



In Cooperation with the University of Arizona, School of Natural Resources

Vascular Plant and Vertebrate Inventory of Gila Cliff Dwellings National Monument



Southwest Biological Science Center
Open-File Report 2005-1187
September 2006

U.S. Department of the Interior
U.S. Geological Survey



Powell, Albrecht, Halvorsen, Schmidt, Docherty, & Auning

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By Brian F. Powell, Eric W. Albrecht, William L. Halvorson, Cecilia A. Schmidt, Kathleen Docherty,
and Pamela Anning

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Mark Myers, Director

U.S. Geological Survey, Reston, Virginia: 2006

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Suggested Citation

Powell, B.F., E. W. Albrecht, W. L. Halvorson, C. A. Schmidt, K. Docherty, and P. Anning 2006. Vascular Plant and Vertebrate Inventory of Gila Cliff Dwellings National Monument. USGS Open-File Report 2005-1187. U.S. Geological Survey, Southwest Biological Science Center, Sonoran Desert Research Station, University of Arizona, Tucson, AZ.



Printed on recycled paper

Cover photo: Namesake cliff dwellings of the Gila Cliff Dwellings National Monument, New Mexico. Photograph by Brian Powell.

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Report Dedication



Eric Wells Albrecht 1970-2004

This report, as others in this series, is dedicated to Eric's life and work; he was an extraordinary ecologist, community member, father, and partner. Eric was co-coordinator of the University of Arizona (UA) biological inventory and monitoring program from 2002 until his sudden and unexpected death on September 20, 2004. Eric was near completion of his MS degree in Wildlife Conservation from the UA, which was awarded posthumously in November 2004. In his last year, Eric spearheaded projects to investigate the efficiency of current monitoring programs; he was passionate about using the best available information to guide vertebrate monitoring efforts in the region. He is survived by his partner, Kathy Moore, and their two young children, Elizabeth and Zachary. We hope that the lives of his children will be enriched by Eric's hard work on behalf of the national parks in the Sonoran Desert Network.

Acknowledgements

Thanks to Park Superintendents Steve Riley and Doug Ballou and the staff and volunteers at Gila Cliff Dwellings NM. This project resulted from the collaboration of many people at the University of Arizona (UA), National Park Service (NPS), U.S. Geological Survey (USGS), and United States Forest Service (USFS), and was facilitated by the Desert Southwest and Colorado Plateau Cooperative Ecosystem Studies Units (CESUs). The NPS Natural Resource Challenge program funded the project and the Desert Southwest CESU provided financial support for a 'Naturalist in Residence' project at the monument, which significantly advanced the projects' objectives. Larry Norris, NPS Research Coordinator, spent considerable time and effort providing clear and timely administrative assistance on all aspects of the inventory project. The Southern Arizona Office of the NPS facilitated development of the original study plan that led directly to initiation of this project. Andy Hubbard, Network Coordinator of the Sonoran Desert Network (SDN) Inventory and Monitoring (I&M) program, has been a strong and convincing advocate for continuing and expanding the role of the USGS/UA Inventory project. Kathy Davis, Superintendent at Tuzigoot and Montezuma Castle national monuments, played an instrumental role in this project, providing important early initiative. Matt Goode, Don Swann, and Dale Turner provided much of the early planning for this project; we are indebted to their vision and work. Eric Albrecht, to whom this report is dedicated, was an outstanding spokesperson and leader of the project; he was an invaluable member of the team and his contributions are sorely missed. This report was the last project that Eric worked on.

We thank a core group of dedicated field biologists who collected a wealth of data at Gila Cliff Dwellings NM: Greta Anderson, Theresa DeKoker, Meg Quinn, and Patty West (plants); Dan Bell, Kevin Bonine, James Borgmeyer, Dave Prival, and Mike Wall (amphibians and reptiles); Gavin Beiber, Chris Kirkpatrick, and Gabe Martinez (birds); Neil Perry, Jason Schmidt, and Ronnie Sidner (mammals). A special thanks to Emily Bennett for serving as the UA inventory representative during her two summers of work as a 'Naturalist in Residence' at the monument. Emily provided much-needed technical support to the monument staff and was a valued and trusted member of that team, all the while advancing the mission of the inventory project. Emily also coordinated collection of data from monument staff and volunteers: Anita Deming, Scott Doty, Trish London, Jim Worthington, and Dave Young.

We are appreciative of the following people whose office tasks made the field effort possible: Debbie Angell, Jennifer Brodsky, Brian Cornelius, Carianne Funicelli, Taylor Edwards, Colleen McClain, Heather McClaren, Lindsay Norpel, Jill Rubio, Brent Sigafus, Taffy Sterpka, Patina Thompson, Jenny Treiber, and Alesha Williams. Additional administrative support was provided by Valery Catt at the USGS Sonoran Desert Research Station and Terri Rice, Andy Honaman, Jenny Ferry, and especially Cecily Westphal of the School of Natural Resources at the UA. Special thanks to Lisa Carder for her years of hard work on all aspects of the project.

Technical support was provided by: Dan Austin, Michael Chamberland, Phil Jenkins, and Charlotte and John Reeder of the UA Herbarium; Arthur Harris and George Worthington of the Centennial Museum at the University of Texas at El Paso; George Bradley of the UA herpetology collection; Tom Huels of the UA ornithology collection; and Yar Petryszyn and Melanie Bucci of the UA mammal collection. Thanks to Sharon Megdal and Peter Wierenga of the UA Water Resources Research Center and all their staff, especially Terry Sprouse and colleagues for use of background information on the monument contained in this report. We received helpful reviews of an early draft of this report from: Debbie Angell, Emily Bennett, Dennis Finn, Brooke Gebow, Bruce Hayward, Larry Laing, Larry Norris, Therresa Mau-Crimmons, Jerry Monzingo, Don Swann, and Charles van Riper. Charlie Painter and Phil Rosen reviewed the amphibian and reptile chapter. All mistakes and omissions are the responsibility of the authors.

Executive Summary

This report summarizes the results of the first comprehensive biological inventory of Gila Cliff Dwellings National Monument (NM) in western New Mexico. This project was part of a larger effort to inventory plants and vertebrates in eight National Park Service units in Arizona and New Mexico. Our surveys address many of the objectives that were set forth in the monument's natural resource management plan almost 20 years ago, but until this effort, those goals were never accomplished.

From 2001 to 2003 we surveyed for vascular plants and vertebrates (amphibians, reptiles, birds, and mammals) at Gila Cliff Dwellings NM to document presence of species within the boundaries of the monument. For all taxonomic groups that we studied, we collected "incidental" sightings on U.S. Forest Service lands adjacent to the monument, and in a few cases we did formal surveys on those lands. Because we used repeatable study designs and standardized field techniques, these inventories can serve as the first step in a biological monitoring program for Gila Cliff Dwellings NM and surrounding lands.

We recorded 552 species at Gila Cliff Dwellings NM and the surrounding lands (Table 1). We found no non-native species of reptiles, birds, or mammals, one non-native amphibian (American bullfrog), and 33 non-native plants. Particularly on lands adjacent to the monument we found that the American bullfrog was very abundant, which is a cause for significant

management concern. Species of non-native plants that are of management concern include red brome, buffleggrass, and cheatgrass.

For a park unit of its size and geographic location, we found the plant and vertebrate communities to be fairly diverse; for each taxonomic group we found representative species from a wide range of taxonomic orders and/or families. The monument's geographic location, with influences from the Rocky Mountain, Chihuahuan Desert, and Madrean ecological provinces, plays an important role in determining the species richness at the monument. Also important is the wide range of conditions at the site. The diversity of plants results from a wide variety of soil types and aspects (from the cool, moist Cliff Dweller Canyon to dry mesa slopes) and an abundance of water from the West Fork of the Gila River. In turn, the vertebrate communities respond to this diversity of vegetation, topography, and microsites. For example, for each taxonomic group we found species that were only associated with a single community type, most often the riparian areas along the West and Middle forks of the Gila River.

We found cause for significant concern with regard to loss of species in the last few decades. One species of amphibian (Chiricahua leopard frog) is certainly extirpated from the area. Three other species of amphibians (Mexican spadefoot, Woodhouse's toad, and red-spotted toad), reported as being "common" in the area

Table 1. Summary results of vascular plant and vertebrate inventories at Gila Cliff Dwellings NM, 2000–2003.

Taxonomic group	Number of species recorded	Number of non-native species	Number of new species added to monument list ^a
Plants	387	32	264
Amphibians and Reptiles	21	1	15
Birds	107	0	107
Mammals	37	0	25
Totals	552	33	411

^a Species that had not been observed or documented by other studies at or near the monument.

in 1971, were not found during our surveys. In addition, we did not find three species of rodents that were found in 1965: silky pocket mouse, Ord's kangaroo rat, and southern grasshopper mouse. The monument's aquatic vertebrate component, in particular, may be at a critical juncture whereby other species, such as gartersnakes, may be poised for extirpation. Declining abundance of native fish species has been demonstrated from long-term monitoring of these communities along the Middle Fork of the Gila River.

This report includes lists of species recorded by us or species likely to be recorded

with additional survey effort. It also includes management implications from our work – how the monument staff might better maintain or enhance the unique biological resources of the monument. This study is the first step in a long-term process of compiling information on the biological resources of the monument and its surrounding areas. We recommend additional inventory and monitoring studies and identify components of our effort that could be improved upon, either through the application of new techniques or by extending the temporal and/or spatial scope of our work.

Chapter 1: Introduction to the Biological Inventories

The natural resources of the small monument are notable for their beauty, but little has yet been done to document them. (Russell 1992)

Project Overview

Inventory: A point-in-time effort to document the resources present in an area.

In the early 1990s, responding to criticism that it lacked basic knowledge of natural resources within parks, the National Park Service (NPS) initiated the Inventory and Monitoring Program (NPS 1992). The purpose of the program is to increase scientific research in NPS units and to detect long-term changes in biological resources. At the time of the program's inception, basic biological information, including lists of plants and animals, were absent or incomplete for many park units (Stohlgren et al. 1995).

Species inventories have both direct and indirect value for management. Species lists facilitate resource interpretation and visitor appreciation of natural resources. Knowledge of which species are present, particularly sensitive species, and where they occur is critical for making management decisions (e.g., locating new facilities). Inventories are also a cornerstone of long-term monitoring. Thorough biological inventories provide a basis for choosing parameters to monitor and can provide initial data (i.e., a baseline) for monitoring ecological populations and communities. Inventories can also test sampling designs, field methods, data collection protocols, and provide estimates of variation that are essential in prospective power analyses.

Goals

The purpose of this study was to complete basic inventories for vascular plants and vertebrates at Gila Cliff Dwellings NM. This effort was part of a larger biological inventory of eight NPS units in southern Arizona and southwestern New Mexico (Davis and Halvorson 2000, Powell et al. 2005a). The results presented in this report supersede those reported by Powell et al. (2002, 2003, and 2005b).

The goals of our biological inventory of Gila Cliff Dwellings NM were to:

1. Conduct field surveys to documenting at least 90% of all species of vascular plants and vertebrates expected to occur at the monument.
2. When appropriate, use repeatable sampling designs and survey methods that allow estimation of parameters of interest with associated estimates of precision.
3. Compile historic occurrence data from three sources: museum records (specimen vouchers), previous studies, and monument records.
4. Create resources useful to monument managers including detailed species lists, maps of study sites, and high-quality digital images for use in resource interpretation and education.

The bulk of our effort addressed the first two goals. To maximize efficiency (i.e., the number of species recorded by effort) we used field techniques designed to detect multiple species. We did not undertake single-species surveys for threatened or endangered species. Lastly, we did not survey for fish, as there is an active monitoring program for fish in both the West Fork and Middle Fork of the Gila River (Propst et al. 1998, Propst 2000).

Administrative History

The original study plan for this project was developed, and an inventory of one SDN park (Tumacácori National Historical Park) was completed, through a cooperative agreement among NPS, UA, and the USGS. This project was funded through Task Agreements UAZ-03, -05, -06, and (under Colorado Plateau CESU cooperative agreement number 1200-99-009). The National Park Service thereafter obligated additional funds through the Colorado Plateau CESU (UAZ-07) and the Desert Southwest CESU (cooperative agreement number CA1248-00-002, reference UAZ-39, UAZ-77, UAZ-87, UAZ-97, and UAZ-128) for administration and management

of the biological inventories. The Desert Southwest CESU allocated additional project funds for a separate, but complementary effort, the Biological Inventory and Interpretive Project at Gila Cliff Dwellings NM (cooperative agreement number CA1248-00-002, UAZ-04 and UAZ-27). Information from that effort supplemented our species lists/surveys and facilitated our biological inventories.

Report Format and Data Organization

This report is intended to be useful for internal planning and outreach and education. We report only common names (listed in phylogenetic sequence for vertebrates) unless we reference a species that is not listed later in an appendix; in this case we present both common and scientific names. For each taxonomic group we include an appendix of all species that we recorded in the monument (Appendices A–D), and species that were likely present historically or that we suspect are currently present and may be recorded with additional survey effort (except for plants; Appendices E–G). Species lists are in phylogenetic sequence and include taxonomic order, family, genus, species, subspecies or variety (if applicable) and common name. Scientific and common names used throughout this document are current according to accepted authorities for each taxonomic group: Integrated Taxonomic Information System (ITIS 2004) and the PLANTS database (USDA 2004; including designation of plants as “non-native”) for plants; Stebbins (2003) for amphibians and reptiles; American Ornithologist Union (AOU 1998, 2003) for birds; and Baker et al. (2003) for mammals. To maintain consistency throughout the document, we do not capitalize the first letter of common names unless they are proper names. In this document we use the International System of Units for measurements.

Spatial Data

Most spatial data are geographically referenced to facilitate mapping of study plots and locations of plants or animals. Coordinates were stored in the Universal Transverse Mercator (UTM)

projection (Zone 12), using the North American Datum of 1983 (NAD 83). We recorded most UTM coordinates using hand-held Garmin E-Map® Global Positioning System (GPS) units (Garmin International Incorporated, Olathe, KS; horizontal accuracy about 10–30 m) because of their convenience and relative simplicity. We obtained some plot or station locations by using more accurate Trimble Pathfinder® GPS units (Trimble Navigation Limited, Sunnyvale, CA; horizontal accuracy about 1 m). For each taxon-specific chapter of this document we mapped the location of all plots or stations overlaid on Digital Orthophoto Quarter Quads (DOQQ; produced by the U.S. Geological Survey). All study-site coordinates are stored at the same locations as for data archiving (below).

Species Conservation Designations

We indicate species conservation designations by the following agencies: U.S. Fish and Wildlife Service (responsible for administering the Endangered Species Act), Bureau of Land Management, U.S. Forest Service (Region 3), New Mexico Game and Fish Department, and Partners in Flight (a partnership of federal, state and local governments, non-governmental organizations, and private industry).

Databases and Data Archiving

We entered field data into taxon-specific databases (Microsoft Access version 97) and checked all data for transcription errors. From these databases we reproduced copies of the original field datasheets using the “Report” function in Access. The output looks similar to the original datasheets but data are easier to read. The databases, printouts, and other data such as digital photographs and GIS layers will be distributed to the monument and to the University of Arizona, Special Collections (Main Library, Tucson). Original copies of all datasheets will be given to the NPS SDN I&M program office in Tucson and may be archived at another location (most likely at the Western Archaeological Conservation Center, Tucson; Andy Hubbard, *pers. comm.*). This redundancy in data archiving is to ensure that these valuable data are never

lost. Along with the archived data we will include copies of the original datasheets and a guide to filling them out. This information, in conjunction with the text of this report, should enable future researchers to repeat our work.

Verification and Assessment of Results

Photographic Vouchers

Whenever possible we documented vertebrate species with analog color photographs. Many of these photos show detail on coloration or other characteristics of visual appearance, and they may serve as educational tools for the monument staff and visitors. Photographs will be archived with other data as described above.

Specimen Vouchers

With proper documentation, specimen vouchers are the most indisputable form of evidence of species occurrence. Before taking vertebrate voucher specimens, we searched for existing vouchers from Gila Cliff Dwellings NM in the collections at the University of Arizona and the Museum of Southwestern Biology at the University of New Mexico (Albuquerque). When we collected specimen vouchers, we tried to use individuals that were killed incidentally (e.g., roadkill) whenever possible, but we occasionally euthanized animals, particularly when identification was uncertain (e.g., many small mammal species exhibit subtle variations in pelage color patterns within species and external measurements overlap among species). The University of Arizona's Institution for Animal Care and Use approved all field protocols for euthanizing animals (Protocol Control Number 03-177). Specimens were prepared according to standardized techniques and accessioned into the appropriate vertebrate collection at the University of Arizona (vertebrate vouchers are listed in Appendix H).

For plants, we searched the University of Arizona and University of Texas at El Paso (UTEP) herbaria databases for existing specimens from the monument. In the field we collected specimens whenever flowers or fruit were present on plants (Appendix A). All specimens that we

collected and mounted were accessioned into the University of Arizona herbarium.

Assessing Inventory Completeness

We evaluated inventory completeness by (1) examining the rate at which new species were recorded in successive surveys (i.e., species accumulation curves; Hayek and Buzas 1997) and (2) by comparing the list of species we recorded with a list of species likely to be present based on previous research and/or expert opinion. For all species accumulation curves, we randomized the order of the sampling periods to break up clusters of new detections that resulted from temporal conditions (e.g., monsoon initiation) independent of cumulative effort. We used the computer program Species Richness and Diversity III (Pisces Conservation Ltd., IRC House, Pennington, Lymington, UK) to calculate species accumulation curves.

Technical Concepts

Sampling Design

Sampling design is the process of selecting sample units from a population or area of interest (for a review, see Thompson [1992]). Random samples allow inference to the larger population from which those samples were drawn, and estimate the true value of a parameter. Non-random samples are less likely to be representative of the entire population, because the sample may (intentionally or not) be biased toward a particular characteristic, perhaps of interest or convenience.

We briefly address sampling design in each chapter. In general, our surveys were not randomly located because we were more interested in detecting the maximum number of species than in providing inference to a larger area. Thus, abundance estimates (relative abundance, useful as an index to true abundance) detailed in this report may be biased because we surveyed in areas likely to have high species richness; however, the nature or extent of that bias is difficult to characterize or quantify. If population estimates were a higher priority, avoiding this potential bias would have greater importance.

Estimates of Abundance

Estimating population size is a common goal of biologists, generally motivated by the desire to reduce (e.g., pest species), increase (e.g., endangered species), maintain (e.g., game species) or monitor (e.g., indicator species) population size. Our surveys at the monument were generally focused on detecting species rather than estimating population size. In many cases, however, we present estimates of “relative abundance” by species, which is an index to population size; we calculate it as the number of individuals of a species recorded, scaled by survey effort. Some researchers (particularly plant, marine, and invertebrate ecologists) prefer to scale such frequency counts by the number of observations of other species, which provides a measure of community dominance; abundance relative to other species present. If we completed multiple surveys in comparable areas (e.g., anywhere within the monument), we included a measure of precision (usually standard error) with the mean of those survey results.

Indices of abundance are presumed to correlate with true population size but do not

typically attempt to account for variation in detectability among different species or groups of species under different conditions. Metrics (rather than indices) of abundance do consider variation in detection probability, and these include density (number of individuals per unit area; e.g., two black-throated sparrow per hectare of semi-desert grassland), and absolute abundance (population size; e.g., 15 black-tailed rattlesnakes at the monument). These latter techniques are beyond the scope of our research. While it is true that indices to abundance have often been criticized (and with good reason, c.f. Anderson 2001), the abundance information that we present in this report is used to characterize the commonness of different species rather than to quantify changes in abundance through space (e.g., habitat-use studies) or time (e.g., monitoring). As such, relative abundance estimates are more useful than (1) detectability-adjusted estimates of density for only a few species or (2) raw count data for all species without scaling counts by search effort. For a review of methods used to estimate abundance, see Lancia et al. (1996).

Chapter 2: Monument Overview

Monument Area and History

Gila Cliff Dwellings National Monument (NM) is located approximately 75 km northwest of Silver City, New Mexico (Fig. 2.1). The monument includes sections of both the West and Middle forks of the Gila River and is surrounded by the Gila National Forest and Gila Wilderness, both administered by the U.S. Forest Service (USFS). The area is sparsely inhabited and the monument is located at the end of a minor highway that connects the monument to Silver City and the town of Mimbres, New Mexico. Recent annual visitation at the monument has exceeded 53,000 (NPS 2004).

Gila Cliff Dwellings NM was established in 1907 to preserve 15th century Mogollon cliff dwellings. The USFS originally managed the monument, but control was transferred in 1933 to the National Park Service (NPS; Russell 1992). The administration of the monument shifted a number of times in the 20th Century between the NPS and USFS, but as of early 2003, an NPS Park Superintendent, who works closely with USFS staff, has managed the monument.

When originally founded, the monument encompassed 65 ha, but it was expanded to 215 ha (with 43 ha of joint USFS/NPS area) in 1962 (Russell 1992). The monument consists of two separate units: the West unit is 194 ha and consists of the “contact station” and the cliff dwellings (Fig 2.2). The “TJ Ruins” unit is 21 ha and is adjacent to the joint USFS/NPS visitor center. We conducted few surveys at the TJ Ruins unit because of access issues to the site, particularly in 2002. Therefore, most study sites were in the main unit.

Natural Resources Overview

Physiography, Geology, and Soils

Gila Cliff Dwellings NM and the associated Gila Wilderness are located in the Rocky Mountains Volcanic Province. Elevation at the monument ranges from approximately 1,700 to 1,900 m. The

monument and surrounding wilderness lie within a large caldera that collapsed approximately 28 million years ago due to an enormous volcanic eruption (USFS 2003). Plateaus dominated by rhyolite, andesite, basalt, and welded tuffs are interbedded with Gila Conglomerate, while shallow floodplain deposits characterize the valleys. Soils derive predominantly from the Tertiary volcanics of the area. Volcanism in the area continues today, as demonstrated by the presence of geothermal springs (with water temperatures ranging from 32–65 °C) such as Lightfeather Hotsprings, located approximately 0.8 km upstream of the monument’s headquarters (Sprouse et al. 2002).

Hydrology

The Continental Divide rises along the eastern boundary of the Gila Wilderness, and the Gila River’s West and Middle forks, straddled by the monument, drain 4,200 km² of the southern Rocky Mountains at an average rate of 5 m³/s (Sprouse et al. 2002). Flooding is significant and recurrent, with major erosion events, particularly after thawing of the snowmelt each spring. In the canyon that contains the monument’s namesake cliff dwellings, there is a similarly named perennial spring, Cliff Dweller Canyon Spring.

Climate

Gila Cliff Dwellings NM experiences an annual bimodal pattern of precipitation which is characterized by heavy summer (monsoonal) storms from the Gulf of Mexico, and less intense frontal storms from the Pacific Ocean in the winter. On average, approximately one-half of the annual precipitation falls from July through September (Table 2.1; WRCC 2004). The area’s hot season occurs from April through October; maximum temperatures in July can exceed 35°C. Winter temperatures are cold and snow is common.

Average annual precipitation totals during the course of our study were similar in the two

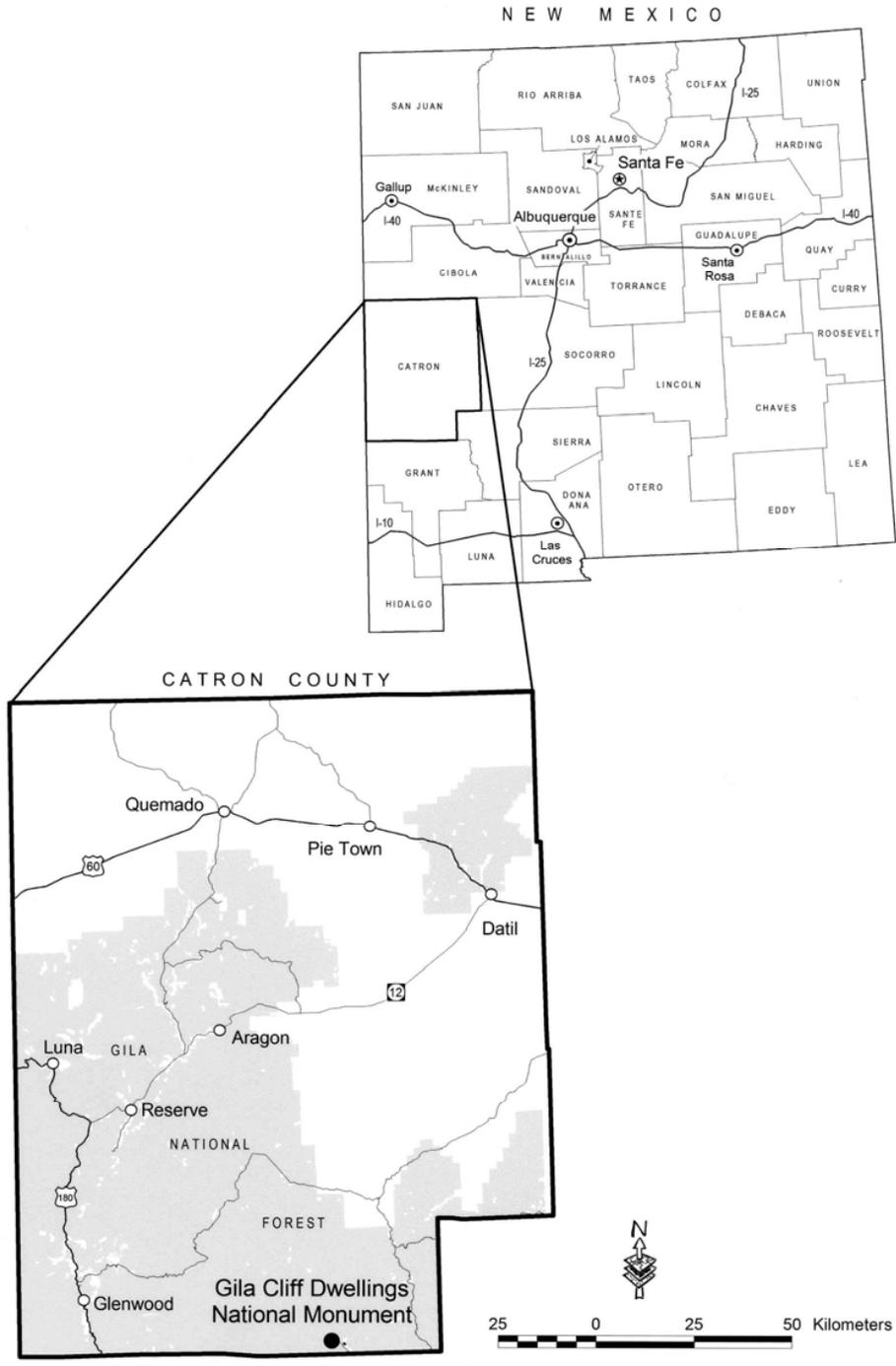


Figure 2.1. Location of Gila Cliff Dwellings NM in western New Mexico.

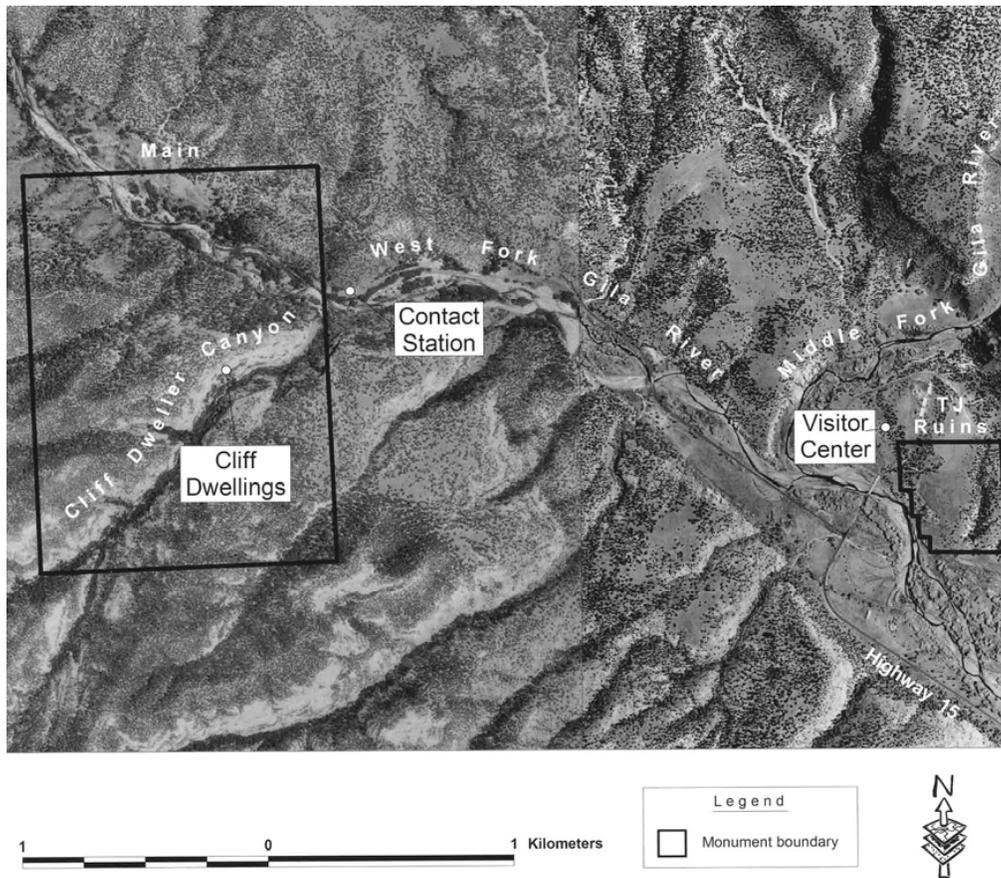


Figure 2.2. Study area and monument boundaries, Gila Cliff Dwellings NM. Digital Orthophoto Quarter Quad image from 1996.

years (31.9 cm in 2001 and 32.2 cm in 2002) but well below the long-term mean of 40.7 cm (Fig. 2.3; WRCC 2004). In the fall of 2000, rainfall was above average (Fig. 2.3); this rain may have increased annual plant seed germination and growth prior to our 2001 plant surveys. Average annual temperatures during both years of our study were slightly below the long-term mean of 11.61 °C (11.37 and 11.35 °C in 2001 and 2002, respectively; WRCC 2004).

Vegetation

Vegetation at the monument consists of Madrean evergreen woodland with oaks, pinyon, and juniper on the mesa above the cliff dwellings and on the south-facing slopes of the TJ Ruins unit; coniferous forests of ponderosa pine and Douglas fir on the north-facing slopes and in Cliff Dweller

Canyon; and deciduous riparian vegetation consisting of narrowleaf cottonwood, ash, and walnut in the canyon bottoms and on the floodplain of the West Fork of the Gila River (see Figure 2.4).

Other Inventories - Fish Surveys

We did not survey for fish because of an active monitoring program by New Mexico Game and Fish Department from 1988–present on both the West and Middle forks of the Gila River (reviewed in Propst 2000). On the West Fork site (in the monument boundary) there have been seven species of native fishes and five species of non-native fishes observed. The most abundant species at the site were the native speckled dace (*Rhinichthys osculus*) and Sonora sucker (*Catostomus insignis*). Other native species were

Table 2.1. Average monthly climate data for Gila Hot Springs, New Mexico, 1915–2004. Data from WRCC (2004).

Characteristic	Month												Annual
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Maximum temperature (°C)	12.6	14.8	17.8	22.3	26.7	31.4	31.4	29.8	27.7	23.2	17.3	12.7	22.3
Minimum temperature (°C)	-7.6	-6.0	-3.9	-1.1	2.4	6.7	12.1	11.7	7.6	1.2	-4.5	-7.4	0.9
Precipitation (cm)	2.4	2.3	2.1	1.2	1.3	1.7	7.1	7.8	5.1	3.9	2.4	3.4	3.4

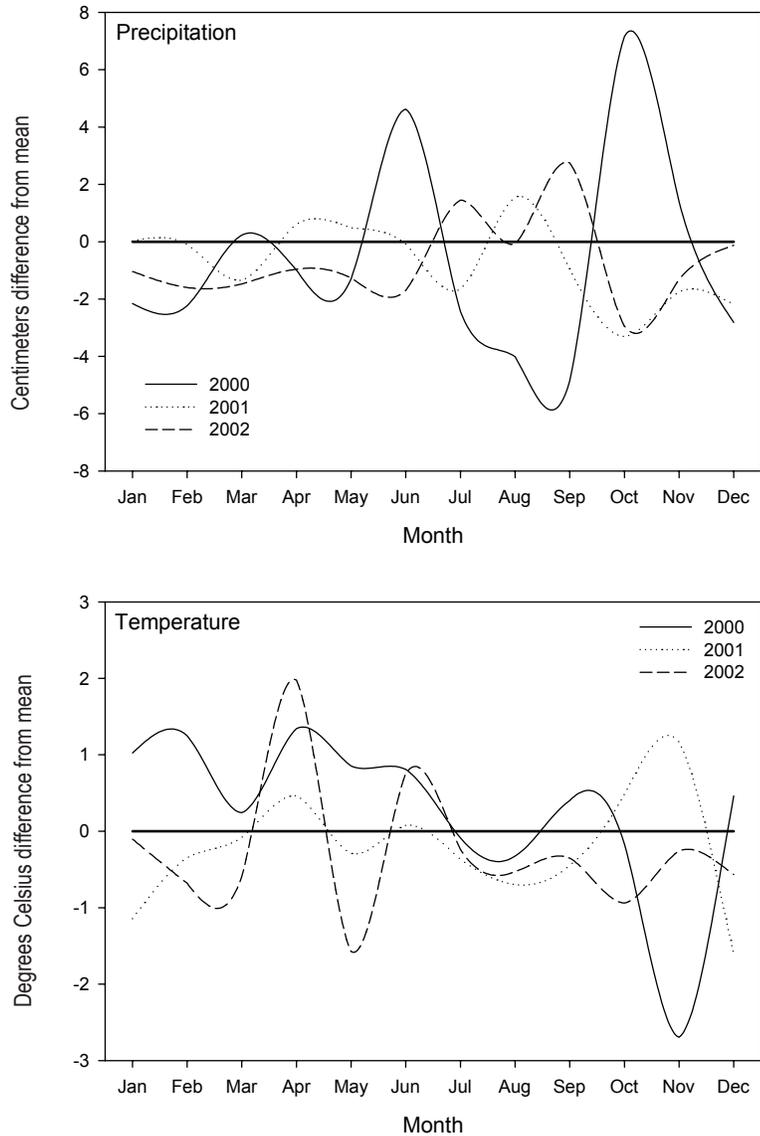


Figure 2.3. Comparison of monthly weather data during the time of the inventory (2000–2002) compared to the mean (1915–2004; thick solid line in both figures), Gila Hot Springs, New Mexico. Data from WRCC (2004).

longfin dace (*Agosia chrysogaster*), roundtail chub (*Gila robusta*), spikedace (*Meda fulgida*), loach minnow (*Tiaroga cobitis*), and desert sucker (*Catostomus clarki*). The loach minnow and spikedace are listed as Threatened under the Endangered Species Act by the US Fish and Wildlife Service, and the roundtail chub is being considered for coverage under the Endangered Species Act (BISON 2004). Non-native fish species found in the monument were: rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), yellow bullhead (*Ameiurus natalis*), western mosquitofish (*Gambusia affinis*), and smallmouth bass (*Micropterus salmoides*). All non-native species were rare or uncommon in all years with only the rainbow trout observed in each survey year (Propst 2000). Although densities of all fish were highly variable among years, there did not appear to be declines of native fish populations.

At the Middle Fork site near the TJ Ruins unit, monitoring of fish populations found significant declines of most native species (Propst 2000). At that site there were seven native (same species as at the West Fork site) and eight non-native species (all of the species at the West Fork site and flathead minnow [*Pimephales promelas*], green sunfish [*Lepomis cyanellus*], and bluegill [*Lepomis macrochirus*]). The proportion of native fish in the community declined from a high of 94% in 1988 to a low of 15% in 1999 (Propst 2000). Densities of the non-native yellow bullhead and smallmouth bass increased dramatically during that time.

Natural Resource Management Issues

Gila Cliff Dwellings NM is located at the end of a two-lane access road and is surrounded by wilderness. As a result, the monument likely has the fewest number of human-encroachment-related threats to its natural resources of any park unit in the Sonoran Desert Network (Hubbard et al. 2003). However, there have been only qualitative assessments of the threats to the monument's resources (Russell 1992). The U.S. Forest Service has not permitted cattle grazing on a large area of the Gila Wilderness adjacent to the monument since 1952. Although the monument is buffered from many natural resource problems found in

other park units, there are a number of issues that require attention (Steve Riley, *pers. comm.*).

Visitor Use

Visitor use at the monument has steadily increased each year, causing monument staff to call for a study of visitor carrying capacity (NPS 1987). Staff have expressed concern that visitors are causing direct damage to the dwellings by climbing on, leaning on, and touching them and indirect damage by generating vibrations (Russell 1992). No visitor impact study has been undertaken and damage to the cliff dwellings is still a significant management concern (Steve Riley, *pers. comm.*).

Visitors may also be harming natural resources such as soil stability and vegetation structure through off-trail hiking and trampling; erosion has occurred on the steep slopes along the trails to the cliff dwellings (NPS 1987). It is unknown whether visitor and maintenance activities along the trails and in the sensitive riparian area affect animal movement patterns, but monument staff and volunteers have long been concerned about the protection of the black-tailed rattlesnakes along the trail to the cliff dwellings (Emily Bennett, *pers. comm.*). This concern was heightened in 2001 when a visitor killed a black-tailed rattlesnake along the trail.

Other disturbances from visitors may include disruption of bird nesting activities. Continual disturbances (e.g., from nearby recreational hiking) may cause some bird species to alter their activity and feeding patterns, and even to abandon their nests or fail to defend the nest against predators (Hockin et al. 1992, Theobald et al. 1997, Swarthout and Steidl 2003). The presence of humans can alter activity patterns of other wildlife as well, especially medium- and large-sized mammals. Visitors may also introduce non-native plant species by dispersing seed attached to clothing or automobiles.

Forest Fires

Two fires have burned in and around the monument in the last ten years and there is potential for an extreme fire in the area (NPS 2003). Fires can damage sensitive cultural sites,

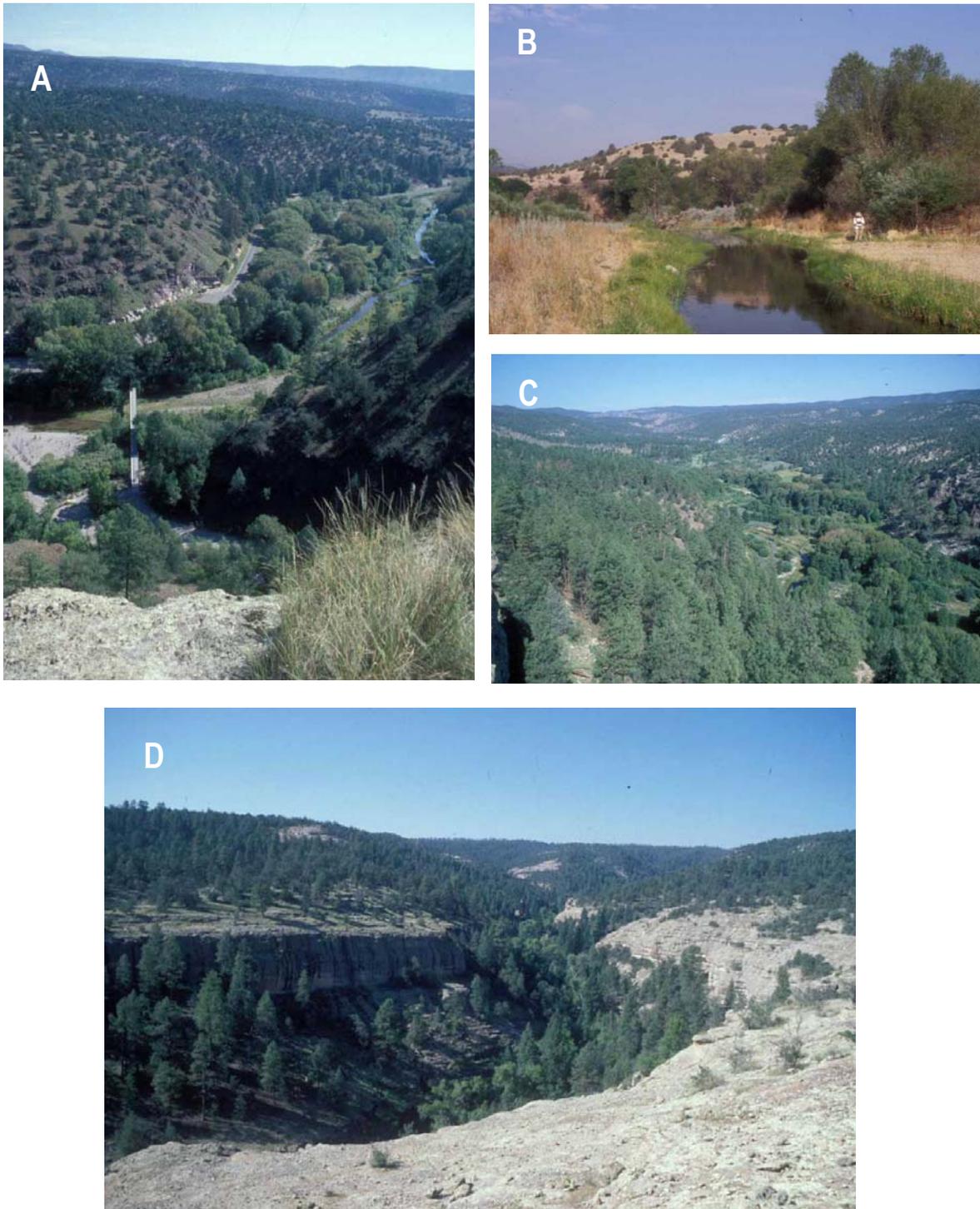


Figure 2.4. Photographs of Gila Cliff Dwellings NM. A = looking at the main access road and foot bridge crossing the West Fork of the Gila River; B = Middle Fork of the Gila River upstream of the visitor center; C = looking northwest along the West Fork of the Gila River with dense Ponderosa pine forest in the left foreground and riparian vegetation in the valley bottom; D = looking southwest into Cliff Dweller Canyon from the ridge above the cliff dwellings.

cause air quality problems, and lead to soil erosion (NPS 2003). They can also increase sediment flow, causing fish mortalities (Rieman and Clayton 1997). Yet fire is a natural part of the ecosystem and implementation of historic fire regimes may have an overall long-term positive impact on the ecosystem. The monument recently completed a fire management plan (in cooperation with the Gila National Forest; NPS 2003).

Air Quality

Smoke from forest fires can adversely affect the air quality at the monument (Russell 1992), but no monitoring data exist for these pollutants at the monument. Air quality affects plant communities by altering regeneration, species composition, and productivity (Coulston et al. 2004). Poor air quality can also restrict views from the monument (Russell 1992).

Non-native Species

The monument and surrounding lands have lacked a list of non-native plants and animals until this inventory effort. There are a number of fish species that are federally threatened or are “species of concern” at the monument, including spiketail

(*Meda fulgida*), speckled dace, longfin dace (*Agosia chrysogaster*), Loach minnow (*Tiaroga cobitis*), Sonora sucker, and roundtail chub (*Gila robusta*) (Propst 2000). These species may be negatively impacted by several non-native fish species known to be present at the monument, such as yellow bullhead and smallmouth bass (Propst 2000; see Fish Surveys above). Non-native fish compete with native species for food and space, adding to the decline of many native species (e.g., Propst and Bestgen 1991). American bullfrogs, a non-native amphibian, may also be negatively impacting native amphibian, reptile, and fish species (see Chapter 4 for more details).

Aircraft Noise

Commercial and low-flying military and emergency aircraft pass over the monument occasionally (Russell 1992, NPS 1994). Vibrations from these aircraft may damage the walls of the dwellings (Russell 1992). Both vibrations and noise generated by these aircraft may also affect the natural quiet and wildlife at the monument (NPS 1994). Aircraft overflights can produce changes in the physiology and behavior of some wildlife species (Luz and Smith 1976, Weisenberger et al. 1996).

Chapter 3: Plant Inventory

Previous Research

To our knowledge, the only other plant inventory work at or near the monument took place in the mid 1970s when Sherman Lambert, then a graduate student at UTEP, collected specimens (reviewed in Appendix A). He collected plants representing a variety of growth forms (trees, shrubs, forbs, and grasses) but did not collect some of the most common plants of the area (e.g., ponderosa pine). Because there was no documentation for his study we attempted to contact Mr. Lambert but were unsuccessful. The most complete collection (204 species) from Lambert's study is at the UTEP herbarium, but some duplicate specimens currently reside at the monument. We obtained data about the UTEP herbarium's collection from the monument, but made no attempt to validate species identifications (see Chapter 8). We evaluated the duplicate specimens at the monument for possible accessioning into the University of Arizona herbarium but the specimens were in poor condition. We found no specimens from the monument in the University of Arizona herbarium.

Methods

We surveyed for plants by general botanizing—opportunistically collecting plants when they were flowering or fruiting (when possible). We also sampled vegetation associated with VCP bird stations (see Chapter 5 for methods).

For this report, statistics such as the number of species collected or percentage of non-native species exclude specimens that we could not identify to species ($n = 27$) unless there were no other specimens identified to species for that genus ($n = 4$; e.g., *Cyperus* sp.; Appendix A). We report multiple subspecies and/or varieties as “species” in the summary statistics. However, occasionally we collected a specimen that was identified to species and a specimen that was identified by subspecies (e.g., *Oenothera caespitosa*). Barring additional information, we consider these to represent two species. Finally, comparing our results to the collection at UTEP, five species were common to

both studies where each species is represented by a specimen identified to species and a specimen identified to subspecies or variety (e.g., *Frangula betulifolia*). Without any additional information, we consider these to be separate species in our analyses.

Spatial Sampling Designs

General botanizing surveys were a mixture of intensive surveys and opportunistic collecting. A crew of up to three individuals intensively surveyed and collected in all areas of the monument (both units) for up to three days in 2001. In 2001 and 2002 we opportunistically collected specimens along the most traveled routes. We conducted a three-day survey in 2003 that covered most areas of the monument. We also collected species in areas outside the monument, particularly along the road leading to the monument and near the visitor center. We include these species in the flora of the monument because they may have been present in the monument, but the collector first observed and collected it outside of the monument.

General Botanizing

Field Methods

Whenever possible we collected at least one representative specimen (with reproductive structures) for each plant species that we encountered. We also maintained a list of species observed but not collected. This list, along with the list of collected species, comprises a “flora” for the monument (Appendix A). When we collected a specimen, we assigned it a collection number and recorded the flower color, associated dominant vegetation, date, collector names, and UTM coordinates. We pressed and processed the specimens on site. Specimens remained pressed for two to three weeks and were later frozen for 48 hours or more to prevent infestation by insects and pathogens. Mounted specimens were accessioned into the University of Arizona herbarium.

Effort

We collected or recorded species on 66 days during the course of 12 months: March and May to September 2001, May to September 2002, and June 2003 (Table 3.1). The intensity of surveys ranged from two trips (with up to three field personnel for up to three days) to a single species collected in a day. Emily Bennett, naturalist in residence, collected 161 species in 52 days of collecting. Most of our collecting was opportunistic; although we had extraordinary spatial and temporal coverage, this type of collecting precludes quantifying survey effort.

Analysis

We present a variety of summary statistics: total number of species found and number and percent of native and non-native species. To estimate inventory completeness we graph the number of new species by the month and year of their first collection.

Results and Discussion

We found 388 species in 2001–2003 (Appendix A). All but 12 species were collected within the monument boundary, and of those 12 species, we collected 11 within 1 km of either unit. Compared to the UTEP collection, we found 264 species (including 24 non-native species), which had not been collected previously for the monument. There were 123 species (including eight non-native species) common to both collections, and 84 species (including five non-native species)

unique to the UTEP collection. Of those that we did not find, 4 species are shrubs or trees (common hoptree, Mexican cliffrose, fragrant sumac, and dewstem willow) and others can take the form of subshrubs. We found no ornamental species (i.e., planted for landscaping). The percentage of non-native species was higher for our study (8.5%) than for the UTEP collection (6.3%) though we don't know if Steve Lambert did a comprehensive inventory. Based on the two collections, a total of 471 species (including 33 non-native species) have been recorded in the monument and surrounding lands. These results indicate high species richness of plants for such a small park unit at its elevation and geographic location.

Plant species richness plays an important role in determining the diversity of the other taxonomic groups that we studied, particularly amphibians, birds, and small mammals (see respective chapters for additional information). The diversity of the plant species is due to the diversity of soil conditions, microsites (from floodplain on the West Fork of the Gila River to the shady Cliff Dweller Canyon to the open mesa tops), and availability of water.

We did not find four species of rare or endangered plants that may occur in the area (based on Sivinski and Lightfoot 1992): Hess' fleabane (*Erigeron hessii*) is known from the Gila Wilderness, and Chenopod brickellbush (*Brickellia chenopodina*), Gila manroot (wild cucumber; *Marah gilensis*), and *Penstemon linarioides* ssp. *maquirei* are all known from the Gila River Valley.

Table 3.1. Field survey effort for general botanizing surveys, Gila Cliff Dwellings NM, 2001–2003.

Year	Month	Number of collection days	Number of species collected/observed
2001	March	1	13
	May	3	216
	June	7	27
	July	9	53
	August	6	94
2002	September	2	8
	May	2	5
	June	5	12
	July	5	8
2003	August	15	54
	September	8	37
	June	3	101

Inventory Completeness

Despite consistent collecting, concentrated in a two-year-period (2001 and 2002), it appears, based on the species accumulation curve, that we did not reach the goal of documenting 90% of the species at the monument (Fig. 3.1). The numbers of new species that we collected after the start of

monsoons (early July) were roughly equal in 2002 and 2001, indicating that additional surveys during a post-monsoon period with above-average rainfall would likely yield many additional species for collecting.

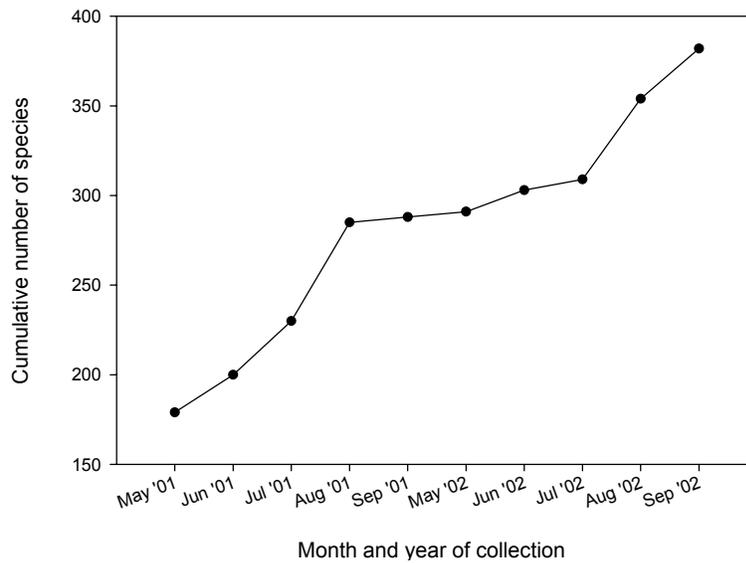


Figure 3.1. Species accumulation curve for the number of new plant species collected by month and year of the most intensive collections, Gila Cliff Dwellings NM, May–September 2001 and 2002. Figure excludes minor collecting that took place in March 2001 (11 species) and June 2003 (6 species).

Chapter 4: Amphibian and Reptile Inventory

Previous Research

To our knowledge, previous work related to amphibians and reptiles (“herpetofauna”) at Gila Cliff Dwellings NM is limited to the brief survey of the area by Hayward and Hunt (1972). There have been some specimens collected in the area (see Appendix I). Painter (1985) studied herpetofauna throughout the region and compiled museum records from New Mexico State University, Western New Mexico University, and University of New Mexico.

Study Area

Due to the relatively small size of the monument, we expanded the boundaries of our study area to include the watershed of Cliff Dweller

Canyon (Fig. 4.1). Because management of the surrounding land is similar to that of the monument, we enlarged the study area to allow a greater number of survey plots and routes to increase the likelihood of detecting species that are present in the monument (e.g., snakes with large home ranges may regularly move across the monument boundaries) and provide more precise estimates of relative abundance (see Chapter 1). All species we recorded in this expanded study area were also recorded within the legislated monument boundaries.

Methods

We surveyed for herpetofauna in 2001 and 2002 using four methods representing plot-based and more flexible, non-plot-based methods (Table 4.1).

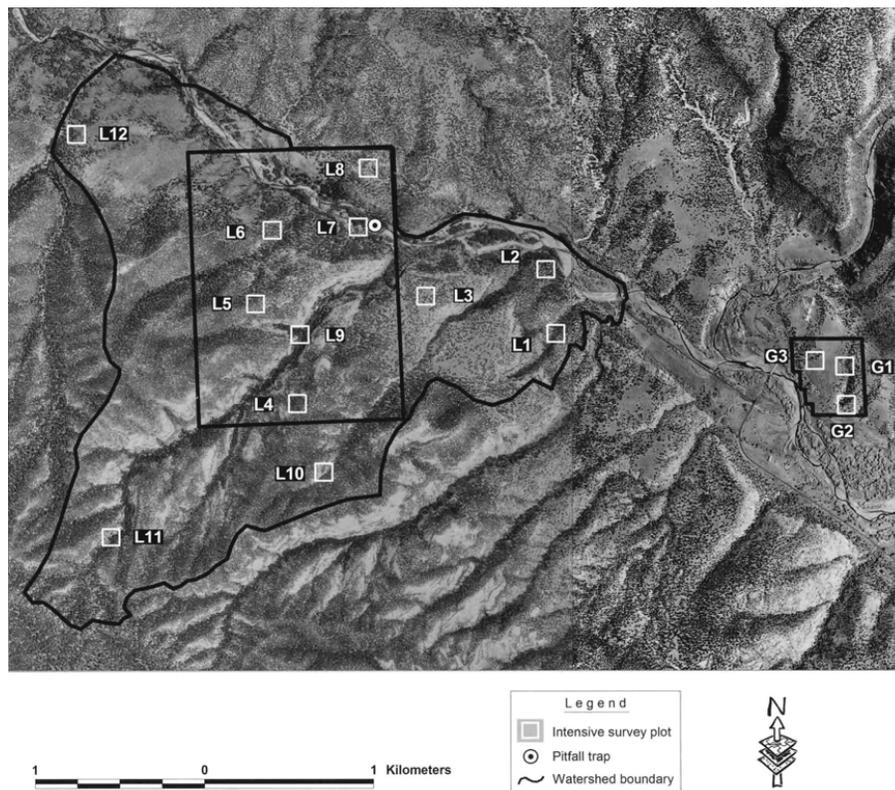


Figure 4.1 Survey plot locations for herpetofauna, Gila Cliff Dwellings NM, 2001 and 2002.

Table 4.1. Herpetofaunal survey effort by method, Gila Cliff Dwellings NM, 2001 and 2002.

Survey method	Timing	Location/community type	2001		2002		Total Hours
			Units ^a	Hours	Units ^a	Hours	
Intensive – Area constrained	Diurnal	Mesa/slopes			1	1.0	1
		West Fork Gila			1	1.0	1
		Cliff Dweller Canyon			2	2.0	2
Intensive – Time constrained	Diurnal	Dry canyons	1	4.0			4
		Cliff Dweller Canyon	1	4.0			4
Intensive – Time-and-area constrained	Diurnal	Burned slopes	1	3.0	1	2.0	5
		Dry canyons	4	8.0			8
		Mesa/slopes	7	14.0			14
		West Fork Gila	1	4.0			4
Extensive	Diurnal	Cliff Dweller Canyon	5	17.0	5	11.6	29
		Dry canyons	2	8.3			8
		Middle Fork Gila			4	10.8	11
	Nocturnal	West Fork Gila	4	13.0	10	23.2	36
		Cliff Dweller Canyon	7	9.2	2	2.1	11
		Mesa/slopes	3	7.8			8
Road transects	Nocturnal	Main access road	14	14.6	14	20.9	35
Pitfall array	Nocturnal	West Fork Gila			22	385.6	386

^a Survey units: number of surveys for extensive and road surveys, number of nights for pitfall array, and number of plots for intensive surveys (1 hour duration).

The latter approach allowed observers to respond to environmental conditions, such as temperature and precipitation, and adjust search time, intensity, and location accordingly. This flexibility was important for detecting rare, elusive, or ephemeral species most likely missing from existing records. We used non-plot-based methods diurnally and nocturnally in an effort to detect species with restricted periods of activity (Ivanyi et al. 2000). We consider amphibians and reptiles together in this report because we used the same search methods for both groups.

Notes on Species Identifications

Whiptail lizards (*Cnemidophorus* [*Aspidoscelus* by some sources] spp.) are notoriously difficult to identify in the field because of the similarity in appearance for several sympatric species (Stebbins 2003). Many parthenogenetic (non-sexually reproducing) whiptails may have arisen as hybrids from the same diploid, sexually reproducing parent species (Degenhardt et al. 1996). Several undescribed “parthenospecies” may exist in the desert Southwest (Wright and Vitt 1993, Cole and Dessauer 1994). Of the whiptails that we found, adults commonly had many spots and greenish/blue tails while juveniles had few to no spots and orange tails; we considered all of these to be

Chihuahuan spotted whiptails. We recorded a few ($n = 6$) unknown whiptails, which were likely juvenile Chihuahuan spotted whiptails. Although the desert grassland whiptail may be present in the area (Degenhardt et al. 1996, Appendix E), our survey crews were familiar with the appearance of this species and are likely to have recognized it if seen.

Spatial Sampling Design

For all methods, we surveyed for herpetofauna in preferential (non-random) locations because we wanted to detect as many species as possible. To determine locations for intensive survey plots, we examined a topographic map of the area and selected areas that represented the community types in the monument and surrounding USFS lands.

Community Types and Locations

We felt that it was important to compare herpetofauna communities among sites in and around the monument where possible. Because of extreme differences in environmental conditions (e.g., soils, vegetation, and aspect) in the area and the difficulty in delineating these environmental boundaries, we established a system for assigning

animals, found during extensive surveys, to locations or community types. The following are descriptions of the locations/community types that we used:

- West Fork Gila River: perennial riparian area in the river bottom; dominated by narrowleaf cottonwood and other deciduous trees.
- Middle Fork Gila River: similar to West Fork but with less vegetation, more open pools, and warmer water due to hot spring.
- Cliff Dweller Canyon: shady, moist, southwest to northeast tending canyon with perennial water; dominated by walnut, oak, Douglas fir, and cottonwood.
- Mesa/Slopes: xeric, open forest of juniper and pinyon pine with rocky soils.
- Burned Slopes: similar to mesa/slopes but burned within the last 15 years; more open understory.
- Dry Canyons: all canyons except Cliff Dweller; dominated by ponderosa pine and oak.

Intensive Surveys

To provide a standardized survey method, we used visual encounter surveys (described by Crump and Scott [1994]) that were constrained by time (time-constrained searches; TCS), by area (area-constrained transects; ACS), and by both time and area (time-and-area constrained plots; TACS). The primary reason for completing intensive surveys was to use repeatable methods with consistent effort for precise estimation of the relative abundance of common species. For time-constrained and time-area-constrained surveys, we visited each plot twice in a morning (with different observers) to increase the probability that a survey occurred during a period of peak activity for diurnal lizards. Inference to associated community type is speculative because plot location was selected subjectively rather than randomly. In 2002 we completed fewer intensive surveys because of the relatively low number of species and individuals recorded and instead focused our efforts on other methods, particularly extensive surveys (discussed later).

Field Methods

We recorded the starting and stopping endpoints for area-constrained transects using Garmin E-map GPS units, but we did not stake the endpoints with rebar. For other plots, we determined UTM coordinates for each of the four plot corners (and end points for time-constrained plots) using a Trimble GPS unit and marked the southwest corner of plots with rubber-capped rebar stakes. Because we did not want to place survey stakes in areas where they would be visible, we occasionally staked corners other than the standard southwest plot corner. At the start of each survey, regardless of method, we wrote a brief description of the vegetation and physical environment of the area. Before and after each survey we recorded weather information: temperature, relative humidity (%), cloud cover (%), wind speed (km/h), and an overall description of the conditions. For each animal that we observed, we recorded species (using a four-letter code), sex and age class if known, and comments regarding characteristics or behavior of interest.

Effort

Area-constrained transects: Transects were 100 m in length and the observer searched 1.0 m on each side of and above (in vegetation) this line from 0900 to 1400 hours. A single observer visited each of the four transects twice for one-half hour, except for one Cliff Dweller Canyon transect that was visited only once and for one hour. A single observer completed all surveys from 13 June to 1 August 2002 ($n = 7$ visits).

Time-constrained searches: Although search area was constant between visits to a single plot (both plots were located in steep-sided canyons), survey area was difficult to quantify and varied among plots. Search time was constant among all surveys (1 person-hour), and each plot was visited twice in a morning (with different observers) from 0800 to 1215 hours, 27 and 28 May 2001 and 21 and 22 August 2001 ($n = 8$ visits).

Time-area-constrained plots: These plots were all 1 ha (100 x 100 m) in size, and one person completed each survey in one hour from 0730 to 1300 hours. We used Garmin E-map GPS units to

ensure that we stayed within the plot boundaries during the search. We visited each plot ($n = 13$) twice in a morning (plot L12 three times), with different observers, from 26 to 30 May 2001. We returned to visit plot L07 twice on the morning of 21 August 2001, and plot L12 twice on the morning of 26 June 2002.

Analysis

We calculated species richness as the sum of species recorded, by community type, in each year, and we estimated relative abundance of species by community type in each year as the mean number of detections per survey (except for area-constrained transects, which were the mean number of detections per person hour), across all surveys.

Extensive Surveys

We designed extensive surveys to enable us to visit most areas of the monument and to search areas that, based on our field experience, were likely to have high species richness or species not previously recorded. Extensive surveys, a type of visual-encounter survey (Crump and Scott 1994), differed from intensive surveys in that they were not constrained by area or time. In 2002 we used this method almost exclusively because of its efficiency. In general, we focused extensive surveys during the cooler morning, evening, and nighttime periods to maximize the chance of encountering snakes and amphibians, which would likely be active during these times (Ivanyi et al. 2000), and as a complement to our intensive surveys, which more often occurred during the warmer late-morning and midday hours.

Field Methods

We used the extensive survey method for both diurnal and nocturnal surveys. Nocturnal surveys were defined as those beginning after 1700 hours, often including the crepuscular period. Search times varied from approximately 0.5 to 5.75 hours (mean = 2.4, SD = 1.3) depending on conditions and logistical constraints. Before and after each survey we recorded weather information:

temperature, relative humidity (%), cloud cover (%), wind speed (km/h), and an overall description of the conditions. For each animal that we observed, we recorded species (using a four-letter code), sex and age class if known, and comments regarding characteristics or behavior of interest. We recorded UTM coordinates to define the boundaries of our search area or the path we followed during our surveys.

Effort

We spent 109 hours on 47 extensive surveys from 26 May to 23 August 2001 and from 26 June to 16 September 2002 (Table 4.1). Most of the surveys ($n = 29$ of 47) were initiated during the cooler evening, nighttime, or morning hours (0500 to 1000 hours). It is not possible to accurately quantify search effort (total number of person-hours of searching) because more than one observer participated in some searches, and observers were occasionally close enough to one another to influence findings (i.e., an observer may have recorded an animal that was flushed by another observer). Also, volunteer observers sometimes accompanied crew members; and although they likely increased the number of observations (by “foot flushing”), they were not as skilled at finding or identifying animals as were crew members.

Analysis

We calculated species richness as a count of species recorded by community type in each year (diurnal and nocturnal surveys combined), and we estimated relative abundance of species by community type in each year as the mean number of detections per survey hour (typically these were person-hours), across all diurnal and nocturnal surveys. It should be noted, however, that community type designations were applied to entire surveys based on where the majority of survey time was spent, and that community type was not established with the aid of a vegetation map. Thus some “West Fork” surveys, for example, included exploration of adjacent dry tributaries as well as the river’s aquatic and riparian components.

Pitfall Traps

Pitfall traps, a live-trap, passive sampling technique, is especially useful in detecting species that may be difficult to observe because of rarity, limited activity periods, or inconspicuous behavior (Corn 1994).

Field Methods

We constructed the pitfall trap array by placing three 19-L buckets roughly 8 m away and at angles of approximately 120 degrees each from a central bucket (Gibbons and Semlitsch 1981). Between buckets we dug shallow trenches in which we placed drift fences (7.6-m long, 0.5-m tall aluminum-flashing, supported with rebar) that connected each of the three outside buckets to the central bucket. Buckets were buried so that the lip of the bucket was at ground level. We placed cover boards (50 x 50 cm pieces of plywood) over the buckets to keep the animals cool during the day, to minimize mortality, and to attract additional animals (Corn 1994).

In an attempt to capture large snakes and other animals that are able to escape from pitfall trap buckets (Corn 1994); we placed one wire-mesh funnel trap (tube with inwardly-directed cones at each end) at the midpoint along each side of the drift fences (total of six funnel traps). Animals entering via the funnels would fall to the bottom of the tube and be unable to escape. We typically opened the pitfall and funnel traps around sunset, then checked and closed the traps the next morning. For each animal captured, we recorded species, sex, and age class (if known).

Effort

We established one pitfall trap array (with four pitfall traps and six funnel traps) in the floodplain adjacent to the West Fork Gila River (Fig. 4.1). We operated the pitfall trap array for a total of 386 hours (22 nights) from 6 August to 16 September 2002 (Table 4.1).

Analysis

We report the total number of animals caught; numbers were too low to calculate relative abundance.

Road Surveys

Driving slowly on roads at night is recognized as an excellent method for surveying some groups of reptiles, particularly nocturnal snakes (e.g., Rosen and Lowe 1994). Before and after each survey we recorded weather information: temperature ($^{\circ}$ C), relative humidity (%), cloud cover (%), and wind speed (km/h). For each amphibian and reptile observed, we recorded species, sex and age class (if known), whether the animal was alive or dead, and location (as measured by distance from the start point of the survey). For all surveys we drove the same section of road from the visitor center to the contact station.

Effort

We completed 14 road surveys in both 2001 and 2002 (Table 4.1).

Analysis

We report the total number of animals observed during both years and for each year and calculate relative abundance of animals as the mean (\pm SE) number of individuals per hour of survey.

Incidental Observations

In 2001 we recorded as incidentals all animals seen when observers were not actively surveying using other survey types. We modified our approach in 2002, however, to include amphibians and reptiles observed outside of formal surveys. In both years we recorded the species, sex and age class (if known), time of observation, and UTM coordinates of the animal. Incidental detections recorded by other survey crews (e.g., bird crew) and by the herpetofaunal crew in 2002 were not accompanied by route descriptions. We collected incidental observations from 25 April to 24 September 2001, and from 30 April to 16 September 2002. We also collected incidental sightings from monument staff and volunteers and made a concerted effort to ensure correct identifications by asking detailed questions about each unusual sighting.

Effort and Analysis

Because we did not quantify search effort with this method, we do not present an analysis of

relative abundance nor compare results among species. Rather, we simply report the number of observations.

Results

We recorded three amphibian and 16 reptile species at Gila Cliff Dwellings NM (Appendix B) and an additional two reptile species within 5 km of the monument (Appendix E). Species recorded include the narrow-headed gartersnake and the Arizona toad, which are regionally recognized as “Sensitive” species (BISON 2004, see summary in Appendix B). The narrow-headed gartersnake is listed as threatened by the State of New Mexico.

Intensive Surveys

We recorded 10 species during intensive surveys; the fewest species ($n = 0-2$) in the Mesa/slopes and Burned Slopes community types and the most ($n = 6$) in the West Fork community type (Table 4.2, 4.3), though there was less sampling effort in that area (Table 4.1). The West Fork was the only area where we recorded snakes or the American bullfrog (Tables 4.2, 4.3). The ornate tree and eastern fence lizards were the most widespread species (based on their presence in all community types and areas) and were the most abundant in all areas except the West Fork, where the American bullfrog was most dominant. The crevice spiny and greater short-horned lizards were only recorded in the Mesa/slopes and Dry Canyon community types (Table 4.3).

Extensive Surveys

We recorded 13 species during 109 hours of extensive surveys (Table 4.4). We observed three species in all community types and in both years (crevice spiny, eastern fence, and ornate tree lizards), whereas we observed three species in only one community type (canyon treefrog, striped whipsnake, and narrow-headed gartersnake). Excluding results from dry mesas/slopes, species richness changed little among community types/areas (eight or nine species) despite significant differences in the amount of time spent surveying in each community type/area. Survey effort in

Cliff Dweller Canyon in 2001 and 2002 was similar (Table 4.1), yet species composition between years was very different. Of the total of nine species found in the canyon, only four were found in both years (Table 4.4). By contrast, we found only slight inter-annual differences in species composition along the West Fork of the Gila River. Despite a doubling of search effort in 2002 only one species (represented by one individual) was found in 2002 that was not found in 2001.

The American bullfrog in the Middle Fork area had the highest relative abundance of any species in all community types (Table 4.4). The Arizona toad and Chihuahuan spotted whiptail were also abundant on surveys along the Middle Fork. The American bullfrog and Arizona toad had a large standard error associated with their relative abundance estimates, however, indicating that their numbers were temporally variable. Despite being present in all but one community type/area, the Chihuahuan spotted whiptail reached a mean relative abundance that was five times higher along the Middle Fork than in any other area.

Incidental Observations

We recorded 18 species in the monument and two species outside of the monument by way of incidental observations (Table 4.4, Appendix E). Of these 20 species, five had not been recorded during the course of other surveys: eastern collared lizard, Clark’s spiny lizard, ring-necked snake, mountain patch-nosed snake, and western box turtle.

Pitfall Traps

In almost 400 hours of pitfall trap operation, we caught only 31 animals representing four species: 28 Arizona toads, two Chihuahuan spotted whiptails, and one western terrestrial gartersnake.

Road Surveys

We found five species during 28 road surveys (Table 4.5). The number of species found on each survey ranged from zero to three (mean = 1.3, SD = 1.05). We found no animals on seven surveys.

Table 4.2. Number of observations (N) and relative abundance (mean ± SE) of herpetofauna detected during area-constrained transects and time-constrained searches, Gila Cliff Dwellings NM, 2001 and 2002. See Table 4.1 for search effort used in calculating relative abundance.

Species	Area-constrained transects (2002) ^a					Time-constrained searches (2001)				
	N	West Fork		Cliff Dweller		N	Dry canyons		Cliff	
		Mean	SE	Mean	SE		Mean	SE	Mean	SE
Arizona toad	5	2.5	2.50			3	0.3	0.25	0.5	0.50
American bullfrog	11	5.5	1.50							
eastern fence lizard						8	1.8	0.48	0.3	0.25
ornate tree lizard	6	2.0	1.00	0.7	0.67	15	2.0	0.41	1.8	1.03
western terrestrial gartersnake						1			0.3	0.25
Species richness		3		1			3		4	
Total no. detections		20		2			16		11	

^a We found no animals in two surveys on the mesa/slopes.

Table 4.3. Number of observations (N) and relative abundance (mean ± SE) of herpetofauna detected during time-and-area constrained searches, by community type, Gila Cliff Dwellings NM, 2001 and 2002. See Table 4.1 for search effort used in calculating relative abundance.

Species	N	West Fork Gila River		Burned Slopes		Dry Canyons		Mesas/slopes			
		2001		2001		2002		2001		2001	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
American bullfrog	8	2.0	0.71								
crevice spiny lizard	6							0.6	0.38	0.1	0.07
eastern fence lizard	69	0.8	0.48	8.3	0.67	6.0	2.00	1.6	0.63	1.1	0.48
ornate tree lizard	58	1.5	0.50	1.3	1.33	1.5	0.50	3.9	0.74	1.0	0.51
greater short-horned lizard	1									0.1	0.07
Chihuahuan spotted whiptail	14	0.8	0.48			0.5	0.50	1.0	0.42	0.1	0.10
western terrestrial gartersnake	6	1.5	0.50								
black-tailed rattlesnake	1	0.3	0.25								
Species richness		6		2		3		4		5	
Total no. detections		27		29		16		57		34	

Table 4.4. Number of observations (N) and relative abundance (mean ± SE) of herpetofauna detected during extensive surveys (diurnal and nocturnal surveys), by community type, and total number of incidental observations, Gila Cliff Dwellings NM, 2001 and 2002. See Table 4.1 for summary of effort.

Species	N	Cliff Dweller Canyon		West Fork Gila River		Middle Fork		Dry canyons		Mesas/slopes		Incidentals				
		2001		2002		2002		2001		2001						
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE					
Arizona toad	182			0.1	0.11	0.3	0.18	2.7	1.12	5.0	3.47	0.3	0.26	18		
canyon treefrog	1	<0.1	0.03											3		
American bullfrog	211	0.1	0.06			3.0	1.95	1.0	0.38	11.6	5.19	0.2	0.17	64		
eastern collared lizard														4		
crevice spiny lizard	33	<0.1	0.05	0.4	0.16	0.2	0.12	0.1	0.07	0.5	0.24	0.2	0.17	10		
Clark's spiny lizard														3		
eastern fence lizard	137	0.9	0.25	0.8	0.30	2.3	1.04	1.3	0.36	0.1	0.13	1.3	0.10	72		
ornate tree lizard	222	2.0	0.62	2.7	0.75	1.7	0.63	1.9	0.42	0.2	0.12	2.3	2.33	80		
greater short-horned lizard														5		
Chihuahuan spotted whiptail	73	<0.1	0.03	0.1	0.05	0.8	0.41	0.3	0.15	4.3	0.91	0.3	0.26	22		
Madrean alligator lizard	2	<0.1	0.03									0.2	0.20	5		
ring-necked snake														2		
striped whipsnake	2			0.2	0.16									4		
mountain patch-nosed snake														2		
gopher snake														10		
narrow-headed gartersnake	1							<0.1	0.04					14		
western terrestrial gartersnake	5					0.3	0.11	0.1	0.04					6		
black-necked gartersnake	10					0.1	0.09	<0.1	0.04	0.2	0.12	0.3	0.11	0.4	0.23	
black-tailed rattlesnake	2							0.1	0.08	0.2	0.20			12		
Species richness		7		6		8		9		8		8		5		18
Total no. detections		98		57		146		262		240		49		29		340

The Arizona toad was the most abundant and at least one individual of this species was observed during 19 surveys (when present, the number of individuals ranged from one to 57). Despite the same survey effort during both 2001 and 2002, we found no American bullfrogs in 2001, yet we found them on six of the 14 surveys in 2002.

Voucher Specimens and Photographs

We documented the presence of species in or near the monument with specimen (15 species) and photographic vouchers (16 species; Appendix H). We obtained specimen or photographic vouchers for all but two species (Sonoran mountain kingsnake [Appendix E] and ring-necked snake).

Inventory Completeness

Based on a review by Rosen (Appendix J), range maps, habitat descriptions by Degenhardt et al. (1996), and our species accumulation curve (Fig. 4.2), we believe that we found all of the common species and most of the species that are expected to occur at the monument. Species that we did not find, but which may be present in the monument or surrounding lands (based on range maps and habitat descriptions in Degenhardt et al. [1996]) fall into three categories: (1) species that are “probable” based on range and/or habitat associations, (2) species that may occur but which are typically found at lower or higher elevations or environments (e.g., deserts or spruce-fir forests,

Table 4.5. Number of observations (N) and relative abundance (mean ± SE) of herpetofauna detected during road transect surveys, Gila Cliff Dwellings NM, 2001 and 2002. See Table 4.1 for summary of effort.

	N	2001		2002	
		Mean	SE	Mean	SE
Arizona toad	197	5.8	2.29	5.2	1.44
canyon treefrog	17	0.1	0.06	0.9	0.35
American bullfrog	20			1.1	0.45
gopher snake	2	0.1	0.11	<0.1	0.03
black-tailed rattlesnake	1			<0.1	0.04
Species richness		3		5	
No. of detections		75		162	

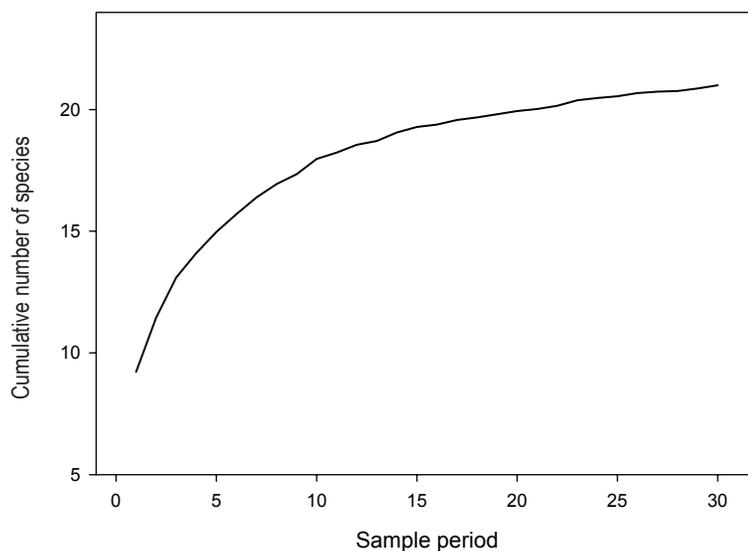


Figure 4.2 Species accumulation curves for intensive and extensive amphibian and reptile surveys, Gila Cliff Dwellings NM, 2001 and 2002.

respectively), and (3) likely extirpated species (Appendix E; see also Discussion section below).

We believe there are five species that are likely to occur in the monument or surrounding lands that we did not find. Tiger salamander needs pools of water to breed, so habitat seems abundant, particularly along the West and Middle forks of the Gila River. The Museum of Southwestern Biology has a specimen obtained approximately 20 km from the monument, and Hayward and Hunt (1972) report that they found the salamander in “almost every stock tank in the [Gila] wilderness.” Red-spotted toads are likely in rock outcrops in areas along the West and Middle forks, and Hayward and Hunt (1972) report that they were “common” near the visitor center. There appears to be an abundance of habitat for Sonoran mud turtles, particularly along the Middle Fork of the Gila River where there are large pools of water created by the American beaver. Although we searched for mud turtles, we did not use turtle traps, and therefore may have missed this species. Hayward and Hunt (1972) report that they photographed an individual not far from the monument in 1971. Many-lined skinks are probably rare but likely to be found along the West and Middle forks. Checkered gartersnake, like the black-necked gartersnake, is not restricted to the aquatic environment and may be found in any area of the monument. The western rattlesnake is possible in rocky outcrops and dry stream beds, particularly on the mesa and dry canyons to the west of the cliff dwellings.

A number of additional species that are “possible” include species that typically live in high elevation and rockier environments (mountain treefrog, western chorus frog, and rock rattlesnake) and some typically associated with lower elevation (broad valley) environments (spiny softshell turtle, desert spiny lizard, desert grassland whiptail, and night snake).

Discussion

As with the other taxonomic groups, this effort is the first comprehensive inventory of the area. Although search effort was not uniform among community types/area, we nevertheless were meticulous in maintaining records of our search effort, which allows us to draw conclusions about

the relative abundance of species in the monument and surrounding lands.

Overall, the herpetofauna community at Gila Cliff Dwellings NM is relatively diverse for an area of its size, elevation, and geographic location. The wide variety of environmental conditions (e.g., soil types, topography, and vegetation) are reflected in the herpetofauna community. In particular, the lush canyon bottoms of the West and Middle forks of the Gila River contained a number of species not found in other community types/areas, particularly the narrow-headed and western terrestrial gartersnakes (Table 4.4). The narrow-headed gartersnake, in particular, is highly aquatic and is thought to be undergoing population declines in other areas (Phil Rosen, Appendix J). Fernandez and Rosen (1996) believed these declines were because of predation by non-native crayfish (*Orconectes* spp.), which have been reported from the Middle Fork but not from the West Fork of the Gila River (David Propst, *pers. comm.*).

Two of the three amphibian species that we documented, Arizona toad and American bullfrog, were the most abundant species in these mesic areas, and based on their high relative abundance in all survey types (except time-and-area constrained searches), they were the most abundant members of the community (Tables 4.2–4.4). The American bullfrog was very abundant along the West and Middle forks of the Gila River (Tables 4.2–4.4) where there appeared to be ample habitat for adults and tadpoles. The American bullfrog was exceptionally abundant in side channels with slow-moving water in both areas. The areas around and downstream of the hot spring along the Middle Fork, in particular, were teeming with American bullfrog tadpoles. (Observers noted the presence of tadpoles, and in some cases attempted to quantify them (e.g., “1,000s”) but our surveys were not well designed to count tadpoles). The American bullfrog is native to eastern North America but have been introduced throughout the western U.S. for food production and sport (Stebbins 2003). Bullfrogs are a species of management concern at the monument because bullfrog adults and tadpoles are voracious predators (Kiesecker and Blaustein 1997) and competitors (Kupferberg 1997) and are thought to be partially responsible for the decline

of some native fish (Minckley and Deacon 1991), and many reptiles (Schwalbe and Rosen 1988), and amphibians (particularly other Ranid frogs; Hayes and Jennings 1986, Lawler et al. 1999) in the Southwest. Hayward and Hunt (1972) note that American bullfrogs were “common” in the area around the visitor center in 1971. We noted American bullfrog adults during road surveys in 2002 only; they are known to travel great distances in search of food or breeding habitat (Dennis Suhre, *unpublished data*).

Despite a concerted effort to find Chiricahua leopard frogs along the Middle and West forks of the Gila River, we found none. Historically, the Chiricahua leopard frog was found in and adjacent to the monument (Appendix J) where they were probably common. Their apparent absence from the area is troubling and may have been caused by the abundance of American bullfrogs. Other explanations for the extirpation of Chiricahua leopard frog may include (1) habitat alteration, (2) drought, (3) increases in ultraviolet radiation, and (4) chytrid fungus (Sredl et al. 2000), (5) non-native fishes, and (5) introduced crayfish. Among these other possible explanations, only chytrid fungus seems plausible here, although with a warm spring present, even this seems unlikely (Phil Rosen, *pers. comm.*). Indeed, the widespread occurrence and abundance of the American bullfrog point to it as the key cause of decline – or at least of final extirpation – for the Chiricahua leopard frog in the area around Gila Cliff Dwellings NM.

There are three other species of amphibians that Hayward and Hunt (1972) reported as being “common” in 1971 near the visitor center: Mexican spadefoot, Woodhouse’s toad, and red-spotted toad. Of these, we could only find a voucher specimen for Woodhouse’s toad (Appendix I). It is possible that we missed red-spotted toads in the rocky outcrops near the West and Middle forks of the Gila River, but it should have appeared along the river or other canyon bottoms. However, the two other species, Mexican spadefoot and Woodhouse’s toad, should have been recorded during one of our 28 road surveys. The absence of these species is cause

for concern (see Chapter 7), although there is no independent confirmation or voucher for the Hayward and Hunt (1972) records for the red-spotted toad and Mexican spadefoot. While these species may all be part of a general amphibian decline, that conclusion would be premature, and probably could only be evaluated with a broader survey, of the West and Middle Forks of Gila River.

The certain extirpation of the Chiricahua leopard frog and possible extirpation of three other species of amphibian indicate an aquatic system that is in serious trouble. Some reptiles may be on their way out as well, including narrow-headed and black-necked gartersnakes (Don Swann, *pers. comm.*). Given the large populations of non-native fishes, American bullfrogs, and crayfish, it is likely that these species will continue to have devastating impacts on the native herpetofauna community (see Chapter 7 for more information).

Arizona toads are thought to be highly sensitive to habitat alteration, and unlike most *Bufo* species in New Mexico, they are generally not found in agricultural areas (Degenhardt et al. 1996). They require permanent water and do not need monsoon rains to initiate breeding, which would explain why we saw them throughout both summers. The abundance of the Arizona toad in the presence of a large American bullfrog population may be explained by the fact that the toads have toxins in their skins, which could make them inedible to bullfrogs (Degenhardt et al. 1996).

An unexpected herpetological observation of our study was a single western box turtle, which was found approximately 5 km from the monument. No other specimens exist for the region, though Hayward and Hunt (1972) note that Bill Rogers, an amateur naturalist, saw them on two occasions near the monument. Phil Rosen (Appendix J) considers the individual that we found to be “questionable or peripheral” because the individual may have been translocated as a captive. He suggests that confirmation of additional individuals (especially young) would clarify their status in the area.

Chapter 5: Bird Inventory

Previous Research

To our knowledge there have been no comprehensive bird surveys at the monument or surrounding area. Joan Day-Martin banded hummingbirds at the visitor center in 2001. Dale Zimmerman (1995) completed a checklist for the Gila National Forest, but he did not indicate how the list was created.

Methods

We surveyed for birds at the West unit in 2001 and 2002. We used three field methods: variable circular-plot counts for diurnal breeding-season birds, nocturnal surveys for owls and nightjars, and incidental observations for all birds. We concentrated our survey effort during the breeding season because bird distribution is relatively uniform due to territoriality among birds (Bibby et al. 2002). This survey timing increased our precision in estimating relative abundance and enabled us to document breeding activity. Our survey period included peak spring migration times for most species, which added many migratory species to our list.

We sampled vegetation associated with diurnal survey stations. Vegetation structure and plant species composition are important predictors of bird species richness and the presence of particular species (MacArthur and MacArthur 1961, Rice et al. 1984, Strong and Bock 1990, Powell and Steidl 2000).

Spatial Sampling Design and General Vegetation Characteristics

We subjectively determined the location of all survey stations as a matter of convenience or logistical necessity. Because of its small size, we surveyed most areas of the monument and some of the surrounding Gila National Forest lands (Fig. 5.1).

We established two transects with six stations each: one along the West Fork of the Gila River (“Riparian”) and another transect with three stations in Cliff Dweller Canyon and three stations on the ridge above the canyon (“Canyon”; Table

5.1; Fig. 5.1). The vegetation along the Riparian transect is dominated by narrowleaf cottonwood and willow along the West Fork of the Gila River (Table 5.1). Juniper and ponderosa pine dominate the adjacent slopes. Stations in the cool, moist Cliff Dweller Canyon (Canyon transect stations 4-6) are dominated by juniper, Gambel oak, and narrowleaf cottonwood with many herbaceous plants in the canyon bottom. Stations on the ridge above Cliff Dweller Canyon (Canyon transect stations 1-3) were more xeric and had pine and juniper with little understory vegetation.

VCP Surveys

Field Methods

We used the variable circular-plot method (VCP) to survey for diurnally active birds during the breeding season (Reynolds et al. 1980, Buckland et al. 2001). Conceptually, these surveys are similar to traditional “point counts” (Ralph et al. 1995) during which an observer spends a standardized length of time at one location and records all birds seen or heard and the distance to each bird or group of birds.

Stations along each transect were a minimum of 250 m apart to help maintain independence among observations at each station. Each year we surveyed from April through July, the period of peak breeding activity. The number of annual visits to each station varied slightly in some cases, but we maintained a minimum of 10 days between surveys. On each visit we alternated observers and the order in which we surveyed stations to minimize bias by observer, time of day, and direction of travel. We began bird surveys approximately 30 minutes before sunrise and concluded no later than four hours after sunrise, or when bird activity decreased markedly. We did not survey when winds exceeded 15 km/h or when precipitation exceeded an intermittent drizzle.

We recorded a number of environmental variables prior to beginning each transect: wind speed category (Beaufort scale), presence and severity of rain (qualitative assessment), air temperature (°F), relative humidity (%), and cloud cover (%). After arriving at a station, we

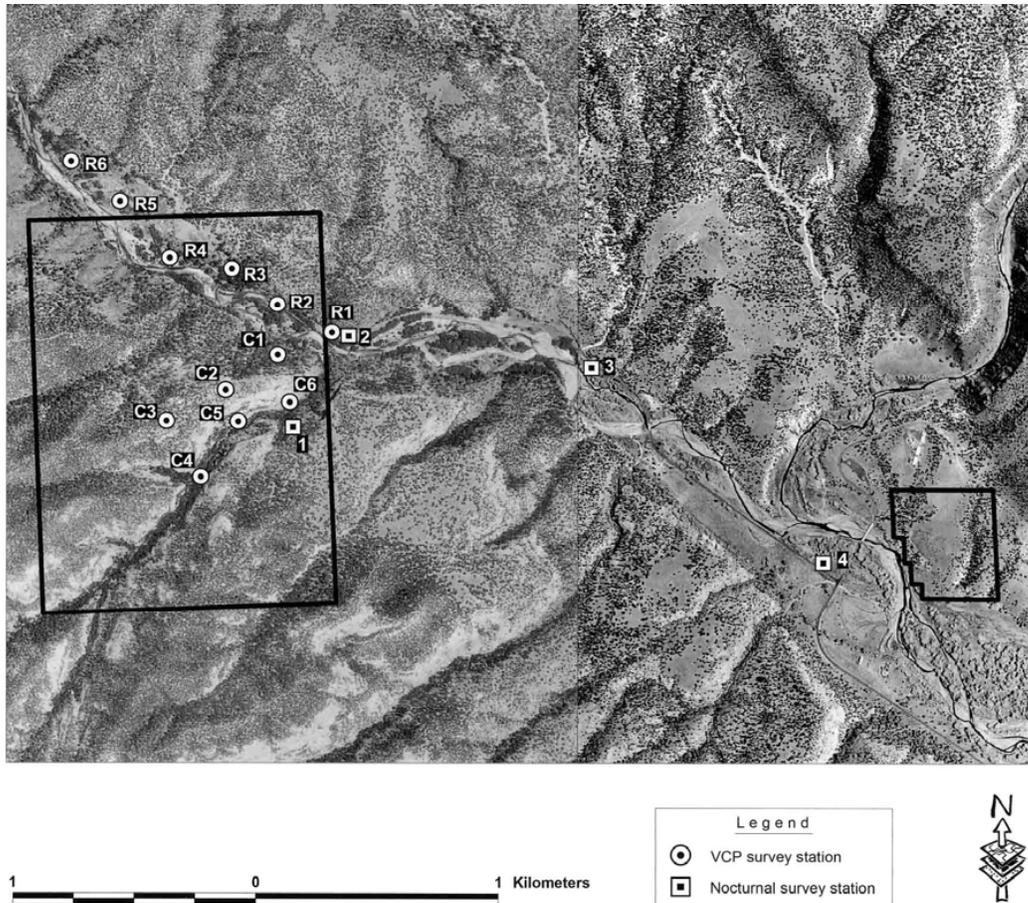


Figure 5.1. Location of bird survey stations, Gila Cliff Dwellings NM, 2001 and 2002.
 “C” = Canyon transect, “R” = Riparian transect.

waited for one minute before beginning the count to allow birds to resume their normal activities. We identified (to species) all birds seen or heard during an eight-minute “active” period. For each detection, we recorded its distance in meters from the observer (measured with laser range finder when possible), time of detection (measured in one-minute intervals beginning at the start of the active period), and the sex and/or age class (adult or juvenile) if known. We did not measure distances to birds that were seen flying overhead, nor did we use techniques to attract birds (e.g., “pishing”). We made an effort to avoid double-counting individuals that had been recorded at previous stations. If we observed a species during the “passive” count period (between the eight-minute counts) that had not been recorded previously at a station on that visit, we recorded its distance to the nearest station.

Effort

We surveyed each of the six stations of the Riparian transect five times in both 2001 and 2002, and each of the six stations of the Canyon transect four times in 2001. In 2002 we surveyed most stations (numbers 1–4) of the Canyon transect five times, but surveyed two stations (numbers 5 and 6) four times because of problems with gaining access to Cliff Dweller Canyon.

Analyses

We calculated relative abundance of each species (on each transect) as the number of detections at all stations and visits divided by sample size (number of visits multiplied by number stations). To estimate our mean and standard error, we included visits to stations for which we did not detect birds. We reduced our full collection of observations (N

Table 5.1. Mean density (ha) of the most common tree species at each station along the two VCP transects, Gila Cliff Dwellings NMON, 2002. Numbers represent the number of individuals observed in the “tree” and “potential cavity-nesting” categories from point-quarter sampling. Species present on ≥ 4 stations are included in this summary. See Appendix A for scientific names.

Transect	Station	juniper species ^a	Two-needle pinyon pine	Ponderosa pine	narrowleaf cottonwood	Gambel oak	gray oak	willow species
Riparian	1	5.4		2.5	14.9		0.4	18.7
	2	64.3	41.8	25.5	43.8		64.3	418.5
	3	28.0		7.8	114.2			
	4	0.5		0.7	181.6			120.2
	5	0.2		1.6	8.5			3.2
	6	31.4		1.1	45.3			23.2
Canyon	1	77.0	19.2	174.3		11.7		
	2	52.0	11.0	11.8			0.7	
	3	91.3	60.6	0.3			0.3	
	4	100.3				65.4	19.0	
	5	38.5	13.4	8.1	30.1	15.0	34.4	
	6	2.7	5.8	2.7	11.4	16.9		

^a alligator, Utah, and Rocky Mountain juniper.

= 1,333) to a subset of data ($n = 551$; 380 for the Riparian transect and 171 for the Canyon transect) that was more appropriate for estimating relative abundance. First, we used only those detections that occurred ≤ 75 m from count stations ($n = 469$ observations) because detectability is influenced by conspicuousness of birds (i.e., loud, large, or colorful species are more detectable than others) and environmental conditions (dense vegetation can reduce likelihood of some detections); truncating detections may reduce the influence of these factors (Verner and Ritter 1983; for a review of factors influencing detectability, see Farnsworth et al. 2002). We also excluded birds that were observed flying over the station (174 observations), birds observed outside of the eight-minute count period (231 observations), and unknown species (23 observations). Some observations met more than one of these criteria for exclusion from analysis.

Nocturnal Surveys

Field Methods

To survey for owls we broadcasted commercially available vocalizations (Colver et al. 1999) using a compact disc player and broadcaster (Bibby et al. 2002), and we recorded other nocturnal species (nighthawks and poorwills) when observed. We established one nocturnal transect (four stations) along the access road and into Cliff Dweller

Canyon (Fig. 5.1). Stations were a minimum of 300 m apart. As with other survey methods, we varied observers and direction of travel along transects and did not survey during periods of excessive rain or wind. We began surveys at approximately 45 minutes after sunset.

We began surveys at each station with a three-minute “passive” listening period during which time we broadcast no calls. We then broadcasted vocalizations for a series of two-minute “active” periods. We used vocalizations of owl species we thought might be present, based on habitat requirements and range: elf, northern pygmy, flamulated, western screech, barn, and long-eared. We broadcast recordings of owls in sequence from smallest to largest size species so that smaller species would not be inhibited by the “presence” of larger predators or competitors (Fuller and Mosher 1987). During active periods, we broadcast owl vocalizations for 30 seconds followed by a 30-second listening period. This pattern was repeated two times for each species. We excluded great horned owl from the broadcast sequence because of its aggressive behavior toward other owls. We did not survey for the federally threatened Mexican spotted owl because that would have required a specific protocol. During the count period we used a flashlight to scan nearby vegetation for visual detections. If we observed a bird during the three-minute passive period, we recorded the minute of the passive

period in which the bird was first observed, the type of detection (aural, visual, or both), and the distance to the bird. If we observed a bird during the two-minute active periods, we recorded in which interval(s) it was detected and the type of detection (aural, visual, or both). As with other survey types, we attempted to avoid double-counting individuals recorded at previous stations. We also used multiple observers, alternated direction of travel, and did not survey during inclement weather.

Effort

We established one transect of four stations and visited each station four times in 2001 and five times in 2002.

Analysis

We report the total number of detections because sample size was inadequate for developing meaningful estimates of relative abundance.

Incidental and Breeding Observations

Field Methods

When we were not conducting formal surveys and encountered a rare species, a species in an unusual location, or an individual engaged in a breeding behavior, we recorded UTM coordinates, time of detection, and (if known) the sex and age class of the bird. We recorded all breeding behavior observations using the standardized classification system (developed by the North American Ornithological Atlas Committee; NAOAC 1990). This system classifies breeding behavior into one of nine categories: adult carrying nesting material, nest building, adult performing distraction display, used nest, fledged young, occupied nest, adult carrying food, adult feeding young, or adult carrying a fecal sac. We made breeding observations during both standardized surveys and incidental observations.

Analysis

We report frequency counts of incidental and breeding observations; we cannot calculate relative abundance (as for VCP surveys) because we did not standardize survey effort.

Vegetation Sampling at Diurnal VCP Stations

We sampled vegetation near each VCP survey station to characterize community composition and structure. These data could be used to help determine habitat associations for bird species and identify important features of species-rich communities at the monument. We sampled vegetation at five *plots* located at a modified-random direction and distance from each station. Each plot was located within a 72° range of the compass from the station (e.g., Plot 3 was located from 145° to 216°) to reduce clustering of plots. We randomly placed plots from 0 to 75 m from each station to correspond with truncation of bird data used in estimating relative abundance.

At each plot we used the point-quarter method (Krebs 1998) to sample vegetation by dividing the plot into four quadrants along cardinal directions. We applied this method to plants in four size categories: sub-shrubs (0.5–1.0 m), shrubs (> 1.0–2.0 m), trees (> 2.0 m), and potential cavity-bearing vegetation (> 20 cm diameter at breast height). If there was no vegetation in a given category within 25 m of the plot center, we indicated this in the species column. For each individual plant we recorded distance from the plot center, species, height, and maximum canopy diameter (excluding errant branches). Association of a plant to a quadrant was determined by the location of its trunk, regardless of which quadrant contained the majority of the plant; no plant was recorded in > 1 quadrant. Standing dead vegetation was only attributed to the “potential cavity-bearing tree” category. On rare occasions when plots overlapped we repeated the selection process for the second plot.

Within a 5-m radius around the center of each plot, we visually estimated (1) percent ground cover by type (bare ground, litter, or rock [loose rocks or stones]) and (2) percent aerial cover of vegetation in each quadrant using three height categories: 0–0.5 m, > 0.5–2 m, and > 2 m.

Analysis

Using point-quarter data, we calculated mean density (number of stems/ha) for all species in

each of the four height/size categories using the computer program “Krebs” (Krebs 1998). We collected these data to quantify vegetation characteristics around survey stations. The detailed results of these surveys will be archived in the same locations as indicated in Chapter 1.

Results

We observed 107 species, all but three of which (peregrine falcon, yellow-headed blackbird, and indigo bunting) were observed inside the monument boundary (Appendix C). We found no non-native species and observed only one species of high conservation concern: peregrine falcon, listed as a “species of conservation concern” by the U.S. Fish and Wildlife Service. Five other species, including the common black hawk and Bell’s vireo, have additional conservation designations (see Appendix C).

VCP Surveys

We recorded 91 species during VCP surveys in 2001 and 2002. From these we were able to calculate relative abundance for 62 species (Tables 5.2, 5.3). After excluding birds observed >75 m from stations and birds seen flying over stations, we found 50 species on the Riparian transect and 39 on the Canyon transect. Among these species, we observed 23 at the Riparian transect that we did not observe at the Canyon transect, and 12 species at the Canyon transect not observed at the Riparian transect (Tables 5.2, 5.3). Abundance ranks among species that we found on both transects changed markedly. In order of abundance, from first to third most abundant species for the Canyon transect were the painted redstart, spotted towhee, and cordilleran flycatcher, but for the Riparian transect the three most abundant were the spotted towhee, house wren, and American robin.

We observed 36 species that were consistent members of the breeding-season bird community at Gila Cliff Dwellings NM (at least one individual present during at least five of the six two-week periods from 1 May to 31 July, both years; Appendix K). Other species were either less common or migratory (e.g., many warbler species).

There were marked intra-transect differences in the number of individuals recorded

at each point in each transect. Along the Riparian transect, we observed 16 species at only one station and in only one year whereas we observed 14 species at $\geq 75\%$ of the stations in both years. Along the Canyon transect we observed 20 species at only one station and in only one year, whereas eight species were found at $\geq 75\%$ of the stations in both years. The violet green swallow was the only species observed at least once at all stations in both transects in 2001 and 2002.

Nocturnal Surveys

Despite consistent effort throughout the two years of the study, we recorded only five observations of four species of nocturnal birds: one observation each of the western screech owl, great horned owl, and common poorwill, and two observations of the common nighthawk (Appendix C).

Incidental and Breeding Observations

We observed 81 species during incidental observations including 13 species that were not recorded using the other two survey types (Appendix C). We made 66 observations, representing 31 species that confirmed breeding in or near the monument (Table 5.4). Breeding behavior was observed most often for the American robin.

Inventory Completeness

Based on the species accumulation curve (Fig. 5.2) and our knowledge of the bird community, we documented at least 90% of the species that bred on or immediately adjacent to the monument during the time of our study. We also base this assertion on the extensive nest searching and incidental observations reported by our field crews. Because our surveys were a snapshot-in-time of the bird community, there may be as many as 40 additional species that may breed at the monument (Appendix F) in any given year (based on a list compiled by Zimmerman [1995]). Many of those species, such as the Mexican jay and crissal thrasher, are associated with drier conditions; others such the sharp-shinned hawk, brown creeper, red-breasted nuthatch, and pine siskin would typically be found at higher elevations. The

Table 5.2. Number of observations (sum) and relative abundance (mean \pm SE) of birds observed within 75 m of stations along the Riparian transect, Gila Cliff Dwellings NM, 2001 and 2002. See Methods section for details on estimation of relative abundance.

Species	2001			Year			2001 and 2002		
	Sum	Mean	SE	Sum	Mean	SE	Sum	Mean	SE
great blue heron	1	0.03	0.033				1	0.02	0.017
turkey vulture				1	0.03	0.033	1	0.02	0.017
American kestrel	3	0.10	0.100				3	0.05	0.050
mourning dove	6	0.20	0.101	12	0.40	0.113	18	0.30	0.076
black-chinned hummingbird	1	0.03	0.033	1	0.03	0.033	2	0.03	0.023
broad-tailed hummingbird	2	0.07	0.046	1	0.03	0.033	3	0.05	0.028
rufous hummingbird	1	0.03	0.033				1	0.02	0.017
acorn woodpecker	4	0.13	0.079	4	0.13	0.063	8	0.13	0.050
hairy woodpecker				1	0.03	0.033	1	0.02	0.017
northern flicker	2	0.07	0.067	8	0.27	0.095	10	0.17	0.059
western wood-pewee	1	0.03	0.033	4	0.13	0.063	5	0.08	0.036
cordilleran flycatcher	1	0.03	0.033				1	0.02	0.017
black phoebe	1	0.03	0.033	1	0.03	0.033	2	0.03	0.023
ash-throated flycatcher	4	0.13	0.079	1	0.03	0.033	5	0.08	0.043
Cassin's kingbird	1	0.03	0.033				1	0.02	0.017
plumbeous vireo	3	0.10	0.056	3	0.10	0.074	6	0.10	0.046
warbling vireo	11	0.37	0.140	11	0.37	0.112	22	0.37	0.089
Steller's jay	2	0.07	0.046	4	0.13	0.079	6	0.10	0.046
Lincoln's sparrow				2	0.07	0.046	2	0.03	0.023
western scrub-jay	1	0.03	0.033	2	0.07	0.046	3	0.05	0.028
purple martin	11	0.37	0.200	17	0.57	0.321	28	0.47	0.188
violet-green swallow	3	0.10	0.100	19	0.63	0.367	22	0.37	0.192
bridled titmouse				3	0.10	0.100	3	0.05	0.050
bush-tit	3	0.10	0.074	4	0.13	0.133	7	0.12	0.076
white-breasted nuthatch	1	0.03	0.033				1	0.02	0.017
pygmy nuthatch				6	0.20	0.200	6	0.10	0.100
Bewick's wren	1	0.03	0.033	1	0.03	0.033	2	0.03	0.023
house wren	29	0.97	0.217	23	0.77	0.141	52	0.87	0.129
blue-gray gnatcatcher	1	0.03	0.033				1	0.02	0.017
Townsend's solitaire				1	0.03	0.033	1	0.02	0.017
American robin	12	0.40	0.113	16	0.53	0.171	28	0.47	0.102
gray catbird				1	0.03	0.033	1	0.02	0.017
Virginia's warbler	3	0.10	0.056	11	0.37	0.102	14	0.23	0.060
yellow warbler	2	0.07	0.046	1	0.03	0.033	3	0.05	0.028
Wilson's warbler				1	0.03	0.033	1	0.02	0.017
painted redstart	2	0.07	0.046	3	0.10	0.056	5	0.08	0.036
yellow-breasted chat	8	0.27	0.082	11	0.37	0.089	19	0.32	0.061
hepatic tanager	2	0.07	0.067	1	0.03	0.033	3	0.05	0.037
western tanager	1	0.03	0.033	4	0.13	0.063	5	0.08	0.036
green-tailed towhee				2	0.07	0.046	2	0.03	0.023
spotted towhee	37	1.23	0.171	38	1.27	0.135	75	1.25	0.108
canyon towhee	6	0.20	0.121				6	0.10	0.062
white-crowned sparrow				2	0.07	0.067	2	0.03	0.033
dark-eyed junco	2	0.07	0.046				2	0.03	0.023
black-headed grosbeak	6	0.20	0.088	16	0.53	0.142	22	0.37	0.086
blue grosbeak	10	0.33	0.121	1	0.03	0.033	11	0.18	0.065
Brewer's blackbird	3	0.10	0.074	6	0.20	0.088	9	0.15	0.057
brown-headed cowbird	2	0.07	0.046	3	0.10	0.056	5	0.08	0.036
Bullock's oriole				4	0.13	0.104	4	0.07	0.052
lesser goldfinch	3	0.10	0.074				3	0.05	0.037

Table 5.3. Number of observations (sum) and relative abundance (mean \pm SE) of birds observed within 75 m of stations along the Canyon transect, Gila Cliff Dwellings NM, 2001 and 2002. See Methods section for details on estimation of relative abundance.

Species	Year								
	2001 (<i>n</i> = 24)			2002 (<i>n</i> = 28)			2001 and 2002 (<i>n</i> = 52)		
	Sum	Mean	SE	Sum	Mean	SE	Sum	Mean	SE
mourning dove	3	0.13	0.092	6	0.21	0.079	9	0.17	0.060
northern pygmy-owl	1	0.04	0.042				1	0.02	0.019
black-chinned hummingbird				1	0.04	0.036	1	0.02	0.019
broad-tailed hummingbird	1	0.04	0.042	1	0.04	0.036	2	0.04	0.027
acorn woodpecker	3	0.13	0.125				3	0.06	0.058
hairy woodpecker				2	0.07	0.050	2	0.04	0.027
northern flicker	1	0.04	0.042				1	0.02	0.019
western wood-pewee				1	0.04	0.036	1	0.02	0.019
gray flycatcher	1	0.04	0.042				1	0.02	0.019
cordilleran flycatcher	7	0.29	0.127	6	0.21	0.094	13	0.25	0.077
ash-throated flycatcher	2	0.08	0.058	3	0.11	0.079	5	0.10	0.050
plumbeous vireo	2	0.08	0.058	6	0.21	0.094	8	0.15	0.058
warbling vireo	2	0.08	0.058	1	0.04	0.036	3	0.06	0.033
Steller's jay	3	0.13	0.069	2	0.07	0.050	5	0.10	0.041
western scrub-jay				1	0.04	0.036	1	0.02	0.019
common raven	1	0.04	0.042	2	0.07	0.050	3	0.06	0.033
violet-green swallow				1	0.04	0.036	1	0.02	0.019
mountain chickadee	1	0.04	0.042	1	0.04	0.036	2	0.04	0.027
bush-tit	5	0.21	0.134	6	0.21	0.130	11	0.21	0.092
white-breasted nuthatch				1	0.04	0.036	1	0.02	0.019
pygmy nuthatch				4	0.14	0.143	4	0.08	0.077
rock wren				2	0.07	0.050	2	0.04	0.027
canyon wren	2	0.08	0.058	4	0.14	0.067	6	0.12	0.045
Bewick's wren	1	0.04	0.042	1	0.04	0.036	2	0.04	0.027
house wren	1	0.04	0.042	1	0.04	0.036	2	0.04	0.027
blue-gray gnatcatcher	1	0.04	0.042	1	0.04	0.036	2	0.04	0.027
American robin	5	0.21	0.085	5	0.18	0.074	10	0.19	0.055
olive warbler				1	0.04	0.036	1	0.02	0.019
Virginia's warbler				1	0.04	0.036	1	0.02	0.019
yellow-rumped warbler				1	0.04	0.036	1	0.02	0.019
black-throated gray warbler	4	0.17	0.078	2	0.07	0.050	6	0.12	0.045
Townsend's warbler	1	0.04	0.042				1	0.02	0.019
Grace's warbler				1	0.04	0.036	1	0.02	0.019
red-faced warbler	4	0.17	0.078	1	0.04	0.036	5	0.10	0.041
painted redstart	10	0.42	0.158	13	0.46	0.109	23	0.44	0.093
western tanager	5	0.21	0.085	5	0.18	0.090	10	0.19	0.062
spotted towhee	9	0.38	0.145	11	0.39	0.130	20	0.38	0.096
black-headed grosbeak	5	0.21	0.085	3	0.11	0.060	8	0.15	0.051
brown-headed cowbird				1	0.04	0.036	1	0.02	0.019

Table 5.4. Number of breeding-behavior observations for birds, Gila Cliff Dwellings NM, 2001 and 2002. Breeding behaviors follow NAOAC (1990).

Species	Nest building	Nest with eggs	Nest with young	Occupied nest	Adults carrying food	Adults carrying nesting material	Used nest or eggshells	Adults feeding recently fledged young	Recently fledged young	Total
great blue heron							2			2
American kestrel				1					1	1
mourning dove										1
common nighthawk		2								2
hairy woodpecker					1					1
black phoebe			1				1	1		3
Say's phoebe									1	1
plumbeous vireo					1				1	2
warbling vireo	1									1
pinyon jay									1	1
purple martin				1					1	2
violet-green swallow				1			1		1	3
northern rough-winged swallow				1						1
cliff swallow				2			1			3
bush-tit				2						2
canyon wren		1							2	3
house wren					1				2	3
western bluebird									1	1
American robin	1		1		2		2	2		8
yellow warbler					1			1		2
black-throated gray warbler						2			1	3
painted redstart			1		2				3	6
hepatic tanager					1					1
western tanager			1							1
chipping sparrow									1	1
spotted towhee					2				2	4
canyon towhee									2	2
black-headed grosbeak								1		1
blue grosbeak									1	1
Brewer's blackbird						2				2
brown-headed cowbird									1	1
Total	2	3	4	8	11	4	7	5	21	66

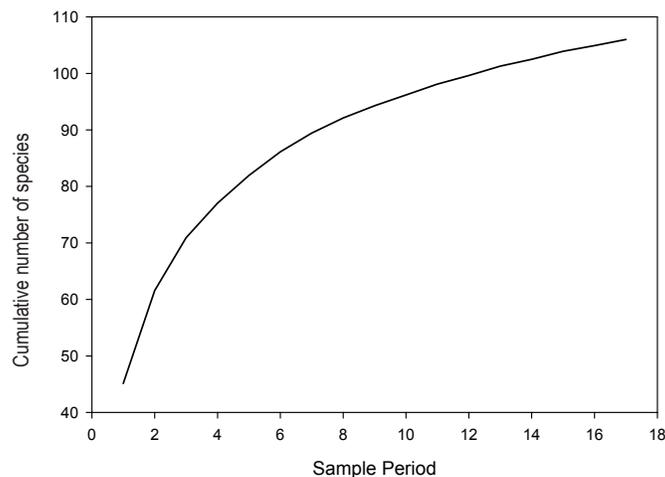


Figure 5.2. Species accumulation curves for detections from all bird surveys combined, Gila Cliff Dwellings NM, 2001 and 2002. Graph shows a completely randomized combination of observations from the three survey types (VCP, nocturnal, and incidental). Each sample period represents approximately 100 observations (N = 1,714 observations for all survey types).

northern goshawk, American dipper, European starling, Hutton's vireo, black-chinned sparrow, and house sparrow are all species that we expected to, but did not, find during our surveys.

We did not survey for the endangered southwestern willow flycatcher (*Empidonax traillii traillii*) or Mexican spotted owls, although our survey crews were familiar with the calls characteristic of these birds, we did not find any individuals. Emily Bennett reported that Scott Stoleson (a regional expert on the southwestern willow flycatcher; USFS, Rocky Mountain Research Station, Albuquerque), visited the monument in 2002 and determined that the area was too high in elevation and did not have the necessary habitat components for the species. Mexican spotted owls have been reported from the monument (NPS 2003), and Gila National Forest personnel regularly conduct surveys for this species, primarily west of the monument.

We conducted surveys entirely during the peak of spring migration and during the breeding season. Although we would not expect winter surveys to be as productive as breeding-season surveys, there are a number of species that might overwinter at the monument, including the bald eagle, northern harrier, long-eared owl, and Cassin's finch (Appendix F). A host of other species likely use the monument and surrounding lands during the early spring and/or fall migration (Appendix F).

Discussion

This is the first comprehensive survey of birds at Gila Cliff Dwellings NM and the surrounding lands. As such it is an important step in understanding the structure of the bird community and the area's role in providing habitat for birds. The bird community at the monument has representative species from a wide range of families and genera, and for the size of the monument and our moderate search effort (approximately 20 field days over two years), we would characterize the community as moderately diverse. None of the 107 species (in over 1,700 observations) were non-native but we did find several species of conservation concern and a few species out of habitat or range including: a gray

catbird found in late June 2002, the yellow-headed blackbird, Bell's vireo, and red crossbill (Appendix C). Further, we found few generalist (i.e., human-adapted) species. Except for mourning dove, those that we did find (such as the Brewer's blackbird, brown-headed cowbird, and house finch) were not abundant (Tables 5.2, 5.3, Appendix C).

The riparian area is probably the most important natural feature of the monument. The tall cottonwood gallery forest along the West Fork of the Gila River is rare in the southwest, and this type of vegetation community accounts for less than 1% of the landscape cover in the region (Ohmart 1994, Skagen et al. 1998). Riparian areas in arid regions support high bird species diversity due to their structural and floristic diversity as compared to surrounding areas (Lee et al. 1989, Strong and Bock 1990). This diversity translates into abundant insects for foraging and large trees for nesting (Powell and Steidl 2000). Bird species such as the common black hawk (Lee et al. 1989), yellow warbler, and yellow-breasted chat (Appendix C) prefer cottonwood/willow forests for nesting habitat. The presence of standing water provides habitat for a number of waterbirds such as the mallard, common merganser, and belted kingfisher.

We were encouraged to have found no non-native species at the monument or surrounding lands. The European starling and house sparrow are the most likely non-native species in the area. These species nest in cavities (and also on ledges in the case of house sparrows; Ehrlich et al. 1988) and are known to be aggressive toward native cavity-nesting species. Brown-headed cowbirds are not considered a non-native species, but they have expanded their range since the arrival of cattle into the southwest (Mehlman 1995). This is notable because cowbirds pose a threat to many native birds because they are brood parasites (i.e., lay their eggs in the nests of other, host species), and thereby reduce the productivity of host species. Brown-headed cowbirds were consistent members of the monument's bird community, particularly in the riparian area, but in that area there were 19 species that were more abundant (Table 5.2). Nevertheless, there are two riparian species at the monument that may be particularly susceptible to brown-headed cowbird parasitism: yellow-breasted

chat and yellow warbler (see review in Schweitzer et al. 1998, Averill-Murray et al. 1999). We made one observation of a recently fledged brown-headed cowbird young (Table 5.4). An evaluation of the impact of cowbird parasitism was beyond the scope of this project.

During the breeding season, brown-headed cowbirds prefer edge communities, the abrupt interface of agricultural fields and human development with areas of dense vegetation, particularly along riparian areas (Rothstein 1994) such as those at the monument. The relative lack of human-induced fragmentation of the vegetation communities surrounding the monument may be one explanation for the low numbers of brown-headed cowbirds and lack of non-native species. In addition to affecting the species composition

of bird communities, fragmentation also plays a role in nesting success; nest predators such as skunks and domestic cats typically thrive in fragmented, human-dominated landscapes (Maestas et al. 2003). The natural edges (ecotones) between the vegetation communities at the monument do not appear to host an abundance of nest predators, and we found no feral cats (see Mammal chapter; Coleman and Temple 1993). Additional research would be needed to determine if the monument and surrounding areas are “source” populations (Pulliam 1988), but research in other areas has shown that birds in ecosystems with little or no unnatural fragmentation have higher nest success than those in fragmented landscapes (Donovan et al. 1995).

Chapter 6: Mammal Inventory

Previous Research

Hayward and Hunt (1972) indicate that Bruce Hayward “trapped mammals and created a list” for the monument. Hayward netted bats at the monument in 1965; he indicated that there were no additional data (beyond species lists) from his efforts (*pers comm.* to Ronnie Sidner, 2001). Williams (1995) trapped small mammals approximately 15 km west of the monument during the spring, summer, and fall of 1995. To our knowledge no other mammal research has taken place at the monument and no mammal specimens have been collected from there.

Methods

We surveyed for mammals using six field methods: (1) netting and investigation of roost sites for bats, (2) live trapping for small terrestrial, nocturnal mammals (primarily rodents, herein referred to as “small mammals”), (3) trapping for pocket gophers, (4) pitfall trapping for shrews, (5) infrared-triggered photography for medium and large mammals, and (6) incidental observations for all mammals.

Spatial Sampling Designs

For small mammal plots we used a simple random design to assign plot locations for six plots: four plots in the West unit (L1, L3, L5, and L6) and two plots in the TJ ruins unit (G1 and G2) (Fig. 6.1). In addition, we subjectively placed 11 small-mammal trapping plots in the West unit: two in Cliff Dweller Canyon (CDC 1 and CDC 2), five in the floodplain of the West Fork of the Gila River (A, B, C, FW, and GRB), and four on the mesa above the cliff dwellings (Mesa D–G). For all other survey types we subjectively placed study sites based on (1) logistical constraints (bats) and (2) areas that we perceived would yield the most results (infrared-triggered cameras, pocket gopher trapping, and pitfall traps for shrews). We netted for bats and made incidental observations outside of the monument, but for all other survey types we established study sites within the monument boundary (Figs. 6.1, 6.2).

Bats

Field Methods: Roost-site Visits

We inspected suspected roost sites (for sign of live bats or guano) in two locations: under the automobile bridge over the Gila River (about 250 m south of the visitor center) and in the cliff dwellings.

Field Methods: Mist Netting

Most insectivorous bats congregate at water sites, so we set mist nets over water. We used three net sizes (5-m, 9-m, or 12-m) depending on the site and set nets singly or stacked, depending on conditions. For each bat captured, we recorded time of capture, species, and sex. When appropriate, we recorded relative age, reproductive condition, forearm length, mass, body condition, toothwear, presence of parasites and other measurements. We determined whether individuals were adult, subadult (by closure of epiphyses), or juvenile (by appearance). We determined age class by an estimation of tooth wear. For females, we recorded reproductive condition as pregnant (palpation for fetal bones), lactating (mammary gland with milk), previous evidence of lactation (misshapen or scarred nipples), or nulliparity (non-use of nipples). We determined reproductive condition for males by degree of swelling of testes or the presence of black epididymides. We recorded genera of parasites when known. We marked all captured bats with a temporary, non-lethal marker to prevent counting the same individual more than once in the same evening. We used sonar detectors (Anabat and/or QMC Mini) at all sites to aid in determining bat presence/absence and relative activity as compared to the visual or mist-net results. We listened passively for the call of the pallid bat, the only species of bat in western New Mexico that can be definitively identified by its directive call.

Effort

We investigated two roost sites and netted for bats at seven sites for approximately 55 hours of netting (Table 6.1).

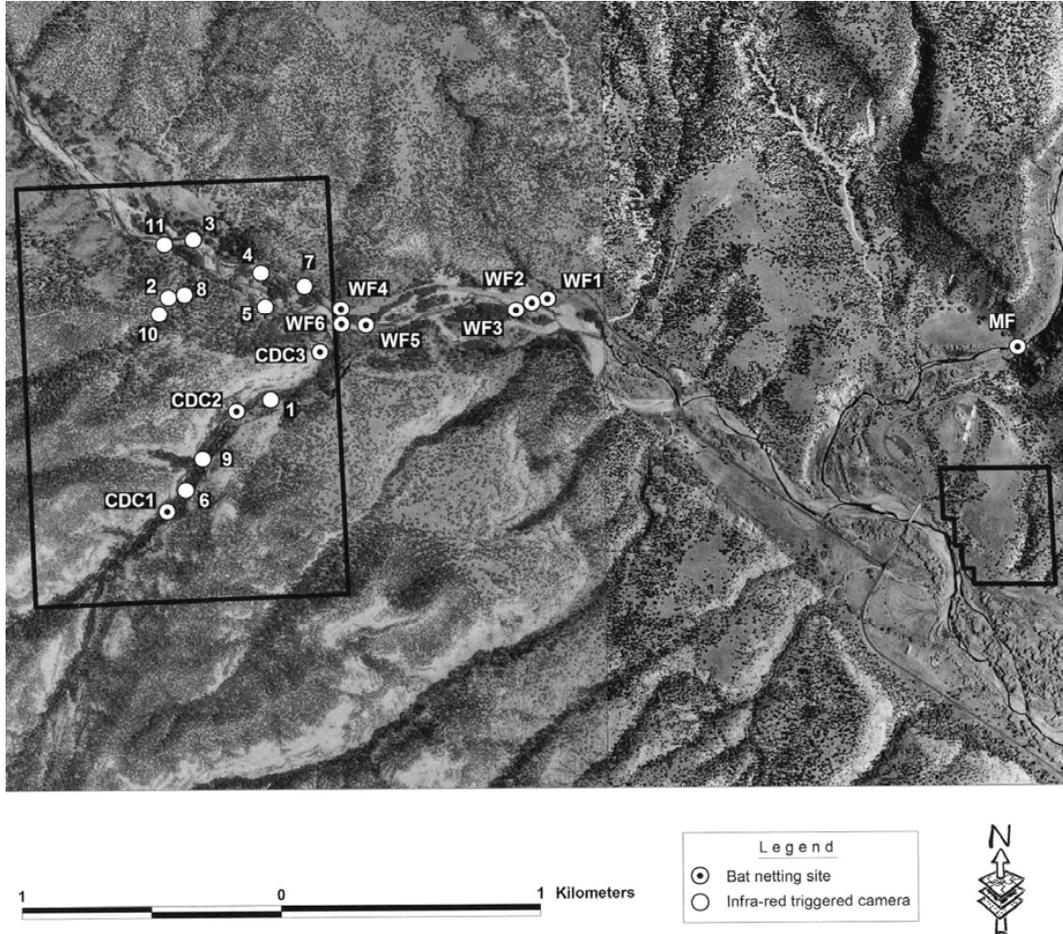


Figure 6.1. Locations of bat-netting sites and Trailmaster (infra-red triggered) cameras, Gila Cliff Dwellings NM, 2001 and 2002.

Analyses

We report the number of species and individuals caught by site, but because of the extreme differences in trapping effort among sites (Table 6.1), we calculated percent netting success (PNS)¹ for comparisons among sites. We calculated PNS as the number of animals caught divided by effort (total length of net coverage multiplied by amount of time nets were open [Table 6.1]). Due to the low number of captures at all sites except WF6 and WF1, we can compare trapping success only for these two sites.

¹ Because netting bats is somewhat a function of chance (many more individuals and species can be present in an area than are caught), we do not attempt to present percent netting success as a measure of relative abundance.

Small Mammals

Field Methods: Sherman Traps

We trapped small mammals at both the TJ Ruins and West units in 2001 and at the West unit in 2002 (Table 6.2). We used Sherman® live traps (large, folding aluminum or steel, 3 x 3.5 x 9"; H. B. Sherman, Inc., Tallahassee, FL) set in grids (White et al. 1983), with 10-m spacing among traps arranged in configurations of five rows and five columns. On two plots in Cliff Dweller Canyon we placed 24 traps into two rows of 12 traps each because of the canyon's narrowness. We opened and baited traps in the evening (one tablespoon; 16 parts dry oatmeal to one part peanut butter), then checked and closed traps the following morning. We placed a small amount of polyester batting

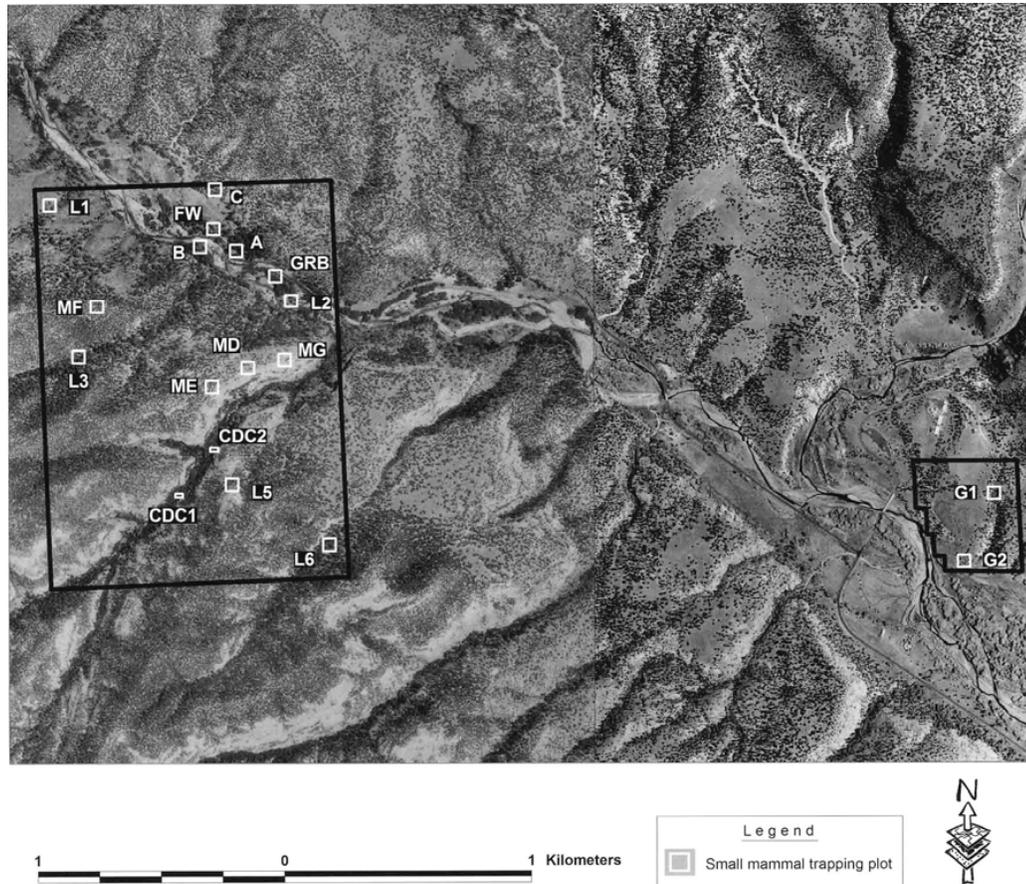


Figure 6.2. Locations of small-mammal trapping plots, Gila Cliff Dwellings NM, 2001 and 2002.

in each trap to prevent mortality from the cold. We marked each captured animal with a semi-permanent marker to facilitate recognition; these “batch marks” appeared to last for the duration of the sampling period (one to three days). For each animal we recorded species, sex, age class (adult, subadult, or juvenile), reproductive condition, weight, and measurements for right-hind foot, tail, ear, head, and body. For males, we recorded reproductive condition as either scrotal or non-reproductive. For females we recorded reproductive condition as one or more of the following: non-reproducing, open pubis, closed pubis, enlarged nipples, small or non-present nipples, lactating, post lactating, or not lactating.

Effort: Sherman Traps

We trapped for a total of 1,675 trap nights: 9 plots in 2001 (962 trap nights) and 8 plots in 2002 (713 trap nights). The number of trap nights varied by plot and visit number (Table 6.2).

Analysis: Sherman Traps

We calculated relative abundance by plot and sampling period (i.e., 1–4 trapping nights at each plot) by dividing the number of captures by the number of trap nights (number of traps multiplied by number of nights they were open) after accounting for sprung traps (misfired or occupied; Beauvais and Buskirk 1999). Sprung traps reduce trap effort because they are no longer “available” to capture animals; we account for this by multiplying the number of sprung traps

Table 6.1. Summary of bat survey effort, Gila Cliff Dwellings NM, 2001 and 2002.

Site type	Site name	Abbreviation	Year	Day/ Month	Total length of net coverage (m) ^a	Amount of time nets open (hrs)	Effort ^b
Roosting	Bridge over Gila River	BGR	2001	29 May			NA
	Cliff Dweller Canyon 3	CDC3	2001	8 Jul			NA
Netting	Cliff Dweller Canyon 1	CDC1	2001	13 Sep	18	9.5	171.0
	Cliff Dweller Canyon 2	CDC2	2001	29 May	10	3.0	30.0
	Middle Fork Gila River	MF	2001	28 May	14	5.5	77.0
	West Fork Gila River 1	WF1	2001	27 May	18	4.0	72.0
			2002	22 Jun	5	5.6	28.0
			2002	29 Aug	19	3.0	57.0
	West Fork Gila River 4	WF4	2002	27 Aug	14	4.6	64.4
	West Fork Gila River 5	WF5	2002	28 Aug	5	1.0	5.0
	West Fork Gila River 6	WF6	2001	25 May	9	1.5	13.5
				26 May	19	5.3	99.8
				12 Sep	12	2.3	27.0
		2002	21 Jun	17	6.5	110.5	
			20 Jun	12	3.0	36.0	

^aWe usually used a combination of nets depending on the physical conditions and logistical constraints. Individual nets were either 5, 9, or 12 meters in length.

^bTotal length of net coverage multiplied by amount of time nets were open.

Table 6.2. Small-mammal trapping effort, Gila Cliff Dwellings NM, 2001 and 2002.

Area or community type ^a	Plot name	Visit number	Year	Month	Nights of trapping	Traps set per night	Sprung traps	Trap nights
Cliff Dweller Canyon	CDC 1	1	2001	May	4	24	2	95.0
		2	2001	Sep	3	24	12	66.0
	CDC 2	1	2002	Jun	1	10	3	8.5
West Fork Gila River	A	1	2002	Apr	3	25	28	61.0
		1	2002	Apr	3	25	39	55.5
	B	2	2002	May	3	25	52	49.0
		3	2002	Jun	2	25	28	36.0
		4	2002	Jul	3	25	35	57.5
		5	2002	Aug	3	25	39	55.5
		6	2002	Sep	3	25	34	58.0
	C	1	2002	May	3	25	19	65.5
		FW	1	2001	Sep	2	25	0
	GRB	1	2001	May	2	25	10	45.0
2		2001	Sep	3	25	5	72.5	
Mesa	MD	1	2002	Aug	3	25	33	58.5
	ME	1	2002	Sep	3	25	4	73.0
	MF	1	2002	Sep	3	25	8	71.0
	MG	1	2002	Sep	3	25	22	64.0
Random - West unit	L1	1	2001	May	2	25	4	48.0
		2	2001	Sep	3	25	2	74.0
	L3	1	2001	May	4	25	5	97.5
		2	2001	Sep	3	25	2	74.0
	L5	1	2001	May	2	25	0	50.0
		2	2001	Sep	2	25	2	49.0
	L6	1	2001	May	2	25	0	50.0
		2	2001	Sep	2	25	0	50.0
Random - TJ Ruins unit	G1	1	2001	May	3	25	12	69.0
	G2	1	2001	May	3	25	6	72.0

^a Most groups or community types follow those established for amphibians and reptiles (see Chapter 4).

by 0.5 (lacking specific information, we estimate sprung traps were available for half of the night; Nelson and Clark 1973). We provide summaries of trapping effort for each site (all sampling periods) and for each sampling period within sites.

Field Methods: Gopher Traps

Pocket gophers (*Thomomys*) are rarely captured in Sherman traps. Therefore, we used Victor® gopher kill-traps ('Easy Set Gopher Trap 0610'; Wildlife Management Supplies, Traverse City, MI) at one site near the West Fork of the Gila River. We selected the area based on the abundance of fresh pocket gopher mounds and for convenience in checking traps. For each of three traps, we uncovered a burrow in a fresh mound and placed the trap 10–25 cm deep in the burrow. For the first two nights of trapping we covered the trap with dirt; however, for the remaining 15 nights we left the burrows and traps uncovered. To prevent trap-loss, we tied a cord (45–60 cm long) to the base of the trap and attached it to a stake.

Effort and Analysis: Gopher Traps

We trapped for pocket gophers for 17 days in August 2002. We report the number of animals captured.

Field Methods: Pitfall Traps

To capture shrews, we set up three 1-L and three 5-L pitfall buckets in the same general area as gopher traps. We placed the buckets adjacent to natural drift features (logs, rocks) and buried them flush with the ground surface. We opened the buckets in the evening and closed them the following morning. For an additional 20 days, we added three additional 5-L buckets and left them open continuously (1-L buckets were too small and we thought they might allow animals to escape). We did not bait the buckets.

Effort and Analysis: Pitfall Traps

We trapped for 26 nights in late August 2002.

Medium and Large Mammals

Field Methods

We used infrared-triggered cameras (Trailmaster®; model 1500, Goodman and Associates, Inc, Lenexa, KS; Kucera and Barrett 1993) to record

the presence of medium and large mammals. Trailmasters have three components: receiver, transmitter, and camera (Fig. 6.3). The transmitter sends an infrared beam to the receiver at a specified rate (5 times per second for this study). The receiver then sends a signal (via cable) to a camera mounted on a tripod 6–8 m away. When an animal blocks the infrared beam, the camera takes a picture. We placed the receiver and transmitter approximately 20 cm above the ground to ensure that medium and large mammals were captured on film but smaller animals such as rodents and birds were avoided. We cleared vegetation from the area to avoid disruption of the infrared beam and to minimize disturbance that might cause animals that regularly use an area to avoid it. We set cameras to take no more than one photograph every five minutes to reduce the chances of recording the same individual more than once on the same occasion. We placed cameras in areas that would capture the most species and highest numbers of animals, typically along animal trails and near water. We baited camera sites with a scent lure (ingredients included synthetic catnip oil, bobcat musk, beaver castorium, and propylene glycol as a preservative) or canned cat food. We checked cameras approximately every two weeks to change film and batteries and to ensure their proper function. We photographed a placard documenting the date and camera location on the first exposure of every new roll of film.

Effort

We placed Trailmaster cameras at 11 sites throughout the West unit (three sites each in Cliff Dweller Canyon and the unnamed canyon to the west of Cliff Dweller Canyon and five sites along the West Fork of the Gila River; Fig 6.2). The number of days that each camera was in operation ranged from 6 to 62 days (mean = 28 ± 14.2 [SD]) for a total of 308 days of operation. We operated one camera in 2001 and two cameras simultaneously in 2002.

Analysis

Infrared-triggered cameras are the most cost-effective and definitive method for recording the presence of medium and large mammal species

(Kucera and Barrett 1993, Cutler and Swann 1999). However, one drawback to this method is an inability to distinguish among individuals, which precludes unbiased estimates of abundance (i.e., one must attempt to determine if one animal has been photographed repeatedly or a new individual is in each photo). Notable exceptions are species with distinctive markings that can be differentiated among individuals, such as bobcats (Heilbrun et al. 2003). We were not able to use size or physical abnormality to differentiate individuals. Therefore, we report the number of times a species was photographed.

Incidental Observations and Sign

As with other taxa, we recorded UTM coordinates of mammal observations. Personnel from all field crews (e.g., bird crew as well as mammal crew) recorded mammal sightings and signs such as identifiable tracks or scat, and took photo vouchers when the sign alone was definitive. We also recorded incidental observations made on lands outside of the monument.

Results

We observed or documented 36 mammal species in or immediately adjacent to the monument in 2001 and 2002 (Appendix D). We observed the largest number of species by incidental observations, documented nine species each with Trailmaster cameras and small-mammal trapping, and trapped/documented eight species of bats during netting. We found neither non-native species nor species with special conservation designations (BISON 2004).

Bats

We captured 65 individuals representing eight species during approximately 55 hours of trapping in 2001 and 2002 (Table 6.4). The Mexican free-tailed and silver haired bats were the two most commonly captured species. Three species were represented by two or fewer individuals: southwestern myotis, California myotis, and big freetail bat. The Mexican freetail bat was found at the most sites ($n = 3$); the California myotis and big freetail bat at the fewest number of sites

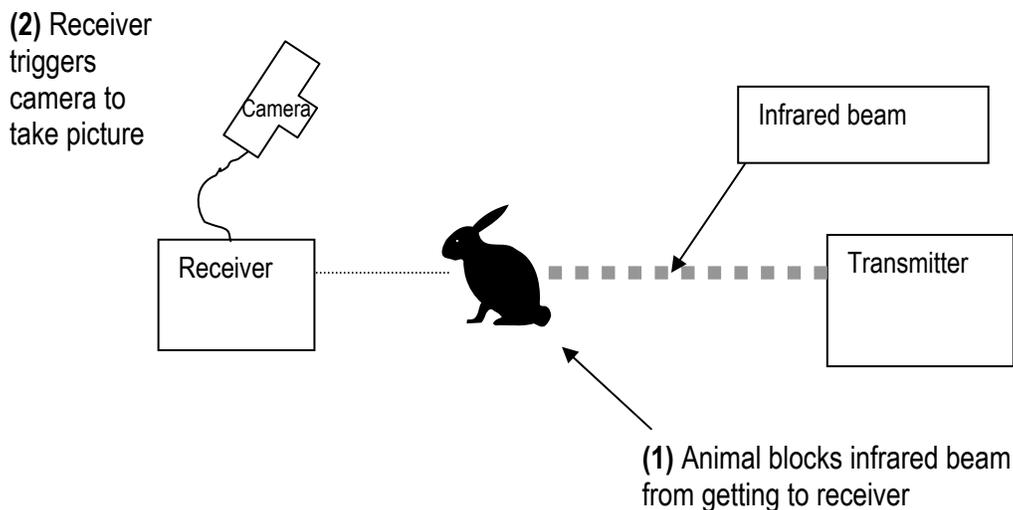


Figure 6.3. Diagram of Trailmaster camera set-up. Image based on Swann et al. (2004).

Table 6.3. Summary of Trailmaster camera effort, Gila Cliff Dwellings NM, 2001 and 2002.

General location	Camera number	Year	Start date	End date	Number of days open
West Fork Gila River	3	2001	10 Oct	11 Dec	62
	4	2002	20 Apr	19 May	29
	5	2002	19 May	08 Jun	20
	7	2002	02 Jul	15 Jul	13
	11	2002	26 Aug	20 Sep	25
Cliff Dweller Canyon	1	2001	01 Jun	01 Jul	30
	6	2002	12 Jun	19 Jul	37
	9	2002	24 Jul	21 Aug	28
Unnamed canyon west of Cliff Dweller Canyon	2	2001	01 Sep	01 Oct	31
	8	2002	30 Jul	05 Aug	6
	10	2002	20 Aug	16 Sep	27

($n = 1$). All captured bats were adults, and males outnumbered females 49 to 17 (Appendix L).

We did not catch bats at four netting sites (CDC1, CDC2, MF, and WF5) or observe them at the two roost sites. We caught seven species at each of the two most sampled sites (WF6 and WF1) and, with the exception of one species at each site, the bat community was similar (Table 6.4). Across all sampling events (i.e., netting nights), WF1 was the most productive netting site; it had a higher mean netting success (2.6 ± 2.14 [SD]) than WF6 (1.7 ± 1.49). Within these two sites there were considerable temporal differences in the number and species caught. On five sampling events at WF6 the number of species caught per sampling event ranged from zero to six (Appendix L). Hoary bats were captured on four sampling events and the Mexican freetail and big brown bats were captured on three sampling events. We found three species that were present at the site in both years and three species that were found in only a single year. On three sampling

events at WF1, the complement of species changed drastically, particularly between 2001 and 2002, as only one of the seven species caught at the site was caught in both years (Appendix L).

Small Mammals

Sherman Traps

We trapped eight species in 1,675 trap nights at both units (Table 6.5). Despite having more trap nights in 2001 than in 2002, we found more species in 2002: six species in 2001 and those same species plus two more in 2002 (Appendix M). The brush mouse was the most abundant species in plots along the West Fork of the Gila River (Table 6.5; Appendix M). The western harvest mouse was also abundant in those plots. Two species were found only in a single area each: piñon mouse in plots on the mesa (above the cliff dwellings) and the Mexican vole along the West Fork of the Gila River.

Table 6.4. Number of bats captured (n) and percent netting success (PNS) at three mist-netting sites at Gila Cliff Dwellings NM, 2001 and 2002. See Table 6.1 for summary of netting effort by site, Appendix L for additional trapping data at each site and date.

Species	Site					
	WF1		WF4		WF6	
	n	PNS	n	PNS	n	PNS
Arizona myotis	8	5.1			2	0.7
southwestern myotis	1	0.6			1	0.3
California myotis	1	0.6				
big brown bat	2	1.3			4	1.4
hoary bat	2	1.3			6	2.1
silver-haired bat	7	4.5			9	3.1
Mexican freetail bat	8	5.1	1	1.6	12	4.2
big freetail bat					1	0.3

We found no species at two plots (L6 and FW) and as many as five species on a single plot in one visit (Mesa G; Appendix M). The most species that we found on a plot was six (plot B) over six visits and 17 trapping nights (Appendix M). Not accounting for the differences in trapping effort among sites, the mean number of species trapped per plot was 2.6 ± 0.38 (SD).

Considering all species, we had low trap success in random areas and much higher trap success on non-random sites, particularly along the West Fork of the Gila River (Table 6.5). Based on presence across plots, the brush mouse was the most widespread; it was found at 13 of the 17 plots (Appendix M). The western white-throated

woodrat was the next most widespread; it was found on eight plots. All other species were found on four or fewer plots.

Gopher and Pitfall Traps

We captured one Botta's pocket gopher in 17 nights using gopher traps. We did not capture any shrews in 26 nights of pitfall-trap operation.

Medium and Large Mammals

We took 68 photographs of animals (67 mammals and one bird) in approximately 308 days of Trailmaster camera operation (Table 6.6). We took photographs of nine species of mammals

Table 6.5. Total number of small mammals trapped (n) and percent relative abundance (RA), excluding recaptures, by trapping group, Gila Cliff Dwellings NM, 2001 and 2002. Data summaries are for all sites, all visits, all trap nights within each group; see Appendix M for additional trapping data by site and visit. See Table 6.2 for trapping effort by site.

Species	Group									
	Random-West unit		Random-TJ Ruins unit		Mesa		West Fork		Cliff Dweller Canyon	
	n	RA	n	RA	n	RA	n	RA	n	RA
cliff chipmunk	1	0.2			2	0.8				
western harvest mouse	1	0.2					37	6.7		
deer mouse					2	0.8	2	0.4		
brush mouse	4	0.8	2	1.4	8	3.0	64	11.5	8	4.7
piñon mouse					3	1.2				
western white-throated woodrat	1	0.2	2	1.4	11	4.1	12	2.2	1	0.6
Mexican woodrat			1	0.7			1	0.2		
Mexican vole							3	0.5		

Table 6.6. Results from Trailmaster cameras, Gila Cliff Dwellings NM, 2001 and 2002. See Table 6.3 for effort.

Group	Species	General location, camera number							Number of Photographs	
		West Fork	Gila River	Cliff Dweller Canyon		Other ^a				
Bird	wild turkey	3	5	7	11	1	6	9	2	1
Mammal	American black bear								2	2
	striped skunk		7			3				10
	white-backed hog-nosed skunk	9								9
	common gray fox		7				1		4	12
	mountain lion			1				1		2
	rock squirrel					1				1
	Abert's squirrel					1				1
	unknown white-footed mouse				8					8
	unknown woodrat				16			1		17
	collared peccary		2						1	3
	elk		2							2
Total		9	18	1	24	5	1	2	8	68

^aUnnamed canyon west of Cliff Dweller Canyon.

that we were able to identify to species. The most frequently photographed species were the common gray fox, striped skunk, and white-backed hog-nosed skunks. However, many of these photographs were on the same roll of film, suggesting that multiple photographs may have been of the same individual.

The number of photographs from each site ranged from zero (camera numbers 4, 8, and 10) to 24 (Table 6.6). Cameras located near or adjacent to the West Fork of the Gila River resulted in the greatest number of photographs and documented the most species. At the Cliff Dweller Canyon sites we took only eight photographs that could be identified to species, and we recorded five species.

Specimen Vouchers and Photographs

We collected 34 specimen vouchers representing 24 species while conducting inventories (Appendix H). We collected many of these specimens during the course of field work (e.g., small-mammal trapping). Others were found as bones; sometimes bones served as the sole

documentation of a species, as in the case of the hooded skunk. We collected photographs of nine species from Trailmaster cameras (Table 6.6).

Incidental Observations

We recorded 43 sightings of 14 species outside of formal surveys and observed seven species that we did not find on any other survey type: coyote, American beaver, common muskrat, northern raccoon, black-tailed jackrabbit, mule deer, and white-tailed deer (Appendix D).

Inventory Completeness

Based on a list of species that have either been observed or are likely in the area (Appendix G), we believe that we recorded or documented most of the common species that occur in the monument. The only species known to have been in the area during the time of our inventory, but which we did not find, were the bobcat and Mexican gray wolf. To assess inventory completeness we address each group separately.

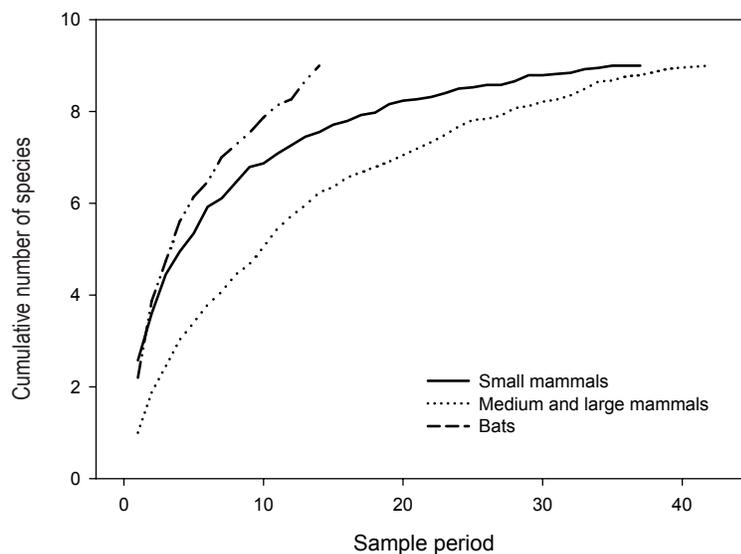


Figure 6.4. Species accumulation curve for mammal surveys, Gila Cliff Dwellings NM, 2001 and 2002. Each sampling period represents different sampling intensities for each group: one night of netting for bats, 1–3 days of trapping for small mammals, and individual photographs of medium and large mammals. The order of each sampling periods was randomized.

Bats

Despite netting at sites throughout the monument during both 2001 and 2002, we believe that there are as many as 12 species of bats that may be found at the monument with additional survey effort, including three species that were found by Bruce Hayward in 1965 (Appendix G). Indeed, the species accumulation curve for bats shows little sign of leveling off (Fig. 6.4) and illustrates the difficulty in completing an inventory of bats, which can show up most places (few insectivorous bats have restricted foraging habitat requirements). Therefore, finding these additional species will require many additional nights of netting (but see Chapter 8 for recommendations).

Small Mammals

Based on the species accumulation curve (Fig. 6.4) and our sampling intensity, we believe that we recorded all but the most rare species of small mammals at the monument. Hayward and Hunt (1972) report that they trapped the silky pocket mouse, Ord's kangaroo rat, and southern grasshopper mouse on the TJ Ruins unit, but we did not record them there nor anywhere else in the monument. The gray squirrel was noted a few kilometers up the West Fork of the Gila River by Hayward and Hunt (1972).

Medium and Large Mammals

We recorded most of the common medium and large mammals. With the exception of the bobcat and Mexican gray wolf, all of the medium and large mammals that we did not record are considered rare or only possible in the area. Long-tailed weasel may use the area during peak years (Bruce Hayward in *pers. comm.* to Ronnie Sidner, 2001). Despite a concerted effort, Hayward and Hunt (1972) did not find any porcupine in the Gila Wilderness during their surveys, though they believed the animal to be most likely in the areas such as Gila Cliff Dwellings NM. American badger is possible at the TJ Ruins unit. Both the porcupine and American badger may be experiencing declines throughout the region (Don Swann, *pers. comm.*) and this may be cause for management concern.

Discussion

This effort is the most comprehensive mammal inventory effort undertaken at Gila Cliff Dwellings NM or in the surrounding area. Of all the taxonomic groups, we spent the most effort inventorying for mammals. Our work produced 36 species, which represented a wide range of families and genera and did not include any non-native species (Appendix D). Based on our work and reports by others (Appendix G), the mammal community at the monument contains an abundance of large mammal species: American black bear, Mexican gray wolf, mountain lion, elk, and mule and white-tailed deer.

A majority of our survey effort involved small mammal trapping at plots set throughout the monument, mostly in the West unit. We assigned plot locations using random and non-random study designs and altered trap configurations, number of trap nights per plot, and number of visits to each plot. These different survey designs provided valuable insights into the spatial and temporal structure of the small-mammal community at the monument. The high trap success along the riparian area of the West Fork of the Gila River suggest that this area is preferred habitat for a number of species, such as the western harvest mouse and brush mouse. Although we did not conduct vegetation sampling at small mammal trapping sites, we sampled vegetation at bird-count stations and found much higher vegetation volume (i.e., structure) at most of the Riparian transect stations (numbers 2–5) than at stations in the canyon transect that were on the mesa (station numbers 1 and 2). This result corresponded to our qualitative characterization of the sites in the floodplain: high vegetation volume close to the ground. Vegetation volume close to the ground, particularly grasses used for food and cover, along with loose soil types, is a consistent predictor of small mammal species richness and abundance in the southwest (Price 1978, Stamp and Ohmart 1979, Sureda and Morrison 1999).

Although the sites on the mesa (above the cliff dwellings) had lower trap success than the sites on the West Fork of the Gila River, they were productive for documenting the presence of small mammals. We trapped two species (cliff chipmunk

and piñon mouse) that we found only on plots located on or near the mesa (Table 6.5).

Hayward and Hunt (1972) report that the brush mouse and western white-throated woodrat were common in the area around the visitor center. Our results concur; at plots in the TJ Ruins unit and along the West Fork of the Gila River, these two species were common (Table 6.5, Appendix M). However, Hayward and Hunt make no mention of the western harvest mouse. On our West Fork plots the western harvest mouse was almost as abundant as the brush mouse (Appendix M). We found no silky pocket mouse, Ord's kangaroo rat, or southern grasshopper mouse at the TJ Ruins unit, but Hayward and Hunt report that they trapped these species on the "TJ Mesa" (the location of the current TJ Ruins unit [Bruce Hayward, *pers. comm.*]). Given the high grass cover and scattered juniper on the TJ Ruins site, we were particularly concerned not to have found silky pocket mouse and Ord's kangaroo rat, in particular, because of their affinities for grasses and junipers (Hoffmeister 1986). No original data or specimens exist from the Hayward and Hunt effort, but Hayward's skill at species identification leave little doubt that these species were present there. Our attempt to trap these species may have been because of our limited trap effort or because the species may no longer be present (see suggestion for additional inventories).

Our bat-netting effort produced eight species of bats, all of them netted at sites over water along the West Fork of the Gila River (Table 6.4). Based on her knowledge of the area and the natural history of bats, Ronnie Sidner expected to find all of the species that we observed (Ronnie

Sidner, *pers. comm.*). Bruce Hayward trapped at sites in the monument in 1965 and found four of the species that we found (California myotis, silver-haired bat, big brown bat, and hoary bat) and three species that we did not (long-eared myotis, Townsend's big-eared bat, and pallid bat) (Bruce J. Hayward in *pers. comm.* to Ronnie Sidner, 2001). As with his small mammal trapping effort, no other data or specimens exist from Hayward's effort at the monument. We found no bats at four netting sites and even on the most sampled site (WFGR6) the number of species captured ranged from zero to six per trapping event (Appendix L). These numbers reflect the difficulty of conducting an inventory of bats; the chance of catching them may be as much a function of luck as of proper net placement.

We did not record the Mexican gray wolf during our inventory work but the species is known to occur in the area as a result of a reintroduction effort by the U.S. Fish and Wildlife Service. Visitors to the area noted three separate sightings of wolves during the time of our inventory effort (visitor center reports, 20 April, 10 May, and 1 June 2002). One sighting (10 May) was along the West Fork of the Gila River within the West unit.

We believe that two species have been extirpated from the area in and around Gila Cliff Dwellings NM: grizzly bear (*Ursus arctos*) and black-tailed prairie dog (*Cynomys ludovicianus*). The last grizzly bear in New Mexico is believed to have been killed in the early 1930s, and the monument is in the area "of probable extirpation" for the black-tailed prairie dog (Findley et al. 1975).

Chapter 7: Management Implications

Based on the data from this study and our knowledge of the natural resource issues at the monument, herein we address issues that affect management of the monument's natural resources.

Species Loss

A comparison of our data to past work in the area indicates that species loss is confirmed to have occurred for the Chiricahua leopard frog, and species loss has probably occurred for three additional species of amphibian, one reptile, and three species of small mammals. In particular, we are concerned about the native aquatic vertebrate community given the abundance of non-native fishes (see Propst 2000), American bullfrogs, and crayfish in the West and Middle forks of the Gila River. The possible loss of so many native species should warn managers that the native aquatic vertebrate community, particularly along the Middle Fork of the Gila River, may have experienced a loss of species and declining populations. In keeping with the NPS mission of maintaining natural environments for future generations, we urge managers to study this system more closely and investigate the possible removal of non-native species (see next section).

Managing Invasive, Non-native Species

There are some non-native plants and one vertebrate that may pose significant threats to the natural resources of the monument and surrounding lands. Plants of concern include red brome, buffleggrass, and cheatgrass. The only non-native vertebrate that we found, the American bullfrog, appears to be very abundant and could pose a threat to many aquatic species, particularly native fishes (Minckley and Deacon 1991) and herpetofauna. It is beyond the scope of this project to review specific control techniques for each species, but a management plan for the eradication of these species, and early detection of new species should help guide future management decisions.

Coordination with National Forest Managers

Gila Cliff Dwellings NM is a small monument that is completely surrounded by the Gila Wilderness and other National Forest lands. The Heart Bar Ranch, administered by the New Mexico Game and Fish Department is located within a kilometer of the monument. The natural resource management of these larger pieces of land will continue to have enormous influence on the monuments' resources and it would be beneficial if land management actions at the monument were coordinated with staff at the Gila National Forest, in particular. The recent collaboration with USFS personnel for the monument's fire management plan (NPS 2003) is an excellent example of this type of cooperation.

Natural Resources and Monument Staff

Current staff at Gila Cliff Dwellings NM includes no natural resource professionals. Thus the monument lacks an efficient means of meeting the inventory, monitoring, and management needs related to maintaining biodiversity as described in this report. With present staffing, the monument will likely not be able to effectively (1) coordinate monitoring activities with the SDN Inventory and Monitoring program, (2) work with adjacent landowners to establish compatible land-use practices, (3) manage non-native species, and (4) coordinate research related to other natural resources management issues at the monument.

Establishment of a Park Superintendent at Gila Cliff Dwellings NM in 2003 demonstrates NPS' commitment to the monument. Our inventory effort was hampered by our lack of understanding of the chain-of-command that was in place during the transition period between the monument's management by USFS personnel and that by the NPS. The current system of reporting to the monument superintendent will significantly improve the efficiency of future research at the monument.

Visitor Impacts

Gila Cliff Dwellings NM and the surrounding area are experiencing an unprecedented increase in the number of visitors, presumably due to the area's cultural and natural treasures. Aside from the impacts that visitors may have on cultural resources (e.g., degradation of the cliff dwellings), we identify a few of the potential impacts to the plants and vertebrates of the area. As the number of visitors increases, so does the number of automobiles on the roads, which in turn leads to the dispersal and establishment of new species, particularly non-native plant species (Seabloom et al. 2003). Increased precipitation runoff from

roads may contribute to this apparent pattern (i.e., seeds are more likely to germinate in areas receiving more moisture), and soils along the main access road to the monument are more likely to be disturbed (facilitating seed germination and plant establishment) than are soils in other parts of the monument. Increased vehicular traffic will also likely increase the mortality of terrestrial vertebrates or result in the modification of their behavior (Rosen and Lowe 1994, Trombulak and Frissell 2000, Cain et al. 2003). Visitors hiking the trails in the monument, particularly the trail to the cliff dwellings, may also affect wildlife movement patterns or cause direct mortality (see Chapter 2).

Chapter 8: Additional Inventories

No inventory is ever truly complete; species distributions expand and contract across boundaries, particularly at small park units such as Gila Cliff Dwellings NM. In general, we feel that we have succeeded in balancing our efforts between qualitative surveys designed to detect the maximum number of species with quantitative, repeatable surveys designed to estimate relative abundance with an associated measure of precision. Additional inventories could reach the 90% completion mark for some taxonomic groups. Given the small size of the monument, however, any study that investigates the monument's resources should be undertaken in the context of the larger landscape, as we did for amphibians and reptiles and for all groups through incidental observations. This approach, which places the natural resources in the monument into a larger spatial context, puts monument staff in a stronger position to maintain, enhance, or selectively eliminate natural resources from the monument and the surrounding areas.

In addition to completing more field work, we also advocate searching natural history collections for specimens that were collected from the area. Most major collections have digitized (or are in the process of digitizing) their databases, thereby making it easy to extract location information. This task may best be accomplished by Sonoran Desert Inventory and Monitoring personnel, who would be interested in obtaining this information for all network park units.

Plants

Additional general botanizing surveys, carried out again during a season of above-average monsoon rains, should increase the species list for annual plants and may possibly detect species that were not recorded by our field crews but were found by others (species in University of Texas-El Paso collection; Appendix A). We suggest that future surveys target areas where non-native plants are likely to become established, such as along the main access road.

Great care was taken when we identified and accessioned plants into the University of

Arizona Herbarium and we are fairly certain of the correct identification of our specimens. We recommend a project to inspect specimens in the UTEP collection to confirm their correct identification and update their taxonomy (e.g., Halvorson 2003). Finally, use of modular plots placed throughout the monument would be an effective tool for monitoring long-term vegetation changes (see Powell et al. 2005a).

Amphibians and Reptiles

As outlined in Chapter 4, there are a number of amphibian species that we did not find, but were observed by Hayward and Hunt (1972). We recommend additional, targeted surveys for these species on lands adjacent to the monument, particularly on the Heart Bar Ranch, and preferably farther afield to determine if the absence of these amphibians is a regional phenomenon. We also recommend targeted surveys for Sonoran mud turtles.

An effective way to increase the species list for amphibians and reptiles is to take high-quality photographs of animals as they are seen. The collection of road-killed animals, particularly snakes and toads, from along the main access road will likely add species to the monument's list. Other inventory efforts in Sonoran Desert Network parks have benefited from collection of these indisputable forms of evidence (Don Swann, *pers. comm.*).

Birds

Additional surveys during the winter season and during the spring and fall migrations will pick up species missed by efforts at other times. It is important to note, however, that bird lists are difficult to complete because birds are highly mobile. Only sites that are visited regularly by avid bird watchers (e.g., Bosque del Apache National Wildlife Refuge in southern New Mexico) have bird lists that can be considered to be "complete."

Mammals

The use of ultrasonic detectors to identify bat species is increasing, and many researchers are helping to refine these field techniques and improve the technology (e.g., Johnson et al. 2002, Gannon et al. 2003). This tool may aid in detecting those species for which additional netting would be cost prohibitive.

We recommend additional small-mammal trapping on and near the TJ Ruins unit to search for the three species of rodents that were found there by Hayward and Hunt (1972) but not by our effort. The absence of these species would mean a loss of species for the monument, but more work needs to be conducted before reaching this conclusion.

Further Trailmaster camera work will document the presence of additional medium and large terrestrial mammals (e.g., bobcat). Camera operation and maintenance are fairly simple and rewarding tasks for technically proficient staff members or volunteers. Care should be taken in determining where to place camera units because of the potential for cameras to be damaged (as happened to one of our cameras in Cliff Dweller Canyon in 2002) or stolen. Finally, we recommend an effort to obtain sightings or reports of porcupine and American badger from the area; these species may be extirpated and local residents may have information about them.

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Appendix A. Plant species that were observed or documented at Gila Cliff Dwellings NM by University of Arizona Inventory personnel (UA) 2001–2003 or by specimens located at the University of Texas-EI Paso (UTEP) herbarium. Species in bold-faced type are non-native (USDA 2004).

Family	Scientific name	Common name	UA	UTEP
Aceraceae	<i>Acer negundo</i> L.	boxelder	X	X
Agavaceae	<i>Yucca baccata</i> Torr.	banana yucca	X	
Amaranthaceae	<i>Amaranthus palmeri</i> S. Wats.	carelessweed	X	X
	<i>Gomphrena caespitosa</i> Torr.	tufted globe amaranth	X	X
	<i>Gomphrena sonora</i> Torr.	Sonoran globe amaranth	X	
	<i>Tidestromia lanuginosa</i> (Nutt.) Standl.	woolly tidestromia	X	
Anacardiaceae	<i>Rhus aromatica</i> Ait.	fragrant sumac		X
	<i>Rhus trilobata</i> var. <i>trilobata</i> Nutt.	skunkbush sumac	X	
	<i>Toxicodendron pubescens</i> P. Mill.	Atlantic poison oak	X	
Apiaceae	<i>Cicuta douglasii</i> (DC.) Coult. & Rose	western water hemlock	X	
	<i>Pseudocymopterus montanus</i> (Gray) Coult. & Rose	alpine false springparsley	X	X
Apocynaceae	<i>Apocynum cannabinum</i> L.	Indianhemp		X
Asclepiadaceae	<i>Asclepias macrotis</i> Torr.	longhood milkweed	X	
	<i>Asclepias nyctaginifolia</i> Gray	Mojave milkweed	X	
	<i>Asclepias subverticillata</i> (Gray) Vail	horsetail milkweed		X
	<i>Asclepias tuberosa</i> L.	butterfly milkweed	X ^a	X
Asteraceae	<i>Achillea millefolium</i> L.	common yarrow	X	X
	<i>Ageratina herbacea</i> (Gray) King & H.E. Robins.	fragrant snakeroot	X	X
	<i>Ageratina rothrockii</i> (Gray) King & H.E. Robins.	Rothrock's snakeroot		X
	<i>Antennaria microphylla</i> Rydb.	littleleaf pussytoes	X	
	<i>Antennaria parvifolia</i> Nutt.	small-leaf pussytoes	X	
	<i>Artemisia carruthii</i> Wood ex Carruth.	Carruth's sagewort	X	
	<i>Artemisia dracunculus</i> L.	tarragon	X	
	<i>Artemisia ludoviciana</i> Nutt.	white sagebrush	X	X
	<i>Baccharis pteronioides</i> DC.	yerba de pasmo	X	
	<i>Bahia dissecta</i> (Gray) Britt.	ragleaf bahia	X	X
	<i>Bidens bigelovii</i> Gray	Bigelow's beggarticks	X	X
	<i>Bidens pilosa</i> L.	hairy beggarticks	X	
	<i>Brickellia brachyphylla</i> (Gray) Gray	plumed brickellbush	X	
	<i>Brickellia eupatorioides</i> var. <i>chlorolepis</i> (Woot. & Standl.) B.L. Turner	false boneset	X	
	<i>Brickellia floribunda</i> Gray	Chihuahuan brickellbush	X	X
	<i>Brickellia rusbyi</i> Gray	stinking brickellbush		X
	<i>Camminatia tenuiflora</i> DC.	plumeweed	X	
	<i>Chaenactis douglasii</i> (Hook.) Hook. & Arn.	Douglas' dustymaiden	X	
	<i>Chaetopappa ericoides</i> (Torr.) Nesom	rose heath	X	X
	<i>Cirsium grahamii</i> Gray	Graham's thistle	X	
	<i>Cirsium neomexicanum</i> Gray	New Mexico thistle	X	X
	<i>Conyza canadensis</i> (L.) Cronq.	Canadian horseweed	X	X
	<i>Cosmos parviflorus</i> (Jacq.) Pers.	southwestern cosmos	X	
	<i>Ericameria nauseosa</i> var. <i>nauseosa</i> (Pallas ex Pursh) Nesom & Baird	rubber rabbitbrush	X	X
	<i>Erigeron arizonicus</i> Gray	Arizona fleabane	X	
	<i>Erigeron colomexicanus</i> A. Nels.	running fleabane		X
	<i>Erigeron divergens</i> Torr. & Gray	spreading fleabane	X	
	<i>Erigeron formosissimus</i> Greene	beautiful fleabane		X
	<i>Erigeron formosissimus</i> var. <i>formosissimus</i> Greene	beautiful fleabane	X	
	<i>Erigeron neomexicanus</i> Gray	New Mexico fleabane		X
	<i>Erigeron oreophilus</i> Greenm.	chaparral fleabane	X	X
	<i>Erigeron speciosus</i> (Lindl.) DC.	aspens fleabane	X	
	<i>Erigeron vreelandii</i> Greene	Vreeland's erigeron	X	
	<i>Eurybia glauca</i> (Nutt.) Nesom	gray aster		X
	<i>Gaillardia pinnatifida</i> Torr.	red dome blanketflower	X	X
	<i>Gaillardia pulchella</i> Foug.	firewheel	X	X
	<i>Gnaphalium</i> sp. L.	cudweed	X	
	<i>Gutierrezia microcephala</i> (DC.) Gray	threadleaf snakeweed	X	X
	<i>Helianthus annuus</i> L.	common sunflower	X	X

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Asteraceae	<i>Heliomeris longifolia</i> var. <i>longifolia</i> (Robins. & Greenm.)	longleaf false goldeneye	X	X
	Cockerell	showy goldeneye		X
	<i>Heliomeris multiflora</i> Nutt.	wingpetal	X	
	<i>Heterosperma pinnatum</i> Cav.	yellow hawkweed	X	
	<i>Hieracium fendleri</i> var. <i>fendleri</i> Schultz-Bip.	singlewhorl burrobrush	X	
	<i>Hymenoclea monogyra</i> Torr. & Gray ex Gray	oldplainsman		X
	<i>Hymenopappus artemisifolius</i> DC.	Mexican woollywhite	X	
	<i>Hymenopappus mexicanus</i> Gray	TransPecos thimblehead	X	
	<i>Hymenothrix wislizeni</i> Gray	Wright's thimblehead	X	X
	<i>Hymenothrix wrightii</i> Gray	grassleaf lettuce	X	
	<i>Lactuca graminifolia</i> Michx.	prickly lettuce	X ^a	
	<i>Lactuca serriola</i> L.	Bigelow's tansyaster		X
	<i>Machaeranthera bigelovii</i> (Gray) Greene	slender goldenweed	X	X
	<i>Machaeranthera gracilis</i> (Nutt.) Shinners	Fendler's desertdandelion	X	X
	<i>Malacothrix fendleri</i> Gray	rough blackfoot	X	
	<i>Melampodium sericeum</i> Lag.	New Mexico groundsel	X	X
	<i>Packera neomexicana</i> var. <i>neomexicana</i> (Gray) W.A. Weber & A. Löve	prairie groundsel		X
	<i>Packera plattensis</i> (Nutt.) W.A. Weber & A. Love	threetooth ragwort		X
	<i>Packera tridenticulata</i> (Rydb.) W.A. Weber & A. Love	fivebract cinchweed	X	X
	<i>Pectis filipes</i> Harvey & Gray	mountain tail-leaf	X	
	<i>Pericome caudata</i> Gray	Wright's cudweed	X	
	<i>Pseudognaphalium canescens</i> (DC.) W.A. Weber	Wright's cudweed		X
	<i>Pseudognaphalium canescens</i> ssp. <i>canescens</i> (DC.) W.A. Weber	cottonbatting plant		X
	<i>Pseudognaphalium stramineum</i> (Kunth) W.A. Weber	New Mexico tansyaster	X	X
	<i>Psilactis asteroides</i> Gray	cutleaf coneflower	X	X
	<i>Rudbeckia laciniata</i> L.	Abert's creeping zinnia	X	
	<i>Sanvitalia abertii</i> Gray	Arizona ragwort	X	
	<i>Senecio arizonicus</i> Greene	threadleaf ragwort		X
	<i>Senecio flaccidus</i> Less.	threadleaf ragwort	X	
	<i>Senecio flaccidus</i> var. <i>flaccidus</i> Less.	Mono ragwort	X	
	<i>Senecio flaccidus</i> var. <i>monoensis</i> (Greene) B.L. Turner & T.M. Barkl.	broomlike ragwort		X
	<i>Senecio spartioides</i> var. <i>multicapitatus</i> (Greenm. ex Rydb.) Welsh	Wright's goldenrod		X
	<i>Solidago wrightii</i> Gray	Wright's goldenrod	X	
<i>Solidago wrightii</i> var. <i>wrightii</i> Gray	spiny sowthistle	X		
<i>Sonchus asper</i> (L.) Hill	brownplume wirelettuce	X		
<i>Stephanomeria pauciflora</i> (Torr.) A. Nels.	Thurber's wirelettuce	X ^a		
<i>Stephanomeria thurberi</i> Gray	western aster		X	
<i>Symphyotrichum ascendens</i> (Lindl.) Nesom	white prairie aster		X	
<i>Symphyotrichum falcatum</i> var. <i>commutatum</i> (Torr. & Gray) Nesom	white panicle aster		X	
<i>Symphyotrichum lanceolatum</i> (Willd.) Nesom var. <i>hesperium</i>	willowleaf aster		X	
<i>Symphyotrichum praealtum</i> var. <i>praealtum</i> (Poir.) Nesom	rock dandelion	X	X	
<i>Taraxacum laevigatum</i> (Willd.) DC.	common dandelion	X		
<i>Taraxacum officinale</i> G.H. Weber ex Wiggers		X		
<i>Townsendia excapa</i> (Richards.) T. Porter	yellow salsify	X		
<i>Tragopogon dubius</i> Scop.	Jack-go-to-bed-at-noon		X	
<i>Tragopogon pratensis</i> L.	golden crownbeard	X	X	
<i>Verbesina encelioides</i> (Cav.) Benth. & Hook. f. ex Gray	heartleaf goldeneye		X	
<i>Viguiera cordifolia</i> Gray	toothleaf goldeneye	X		
<i>Viguiera dentata</i> (Cav.) Spreng.	Arizona alder	X	X	
Betulaceae	<i>Alnus oblongifolia</i> Torr.	James' cryptantha	X ^a	
Boraginaceae	<i>Cryptantha cinerea</i> (Greene) Cronq. var. <i>cinerea</i>	James' cryptantha		X
	<i>Cryptantha cinerea</i> var. <i>jamesii</i> Cronq.	Yampa River cryptantha	X	
	<i>Cryptantha stricta</i> (Osterhout) Payson	manyflower stickseed		X
	<i>Hackelia floribunda</i> (Lehm.) I.M. Johnston	Livermore stickseed	X	
	<i>Hackelia pinetorum</i> (Greene ex Gray) I.M. Johnston	Chiuhuan stickseed		X
	<i>Hackelia ursina</i> (Greene ex Gray) I.M. Johnston	flatspine stickseed	X	
	<i>Lappula occidentalis</i> (S. Wats.) Greene	flatspine stickseed	X	
	<i>Lappula occidentalis</i> var. <i>cupulata</i> (Gray) Higgins	flatspine stickseed	X	

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Boraginaceae	<i>Lappula occidentalis</i> var. <i>occidentalis</i> (S. Wats.) Greene	flatspine stickseed		X
	<i>Lithospermum incisum</i> Lehm.	narrowleaf stone seed	X	X
	<i>Lithospermum multiflorum</i> Torr. ex Gray	manyflowered stone seed	X	X
	<i>Macromeria viridiflora</i> DC.	giant-trumpets	X	
	<i>Mertensia franciscana</i> Heller	Franciscan bluebells	X	
Brassicaceae	<i>Arabis fendleri</i> (S. Wats.) Greene	Fendler's rockcress	X	
	<i>Barbarea orthoceras</i> Ledeb.	American yellowrocket	X	
	<i>Descurainia incana</i> ssp. <i>incana</i> (Bernh. ex Fisch. & C.A. Mey.)	mountain tansymustard		X
	<i>Descurainia obtusa</i> (Greene) O.E. Schulz	blunt tansymustard		X
	<i>Descurainia obtusa</i> ssp. <i>adenophora</i> (Woot. & Standl.) Detling	blunt tansymustard	X	
	<i>Descurainia obtusa</i> ssp. <i>obtusa</i> (Greene) O.E. Schulz	blunt tansymustard	X	
	<i>Descurainia sophia</i> (L.) Webb ex Prantl	herb sophia	X	
	<i>Draba crassifolia</i> Graham	snowbed draba	X	
	<i>Draba cuneifolia</i> Nutt. ex Torr. & Gray	wedgeleaf draba	X	X
	<i>Draba mogollonica</i> Greene	Mongollon Mountain draba		X
	<i>Erysimum capitatum</i> (Dougl. ex Hook.) Greene	sanddune wallflower	X	X
	<i>Lepidium lasiocarpum</i> Nutt.	shaggyfruit pepperweed	X	
	<i>Lepidium thurberi</i> Woot.	Thurber's pepperweed	X	
	<i>Lepidium virginicum</i> L.	Virginia pepperweed		X
	<i>Lepidium virginicum</i> var. <i>medium</i> (Greene) C.L. Hitchc.	medium pepperweed	X	
	<i>Lesquerella aurea</i> Woot.	golden bladderpod		X
	<i>Lesquerella gooddingii</i> Rollins & Shaw	Goodding's bladderpod	X	
	<i>Lesquerella gordonii</i> (Gray) S. Wats.	Gordon's bladderpod	X	
	<i>Lesquerella intermedia</i> (S. Wats.) Heller	mid bladderpod		X
	<i>Rorippa nasturtium-aquaticum</i> (L.) Hayek	watercress	X	X
	<i>Schoenocrambe linearifolia</i> (Gray) Rollins	slimleaf plainsmustard	X	X
	<i>Sisymbrium altissimum</i> L.	tall tumbledustard	X	
<i>Thlaspi montanum</i> var. <i>fendleri</i> (Gray) P. Holmgren	Fendler's pennycress		X	
<i>Thlaspi montanum</i> var. <i>montanum</i> L.	alpine pennycress	X		
Cactaceae	<i>Echinocereus fendleri</i> (Engelm.) F. Seitz	pinkflower hedgehog cactus	X	
	<i>Echinocereus triglochidiatus</i> Engelm.	kingcup cactus	X	
	<i>Escobaria vivipara</i> var. <i>vivipara</i> (Nutt.) Buxbaum	spinystar	X	
	<i>Opuntia macrorhiza</i> Engelm.	twistspine pricklypear	X	
	<i>Opuntia phaeacantha</i> Engelm.	tulip pricklypear	X	
	<i>Opuntia spinosior</i> (Engelm.) Toumey	walkingstick cactus	X	
Callitricheaceae	<i>Callitriche heterophylla</i> Pursh	twoheaded water-starwort	X	
Campanulaceae	<i>Triodanis perfoliata</i> (L.) Nieuwl.	clasping Venus' looking-glass	X	
Cannabinaceae	<i>Humulus lupulus</i> var. <i>neomexicanus</i> A. Nels. & Cockerell	common hop	X	
Capparaceae	<i>Cleome serrulata</i> Pursh	Rocky Mountain beeplant	X	X
	<i>Polanisia dodecandra</i> (L.) DC.	redwhisker clammyweed	X	X
	<i>Polanisia dodecandra</i> ssp. <i>trachysperma</i> (Torr. & Gray) Iltis	sandyseed clammyweed		X
Caprifoliaceae	<i>Lonicera albiflora</i> Torr. & Gray	western white honeysuckle	X	X
Caryophyllaceae	<i>Cerastium brachypodium</i> (Engelm. ex Gray) B.L. Robins.	shortstalk chickweed	X	
	<i>Cerastium glomeratum</i> Thuill.	sticky chickweed	X	
	<i>Drymaria glandulosa</i> K. Presl	Fendler's drymary	X	
	<i>Silene antirrhina</i> L.	sleepy silene	X	
	<i>Silene laciniata</i> Cav.	cardinal catchfly	X	X
	Chenopodiaceae	<i>Atriplex canescens</i> (Pursh) Nutt.	fourwing saltbush	X
<i>Chenopodium fremontii</i> S. Wats.		Fremont's goosefoot		X
	<i>Chenopodium glaucum</i> L.	oakleaf goosefoot	X	
	<i>Chenopodium graveolens</i> Willd.	fetid goosefoot	X	
Clusiaceae	<i>Hypericum formosum</i> H.B.K.		X	
Commelinaceae	<i>Commelina dianthifolia</i> Delile	birdbill dayflower	X	
	<i>Tradescantia pinetorum</i> Greene	pinewoods spiderwort	X	
Convolvulaceae	<i>Evolvulus sericeus</i> var. <i>sericeus</i> Sw.	silver dwarf morning-glory	X	
	<i>Ipomoea capillacea</i> (Kunth) G. Don	purple morning-glory	X	
	<i>Ipomoea costellata</i> Torr.	crestrub morning-glory	X	
	<i>Ipomoea purpurea</i> (L.) Roth	tall morning-glory	X	
Cornaceae	<i>Cornus sericea</i> ssp. <i>sericea</i> L.	redosier dogwood	X	
Crassulaceae	<i>Sedum cockerellii</i> Britt.	Cockerell's stonecrop	X	X
	<i>Sedum wrightii</i> Gray	Wright's stonecrop	X	
Cucurbitaceae	<i>Cucurbita foetidissima</i> Kunth	Missouri gourd	X	X

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Cucurbitaceae	<i>Echinopepon wrightii</i> (Gray) S. Wats.	wild balsam apple	X	
	<i>Sicyos ampelophyllus</i> Woot. & Standl.	streamside burr cucumber		X
Cupressaceae	<i>Cupressus arizonica</i> Greene	Arizona cypress	X	
	<i>Juniperus deppeana</i> Steud.	alligator juniper	X	
	<i>Juniperus osteosperma</i> (Torr.) Little	Utah juniper	X	
	<i>Juniperus scopulorum</i> Sarg.	Rocky Mountain juniper	X	
Cyperaceae	<i>Carex lenticularis</i> var. <i>lipocarpa</i> (Holm) L.A. Standley	Kellogg's sedge	X	
	<i>Carex occidentalis</i> Bailey	western sedge	X	
	<i>Carex praegracilis</i> W. Boott	clustered field sedge		X
	<i>Carex vallicola</i> Dewey	valley sedge	X	
	<i>Cyperus</i> sp. L.	flatsedge	X	
	<i>Eleocharis montevidensis</i> Kunth	sand spikerush	X	
	<i>Eleocharis palustris</i> (L.) Roemer & J.A. Schultes	common spikerush		X
	<i>Eleocharis parishii</i> Britt.	Parish's spikerush	X	
Equisetaceae	<i>Equisetum arvense</i> L.	field horsetail	X	X
	<i>Equisetum hyemale</i> L.	scouringrush horsetail		X
	<i>Equisetum laevigatum</i> A. Braun	smooth horsetail	X	X
Euphorbiaceae	<i>Chamaesyce albomarginata</i> (Torr. & Gray) Small	whitemargin sandmat	X	X
	<i>Chamaesyce serpyllifolia</i> ssp. <i>serpyllifolia</i> (Pers.) Small	thymeleaf sandmat	X	
	<i>Euphorbia bilobata</i> Engelm.	blackseed spurge	X	
	<i>Euphorbia brachycera</i> Engelm.	horned spurge	X	
	<i>Euphorbia chamaesula</i> Boiss.	mountain spurge		X
	<i>Euphorbia exstipulata</i> Engelm.	squareseed spurge		X
	<i>Euphorbia heterophylla</i> L.	Mexican fireplant	X	
	<i>Jatropha cardiophylla</i> (Torr.) Muell.-Arg.	sangre de cristo	X	
	<i>Tragia nepetifolia</i> Cav.	catnip noseburn	X	
	<i>Tragia ramosa</i> Torr.	branched noseburn	X	X
Fabaceae	<i>Astragalus crassicaupus</i> Nutt.	groundplum milkvetch	X	
	<i>Astragalus tephrodes</i> Gray	ashen milkvetch	X	
	<i>Calliandra humilis</i> Benth.	dwarf stickpea	X	
	<i>Cologania angustifolia</i> Kunth	longleaf cologania	X	
	<i>Dalea albiflora</i> Gray	whiteflower prairie clover	X	X
	<i>Dalea candida</i> Michx. ex Willd.	white prairie clover	X ^a	
	<i>Dalea candida</i> var. <i>oligophylla</i> (Torr.) Shinnars	white prairie clover		X
	<i>Dalea filiformis</i> Gray	Sonoran prairie clover	X	
	<i>Dalea urceolata</i> Greene	pineforest prairie clover	X	
	<i>Desmodium grahamii</i> Gray	Graham's ticktrefoil	X	
	<i>Desmodium neomexicanum</i> Gray	New Mexico ticktrefoil	X	
	<i>Desmodium procumbens</i> (P. Mill.) A.S. Hitchc.	western trailing ticktrefoil	X	
	<i>Lathyrus graminifolius</i> (S. Wats.) White	grassleaf pea	X	
	<i>Lathyrus lanszwertii</i> var. <i>leucanthus</i> (Rydb.) Dorn	Nevada pea	X	X
	<i>Lotus wrightii</i> (Gray) Greene	Wright's deervetch	X ^a	X
	<i>Lupinus argenteus</i> Pursh	silvery lupine	X	
	<i>Lupinus brevicaulis</i> S. Wats.	shortstem lupine	X	X
	<i>Lupinus hillii</i> Greene	Hill's lupine	X	
	<i>Macroptilium gibbosifolium</i> (Ortega) A. Delgado	variableleaf bushbean	X	
	<i>Medicago lupulina</i> L.	black medick		X
	<i>Melilotus alba</i> Medikus	white sweetclover		X
	<i>Melilotus indica</i> (L.) All.	sourclover	X	
	<i>Melilotus officinalis</i> (L.) Lam.	yellow sweetclover	X	X
	<i>Parkinsonia microphylla</i> Torr.	yellow paloverde	X	
	<i>Phaseolus acutifolius</i> Gray	tepany bean	X	
	<i>Phaseolus angustissimus</i> Gray	slimleaf bean	X ^a	X
	<i>Psoraleidum tenuiflorum</i> (Pursh) Rydb.	slimflower scurfpea		X
	<i>Rhynchosia senna</i> Gillies ex Hook.	Texas snoutbean	X	X
	<i>Robinia neomexicana</i> Gray	New Mexico locust	X	X
	<i>Trifolium wormskioldii</i> Lehm.	cows clover	X	
	<i>Vicia americana</i> Muhl. ex Willd.	American vetch	X	X
	<i>Vicia leucophaea</i> Greene	Mogollon Mountain vetch	X	
Fagaceae	<i>Quercus arizonica</i> Sarg.	Arizona white oak	X	X
	<i>Quercus gambelii</i> Nutt.	Gambel oak	X	X
	<i>Quercus grisea</i> Liebm.	gray oak	X	X

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Fumariaceae	<i>Corydalis aurea</i> Willd.	scrambled eggs	X	X
Garryaceae	<i>Garrya wrightii</i> Torr.	Wright's siltassel	X	
Gentianaceae	<i>Frasera speciosa</i> Dougl. ex Griseb.	elkweed	X	X
Geraniaceae	<i>Erodium cicutarium</i> (L.) L'Hér. ex Ait.	redstem stork's bill	X	
	<i>Geranium caespitosum</i> James	pineywoods geranium	X	X
	<i>Geranium richardsonii</i> Fisch. & Trautv.	Richardson's geranium	X	X
Grossulariaceae	<i>Ribes aureum</i> Pursh	golden currant	X	
	<i>Ribes cereum</i> Dougl.	wax currant	X	
	<i>Ribes leptanthum</i> Gray	trumpet gooseberry	X	X
Hydrophyllaceae	<i>Nama dichotomum</i> (Ruiz & Pavón) Choisy	wishbone fiddleleaf	X	
	<i>Phacelia caerulea</i> Greene	skyblue phacelia	X	X
	<i>Phacelia heterophylla</i> Pursh	varileaf phacelia	X	X
Juglandaceae	<i>Juglans major</i> (Torr.) Heller	Arizona walnut	X	X
	<i>Juglans microcarpa</i> Berl.	little walnut		X
Juncaceae	<i>Luzula</i> sp. DC.	woodrush	X	
Lamiaceae	<i>Agastache pallidiflora</i> (Heller) Rydb.	Bill Williams Mountain giant hyssop	X	X
	<i>Dracocephalum parviflorum</i> Nutt.	American dragonhead	X	
	<i>Hedeoma nana</i> (Torr.) Briq.	dwarf false pennyroyal	X	
	<i>Hedeoma oblongifolia</i> (Gray) Heller	oblongleaf false pennyroyal	X	X
	<i>Marrubium vulgare</i> L.	horehound	X	X
	<i>Mentha arvensis</i> L.	wild mint	X	X
	<i>Monarda fistulosa</i> L.	wild bergamot		X
	<i>Monarda fistulosa</i> var. <i>mentifolia</i> (Graham) Fern.	wild bergamot	X	
	<i>Salvia reflexa</i> Hornem.	lanceleaf sage	X	X
	<i>Salvia subincisa</i> Benth.	sawtooth sage	X	
Liliaceae	<i>Allium cernuum</i> var. <i>obtusum</i> Cockerell ex J.F. Macbr.	nodding onion	X	
	<i>Allium macropetalum</i> Rydb.	largeflower onion	X	
	<i>Echeandia flavescens</i> (J.A. & J.H. Schultes) Cruden	Torrey's craglily	X	
	<i>Maianthemum racemosum</i> (L.) Link	feathery false lily of the valley		X
	<i>Maianthemum racemosum</i> ssp. <i>amplexicaule</i> (Nutt.) LaFrankie	feathery false lily of the valley	X	
	<i>Maianthemum stellatum</i> (L.) Link	starry false lily of the valley	X	
	<i>Polygonatum cobrense</i> (Woot. & Standl.) R.R. Gates	McKittrick's Solomon's seal		X
Linaceae	<i>Linum neomexicanum</i> Greene	New Mexico yellow flax	X	
Loasaceae	<i>Mentzelia albicaulis</i> (Dougl. ex Hook.) Dougl. ex Torr. & Gray	whitestem blazingstar	X	
	<i>Mentzelia pumila</i> Nutt. ex Torr. & Gray	dwarf mentzelia	X	
Malvaceae	<i>Anoda cristata</i> (L.) Schlecht.	crested anoda	X	
	<i>Sphaeralcea fendleri</i> Gray	Fendler's globemallow	X	X
Monotropaceae	<i>Monotropa hypopithys</i> L.	pinemap		X ^a
	<i>Pterospora andromedea</i> Nutt.	woodland pinedrops		X ^a
Nyctaginaceae	<i>Boerhavia coccinea</i> P. Mill.	scarlet spiderling	X	X
	<i>Boerhavia purpurascens</i> Gray	purple spiderling	X	
	<i>Mirabilis albida</i> (Walt.) Heimerl	white four o'clock	X	
	<i>Mirabilis coccinea</i> (Torr.) Benth. & Hook. f.	scarlet four o'clock	X	X
	<i>Mirabilis linearis</i> (Pursh) Heimerl	narrowleaf four o'clock	X	
	<i>Mirabilis longiflora</i> L.	sweet four o'clock	X	X
	<i>Mirabilis multiflora</i> (Torr.) Gray	Colorado four o'clock	X	X
	<i>Mirabilis oxybaphoides</i> (Gray) Gray	smooth spreading four o'clock	X	X
	<i>Mirabilis pumila</i> (Standl.) Standl.	dwarf four o'clock	X	
Oleaceae	<i>Forestiera pubescens</i> var. <i>pubescens</i> Nutt.	stretchberry	X	X
	<i>Fraxinus velutina</i> Torr.	velvet ash	X	X
	<i>Menodora scabra</i> Gray	rough menodora	X	X
Onagraceae	<i>Epilobium ciliatum</i> Raf.	fringed willowherb	X	
	<i>Gaura coccinea</i> Nutt. ex Pursh	scarlet beeblossom	X	
	<i>Gaura hexandra</i> ssp. <i>gracilis</i> (Woot. & Standl.) Raven & Gregory	harlequinbush	X	X
	<i>Gaura mollis</i> James	velvetweed	X ^a	
	<i>Oenothera albicaulis</i> Pursh	whitest evening-primrose	X	
	<i>Oenothera caespitosa</i> Nutt.	tufted evening-primrose	X	X
	<i>Oenothera caespitosa</i> ssp. <i>caespitosa</i> Nutt.	tufted evening-primrose	X	
	<i>Oenothera elata</i> ssp. <i>hookeri</i> (Torr. & Gray) W. Dietr. & W.L. Wagner	Hooker's evening-primrose	X ^a	
	<i>Oenothera neomexicana</i> (Small) Munz	New Mexico evening-primrose	X	

Family	Scientific name	Common name	UA	UTEP
Orchidaceae	<i>Malaxis macrostachya</i> (Lex.) Kuntze	Chiricahua adder's-mouth orchid		X ^a
	<i>Malaxis wendtii</i> Salazar	Wendt's adder's-mouth orchid		X ^a
	<i>Platanthera sparsiflora</i> (S. Wats.) Schlechter var. <i>sparsiflora</i>	sparse-flowered bog orchid		X ^a
Oxalidaceae	<i>Oxalis alpina</i> (Rose) Rose ex R. Knuth	alpine woodsorrel	X	
	<i>Oxalis corniculata</i> L.	creeping woodsorrel	X	
	<i>Oxalis decaphylla</i> Kunth	tenleaf woodsorrel	X	
	<i>Oxalis drummondii</i> Gray	Drummond's woodsorrel	X ^a	
Papaveraceae	<i>Argemone pleiacantha</i> Greene	southwestern pricklypoppy	X	
Parmeliaceae	<i>Usnea arizonica</i> Mot.	Arizona beard lichen	X	
Pinaceae	<i>Abies lasiocarpa</i> (Hook.) Nutt.	subalpine fir	X	
	<i>Pinus cembroides</i> Zucc.	Mexican pinyon	X	X ^a
	<i>Pinus edulis</i> Engelm.	twoneedle pinyon	X	
	<i>Pinus ponderosa</i> P.&C. Lawson	ponderosa pine	X	
	<i>Pseudotsuga menziesii</i> (Mirbel) Franco	Douglas-fir	X	
Plantaginaceae	<i>Plantago major</i> L.	common plantain		X
Poaceae	<i>Agrostis gigantea</i> Roth	redtop		X
	<i>Agrostis scabra</i> Willd.	rough bentgrass	X	
	<i>Alopecurus aequalis</i> Sobol.	shortawn foxtail	X	
	<i>Aristida purpurea</i> var. <i>fendleriana</i> (Steud.) Vasey	Fendler's threeawn	X	
	<i>Aristida purpurea</i> var. <i>longiseta</i> (Steud.) Vasey	Fendler threeawn	X	
	<i>Aristida ternipes</i> var. <i>gentilis</i> (Henr.) Allred	spidergrass	X	
	<i>Bothriochloa barbinodis</i> (Lag.) Herter	cane bluestem	X	
	<i>Bothriochloa springfieldii</i> (Gould) Parodi	Springfield's beardgrass		X
	<i>Bouteloua curtispindula</i> (Michx.) Torr.	sideoats grama	X	X
	<i>Bouteloua eriopoda</i> (Torr.) Torr.	black grama	X	
	<i>Bouteloua gracilis</i> (Willd. ex Kunth) Lag. ex Griffiths	blue grama	X	X
	<i>Bouteloua hirsuta</i> Lag.	hairy grama	X	
	<i>Bouteloua radicata</i> (Fourn.) Griffiths	purple grama	X	
	<i>Bromus anomalus</i> Rupr. ex Fourn.	nodding brome	X	
	<i>Bromus carinatus</i> Hook. & Arn.	California brome		X
	<i>Bromus frondosus</i> (Shear) Woot. & Standl.	weeping brome		X
	<i>Bromus hordeaceus</i> L.	soft brome		
	<i>Bromus inermis</i> Leyss.	smooth brome	X	X
	<i>Bromus japonicus</i> Thunb. ex Murr.	Japanese brome	X	
	<i>Bromus kalmii</i> Gray	arctic brome		X
	<i>Bromus rubens</i> L.	red brome	X	
	<i>Bromus tectorum</i> L.	cheatgrass	X	
	<i>Chloris virgata</i> Sw.	feather fingergrass	X ^a	
	<i>Dasyochloa pulchella</i> (Kunth) Willd. ex Rydb.	low woollygrass	X	
	<i>Echinochloa crus-galli</i> (L.) Beauv.	barnyardgrass	X	X
	<i>Elymus arizonicus</i> (Scribn. & J.G. Sm.) Gould	Arizona wheatgrass	X	
	<i>Elymus canadensis</i> L.	Canada wildrye	X	X
	<i>Elymus elymoides</i> (Raf.) Swezey	squirreltail	X	X
	<i>Eragrostis curvula</i> (Schrad.) Nees	weeping lovegrass	X	
	<i>Eragrostis mexicana</i> (Hornem.) Link	Mexican lovegrass	X	
	<i>Glyceria striata</i> (Lam.) A.S. Hitchc.	fowl mannagrass	X	
	<i>Hesperostipa neomexicana</i> (Thurb. ex Coult.) Barkworth	New Mexico feathergrass	X	
	<i>Koeleria macrantha</i> (Ledeb.) J.A. Schultes	prairie Junegrass	X	
	<i>Leptochloa dubia</i> (Kunth) Nees	green sprangletop	X	X
	<i>Leptochloa fascicularis</i> var. <i>fascicularis</i> (Lam.) Gray	bearded sprangletop	X	
	<i>Lycurus setosus</i> (Nutt.) C.G. Reeder	bristly wolfstail	X	
	<i>Muhlenbergia emersleyi</i> Vasey	bullgrass		X
	<i>Muhlenbergia mexicana</i> (L.) Trin.	Mexican muhly	X	
	<i>Muhlenbergia polycaulis</i> Scribn.	cliff muhly	X	
	<i>Muhlenbergia racemosa</i> (Michx.) B.S.P.	marsh muhly		X
	<i>Muhlenbergia repens</i> (J. Presl) A.S. Hitchc.	creeping muhly	X	
	<i>Muhlenbergia rigens</i> (Benth.) A.S. Hitchc.	deergrass	X	
	<i>Muhlenbergia rigida</i> (Kunth) Trin.	purple muhly	X	
	<i>Muhlenbergia sinuosa</i> Swallen	marshland muhly	X	
	<i>Panicum capillare</i> L.	witchgrass		X
	<i>Panicum hirticaule</i> var. <i>hirticaule</i> J. Presl	Mexican panicgrass	X	

Family	Scientific name	Common name	UA	UTEP
Poaceae	<i>Panicum obtusum</i> Kunth	vine mesquite	X	
	<i>Pascopyrum smithii</i> (Rydb.) A. Löve	western wheatgrass	X	X
	<i>Pennisetum ciliare</i> (L.) Link	buffelgrass	X	
	<i>Piptochaetium fimbriatum</i> (Kunth) A.S. Hitchc.	pinyon ricegrass	X	
	<i>Poa fendleriana</i> (Steud.) Vasey	muttongrass	X	X
	<i>Poa pratensis</i> L.	Kentucky bluegrass	X	X
	<i>Schizachyrium cirratum</i> (Hack.) Woot. & Standl.	Texas bluestem	X	
	<i>Setaria grisebachii</i> Fourn.	Grisebach's bristlegrass	X	
	<i>Sphenopholis obtusata</i> (Michx.) Scribn.	prairie wedgescale	X	
	<i>Sporobolus cryptandrus</i> (Torr.) Gray	sand dropseed	X	
	<i>Vulpia octoflora</i> (Walt.) Rydb.	sixweeks fescue	X	X
	Polemoniaceae	<i>Gilia inconspicua</i> (Sm.) Sweet	shy gilia	X
<i>Gilia mexicana</i> A. & V. Grant		El Paso gilia	X	
<i>Gilia sinuata</i> Dougl. ex Benth.		rosy gilia	X	
<i>Ipomopsis aggregata</i> (Pursh) V. Grant		scarlet gilia	X	
<i>Ipomopsis maccombii</i> (Torr. ex Gray) V. Grant		Maccomb's ipomopsis		X
<i>Linanthus nuttallii</i> (Gray) Greene ex Milliken		Nuttall's linanthus	X	
<i>Linanthus nuttalli</i> (Gray) Greene ex Milliken ssp <i>nuttallii</i>		Nuttall's linanthus		X
<i>Phlox gracilis</i> ssp. <i>gracilis</i> (Hook.) Greene		slender phlox		X
<i>Phlox longifolia</i> Nutt.		longleaf phlox		X
Polygalaceae		<i>Monnina wrightii</i> Gray	blue pygmyflower	X
	<i>Polygala obscura</i> Benth.	velvetseed milkwort	X	
Polygonaceae	<i>Eriogonum abertianum</i> Torr.	Abert's buckwheat	X	X
	<i>Eriogonum alatum</i> Torr.	winged buckwheat	X	
	<i>Eriogonum pharaceoides</i> Torr.	wirestem buckwheat	X	X
	<i>Eriogonum polycladon</i> Benth.	sorrel buckwheat		X
	<i>Eriogonum wrightii</i> Torr. ex Benth.	bastardsage	X	X
	<i>Polygonum convolvulus</i> L.	black bindweed	X	
	<i>Polygonum lapathifolium</i> L.	curlytop knotweed	X	X
	<i>Polygonum persicaria</i> L.	spotted ladysthumb	X	X
	<i>Rumex acetosella</i> L.	common sheep sorrel	X	
	<i>Rumex crispus</i> L.	curly dock		X
Pontederiaceae	<i>Heteranthera limosa</i> (Sw.) Willd.	blue mudplantain	X	
Portulacaceae	<i>Portulaca oleracea</i> L.	little hogweed	X	
	<i>Talinum pulchellum</i> Woot. & Standl.	showy fameflower	X	
Primulaceae	<i>Androsace occidentalis</i> Pursh	western rockjasmine	X	X
	<i>Androsace septentrionalis</i> L.	pygmyflower rockjasmine	X	X
	<i>Androsace septentrionalis</i> ssp. <i>puberulenta</i> (Rydb.) G.T. Robbins	pygmyflower rockjasmine	X	
Pteridaceae	<i>Bommeria hispida</i> (Mett. ex Kuhn) Underwood	copper fern	X	
	<i>Dryopteris filix-mas</i> (L.) Schott	male fern	X	
	<i>Pellaea atropurpurea</i> (L.) Link	purple cliffbrake	X	
	<i>Pellaea wrightiana</i> Hook.	Wright's cliffbrake	X	
	<i>Pteridium aquilinum</i> (L.) Kuhn	western brackenfern		X ^a
	<i>Selaginella underwoodii</i> Hieron.	Underwood's spikemoss	X	
Ranunculaceae	<i>Aquilegia chrysantha</i> Gray	golden columbine	X	X
	<i>Clematis ligusticifolia</i> Nutt.	western white clematis	X	X
	<i>Myosurus cupulatus</i> S. Wats.	Arizona mousetail	X	
	<i>Ranunculus aquatilis</i> L.	whitewater crowfoot	X	
	<i>Ranunculus hydrocharoides</i> Gray	frogbit buttercup	X	
	<i>Ranunculus uncinatus</i> D. Don ex G. Don	woodland buttercup	X	
	<i>Thalictrum fendleri</i> Engelm. ex Gray	Fendler's meadow-rue	X	X
		<i>Frangula betulifolia</i> ssp. <i>betulifolia</i> (Greene) V. Grub.	beechleaf frangula	X
Rhamnaceae	<i>Agrimonia striata</i> Michx.	roadside agrimony	X	
Rosaceae	<i>Cercocarpus montanus</i> Raf.	alderleaf mountain mahogany	X	
	<i>Cercocarpus montanus</i> var. <i>paucidentatus</i> (S. Wats.) F.L. Martin	hairy mountain mahogany		X
	<i>Fallugia paradoxa</i> (D. Don) Endl. ex Torr.	Apache plume	X	X
	<i>Malus</i> sp. P. Mill.	apple	X	
	<i>Potentilla rivalis</i> Nutt.	brook cinquefoil	X	
	<i>Potentilla thurberi</i> Gray	scarlet cinquefoil	X	
	<i>Prunus serotina</i> var. <i>virens</i> (Woot. & Standl.) McVaugh	black cherry	X	X
	<i>Purshia mexicana</i> (D. Don) Henrickson	Mexican cliffrose		X

Family	Scientific name	Common name	UA	UTEP	
Rosaceae	<i>Rosa woodsii</i> Lindl.	Woods' rose		X	
	<i>Rosa woodsii</i> var. <i>ultramontana</i> (S. Wats.) Jepson	Woods' rose	X		
Rubiaceae	<i>Galium fendleri</i> Gray	Fendler's bedstraw	X		
	<i>Galium mexicanum</i> Kunth	Mexican bedstraw	X		
	<i>Galium microphyllum</i> Gray	bracted bedstraw		X	
	<i>Galium wrightii</i> Gray	Wright's bedstraw	X	X	
	<i>Houstonia rosea</i> (Raf.) Terrell	rose bluet		X	
	<i>Houstonia wrightii</i> Gray	pygmy bluet	X		
Rutaceae	<i>Ptelea trifoliata</i> L.	common hoptree		X	
	<i>Ptelea trifoliata</i> ssp. <i>angustifolia</i> (Benth.) V. Bailey	common hoptree	X		
Salicaceae	<i>Populus angustifolia</i> James	narrowleaf cottonwood	X	X	
	<i>Salix exigua</i> Nutt.	narrowleaf willow	X	X	
	<i>Salix irrorata</i> Anderss.	dewystem willow		X	
	<i>Salix taxifolia</i> Kunth	yewleaf willow	X		
Saxifragiaceae	<i>Fendlera wrightii</i> (Gray) Heller	Wright's fendlerbush	X		
	<i>Heuchera parviflora</i> Bartl.	littleflower alumroot	X		
	<i>Heuchera novomexicana</i> Wheelock	New Mexico alumroot	X		
Scrophulariaceae	<i>Castilleja integra</i> Gray	wholeleaf Indian paintbrush	X	X	
	<i>Maurandella antirrhiniflora</i> (Humb. & Bonpl. ex Willd.) Rothm.	roving sailor	X	X	
	<i>Mimulus glabratus</i> Kunth	roundleaf monkeyflower		X	
	<i>Mimulus guttatus</i> DC.	seep monkeyflower	X	X	
	<i>Mimulus rubellus</i> Gray	little redstem monkeyflower	X		
	<i>Penstemon barbatus</i> (Cav.) Roth	beardlip penstemon	X	X	
	<i>Penstemon jamesii</i> Benth.	James' beardtongue	X		
	<i>Penstemon virgatus</i> Gray	upright blue beardtongue	X	X	
	<i>Scrophularia parviflora</i> Woot. & Standl.	pineland figwort	X	X	
		<i>Verbascum thapsus</i> L.	common mullein	X	
		<i>Veronica anagallis-aquatica</i> L.	water speedwell	X	
Solanaceae	<i>Datura wrightii</i> Regel	sacred thorn-apple	X		
	<i>Lycium pallidum</i> Miers	pale desert-thorn	X		
	<i>Physalis hederifolia</i> Gray	ivyleaf groundcherry	X	X	
	<i>Solanum americanum</i> P. Mill.	American black nightshade		X	
	<i>Solanum douglasii</i> Dunal	greenspot nightshade	X		
	<i>Solanum elaeagnifolium</i> Cav.	silverleaf nightshade	X		
	<i>Solanum fendleri</i> Gray ex Torr.	Fendler's horsenettle	X	X	
	<i>Solanum heterodoxum</i> Dunal	melonleaf nightshade	X		
	<i>Solanum jamesii</i> Torr.	wild potato	X		
Typhaceae	<i>Typha latifolia</i> L.	broadleaf cattail	X		
Ulmaceae	<i>Celtis pallida</i> Torr.	spiny hackberry	X		
Urticaceae	<i>Parietaria pensylvanica</i> Muhl. ex Willd.	Pennsylvania pellitory	X		
		<i>Urtica dioica</i> L.	stinging nettle	X	
Valerianaceae	<i>Valeriana arizonica</i> Gray	Arizona valerian	X	X	
	<i>Valeriana edulis</i> Nutt. ex Torr. & Gray	tobacco root		X	
Verbenaceae	<i>Glandularia bipinnatifida</i> (Nutt.) Nutt.	Dakota mock vervain	X		
	<i>Verbena hastata</i> L.	swamp verbena	X ^a		
	<i>Verbena neomexicana</i> (Gray) Small	New Mexico vervain	X		
Violaceae	<i>Viola affinis</i> Le Conte	sand violet	X		
	<i>Viola canadensis</i> L.	Canadian white violet	X	X	
Viscaceae	<i>Phoradendron juniperinum</i> Engelm. ex Gray	juniper mistletoe	X	X	
Vitaceae	<i>Parthenocissus quinquefolia</i> (L.) Planch.	Virginia creeper	X		
	<i>Vitis arizonica</i> Engelm.	canyon grape	X	X	
Zygophyllaceae	<i>Kallstroemia parviflora</i> J.B.S. Norton	warty caltrop	X		

^a Found only outside of the monument boundary.

Appendix B. Amphibian and reptile species observed, documented with photo voucher, or documented with specimen voucher by University of Arizona Inventory personnel, Gila Cliff Dwellings NM, 2001 and 2002. Species in bold-faced type is non-native. See Appendix H for additional information on vouchers.

Order	Family	Scientific name	Common name	Documentation type		
				Observation	Photo voucher	Specimen voucher
Anura	Bufonidae	<i>Bufo microscaphus</i>	Arizona toad ^a	X	X	X
	Hylidae	<i>Hyla arenicolor</i>	canyon treefrog	X	X	X
	Ranidae	<i>Rana catesbeiana</i>	American bullfrog	X	X	X
Squamata	Crotaphytidae	<i>Crotaphytus collaris</i>	eastern collared lizard	X	X	
	Phrynosomatidae	<i>Sceloporus poinsettii</i>	crevice spiny lizard	X	X	
		<i>Sceloporus clarkii</i>	Clark's spiny lizard	X	X	X
		<i>Sceloporus undulatus</i>	eastern fence lizard	X	X	X
		<i>Urosaurus ornatus</i>	ornate tree lizard	X	X	X
		<i>Phrynosoma hernandesi</i>	greater short-horned lizard	X	X	X
		<i>Cnemidophorus exsanguis</i>	Chihuahuan spotted whiptail	X	X	X
	Teiidae	<i>Elgaria kingii</i>	Madrean alligator lizard	X	X	X
	Anguidae	<i>Diadophis punctatus</i>	ring-necked snake	X		
		<i>Masticophis taeniatus</i>	striped whipsnake	X		X
	Colubridae	<i>Salvadora grahamiae</i>	mountain patch-nosed snake	X		X
		<i>Pituophis catenifer</i>	gopher snake	X		X
		<i>Thamnophis rufipunctatus</i>	narrow-headed gartersnake ^a	X	X	
<i>Thamnophis elegans</i>		western terrestrial gartersnake	X	X		
<i>Thamnophis cyrtopsis</i>		black-necked gartersnake	X	X	X	
Viperidae	<i>Crotalus molossus</i>	black-tailed rattlesnake	X	X	X	

^a Species have the following conservation designations: "Sensitive" species, U.S. Forest Service (Region 3) and Bureau of Land Management; "Species of concern," U.S. Fish and Wildlife Service. Arizona toad is considered "sensitive" and the narrow-headed gartersnake is considered "threatened" by the New Mexico Game and Fish Department. Data from BISON (2004).

Appendix C. Number of observations of bird species by survey type by University of Arizona Inventory personnel, Gila Cliff Dwellings NM, 2001 and 2002. Numbers of observations are not scaled by search effort and should not be used for comparison among species or survey types. Underlined species are neotropical migrants (from Rappole 1995).

Order	Family	Scientific name	Common name	Survey type		
				VCP	Incidental	Nocturnal
Anseriformes	Anatidae	<u>Anas platyrhynchos</u>	mallard	7		
		<u>Mergus merganser</u>	common merganser	10	5	
Galliformes	Phasianidae	<u>Meleagris gallopavo</u>	wild turkey	3	7	
	Odontophoridae	<u>Callipepla gambelii</u>	Gambel's quail	1	1	
Ciconiiformes	Ardeidae	<u>Cyrtonyx montezumae</u>	Montezuma quail			5
		<u>Ardea herodias</u>	great blue heron	7	14	
Falconiformes	Accipitridae	<u>Cathartes aura</u>	turkey vulture	8	56	
		<u>Accipiter cooperii</u>	Cooper's hawk			1
Falconiformes	Falconidae	<u>Buteogallus anthracinus</u>	common black-hawk ^{a,b}			3
		<u>Buteo albonotatus</u>	zone-tailed hawk ^b	1		
		<u>Buteo jamaicensis</u>	red-tailed hawk	3	1	
		<u>Aquila chrysaetos</u>	golden eagle	1		
		<u>Falco sparverius</u>	American kestrel	8	2	
		<u>Falco peregrinus</u>	peregrine falcon ^{a,b,c}			2
Charadriiformes	Charadriidae	<u>Charadrius vociferus</u>	killdeer	1	3	
Columbiformes	Scolopacidae	<u>Actitis macularia</u>	spotted sandpiper	1	2	
	Columbidae	<u>Patagioenas fasciata</u>	band-tailed pigeon			2
Strigiformes	Strigidae	<u>Zenaida macroura</u>	mourning dove	58	12	
		<u>Megascops kennicottii</u>	western screech-owl			1
Strigiformes	Strigidae	<u>Bubo virginianus</u>	great horned owl		2	1
		<u>Glaucidium gnoma</u>	northern pygmy-owl	2		
		<u>Chordeiles minor</u>	common nighthawk	1	3	2
Caprimulgiformes	Caprimulgidae	<u>Phalaenoptilus nuttallii</u>	common poorwill			1
Apodiformes	Apodidae	<u>Aeronautes saxatalis</u>	white-throated swift	2	5	
	Trochilidae	<u>Archilochus alexandri</u>	black-chinned hummingbird	3	15	
		<u>Stellula calliope</u>	calliope hummingbird	1	5	
		<u>Selasphorus platycercus</u>	broad-tailed hummingbird	21	17	
		<u>Selasphorus rufus</u>	rufous hummingbird	3	38	
Coraciiformes	Alcedinidae	<u>Ceryle alcyon</u>	belted kingfisher ^b			3
Piciformes	Picidae	<u>Melanerpes formicivorus</u>	acorn woodpecker	33	3	
		<u>Sphyrapicus nuchalis</u>	red-naped sapsucker	2		
		<u>Picoides villosus</u>	hairy woodpecker	11	5	
		<u>Colaptes auratus</u>	northern flicker	46	3	
Passeriformes	Tyrannidae	<u>Contopus sordidulus</u>	western wood-pewee	21	8	
		<u>Empidonax wrightii</u>	gray flycatcher	2		
		<u>Empidonax occidentalis</u>	cordilleran flycatcher	18	3	
		<u>Sayornis nigricans</u>	black phoebe	7	8	
		<u>Sayornis saya</u>	Say's phoebe	2	5	
		<u>Myiarchus tuberculifer</u>	dusky-capped flycatcher	1		
		<u>Myiarchus cinerascens</u>	ash-throated flycatcher	31	6	
		<u>Tyrannus vociferans</u>	Cassin's kingbird	9	20	
		<u>Vireo bellii</u>	Bell's vireo ^{a,b}	1		
	Vireonidae	<u>Vireo plumbeus</u>	plumbeous vireo	22	3	
		<u>Vireo gilvus</u>	warbling vireo	43	2	
		<u>Cyanocitta stelleri</u>	Steller's jay	44	1	
		<u>Aphelocoma californica</u>	western scrub-jay	31	7	
		<u>Gymnorhinus cyanocephalus</u>	pinyon jay	45		
		<u>Corvus corax</u>	common raven	30	8	
	Hirundinidae	<u>Progne subis</u>	purple martin	70	8	
		<u>Tachycineta thalassina</u>	violet-green swallow	166	62	
		<u>Stelgidopteryx serripennis</u>	northern rough-winged swallow	2	7	
		<u>Petrochelidon pyrrhonota</u>	cliff swallow	4	62	
<u>Hirundo rustica</u>		barn swallow	1			
Paridae	<u>Poecile gambeli</u>	mountain chickadee	5			

Order	Family	Scientific name	Common name	Survey type			
				VCP	Incidental	Nocturnal	
Passeriformes	Paridae	<i>Baeolophus wollweberi</i>	bridled titmouse	8	4		
		<i>Baeolophus ridgwayi</i>	juniper titmouse		3		
	Aegithalidae	<i>Psaltriparus minimus</i>	bushtit	55	27		
	Sittidae	<i>Sitta carolinensis</i>	white-breasted nuthatch	12	4		
		<i>Sitta pygmaea</i>	pygmy nuthatch	14			
	Troglodytidae	<i>Salpinctes obsoletus</i>	rock wren	3	2		
		<i>Catherpes mexicanus</i>	canyon wren	29	8		
		<i>Thryomanes bewickii</i>	Bewick's wren	7	1		
		<i>Troglodytes aedon</i>	house wren	80	4		
	Sylviidae	<i>Poliotilta caerulea</i>	blue-gray gnatcatcher	8	3		
	Turdidae	<i>Sialia mexicana</i>	western bluebird	2	11		
		<i>Myadestes townsendi</i>	Townsend's solitaire	1			
		<i>Catharus guttatus</i>	hermit thrush		1		
		<i>Turdus migratorius</i>	American robin	98	13		
	Mimidae	<i>Dumetella carolinensis</i>	gray catbird ^b	1			
		<i>Mimus polyglottos</i>	northern mockingbird	1	2		
		<i>Toxostoma curvirostre</i>	curve-billed thrasher	1			
	Peucedramidae	<i>Peucedramus taeniatus</i>	olive warbler	1			
	Parulidae	<i>Vermivora celata</i>	orange-crowned warbler		2		
		<i>Vermivora virginiae</i>	Virginia's warbler	38			
		<i>Dendroica petechia</i>	yellow warbler	7	21		
		<i>Dendroica coronata</i>	yellow-rumped warbler	3	1		
		<i>Dendroica nigrescens</i>	black-throated gray warbler	8	7		
		<i>Dendroica townsendi</i>	Townsend's warbler	2			
		<i>Dendroica graciae</i>	Grace's warbler	2	1		
		<i>Oporornis tolmiei</i>	Macgillivray's warbler	4	2		
		<i>Geothlypis trichas</i>	common yellowthroat	1	2		
		<i>Wilsonia pusilla</i>	Wilson's warbler	8	3		
		<i>Cardellina rubrifrons</i>	red-faced warbler	11			
		<i>Myioborus pictus</i>	painted redstart	43	4		
		<i>Icteria virens</i>	yellow-breasted chat	43	6		
		Thraupidae	<i>Piranga flava</i>	hepatic tanager	22	8	
			<i>Piranga ludoviciana</i>	western tanager	50	4	
	Emberizidae	<i>Pipilo chlorurus</i>	green-tailed towhee	5	2		
		<i>Pipilo maculatus</i>	spotted towhee	127	17		
		<i>Pipilo fuscus</i>	canyon towhee	12	12		
		<i>Spizella passerina</i>	chipping sparrow	4	4		
		<i>Spizella breweri</i>	Brewer's sparrow		1		
		<i>Chondestes grammacus</i>	lark sparrow	3	24		
		<i>Melospiza lincolni</i>	Lincoln's sparrow	2	3		
		<i>Zonotrichia leucophrys</i>	white-crowned sparrow	2	2		
		<i>Junco hyemalis</i>	dark-eyed junco	12			
Cardinalidae	<i>Pheucticus melanocephalus</i>	black-headed grosbeak	70	4			
	<i>Passerina caerulea</i>	blue grosbeak	20	13			
	<i>Passerina amoena</i>	lazuli bunting		8			
	<i>Passerina cyanea</i>	indigo bunting		2			
Icteridae	<i>Xanthocephalus</i>	yellow-headed blackbird		1			
	<i>xanthocephalus</i>						
	<i>Euphagus cyanocephalus</i>	Brewer's blackbird	12	1			
	<i>Molothrus ater</i>	brown-headed cowbird	20	5			
	<i>Icterus bullockii</i>	Bullock's oriole	4	8			
Fringillidae	<i>Carpodacus mexicanus</i>	house finch	2	19			
	<i>Loxia curvirostra</i>	red crossbill	1				
	<i>Carduelis psaltria</i>	lesser goldfinch	18	26			
Number of species				91	84	4	

^a "Threatened"; New Mexico Game and Fish Department (BISON 2004).

^b "Sensitive"; U.S. Forest Service (BISON 2004).

^c "Species of Concern"; U.S. Fish and Wildlife Service (BISON 2004).

Appendix D. Number of observations of mammal species by survey type by University of Arizona Inventory personnel, Gila Cliff Dwellings NM, 2001 and 2002. Underlined species indicate that we obtained voucher specimen(s) and/or photograph(s)^a.

Order	Family	Scientific name	Common name	Survey type				
				Bat netting	Small mammal trapping	Trail-master	Incidental	
Insectivora	Soricidae	<i>Notiosorex crawfordi</i>	desert shrew				1	
Chiroptera	Vespertilionidae	<i>Myotis occultus</i>	<u>Arizona myotis</u>	10				
		<i>Myotis auricolus</i>	<u>southwestern myotis</u>	2				
		<i>Myotis californicus</i>	California myotis	1				
		<i>Lasionycteris noctivagans</i>	<u>silver-haired bat</u>	16				
		<i>Eptesicus fuscus</i>	<u>big brown bat</u>	6				
		<i>Lasiurus cinereus</i>	hoary bat	8				
		Molossidae	<i>Tadarida brasiliensis</i>	<u>Mexican freetail bat</u>	21			
			<i>Nyctinomops macrotis</i>	<u>big freetail bat</u>	1			
Carnivora	Ursidae	<i>Ursus americanus</i>	American black bear			2	3	
	Procyonidae	<i>Procyon lotor</i>	<u>northern raccoon</u>				1	
	Mephitidae	<i>Mephitis mephitis</i>	striped skunk			10		
		<i>Mephitis macroura</i>	<u>hooded skunk</u>					
		<i>Conepatus mesoleucus</i>	<u>white-backed hog-nosed skunk</u>			9		
	Canidae	<i>Canis latrans</i>	<u>coyote</u>				1	
		<i>Urocyon cinereoargenteus</i>	<u>common gray fox</u>			12		
	Felidae	<i>Puma concolor</i>	mountain lion			2	8	
Rodentia	Sciuridae	<i>Spermophilus variegatus</i>	<u>rock squirrel</u>			1	4	
		<i>Neotamias dorsalis</i>	<u>cliff chipmunk</u>		3		3	
		<i>Sciurus aberti</i>	Abert's squirrel			1	1	
	Geomyidae	<i>Thomomys bottae</i>	<u>Botta's pocket gopher</u>		1			
	Castoridae	<i>Castor canadensis</i>	<u>American beaver</u> ^b				5	
	Muridae	<i>Reithrodontomys megalotis</i>	<u>western harvest mouse</u>		54			
		<i>Peromyscus maniculatus</i>	<u>deer mouse</u>		6			
		<i>Peromyscus boylii</i>	<u>brush mouse</u>		160			
		<i>Peromyscus truei</i>	<u>piñon mouse</u>		4			
		<i>Neotoma albigula</i>	<u>western white-throated woodrat</u>		47			
		<i>Neotoma mexicana</i>	<u>Mexican woodrat</u>		5			
		<i>Microtus mexicanus</i>	<u>Mexican vole</u>		3			
		<i>Ondatra zibethicus</i>	common muskrat ^b				1	
Lagomorpha	Leporidae	<i>Lepus californicus</i>	<u>black-tailed jackrabbit</u> ^b				4	
		<i>Sylvilagus audubonii</i>	<u>desert cottontail</u>					
Artiodactyla	Tayassuidae	<i>Pecari tajacu</i>	collared peccary			3		
	Cervidae	<i>Cervus canadensis</i>	<u>elk</u>			2	4	
		<i>Odocoileus hemionus</i>	<u>mule deer</u>				7	
		<i>Odocoileus virginianus</i>	<u>white-tailed deer</u> ^b				1	
Number of species				8	9	9	14	

^a See Appendix H for additional information.

^b Observed only outside of monument boundary but within 500 m of the TJ Ruins site near the Middle Fork of the Gila River.

Appendix E. Amphibian and reptile species that were not recorded by University of Arizona Inventory personnel but that may occur at Gila Cliff Dwellings NM. Species may occur based on documentation in the area outside of the monument by UA personnel, specimen collected in or near the monument and reported in Degenhardt et al. (1996), or by other sources.

Order	Family	Scientific name	Common name	Found by UA		
				Degenhardt et al. (1996)	outside of boundary	Specimen at MSB ^a
Caudata	Ambystomatidae	<i>Ambystoma tigrinum</i>	tiger salamander	X		X
Anura	Pelobatidae	<i>Spea multiplicata</i>	Mexican spadefoot	X		
	Bufonidae	<i>Bufo woodhousii</i>	Woodhouse's toad	X		X
		<i>Bufo punctatus</i>	red-spotted toad	X		
	Hylidae	<i>Hyla eximia</i>	mountain treefrog	X		
	Ranidae	<i>Rana chiricahuensis</i>	Chiricahua leopard frog	X		X
Testudines	Kinosternidae	<i>Kinosternon sonoriense</i>	Sonoran mud turtle	X		
	Emydidae	<i>Terrapene ornata</i>	western box turtle		X	
	Trionychidae	<i>Trionyx spiniferus</i>	spiny softshell turtle			
Squamata	Phrynosomatidae	<i>Sceloporus magister</i>	desert spiny lizard	X		
	Scincidae	<i>Eumeces multivirgatus</i>	many-lined skink	X		
		<i>Eumeces obsoletus</i>	Great Plains skink	X		
	Teiidae	<i>Cnemidophorus uniparens</i>	desert grassland whiptail	X		
		<i>Lampropeltis pyromelana</i>	Sonoran mountain kingsnake	X	X	
	Colubridae	<i>Hypsiglena torquata</i>	night snake	X		
		<i>Thamnophis marcianus</i>	checkered gartersnake	X		
	Viperidae	<i>Crotalus lepidus</i>	rock rattlesnake	X		
<i>Crotalus viridis</i>		western rattlesnake	X			

^a Museum of Southwestern Biology, University of New Mexico. See Appendix I for additional information.

Appendix F. Bird species that were not observed by University of Arizona Inventory personnel but that may occur at Gila Cliff Dwellings NM. List taken from Zimmerman (1995) and includes all species in each residence status except those listed as “rare.” List only includes those species that Zimmerman listed as being present in the oak-juniper, pinyon-juniper, ponderosa pine, and deciduous riparian vegetation types.

Order	Family	Scientific name	Common name	Residence status				
				Permanent	Summer	Winter	Migrant	
Anseriformes	Anatidae	<i>Anas crecca</i>	green-winged teal		X			
Pelicaniformes	Phalacrocoracidae	<i>Phalacrocorax auritus</i>	double-crested cormorant				X	
Ciconiiformes	Ardeidae	<i>Nycticorax nycticorax</i>	black-crowned night-heron		X			
Falconiformes	Accipitridae	<i>Pandion haliaetus</i>	osprey				X	
		<i>Haliaeetus leucocephalus</i>	bald eagle			X		
		<i>Circus cyaneus</i>	northern harrier			X		
			<i>Accipiter striatus</i>	sharp-shinned hawk	X			
			<i>Accipiter gentilis</i>	northern goshawk	X			
			<i>Buteo swainsoni</i>	Swainson's hawk		X		
			<i>Buteo regalis</i>	ferruginous hawk			X	X
	Falconidae	<i>Falco columbarius</i>	merlin				X	
		<i>Falco mexicanus</i>	prairie falcon	X				
Gruiformes	Gruidae	<i>Grus canadensis</i>	sandhill crane			X		
	Laridae	<i>Larus delawarensis</i>	ring-billed gull				X	
Columbiformes	Columbidae	<i>Zenaidura macroura</i>	white-winged dove		X			
Cuculiformes	Cuculidae	<i>Coccyzus americanus</i>	yellow-billed cuckoo		X			
		<i>occidentalis</i>			X			
		<i>Geococcyx californianus</i>	greater roadrunner	X				
Strigiformes	Tytonidae	<i>Tyto alba</i>	barn owl	X				
	Strigidae	<i>Strix occidentalis lucida</i>	Mexican spotted owl	X				
		<i>Asio otus</i>	long-eared owl				X	
Caprimulgiformes	Caprimulgidae	<i>Chordeiles acutipennis</i>	lesser nighthawk		X			
		<i>Caprimulgus vociferus</i>	whip-poor-will		X			
Piciformes	Picidae	<i>Melanerpes lewis</i>	Lewis's woodpecker		X			
		<i>Picoides scalaris</i>	ladder-backed woodpecker	X				
		<i>Picoides pubescens</i>	downy woodpecker	X				
Passeriformes	Tyrannidae	<i>Contopus cooperi</i>	olive-sided flycatcher		X			
		<i>Empidonax hammondi</i>	Hammond's flycatcher				X	
		<i>Empidonax oberholseri</i>	dusky flycatcher				X	
		<i>Pyrocephalus rubinus</i>	vermillion flycatcher		X			
		<i>Tyrannus verticalis</i>	western kingbird		X			
		Laniidae	<i>Lanius ludovicianus</i>	loggerhead shrike			X	X
		Vireonidae	<i>Vireo huttoni</i>	Hutton's vireo		X		
		Corvidae	<i>Aphelocoma ultramarina</i>	Mexican jay	X			
	<i>Corvus brachyrhynchos</i>		American crow	X				
		Hirundinidae	<i>Tachycineta bicolor</i>	tree swallow				X
		Sittidae	<i>Sitta canadensis</i>	red-breasted nuthatch	X			
		Certhiidae	<i>Certhia americana</i>	brown creeper	X			
		Cinclidae	<i>Cinclus mexicanus</i>	American dipper	X			
		Regulidae	<i>Regulus satrapa</i>	golden-crowned kinglet	X			
		Turdidae	<i>Sialia currucoides</i>	mountain bluebird		X	X	X
		Mimidae	<i>Oreoscoptes montanus</i>	sage thrasher			X	X
	<i>Toxostoma crissale</i>		crissal thrasher	X				
		Sturnidae	<i>Sturnus vulgaris</i>	European starling	X			
		Motacillidae	<i>Anthus rubescens</i>	American pipit			X	
	Bombycillidae	<i>Bombycilla cedrorum</i>	cedar waxwing			X	X	
	Ptilonotidae	<i>Phainopepla nitens</i>	phainopepla	X				
	Parulidae	<i>Vermivora ruficapilla</i>	Nashville warbler				X	
<i>Vermivora luciae</i>		Lucy's warbler		X				
<i>Dendroica occidentalis</i>		hermit warbler					X	
<i>Setophaga ruticilla</i>		American redstart					X	
	Parulidae	<i>Seiurus noveboracensis</i>	northern waterthrush				X	
	Thraupidae	<i>Piranga rubra</i>	summer tanager		X			
	Emberizidae	<i>Pipilo aberti</i>	Abert's towhee	X				
<i>Aimophila ruficeps</i>		rufous-crowned sparrow		X				

Order	Family	Scientific name	Common name	Residence status			
				Permanent	Summer	Winter	Migrant
Passeriformes	Emberizidae	<i>Spizella atrogularis</i>	black-chinned sparrow		X		
		<i>Melospiza melodia</i>	song sparrow			X	
	Cardinalidae	<i>Cardinalis cardinalis</i>	northern cardinal	X			
		<i>Cardinalis sinuatus</i>	pyrrhuloxia			X	
	Icteridae	<i>Agelaius phoeniceus</i>	red-winged blackbird		X	X	X
		<i>Quiscalus mexicanus</i>	great-tailed grackle	X			
	Fringillidae	<i>Icterus parisorum</i>	Scott's oriole		X		
		<i>Carpodacus cassinii</i>	Cassin's finch			X	X
		<i>Carduelis pinus</i>	pine siskin		X	X	X
	Passeridae	<i>Carduelis tristis</i>	American goldfinch			X	
		<i>Passer domesticus</i>	house sparrow	X			
Number of species				21	20	16	10

Appendix G. Mammal species that were not recorded by University of Arizona Inventory personnel but that are known to or may occur at Gila Cliff Dwellings NM. List based on range maps by Findley et al. (1975) and trapping or observations at or near the monument by Hayward and Hunt (1972).

Order	Family	Scientific name	Common name	Findley	Hayward and Hunt	Comments from Hayward and Hunt
Chiroptera						
	Vespertilionidae	<i>Myotis evotis</i>	long-eared myotis		X ^a	
		<i>Myotis yumanensis</i>	Yuma myotis	X		
		<i>Myotis thysanodes</i>	fringed myotis	X		
		<i>Myotis volans</i>	long-legged myotis	X		
		<i>Myotis ciliabrum</i>	western small-footed myotis	X		
		<i>Pipistrellus hesperus</i>	western pipistrelle	X		
		<i>Lasiurus blossevillii</i>	western red bat	X		
		<i>Plecotus townsendii</i>	Townsend's big-eared bat		X ^a	
		<i>Idionycteris phyllotis</i>	Allen's big-eared bat	X		
		<i>Antrozous pallidus</i>	pallid bat		X ^a	
	Molossidae	<i>Nyctinomops femorosaccus</i>	pocketed free-tailed bat	X		
		<i>Eumops perotis californicus</i>	western bonneted bat	X		
Carnivora						
	Procyonidae	<i>Bassariscus astutus</i>	ringtail	X		Doc Campbell had a ringtail living in his attic in Gila Hot Springs
	Mustelidae	<i>Mustela frenata</i>	long-tailed weasel	X		
		<i>Taxidea taxus</i>	American badger	X		
	Canidae	<i>Canis lupus baileyi</i>	Mexican gray wolf	X		
	Felidae	<i>Lynx rufus</i>	bobcat	X	X	Rabid individual at monument visitor center in August 1971
Rodentia						
	Sciuridae	<i>Neotamias cinereiolis</i>	gray-collared chipmunk	X		
		<i>Sciurus arizonensis</i>	Arizona gray squirrel	X	X	2 miles up West Fork of the Gila River
						Trapped at TJ Ruins unit- only site in Wilderness Ranger district of Gila National Forest
	Heteromyidae	<i>Perognathus flavus</i>	silky pocket mouse	X	X ^b	
		<i>Chaetodipus hispidus</i>	hispid pocket mouse?	X		
		<i>Dipodomys ordii</i>	Ord's kangaroo rat		X ^b	Trapped at TJ Ruins unit - they believed that it was an unusual location
						Specimens taken from west of monument - out of characteristic habitat
	Muridae	<i>Peromyscus leucopus</i>	white-footed mouse		X	
		<i>Onychomys leucogaster</i>	northern grasshopper mouse	X		
		<i>Onychomys torridus</i>	southern grasshopper mouse		X ^b	Trapped at TJ Ruins unit - only site in Wilderness Ranger district of Gila National Forest
						common below 6,000 in the area
	Erethizontidae	<i>Erethizon dorsatum</i>	North American porcupine	X		
Lagomorpha						
	Leporidae	<i>Sylvilagus floridanus</i>	eastern cottontail	X		
Artiodactyla						
	Antilocarpidae	<i>Antilocapra americana</i>	pronghorn (antelope)		X	150 spent winter of 1967 in the Gila Center area

^a B. J. Hayward in personal communication to Ronnie Sidner (2001); bats were caught at the monument in 1965.

^b To our knowledge, no specimens are known to have been accessioned from these collections.

Appendix H. Vertebrate specimen and photograph vouchers collected by University of Arizona Inventory personnel, Gila Cliff Dwellings NM, 2001 and 2002. All specimen vouchers are located in University of Arizona (AZ) collections.

Voucher type		Date of	AZ	Specimen	
Taxon	Species	collection	collection #	type	
Specimen					
Amphibian	Arizona toad	Emily Bennett	7/6/2001	53627	whole
	canyon treefrog	Michael Wall	5/27/2001	53398	whole
	American bullfrog	James Borgmeyer	5/26/2001	53397	whole
Reptile	Clark's spiny lizard	Emily Bennett	6/3/2002		whole
	eastern fence lizard	Kevin Bonine and Dan Bell	8/6/2002		whole
	ornate tree lizard	Trish London	5/27/2002		whole
	greater short-horned lizard	Michael Wall	5/27/2001	53396	whole
	Chihuahuan spotted whiptail	James Borgmeyer	5/29/2001	53394	whole
	Chihuahuan spotted whiptail	Emily Bennett	7/16/2001	53628	whole
	Chihuahuan spotted whiptail	Emily Bennett	8/5/2002		whole
	Madrean alligator lizard	James Borgmeyer	5/25/2001	53395	whole
	Madrean alligator lizard	Anita Deming	7/26/2002		whole
	striped whipsnake	Trishia London	7/4/2001	53635	whole
	mountain patch-nosed snake	Jimmy Wethington	7/28/2001	53632	whole
	mountain patch-nosed snake	Laura Zuller	9/3/2001	53683	whole
	gopher snake	Monument staff	5/11/2001	53392	whole
	gopher snake	Michael Wall	5/27/2001	53393	whole
	gopher snake	Emily Bennett	7/21/2001	53633	whole
	gopher snake	Trishia London	7/8/2001	53634	whole
	black-necked gartersnake	Emily Bennett	7/10/2001	53629	whole
black-necked gartersnake	Trishia London	8/5/2001	53630	whole	
black-necked gartersnake	Jimmy Wethington	8/10/2001	53682	whole	
black-tailed rattlesnake	Trishia London	8/3/2001	53675	whole	
Mammal	desert shrew	Neil Perry	9/3/2001	26829	Skin and skull
	Arizona myotis	Ronnie Sidner	6/22/2002	26935	Skull
	Arizona myotis	Ronnie Sidner	6/21/2002	26842	Skin and skull
	Arizona myotis	Ronnie Sidner	6/22/2002	26936	Skull
	southwestern myotis	Ronnie Sidner	9/4/2002		Skin and skull
	silver-haired bat	Ronnie Sidner	5/27/2001	26896	Skin and skull
	big brown bat	Ronnie Sidner	5/29/2001	26840	Skin and skull
	northern raccoon	Jason Schmidt	5/16/2001		Maxilla
	northern raccoon	Dale Turner	5/15/2001	26773	Skull
	hooded skunk	Neil Perry	8/28/2002	26765	Skull
	white-backed hog-nosed skunk	Neil Perry	5/5/2001	26778	Skull
	coyote	Neil Perry	9/10/2001	26770	Skull
	common gray fox	Jason Schmidt	9/2/2001	Submitted Fall 2001	Skull
	cliff chipmunk	Neil Perry	8/18/2001	26749	Skin
	Botta's pocket gopher	Emily Bennett	9/15/2002	26883	Skin and skull
	Botta's pocket gopher	Neil Perry	5/5/2002	26927	Skull
	American beaver	Neil Perry	8/22/2001	26777	Skull
	western harvest mouse	Neil Perry	5/26/2001	26825	Skin and skull
	western harvest mouse	Emily Bennett	4/22/2002	26869	Skin and skull
	deer mouse	Emily Bennett	4/20/2002	26881	Skin and skull
	brush mouse	Emily Bennett	4/21/2002	26919	Skull
	piñon mouse	Neil Perry	9/4/2001	26828	Skin and skull
	piñon mouse	Emily Bennett	9/10/2002	26872	Skin and skull
	piñon mouse	Emily Bennett	9/6/2002	26882	Skin and skull
	piñon mouse	Neil Perry	5/26/2001	26831	Skin and skull
	western white-throated woodrat	Emily Bennett	8/11/2002	26847	Skin and skull
	Mexican woodrat	Emily Bennett	9/8/2002	26926	Skull
	Mexican woodrat	Neil Perry	5/26/2001	26750	Skin
	Mexican vole	Emily Bennett	7/16/2002	26871	Skin and skull
desert cottontail	Neil Perry	10/9/2001	26781	Skull and mandible	
elk	Jason Schmidt	5/30/2001	26764	Skull no antlers	
mule deer	Neil Perry	5/26/2001	26776	Skull	

Voucher type		Date of	AZ	Specimen
Taxon	Species	collection	collection #	type
Photograph				
Amphibian	canyon treefrog	Dave Prival	5/27/2001	
	American bullfrog	Dave Prival	5/26/2001	
	American bullfrog	Dave Prival	5/26/2001	
	Arizona toad	Kevin Bonine	6/27/2002	
Reptile	Chihuahuan spotted whiptail	Dave Prival	5/26/2001	
	Chihuahuan spotted whiptail	Dave Prival	5/26/2001	
	Madrean alligator lizard	Dave Prival	5/25/2001	
	greater short-horned lizard	Dave Prival	5/29/2001	
	greater short-horned lizard	Dave Prival	5/29/2001	
	crevice spiny lizard	Dave Prival	5/27/2001	
	crevice spiny lizard	Dave Prival	5/27/2001	
	eastern fence lizard	Dave Prival	5/26/2001	
	eastern fence lizard	Dave Prival	5/26/2001	
	ornate tree lizard	Dave Prival	5/26/2001	
	black-tailed rattlesnake	Dave Prival	5/30/2001	
	black-tailed rattlesnake	Dave Prival	5/30/2001	
	black-necked gartersnake	Dave Prival	5/29/2001	
	black-necked gartersnake	Dave Prival	5/29/2001	
	gopher snake	Dave Prival	8/20/2001	
	western terrestrial gartersnake	Dave Prival	5/26/2001	
	western terrestrial gartersnake	Dave Prival	5/26/2001	
	eastern collared lizard	Dave Prival	8/21/2001	
	eastern collared lizard	Dave Prival	8/21/2001	
	narrow-headed gartersnake	Dan Bell	8/7/2002	
	narrow-headed gartersnake	Dan Bell	8/7/2002	
	gopher snake	Emily Bennett	6/13/2001	
	western box turtle	Emily Bennett	7/24/2001	
	Clark's spiny lizard	Emily Bennett	6/3/2002	
Bird	wild turkey	Emily Bennett/Neil Perry	10/15/2001	
	great blue heron	Ronnie Sidner	6/21/2002	
Mammal	mountain lion	Emily Bennett/Neil Perry	8/26/2002	
	Abert's squirrel	Emily Bennett/Neil Perry	6/23/2002	
	collared peccary	Emily Bennett/Neil Perry	10/15/2001	
	American black bear	Emily Bennett/Neil Perry	10/15/2001	
	American black bear	Emily Bennett/Neil Perry	10/15/2001	
	white-backed hog-nosed skunk	Emily Bennett/Neil Perry	12/11/2001	
	white-backed hog-nosed skunk	Emily Bennett/Neil Perry	12/11/2001	
	wapiti	Emily Bennett/Neil Perry	6/17/2002	
	striped skunk	Emily Bennett/Neil Perry	6/17/2002	
	striped skunk	Emily Bennett/Neil Perry	6/17/2002	
	common gray fox	Emily Bennett/Neil Perry	6/17/2002	
	common gray fox	Emily Bennett/Neil Perry	6/17/2002	
	black-tailed jackrabbit	Emily Bennett	7/7/2002	
	big brown bat	Ronnie Sidner	5/26/2001	
	Brazilian free-tailed bat	Ronnie Sidner	5/26/2001	
	silver-haired bat	Ronnie Sidner	5/26/2001	
	northern raccoon	Emily Bennett	5/28/2001	
Mammal	cliff chipmunk	Neil Perry	5/28/2001	
	rock squirrel	Emily Bennett	6/30/2001	

Appendix I. Number of amphibian and reptile specimen vouchers located at the Museum of Southwestern Biology, University of New Mexico. Location information indicates that specimens were collected either from inside or outside (but within 30 km) of Gila Cliff Dwellings NM.

Species	Found in monument	Found outside of monument
tiger salamander		1
Woodhouse's toad	1	
Arizona toad	1	12
canyon treefrog		1
Chiricahua leopard frog	1	1
American bullfrog	6	10
crevice spiny lizard		2
Clark's spiny lizard		1
eastern fence lizard		2
ornate tree lizard		5
Chihuahuan spotted whiptail		2
Madrean alligator lizard		1
narrow-headed gartersnake	1	3
western terrestrial gartersnake	1	7
black-necked gartersnake		3

Appendix J. Report by Philip C. Rosen on the expected amphibians and reptiles of Gila Cliff Dwellings NM.

Gila Cliff Dwellings is a small-acreage National Monument surrounded by the Gila Wilderness, in a region at moderately high elevations of about 5600 – 6700 ft. While ponderosa pine is the most prominent plant species, the vegetation is mixed, and habitat conditions for herpetofauna are more varied than those presented by the core of the ponderosa forest at higher elevations.

Based on the vegetation components, the site has a diverse flora with strong elements of the mid-elevation pinyon-juniper assemblage within a matrix dominated moderately by ponderosa pine and Gambel oak – the classic Transition Life Zone dominants seen widely in Arizona. The vegetation had about 91 Transition Zone (i.e., Ponderosa, or Petran Montane Woodland-related) trees in the tree overstory and understory, versus about 81 Upper Sonoran (i.e., Pinyon-Juniper, or Great Basin Woodland-related) trees. The area was mapped as Great Basin Conifer Woodland, but corresponds to a mix with a moderate dominance of Lower Montane Coniferous Forest (Ponderosa Pine-Pinyon Pine-Gray Oak series of Dick-Peddie 1993) over Pinyon-Juniper Woodland.

The riparian and stream environments have a middle elevation character, as indicated by species lists and the overall aspect, which is rich in marshland plants and reflects a mixture of slow and swiftly flowing waters. In the absence of introduced species, this should be an excellent aquatic system for native herpetofauna.

Overall, therefore, I expect a fairly high diversity of amphibians and reptiles, with a core of species composed of higher elevation taxa in the woodland-forest group, without the depauperate character found at higher elevations in the Transition Zone, and with some representation of lower elevation woodland taxa. In addition, there should be a strongly developed complement of aquatic species, such as gartersnakes, the Sonoran mud turtle, and aquatic anurans such as Woodhouse toad, Arizona toad, and the Chiricahua leopard frog, as well as some members of the family Hylidae.

Potential and Known Herpetofauna

Based on geographic proximity, elevational range, and habitat, a total of 49 amphibians and reptiles might potentially be found at Gila Cliff Dwellings NM (Appendices B, E). Of these, 21 are confirmed to be present, of which 20 were recorded by the NPS I&M survey team. One species, the Chiricahua leopard frog was present historically but is presumed extirpated. An additional 5 species can be expected to occur, but may be rare and difficult to find, and 6 more are possible (including the box turtle – see below), for a total of 30 to 34 species expected in the herpetofauna.

A western box turtle was found by the I&M survey team within about three miles from the monument, a species that would not be expected based on the criteria I used. The individual could have been translocated as a captive. However, despite a 50+ km gap between this record along the Gila River and the nearest record to the south, Degenhardt et al. (1996) reports occasional records to above 2100 m and discusses a possibly valid record in Pinyon-Juniper-Ponderosa habitat near Albuquerque. Thus, while I consider the box turtle record questionable or peripheral, needing confirmation both on-site, as a population, and with evidence of recruitment (at least with a variety of ages, but especially with young ones less than 10 or 12 years old), the observation should alert the NPS to the possibility of an unusual, higher elevation population of box turtles at or near the monument.

A similar situation may exist for the checkered gartersnake and desert spiny lizard, but at the least photo vouchers will be needed to verify their occurrence. Both are examples of typically lower elevation species occurring in higher life zones in the Gila Wilderness than elsewhere in their range (see Degenhardt et al. 1996), and both could occur at the monument and be rare, secretive, and hard to document.

However, some of the species judged to possibly occur at the monument, may occur only at higher elevations, such as the mountain treefrog, or in special breeding environments, such as the western chorus frog.

Overall, it appears that local and regional herpetofaunal diversity is quite high on an elevation-specific basis, and the herpetofauna appears to be intact (except for some, possibly several, aquatic species) and adequately sampled overall by the University of Arizona I&M team. The diversity corresponds to the substantial habitat diversity, whereas the threats to the aquatic species are driven first and foremost by harmful non-native species such as the American bullfrog, crayfish, and various predatory fishes.

Key Features of the Herpetofauna

The most notable part of the monument's herpetofauna appears to be the aquatic element, for which the gartersnake species list appears good both historically and currently. However, abundance declines could be ongoing in the

narrow-headed gartersnake, as is being found in other areas; further, the absence of Sonoran mud turtle records and Chiricahua leopard frog records may be cause for concern. The presence of a warm spring may be significant for potential recovery of the Chiricahua leopard frog on-site, as warm- and hot-springs appear to allow the frogs to clear or avoid the emergent disease chytridiomycosis.

Secondly, the riparian component, which is not as well documented, should be strong at the monument. The nature of this herpetofaunal element at the site remains to be described. Species such as the many-lined skink, western chorus frog, and checkered gartersnake might be expected to be included, but have yet to be documented.

In the longer term, peripheral species such as the desert spiny lizard, mountain treefrog, and night snake may be added to the known herpetofauna of the monument, reflecting its transitional position on a habitat gradient that corresponds to its position on the gradient between Transition and Upper Sonoran Life Zones.

Appendix K. Number of birds observed during VCP and incidental surveys, Gila Cliff Dwellings NM, April–July 2001 and 2002. Numbers should not used as a measure of relative abundance because there was not consistent sampling effort across time or between survey types. See Tables 5.2 and 5.3 for relative abundance of the most common species.

Species	April		May		June		July	
	15-30	1-15	16-31	1-15	16-30	1-15	15-31	
mallard		5	2					
common merganser		5	6		1		3	
wild turkey	1	1	1			5	2	
Gambel's quail					2			
Montezuma quail					2		3	
great blue heron		1	1		13		5	
turkey vulture	1	1	6		22		33	
common black-hawk				1	2			
zone-tailed hawk		1						
red-tailed hawk			1		1	1	1	
golden eagle		1						
American kestrel				2	2	1	5	
peregrine falcon	2							
killdeer				1	2		1	
spotted sandpiper			1				2	
mourning dove	1	18	12	11	17	2	9	
great horned owl		1						
northern pygmy-owl		1	1					
common nighthawk						2	2	
white-throated swift			3		4			
black-chinned hummingbird			6	2	2		7	
calliope hummingbird							3	
broad-tailed hummingbird		8	7	2	7	2	12	
rufous hummingbird					1		40	
acorn woodpecker	1	2	11	1	8	3	7	
red-naped sapsucker		2						
hairy woodpecker	1		5	3	1	2	2	
northern flicker	1	6	7	4	18	3	8	
western wood-pewee			7	4	7	2	9	
gray flycatcher					2			
cordilleran flycatcher			5	2	5	5	4	
black phoebe	1	1	3	1	5	1	3	
Say's phoebe	1	2			1		3	
dusky-capped flycatcher		1						
ash-throated flycatcher		4	4	2	9	7	10	
Cassin's kingbird			6		7		16	
Bell's vireo		1						
plumbeous vireo		5	1	7	4	3	5	
warbling vireo		7	14		10	6	8	
Steller's jay		8	9	2	11	6	7	
western scrub-jay	1	1	4	2	5	14	7	
pinyon Jay		5		27		10	3	
common raven	1	10	7	4	5	6	5	
purple martin		15	6	5	17	4	30	
violet-green swallow		20	36	3	63	19	87	
northern rough-winged swallow	1		5	1	2			
cliff swallow	1		1		39		25	
barn swallow				1				
mountain chickadee		2	1		2			
bridled titmouse	1	2		4	4		1	
bush-tit		4	11	14	4	3	46	
white-breasted nuthatch		5			3	1	7	
pygmy nuthatch					9	1	4	
rock wren		1			3		1	
canyon wren		3	7	9	4	4	8	
Bewick's wren	1	1	1	1	2	1	1	

Species	April	May		June		July	
	15-30	1-15	16-31	1-15	16-30	1-15	15-31
house wren	1	12	23	7	17	7	15
blue-gray gnatcatcher		4	4	1		1	1
western bluebird		1	4		2		4
Townsend's solitaire				1			
hermit thrush		1					
American robin	1	17	24	15	26	13	14
gray catbird					1		
northern mockingbird							3
curve-billed thrasher					1		
olive warbler				1			
orange-crowned warbler		1	1				
Virginia's warbler		6	12	2	9	2	5
yellow warbler	1	2	2		15	1	7
yellow-rumped warbler	1	3					
black-throated gray warbler		5	3	1	5		1
Townsend's warbler		2					
Grace's warbler		2			1		
Macgillivray's warbler		2	4				
common yellowthroat			1	1	1		
Wilson's warbler	1	4	6				
red-faced warbler		3	2		3	2	1
painted redstart		6	9	3	10	6	11
yellow-breasted chat		7	6	3	16	5	12
hepatic tanager		6	3	2	7	4	6
western tanager		11	12	5	11	6	9
green-tailed towhee		5	2				
spotted towhee	1	16	28	13	34	12	35
canyon towhee	1	2	1	1	7		12
chipping sparrow		4					4
Brewer's sparrow		1					
lark sparrow						2	23
Lincoln's sparrow		5					
white-crowned sparrow	2		2				
dark-eyed junco		11			1		
black-headed grosbeak		15	29	4	14	5	7
blue grosbeak			1	3	5	5	19
lazuli bunting			1				2
indigo bunting					1		1
yellow-headed blackbird						1	
Brewer's blackbird		5	6		2		
brown-headed cowbird		9	6	2	5	2	1
Bullock's oriole			5		1		6
house finch	1	2	1		8	1	8
red crossbill			1				
lesser goldfinch	1		1		16	1	25

Appendix L. Additional bat-netting data, Gila Cliff Dwellings NM, 2001 and 2002.
See Table 6.4 for additional analyses by site.

Site	Date	Species	Sex	Number of individuals captured
Cliff Dweller Canyon 1	09/13/2001	no bats caught		
Cliff Dweller Canyon 2	05/29/2001	no bats caught		
Middle Fork of Gila River	05/28/2003	no bats caught		
West Fork Gila River 1	05/27/2001	big brown bat	M	1
		hoary bat	M	2
		silver-haired bat	M	7
	06/22/2002	California myotis	F	1
		Mexican freetail bat	F	1
		Mexican freetail bat	M	7
		Arizona myotis	F	4
		Arizona myotis	M	2
	08/29/2002	big brown bat	M	1
		Arizona myotis	F	1
		Arizona myotis	M	1
		southwestern myotis	F	1
West Fork Gila River 4	08/27/2002	Mexican freetail bat	M	1
West Fork Gila River 5	08/28/2002	no bats caught		
West Fork Gila River 6	05/25/2001	hoary bat	M	1
	05/26/2001	Mexican freetail bat	F	1
		big brown bat	M	1
		hoary bat	M	3
		Arizona myotis	F	1
		silver-haired bat	M	9
		southwestern myotis	F	1
	09/12/2001	no bats caught		
	06/20/2002	Mexican freetail bat	F	3
		Mexican freetail bat	M	3
		big brown bat	F	1
		big freetail bat	F	1
		hoary bat	M	1
	06/21/2002	Mexican freetail bat	M	5
		big brown bat	M	2
		hoary bat	M	1
		Arizona myotis	M	1

Appendix M. Number of individual small mammals trapped (*n*) and relative abundance (RA) adjusted for trap nights at each group, site, and visit number, Gila Cliff Dwellings NM, 2001 and 2002. Data are summarized in Table 6.5. See Table 6.2 for information on trapping effort by site.

Species	Group, Site name, Visit number																			
	West Fork ^a																			
	A		B						C		GRB									
	1	1	2	3	4	5	6	1	1	2	1	2								
<i>n</i>	RA	<i>n</i>	RA	<i>n</i>	RA	<i>n</i>	RA	<i>n</i>	RA	<i>n</i>	RA	<i>n</i>	RA	<i>n</i>	RA					
western harvest mouse	7	11.5	7	12.6	2	4.1	2	5.6	3	5.2	7	12.6	2	3.4	3	4.6	3	6.7	1	1.4
deer mouse			1	1.8									1	1.7						
brush mouse	5	8.2	8	14.4	11	22.4	9	25.0	11	19.1	5	9.0	3	5.2	5	7.6	6	13.3	1	1.4
western white-throated woodrat			1	1.8	3	6.1	3	8.3	4	7.0			1	1.7						
Mexican woodrat													1	1.7						
Mexican vole								2	3.5	1	1.8									

^aNo animals were trapped at "FW" site.

Species	Group, Site name, Visit number													
	Random- TJ Ruins Unit				Random- West unit ^a									
	G1		G2		L1		L3		L5					
	1	1	1	1	1	2	1	2	1	2	1	2		
<i>n</i>	RA	<i>n</i>	RA	<i>n</i>	RA	<i>n</i>	RA	<i>n</i>	RA	<i>n</i>	RA	<i>n</i>	RA	
cliff chipmunk								1	1.0					
western harvest mouse					1	2.1								
brush mouse	1	1.4	1	1.4	1	2.1			2	2.1	1	1.4		
western white-throated woodrat			2	2.8									1	2.0
Mexican woodrat			1	1.4										

^a No animals were trapped at "L6" site.

Species	Group, Site name, Visit number													
	Mesa				Cliff Dweller Canyon									
	Mesa D		Mesa E		Mesa F		Mesa G		CDC 1		CDC 2			
	1	1	1	1	1	1	1	2	1	1				
<i>n</i>	RA	<i>n</i>	RA	<i>n</i>	RA	<i>n</i>	RA	<i>n</i>	RA	<i>n</i>	RA			
cliff chipmunk	1	1.7					1	1.6						
deer mouse	1	1.7					1	1.6						
brush mouse	3	5.1			1	1.4	4	6.3	2	2.1	4	6.1	2	23.5
piñon mouse					2	2.8	1	1.6						
western white-throated woodrat	3	5.1	2	2.7	1	1.4	5	7.8					1	11.8

