National Park Service
U.S. Department of the Interior

Natural Resource Program Center

Mammal Inventory for Hubbell Trading Post National Historic Site

Natural Resource Technical Report NPS/SCPN/NRTR—2010/376

ON THE COVER

The deer mouse was one of the most abundant mammal species found during this inventory.
Photograph by: John Good

Mammal Inventory for Hubbell Trading Post National Historic Site

Natural Resource Technical Report NPS/SCPN/NRTR—2010/376

Shauna Haymond
Holistic Wildlife Services NM, LLC
112 Hampton Roads Avenue
Hampton, VA 23661

Richard E. Sherwin
Department of Biology, Chemistry, and Environmental Science
Christopher Newport University
1 University Place
Newport News, VA 23606-2998

September 2010

U.S. Department of the Interior
National Park Service
Natural Resource Program Center
Fort Collins, Colorado

The National Park Service, Natural Resource Program Center publishes a range of reports that address natural resource topics of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Technical Report Series is used to disseminate results of scientific studies in the physical, biological, and social sciences for both the advancement of science and the achievement of the National Park Service mission. The series provides contributors with a forum for displaying comprehensive data that are often deleted from journals because of page limitations.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

This project was funded through Colorado Plateau Cooperative Ecosystem Studies Unit agreements (CA-120099009, Tasks NN-02 and NN-04; CA-H1200040002, Task NN-5). This report is available from the Southern Colorado Plateau Network website (http://www.nature.nps.gov/im/units/SCPN) and the Natural Resource Publications Management Web site (http://www.nature.nps.gov/publications/NRPM) on the Internet. Please cite this publication as:

Haymond, S., and R. Sherwin. 2010. Mammal inventory for Hubbell Trading Post National Historic Site. Natural Resource Technical Report NPS/SCPN/NRTR—2010/376. National Park Service, Fort Collins, Colorado.

NPS 433/105743, September 2010

Contents

Figures

Tables

Abstract

The Navajo Nation Department of Fish and Wildlife contracted Holistic Wildlife Services NM to conduct mammal inventories at Hubbell Trading Post National Historic Site (HUTR) 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; to provide distributional information, estimates of species richness, and measurements of the relative abundance of the mammals; and to provide baseline information and to make recommendations for developing future management and monitoring plans for mammals in the park.

There had been no baseline mammal work conducted at HUTR prior to these surveys, but based on species-area models, the National Park Service Inventory and Monitoring program had estimated that a total of 23 mammal species inhabited the park (Stuart 2000). However, using known specific ranges and available museum records, we estimated that 39 mammal species inhabited the park.

We conducted the field inventories from June 26-August 28, 2003 and from May 10-June 17, 2004. We used a variety of survey methods, including live-trapping, mist netting and acoustic surveys, track-scat surveys, and opportunistic observations. We documented a total of 32 species (Chiroptera, 8 species; Lagomorpha, 2 species; Rodentia, 15 species; Carnivora, 6 species; and Artiodactyla, 1 species). Our survey efforts documented 82% of the 39 species that we considered likely to occur, and we documented over 30% more species than the 23 species predicted by species-area models.

Pinyon mice (*Peromyscus truei*)were the most abundant species of mammal at HUTR during 2003 (17.8% of all captures), while deer mice (*Peromyscus maniculatus*) were the most abundant species (almost 40% of all captures) in 2004. No federal or Navajo Tribal-listed endangered species were documented during this study.

Acknowledgements

Many people were instrumental in helping us accomplish the work reported here. J. Goheen, T. Orr, and D. Tinnin assisted with field inventories. N. Stone, R. Moder, and the seasonal rangers provided logistical support and assistance at the parks. C. Ramotnik assisted with the deposition of specimens to the US Geological Survey mammal collection at the Museum of Southwestern Biology and with the identification of voucher specimens. The National Park Service provided funding for the project. The National Park Service and the Navajo Nation provided research and collecting permits.

Introduction

The Colorado Plateau of the southwestern United States is a topographically diverse region that contains the highest species richness of native mammals in the country (Mac et al. 1998). More than 140 mammalian species inhabit Arizona's landscape of pine forests, cactus deserts, high plateaus, and deep canyons (Hoffmeister 1986). Historically, this area has been the focus of many biological studies, starting in the 1800s. In 1853 and 1854, Dr. C. B. R. Kennerly collected specimens and recorded observations as part of a survey team seeking railroad routes to the Pacific Coast. Dr. Samuel Woodhouse, a naturalist, studied the Colorado and Little Colorado rivers in 1851. Many naturalists were also associated with military outposts in Arizona during the mid 1800s; for example Dr. Elliot Coues collected mammals around Fort Whipple and wrote the first published account of the mammals of Arizona in 1867. After the United States Biological Survey was established in the late 1800s, mammal collecting intensified when they sent many biologists to Arizona to prepare a report on its mammals. 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.

Extensive scientific research and collecting has continued to the present day in the region. But despite nearly two hundred years of scientific interest in Arizona, some areas remain relatively unstudied. One of these is Hubbell Trading Post National Historic Site (HUTR). The Southern Colorado Plateau Network (SPCN), a network of the National Park Service (NPS) Inventory and Monitoring (I&M) program, had identified HUTR as a park with poorly documented natural resources. No baseline mammal work had been conducted there, and the estimated completeness for needed inventories was 0% (Stuart 2000) prior to this work. In this report, we describe the results of the full mammal inventories that we conducted at the park during 2003 and 2004.

The NPS I&M program provides park resource managers with systematically rigorous baseline inventories that can be used to develop long-term monitoring strategies. Considering this aim, we established three objectives for the mammal inventory:

1. Document at least 90% of the mammals at the park using verifiable documentation and taxa-specific field surveys. Use the same methods at HUTR that were employed at other SCPN parks.

2. Provide distributional information and estimates of species richness and relative abundance.

3. Provide baseline information and make recommendations to develop future management and monitoring plans for mammals in the park.

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 wetter 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. Pacific Ocean storm patterns most strongly influence winter weather, while monsoons from the Gulf of Mexico most strongly influence summer weather (on the southern portions of the Plateau). Low, open woodlands of drought-adapted conifers characterize the vegetation at higher elevations and extensive areas of drought-tolerant shrubs and grasses characterize the vegetation at lower elevations.

Hubbell Trading Post is 64.8 ha (160 ac), and it is located in northeastern Arizona, at Ganado, in Apache County, Arizona. The park's elevation ranges from 1920 m to 1940 m (6300 ft to 6365 ft)—moderate elevations for the region.

The landscape of Hubbell Trading Post is made up of old agricultural land, developed

Figure 1. The Pueblo Colorado Wash makes up part of the landscape of Hubbell Trading Post.

areas with structures, and a small portion of

Pueblo Colorado wash (fig. 1). In the old agricultural fields, the vegetation is dominated by four-wing saltbush (*Atriplex canescens*), rabbitbrush (*Chrysothamnus* sp.), snakeweed (*Gutierrezia sarothrae*), shad scale (*Atriplex confertifolia*), and Russian thistle (*Salsola tragus*). Cottonwoods (*Populus* spp.) and planted fruit trees are also present. Vegetation in the developed areas includes various native and exotic trees, shrubs, and herbaceous plants and grasses. Vegetation in and along Pueblo Colorado wash and the arroyo west of the housing area includes rabbitbrush, willows (*Salix* spp.), many of which had been recently planted, sedges (*Carex* spp.), and horsetail (*Equisetum* sp.). At the time of this report, the wash was undergoing a restoration project to replace nonnative vegetation with native vegetation. Much of the saltcedar (*Tamarix* sp.) and Russian olive (*Eleagnus angustifolia*) along the wash had been recently removed, but a narrow row of saltcedar and Russian olive north of the wash remained. Several junipers (*Juniperus* spp.) are also found in the park.

Methods

Initial species richness estimations

Before beginning our inventory, we examined the Biological Inventory Proposal (Stuart 2000), a collaborative proposal by NPS and US Geological Survey authors. It included an effort to predict the number of mammal species that might be present in the park, based on species-area models. We then added species to that estimation by studying the known ranges and habitat associations of mammal species in Arizona and by consulting museum records and other accessible databases that might include more recent information. The Biological Inventory Proposal (Stuart 2000) predicted that 23 species of mammals would be found at HUTR, and we added 16 species to the initial estimation, for a total of 39 potential species. This estimate allowed us to determine when we had inventoried 90% of the mammal species in the park and to calculate the percentage of each order of mammals that we were able to document.

Field methods

We used similar field methods at each of the SCPN parks that we inventoried for mammals.

Small terrestrial mammal inventories

We used Sherman live traps arranged in traplines to inventory rodents and other small mammals (Wilson et al. 1996). Traplines generally consisted of 20 paired trap stations placed at 15 m (50 ft) intervals for a minimum distance of 300 m (984 ft). Traps were baited with dry oatmeal and left open overnight, and sometimes they were left open during the daylight hours to catch diurnal species.

We selected trapping areas in each of the major habitat types within the park. We stratified traplines by habitat and used randomly

selected starting points in each, and, where feasible, we extended traplines through only one habitat (Stuart 2000). We reported sampling effort as the number of trap-nights (total number of traps multiplied by number of days).

Bat inventories

We used mist nets and acoustic surveys to inventory bats. The mist nets were strung across and around bodies of water in order to capture bats coming in to drink or feed on the insects flying over the water (Kunz 1988). The net sizes we used ranged from 6 to 20 m (18 to 60 ft), and the number of nets we used depended on the area of the body of water. We set up the mist nets shortly before sunset and tended them for several hours or until sunrise. These methods are especially effective when water sources in the landscape are limited because bats then concentrate in a relatively small area, allowing them to be more easily captured.

Where no water was present or when the water body was too large to concentrate the bats enough for easy capture with mist nets, we conducted acoustic surveys. These surveys were also useful for detecting species not easily captured in mist nets. To conduct acoustic surveys, we used a bat detector to record echolocation calls, which were then processed with a zero-crossing analysis interface module (ZCAIM, Anabat II hardware, Anabat software version 6.3. Titley Electronics, Ballina, New South Wales, Australia) connected to a laptop computer. We used Analook software (version 4.8n, Titley Electronics, Ballina, New South Wales, Australia) to analyze the processed signals. To identify an unknown species, we used the frequency-time display generated by the software to qualitatively compare its call parameters to reference calls from known species (Fenton and Bell 1981; O'Farrell et. al. 1999).

We recorded sampling effort 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

We documented carnivores primarily through track and scat surveys. We searched areas on foot that were likely to attract and show evidence of animals, such as around water sources, in canyon bottoms, in sandy soils, and near areas where humans leave refuse (e.g. campgrounds and housing areas). We quantified effort for the carnivore inventories as estimated distance surveyed (km).

Opportunistic observations

Anytime we observed a species or sign of a species (e.g. tracks, scat, middens) not documented by trapping or other means, we noted the species. We recorded the location of all opportunistic observations, and when possible, we obtained a voucher photograph. Opportunistic observations are the predominant means of documenting ungulates, but many other species can also be documented in this manner. We also confirmed the presence of some species with reliable park observation files and by talking with knowledgeable park staff and local residents.

Data methods

We calculated the total species richness (number of species documented) and the relative abundance of each species (percent of all individuals detected) at HUTR. We calculated effort by 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. We provided copies of all data sheets, photographs, and field journals to the Navajo Nation Department of Fish and Wildlife, and we sent the data to the Natural Heritage Program. We deposited voucher specimens in the U.S. Geological Survey mammal collection at the Museum of Southwestern Biology, University of New Mexico.

Results

Sampling effort

Sampling effort at HUTR yielded 21 person days, 1,456 trap nights, 14 mist net nights, 31.9 hours of acoustic surveys, and 27.4 km of track and scat surveys (table 1). The live trapping success rate for small mammals was approximately 2.6% in 2003 and 21.8% in 2004.

Species richness and abundance

In two years of mammal inventories at HUTR, we documented 82% of the 39 mammal species that we estimated could potentially occur in the park (tables 2 and 3). We documented 8 bat species (73% of the total number of potential bat species), 2 lagomorphs (100%), 15 rodents (88%), 6 carnivores (75%), and 1 ungulate (100%), for a total species richness of 32 species.

During 2003, the pinyon mouse (*Peromyscus truei*) was the most abundant mammal species at HUTR, accounting for 17.4% of all captures. The second most abundant species was the deer mouse (*Peromyscus maniculatus*), accounting for 10.9% of all captures. All other species each accounted for <7% of total captures (table 4).

During 2004, the deer mouse was the most abundant species captured, comprising almost 40% of all captures. The second most abundant species captured was the western harvest mouse (*Reithrodontomys megalotis*), which accounted for nearly 30% of all individuals captured.

Species distribution

During the first year of the inventories, sampling was evenly distributed among different habitat types. We found that both species abundance and richness were highest in locations surrounding Pueblo Colorado Wash (seven species in the rabbitbrush along the south bank and in the salt cedar and Russian olive trees along the north bank). Therefore during the second year of inventories, we targeted our sampling on those areas (fig. 2). Another way we tried to add to the species list during the second year was to focus on documenting less common carnivores, bats, and rodents.

Some species had noticeable associations with particular habitats within the park. The only place we captured white-throated woodrats (*Neotoma albigula*) was the rocky

Table 1. Sampling effort, schedule, and methods for 2003-2004 mammal inventories at Hubbell Trading Post National Historic Site.

		Effort					
Date(s)	**Observer(s)**	**Person days**	**Trap nights**	**Net nights**	**Acoustic hours**	**Track/scat survey distance (km)**	**Sampling method(s)**
26-29 June 2003	S. Haymond, R. Sherwin	6	237		11.5	4.9	Sherman live traps, acoustic surveys, track/scat surveys, opportunistic observations
30 July-2 August 2003	S. Haymond	3	280	2		4.7	Sherman live traps, mist nets, track/scat surveys, opportunistic observations
25-28 August 2003	S. Haymond	3	245	6	8.7	3.8	Sherman live traps, mist nets, acoustic surveys, track-scat surveys, opportunistic observations
	Total (2003)	**41**	**2621**	**23**	**43.0**	**245.8**	
10-13 May 2004	S. Haymond, D. Tinnin	6	514	2	2.6	7.0	Sherman live traps, acoustic surveys, track/scat surveys, opportunistic observations
14-17 June 2004	S. Haymond	3	180	4	9.1	7.0	Sherman live traps, mist nets, track/scat surveys, opportunistic observations
	Total (2004)	**39**	**2416**	**15**	**21.7**	**42.0**	

Table 2. Number of species documented compared to the number of species estimated for each mammal order at Hubbell Trading Post National Historic Site.

Order	Number of confirmed species	Number of species possible	Percent of possible species (%)
Chiroptera	8	11	73
Lagomorpha	2	2	100
Rodentia	15	17	88
Carnivora	6	8	75
Artiodactyla	1	1	100
Total	**32**	**39**	**82**

slope of Hubbell Hill. Pinyon mice were also common there. We frequently captured Northern grasshopper mice (*Onychomys leucogaster*) among the shrubs along the gravel roads in the park. We found Gunnison's prairie dogs (*Cynomys gunnisonii*) and Ord's kangaroo rats (*Dipodomys ordii*) only in the old agricultural fields, while we observed mounds of Botta's pocket gophers (*Thomomys bottae*) only in Pueblo Colorado Wash and the arroyo. We documented brush mice and harvest mice primarily from the Pueblo Colorado Wash. The wash is also important for bats and large mammals because it provides drinking water and acts as a travel corridor. Desert cottontail (*Sylvilagus audubonii*) and deer mice were widespread.

Species of Concern

We documented four Species of Concern (listed by the Arizona Natural Heritage Data Management System, January 2003): western small footed myotis (*Myotis ciliolabrum*), long-legged myotis (*Myotis volans*), Yuma myotis (*Myotis yumanensis*), and big free-tailed bat (*Nyctinomops macrotis*). We did not find any mammal species of concern listed by the Navajo Nation Department of Fish and Wildlife (March 2001 list).

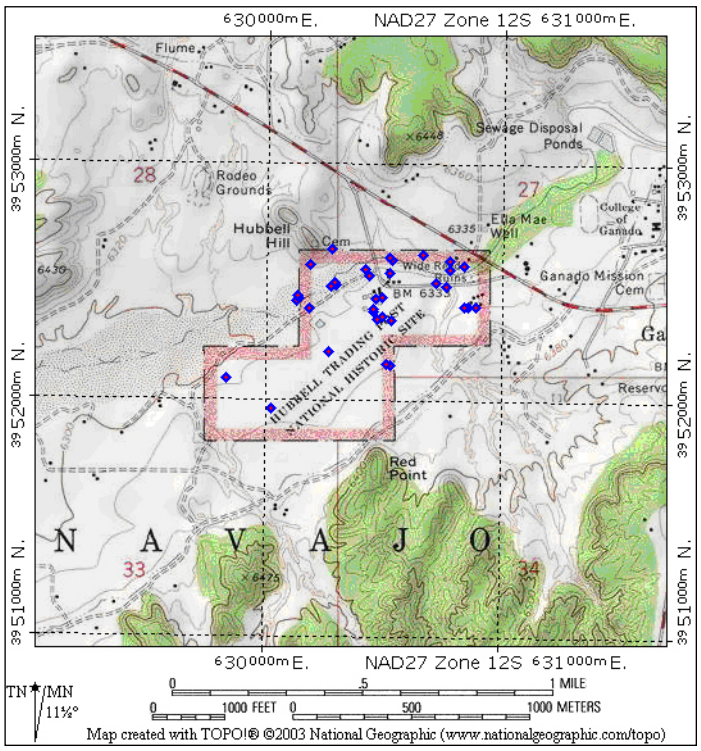

Figure 2. Approximate locations of mammal inventory sampling points (mist nets, beginnings of traplines, acoustic sampling stations, and beginnings of track and scat surveys).

Table 3. Confirmed and probable mammals at Hubbell Trading Post National Historic Site.

Common name	Scientific name	Park status	Reference/observation
Chiroptera			
California myotis	*Myotis californicus*	Present	This inventory, 2003; acoustic
Western small-footed myotis	*Myotis ciliolabrum*	Present	This inventory, 2004; voucher
Fringed myotis	*Myotis thysanodes*	Probable	Hoffmeister 1986
Long-legged myotis	*Myotis volans*	Present	This inventory, 2003; voucher
Yuma myotis	*Myotis yumanensis*	Present	This inventory, 2004; voucher
Townsend's big-eared bat	*Corynorhinus townsendii*	Probable	Hoffmeister 1986
Big brown bat	*Eptesicus fuscus*	Present	This inventory, 2004; capture
Pallid bat	*Antrozous pallidus*	Present	This inventory, 2004; voucher
Hoary bat	*Lasiurus cinereus*	Present	This inventory, 2004; voucher
Brazilian free-tailed bat	*Tadarida brasiliensis*	Probable	Hoffmeister 1986
Big free-tailed bat	*Nyctinomops macrotis*	Present	This inventory, 2003; acoustic
Lagomorpha			
Desert cottontail	*Sylvilagus audubonii*	Present	This inventory, 2003; observed animal
Black-tailed jack rabbit	*Lepus californicus*	Present	This inventory, 2003; observed animal
Rodentia			
White-tailed antelope squirrel	*Ammospermophilus leucurus*	Probable	Hoffmeister 1986
Colorado chipmunk	*Neotamias quadrivittatus*	Probable	Hoffmeister 1986
Rock squirrel	*Spermophilus variegatus*	Present	This inventory, 2003; observed animal
Spotted ground squirrel	*Spermophilus spilosoma*	Present	Hoffmeister 1986, near Ganado
Gunnison's prairie dog	*Cynomys gunnisoni*	Present	This inventory, 2003; observed animals
Botta's pocket gopher	*Thomomys bottae*	Present	This inventory, 2003; observed mounds
Silky pocket mouse	*Perognathus flavus*	Present	This inventory, 2004; voucher
Ord's kangaroo rat	*Dipodomys ordii*	Present	This inventory, 2004; capture
Western harvest mouse	*Reithrodontomys megalotis*	Present	This inventory, 2004; voucher
Canyon mouse	*Peromyscus crinitis*	Present	Hoffmeister 1986, Ganado
Brush mouse	*Peromyscus boylii*	Present	This inventory, 2004; voucher
Deer mouse	*Peromyscus maniculatus*	Present	This inventory, 2003; voucher
Pinyon mouse	*Peromyscus truei*	Present	This inventory, 2003; voucher
Northern grasshopper mouse	*Onychomys leucogaster*	Present	This inventory, 2003; capture
White-throated woodrat	*Neotoma albigula*	Present	This inventory, 2003; capture
Stephen's woodrat	*Neotoma stephensi*	Present	Hoffmeister 1986, Ganado
Porcupine	*Erethizon dorsatum*	Present	NPS observation; observed quills
Carnivora			
Coyote	*Canis latrans*	Present	This inventory, 2003; heard howling
Kit fox	*Vulpes macrotis*	Probable	Hoffmeister 1986
Red fox	*Vulpes vulpes*	Present	NPS observation 2003; observed animal
Gray fox	*Urocyon cinereoargenteus*	Present	NPS observation 2001; road kill in park
Raccoon	*Procyon lotor*	Present	This inventory, 2003; observed tracks
Badger	*Taxidea taxus*	Probable	Hoffmeister 1986
Striped skunk	*Mephitis mephitis*	Present	This inventory, 2003; observed tracks
Bobcat	*Lynx rufus*	Present	Hoffmeister 1986, Ganado
Artiodactyla			
Mule deer	*Odocoileus hemionus*	Present	This inventory, 2003; observed tracks

Note: Nomenclature follows Baker et al., 2003.

Table 4. Abundance of mammal species captured and observed at Hubbell Trading Post National Historic Site during 2003 and 2004 inventories.

	2003		2004		Total	
Species common name	**Captured or observed**	**Relative abundance (%)**	**Captured or observed**	**Relative abundance (%)**	**Captured or observed**	**Relative abundance (%)**
Chiroptera						
California myotis	1	2.2			1	0.4
Western small-footed myotis	3	6.5	6	3.3	9	4.0
Long-legged myotis	1	2.2	7	3.9	8	3.5
Yuma myotis	2	4.3	3	1.7	5	2.2
Big brown bat			3	1.7	3	1.3
Pallid bat			2	1.1	2	0.9
Hoary bat			2	1.1	2	0.9
Big free-tailed bat	1	2.2			1	0.4
Lagomorpha						
Desert cottontail	2	4.3	1	0.6	3	1.3
Black-tailed jackrabbit	1	2.2			1	0.4
Rodentia						
Rock squirrel	2	4.3			2	0.9
Gunnison's prairie dog	2	4.3	1	0.6	3	1.3
Botta's pocket gopher	2	4.3			2	0.9
Silky pocket mouse			2	1.1	2	0.9
Ord's kangaroo rat	3	6.5	4	2.2	7	3.1
Western harvest mouse			54	29.8	54	23.8
Brush mouse	1	2.2	1	0.6	2	0.9
Deer mouse	5	10.9	72	39.8	77	33.9
Pinyon mouse	8	17.4	10	5.5	18	7.9
Unknown mouse	2	4.3			2	0.9
Northern grasshopper mouse	2	4.3	10	5.5	12	5.3
White-throated woodrat	2	4.3			2	0.9
Porcupine	1	2.2			1	0.4
Carnivora						
Coyote	1	2.2			1	0.4
Red fox			1	0.6	1	0.4
Raccoon	2	4.3	1	0.6	3	1.3
Striped skunk	1	2.2			1	0.4
Artiodactyla						
Mule deer	1	2.2	1	0.6	2	0.9
Total	**46**	**100.0**	**181**	**100.0**	**227**	**100.0**

Discussion

Species richness estimation

Interestingly, we confirmed 30% more species than the Biological Inventory Proposal (Stuart 2000) had predicted—32 observed species versus the 23 predicted by the species-area model. The species-area model assumes that the area being studied is an island. The authors of the proposal, then, assumed the park to be a homogeneous, insular unit surrounded by landscapes of unusable habitat, where park size alone would determine species diversity. By using this model to predict the number of species in the park, the authors did not take landscape heterogeneity into account, or they assumed that there is always a positive correlation between park size and habitat diversity.

These assumptions have been controversial since the first publication of *The Theory of Island Biogeography* by MacArthur and Wilson (1963), and further studies have shown that species-area relationships lose sensitivity at small spatial scales (for example, see Simberloff 1982). Additionally, the estimates in the Biological Inventory Proposal (Stuart 2000) did not distinguish residents from vagrants, nor did they clearly define species presence (i.e., breeding populations). Our results indicate that for this park, using the species-area model alone underestimated mammalian diversity. Stuart (2000) also may not have accounted for conditions of individual parks nor taken advantage of the investigators' specialized knowledge of species or habitats in predicting species richness.

Species richness and abundance

By creating our own list of potential species, we conducted more intensive sampling than the Biological Inventory Proposal (Stuart 2000) had recommended. We documented 32 species of mammals at HUTR (82% of 39 species on our list). Through these surveys, we were able to document species richness at HUTR as 32 species.

Patterns of abundance and distribution of mammal species differed between the two years of this study. During 2003, the pinyon mouse was the most abundant species of mammal at HUTR, accounting for 17.8% of all captures, and the second most abundant species was the deer mouse, accounting for 11.1% of all captures. All other individual species accounted for <7% of total captures (table 4). During 2004, the deer mouse was the most abundant species captured, comprising almost 40% of all captures, and the second most abundant species captured was the western harvest mouse, which accounted for nearly 30% of all individuals captured. Temporal variation in the relative abundance of rodent species is not uncommon. Rodent populations 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.

We documented the most species in orders that occupy the lower trophic levels (primary consumers). Primary consumers tend to occur in higher local densities than organisms that occupy higher tropic levels. Within the primary consumers, we documented the highest percentage species among the easily observed taxa, such as ungulates (100%) and lagomorphs (100%). We also documented a high percentage of primary consumers with small home ranges and limited capability for dispersal, such as rodents (88%). We documented the lowest percentage of species among the secondary and tertiary consumers (predators). We documented 75% of the carnivores from our species list. Similarly, we confirmed 73% of bats, which are also predators, at HUTR.

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 in trophic level. Therefore, fewer predators will be found per unit area relative to primary consumers, and predators will likely have much larger home ranges than 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 the park lands, but their presence was masked by low

densities, or they may use the park occasionally, in a transitory fashion, and were simply not present during the period of this study.

Species distribution

The highest levels of species abundance and richness at HUTR were found in areas with extensive vegetative cover, regardless of plant species. For example, areas with the highest richness occurred in the Pueblo Colorado Wash, especially in areas where invasive species like saltcedar and Russian olive composed much of the vegetation. These species tend to degrade animal habitat and are not usually associated with high levels of diversity. However, much of the nonnative vegetation in the wash was being cleared through an aggressive and ambitious restoration project, leaving much of the wash with very limited ground cover. Therefore the animal populations in the wash may have concentrated in the remaining vegetation. As restoration activities continue and native vegetation becomes established, the mammal community will likely become more evenly distributed throughout the wash, and this area will continue to be critical in maintaining a diverse mammal community.

Recommendations

Based on the information collected during these surveys we strongly recommend that the park prioritize, maintain, and promote vegetative diversity within their park boundaries. HUTR had higher levels of species richness than would be expected based on its size, suggesting that its habitat diversity increases the species diversity in the park.

We recommend that future monitoring be conducted over a long period of time. The dynamic nature of mammal communities observed in these surveys (variation in trapping success, relative abundance of species, and detectability) demonstrates the importance of sampling over multiple years to establish good baseline data. Long-term monitoring helps ensure that the natural variation in community dynamics does not become confused with population trends (declines or increases).

We also recommend that HUTR continue to restore riparian habitat in the Pueblo Colorado Wash and that the park establish permanent sampling locations both within and outside the restoration area. Because species diversity was highest in an area that was undergoing aggressive restoration, NPS has a unique opportunity to investigate the effects of riparian restoration on mammal communities. Communities of small terrestrial mammals (i.e., rodents) are often sensitive to habitat perturbations because their territories are generally small, and they have high reproductive output, low dispersal abilities, and strong habitat associations. Monitoring them during restoration activities would provide invaluable data on the short and long-term effects of habitat modification on mammals. This data would be relevant throughout the Southern Colorado Plateau Network. To sample the small terrestrial mammals, we recommend establishing permanent sampling grids that include trap stations as described by Wilson et al. (1996) and then using capture/recapture techniques.

Finally, we recommend that the park establish two permanent acoustic stations in the riparian corridor to collect echolocation calls from flying bats. We found that the Pueblo Colorado Wash, which was undergoing restoration, was important foraging habitat for bats. Since all of the Arizona Natural Heritage Species of Concern found at HUTR were bats, it is critical that data regarding the response of bats to changes in the riparian corridor be collected. These data would ultimately provide valuable information regarding the impacts of river corridor alteration on bats.

Literature Cited

Baker, R. J., L. C. Bradley, R. D. Bradley, J. W. Dragoo, M. D. Engstrom, R. S. Hoffman, C. A. Jones, F. Reid, D. W. Rice, and C. Jones. 2003. Revised checklist of North American mammals north of Mexico, 2003. Occasional Papers, Museum of Texas Tech University, Number 229.

Fenton, M. B., and G. P. Bell. 1981. Recognition of species of insectivorous bats by their echolocation calls. Journal of Mammalogy 62: 233-243.

Hoffmeister, D. F. 1986. Mammals of Arizona. University of Arizona Press and the Arizona Game and Fish Department, Tucson, AZ.

Kunz, T. H., editor. 1988. Ecological and behavioral methods for the study of bats. Smithsonian Press, Washington, DC.

Mac, M. J., P. A. Opler, C. E. Puckett Haecker, and P. D. Doran. 1998. Status and trends of the nation's biological resources. 2 Volumes. U.S. Department of the Interior, U.S. Geological Survey, Reston, VA.

MacArthur, R. H., and E. O. Wilson. 1963. The theory of island biogeography. Princeton University Press, Princeton, NJ.

O'Farrell, M. J., B. W. Miller, and W. L. Gannon. 1999. Qualitative identification of free-flying bats using the Anabat detector. Journal of Mammalogy 80: 11-23.

Simberloff, D. S. 1982. Big advantages of small refuges. Natural History 91: 6-14.

Stuart, M., editor. 2000. Biological inventory of national park areas on the southern Colorado Plateau. Colorado Plateau Cooperative Ecosystem Studies Unit and USGS/Colorado Plateau Field Station Unpublished document, Flagstaff, AZ.

Wheeler, R. 1990. Wilderness at the edge: A citizen proposal to protect Utah's canyons and deserts. Utah Wilderness Coalition, Salt Lake City, UT.

Wilson, D. E., F. C. Cole, J. D. Nichols, R. Rudran, and M. S. Foster, editors. 1996. Measuring and monitoring biological diversity: Standard methods for mammals. Smithsonian Press, Washington, DC.

NPS 433/105743, September 2010

National Park Service
U.S. Department of the Interior

Natural Resource Program Center
1201 Oak Ridge Drive, Suite 150
Fort Collins, Colorado 80525

www.nature.nps.gov