal
Spotted ground squirrel	Probable	Hoffmeister 1986
Botta's pocket gopher	Present	This inventory, 2004 (Table 5); observed mounds
Plains pocket mouse	Present	This inventory, 2003 (Table 5); capture
Silky pocket mouse	Present	This inventory, 2003 (Table 5); capture
Ord's kangaroo rat	Present	This inventory, 2003 (Table 5); observed mounds
Western harvest mouse	Probable	Hoffmeister 1986
Canyon mouse	Present	This inventory, 2003 (Table 5); voucher
Brush mouse	Present	This inventory, 2003 (Table 5); voucher
Deer mouse	Present	This inventory, 2003 (Table 5); capture
Piñon mouse	Present	This inventory, 2003 (Table 5); capture
Northern grasshopper mouse	Present	This inventory, 2003 (Table 5); capture
White-throated woodrat	Present	This inventory, 2003 (Table 5); capture
Desert woodrat	Present	This inventory, 2004 (Table 5); voucher
Stephen's woodrat	Present	Hoffmeister 1986, Long Canyon
Mexican woodrat	Present	Hoffmeister 1986, Betatakin and Tsegi Canyon
Bushy-tailed woodrat	Present	This inventory, 2004 (Table 5); observed latrine
Porcupine	Present	This inventory, 2004 (Table 5); carcass found

Table 4. Continued.

Common Name	Park Status	Reference/Observation
Coyote	Present	This inventory, 2003 (Table 5); observed animal
Kit fox	Probable	Hoffmeister 1986
Red fox	Present	This inventory, 2004 (Table 5); observed scat
Gray fox	Present	This inventory, 2004 (Table 5); observed tracks
Mountain lion	Present	NPS observation 2003; observed animal
Raccoon	Probable	Hoffmeister 1986
Badger	Present	This inventory, 2004 (Table 5); observed tracks
Ringtail	Probable	Unconfirmed park record
Spotted skunk	Present	Hoffmeister 1986, Betatakin Canyon
Striped skunk	Present	This inventory, 2003 (Table 5); observed tracks
Bobcat	Present	This inventory, 2003 (Table 5); observed tracks
American black bear	Probable	Unconfirmed park record
Mule deer	Present	This inventory, 2003 (Table 5); tracks and scat

Table 5. Relative abundance of mammal species captured and observed at Navajo National Monument during 2003 and 2004 inventories.

	2003		2004		Total	
Species Common Name	Number Captured and Observed	% Relative Abundance	Number Captured and Observed	% Relative Abundance	Number Captured and Observed	% Relative Abundance
California myotis	2	0.5	2	0.7	4	0.6
Western small-footed myotis	1	0.3	2	0.7	3	0.4
Long-eared myotis			1	0.3	1	0.1
Little brown bat	1	0.3			1	0.1
Yuma myotis			3	1.0	3	0.4
Unknown bat			2	0.7	2	0.3
Western pipistrelle	2	0.5	2	0.7	4	0.6
Townsend's big-eared bat			1	0.3	1	0.1
Allen's big-eared bat			4	1.4	4	0.6
Big brown bat	1	0.3	3	1.0	4	0.6
Brazilian free-tailed bat			1	0.3	1	0.1
Desert cottontail			7	2.4	7	1.0
Black-tailed jackrabbit	1	0.3			1	0.1
White-tailed antelope squirrel	1	0.3	4	1.4	5	0.7
Hopi chipmunk	30	7.7	5	1.7	35	5.1
Rock squirrel	2	0.5	1	0.3	3	0.4
Botta's pocket gopher			1	0.3	1	0.1
Plains pocket mouse	1	0.3			1	0.1
Silky pocket mouse	1	0.3	1	0.3	2	0.3
Ord's kangaroo rat	1	0.3			1	0.1
Brush mouse	21	5.4	94	32.1	115	16.8

Table 5. Continued.

Species Common Name	2003		2004		Total	
	Number Captured and Observed	% Relative Abundance	Number Captured and Observed	% Relative Abundance	Number Captured and Observed	% Relative Abundance
Canyon mouse	21	5.4	10	3.4	31	4.5
Deer mouse	258	66.2	114	38.9	372	54.5
Pinon mouse	17	4.4	16	5.5	33	4.8
Unknown mouse	12	3.1			12	1.8
Northern grasshopper mouse	2	0.5			2	0.3
White-throated woodrat	8	2.1	12	4.1	20	2.9
Bushy-tailed woodrat			1	0.3	1	0.1
Desert woodrat			1	0.3	1	0.1
Porcupine			1	0.3	1	0.1
Coyote	2	0.5	1	0.3	3	0.4
Gray fox	1	0.3			1	0.1
Red fox			1	0.3	1	0.1
Raccoon	1	0.3			1	0.1
Badger			1	0.3	1	0.1
Striped skunk	1	0.3			1	0.1
Unknown skunk			1	0.3	1	0.1
Mountain lion	1	0.3			1	0.1
Bobcat	1	0.3			1	0.1
Mule deer	1	0.3			1	0.1
Total	391	100.0	293	100.0	684	100.0

Figure 1. Approximate locations of mammal inventory sampling points (mist nets, beginnings of traplines, acoustic sampling stations, beginnings or track and scat surveys) at Navajo National Monument, Betatakin.

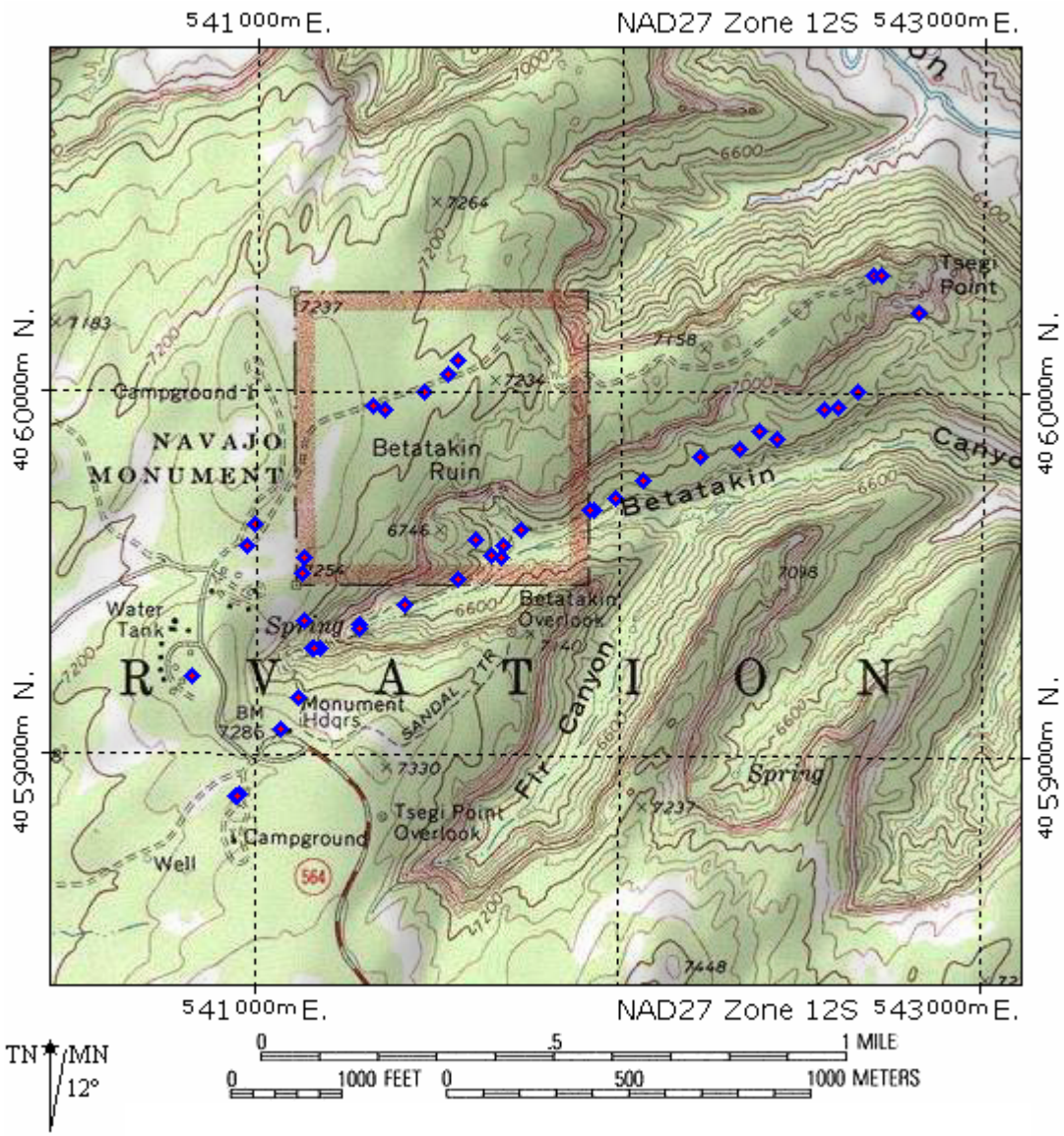


Figure 2. Approximate locations of mammal inventory sampling points (mist nets, beginnings of traplines, acoustic sampling stations, beginnings or track and scat surveys) at Navajo National Monument, Keet Seel.

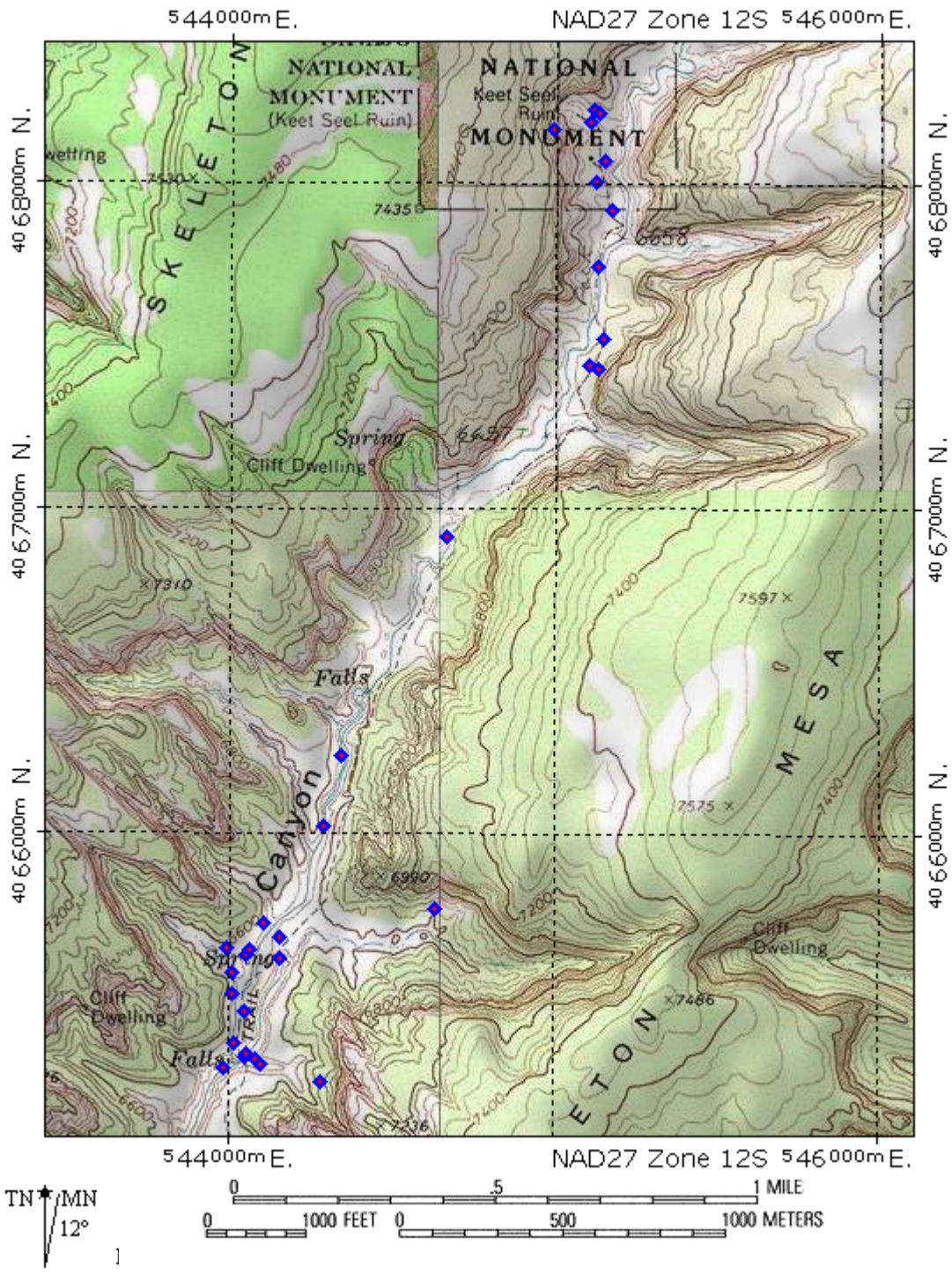
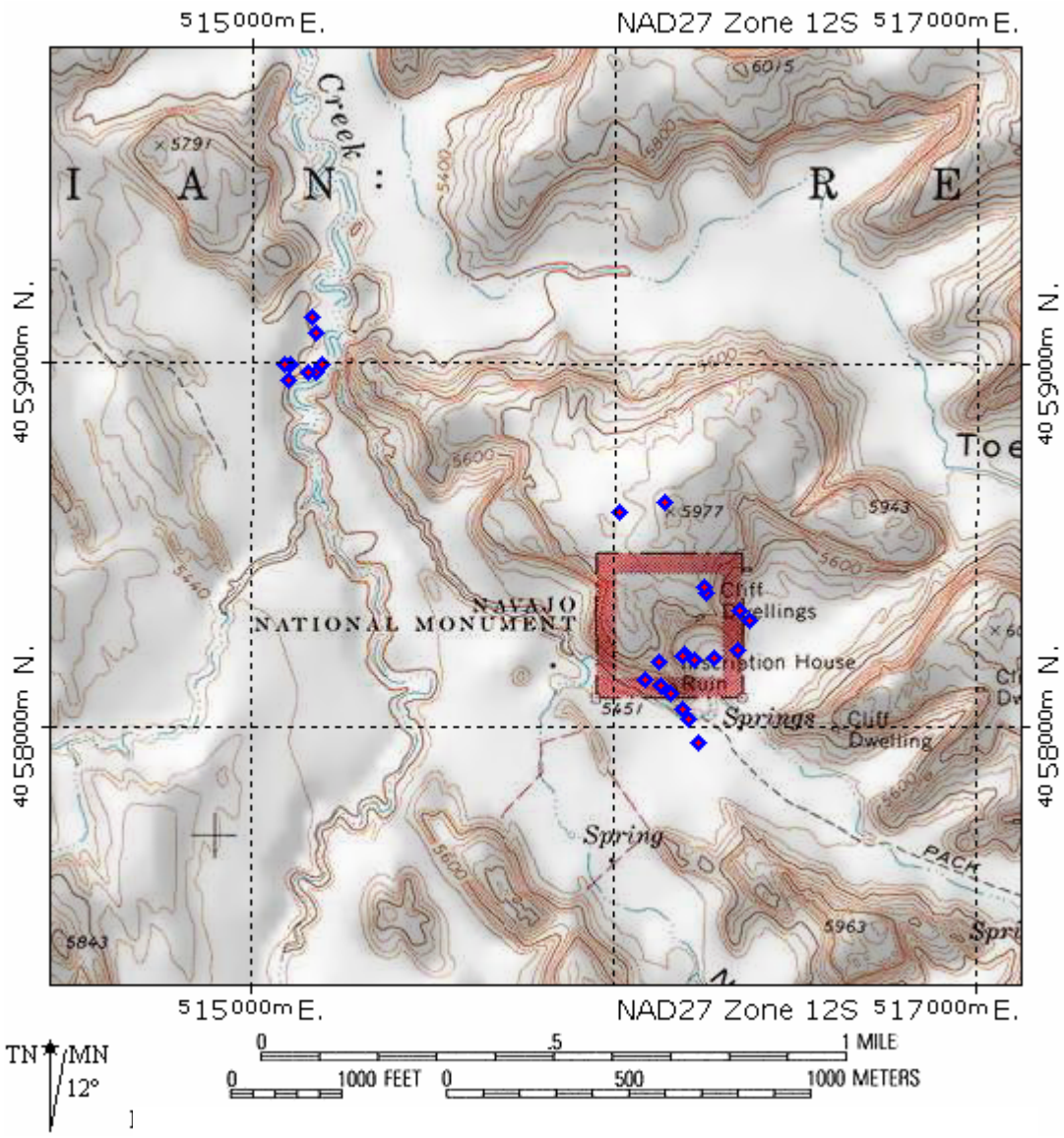


Figure 3. Approximate locations of mammal inventory sampling points (mist nets, beginnings of traplines, acoustic sampling stations, beginnings or track and scat surveys) at Navajo National Monument, Inscription House.



Appendix A. Common and scientific names of mammals used in this report. Nomenclature follows Baker et. al., 2003.

Common Name	Scientific Name
Chiroptera	
California myotis	*Myotis californicus*
Western small-footed myotis	*Myotis ciliolabrum*
Long-eared myotis	*Myotis evotis*
Little brown bat	*Myotis lucifugus*
Fringed myotis	*Myotis thysanodes*
Long-legged myotis	*Myotis volans*
Yuma myotis	*Myotis yumanensis*
Hoary bat	*Lasiurus cinereus*
Silver-haired bat	*Lasionycteris noctivagans*
Western pipistrelle	*Pipistrellus hesperus*
Big brown bat	*Eptesicus fuscus*
Spotted bat	*Euderma maculatum*
Townsend's big-eared bat	*Corynorhinus townsendii*
Allen's big-eared bat	*Idionycteris phyllotis*
Pallid bat	*Antrozous pallidus*
Brazilian free-tailed bat	*Tadarida brasiliensis*
Big free-tailed bat	*Nyctinomops macrotis*
Lagomorpha	
Desert cottontail	*Sylvilagus audubonii*
Black-tailed jackrabbit	*Lepus californicus*
Rodentia	
Colorado chipmunk	*Neotamias quadrivittatus*
Hopi chipmunk	*Neotamias rufus*
White-tailed antelope squirrel	*Ammospermophilus leucurus*
Spotted ground squirrel	*Spermophilus spilosoma*
Rock squirrel	*Spermophilus variegatus*
Gunnison's prairie dog	*Cynomys gunnisoni*
Botta's pocket gopher	*Thomomys bottae*
Plains pocket mouse	*Perognathus flavescens*
Silky pocket mouse	*Perognathus flavus*
Ord's kangaroo rat	*Dipodomys ordii*
Western harvest mouse	*Reithrodontomys megalotis*
Brush mouse	*Peromyscus boylii*
Canyon mouse	*Peromyscus crinitis*
Deer mouse	*Peromyscus maniculatus*
Pinon mouse	*Peromyscus truei*
Northern grasshopper mouse	*Onychomys leucogaster*
Western white-throated woodrat	*Neotoma albigula*
Bushy-tailed woodrat	*Neotoma cinerea*

Appendix A. Continued.

Common Name	Scientific Name
Desert woodrat	*Neotoma lepida*
Mexican woodrat	*Neotoma mexicana*
Stephens's woodrat	*Neotoma stephensi*
North American porcupine	*Erethizon dorsatum*
Carnivora	
Coyote	*Canis latrans*
Kit fox	*Vulpes macrotis*
Red fox	*Vulpes vulpes*
Gray fox	*Urocyon cinereoargenteus*
American black bear	*Ursus americanus*
Ringtail	*Bassariscus astutus*
Northern racoon	*Procyon lotor*
Badger	*Taxidea taxus*
Western spotted skunk	*Spilogale gracilis*
Striped skunk	*Mephitis mephitis*
Mountain lion	*Puma concolor*
Bobcat	*Lynx rufus*
Artiodactyla	
Mule deer	*Odocoileus hemionus*