Powell, Schmidt, Halvorson

Vascular Plant and Vertebrate Inventory of Fort Bowie National Historic Site

Open-File Report 2005-1167

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NATIONAL PARK SERVICE

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

Vascular Plant and Vertebrate Inventory of Fort Bowie National Historic Site

Southwest Biological Science Center
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U.S. Department of the Interior
U.S. Geological Survey
National Park Service

SONORAN DESERT NETWORK
Inventory and Monitoring Program

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

Vascular Plant and Vertebrate Inventory of Fort Bowie National Historic Site

By Brian F. Powell, Cecilia A. Schmidt , and William L. Halvorson

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December 2006

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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 Fort Bowie NHS staff members Larry Ludwig and Barbara Herman-Reese for their on-site support and Superintendent Alan Whalon, Chief of Resources Carrie Dennett, Biological Technician Ruth Olsen, and all the staff at Chiricahua National Monument for their administrative support of our program. This project resulted from the collaboration of many people at the U.S. Geological Survey (USGS), University of Arizona (UA) and the National Park Service (NPS), and was facilitated by the Desert Southwest and Colorado Plateau Cooperative Ecosystem Studies Units (CESUs). The project was funded by the National Park Service Natural Resource Challenge Program. The Southern Arizona Office of 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 the role of the USGS/UA Inventory program in the I&M program. Kathy Davis at Tuzigoot and Montezuma Castle national monuments played an instrumental role in this project by providing important early initiative. Larry Norris at the Desert Southwest CESU has provided strong support for our program and spent considerable time and effort providing clear and timely administrative assistance. Matt Goode, Don Swann, and Dale Turner provided much of the early planning for this project; we are indebted to their vision. Special thanks to Lisa Carder and Kathleen Docherty for their years of hard work on all aspects of the project. Eric Albrecht, to whom this report is dedicated, was an outstanding spokesperson and leader of the program; he was an invaluable member of the team and his contributions are sorely missed.

We thank a core group of dedicated field biologists who collected a wealth of data at Fort Bowie NHS: James MacAdam, and Meg Quinn (plants); Eric Albrecht, Gabe Martinez, and Janine McCabe (birds); and Patina Thompson (mammals). Barbara Herman-Reese provided Trailmaster data. We are appreciative of the following people, whose work in the office made the field effort more successful: Debbie Angell, Jennifer Brodsky, Brian Cornelius, Taylor Edwards, Carianne Funicelli, Marina Hernandez, Colleen McClain, Heather McClaren, Lindsay Norpel, Ryan Reese, Jill Rubio, Brent Sigafus, Taffy Sterpka, Jenny Treiber, and Alesha Williams.

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We received helpful reviews of an earlier version of this report by: Carrie Dennett, Dennis Fenn, Michele Girard, Andy Hubbard, Larry Laing, Theresa Mau-Crimmons, Larry Norris, Ruth Olsen, and Alan Whalon. All mistakes or omissions are the responsibility of the authors.

Executive Summary

This report summarizes results of an inventory of plants, birds, and mammals of Fort Bowie National Historic Site (NHS) in southeastern Arizona. Surveys at the park were part of a larger effort to inventory vascular plants and vertebrates in eight National Park Service (NPS) units in Arizona and New Mexico. Our inventory efforts build on past research for the park; included in this report is the most comprehensive synthesis of species lists from past studies of plants and vertebrates. Though we did not survey specifically for them, we also include a species lists of amphibians and reptiles that have been observed or documented at the park.

For a park of its size (405 ha), Fort Bowie NHS has extraordinary species richness, especially for plants (638 species) and mammals (57 species). This diversity results from its geographic location at the junction of three biogeographical provinces, its diverse geology, and the presence of year-round water from an active spring.

We found 45 new plant and vertebrate species for the park (Table 1) including:

- Plants: two species representing new families and nine species representing new genera, including one new genus *(Euphorbia)* represented by three species;
- Birds: zone-tailed hawk and common ground dove;
- Mammals: domestic dog and hooded skunk.

Based on a review of past studies and our own work, we consider the inventories of plants and vertebrates to be 90% complete. With baseline inventories at Fort Bowie NHS among the most complete of the 11 parks in the Sonoran Desert Network, park staff are now in an excellent position to monitor changes in these resources.

Table 1. Summary results of plant and vertebrate inventories at Fort Bowie NHS, 2002 to 2004.

	UA Effort			
Taxonomic group	Number of species recorded	Number of non-native species	Number of new species added to park list[a]	Total number of species on park list[b]
Plants	193	13	33	638
Amphibians and Reptiles	8	0	0	40
Birds	109	0	6	189
Mammals	14	1	2	59
Totals	**324**	**14**	**41**	**926**

[a]Species that had not been observed or documented by previous studies.
[b]From all sources (see Appendices A-D for complete lists).

Chapter 1: Introduction to the Biological Inventories

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 (NPS 1992). At the time of the program's inception, basic biological information, including lists of plants and animals, were absent or incomplete for many parks (Stohlgren et al. 1995).

Species inventories have both direct and indirect value for management of the park. 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 strategies, field methods, data collection protocols, and provide estimates of variation that are essential in prospective power analysis.

Goals

The purpose of this study was to complete basic inventories for vascular plants, birds, and mammals at Fort Bowie National Historic Site (NHS). 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. 2003, 2004, 2005a). The results presented in this report supersede those reported by Powell et al. (2003, 2004, and 2005b).

The goals of our biological inventory of Fort Bowie NHS were to:

1. Conduct field surveys to bring the current species lists for vascular plants, birds, and mammals to at least 90% of the species expected to occur at the park.
2. Use repeatable sampling designs and survey methods (when appropriate) that allow estimation of parameters of interest with associated estimates of precision.
3. Compile historic occurrence data for plants and vertebrates (including amphibians and reptiles) from three sources: museum records (specimen vouchers), previous studies, and park records.
4. Create resources useful to park 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 goals number 1 and 2. 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.

Administrative History

The original study plan for this project was developed, and an inventory of one Sonoran Desert Network (SDN) park (Tumacácori National Historical Park) was completed, through a cooperative agreement between NPS, UA, and the USGS. This project comprises biological inventories for seven additional parks and was funded through Task Agreements UAZ-03, -05, -06, and -07 (under Colorado Plateau CESU cooperative agreement number 1200-99-009). The National Park Service thereafter obligated additional funds for administration, management, and technical oversight of the biological inventories through the Colorado Plateau CESU (UAZ-07) and the Desert Southwest CESU (cooperative agreement number CA 1248-00-002, reference UAZ39, -77, -87, -97, and 128).

Report Format and Data Organization

This report includes summaries and analyses of data related to vascular plants, birds, and mammals collected from 2002 to 2004 at Fort Bowie NHS. This report is intended to be useful in internal planning processes and outreach and education, and as such we strive to make it relevant, easy to read, and well organized. We report only common names (listed in phylogenetic sequence) unless the species 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 at the park (Appendices A, C, and D). Although we did not survey specifically for amphibians and reptiles, we made a few incidental observations and we include a list of species observed or documented by others (Appendix B). Species lists are in phylogenetic sequence and include taxonomic order, family, genus, species, subspecies or varieties (if applicable) and common name. Scientific and common names used throughout this document are current according to accepted authorities for each 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.

Previous Amphibian and Reptile Inventories

We did not survey for amphibians and reptiles because there have been two thorough inventories for them: the first by Lowe and Johnson (1976) and more recently by Swann et al. (2001). In addition to re-surveying Lowe and Johnson's line-transects, Swann et al. set up long-term monitoring plots, surveyed road transects, and produced an annotated species list. In total, these studies found one non-native species (American bullfrog), and 31 reptile species (16 lizards, one turtle, and 14 snakes) including Texas horned lizard, a federally listed species of concern. The most notable species is now-extirpated Chiricahua leopard frog (a federally threatened species; HDMS 2004). In this report, we list the species found by these studies and species that our crews found while conducting surveys for other taxa (Appendix B). We also summarize specimens located in the University of Arizona herpetology collection (Appendix E), and a few photographic vouchers that we took during our course of other field research (Appendix I).

Spatial Data

Most spatial data are geographically referenced to facilitate mapping of study plots and locations of plants or animals. Coordinate storage is the Universal Transverse Mercator (UTM) projection, using North American datum 1983 (NAD 83), Zone 12. We recorded UTM coordinates using hand-held Garmin eMap® Global Positioning System (GPS) units (Garmin International Incorporated, Olathe, KS; horizontal accuracy is about 10–30 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.D.A. Forest Service, Arizona 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 park 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 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 park 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. For plants, we searched the University of Arizona Herbarium for existing specimens from Fort Bowie NHS (see Appendix A for results), but we collected herbarium specimens whenever flowers or fruit were present on plants in the field (Appendix A). All specimens that we collected were accessioned into the University of Arizona Herbarium. Although we did not collect specimen vouchers for vertebrates, we searched for existing vouchers from Fort Bowie NHS in records from 23 natural history museums (Table 1.1 see Appendix E for results).

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 where the order of samples was shuffled >10 times and the average is plotted, thereby smoothing the curve.

Table 1.1. Museums that were queried in 1998 for vertebrate specimen vouchers with "Arizona" and "Fort Bowie National Historic Site" in the collection location. Collections in bold-faced type had specimens from Fort Bowie NHS. See Appendix E for results.

Collection	Collection cont.
Chicago Academy of Sciences	Peabody Museum, Yale University
Cincinnati Museum of Natural History & Science	Saguaro National Park
Cornell Vertebrate Collections, Cornell University	Strecker Museum, Baylor University, Waco
George Mason University (Fairfax, VA)	Texas Cooperative Wildlife Collection
Marjorie Barrick Museum, University of Nevada-Las Vegas	**University of Arizona**
Michigan State University Museum (East Lansing)	University of Texas, Arlington
Milwaukee Public Museum	University of Illinois, Champaign-Urbana
Museum of Texas Tech University	**University of Colorado Museum**
Museum of Vertebrate Zoology, University of California, Berkeley	Walnut Canyon National Monument, Arizona
Museum of Life Sciences, Louisiana State University, Shreveport	Western Archaeological and Conservation Center, Tucson
North Carolina State Museum of Natural Sciences	Wupatki National Monument, Arizona
Oklahoma Museum of Natural History, Norman	

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. 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 Fort Bowie NHS 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 Fort Bowie NHS), 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., 28 black-throated sparrow at Fort Bowie NHS). 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: Park Overview

Park Area and History

Fort Bowie National Historic Site (NHS) is located in southeastern Arizona approximately 22 km south of the town of Bowie, Arizona (Fig. 2.1). The park lies in Apache Pass between the Chiricahua Mountains to the south and the Dos Cabezas Mountains to the north.

Fort Bowie NHS was established in 1964 to preserve the historic dwellings of Fort Bowie, a 19th century U.S. military outpost, prehistoric structures associated with Apache Spring, and a portion of the Butterfield Overland Trail and Station (NPS 2001). The park also commemorates the fort's soldiers, the Chiricahua Apaches, and the settlement of the west (NPS 2001). The park, which encompasses 405 ha, is administered by Chiricahua National Monument. Recent annual visitation is approximately 9,500 (NPS 2005).

Natural Resources Overview

Physiography, Geology and Soils

Fort Bowie NHS is located in Apache Pass, which separates the San Simon and the Sulphur Springs Valleys. Elevation at the park ranges from 1,400 m to 1,600 m. The park contains three riparian areas: Siphon Canyon, Cutoff Canyon, and Willow Gulch. The geology of the park is characterized by the Apache Pass Fault made of Pennsylvanian and Cretaceous limestone on top of Precambrian granite (Denney and Peacock 2000). In some areas small fan terraces have formed from the granitic alluvium deposited by drainageways. For a complete soil survey, see Denny and Peacock (2000).

Hydrology

There are no perennial-flowing streams, but two springs, Apache and Mine Tunnel, are found within the park. Three other springs are outside, but near to the boundary of the park: Siphon, Bear, and Goodwin springs. Currently, half of the water flow of Apache Springs can be diverted to adjacent lands for use in cattle tanks, though this is rarely realized (Alan Whalon, *pers. comm.*). Siphon Canyon and Willow Gulch have ephemeral flow during summer (monsoonal) and winter rains (NPS 2001).

Climate

Fort Bowie NHS experiences an annual bimodal pattern of precipitation that is characterized by heavy summer (monsoon) storms from the Gulf of Mexico, and less intense frontal systems 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 2005). The area's hot season occurs from April through October; maximum temperatures in July can exceed 40°C. Winter temperatures dip below freezing and snow is occasional. Based on data from Bowie, Arizona (the closest climate station), average annual precipitation totals during the course of our study were significantly lower than the long-term mean (27.3 cm) in 2002 (21.5 cm) and 2003 (19.3 cm), but similar for 2004 (29.3 cm through October 2004) (Fig 2.3; WRCC 2005). Average annual temperatures during all years of our survey were above the long-term mean of 17.7°C (17.8°C in 2002, 18.3°C in 2003, and 18.9°C through October 2004).

Table 2.1. Average monthly climate data for Bowie, Arizona, 1899–2004. Data from WRCC (2005).

	Month												
Characteristic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Maximum temperature (°C)	16.2	18.7	22.2	26.8	31.7	36.8	36.8	35.3	33.2	27.8	20.7	15.7	26.8
Minimum temperature (°C)	-0.7	1.2	3.7	7.0	11.5	16.6	19.7	18.7	15.2	9.0	2.6	-0.5	8.7
Precipitation (cm)	2.1	2.0	1.5	0.7	0.6	0.9	5.2	5.3	2.6	2.2	1.5	2.4	2.3

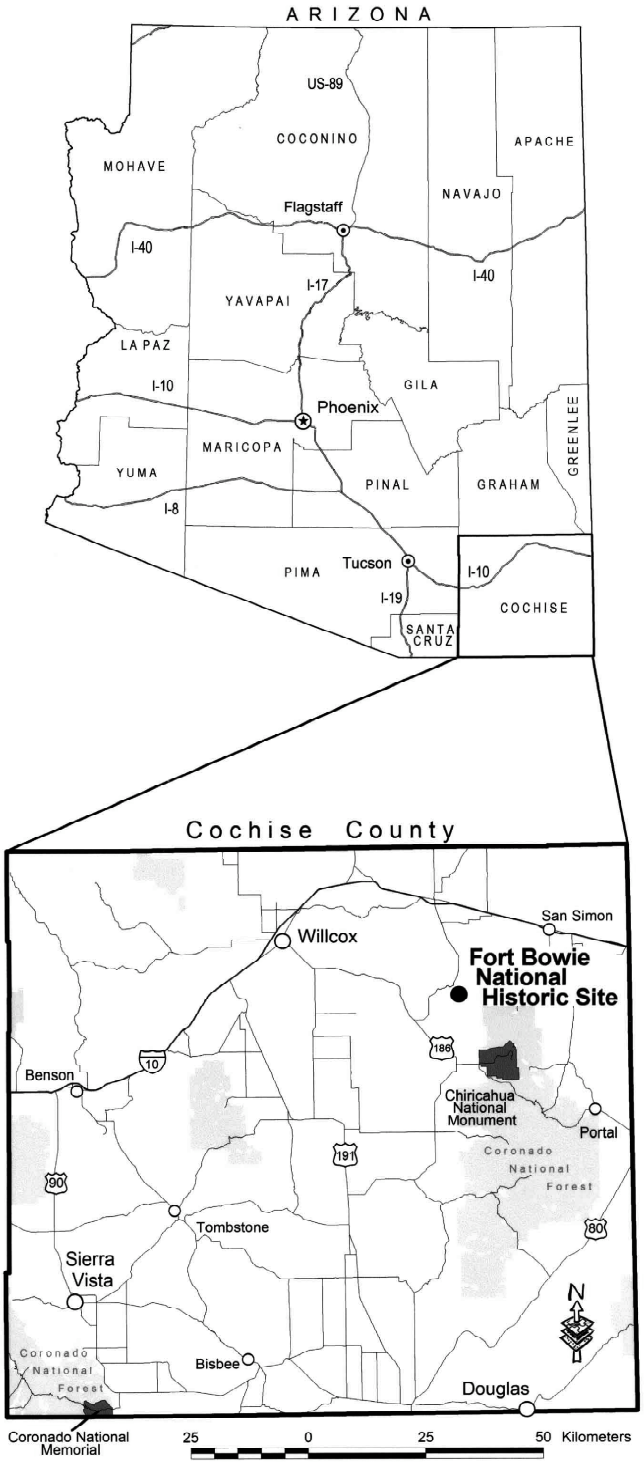

Figure 2.1. Location of Fort Bowie NHS in southern Arizona.

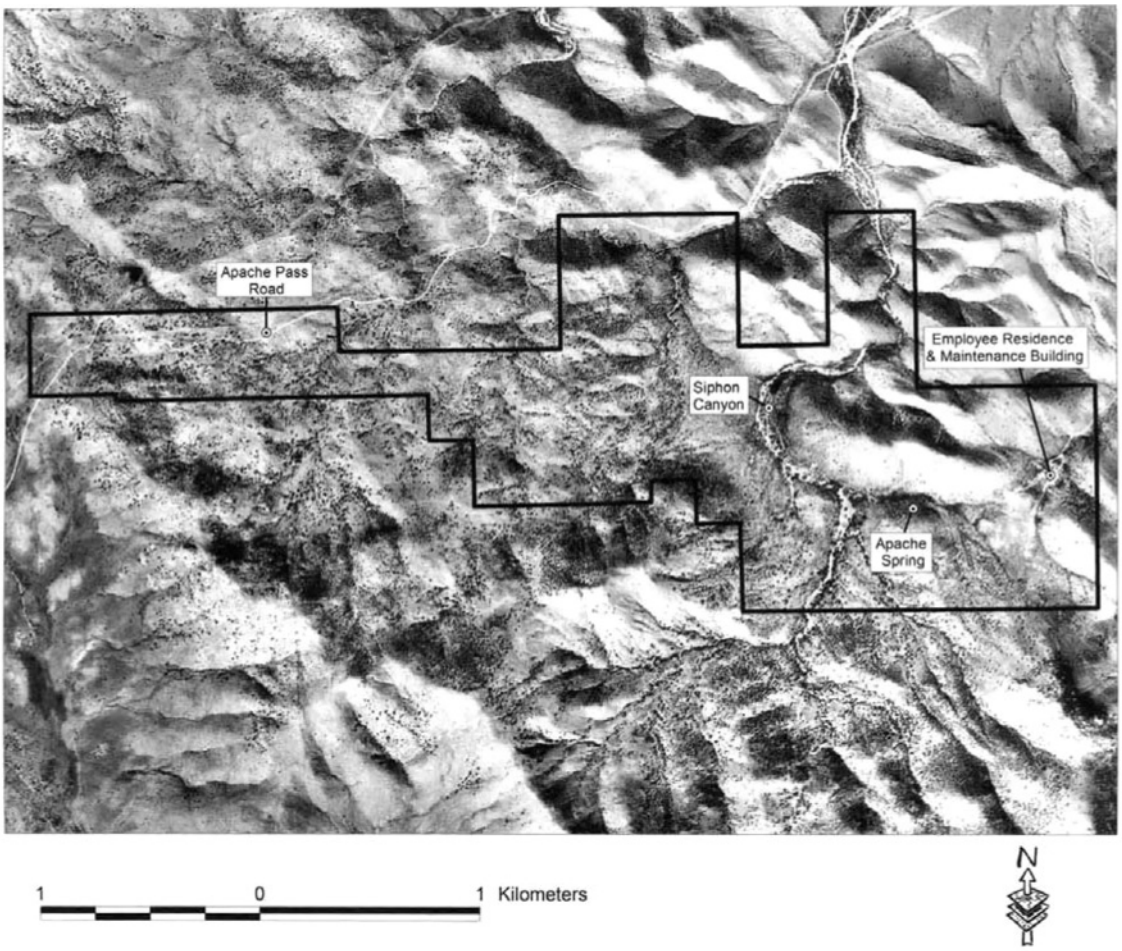

Figure 2.2. Aerial photograph of Fort Bowie NHS showing some of the major features.

Vegetation

Fort Bowie NHS contains four major vegetation communities (based on Warren et al. [1992]):

- **Madrean Evergreen Forest and Woodland** containing Emory Oak–Point-leaf Manzanita– Beargrass Association, Emory Oak–Turpentine bush–Grama Grass Association, Scrub Oak–Bear Grass–Oneseed Juniper Association and Desert Deerbrush–Alder-leaf Mountain-mohogany–Desert Sumac Association;
- **Semi-desert Grassland** containing Velvet Mesquite–Turpentine bush–Burroweed Association, Turpentine bush–Fairy Duster–Ocotillo Association, Ocotillo–Mariola–Grama Grass Association, Velvet Mesquite–Desert Sumac–Snakeweed Associations and Russian Thistle–Snakeweed–Mixed Grass Association;
- **Chihuahuan Desertscrub** containing Creosote-bush–Velvet Mesquite–Mariola Association; and
- **Interior Southwestern Riparian Deciduous Forest and Woodland** containing Arizona Walnut–Netleaf Hackberry–Gum Bumelia Association.

Historic photographs from the era of settlement show that juniper and oak trees were not abundant in the area near the fort, presumably because the trees had been cut for firewood (Warren et al. 1992). More recently, mesquite trees have invaded the semi-desert grassland areas of the park, most likely as a result of fire suppression and cattle grazing (NPS 2000b). Park personnel have removed many of the large mesquite trees that encroached into the area near the fort ruins. (NPS 2001).

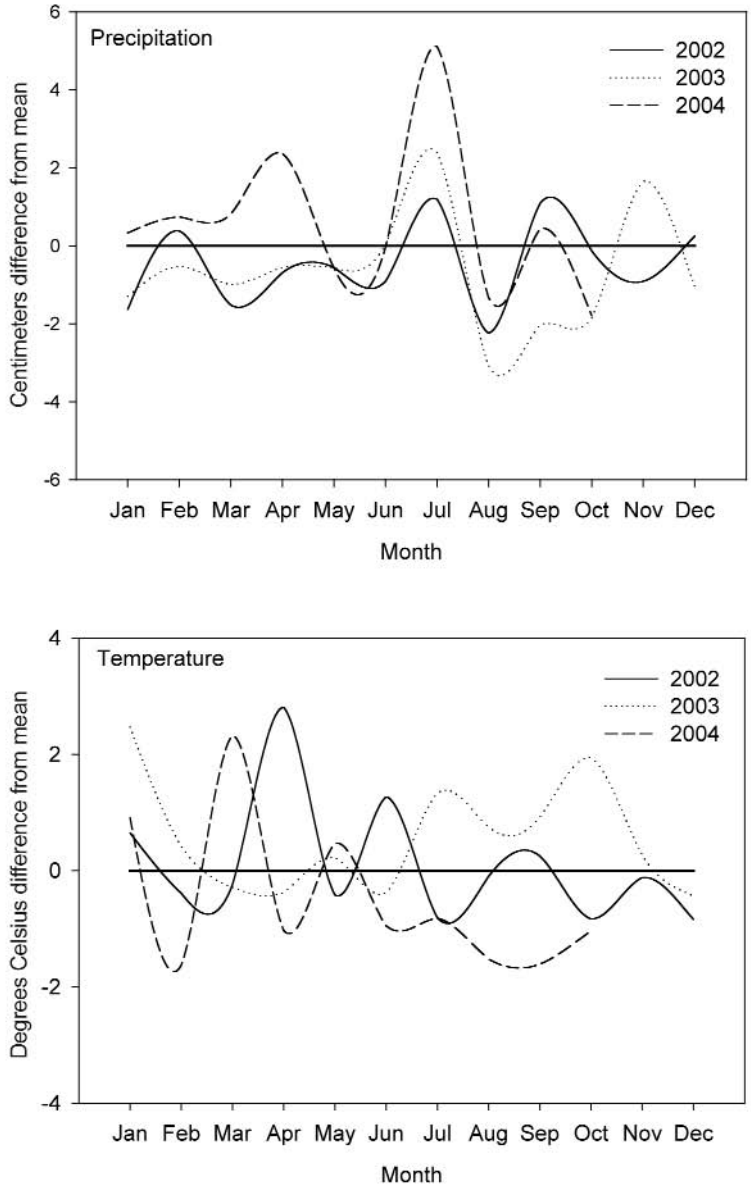

Figure 2.3. Comparison of monthly weather data during the time of the inventory (2002–2004) compared to the long-term mean (1899–2004; thick solid line in both figures), Bowie, Arizona. Data from WRCC (2005).

Natural Resource Management Issues

Cattle Grazing

Two cattle grazing allotments at the park were recently retired, though trespass of cattle onto the park is common. Livestock grazing has degraded an estimated 80% of streams and riparian ecosystems in the western United States through loss of vegetation, stream-bank erosion, soil compaction, flooding, and water pollution (Bahre 1991, BLM 1994, Fleischner 1994). Livestock grazing can also increase the number and extent of non-native plants (Belsky et al. 1999) and can negatively affect wildlife through habitat modification and competition for resources (Saab et al. 1995). At Fort Bowie, cattle have decreased grass cover, damaged historic artifacts, and helped to spread woody plants, such as mesquite, into what was once predominantly semi-desert grassland (NPS 2001).

Non-Native Species

Lehmann lovegrass and other non-native grasses are the most important non-native species issue at the park. The change in species composition in the semi-desert grassland to a community dominated by Lehmann lovegrass, in particular, can alter the fire regime of the area by supporting higher fire frequencies, thereby leading to other changes in vegetation composition and structure including a loss of species richness (Anable et al. 1992).

The presence of American bullfrogs is another important non-native species management issue. Bullfrogs are native to eastern North America but have been introduced throughout the western U.S. for food production and sport (Stebbins 2003). American bullfrog adults and tadpoles are voracious predators (Kiesecker and Blaustein 1997) and are thought to be partially responsible for the decline of many native reptiles (Schwalbe and Rosen 1988) and amphibians (particularly other Ranid frogs; Hayes and Jennings 1986, Lawler et al. 1999) in the southwest.

Undocumented Immigrants

Approximately 20 undocumented immigrants pass through the park each week (NPS 2003). In addition to compromising visitor safety, border crossers also adversely impact the natural resources; they have created trails (including into the fort ruins), damaged vegetation, and have left trash behind. These impacts affect water quality and wildlife movement patterns, though the extent of these impacts has not been established.

Adjacent Land Use

Due to its small size, the park is easily affected by land management practices (e.g., development, mining, grazing, and hunting) outside its boundaries. Currently there is a Buddhist retreat center being built to the north of the park, but because the remainder of the land surrounding the park is managed by the BLM, ex-urban housing development is unlikely to significantly affect the park's resources.

Chapter 3: Plant Inventory

Previous Research

Warren et al. (1992) completed the most thorough inventory of plants at Fort Bowie NHS (Appendix A). Most of the specimen vouchers reported by Warren et al. were collected by Marina Hoy from 1972 to 1977. The collection is comprised of 471 species and subspecies. Warren et al. reported that most of the specimens were located at the park with "duplicates of selected species at the University of Arizona". However, in a recent search of the UA collections, Halvorson (2003) did not find any specimens from this study. Bennett et al. (1996) compiled a species list for the Chiricahua Mountains and vicinity (including Fort Bowie NHS) from a variety of sources including: complete examination of herbaria at Chiricahua National Monument, Fort Bowie NHS, the Southwestern Research Station, and minimal examination of herbaria at the University of Arizona, Arizona State University, and New Mexico State University. In their annotated species list, Bennett et al. indicated if the plant was found at Fort Bowie NHS. Most of the species attributed to Fort Bowie NHS were from the collections made by Marina Hoy, therefore there is considerable overlap between the Bennett et al. list and that by Warren et al. (1992; Appendix A). Ruyle (2001) assessed range conditions at eight permanently marked transects: six in the park and two outside (but near) the park. He found ten species of plants new to the park though he did not, to our knowledge, collect specimens. His work remains the only plot-based plant research at the park. Halvorson and Guertin (2003) mapped the distribution of 22 non-native plant species in the park from the fall of 1999 to the spring of 2001. There are two other poorly documented plant species lists for the park. NPS (2000a) produced an annotated species list for Fort Bowie NHS. This list appears to be compiled from Warren et al. (1992) and Bennett et al. (1996) but these sources do not entirely make up the list (Appendix A). Finally, Hartman and Rottman (1998) compiled a checklist for the park but again, no documentation exists from their work.

Methods

To complete the species list for the park, we used "general botanizing" surveys, during which observers walked throughout the park (particularly around the parade grounds and along trails) and opportunistically collected and recorded plants. In addition to our own results, we present here the first synthesis of findings from past studies and collections.

Spatial Sampling Design

Our survey crews walked throughout the park on each visit. They did not record their search paths, but indicated the location of each collection.

General Botanizing

Field Methods

Whenever possible we collected at least one representative specimen (with reproductive structures) for each plant species that were thought to represent a new species for the park. When we collected a specimen we recorded flower color, associated dominant vegetation, date, collector name(s), and UTM coordinates. We pressed the specimens immediately upon collection. Specimens remained pressed for 2–3 weeks and were frozen for 48 hours to prevent infestation by insects and pathogens. We then mounted the specimens and accessioned them into the University of Arizona Herbarium.

Effort

We made nine day-long visits, typically with two observers, on 28 September and 5, 6, 9, 23, 29, and 31 October 2002 and on 6 and 9 May 2003.

Results and Discussion

We found 193 species and subspecies, including 33 new species for the park (Appendix A). Of these, we found two species representing new families for the park and nine species representing new genera for the park. Of particular note were three species of *Euphorbia*, a new genus for the park. Of the 33 species new for the park, only one was non-native.

Considering all available sources, there have been 638 species and subspecies recorded at the park, of which 38 (6%) are non-native (Appendix A). The percentage of non-native plants in the park's flora is low compared to other sites in southeastern Arizona (e.g., Burgess et al. 1991, Powell et al. 2005a). The number and extent of non-native plants may be buffered by the lack of roads through the park. Roads act as dispersal corridors for non-native plant species, which often thrive in the adjacent disturbed soils. Although the park has a low percentage of non-native species, the percent of area covered by them is greater. Halvorson and Guertin (2003) mapped the distribution of 22 species of non-native plants at the park. Lehmann lovegrass was the most widespread of the non-native species and other non-native species were especially prevalent around the visitor center. Ruyle (2001) established plots and his work remains the only study that is able to quantify the dominance and relative abundance of plants. Yet because of the diversity of vegetation communities and conditions in the park, Ruyle did not survey enough plots to address the dominance of non-native species; he found no non-native species during his surveys, but clearly did not have plots in the semi-desert grasslands west of Siphon Canyon (near the cemetery) where Lehmann lovegrass dominates. In Chapter 6 we make recommendations for more plot-based survey work.

The number of species documented for the park far outnumbers the expected species richness (330), based on size and topographic relief of the park (Warren et al. 1992). The extraordinary species richness that has been found at the park is due to three main factors: geographic location of park, geologic faults separating different rock substrates, and the presence of permanent water.

Fort Bowie NHS lies at the juncture to four major biogeographical provinces: Madrean, Rocky Mountain, and Sonoran and Chihuahuan deserts. The Madrean biogeographic region in particular is well represented in the flora of the park, and this region has the highest plant species richness in Arizona (Bowers and McLaughlin 1982). Other floristic influences are from the Great Plains and Chihuahuan regions (Warren et al. 1992).

The high species richness at the park is also the result of local influences from two faults that pass through the park: Apache Pass and Fort Bowie faults (Denny and Peacock 2000). These faults separate major geologic substrates including limestone, shale, sandstone, and granitic and metamorphic rock, all of which give rise to conditions that favor certain plant species. For example, Warren et al. (1992) noted that a number of species with primarily Chihuahuan desert distributions are found on limestone outcrops at Fort Bowie NHS.

Finally, the perennial Apache Spring gives rise to the third determinant of high species richness and vegetation communities at the park. The presence of water is responsible for the vegetation structure in the riparian area, which is in stark contrast to upland areas, and also is an important determinant of vertebrate species richness and abundance (see Chapters 4 and 5).

Inventory Completeness

Fort Bowie NHS has one of the most complete inventories for vascular plants in all of the Sonoran Desert Network parks. Based on our work and that by others, we believe that the inventory is likely 90% complete. We found 33 new species, a 5% increase in the number of plants for the park. Additional surveys, particularly during the late spring, will add more species to the park list, but considering our survey effort, we believe the percentage of new species found will not be significant (see Chapter 7 for additional information on more studies). However, of particular concern in all natural areas is the increase in the abundance and distribution of non-native species. This will likely happen if Cochise County paves Apache Pass Road, thereby increasing the number of vehicles in the area (see Chapter 6).

Chapter 4: Bird Inventory

Previous Bird Research

The first comprehensive inventory of birds at the park was in 1975 and 1976 by Russell and Johnson (1976) who surveyed five transect routes multiple times in all seasons. They reported abundance of species based on the number of observations per hour of surveys. Although no original data exist from that study (Terry Johnson, *pers. comm.*), the transect routes were similar to those used by our survey crews and we therefore make gross comparisons between our two studies. Many of the observations of rare birds noted in that report are from Marina Hoy. Fischer (2002) compiled a list of bird species at the park based on: (1) field observations made in the early 1990s (Dan Fischer, *pers. comm.*) and (2) review of bird lists and specimens from the region. Typically we do not consider species lists credible forms of evidence of species occurrence in an area; often these lists are not well documented. However, the list by Fischer (2002) is well documented and is mostly based on his field experience. We therefore use it to create the species list for the park (Appendix C). In 2002 and 2003 there was a Monitoring Avian Productivity and Survivorship (MAPS; DeSante and O'Grady 2000) banding station at the park, which was operated by staff from the Southeastern Arizona Bird Observatory. Finally, we found specimen vouchers, representing 20 species, which were collected in 1893 and 1894 (Appendix E).

Methods

We surveyed for birds at Fort Bowie NHS in 2003 and 2004. We used four field methods: variable circular-plot (VCP) counts for diurnal birds during the breeding season, nocturnal surveys for owls and nightjars, line transects for birds in the non-breeding season, and incidental observations for all birds in all seasons. Although winter bird surveys were not included in the original study proposal (Davis and Halvorson 2000), we felt they were important in our effort to inventory birds at the park because many species that use the area during the fall and winter may not be present during spring and summer (breeding season) surveys. We concentrated most of our survey effort during the breeding season because bird distribution is relatively uniform at this time (due to territoriality among most landbird species) (Bibby et al. 2000). Therefore, surveying during the breeding season increased our precision in estimating relative abundance and also enabled us to document breeding activity. Our survey period included peak spring migration times for most species, adding many migratory species to our list. We also sampled vegetation in the vicinity of VCP stations. Vegetation structure and plant species composition are important predictors of bird species richness or the presence of particular species (MacArthur and MacArthur 1961, Rice et al. 1984, Strong and Bock 1990, Powell and Steidl 2000).

In most cases we do not report observations that failed to determine species (e.g., "unknown woodpeckers"). Ravens are an exception. Both Chihuahuan and common ravens occur at the park and both species are difficult to differentiate unless they are viewed at a short range under certain conditions or if they are seen flying together (Bednarz and Raitt 2002). We were not able to positively determine the species for any raven sighting and therefore report all observations as "unknown raven."

Spatial Sampling Design and General Vegetation Characteristics

We subjectively placed the two VCP transects in areas that we believed would have the highest species richness (Siphon Canyon) and would be representative of the dominant vegetation at the park (Butterfield). Some sections of our survey locations correspond to those of Russell and Johnson (1976). The Siphon Canyon transect ran from Apache Spring to where the canyon exits the park (Fig. 4.1). The Butterfield transect began near the junction of the namesake trail and Siphon Canyon and ended near the western boundary of the park (Fig. 4.1; see also Fig. 4.2).

The Butterfield transect follows its namesake trail and it is more xeric than the Siphon Canyon transect. It is dominated by Emory oak and oneseed juniper (Table 4.1) with a wide variety of shrub such as turpentine bush, sotol, manzanita, agave, and yucca (Fig. 4.1). The Siphon Canyon

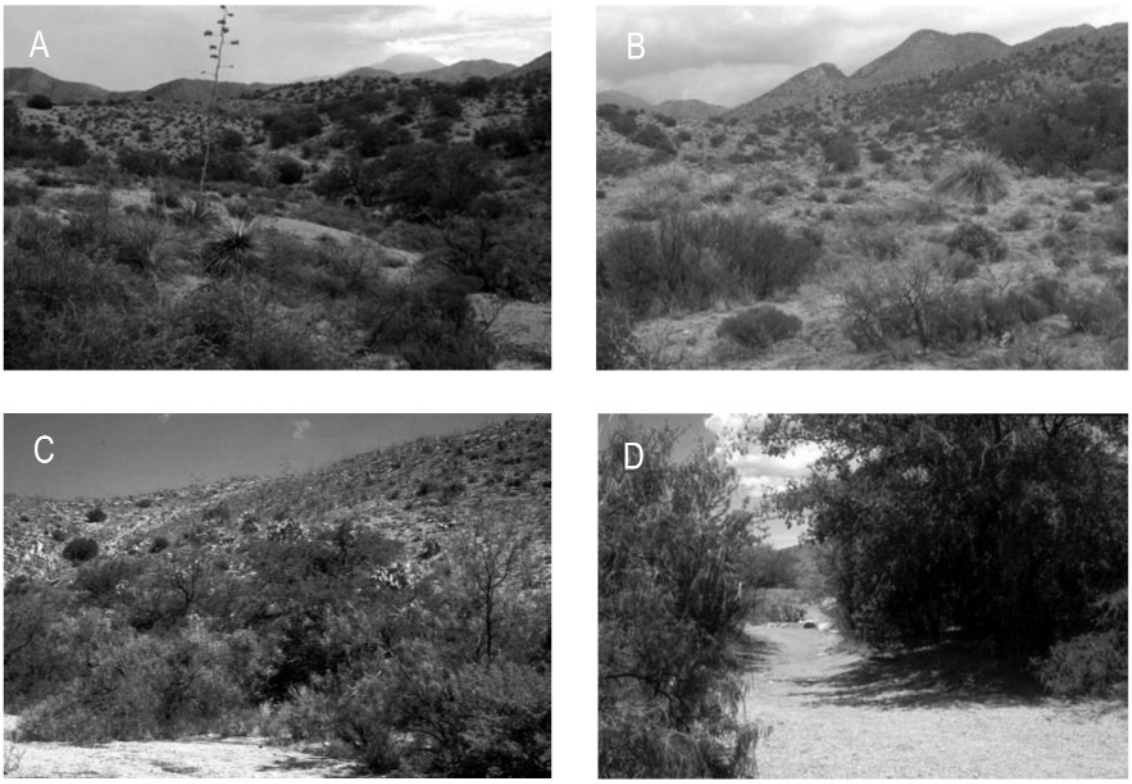

Figure 4.1. Photographs taken from bird survey stations, Fort Bowie NHS. Photographs A and B are looking east from Butterfield transect station numbers 8 and 6, respectively. Photographs C and D are looking north from Siphon Canyon station numbers 6 and 5, respectively. See Fig. 4.2 for location of stations.

transect has some areas of very dense vegetation, including netleaf hackberry, Arizona oak, and Utah juniper near Apache Spring (Table 4.1). Other riparian vegetation, including desert willow and Arizona walnut, is in the bottom of Siphon Canyon (Fig. 4.1). The upslope areas are similar to the Butterfield transect, but with few Emory oak (Table 4.1).

VCP Surveys

Field Methods

We used the variable circular-plot method 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 (i.e., station) and records all birds seen or heard and the distance to each bird or group of birds.

We surveyed the Siphon Canyon transect in 2003 and 2004 and the Butterfield transect in 2004 (Table 4.2). Each transect consisted of eight stations, each located a minimum of 250 m apart to maintain independence among observations at each station. We surveyed each year from mid April through early July, the period of peak breeding activity for most species in the area.

On each visit to a transect we alternated the order in which we surveyed stations to minimize bias by time of day and direction of travel. We did not survey when wind speed exceeded 15 km/h or when precipitation exceeded an intermittent drizzle. We began bird surveys approximately 30 minutes before sunrise and concluded no later than three hours after sunrise.

We recorded a number of environmental variables at the beginning of each transect: wind speed (Beaufort scale), presence and severity of rain (qualitative assessment), air temperature (ºF), relative humidity (%), and cloud cover (%). After arriving at a station, we waited 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 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 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. During the "passive" count period (between the eight-minute counts), if we observed a species that had not been recorded previously at a station on that visit, we recorded its distance to the nearest station.

Effort

We surveyed the eight stations of the Siphon Canyon transect five times in 2003 and the Siphon Canyon and Butterfield transects (also eight stations) six times each in 2004 (Table 4.2). We visited each station for eight minutes on each visit.

Table 4.1. Mean density (ha) of the most common tree species at each station along the two VCP transects, Fort Bowie NHS, 2004. Data summarized from Appendix F. 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.

		Species									
Transect	Station	netleaf hackberry	desert willow	Arizona walnut	oneseed juniper	Utah juniper	velvet mesquite	Arizona oak	Emory oak	desert sumac	gum belly
Butterfield	1	0.7		2.4	0.7	0.7	8.7			2.7	
	2	6.9				6.9	20.8		14.4		
	3					1.9	1.8	1.9	25.9		
	4				4.1		10.1	1.7	23.1		
	5				2.8			3.4	7.4		
	6				11.3		3.8		14.0		
	7				3.5		2.6	1.8	11.5		
	8				6.0		1.5	1.6	3.7		
Siphon Canyon	1	5.1		2.2	5.1	6.2	8.1	6.3			12.2
	2	8.6		0.8	6.5		15.5	2.3		4.2	21.0
	3	7.0	11.0	4.4			11.4		1.3	16.7	
	4	46.8	11.2	5.4			19.3			20.9	15.8
	5	6.9	3.1	6.2	1.5		6.9				9.2
	6	8.2	17.0	3.0	2.5		14.0			9.3	0.3
	7	14.4		3.0	3.1	3.4	3.1			15.7	3.1
	8	4.2		1.8			6.3	5.8			15.8

Table 4.2. Summary of bird survey effort, Fort Bowie NHS, 2002–2004. Sample size (*n;* number of visits multiplied by number of stations) was used to calculate relative abundance for each transect and year.

Survey type	Transect name	Year(s)	Visits	Stations/ sections	*n*
VCP	Butterfield	2004	6	8	48
	Siphon Canyon	2003	5	8	40
		2004	6	8	48
Line transect	Coach	2002-2003	4	6	24
	Siphon Canyon	2002-2003	4	5-6	23
Nocturnal survey	Owl	2003	3	5	15
		2004	3	5	15

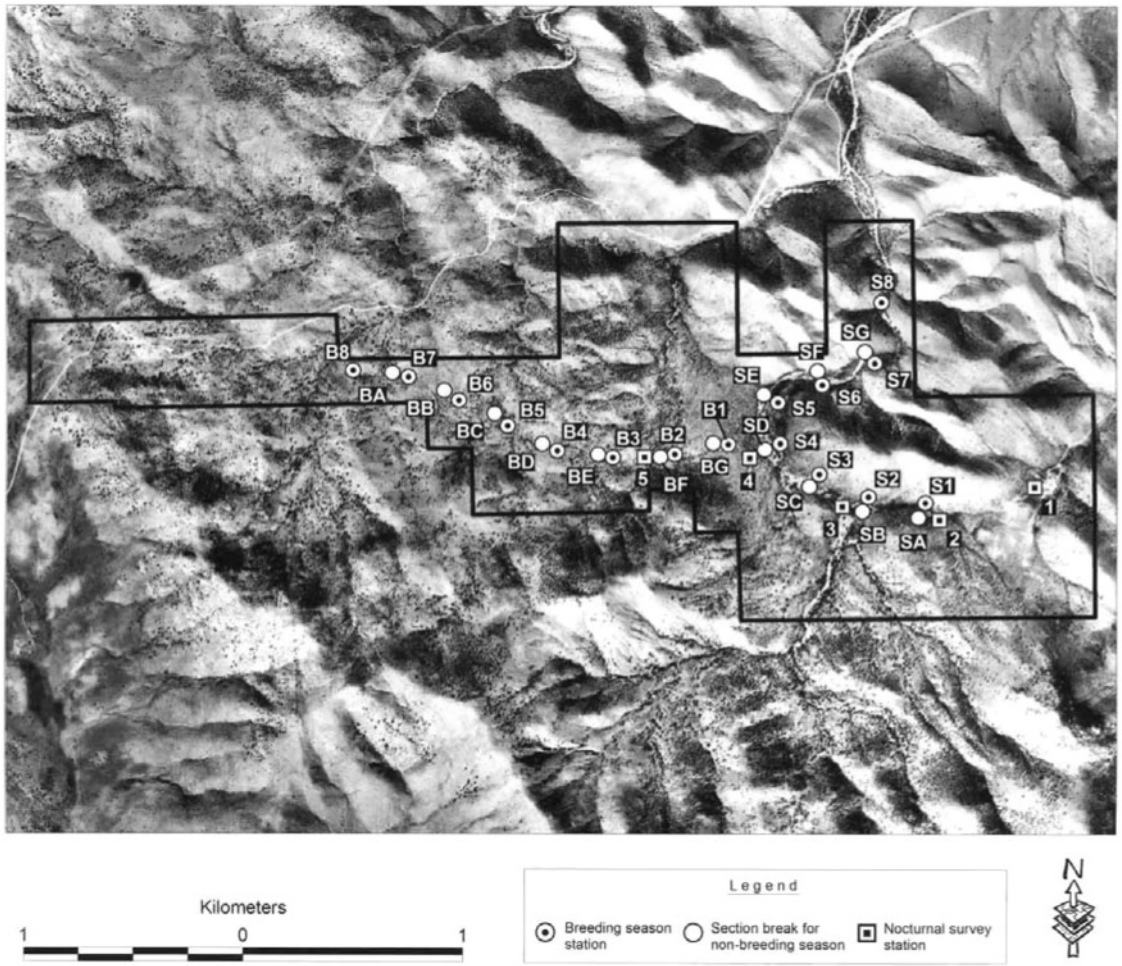

Figure 4.2. Location of bird surveys, Fort Bowie NHS, 2002–2004.

Analyses

We calculated relative abundance of each species along each transect as the number of detections at all stations and visits (including zero values) divided by effort (sample size: total number of visits multiplied by total number of stations). We reduced our full collection of observations for each VCP station (n = 1,986: 1,378 and 608 for Siphon Canyon and Butterfield transects, respectively) to a subset of data (n = 1,093; 793 and 244 for Siphon Canyon and Butterfield transects, respectively) that was more appropriate for estimating relative abundance. We used only those detections that occurred ≤ 75 m from count stations (thereby excluding 344 and 273 observations, respectively) 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 Anderson 2001, Farnsworth et al. 2002). We also excluded observations of birds that were flying over the station (145 and 71 observations, respectively), birds observed outside of the eight-minute count period (128 and 45 observations, respectively), and unknown species (38 and 7 observations, respectively). Some observations met more than one of these criteria for exclusion from analysis.

Line-transect Surveys

Field Methods

From 15 October 2002 to 9 January 2003 we surveyed for birds using the line-transect method (Bibby et al. 2002). Line transects differ from VCP transects, in that an observer records birds seen or heard while the observer walks a line, rather than remaining stationary. The transect method is more effective during the non-breeding season because bird vocalizations are less conspicuous and frequent, making birds more difficult to detect (Bibby et al. 2000). This method was once the preferred survey technique for surveys in all seasons and was used by Russell and Johnson (1976) in their surveys of the park.

We established two transects at the park (Fig. 4.2). The transects were broken into sections, with the start and finish locations corresponding to the breeding-season stations. Each section was approximately 250 m in length. As with other survey methods, we alternated direction of travel along transects to reduce biases and did not survey during periods of excessive rain or wind (see breeding-season survey methods for details). We began surveys at sunrise and continued until we completed both transects. As with breeding-season surveys, we recorded weather conditions at the beginning and end of each survey. Prior to beginning a section, we recorded the section name (e.g., "A–B") and the start time.

We timed our travel so that we traversed each section in ten minutes, during which time we assigned all birds seen and/or heard into one of the following distance categories: ≤ 100 m, > 100 m, or "flyover." When possible, we noted the sex and age class of birds. We recorded birds observed before or after surveys as "incidentals" (see section below), and we did not use techniques to attract birds (e.g., "pishing").

Effort

We surveyed all six sections of the Siphon Canyon and Butterfield transects four times each in the fall and winter of 2002 and 2003 (Table 4.2).

Analysis

We used all observations ($N = 483$), except unknown species, to estimate relative abundance (see Methods section of VCP surveys for more details).

Nocturnal Surveys

Field Methods

To survey for owls we broadcast commercially available vocalizations using a compact disc player and broadcaster (Colver et al. 1999, Bibby et al. 2002) and recorded other nocturnal species (nighthawks and poorwills) when detected. We established one transect from approximately the visitor center to 600 m west of Siphon Canyon, along the Butterfield Trail (Fig. 4.2). The transect had five stations that were a minimum of 300 m apart. As with other survey methods, we varied direction of travel along transects and did not survey during periods of excessive rain or wind. We began surveys 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 broadcast vocalizations for a series of two-minute "active" periods. We used vocalizations of species that we suspected, based on habitat and range, might be present: elf, western screech, whiskered-screech, barn, and (on one occasion) northern pygmy owl. We excluded great horned owl from the broadcast sequence because of its aggressive behavior toward other owls. 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. During the count period we used a flashlight to scan nearby vegetation and structures 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 a bird was observed during any of 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 along transects, and did not survey during inclement weather.

Effort

We surveyed all five stations on each of the three visits during the breeding season in both 2003 and 2004 (Table 4.2).

Analysis

Because of the low number of detections, we report only the number of detections and do not calculate relative abundance as for the other survey methods.

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 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 because we did not standardize survey effort.

Vegetation Sampling at VCP Stations

In 2004 we sampled vegetation associated with each of the breeding-season stations along the Siphon Canyon and Butterfield transects. We sampled vegetation at five subplots 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 between 145° and 216°) to reduce clustering of plots. We randomly placed plots within 75 m of the stations to correspond with truncation of 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 three height categories: sub-shrubs (0.5–1.0 m), shrubs (> 1.0–2.0 m), trees (> 2.0 m), and one size category: 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 its distance from the plot center, species, height, and maximum canopy diameter (including errant branches). Association of a plant to a quadrant was determined by the location of its trunk, regardless of which quadrant the majority of the plant was in; no plant was recorded in more than one quadrant. Standing dead vegetation was only recorded in 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); and (2) percent aerial cover of vegetation in each quadrant using three height categories: 0–0.5 m, > 0.5–2.0 m, and > 2.0 m. For both estimates we used one of six categories for percent cover: 0 (0%), 10 (1–20%), 30 (21–40%), 50 (41–60%), 70 (61–80%), and 90 (81–100%).

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 (Appendix F).

Comparisons to Surveys by Russell and Johnson (1976)

We summarized data from Russell and Johnson (1976) and made limited comparisons between their results and ours. To facilitate these comparisons, we used only those data from our surveys that corresponded to the study sites used by Russell and Johnson: their "wash-riparian" corresponds to our VCP stations numbers 1–4 and line transects sections A-B to D-E of our Siphon Canyon transect; their "mesquite-grassland" corresponds to our VCP stations numbers 1–4 and line-transect sections A-B to D-E of our Butterfield

transect; and their "oak-juniper woodland" corresponds to our VCP stations numbers 5–8 and line-transect sections E-F to I-J of our Butterfield transect. We combined relative abundance scores from Russell and Johnson for the spring and summer surveys and compared these data to our VCP surveys. We excluded fall surveys from comparison (they visited the park only twice in the fall of 1975) and made direct comparisons between their "winter" surveys and our line-transect surveys. Because of the different field methods (and therefore inappropriateness of comparing relative abundance estimates), we compared ranks of only the most abundant species.

Results

We found 109 species during surveys from October 2002 to July 2004 (Appendix C). We found 77 species during VCP surveys, 51 species during line transect surveys, four species during nocturnal surveys, and 72 species by incidental observation during all seasons. We found no non-native species. We found a number of species of high conservation concern including peregrine falcon, loggerhead shrike, and Baird's sparrow. Based on a review of other studies at the park, there have been 189 species observed at the park (Appendix C).

VCP Surveys

We found three species on the Butterfield transect that we did not find on the Siphon Canyon transect, and 36 species on the Siphon Canyon transect that we did not find on the Butterfield transect (Tables 4.3, 4.4). Among the 36 species found only on the Siphon Canyon transect, some were among the most abundant on the transect: the Cassin's and western kingbirds, Bell's vireo, summer tanager, Bullock's and hooded orioles, and northern cardinal (Table 4.3). Most of these species are riparian obligate species. Among species that we found on both transects, and for which we were able to calculate relative abundance, there were some notable differences among transects: 10 species had higher mean relative abundance on the Butterfield transect, while 12 species had higher mean relative abundance on the Siphon Canyon transect (using the mean relative abundance scores from 2003 and 2004). There were no surprises in these numbers. Abundant species on the Butterfield transect are known to be associated with drier conditions: the black-throated sparrow, rufous-crowned sparrow, Bewick's wren, Scott's oriole, and canyon towhee. Similarly, the Siphon Canyon transect had species that reach their highest abundance in areas of dense vegetation: the white-winged dove, Gambel's quail, verdin, and Lucy's warbler. In the Siphon Canyon transect in both 2003 and 2004 the northern cardinal, Gambel's quail, and white-winged dove were the most abundant (Table 4.3). On the Butterfield transect the mourning dove, black-throated sparrow, and Bewick's wren were the most abundant (Table 4.4).

We observed 69 species along the Siphon Canyon transect in 2003 and 2004, of which we were able to calculate relative abundance for 47 species (Table 4.3). We found 12 species in each year that we did not find the other year. With the exception of the crissal thrasher, the species not found in the other year were not among the most abundant (Table 4.3). Almost all relative abundance estimates were higher in 2004 (mean ± SE = 0.24 ± 0.040) than in 2003 (0.18 ± 0.030; $t = 6.3$, $P < .0001$ on log transformed data). Among the most common species, only ash-throated flycatcher and verdin had much greater relative abundance estimates in 2003 than in 2004. Conversely, many abundant species such as mourning dove, Cassin's kingbird, Bewick's wren, and northern mockingbird had much higher relative abundance estimates in 2004 than in 2003.

Line-transect Surveys

We observed 50 species during line-transect surveys in 2002 and 2003, 35 species on the Butterfield transect and 41 species on the Siphon Canyon transect (Table 4.5). Nine species were unique to the Butterfield transect, while 16 species were unique to the Siphon Canyon transect. Excluding sandhill crane (observed only on one occasion flying over the park), Gambel's quail, chipping sparrow, and white-crowned sparrow were most abundant on the Butterfield transect (Table 4.5). On the Siphon Canyon transect, white-crowned sparrow, Gambel's quail, American robin, and spotted towhee were the most abundant.

Table 4.3. Total number of observations (Total obs.) and relative abundance (mean ± SE) of birds observed during VCP surveys, Siphon Canyon transect, Fort Bowie NHS, 2003 and 2004. Total number of observations includes all birds observed during surveys whereas relative abundance estimates exclude birds observed > 75 m from stations, flyovers, and observations made outside of the eight-minute count period. Sum is the number of observations used in calculating relative abundance estimates. See Methods section for additional details on estimation of relative abundance and effort used in those calculations.

		Relative abundance by year					
		2003 (*n* = 40)			2004 (*n* = 48)		
Species	**Total obs.**	**Sum**	**Mean**	**SE**	**Sum**	**Mean**	**SE**
Gambel's quail	101	27	0.68	0.169	30	0.63	0.128
turkey vulture	21				2	0.04	0.029
Cooper's hawk	8	5	0.13	0.082	2	0.04	0.029
zone-tailed hawk	1						
red-tailed hawk	4						
golden eagle	1						
white-winged dove	122	22	0.55	0.101	34	0.71	0.126
mourning dove	84	15	0.38	0.117	43	0.90	0.158
white-throated swift	7						
black-chinned hummingbird	8	3	0.08	0.042			
broad-tailed hummingbird	14	1	0.03	0.025	4	0.08	0.040
ladder-backed woodpecker	23	5	0.13	0.053	8	0.17	0.062
greater pewee	1						
western wood-pewee	6	2	0.05	0.035			
gray flycatcher	2				1	0.02	0.021
dusky-capped flycatcher	1						
ash-throated flycatcher	54	25	0.63	0.142	14	0.29	0.079
brown-crested flycatcher	3	1	0.03	0.025			
Cassin's kingbird	61	8	0.20	0.082	33	0.69	0.130
western kingbird	13	3	0.08	0.055	5	0.10	0.054
Bell's vireo	14	5	0.13	0.082	6	0.13	0.048
plumbeous vireo	2				2	0.04	0.029
warbling vireo	3						
curve-billed thrasher	8	1	0.03	0.025	5	0.10	0.054
crissal thrasher	18				11	0.23	0.068
western scrub-jay	22	8	0.20	0.082	12	0.25	0.082
Mexican jay	1						
unknown raven	17						
violet-green swallow	5						
verdin	32	15	0.38	0.078	9	0.19	0.057
bushtit	5	2	0.05	0.050	11	0.23	0.124
cactus wren	71	19	0.48	0.095	33	0.69	0.130
rock wren	2				1	0.02	0.021
canyon wren	3				1	0.02	0.021
Bewick's wren	57	10	0.25	0.069	28	0.58	0.111
house wren	2	1	0.03	0.025			
ruby-crowned kinglet	13	6	0.15	0.057	6	0.13	0.057
blue-gray gnatcatcher	4	1	0.03	0.025	2	0.04	0.029
American robin	1	1	0.03	0.025			
northern mockingbird	72	14	0.35	0.084	35	0.73	0.139
phainopepla	10				6	0.13	0.048
Lucy's warbler	14	1	0.03	0.025	13	0.27	0.071
yellow-rumped warbler	4	1	0.03	0.025	1	0.02	0.021
black-throated gray warbler	4				3	0.06	0.046
Townsend's warbler	1				1	0.02	0.021
Wilson's warbler	8	2	0.05	0.035	2	0.04	0.029

		Relative abundance by year					
		2003 (*n* = 40)			2004 (*n* = 48)		
Species	**Total obs.**	**Sum**	**Mean**	**SE**	**Sum**	**Mean**	**SE**
summer tanager	31	4	0.10	0.048	13	0.27	0.088
western tanager	7	1	0.03	0.025			
green-tailed towhee	8	6	0.15	0.057	1	0.02	0.021
spotted towhee	7	3	0.08	0.042	3	0.06	0.046
canyon towhee	40	20	0.50	0.139	26	0.54	0.111
Botteri's sparrow	1	1	0.03	0.025			
rufous-crowned sparrow	14	2	0.05	0.035	6	0.13	0.064
chipping sparrow	2	1	0.03	0.025			
Brewer's sparrow	2	4	0.10	0.078			
black-throated sparrow	40	7	0.18	0.071	22	0.46	0.123
Oregon junco	1	1	0.03	0.025			
northern cardinal	112	38	0.95	0.129	56	1.17	0.113
pyrrhuloxia	1	1	0.03	0.025			
black-headed grosbeak	7				1	0.02	0.021
blue grosbeak	2	2	0.05	0.050	1	0.02	0.021
lazuli bunting	1				1	0.02	0.021
bronzed cowbird	1	2	0.05	0.050			
brown-headed cowbird	33	5	0.13	0.053	13	0.27	0.077
hooded oriole	36	15	0.38	0.111	13	0.27	0.083
Bullock's oriole	25	6	0.15	0.067	11	0.23	0.074
Scott's oriole	6	2	0.05	0.035	3	0.06	0.035
house finch	40	8	0.20	0.073	14	0.29	0.079
lesser goldfinch	3				2	0.04	0.029

Nocturnal Surveys

We recorded four species of nocturnal birds: one observation each of the western screech owl and great-horned owl, three observations of the elf owl, and 12 observations of the common poorwill.

Incidental and Breeding Observations

We made incidental observations of 72 species, including 12 species that were not detected during any other survey type (Appendix C). These species included: long-eared owl, common ground dove, greater roadrunner, Bendire's thrasher, Baird's sparrow, and grasshopper sparrow. We made 84 observations of breeding behavior, representing 32 species (Table 4.6). We made the most breeding observations of mourning dove (14 observations). We confirmed breeding for Bell's vireo and summer tanager, two riparian-obligate species.

Inventory Completeness

Based on the results from our surveys and the list by Fischer (2002), the inventory of birds that regularly use the park is probably close to completion. A look at the species accumulation curve for our work indicates that our effort alone was not sufficient to document all of the species that occur in the park; the cumulative number of new species for this study was not approaching an asymptote (Fig. 4.3). We found 6 species that were new to the park list: Baird's sparrow, Hutton's vireo, common ground-dove, dusky-capped flycatcher, greater pewee, and zone-tailed hawk (Appendix C). Of these species, only Hutton's vireo may nest at the park. Because of the location of the park near to the species-rich Chiricahua Mountains (one of the most popular destinations in the United States for bird watchers), we expect that new species of birds will be added to the list for years to come, but that these species will likely be uncommon or rare at the park. Only through major modification of the vegetation community (either by the use of fire or removal of mesquite) will additional species, such as grassland-associated sparrows (e.g., grasshopper, Cassin's, and Botteri's), nest in the park.

Table 4.4. Total number of observations (Total obs.) and relative abundance (mean ± SE) of birds during VCP surveys, Butterfield transect, Fort Bowie NHS, 2004. Total number of observations includes all birds observed during surveys whereas relative abundance estimates exclude birds observed > 75 m from stations, flyovers, and observations made outside of the eight-minute count period. Sum is the number of observations used in calculating relative abundance estimates. See Methods section for additional details on estimation of relative abundance and Table 4.2 for sample size.

		Relative abundance (n = 48)		
Species	**Total obs.**	**Sum**	**Mean**	**SE**
Gambel's quail	34	7	0.15	0.089
turkey vulture	17	1	0.02	0.021
red-tailed hawk	3			
white-winged dove	38	2	0.04	0.029
mourning dove	71	15	0.31	0.095
black-chinned hummingbird	3			
ladder-backed woodpecker	20	8	0.17	0.069
western wood-pewee	1			
Hammond's flycatcher	1	1	0.02	0.021
ash-throated flycatcher	42	19	0.40	0.093
Cassin's kingbird	6			
western kingbird	1			
crissal thrasher	12	8	0.17	0.062
western scrub-jay	17	5	0.10	0.045
unknown raven	5			
bridled titmouse	1	1	0.02	0.021
juniper titmouse	3	4	0.08	0.065
verdin	2	2	0.04	0.029
bushtit	4	11	0.23	0.124
cactus wren	39	23	0.48	0.094
rock wren	7	4	0.08	0.050
Bewick's wren	50	32	0.67	0.113
ruby-crowned kinglet	2	2	0.04	0.029
northern mockingbird	28	4	0.08	0.050
phainopepla	4	3	0.06	0.046
Lucy's warbler	3	1	0.02	0.021
green-tailed towhee	1	1	0.02	0.021
canyon towhee	36	31	0.65	0.117
rufous-crowned sparrow	29	17	0.35	0.070
chipping sparrow	1	1	0.02	0.021
black-throated sparrow	67	47	0.98	0.141
northern cardinal	2			
black-headed grosbeak	5			
blue grosbeak	3	3	0.06	0.046
brown-headed cowbird	18	11	0.23	0.068
Scott's oriole	18	10	0.21	0.073
house finch	10	2	0.04	0.029

Table 4.5. Relative abundance of birds observed during line-transect surveys, Fort Bowie NHS, 2002 and 2003.

	Transect					
	Butterfield (*n* = 24)			Siphon Canyon (*n* = 23)		
Species	Sum	Mean	SE	Sum	Mean	SE
Gambel's quail	80	3.33	2.383	40	1.74	0.796
Montezuma quail	1	0.04	0.042			
Cooper's hawk				1	0.04	0.043
red-tailed hawk	1	0.04	0.042			
sandhill crane[a]	52	2.17	2.167			
red-naped sapsucker				1	0.04	0.043
ladder-backed woodpecker	4	0.17	0.078	7	0.30	0.132
northern flicker	8	0.33	0.098	12	0.52	0.187
loggerhead shrike	1	0.04	0.042			
solitary vireo type[b]				1	0.04	0.043
western scrub-jay	12	0.50	0.170	21	0.91	0.259
unknown raven				2	0.09	0.087
Steller's jay	2	0.08	0.083			
curve-billed thrasher				2	0.09	0.060
crissal thrasher	6	0.25	0.090	10	0.43	0.138
bridled titmouse	10	0.42	0.232	1	0.04	0.043
juniper titmouse	2	0.08	0.083			
verdin	6	0.25	0.090	4	0.17	0.102
bushtit	28	1.17	0.809			
brown creeper				1	0.04	0.043
cactus wren	6	0.25	0.109	12	0.52	0.165
rock wren				3	0.13	0.072
Bewick's wren	3	0.13	0.092	8	0.35	0.119
ruby-crowned kinglet	11	0.46	0.159	21	0.91	0.188
western bluebird	18	0.75	0.391	9	0.39	0.272
Townsend's solitaire	4	0.17	0.078			
hermit thrush				1	0.04	0.043
American robin	2	0.08	0.058	37	1.61	0.838
northern mockingbird	3	0.13	0.069	7	0.30	0.117
cedar waxwing				12	0.52	0.522
phainopepla	7	0.29	0.127	9	0.39	0.137
yellow-rumped warbler	2	0.08	0.083	1	0.04	0.043
black-throated gray warbler				1	0.04	0.043
green-tailed towhee	6	0.25	0.090	28	1.22	0.259
spotted towhee	15	0.63	0.189	37	1.61	0.249
canyon towhee	13	0.54	0.170	27	1.17	0.249
rufous-crowned sparrow				1	0.04	0.043
chipping sparrow	54	2.25	0.738	29	1.26	0.389
Brewer's sparrow	21	0.88	0.641	30	1.30	0.531
Lincoln's sparrow				6	0.26	0.113
black-chinned sparrow	1	0.04	0.042	4	0.17	0.136
vesper sparrow	4	0.17	0.130	29	1.26	1.171
black-throated sparrow	9	0.38	0.145	3	0.13	0.072
white-crowned sparrow	78	3.25	1.277	56	2.43	0.612
dark-eyed junco	6	0.25	0.090	2	0.09	0.060
northern cardinal				13	0.57	0.197
pyrrhuloxia				1	0.04	0.043
house finch				4	0.17	0.081
pine siskin	1	0.04	0.042			
lesser goldfinch				6	0.26	0.180

[a]All observed flying over the park on one occasion.
[b]Either solitary or cordilleran.

Table 4.6. Number of observations by breeding behavior for birds, Fort Bowie NHS, 2003 and 2004. Breeding behaviors follow standards set by NAOAC (1990).

	Nest				Adults carrying		Other			
Common name	Building	With eggs	With young	Occupied	Food	Nesting material	Distraction displays	Feeding recently fledged young	Recently fledged young	**Totals**
Gambel's quail								1		**1**
Cooper's hawk				2						**2**
white-winged dove		1		4						**5**
mourning dove				14						**14**
black-chinned hummingbird				1						**1**
broad-tailed hummingbird	1			3			2			**6**
ladder-backed woodpecker				1						**1**
Say's phoebe								2	1	**3**
brown-crested flycatcher				1						**1**
Cassin's kingbird	1			2					1	**4**
western kingbird								1		**1**
Bell's vireo				1				1		**2**
western scrub-jay									1	**1**
barn swallow	1									**1**
verdin	1									**1**
cactus wren				1	1			2		**4**
rock wren					1					**1**
canyon wren					1			1		**2**
Bewick's wren					1				1	**2**
black-tailed gnatcatcher								1		**1**
northern mockingbird					1			2		**3**
curve-billed thrasher									1	**1**
crissal thrasher									1	**1**
phainopepla				1						**1**
summer tanager								2		**2**
canyon towhee				1	2	2		1	1	**7**
black-throated sparrow			1		1			1		**4**
northern cardinal				1	1				1	**3**
brown-headed cowbird									1	**1**
hooded oriole	1			1		1				**3**
Bullock's oriole			1	1				1		**3**
house finch				1						**1**
Totals	**5**	**1**	**2**	**35**	**10**	**3**	**2**	**16**	**9**	**84**

Discussion

Based on our research and that by others, Fort Bowie NHS has a diverse bird community (n = 189 species) for a small area (405 ha) with little topographic relief. Although the pattern of extraordinary species richness that we observed in plants (Chapter 3) was not mirrored in the bird community, the diversity of vegetation communities at the sites clearly plays a role in determining the bird community. For example, there were notable differences in the bird communities along the two repeat-visit VCP transects where the Siphon Canyon transect had almost twice as many species as the Butterfield transect (Tables 4.3, 4.4).

Many of the species that we found in the Siphon Canyon transect are known to occur primarily in riparian areas or areas of dense vegetation: Bell's vireo, summer tanager, hooded

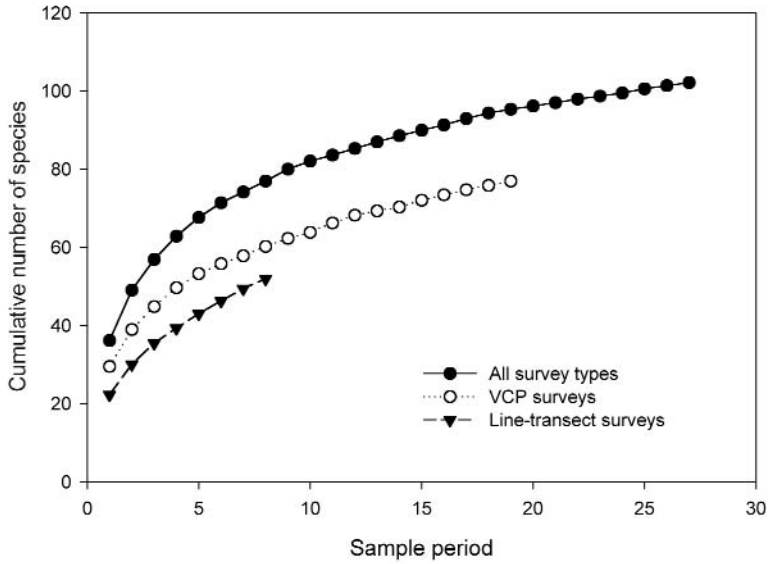

Figure 4.3. Species accumulation curves, by survey type, for the UA bird inventory effort, Fort Bowie NHS, 2002–2004. Each sample period for all survey types represents a randomized ordering of 101 observations (*N* = 2,821; a completely randomized combination of the four survey types). Each sample period for VCP and line-transect surveys represents one survey day.

oriole, and northern cardinal (Powell and Steidl 2000). Although not as species rich as in Siphon Canyon, the bird community along the Butterfield transect had species that are associated with the oak savanna and chaparral including juniper titmouse, Crissal thrasher, and rufous-crowned sparrow. Each bird species is closely tied to gross vegetation characteristics such as (1) vertical structure (MacArthur and MacArthur 1961, Cody 1981), (2) horizontal patchiness (Roth 1976, Kotliar and Weins 1990), and (3) floristics (Rice et al. 1984, Strong and Bock 1990, Powell and Steidl 2002). Given the differences in vegetation structure and composition between the two transects, the differences that we noted in the bird communities were not surprising.

The dense riparian vegetation near Apache Spring plays an important role in providing nesting habitat for Cooper's hawk and summer tanager; they were found nesting in that area. Research in the southwestern U.S. has consistently shown that areas with riparian trees have bird communities that are more diverse than adjacent sites (Carothers et al. 1974, Szaro and Jakle 1985, Strong and Bock 1990), which is due, in part, to the variety of microhabitats that riparian vegetation provides for nesting (Powell and Steidl 2002), cover, and foraging.

Park managers are interested in the impact that the invasion of the native velvet mesquite is having on the visitors experience in the park (NPS 2000b) because mesquite was not identified in historic photographs of the area. Velvet mesquite has increased in density and distribution in the region since the late 1800s, primarily due to disruption of historical fire regimes and the introduction of cattle grazing (Humphrey 1974, Brown 1994, Van Auken 2000). The conversion of semi-desert grasslands to mesquite woodlands has important implications for the bird community by favoring shrub-associated species such as northern cardinal, verdin, and black-throated sparrow (Lloyd et al. 1998) while not favoring many species of management concern such as Botteri's, Cassin's, and grasshopper sparrows. The loss of native grassland has been identified as a primary factor in population declines of grassland birds as a group (Herkert 1994, Knopf 1994, Peterjohn and Sauer 1999).

Comparisons to Russell and Johnson (1976)

The research by Russell and Johnson (1976) was the first comprehensive survey of birds at the park.

Unfortunately we can only make very gross comparisons between our two studies because we did not use the same survey methods and exactly the same area. Yet a number of species and communities were quite different between the two studies. We found 14 species that Russell and Johnson did not find and they found 62 species that we did not find (Appendix C). We found black-throated sparrow to be among the most common species in the oak-juniper woodland, but Russell and Johnson did not find them to be very abundant (Appendix G). Conversely, in Siphon Canyon, they found black-chinned hummingbird to be the most common species, whereas it was among the least common species in 2003 and was not found at all in 2004 (Table 4.3). There is little indication of a regional population decline in this species (Sauer et al. 2004), though banding data from Hummingbird Monitoring Network sites is showing some decline for 2005 (Larry Norris, *pers. comm.*). Nevertheless, the decline that we saw may have been an artifact of different field methods; species such as hummingbirds may be more conspicuous while walking a transect line.

During the non-breeding season the mesquite-grassland vegetation community had the most bird species that did not rank as abundant for the other study (Appendix G). This may have been an artifact of small sample size from both studies. It could also reflect the variability of non-breeding season birds. For example, species such as white-crowned, black-throated, Brewer's, and chipping sparrows can form large, sometimes mixed-species flocks which, if encountered, can radically affect the relative abundance estimates for a transect.

Chapter 5: Mammal Inventory

Previous Research

The documented species list of mammals from the park is largely complete. The first inventory of mammals at Fort Bowie was completed by Roth and Cockrum (1976). More recently Petryszyn (1999) and Hermann-Reese (unpublished data) completed surveys for rodents, and Krebbs (2005) surveyed for bats from 2001 to 2004. Hermann-Reese also surveyed for medium and large mammals using infrared-triggered cameras and in this report we summarize that work (Appendix H). Swann et al. (2001) noted mammals seen incidentally to their surveys of reptiles and amphibians. In all, there have been 57 species documented (including specimens at the University of Arizona mammal collection) for the park: 12 bats, 30 small mammals (Orders Insectivora, Rodentia, and Lagomorpha), and 15 medium to large mammals (Orders Carnivora and Artiodactyla; Appendix D).

Methods

Because mammals have been surveyed extensively, we surveyed only for medium and large mammals using infrared-triggered cameras at three sites (Fig. 5.1). For this report our purpose was to (1) augment the infrared-triggered camera effort of Herman-Reese and (2) synthesize species lists from the previously mentioned survey efforts. We refer the reader to the other inventory efforts for more detailed species accounts.

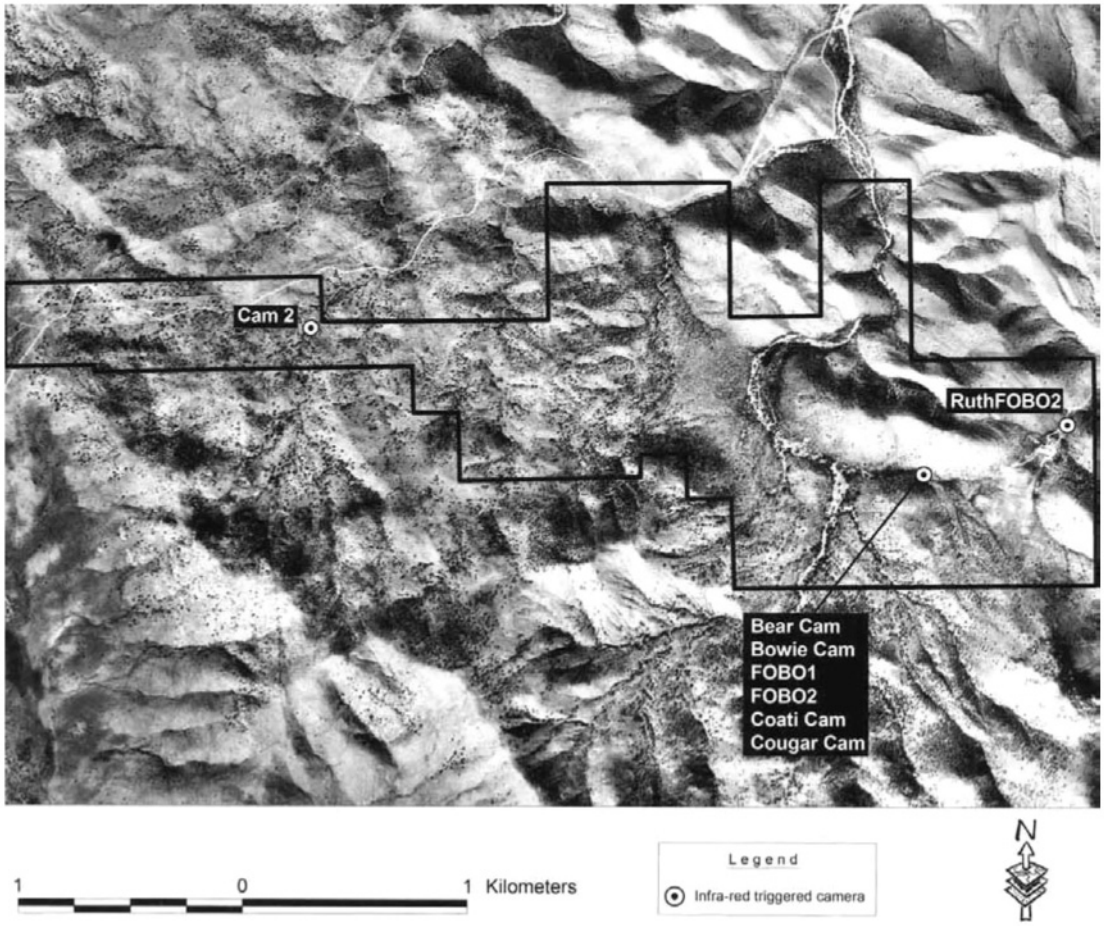

Figure 5.1. Location of Trailmaster camera sites, Fort Bowie NHS, 2002–2003.

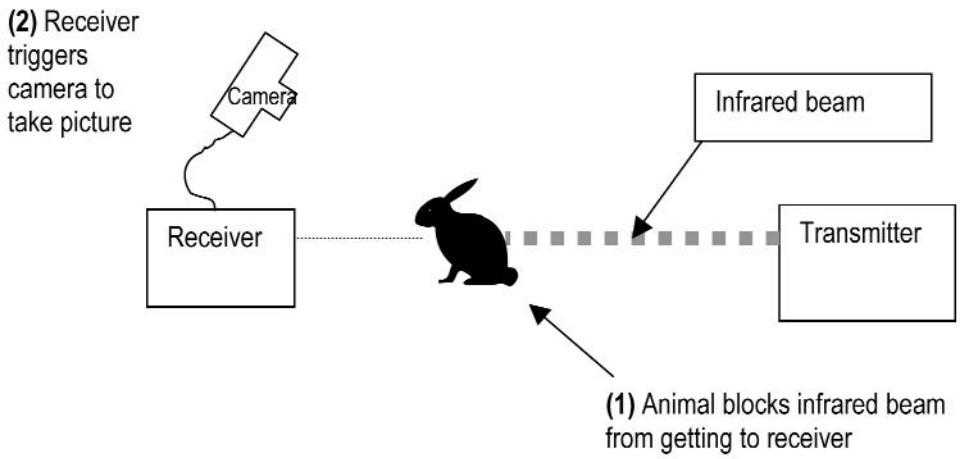

Figure 5.2. Diagram of infrared-triggered camera (Trailmaster) set-up. Image based on Swann et al. (2004).

Trailmaster Cameras

We used infrared-triggered cameras (herein referred to as "Trailmaster"; 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. 5.2). 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 set the receiver and transmitter approximately 8 m apart and 20 cm above the ground so that medium and large mammals were captured on film but smaller animals such as rodents and birds were not. 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 three areas of the park (Fig. 6.1; UTM coordinates for Willow Gulch = 644390 N, 3558289 E; Apache Spring = 647101 N, 3557644 E; Visitor Center Road = 647729 N, 3557866 E) that we thought would record the highest number of species; typically these were in areas of dense vegetation. We baited camera sites with a commercial 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.

Spatial Sampling Design

We selectively placed cameras in areas that we felt would have the most success, primarily near Apache Spring.

Effort

We operated Trailmaster cameras at three locations from May 2002 to May 2003 for a total of 278 days of camera operation (Table 5.1). Of the three locations, Apache Spring had the most effort (47%), followed by visitor center road (38%) and Willow Gulch (15%).

Analysis

Trailmaster cameras are the most cost-effective 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 differentiate individuals, which precludes any estimates of abundance (i.e., one must be able to determine whether one animal has been photographed repeatedly or whether more than one individual has been photographed). In some cases, size or physical abnormality may differentiate individuals of any species, but this was not evident in our photographs. Also, each species is more or less likely to be attracted to the camera area. Therefore, we report the number of times a species was photographed to indicate species that may be common, based on the number of photographs.

Table 5.1. Summary of Trailmaster camera effort, Fort Bowie NHS, 2002 and 2003.

General location	Camera name	Year	Start date	End date	Number of days open
Willow Gulch	Cam 2	2002	6 Oct	19 Oct	13
		2002	19 Oct	17 Nov	29
Apache Spring	Bowie Cam	2002	12 May	25 May	13
	FOBO2	2002	2 Jun	16 Jun	14[a]
	Coati Cam	2002	30 Jun	7 Jul	7[a]
	Cougar Cam	2002	14 Jul	21 Jul	7[a]
		2002	28 Jul	31 Jul	3[a]
		2002	22 Sep	4 Oct	12
		2002	19 Oct	13 Nov	25
		2002	17 Nov	28 Nov	11
	Bear Cam	2002	25 Aug	21 Sep	27
	FOBO1	2002	6 Oct	18 Oct	12
Visitor Center Road	RuthFOBO2	2002-2003	19 Dec	3 May	105

[a]Due to improper documentation, this number is an estimate of the number of days the camera was available to take photographs.

Incidental Observations and Signs

As with other taxa, we recorded UTM coordinates of mammal sightings made outside of formal surveys. Observers from all field crews (e.g., bird crew) recorded mammal sightings.

Results and Discussion

We documented two birds (common black hawk and American robin) and 11 species of mammals using Trailmaster cameras at Fort Bowie NHS in 2002 and 2003 (Table 5.2). We documented two new species of mammals for the park: hooded skunk and feral dog (Appendix D). The photo of the dog is the first documentation of a non-native mammal in the park. The most photographs were of the white-nosed coati (Table 5.2). Collared peccary and striped skunk were also in many of the photographs.

As we expected, most of the photos were from Apache Spring (Table 5.2). In general, this was an extremely dry period (Fig. 2.3) and the spring was an important resource, drawing in many animals including an American black bear, which was likely dispersing from the Pinaleño or Chiricahua Mountains. We did not document any animals at the Willow Gulch site.

Table 5.2. Number of photographs of animals, by Trailmaster camera site, Fort Bowie NHS, 2002 and 2003. Number in parentheses is the total number of individuals if >1 individual was seen in a picture.

		Site		
		Apache Spring		Visitor Center Road
Group	Species	Number of photographs	Number of individuals in photographs	Number of photographs and individuals
Bird	common black-hawk	1	1	
	American robin			4
Mammal	American black bear	4	4	
	white-nosed coati	29	55	
	striped skunk	18	19	2
	hooded skunk	2	2	
	white-backed hog-nosed skunk			1
	feral dog	1	1	
	common gray fox	6	6	
	mountain lion	11	12	2
	bobcat	6	6	
	collared peccary	15	20	6
	mule deer	9	12	

Chapter 6: Management Implications

Based on the data from this study and our knowledge of the natural resource issues at the park, we highlight issues that affect the park's natural resources. Coordination with other agencies, non-governmental organizations, and/or adjacent landowners may prove the best route to resolving some of these challenges.

Development Adjacent to the Park

One of the most serious threats to the biological diversity of Fort Bowie NHS may be residential development to the north of the park. The development may lead to an increase in the number and extent of non-native plants (Seabloom et al. 2003) and may disrupt animal movement patterns and result in the loss and/or fragmentation of habitat (Mills et al. 1989, Theobald et al. 1997, Riley et al. 2003), particularly for larger mammals. Also, free-roaming pets, normally associated with development, can negatively impact native vertebrates through harassment and mortality (Coleman and Temple 1993). This may not be a problem because the Buddhist retreat, on which most of the adjacent development is taking place, does not allow pets.

Cattle Grazing

The impact of cattle grazing on the park's natural resources has never been documented. As mentioned in the Park Introduction chapter, cattle grazing can have harmful impacts on the native biota by causing changes in the distribution, abundance, and composition of plant populations as well as soil erosion and compaction. Ruyle (2001) assessed the range condition on eight sites; his results indicate that conditions ranged from fair to good, but those conditions were only assessed using vegetation measures. We suggest that if grazing were to continue at the park, managers establish more long-term monitoring protocols and sites to determine the impact of grazing on the natural resources of the park, particularly soils, vegetation, and vertebrates.

Perhaps the most damaging practice relating to grazing is the use of water from Apache Spring to supply water to adjacent cattle allotments. Although the allotment of one-half of the water from the spring is rarely realized (Larry Ludwig, *pers. comm.* to Michele Gerard), there is a potential for that amount of water to be diverted. The water from the spring is a vital resource for the park and is responsible for the riparian area that is so valuable for plants and wildlife in the area. A hydrologist could help park managers determine the impact of water diversion on the riparian area.

Visitor Impacts

If the road over Apache Pass is paved, there will likely be increased mortality of reptiles, particularly snakes, which seek out the pavement on hot summer nights to bask (Rosen and Lowe 1994). Increased vehicular volume and speed will also likely increase the modification of animal behavior (Trombulak and Frissell 2000). Modification of behavior probably already takes place at Apache Spring, which is the only source of perennial water for animals, but is also a popular resting spot for hikers. The effect of this conflict has never been quantified, but given the high abundance and species richness of birds and large mammals in that area (see Tables 4.3, 5.2), conflicts are inevitable.

Chapter 7: Additional Inventories

No inventory is ever truly complete; species distributions expand and contract across boundaries, particularly at smaller parks such as Fort Bowie NHS. In general, we feel that the inventories for vascular plants and vertebrates are nearly complete and that the park is in a good position to monitor changes in species composition. Through the continuous collection of data, such as specimens from road kill, photographs, and through research studies at the park, managers can continue to monitor changes. An additional step would be to coordinate additional inventory-like field efforts with adjacent landowners to increase the spatial scope of the inventory effort. Below we suggest ways to complete the species inventories and/or implement monitoring on the park.

Plants

A number of woody invasive species such as velvet mesquite and burroweed are of concern to park managers (NPS 2000b) and there is currently a program to remove mesquite. We suggest that a more rigorous, plot-based vegetation monitoring program be established at the park (e.g., Powell et al. 2005a), including a number of plots in the area of mesquite removal. This monitoring would inform the park managers of the effectiveness of the program as well as document changes in the plant community concurrent to this removal (of particular concern is the spread of non-native grasses such as Lehmann lovegrass). Repeat inventories for plants, particularly the early detection of non-native plants, should be carried out at least every five years.

Specimen vouchers from the park may be residing in the herbarium collections at Arizona State University and Northern Arizona University. In early 2005 it became possible to access information about these collections. We suggest that these databases be searched for specimens from the park. However, care should be taken in accepting the list of species without confirming the proper identification of species or updating taxonomy (Halvorson 2003).

Many of the specimens cited in the report by Warren et al. (1992) are currently housed at the park, but because the park does not have a natural resource staff member who is responsible for the proper curation of that collection, it is unlikely that the plant specimens are receiving proper care. Therefore, we recommend removing them to a collection that has proper archival conditions, such as the University of Arizona.

Reptiles and Amphibians

Swann et al. (2001) surveyed for amphibians and reptiles in 1997 and 1998 and their study remains one of the best examples of a biological inventory in the region. Because they designed their study to form the basis for long-term monitoring, we suggest repeating their effort (or some portion) at least every ten years. It will especially important to survey for amphibians and aquatic reptiles because these groups are experiencing sharp declines in distribution and abundance (Wake 1990).

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., Madera Canyon, Ramsey Canyon, and Patagonia-Sonoita Creek Preserve in southern Arizona) have bird lists that can be considered to be “complete.”

Mammals

Herman-Reese did not write up the results of either the small mammal trapping or Trailmaster studies that she undertook. Although we published an appendix of her Trailmaster camera results (Appendix H), this effort is insufficient to properly document and archive data from that project. We encourage park staff to work with her to complete that effort before too much time passes; her field effort was considerable and it would be unfortunate not to have a report to document her effort.

The one group of mammals that may require additional inventory work is bats. Krebbs (2005) netted at the park from 2001-2004 for a total of five nights of netting. It did not appear to

be sufficient for documenting all of the species of insectivorous bats at the park; new species continued to be found. We therefore recommend additional netting at Apache Spring. The use of ultrasonic detectors to identify bat species is increasing, and many researchers are refining the field techniques and improving the technology (e.g., Johnson et al. 2002, Gannon et al. 2003). These technologies may become more useful in the coming years with these refinements.

Chapter 8: Literature Cited

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Appendix A. Plant species that were observed or collected at Fort Bowie NHS by the University of Arizona inventory personnel (UA; 2002 and 2003) and other studies: Warren et al. (1992; WEA), Bennett et al. (1996; BEA), Ruyle (1996; RUL), Hartman and Rottman (1998; H&R), NPS (2000; NPS), and Halvorson and Guertin (2003; H&G).[a]
Species in bold-faced type are non-native.

Family	Scientific name	Common name	UA	UA Herbarium[b]	WEA	BEA	RUL	H&R	NPS	H&G
Acanthaceae	*Anisacanthus thurberi* (Torr.) Gray	Thurber's desert honeysuckle	X		X	X	X	X	X	
	Carlowrightia arizonica Gray	Arizona wrightwort			X	X		X	X	
Agavaceae	*Agave palmeri* Engelm.	Palmer's century plant			X	X		X	X	
	Agave parryi Engelm.	Parry's agave	X		X	X		X	X	
	Yucca baccata Torr.	banana yucca	X		X			X	X	
	Yucca baccata var. brevifolia (Schott ex Torr.) L. Benson & Darrow	Spanish dagger				X				
	Yucca elata (Engelm.) Engelm.	soaptree yucca			X	X		X	X	
Aizoaceae	*Trianthema portulacastrum* L.	desert horsepurslane	X		X	X		X	X	
Amaranthaceae	*Amaranthus fimbriatus* (Torr.) Benth. ex S. Wats.	fringed amaranth				X			X	
	Amaranthus palmeri S. Wats.	carelessweed			X	X		X	X	
	Froelichia arizonica Thornb. ex Standl.	Arizona snakecotton	X		X	X		X	X	
	Gomphrena caespitosa Torr.	tufted globe amaranth			X	X		X	X	
	Guilleminea densa (Humb. & Bonpl. ex Willd.) Moq.	small matweed	X	X	X				X	
	Guilleminea densa var. densa (Humb. & Bonpl. ex Willd.) Moq.	small matweed				X		X		
Anacardiaceae	*Rhus aromatica* Ait.	fragrant sumac	X							
	Rhus microphylla Engelm. ex Gray	littleleaf sumac	X	X	X	X		X	X	
	Rhus trilobata Nutt.	skunkbush sumac			X			X	X	
	Rhus trilobata var. pilosissima Engelm.	pubescent squawbush				X		X	X	
	Rhus virens var. choriophylla (Woot. & Standl.) L. Benson	evergreen sumac			X	X		X	X	
	Toxicodendron radicans (L.) Kuntze	eastern poison ivy			X				X	
	Toxicodendron radicans ssp. divaricatum (Greene) Gillis	eastern poison ivy				X				
	Toxicodendron radicans ssp. radicans (L.) Kuntze	eastern poison ivy	X					X		
	Toxicodendron rydbergii (Small ex Rydb.) Greene	western poison ivy				X				
Apiaceae	*Cymopterus multinervatus* (Coult. & Rose) Tidestrom	purplenerve springparsley			X	X		X	X	
	Daucus pusillus Michx.	American wild carrot			X	X		X	X	
	Lomatium nevadense (S. Wats.) Coult. & Rose	Nevada biscuitroot			X			X	X	
	Lomatium nevadense var. parishii (Coult. & Rose) Jepson	Parish's biscuitroot				X				
	Pseudocymopterus montanus (Gray) Coult. & Rose	alpine false springparsley			X	X		X	X	
	Spermolepis echinata (Nutt. ex DC.) Heller	bristly scaleseed			X	X		X	X	
Apocynaceae	*Macrosiphonia brachysiphon* (Torr.) Gray	Huachuca Mountain rocktrumpet			X	X		X	X	
Aristolochiaceae	*Aristolochia watsonii* Woot. & Standl.	Watson's dutchman's pipe			X	X		X	X	
Asclepiadaceae	*Asclepias asperula* (Dcne.) Woods.	spider milkweed	X		X			X	X	
	Asclepias asperula (Dcne.) Woods. *ssp. asperula*	spider milkweed				X				

Family	Scientific name	Common name	UA	UA Herbarium[b]	WEA	BEA	RUL	H&R	NPS	H&G
Asclepiadaceae	*Asclepias asperula ssp. capricornu* (Woods.) Woods.	antelopehorns	X							
	Asclepias engelmanniana Woods.	Engelmann's milkweed			X	X		X	X	
	Asclepias macrotis Torr.	longhood milkweed			X	X		X	X	
	Asclepias nyctaginifolia Gray	Mojave milkweed			X	X		X	X	
	Funastrum crispum (Benth.) Schlechter	wavyleaf twinevine	X		X	X		X	X	
	Funastrum cynanchoides ssp. cynanchoides (Dcne.) Schlechter	fringed twinevine						X		
	Funastrum cynanchoides ssp. heterophyllum (Vail) Kartesz, comb. nov. ined.	Hartweg's twinevine			X	X			X	
Asteraceae	*Acourtia nana* (Gray) Reveal & King	dwarf desertpeony			X	X		X	X	
	Acourtia wrightii (Gray) Reveal & King	brownfoot			X	X		X	X	
	Ambrosia confertiflora DC.	weakleaf burr ragweed			X	X		X	X	
	Artemisia dracunculus L.	tarragon			X			X	X	
	Artemisia dracunculus ssp. dracunculus L.	wormwood				X				
	Artemisia ludoviciana Nutt.	white sagebrush	X		X			X	X	
	Artemisia ludoviciana ssp. mexicana (Willd. ex Spreng.) Keck	white sagebrush				X				
	Baccharis bigelovii Gray	Bigelow's false willow	X		X	X		X	X	
	Baccharis pteronioides DC.	yerba de pasmo			X	X	X	X	X	
	Baccharis salicifolia (Ruiz & Pavón) Pers.	mule's fat			X	X		X	X	
	Baccharis sarothroides Gray	desertbroom	X		X	X	X	X	X	
	Baccharis sergiloides Gray			X		X				
	Baccharis thesioides Kunth	Arizona baccharis				X			X	
	Baccharis wrightii Gray	Wright's baccharis			X	X			X	
	Bahia absinthifolia Benth.	hairyseed bahia	X	X	X		X	X	X	
	Bahia absinthifolia var. dealbata (Gray) Gray	Dealbata's bahia				X				
	Baileya multiradiata Harvey & Gray ex Gray	desert marigold	X		X	X	X	X	X	
	Baileya pauciradiata Harvey & Gray ex Gray	laxflower			X			X	X	
	Baileya pleniradiata Harvey & Gray ex Gray	woolly desert marigold				X			X	
	Berlandiera lyrata Benth.	lyreleaf greeneyes			X	X		X	X	
	Bidens leptocephala Sherff	fewflower beggarticks			X	X		X	X	
	Brickellia baccharidea Gray	resinleaf brickellbush				X			X	
	Brickellia californica (Torr. & Gray) Gray	California brickellbush			X	X			X	
	Brickellia eupatorioides var. chlorolepis (Woot. & Standl.) B.L. Turner	false boneset			X	X		X	X	
	Brickellia venosa (Woot. & Standl.) B.L. Robins.	veiny brickellbush	X		X	X		X	X	
	Carminatia tenuiflora DC.	plumeweed	X							
	Carphochaete bigelovii Gray	Bigelow's bristlehead			X	X		X	X	
	Chaenactis stevioides Hook. & Arn.	Steve's dustymaiden			X			X	X	
	Chaetopappa ericoides (Torr.) Nesom	rose heath			X	X		X	X	

Family	Scientific name	Common name	UA	UA Herbarium[b]	WEA	BEA	RUL	H&R	NPS	H&G
Asteraceae	*Cirsium neomexicanum* Gray	New Mexico thistle	X		X	X		X	X	
	Cirsium ochrocentrum Gray	yellowspine thistle			X	X		X	X	
	Conyza canadensis (L.) Cronq.	Canadian horseweed			X			X	X	
	Conyza canadensis (L.) Cronq. *var. canadensis*	Canadian horseweed				X			X	
	Ericameria laricifolia (Gray) Shinners	turpentine bush	X		X	X	X	X	X	
	Ericameria nauseosa (Pallas ex Pursh) Nesom & Baird	rubber rabbitbrush					X			
	Ericameria nauseosa var. latisquamea (Gray) Nesom & Baird	rubber rabbitbrush				X				
	Ericameria nauseosa var. nauseosa (Pallas ex Pursh) Nesom & Baird	rubber rabbitbrush	X		X				X	
	Erigeron colomexicanus A. Nels.	running fleabane			X	X			X	
	Erigeron divergens Torr. & Gray	spreading fleabane			X			X	X	
	Erigeron modestus Gray	plains fleabane						X	X	
	Erigeron oreophilus Greenm.	chaparral fleabane			X	X		X	X	
	Flourensia cernua DC.	American tarwort			X	X		X	X	
	Gaillardia pulchella Foug.	firewheel			X			X	X	
	Gaillardia pulchella Foug. *var. pulchella*	firewheel				X				
	Gnaphalium sp. L.	cudweed					X			
	Gutierrezia microcephala (DC.) Gray	threadleaf snakeweed			X	X		X	X	
	Gutierrezia sarothrae (Pursh) Britt. & Rusby	broom snakeweed	X	X	X	X	X		X	
	Gymnosperma glutinosum (Spreng.) Less.	gumhead	X							
	Helianthus annuus L.	common sunflower			X	X		X	X	
	Helianthus petiolaris Nutt.	prairie sunflower				X				
	Heliomeris multiflora var. multiflora Nutt.	showy goldeneye			X	X		X	X	
	Heterosperma pinnatum Cav.	wingpetal	X		X	X		X	X	
	Heterotheca subaxillaris (Lam.) Britt. & Rusby	camphorweed								X
	Hymenoclea monogyra Torr. & Gray ex Gray	singlewhorl burrobrush			X	X		X	X	
	Hymenothrix wislizeni Gray	TransPecos thimblehead			X	X		X	X	
	Hymenothrix wrightii Gray	Wright's thimblehead				X				
	Hymenoxys microcephala (Gray) Bierner	Apache Passe rubberweed			X	X		X	X	
	Isocoma coronopifolia (Gray) Greene	common goldenbush		X		X				
	Isocoma tenuisecta Greene	burroweed	X		X	X	X	X	X	
	Iva ambrosiifolia (Gray) Gray	ragged marshelder			X	X		X	X	
	Iva dealbata Gray	woolly marshelder			X	X		X	X	
	***Lactuca serriola* L.**	**prickly lettuce**			**X**	**X**		**X**	**X**	**X**
	Laennecia coulteri (Gray) Nesom	conyza			X	X			X	
	Lasthenia californica DC. ex Lindl.	California goldfields				X				
	Machaeranthera canescens var. incana (Lindl.) Gray	hoary tansyaster			X	X		X	X	

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Asteraceae	*Machaeranthera gracilis* (Nutt.) Shinners	slender goldenweed				X				
	Machaeranthera pinnatifida (Hook.) Shinners	lacy tansyaster			X				X	
	Machaeranthera pinnatifida ssp. gooddingii (A. Nels.) B.L.	Goodding's tansyaster				X				
	Machaeranthera pinnatifida var. pinnatifida (Hook.) Shinners	lacy tansyaster				X		X		
	Machaeranthera tagetina Greene	mesa tansyaster			X	X		X	X	
	Malacothrix fendleri Gray	Fendler's desertdandelion			X	X		X	X	
	Packera neomexicana var. neomexicana (Gray) W.A. Weber & A. Löve	New Mexico groundsel			X	X		X	X	
	Packera quercetorum (Greene) C. Jeffrey	Oak Creek ragwort			X	X		X	X	
	Parthenium incanum Kunth	mariola	X		X	X	X	X	X	
	Pectis filipes Harvey & Gray	fivebract cinchweed			X			X	X	
	Pectis filipes var. subnuda Fern.	fivebract cinchweed				X				
	Pectis longipes Gray	longstalk cinchweed			X	X		X	X	
	Pectis prostrata Cav.	spreading cinchweed			X	X		X	X	
	Pseudognaphalium canescens ssp. canescens (DC.) W.A. Weber	Wright's cudweed	X		X	X		X	X	
	Psilostrophe cooperi (Gray) Greene	whitestem paperflower				X	X		X	
	Psilostrophe sparsiflora (Gray) A. Nels.	greenstem paperflower			X	X		X	X	
	Psilostrophe tagetina (Nutt.) Greene	woolly paperflower	X		X			X	X	
	Psilostrophe tagetina (Nutt.) Greene *var. tagetina*	woolly paperflower				X				
	Rafinesquia neomexicana Gray	New Mexico plumseed			X	X			X	
	Ratibida columnifera (Nutt.) Woot. & Standl.	upright prairie coneflower			X	X		X	X	
	Sanvitalia abertii Gray	Albert's creeping zinnia	X		X	X		X	X	
	Schkuhria wislizenii Gray		X							
	Senecio flaccidus var. douglasii (DC.) B.L. Turner & T.M. Barkl.	Douglas' ragwort	X			X				
	Senecio flaccidus var. flaccidus Less.	threadleaf ragwort			X	X		X	X	
	Senecio flaccidus var. monoensis (Greene) B.L. Turner & T.M. Barkl.	Mono ragwort			X			X	X	
	Senecio spartioides var. multicapitatus (Greenm. ex Rydb.) Welsh	broomlike ragwort	X		X	X		X	X	
	Solidago velutina DC.	threenerve goldenrod			X	X		X	X	
	***Sonchus oleraceus* L.**	**common sowthistle**			**X**	**X**			**X**	
	Stephanomeria pauciflora (Torr.) A. Nels.	brownplume wirelettuce	X		X	X		X	X	
	Tagetes micrantha Cav.	licorice marigold	X							
	Thelesperma longipes Gray	longstalk greenthread			X	X		X	X	
	Thelesperma megapotamicum (Spreng.) Kuntze	Hopi tea greenthread	X		X	X		X	X	
	Thymophylla acerosa (DC.) Strother	pricklyleaf dogweed			X	X		X	X	
	Thymophylla pentachaeta var. pentachaeta (DC.) Small	fiveneedle pricklyleaf			X	X		X	X	
	Trixis californica Kellogg	American threefold			X	X		X	X	
	Uropappus lindleyi (DC.) Nutt.	Lindley's silverpuffs			X	X		X	X	

Family	Scientific name	Common name	UA	UA Herbarium[b]	WEA	BEA	RUL	H&R	NPS	H&G
Asteraceae	*Verbesina encelioides* (Cav.) Benth. & Hook. f. ex Gray	golden crownbeard			X	X		X	X	
	Verbesina rothrockii Robins. & Greenm.	Rothrock's crownbeard	X	X	X	X		X	X	
	Viguiera deltoidea Gray	Parish's goldeneye			X				X	
	Viguiera dentata (Cav.) Spreng.	toothleaf goldeneye			X	X		X	X	
	Viguiera parishii Greene	Parish's goldeneye				X		X		
	Zinnia acerosa (DC.) Gray	desert zinnia	X		X	X		X	X	
	Zinnia grandiflora Nutt.	Rocky Mountain zinnia			X	X		X	X	
Bignoniaceae	*Chilopsis linearis* (Cav.) Sweet	desert willow	X		X		X	X	X	
	Chilopsis linearis (Cav.) Sweet *ssp. linearis*	desert willow				X				
Boraginaceae	*Amsinckia menziesii var. intermedia* (Fisch & C.A. Mey.) Ganders	common fiddleneck			X	X		X	X	
	Cryptantha crassisepala (Torr. & Gray) Greene	thicksepal cryptantha			X	X		X	X	
	Cryptantha micrantha (Torr.) I.M. Johnston	redroot cryptantha			X	X		X	X	
	Cryptantha pterocarya (Torr.) Greene	wingnut cryptantha	X							
	Lappula occidentalis (S. Wats.) Greene	flatspine stickseed	X							
	Lappula occidentalis var. cupulata (Gray) Higgins	flatspine stickseed			X			X	X	
	Lappula occidentalis var. occidentalis (S. Wats.) Greene	flatspine stickseed			X	X		X	X	
	Lithospermum cobrense Greene	smooththroat stoneseed			X	X		X	X	
	Lithospermum incisum Lehm.	narrowleaf stoneseed				X				
	Pectocarya platycarpa (Munz & Johnston) Munz & Johnston	broadfruit combseed				X				
	Pectocarya recurvata I.M. Johnston	curvenut combseed			X	X		X	X	
	Plagiobothrys arizonicus (Gray) Greene ex Gray	Arizona popcornflower			X	X		X	X	
	Tiquilia canescens (DC.) A. Richards.	woody crinklemat			X			X	X	
	Tiquilia canescens (DC.) A. Richards. *var. canescens*	woody crinklemat				X				
Brassicaceae	*Arabis perennans* S. Wats.	perennial rockcress	X		X	X		X	X	
	Descurainia pinnata (Walt.) Britt.	western tansymustard	X		X			X	X	
	Descurainia pinnata ssp. glabra (Woot. & Standl.) Detling	western tansymustard				X				
	***Descurainia sophia* (L.) Webb ex Prantl**	**herb sophia**			**X**	**X**		**X**	**X**	**X**
	Draba cuneifolia Nutt. ex Torr. & Gray	wedgeleaf draba			X			X	X	
	Draba cuneifolia Nutt. ex Torr. & Gray *var. cuneifolia*	wedgeleaf draba				X				
	Draba standleyi J.F. Macbr. & Payson	Standley's draba				X				
	Lepidium lasiocarpum Nutt.	shaggyfruit pepperweed			X			X	X	
	Lepidium lasiocarpum Nutt. *var. lasiocarpum*	shaggyfruit pepperweed				X				
	Lepidium thurberi Woot.	Thurber's pepperweed			X	X		X	X	
	Lepidium virginicum var. medium (Greene) C.L. Hitchc.	medium pepperweed			X	X		X	X	
	Lesquerella fendleri (Gray) S. Wats.	Fendler's bladderpod			X	X		X	X	
	Lesquerella gordonii (Gray) S. Wats.	Gordon's bladderpod			X	X		X	X	

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Brassicaceae	*Lesquerella tenella* A. Nels.	Moapa bladderpod	X							
	Pennellia longifolia (Benth.) Rollins	longleaf mock thelypody			X			X	X	
	Schoenocrambe linearifolia (Gray) Rollins	slimleaf plainsmustard			X	X		X	X	
	Schoenocrambe linifolia (Nutt.) Greene	flaxleaf plainsmustard	X							
	***Sisymbrium irio* L.**	**London rocket**	**X**		**X**	**X**		**X**	**X**	**X**
	Streptanthella longirostris (S. Wats.) Rydb.	longbeak streptanthella			X	X		X	X	
	Streptanthus carinatus ssp. arizonicus (S. Wats.) Kruckeberg, Rodman & Worthington	lyreleaf jewelflower			X	X		X	X	
	Thelypodium wrightii Gray	Wright's thelypody			X			X	X	
	Thelypodium wrightii Gray *ssp. wrightii*	Wright's thelypody				X				
Cactaceae	*Echinocereus coccineus* Engelm. *var. coccineus*	scarlet hedgehog cactus							X	
	Echinocereus fendleri (Engelm.) F. Seitz	pinkflower hedgehog cactus	X					X	X	
	Echinocereus fendleri var. fasciculatus (Engelm. ex B.D. Jackson) N.P. Taylor	pinkflower hedgehog cactus							X	
	Echinocereus fendleri var. ledingii (Peebles) N.P. Taylor	Leding's hedgehog cactus			X	X			X	
	Echinocereus fendleri var. rectispinus (Peebles) L. Benson	pinkflower hedgehog cactus			X	X		X	X	
	Echinocereus pectinatus (Scheidw.) Engelm.	rainbow cactus				X				
	Echinocereus rigidissimus (Engelm.) Haage f.	rainbow hedgehog cactus			X			X	X	
	Echinocereus triglochidiatus Engelm.	kingcup cactus							X	
	Escobaria vivipara var. bisbeeana (Orcutt) D.R. Hunt	Bisbee spinystar			X	X			X	
	Escobaria vivipara var. vivipara (Nutt.) Buxbaum	spinystar	X					X		
	Ferocactus wislizeni (Engelm.) Britt. & Rose	candy barrelcactus	X		X	X	X	X	X	
	Mammillaria grahamii var. grahamii Engelm.	Graham's nipple cactus			X	X		X	X	
	Mammillaria grahamii var. oliviae (Orcutt) L. Benson	Graham's nipple cactus				X			X	
	Mammillaria heyderi var. macdougalii (Rose) L. Benson	Macdougal's nipple cactus			X	X		X	X	
	Opuntia chlorotica Engelm. & Bigelow	dollarjoint pricklypear			X	X		X	X	
	Opuntia engelmannii Salm-Dyck	cactus apple	X						X	
	Opuntia engelmannii Salm-Dyck *var. engelmannii*	cactus apple			X	X		X	X	
	Opuntia kleiniae DC.	candle cholla			X				X	
	Opuntia leptocaulis DC.	Christmas cactus			X	X		X	X	
	Opuntia macrocentra Engelm.	purple pricklypear							X	
	Opuntia macrocentra var. macrocentra Engelm.	purple pricklypear	X		X	X		X	X	
	Opuntia martiniana (L. Benson) Parfitt	seashore cactus							X	
	Opuntia phaeacantha var. major Engelm.	Mojave pricklypear	X		X	X		X	X	
	Opuntia santa-rita (Griffiths & Hare) Rose	Santa Rita pricklypear				X				
	Opuntia spinosior (Engelm.) Toumey	walkingstick cactus	X		X	X		X	X	
	Opuntia ?tetracantha Toumey (pro sp.)	[acanthocarpa ? leptocaulis]				X		X		
	Peniocereus greggii var. greggii (Engelm.) Britt. & Rose	nightblooming cereus			X	X		X	X	

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Cactaceae	*Peniocereus greggii var. greggii* (Engelm.) Britt. & Rose	nightblooming cereus			X	X		X	X	
Campanulaceae	*Nemacladus glanduliferus* Jepson	glandular threadplant	X							
	Triodanis perfoliata (L.) Nieuwl.	clasping Venus' looking-glass			X			X	X	
	Triodanis perfoliata var. perfoliata (L.) Nieuwl.	clasping Venus' looking-glass				X				
Capparaceae	*Polanisia dodecandra* (L.) DC.	redwhisker clammyweed			X				X	
	Polanisia dodecandra ssp. trachysperma (Torr. & Gray) Iltis	sandyseed clammyweed				X		X		
Caryophyllaceae	*Silene antirrhina* L.	sleepy silene	X							
Chenopodiaceae	*Atriplex canescens* (Pursh) Nutt.	fourwing saltbush			X	X		X	X	
	Atriplex elegans (Moq.) D. Dietr.	wheelscale saltbush			X			X	X	
	Atriplex elegans (Moq.) D. Dietr. var. elegans	wheelscale saltbush				X				
	Chenopodium desiccatum A. Nels.	aridland goosefoot			X				X	
	Chenopodium fremontii S. Wats.	Fremont's goosefoot			X			X	X	
	Chenopodium fremontii S. Wats. *var. fremontii*	Fremont's goosefoot				X				
	Chenopodium leptophyllum (Moq.) Nutt. ex S. Wats.	narrowleaf goosefoot				X				
	***Chenopodium murale* L.**	**nettleleaf goosefoot**				**X**			**X**	
	Chenopodium pratericola Rydb.	desert goosefoot	X					X		
	Chenopodium watsonii A. Nels.	Watson's goosefoot			X	X		X	X	
	Krascheninnikovia lanata (Pursh) A.D.J. Meeuse & Smit	winterfat	X		X	X	X	X	X	
	***Salsola kali* L.**	**Russian thistle**	**X**			**X**				
	***Salsola tragus* L.**	**prickly Russian thistle**			**X**			**X**	**X**	
Commelinaceae	*Commelina dianthifolia* Delile	birdbill dayflower			X	X		X	X	
Convolvulaceae	***Convolvulus arvensis* L.**	**field bindweed**	**X**		**X**	**X**			**X**	
	Convolvulus equitans Benth.	Texas bindweed						X	X	
	Evolvulus nuttallianus J.A. Schultes	shaggy dwarf morning-glory	X							
	Evolvulus sericeus Sw.	silver dwarf morning-glory			X			X	X	
	Evolvulus sericeus var. sericeus Sw.	silver dwarf morning-glory				X				
	Ipomoea barbatisepala Gray	canyon morning-glory			X	X		X	X	
	***Ipomoea coccinea* L.**	**redstar**			**X**			**X**	**X**	
	***Ipomoea hederacea* Jacq.**	**ivyleaf morning-glory**						**X**		
	Ipomoea hederifolia L.	scarletcreeper				X		X		
	***Ipomoea purpurea* (L.) Roth**	**tall morning-glory**			**X**	**X**			**X**	**X**
Crassulaceae	*Sedum cockerellii* Britt.	Cockerell's stonecrop			X	X		X	X	
Cucurbitaceae	*Apodanthera undulata* Gray	melon loco			X	X		X	X	
	Cucurbita digitata Gray	fingerleaf gourd			X	X		X	X	
	Cucurbita foetidissima Kunth	Missouri gourd			X	X		X	X	

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Cucurbitaceae	*Marah gilensis* Greene	Gila manroot			X	X		X	X	
Cupressaceae	*Juniperus coahuilensis* (Martinez) Gaussen ex R.P. Adams	redberry juniper			X	X			X	
	Juniperus deppeana Steud.	alligator juniper			X	X		X	X	
	Juniperus monosperma (Engelm.) Sarg.	oneseed juniper	X				X	X		
Cyperaceae	*Carex* sp. L.	sedge					X			
	***Cyperus esculentus* L.**	**chufa flatsedge**			**X**	**X**		**X**	**X**	**X**
	Cyperus sphaerolepis Boeckl.	Rusby's flatsedge			X	X		X	X	
	Cyperus squarrosus L.	bearded flatsedge			X	X		X	X	
Dryopteridaceae	*Woodsia mexicana* Fée	phanerophlebia			X			X	X	
Ephedraceae	*Ephedra trifurca* Torr. ex S. Wats.	longleaf jointfir			X	X	X	X	X	
Ericaceae	*Arctostaphylos pringlei* Parry	Pringle manzanita				X			X	
	Arctostaphylos pungens Kunth	pointleaf manzanita	X		X	X		X	X	
Euphorbiaceae	*Acalypha neomexicana* Muell.-Arg.	New Mexico copperleaf	X		X	X		X	X	
	Chamaesyce albomarginata (Torr. & Gray) Small	whitemargin sandmat	X		X	X		X	X	
	Chamaesyce hyssopifolia (L.) Small	hyssopleaf sandmat			X	X		X	X	
	Chamaesyce revoluta (Engelm.) Small	threadstem sandmat	X		X	X		X	X	
	Chamaesyce serpyllifolia ssp. serpyllifolia (Pers.) Small	thymeleaf sandmat	X							
	Chamaesyce serrula (Engelm.) Woot. & Standl.	sawtooth sandmat	X							
	Chamaesyce stictospora (Engelm.) Small	slimseed sandmat			X	X		X	X	
	Croton pottsii var. pottsii (Klotzsch) Muell.-Arg.	leatherweed	X		X	X		X	X	
	Euphorbia bilobata Engelm.	blackseed spurge	X							
	Euphorbia exstipulata Engelm.	squareseed spurge	X							
	Euphorbia heterophylla L.	Mexican fireplant	X							
	Tragia nepetifolia Cav.	catnip noseburn			X				X	
	Tragia ramosa Torr.	branched noseburn	X			X		X	X	
Fabaceae	*Acacia angustissima* (P. Mill.) Kuntze	prairie acacia			X			X	X	
	Acacia angustissima var. suffrutescens (Rose) Isely	prairie acacia				X				
	Acacia constricta Benth.	whitethorn acacia			X	X	X	X	X	
	Acacia greggii Gray	catclaw acacia			X	X	X	X	X	
	Amorpha fruticosa L.	desert false indigo			X	X		X	X	
	Astragalus allochrous Gray	halfmoon milkvetch			X	X		X	X	
	Astragalus allochrous var. playanus Isely	halfmoon milkvetch			X	X		X	X	
	Astragalus arizonicus Gray	Arizona milkvetch			X	X		X	X	
	Astragalus calycosus Torr. ex S. Wats.	Torrey's milkvetch			X			X	X	
	Astragalus calycosus Torr. ex S. Wats. *var. calycosus*	Torrey's milkvetch				X				
	Astragalus nothoxys Gray	sheep milkvetch			X	X		X	X	

Family	Scientific name	Common name	UA	UA Herbarium[b]	WEA	BEA	RUL	H&R	NPS	H&G
Fabaceae	*Astragalus nuttallianus* DC.	smallflowered milkvetch			X			X	X	
	Astragalus nuttallianus var. austrinus (Small) Barneby	smallflowered milkvetch				X				
	Astragalus tephrodes Gray	ashen milkvetch			X	X		X	X	
	Astragalus thurberi Gray	Thurber's milkvetch			X	X		X	X	
	Caesalpinia drepanocarpa (Gray) Fisher	sicklepod holdback			X	X		X	X	
	Calliandra eriophylla Benth.	fairyduster	X		X	X	X	X	X	
	Calliandra humilis Benth.	dwarf stickpea						X		
	Calliandra humilis Benth. *var. humilis*	dwarf stickpea			X	X			X	
	Calliandra humilis var. reticulata (Gray) L. Benson	dwarf stickpea			X	X		X	X	
	Chamaecrista nictitans (L.) Moench	partridge pea	X							
	Crotalaria pumila Ortega	low rattlebox	X							
	Dalea albiflora Gray	whiteflower prairie clover			X	X		X	X	
	Dalea candida var. oligophylla (Torr.) Shinners	white prairie clover	X							
	Dalea formosa Torr.	featherplume	X		X	X	X	X	X	
	Dalea nana Torr. ex Gray	dwarf prairie clover			X			X	X	
	Dalea nana var. carnescens Kearney & Peebles	dwarf prairie clover				X				
	Dalea nana Torr. ex Gray var. nana	dwarf prairie clover	X							
	Dalea pogonathera Gray	bearded prairie clover			X	X		X	X	
	Dalea pringlei Gray	Pringle's prairie clover	X							
	Dalea versicolor Zucc.	oakwoods prairie clover			X				X	
	Dalea versicolor var. sessilis (Gray) Barneby	oakwoods prairie clover	X			X		X		
	Dalea wrightii Gray	Wright's prairie clover	X		X	X		X	X	
	Desmanthus cooleyi (Eat.) Trel.	Cooley's bundleflower	X		X	X		X	X	
	Desmanthus virgatus (L.) Willd.	wild tantan							X	
	Desmanthus virgatus var. depressus (Humb. & Bonpl. ex Willd.) B.L. Turner	wild tantan				X				
	Desmodium neomexicanum Gray	New Mexico ticktrefoil	X							
	Desmodium procumbens (P. Mill.) A.S. Hitchc.	western trailing ticktrefoil			X			X	X	
	Desmodium procumbens var. exiguum (Gray) Schub.	western trailing ticktrefoil				X				
	Erythrina flabelliformis Kearney	coralbean					X			
	Galactia wrightii Gray	Wright's milkpea		X	X			X	X	
	Galactia wrightii var. mollissima Kearney & Peebles					X				
	Hoffmannseggia glauca (Ortega) Eifert	Indian rushpea			X	X		X	X	
	Lotus greenei Ottley ex Kearney & Peebles	Greene's bird's-foot trefoil			X	X		X	X	
	Lotus humistratus Greene	foothill deervetch			X	X			X	
	Lotus plebeius (Brand) Barneby	New Mexico bird's-foot trefoil			X	X		X	X	
	Lotus rigidus (Benth.) Greene	shrubby deervetch			X	X		X	X	

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Fabaceae	*Lotus wrightii* (Gray) Greene	Wright's deervetch			X	X		X	X	
	Lupinus brevicaulis S. Wats.	shortstem lupine			X	X		X	X	
	Lupinus concinnus J.G. Agardh	scarlet lupine			X	X		X	X	
	Lupinus sparsiflorus Benth.	Mojave lupine			X	X		X	X	
	***Macroptilium gibbosifolium* (Ortega) A. Delgado**	**variableleaf bushbean**	**X**		**X**	**X**		**X**	**X**	
	Marina calycosa (Gray) Barneby	San Pedro false prairie-clover			X	X		X	X	
	Mimosa aculeaticarpa Ortega	catclaw mimosa	X							
	Mimosa aculeaticarpa var. biuncifera (Benth.) Barneby	catclaw mimosa			X	X	X	X	X	
	Phaseolus acutifolius Gray	tepary bean	X		X			X	X	
	Phaseolus acutifolius var. tenuifolius Gray	tepary bean				X				
	Prosopis glandulosa Torr.	honey mesquite	X					X		
	Prosopis glandulosa var. torreyana (L. Benson) M.C. Johnston	western honey mesquite			X	X			X	
	Prosopis velutina Woot.	velvet mesquite			X	X	X	X	X	
	Rhynchosia senna var. texana (Torr. & Gray) M.C. Johnston	Texas snoutbean			X	X		X	X	
	Robinia neomexicana Gray	New Mexico locust			X			X	X	
	Robinia neomexicana Gray *var. neomexicana*	New Mexico locust				X				
	Senna bauhinioides (Gray) Irwin & Barneby	twinleaf senna			X	X		X	X	
	Senna covesii (Gray) Irwin & Barneby	Coves' cassia				X			X	
	Vicia ludoviciana ssp. ludoviciana Nutt.	Louisiana vetch				X		X	X	
	Vicia pulchella Kunth	sweetclover vetch			X	X		X	X	
Fagaceae	*Quercus arizonica* Sarg.	Arizona white oak	X		X	X		X	X	
	Quercus dunnii Kellogg	Palmer oak			X	X		X	X	
	Quercus emoryi Torr.	Emory oak	X		X	X	X	X	X	
	Quercus grisea Liebm.	gray oak	X		X	X		X	X	
	Quercus hypoleucoides A. Camus	silverleaf oak			X	X		X	X	
	Quercus pungens Liebm.	pungent oak	X		X	X		X	X	
	Quercus rugosa Née	netleaf oak			X	X		X	X	
	Quercus toumeyi Sarg.	Toumey oak			X	X		X	X	
	Quercus turbinella Greene	Sonoran scrub oak			X	X		X	X	
Fouquieriaceae	*Fouquieria splendens* Engelm.	ocotillo	X		X	X	X	X	X	
Fumariaceae	*Corydalis aurea* Willd.	scrambled eggs	X		X			X	X	
	Corydalis curvisiliqua ssp. occidentalis (Engelm. ex Gray) W.A. Weber	curvepod fumewort				X				
Garryaceae	*Garrya flavescens* S. Wats.	ashy silktassel				X			X	
	Garrya wrightii Torr.	Wright's silktassel	X		X	X		X	X	
Geraniaceae	***Erodium cicutarium* (L.) L'Hér. ex Ait.**	**redstem stork's bill**	**X**		**X**			**X**	**X**	**X**
	***Erodium cicutarium ssp. jacquinianum* (Fisch., C.A. Mey. & Avé-Lall.) Briq.**	**redstem stork's bill**				**X**				

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Geraniaceae	*Erodium texanum* Gray	Texas stork's bill			X	X		X	X	
Hydrangeaceae	*Fendlera rupicola* Gray	cliff fendlerbush			X	X		X	X	
Hydrophyllaceae	*Nama hispidum* Gray	bristly nama			X	X		X	X	
	Phacelia arizonica Gray	Arizona phacelia			X	X		X	X	
	Phacelia congesta Hook.	caterpillars			X	X			X	
	Phacelia crenulata Torr. ex S. Wats.	cleftleaf wildheliotrope	X		X	X		X	X	
	Phacelia rupestris Greene	rock phacelia						X	X	
Juglandaceae	*Juglans major* (Torr.) Heller	Arizona walnut	X		X	X	X	X	X	
Juncaceae	*Juncus bufonius* L.	toad rush						X	X	
	Juncus drummondii E. Mey.	Drummond's rush			X	X			X	
	Juncus saximontanus A. Nels.	Rocky Mountain rush			X	X		X	X	
	Juncus tenuis Willd.	poverty rush			X			X	X	
Krameriaceae	*Krameria erecta* Willd. ex J.A. Schultes	littleleaf ratany					X			
	Krameria lanceolata Torr.	trailing krameria			X			X	X	
Lamiaceae	*Hedeoma drummondii* Benth.	Drummond's false pennyroyal			X	X		X	X	
	Hedeoma hyssopifolia Gray	aromatic false pennyroyal				X		X	X	
	Hedeoma nana (Torr.) Briq. *ssp. nana*	dwarf false pennyroyal				X				
	Hedeoma nanum (Torrey) Briq.				X			X	X	
	Hedeoma oblongifolia (Gray) Heller	oblongleaf false pennyroyal	X							
Lamiaceae	***Lamium amplexicaule* L.**	**henbit deadnettle**			**X**	**X**		**X**	**X**	
	***Marrubium vulgare* L.**	**horehound**	**X**		**X**	**X**		**X**	**X**	**X**
	Salvia columbariae Benth.	chia	X		X	X		X	X	
	Salvia henryi Gray	crimson sage			X	X		X	X	
	Salvia lemmonii Gray	Lemmon's sage			X	X		X	X	
	Salvia subincisa Benth.	sawtooth sage	X		X	X		X	X	
	Stachys coccinea Ortega	scarlet hedgenettle			X	X		X	X	
	Trichostema arizonicum Gray	Arizona bluecurls	X		X	X		X	X	
Liliaceae	*Allium acuminatum* Hook.	tapertip onion				X			X	
	Allium macropetalum Rydb.	largeflower onion			X	X		X	X	
	Calochortus ambiguus (M.E. Jones) Ownbey	doubting mariposa lily			X	X		X	X	
	Dasylirion wheeleri S. Wats.	common sotol	X		X	X	X	X	X	
	Dichelostemma capitatum (Benth.) Wood *ssp. capitatum*	wild hyacinth			X	X		X	X	
	Echeandia flavescens (J.A. & J.H. Schultes) Cruden	Torrey's craglily			X	X		X	X	
	Nolina microcarpa S. Wats.	sacahuista	X		X	X	X	X	X	
	Zephyranthes longifolia Hemsl.	copper zephyrlily			X	X		X	X	

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Linaceae	*Linum lewisii* Pursh	prairie flax			X			X	X	
	Linum lewisii Pursh *var. lewisii*	prairie flax				X				
	Linum puberulum (Engelm.) Heller	plains flax			X	X		X	X	
	***Linum usitatissimum* L.**	**common flax**			**X**	**X**		**X**	**X**	
Loasaceae	*Cevallia sinuata* Lag.	stinging serpent	X		X	X		X	X	
	Mentzelia albicaulis (Dougl. ex Hook.) Dougl. ex Torr. & Gray	whitestem blazingstar	X		X	X		X	X	
	Mentzelia multiflora (Nutt.) Gray	Adonis blazingstar	X		X				X	
	Mentzelia multiflora var. integra M.E. Jones	Adonis blazingstar				X				
	Mentzelia pumila Nutt. ex Torr. & Gray	dwarf mentzelia						X		
Malpighiaceae	*Janusia gracilis* Gray	slender janusia			X	X	X	X	X	
Malvaceae	*Abutilon parvulum* Gray	dwarf Indian mallow			X	X		X	X	
	Gossypium thurberi Todaro	Thurber's cotton					X			
	Malvella lepidota (Gray) Fryxell	scurfymallow			X	X		X	X	
	Rhynchosida physocalyx (Gray) Fryxell	buffpetal			X	X		X	X	
	***Sida abutifolia* P. Mill.**	**spreading fanpetals**	**X**		**X**	**X**		**X**	**X**	
	Sphaeralcea hastulata Gray	spear globemallow			X	X		X	X	
	Sphaeralcea laxa Woot. & Standl.	caliche globemallow	X		X	X		X	X	
	Sphaeralcea wrightii Gray	Wright's globemallow				X			X	
Moraceae	*Morus microphylla* Buckl.	Texas mulberry	X	X	X	X		X	X	
Nyctaginaceae	*Allionia incarnata* L.	trailing windmills	X		X	X		X	X	
	Boerhavia coccinea P. Mill.	scarlet spiderling						X		X
	Boerhavia coulteri (Hook. f.) S. Wats.	Coulter's spiderling				X				
	Boerhavia diffusa L.	red spiderling			X	X			X	
	Boerhavia erecta L.	erect spiderling						X	X	
	Boerhavia intermedia M.E. Jones	fivewing spiderling			X	X			X	
	Boerhavia purpurascens Gray	purple spiderling	X		X	X		X	X	
	Boerhavia spicata Choisy	creeping spiderling	X		X	X		X	X	
	Mirabilis albida (Walt.) Heimerl	white four o'clock	X		X	X			X	
	Mirabilis bigelovii Gray	wishbone-bush			X			X	X	
	Mirabilis bigelovii Gray *var. bigelovii*	wishbone-bush				X				
	Mirabilis coccinea (Torr.) Benth. & Hook. f.	scarlet four o'clock			X	X		X	X	
	Mirabilis comata (Small) Standl.	hairy-tuft four o'clock						X		
	Mirabilis linearis (Pursh) Heimerl	narrowleaf four o'clock	X		X	X		X	X	
	Mirabilis longiflora L.	sweet four o'clock			X	X		X	X	
	Mirabilis multiflora (Torr.) Gray	Colorado four o'clock			X			X	X	
	Mirabilis multiflora (Torr.) Gray *var. multiflora*	Colorado four o'clock				X				

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Nyctaginaceae	*Mirabilis pumila* (Standl.) Standl.	dwarf four o'clock			X	X		X	X	
Oleaceae	*Fraxinus velutina* Torr.	velvet ash	X		X	X	X	X	X	
	Menodora scabra Gray	rough menodora			X	X		X	X	
Onagraceae	*Calylophus hartwegii* (Benth.) Raven	Hartweg's sundrops			X			X	X	
	Calylophus hartwegii ssp. pubescens (Gray) Towner & Raven	Hartweg's sundrops				X				
	Camissonia californica (Nutt. ex Torr. & Gray) Raven	California suncup			X	X		X	X	
	Camissonia contorta (Dougl. ex Lehm.) Kearney	plains evening-primrose			X			X	X	
	Epilobium canum ssp. latifolium (Hook.) Raven	hummingbird trumpet			X	X		X	X	
	Epilobium ciliatum ssp. ciliatum Raf.	fringed willowherb	X							
	Gaura hexandra ssp. gracilis (Woot. & Standl.) Raven & Gregory	harlequinbush			X	X		X	X	
	Oenothera brachycarpa Gray	shortfruit evening-primrose	X		X	X		X	X	
	Oenothera caespitosa Nutt.	tufted evening-primrose			X			X	X	
	Oenothera caespitosa ssp. caespitosa Nutt.	tufted evening-primrose				X				
	Oenothera elata ssp. hirsutissima (Gray ex S. Wats.) W. Dietr.	Hooker's evening-primrose				X				
	Oenothera elata ssp. hookeri (Torr. & Gray) W. Dietr. & W.L. Wagner	Hooker's evening-primrose							X	
	Oenothera pallida ssp. runcinata (Engelm.) Munz & W. Klein	pale evening-primrose			X	X		X	X	
	Oenothera primiveris Gray	desert evening-primrose			X	X		X	X	
Orobanchaceae	*Orobanche cooperi* (Gray) Heller	desert broomrape			X	X			X	
	Orobanche ludoviciana Nutt.	Louisiana broomrape						X		
Papaveraceae	*Argemone pleiacantha* Greene	southwestern pricklypoppy						X		
	Argemone pleiacantha ssp. pinnatisecta G.B. Ownbey	southwestern pricklypoppy			X				X	
	Argemone pleiacantha Greene *ssp. pleiacantha*	southwestern pricklypoppy				X				
	Eschscholzia californica ssp. mexicana (Greene) C. Clark	California poppy	X		X	X		X	X	
Pedaliaceae	*Proboscidea parviflora* (Woot.) Woot. & Standl.	doubleclaw			X	X		X	X	
Pinaceae	*Pinus cembroides* Zucc.	Mexican pinyon						X		
	Pinus discolor D.K. Bailey & Hawksworth	border pinyon			X	X			X	
	Pinus edulis Engelm.	twoneedle pinyon	X	X	X	X		X	X	
	Pinus monophylla Torr. & Frém.	singleleaf pinyon			X				X	
	Pinus monophylla var. fallax (Little) Silba	singleleaf pinyon				X				
Plantaginaceae	*Plantago patagonica* Jacq.	woolly plantain	X		X	X		X	X	
Platanaceae	*Platanus wrightii* S. Wats.	Arizona sycamore					X			
Poaceae	*Aristida adscensionis* L.	sixweeks threeawn	X		X	X		X	X	
	Aristida pansa Woot. & Standl.	Wooton's threeawn		X						
	Aristida purpurea Nutt.	purple threeawn			X		X	X	X	
	Aristida purpurea var. longiseta (Steud.) Vasey	Fendler threeawn			X	X		X	X	
	Aristida purpurea var. nealleyi (Vasey) Allred	blue threeawn		X	X	X		X	X	

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Poaceae	*Aristida purpurea var. purpurea* Nutt.	purple threeawn				X				
	Aristida ternipes var. gentilis (Henr.) Allred	spidergrass			X	X		X	X	
	Aristida ternipes Cav.	spidergrass			X			X	X	
	Aristida ternipes Cav. *var. ternipes*	spidergrass	X							
	Avena fatua L.	oat								X
	Bothriochloa barbinodis (Lag.) Herter	cane bluestem	X		X	X	X	X	X	
	Bothriochloa saccharoides (Sw.) Rydb.	silver bluestem			X			X	X	
	Bouteloua aristidoides (Kunth) Griseb.	needle grama			X	X		X	X	
	Bouteloua barbata Lag.	sixweeks grama			X	X	X	X	X	
	Bouteloua chondrosioides (Kunth) Benth. ex S. Wats.	sprucetop grama		X	X	X	X	X	X	
	Bouteloua curtipendula (Michx.) Torr.	sideoats grama	X		X	X	X	X	X	
	Bouteloua eriopoda (Torr.) Torr.	black grama	X		X	X	X	X	X	
	Bouteloua gracilis (Willd. ex Kunth) Lag. ex Griffiths	blue grama	X		X	X	X	X	X	
	Bouteloua hirsuta Lag.	hairy grama	X		X		X	X	X	
	Bouteloua hirsuta Lag. *var. hirsuta*	hairy grama				X				
	Bouteloua repens (Kunth) Scribn. & Merr.	slender grama	X	X	X	X	X	X	X	
	Bromus carinatus Hook. & Arn.	California brome								X
	***Bromus rubens* L.**	**red brome**	**X**							**X**
	***Bromus tectorum* L.**	**cheatgrass**			**X**	**X**		**X**	**X**	
	Cenchrus spinifex Cav.	coastal sandbur			X	X		X	X	
	Chloris virgata Sw.	feather fingergrass	X		X	X		X	X	X
	***Cynodon dactylon* (L.) Pers.**	**Bermudagrass**			**X**	**X**		**X**	**X**	**X**
	Dasyochloa pulchella (Kunth) Willd. ex Rydb.	low woollygrass	X		X	X		X	X	
	Digitaria californica (Benth.) Henr.	Arizona cottontop	X		X	X	X	X	X	
	Digitaria cognata (J.A. Schultes) Pilger	Carolina crabgrass			X	X			X	
	Digitaria cognata (J.A. Schultes) Pilger *var. cognata*	Carolina crabgrass					X	X	X	
	Digitaria sanguinalis (L.) Scop.	hairy crabgrass			X	X		X	X	
	***Echinochloa colona* (L.) Link**	**jungle rice**	**X**		**X**	**X**		**X**	**X**	**X**
	***Echinochloa crus-galli* (L.) Beauv.**	**barnyardgrass**			**X**	**X**		**X**	**X**	
	Elymus elymoides (Raf.) Swezey	squirreltail	X			X				
	Elymus elymoides ssp. elymoides (Raf.) Swezey	squirreltail			X			X	X	
	Enneapogon desvauxii Desv. ex Beauv.	nineawn pappusgrass	X		X	X		X	X	
	***Eragrostis cilianensis* (All.) Vign. ex Janchen**	**stinkgrass**	**X**		**X**	**X**		**X**	**X**	**X**
	***Eragrostis curvula* (Schrad.) Nees**	**weeping lovegrass**	**X**	**X**						**X**
	Eragrostis intermedia A.S. Hitchc.	plains lovegrass	X		X	X	X	X	X	

Family	Scientific name	Common name	UA	UA Herbarium[b]	WEA	BEA	RUL	H&R	NPS	H&G
Poaceae	***Eragrostis lehmanniana* Nees**	**Lehmann lovegrass**	**X**		**X**	**X**		**X**	**X**	**X**
	Eragrostis pectinacea (Michx.) Nees ex Steud.	tufted lovegrass			X				X	
	Eragrostis pectinacea var. miserrima (Fourn.) J. Reeder	desert lovegrass			X	X		X	X	
	Eragrostis pectinacea (Michx.) Nees ex Steud. *var. pectinacea*	tufted lovegrass						X		
	Eriochloa acuminata (J. Presl) Kunth	tapertip cupgrass	X	X						
	Eriochloa lemmonii Vasey & Scribn.	canyon cupgrass			X	X		X	X	
	Erioneuron avenaceum (Kunth) Tateoka	shortleaf woollygrass	X	X	X			X	X	
	Hesperostipa neomexicana (Thurb. ex Coult.) Barkworth	New Mexico feathergrass			X	X		X	X	
	Heteropogon contortus (L.) Beauv. ex Roemer & J.A. Schultes	tanglehead	X	X	X	X	X	X	X	
	Hilaria belangeri (Steud.) Nash	curly-mesquite			X		X	X	X	
	Hilaria belangeri (Steud.) Nash *var. belangeri*	curly-mesquite				X				
	***Hordeum murinum ssp. leporinum* (Link) Arcang.**	**leporinum barley**			**X**	**X**		**X**	**X**	
	Koeleria macrantha (Ledeb.) J.A. Schultes	prairie Junegrass			X	X	X	X	X	
	Leptochloa dubia (Kunth) Nees	green sprangletop	X		X	X	X	X	X	
	Lycurus phleoides Kunth	common wolfstail			X		X	X	X	
	Lycurus setosus (Nutt.) C.G. Reeder	bristly wolfstail	X			X				
	Muhlenbergia arenacea (Buckl.) A.S. Hitchc.	ear muhly			X	X		X	X	
	Muhlenbergia arenicola Buckl.	sand muhly	X		X	X		X	X	
	Muhlenbergia emersleyi Vasey	bullgrass	X		X	X		X	X	
	Muhlenbergia fragilis Swallen	delicate muhly	X							
	Muhlenbergia porteri Scribn. ex Beal	bush muhly	X		X	X	X	X	X	
	Muhlenbergia repens (J. Presl) A.S. Hitchc.	creeping muhly			X	X		X	X	
	Muhlenbergia rigens (Benth.) A.S. Hitchc.	deergrass	X			X			X	
	Panicum capillare L.	witchgrass			X	X		X	X	
	Panicum hallii Vasey	Hall's panicgrass			X			X	X	
	Panicum hallii Vasey *var. hallii*	Hall's panicgrass				X				
	Panicum hirticaule J. Presl	Mexican panicgrass	X							
	Panicum obtusum Kunth	vine mesquite	X		X	X		X	X	
	Phalaris sp. L.	canarygrass								X
	Pleuraphis mutica Buckl.	tobosagrass			X	X		X	X	
	***Poa annua* L.**	**annual bluegrass**			**X**	**X**		**X**	**X**	
	***Polypogon viridis* (Gouan) Breistr.**	**beardless rabbitsfoot grass**			**X**	**X**			**X**	
	Schizachyrium cirratum (Hack.) Woot. & Standl.	Texas bluestem			X			X	X	
	Scleropogon brevifolius Phil.	burrograss			X			X	X	
	Setaria grisebachii Fourn.	Grisebach's bristlegrass	X		X			X	X	
	Setaria leucopila (Scribn. & Merr.) K. Schum.	streambed bristlegrass	X			X				

Family	Scientific name	Common name	UA	UA Herbarium[b]	WEA	BEA	RUL	H&R	NPS	H&G
Poaceae	*Setaria vulpiseta* (Lam.) Roemer & J.A. Schultes	plains bristlegrass			X	X	X	X	X	
	***Sorghum halepense* (L.) Pers.**	**Johnsongrass**								**X**
	Sporobolus airoides (Torr.) Torr.	alkali sacaton	X			X				
	Sporobolus contractus A.S. Hitchc.	spike dropseed	X		X	X	X	X	X	
	Sporobolus cryptandrus (Torr.) Gray	sand dropseed	X		X	X	X	X	X	
	Sporobolus wrightii Munro ex Scribn.	big sacaton			X			X	X	
	Stipa L.	needlegrass					X			
	Trachypogon spicatus (L.) Kuntze	spiked crinkleawn					X			
	Tragus berteronianus J.A. Schultes	spiked burr grass			X	X		X	X	
	Tridens muticus (Torr.) Nash	slim tridens	X	X	X		X	X	X	
	Tridens muticus var. muticus (Torr.) Nash	slim tridens				X				
	Urochloa arizonica (Scribn. & Merr.) O. Morrone & F. Zuloaga	Arizona signalgrass	X	X						
	Vulpia octoflora (Walt.) Rydb.	sixweeks fescue	X		X			X	X	
	Vulpia octoflora var. octoflora (Walt.) Rydb.	sixweeks fescue				X			X	
Polemoniaceae	*Allophyllum gilioides* (Benth.) A.& V. Grant	dense false gilyflower			X				X	
	Allophyllum gilioides (Benth.) A.& V. Grant *ssp. gilioides*	dense false gilyflower				X		X		
	Eriastrum diffusum (Gray) Mason	miniature woollystar	X		X	X		X	X	
	Gilia mexicana A.& V. Grant	El Paso gilia	X							
	Gilia ophthalmoides Brand	eyed gilia			X	X			X	
	Gilia sinuata Dougl. ex Benth.	rosy gilia			X	X		X	X	
	Ipomopsis longiflora (Torr.) V. Grant	flaxflowered ipomopsis			X			X	X	
	Ipomopsis longiflora (Torr.) V. Grant *ssp. longiflora*	flaxflowered ipomopsis				X				
	Ipomopsis multiflora (Nutt.) V. Grant	manyflowered ipomopsis			X	X		X	X	
	Linanthus aureus (Nutt.) Greene	golden linanthus	X		X	X		X	X	
	Phlox austromontana Coville	mountain phlox			X			X	X	
	Phlox austromontana Coville *ssp. austromontana*	mountain phlox				X				
	Phlox gracilis ssp. gracilis (Hook.) Greene	slender phlox			X	X		X	X	
	Phlox nana Nutt.	Santa Fe phlox			X				X	
	Phlox triovulata ex Torr.	threeseed phlox				X		X		
Polygalaceae	*Polygala barbeyana* Chod.	blue milkwort			X	X		X	X	
	Polygala barbeyana Chod. *ssp. barbeyana*		X							
	Polygala macradenia Gray	glandleaf milkwort			X	X		X	X	
	Eriogonum abertianum Torr.	Abert's buckwheat			X			X	X	
	Eriogonum abertianum Torr. *var. abertianum*	Abert's buckwheat				X				
	Eriogonum deflexum Torr.	flatcrown buckwheat			X			X	X	
	Eriogonum deflexum Torr. *var. deflexum*	flatcrown buckwheat				X				

Family	Scientific name	Common name	UA	UA Herbarium[b]	WEA	BEA	RUL	H&R	NPS	H&G
Polygonaceae	*Eriogonum jamesii* Benth.	James' buckwheat						X	X	
	Eriogonum jamesii var. undulatum (Benth.) S. Stokes ex M.E. Jones	James' buckwheat				X				
	Eriogonum polycladon Benth.	sorrel buckwheat	X	X	X	X		X	X	
	Eriogonum wrightii Torr. ex Benth.	bastardsage	X	X	X		X	X	X	
	Eriogonum wrightii var. wrightii Torr. ex Benth.	bastardsage				X				
	***Polygonum convolvulus* L.**	**black bindweed**			**X**			**X**	**X**	
	***Rumex crispus* L.**	**curly dock**			**X**	**X**		**X**	**X**	
	Rumex hymenosepalus Torr.	canaigre dock			X	X		X	X	
Portulacaceae	*Portulaca halimoides* L.	silkcotton purslane			X	X		X	X	
	Portulaca oleracea L.	little hogweed			X	X		X	X	
	Portulaca suffrutescens Engelm.	shrubby purslane			X	X		X	X	
	Portulaca umbraticola Kunth	wingpod purslane	X							
	Talinum aurantiacum Engelm.	orange fameflower	X		X	X		X	X	
	Talinum parviflorum Nutt.	sunbright			X	X		X	X	
Primulaceae	*Androsace occidentalis* Pursh	western rockjasmine				X				
Pteridaceae	*Argyrochosma limitanea ssp. limitanea* (Maxon) Windham	southwestern false cloakfern			X	X		X	X	
	Astrolepis sinuata (Lag. ex Sw.) Benham & Windham *ssp. sinuata*	wavy scaly cloakfern			X	X		X	X	
	Bommeria hispida (Mett. ex Kuhn) Underwood	copper fern			X	X		X	X	
	Cheilanthes eatonii Baker	Eaton's lipfern		X	X	X		X	X	
	Cheilanthes lindheimeri Hook.	fairyswords			X	X		X	X	
	Cheilanthes wootonii Maxon	beaded lipfern			X	X		X	X	
	Cheilanthes wrightii Hook.	Wright's lipfern			X	X		X	X	
	Notholaena standleyi Maxon	star cloak fern			X	X		X	X	
	Pellaea truncata Goodding	spiny cliffbrake			X	X		X	X	
Ranunculaceae	*Anemone tuberosa* Rydb.	desert anemone			X	X		X	X	
	Clematis drummondii Torr. & Gray	Drummond's clematis			X	X		X	X	
	Delphinium carolinianum ssp. virescens (Nutt.) Brooks	Carolina larkspur			X			X	X	
	Delphinium wootonii Rydb.	Organ Mountain larkspur				X				
Rhamnaceae	*Ceanothus fendleri* Gray	Fendler's ceanothus					X			
	Ceanothus greggii Gray	desert ceanothus			X			X	X	
	Ceanothus greggii var. vestitus (Greene) McMinn	Mojave ceanothus				X				
	Condalia spathulata Gray	squawbush				X		X		
	Condalia warnockii M.C. Johnston	Warnock's snakewood	X							
	Condalia warnockii var. kearneyana M.C. Johnston	Kearney's snakewood			X				X	
	Frangula californica ssp. californica (Eschsch.) Gray	California buckthorn			X			X	X	
	Frangula californica ssp. ursina (Greene) Kartesz & Gandhi	California buckthorn				X				

Family	Scientific name	Common name	UA	UA Herbarium[b]	WEA	BEA	RUL	H&R	NPS	H&G
Rhamnaceae	*Ziziphus obtusifolia* (Hook. ex Torr. & Gray) Gray	lotebush	X		X		X		X	
	Ziziphus obtusifolia var. canescens (Gray) M.C. Johnston	lotebush				X				
	Ziziphus obtusifolia var. obtusifolia (Hook. ex Torr. & Gray) Gray	lotebush						X		
Rosaceae	*Cercocarpus montanus* Raf.	alderleaf mountain mahogany	X							
	Cercocarpus montanus var. argenteus (Rydb.) F.L. Martin	silver mountain mahogany				X				
	Cercocarpus montanus var. glaber (S. Wats.) F.L. Martin	birchleaf mountain mahogany				X			X	
	Cercocarpus montanus var. paucidentatus (S. Wats.) F.L. Martin	hairy mountain mahogany			X			X	X	
	Fallugia paradoxa (D. Don) Endl. ex Torr.	Apache plume			X	X	X	X	X	
	Purshia mexicana (D. Don) Henrickson	Mexican cliffrose					X			
Rubiaceae	*Bouvardia ternifolia* (Cav.) Schlecht.	firecrackerbush			X	X		X	X	
	Diodia teres Walt.	poorjoe	X		X			X	X	
	Diodia teres var. angustata Gray	poorjoe				X				
	Galium proliferum Gray	limestone bedstraw	X		X	X		X	X	
	Galium stellatum Kellogg	starry bedstraw	X							
	Galium wrightii Gray	Wright's bedstraw	X		X	X		X	X	
	Houstonia rubra Cav.	red bluet				X		X		
Rutaceae	*Ptelea trifoliata* L.	common hoptree	X		X				X	
	Ptelea trifoliata ssp. angustifolia (Benth.) V. Bailey	common hoptree				X		X		
	Thamnosma texana (Gray) Torr.	Texas rue	X		X	X		X	X	
Salicaceae	*Populus fremontii* S. Wats.	Fremont cottonwood			X		X	X	X	
	Populus fremontii S. Wats. *ssp. fremontii*	Fremont cottonwood				X				
	Salix bonplandiana Kunth	Bonpland willow							X	
	Salix exigua Nutt.	narrowleaf willow			X	X	X	X	X	
	Salix gooddingii Ball	Goodding's willow			X	X	X	X	X	
Santalaceae	*Comandra umbellata ssp. pallida* (A. DC.) Piehl	pale bastard toadflax			X			X	X	
Sapindaceae	*Sapindus saponaria* L.	wingleaf soapberry	X					X		
	Sapindus saponaria var. drummondii (Hook. & Arn.) L. Benson	western soapberry			X	X	X		X	
Sapotaceae	*Sideroxylon lanuginosum* Michx.	gum bully	X	X						
	Sideroxylon lanuginosum ssp. rigidum (Gray) T.D. Pennington	gum bully			X	X		X	X	
Saxifragaceae	*Heuchera sanguinea* Engelm.	coralbells			X	X		X	X	
Scrophulariaceae	*Castilleja austromontana* Standl. & Blumer	Rincon Mountain Indian paintbrush			X	X		X	X	
	Castilleja integra Gray	wholeleaf Indian paintbrush			X			X	X	
	Castilleja integra var. gloriosa (Britt.) Cockerell	wholeleaf Indian paintbrush				X				
	Castilleja lanata Gray	Sierra woolly Indian paintbrush	X		X	X		X	X	
	Castilleja sessiliflora Pursh	downy paintedcup			X	X		X	X	
	Castilleja tenuiflora Benth.	Santa Catalina Indian paintbrush				X				

Family	Scientific name	Common name	UA	UA Herbarium[b]	WEA	BEA	RUL	H&R	NPS	H&G
Scrophulariaceae	***Linaria dalmatica* (L.) P. Mill.**	**Dalmatian toadflax**				**X**		**X**		
	***Linaria genistifolia* (L.) P. Mill.**	**broomleaf toadflax**			**X**				**X**	
	Maurandella antirrhiniflora (Humb. & Bonpl. ex Willd.) Rothm.	roving sailor	X		X	X		X	X	
	Mimulus guttatus DC.	seep monkeyflower	X		X	X		X	X	
	Mimulus rubellus Gray	little redstem monkeyflower			X	X		X	X	
	Pedicularis procera Gray	giant lousewort			X	X		X	X	
	Penstemon barbatus (Cav.) Roth	beardlip penstemon			X			X	X	
	Penstemon barbatus ssp. torreyi (Benth.) Keck	Torrey's penstemon				X				
	Penstemon linarioides Gray	toadflax penstemon	X		X			X	X	
	Penstemon linarioides Gray *ssp. linarioides*	toadflax beardtongue				X				
	Penstemon ramosus Crosswhite	lanceleaf beardtongue			X	X		X	X	
	***Verbascum virgatum* Stokes**	**wand mullein**	**X**							
	Veronica peregrina L.	neckweed			X			X	X	
	Veronica peregrina ssp. xalapensis (Kunth) Pennell	hairy purslane speedwell				X				
Solanaceae	*Chamaesaracha coronopus* (Dunal) Gray	greenleaf five eyes			X	X		X	X	
	Chamaesaracha sordida (Dunal) Gray	hairy five eyes	X		X	X		X	X	
	***Datura inoxia* P. Mill.**	**pricklyburr**			**X**				**X**	
	Datura wrightii Regel	sacred thorn-apple	X			X		X		
	Lycium fremontii Gray	Fremont's desert-thorn			X	X		X	X	
	Lycium pallidum Miers	pale desert-thorn			X	X	X	X	X	
	Margaranthus solanaceus Schlecht.	netted globecherry	X							
	Nicotiana obtusifolia Mertens & Galeotti	desert tobacco	X							
	Nicotiana obtusifolia var. obtusifolia Mertens & Galeotti	desert tobacco			X	X		X	X	
	Physalis acutifolia (Miers) Sandw.	sharpleaf groundcherry			X	X		X	X	
	Physalis hederifolia var. fendleri (Gray) Cronq.	Fendler's groundcherry			X	X		X	X	
	Physalis longifolia Nutt. *var. longifolia*	longleaf groundcherry			X	X			X	
	Solanum americanum P. Mill.	American black nightshade			X	X		X	X	
	Solanum elaeagnifolium Cav.	silverleaf nightshade			X	X		X	X	
Sterculiaceae	*Ayenia filiformis* S. Wats.	TransPecos ayenia	X							
Tamaricaceae	*Tamarix* sp. L.	tamarisk								X
Ulmaceae	*Celtis laevigata var. reticulata* (Torr.) L. Benson	netleaf hackberry	X		X	X	X	X	X	
	Celtis pallida Torr.	spiny hackberry					X			
Verbenaceae	*Aloysia wrightii* Heller ex Abrams	Wright's beebrush	X	X	X	X		X	X	
	Glandularia bipinnatifida (Nutt.) Nutt.	Dakota mock vervain		X	X				X	
	Glandularia bipinnatifida var. bipinnatifida (Nutt.) Nutt.	Dakota mock vervain				X		X		
	Glandularia wrightii (Gray) Umber	Davis Mountain mock vervain	X		X	X		X	X	

Family	Scientific name	Common name	UA	UA Herbarium[b]	WEA	BEA	RUL	H&R	NPS	H&G
Verbenaceae	*Tetraclea coulteri* Gray	Coulter's wrinklefruit			X	X		X	X	
Violaceae	*Verbena gracilis* Desf.	Fort Huachuca vervain			X	X		X	X	
	Hybanthus verticillatus (Ortega) Baill.	babyslippers			X			X	X	
	Hybanthus verticillatus (Ortega) Baill. *var. verticillatus*	babyslippers				X				
Viscaceae	*Phoradendron bolleanum* (Seem.) Eichl.	Bollean mistletoe						X	X	
	Phoradendron californicum Nutt.	mesquite mistletoe			X	X		X	X	
	Phoradendron capitellatum Torr. ex Trel.	downy mistletoe			X	X			X	
	Phoradendron coryae Trel.	Cory's mistletoe			X	X		X	X	
	Phoradendron pauciflorum Torr.	fir mistletoe				X				
Vitaceae	*Vitis arizonica* Engelm.	canyon grape	X		X	X	X	X	X	
Zygophyllaceae	*Kallstroemia grandiflora* Torr. ex Gray	Arizona poppy			X	X		X	X	
	Kallstroemia parviflora J.B.S. Norton	warty caltrop			X	X		X	X	
	Larrea tridentata (Sessé & Moc. ex DC.) Coville	creosote bush			X			X	X	
	Larrea tridentata var. tridentata (Sessé & Moc. ex DC.) Coville	creosote bush	X			X				
	***Tribulus terrestris* L.**	**puncturevine**			**X**	**X**		**X**	**X**	**X**

[a] This list includes many species (n = 54) for which we included separate lines for specimens that were identified to species only and specimens that were identified to its nominate species (e.g., *Guilleminea densa* and *Guilleminea densa* var. *densa*). In these cases we do not determine these to be separate species in the tally of the number of species for the park or number of new species.

[b] Specimens at the University of Arizona Herbarium. Specimens date from 1902–1994.

Appendix B. Amphibians and reptiles observed or documented at Fort Bowie NHS by University of Arizona (UA) personnel, Swann et al. (2001; Swann), Lowe and Johnson (1976; L&J), and from voucher specimens reported in Appendix E (AE). "Possible" species have not been observed or documented in the park, but may occur based on habitat and range (reported in Swann et al. [2001]).

				Observed or documented				
Order	Family	Scientific name	Common name	UA	Swann	L&J	AE	Possible
Caudata	Ambystomatidae	*Ambystoma tigrinum mavortium*	barred tiger salamander					X
Anura	Pelobatidae	*Scaphiopus couchii*	Couch's spadefoot		X	X		
		Spea bombifrons	plains spadefoot			X		X
		Spea multiplicata	Mexican spadefoot		X	X		
	Bufonidae	*Bufo punctatus*	red-spotted toad		X	X		
		Bufo cognatus	Great Plains toad		X	X		
		Bufo alvarius	Sonoran desert toad					X
		Bufo woodhousii	Woodhouse's toad					X
		Bufo debilis	Green toad			X		
	Hylidae	*Hyla arenicolor*	canyon treefrog		X	X		
	Ranidae	*Rana catesbeiana*	American bullfrog					X
		Rana chiricahuensis[a]	Chiricahua leopard frog		X	X		
		Rana blairi	plains leopard frog					X
Testudines	Kinosternidae	*Kinosternon flavescens*	yellow mud turtle					X
		Kinosternon sonoriense	Sonoran mud turtle					X
	Emydidae	*Terrapene ornata*	western box turtle			X		X
	Testudinidae	*Gopherus agassizii sonoran*[b]	Sonoran desert tortoise					X
Squamata	Eublepharidae	*Coleonyx variegatus*	western banded gecko		X	X		
	Crotaphytidae	*Crotaphytus collaris*	eastern collared lizard		X	X	X	
		Gambelia wislizenii	long-nosed leopard lizard					X
	Phrynosomatidae	*Holbrookia maculata*	lesser earless lizard	X				
		Cophosaurus texanus	greater earless lizard	X	X	X		
		Callisaurus draconoides	zebra-tailed lizard					X
		Sceloporus clarkii	Clark's spiny lizard		X		X	
		Sceloporus virgatus	striped plateau lizard	X				
		Sceloporus slevini	Slevin's bunchgrass lizard					X
		Sceloporus jarrovii	mountain spiny lizard					X
		Sceloporus magister	desert spiny lizard					X
		Sceloporus undulatus	eastern fence lizard					X
		Urosaurus ornatus	ornate tree lizard	X	X	X	X	
		Uta stansburiana	common side-blotched lizard					X
		Phrynosoma cornutum	Texas horned lizard		X	X		
		Phrynosoma douglasii	pygmy short-horned lizard		X	X		
		Phrynosoma modestum	round-tailed horned lizard		X	X		
		Phrynosoma solare	regal horned lizard					X
	Scincidae	*Eumeces obsoletus*	Great Plains skink		X	X		
	Teiidae	*Cnemidophorus uniparens*	desert grassland whiptail		X	X		
		Cnemidophorus exsanguis	Chihuahuan spotted whiptail		X		X	
		Cnemidophorus sonorae	Sonoran spotted whiptail		X	X		
		Cnemidophorus tigris	western whiptail (tiger whiptail)		X	X		
		Cnemidophorus burti	canyon spotted whiptail					X

Order	Family	Scientific name	Common name	Observed or documented				Possible
				UA	Swann	L&J	AE	
Squamata	Teiidae	*Cnemidophorus inornatus*	little striped whiptail					X
	Anguidae	*Elgaria kingii*	Madrean alligator lizard		X	X		
	Helodermatidae	*Heloderma suspectum*	Gila monster	X	X	X		
		Leptotyphlops humilis	western blind snake					X
		Leptotyphlops dulcis	Texas blind snake					X
	Colubridae	*Diadophis punctatus*	ring-necked snake			X		
		Heterodon nasicus	western hog-nosed snake					X
	Colubridae	*Masticophis flagellum*	coachwhip		X	X		
		Masticophis bilineatus	Sonoran whipsnake	X	X	X		
		Salvadora hexalepis deserticola	Big Bend patch-nosed snake		X	X		
		Salvadora grahamiae	mountain patch-nosed snake		X	X		
		Senticolis triaspis	green rat snake	X	X	X		
		Pituophis catenifer	gopher snake	X	X	X		
		Arizona elegans	western glossy snake					X
		Lampropeltis getula	common kingsnake					X
		Lampropeltis pyromelana	Sonoran mountain kingsnake					X
		Lampropeltis triangulum	milk snake					X
		Rhinocheilus lecontei	long-nosed snake					X
		Thamnophis cyrtopsis	black-necked garter snake		X	X		
		Thamnophis marcianus	checkered garter snake					X
		Sonora semiannulata	western ground snake					X
		Gyalopion canum	Chihuahuan hook-nosed snake					X
		Tantilla yaquia	Yaqui black-headed snake		X	X		
		Tantilla hobartsmithi	southwestern black-headed snake					X
		Tantilla nigriceps	plains black-headed snake					X
		Trimorphodon biscutatus	western lyre snake			X		
		Hypsiglena torquata	night snake		X			
	Elapidae	*Micruroides euryxanthus*	Sonoran coral snake		X			
	Viperidae	*Sistrurus catenatus*	massasauga					X
		Crotalus lepidus	rock rattlesnake					X
		Crotalus viridis cerberus	Arizona black rattlesnake					X
		Crotalus scutulatus	Mojave rattlesnake					X
		Crotalus pricei	twin-spotted rattlesnake					X
		Crotalus atrox	western diamond-backed rattlesnake		X	X	X	
		Crotalus molossus	black-tailed rattlesnake		X	X		

[a] Now extirpated from the park. Listed as "Threatened" under the Endangered Species Act, "Sensitive" by the U.S.D.A. Forest Service, and "Wildlife of Special Concern" by the Arizona Game and Fish Department (HDMS 2004).

[b] "Species of Concern" by U.S. Fish and Wildlife Service, and "Wildlife of Special Concern" by the Arizona Game and Fish Department (HDMS 2004).

Appendix C. Number of observations of bird species, by detection type, at Fort Bowie NHS by University of Arizona (UA) inventory personnel, 2002–2004. Numbers of individuals recorded are not scaled by search effort and should not to be used for comparison among species. List also includes species reported as seen by Russell and Johnson (1976; R&J), Fisher (2002; FI), and specimen vouchers reported in Appendix E (AE). Underlined species are Neotropical migrants (Rappole 1995). Species in bold-faced type are non-native.

				UA survey method				Observed or documented			Conservation designation				
Order	Family	Scientific name	Common name	VCP	Line transect	Noc-turnal	Incid-ental	R&J	FI	AE	ESA[a]	USFS[b]	AZ[c]	AZ PIF[d]	U.S. FWS[e]
Anseriformes	Anatidae	*Branta canadensis*	Canada goose					X							
Galliformes	Odontophoridae	*Callipepla squamata*	scaled quail					X	X						
		Callipepla gambelii	Gambel's quail	146	120		1	X	X						
		Cyrtonyx montezumae	Montezuma quail		1			X	X						
Ciconiiformes	Ardeidae	*Ardea herodias*	great blue heron						X						
		Butorides virescens	green heron					X							
	Cathartidae	*Coragyps atratus*	black vulture					X							
		Cathartes aura	turkey vulture	38			1	X	X						
Falconiformes	Accipitridae	*Pandion haliaetus*	osprey						X						
		Haliaeetus leucocephalus	bald eagle						X						
		Circus cyaneus	northern harrier				1	X	X						
		Accipiter striatus	sharp-shinned hawk					X	X			X			
		Accipiter cooperii	Cooper's hawk	9	1		5	X	X						
		Buteogallus anthracinus	common black-hawk				1	X	X			X	X	X	
		Buteo swainsoni	Swainson's hawk					X	X	X					
		Buteo albonotatus	zone-tailed hawk	1			1								
		Buteo jamaicensis	red-tailed hawk	8	1		2	X	X	X					
		Buteo regalis	ferruginous hawk						X						
		Buteo lagopus	rough-legged hawk						X						
		Aquila chrysaetos	golden eagle	1				X	X						
	Falconidae	*Falco sparverius*	American kestrel					X	X						
		Falco columbarius	merlin					X	X						
		Falco peregrinus	peregrine falcon	1					X		SC		X		X
		Falco mexicanus	prairie falcon					X	X						
Gruiformes	Gruidae	*Grus canadensis*	sandhill crane		52				X						
Charadriiformes	Charadriidae	*Charadrius vociferus*	killdeer					X	X						
	Scolopacidae	*Tringa flavipes*	lesser yellowlegs					X							

				UA survey method				Observed or documented			Conservation designation				
Order	Family	Scientific name	Common name	VCP	Line transect	Noc-turnal	Incid-ental	R&J	FI	AE	ESA[a]	USFS[b]	AZ[c]	AZ PIF[d]	U.S. FWS[e]
Charadriiformes	Scolopacidae	*Actitis macularia*	spotted sandpiper					X							
Columbiformes	Columbidae	*Patagioenas fasciata*	band-tailed pigeon					X							
		Zenaida asiatica	white-winged dove	180			8	X	X						
		Zenaida macroura	mourning dove	168			16	X	X						
		Columbina passerina	common ground-dove				2								
Cuculiformes	Cuculidae	*Geococcyx californianus*	greater roadrunner				3	X	X	X					
Strigiformes	Tytonidae	*Tyto alba*	barn owl						X						
Strigiformes	Strigidae	*Megascops kennicottii*	western screech-owl			1		X	X						
		Bubo virginianus	great horned owl			1		X	X						
		Micrathene whitneyi	elf owl			3		X	X						X
		Strix occidentalis lucida	Mexican spotted owl					X			LT	X	X		
		Asio otus	long-eared owl				1	X	X						
Caprimulgiformes	Caprimulgidae	*Chordeiles acutipennis*	lesser nighthawk				2	X	X						
		Chordeiles minor	common nighthawk					X							
		Phalaenoptilus nuttallii	common poorwill			12	2	X	X						
		Caprimulgus vociferus	whip-poor-will					X							
Apodiformes	Apodidae	*Chaetura vauxi*	Vaux's swift					X	X						
		Aeronautes saxatalis	white-throated swift	8				X							
	Trochilidae	*Cynanthus latirostris*	broad-billed hummingbird						X						
		Eugenes fulgens	magnificent hummingbird					X							
		Calothorax lucifer	Lucifer hummingbird					X	X						
		Archilochus alexandri	black-chinned hummingbird	14			2	X	X						
		Calypte anna	Anna's hummingbird					X	X						
		Calypte costae	Costa's hummingbird					X	X						X
		Stellula calliope	calliope hummingbird						X						
		Selasphorus platycercus	broad-tailed hummingbird	14			4	X	X						
		Selasphorus rufus	rufous hummingbird					X	X						
Coraciiformes	Alcedinidae	*Ceryle alcyon*	belted kingfisher					X	X					X	
Piciformes	Picidae	*Melanerpes lewis*	Lewis's woodpecker					X							
		Melanerpes formicivorus	acorn woodpecker					X	X						

				UA survey method				Observed or documented			Conservation designation				
Order	Family	Scientific name	Common name	VCP	Line transect	Noc-turnal	Incid-ental	R&J	FI	AE	ESA[a]	USFS[b]	AZ[c]	AZ PIF[d]	U.S. FWS[e]
Piciformes	Picidae	*Melanerpes uropygialis*	Gila woodpecker					X	X						X
		Sphyrapicus thyroideus	Williamson's sapsucker					X	X						
		Sphyrapicus nuchalis	red-naped sapsucker		1				X						
		Sphyrpicus varius	yellow-bellied sapsucker					X							
		Picoides scalaris	ladder-backed woodpecker	48	11		1	X	X						
		Colaptes auratus	northern flicker		20			X	X						
Passeriformes	Vireonidae	*Vireo bellii*	Bell's vireo	14			5	X	X			X			X
	Tyrannidae	*Contopus cooperi*	olive-sided flycatcher					X			SC				
		Contopus pertinax	greater pewee	1											
		Contopus sordidulus	western wood-pewee	7				X	X						
		Empidonax traillii	willow flycatcher						X						
Passeriformes	Tyrannidae	*Empidonax hammondii*	Hammond's flycatcher	1			3		X						
		Empidonax wrightii	gray flycatcher	2			2	X	X						
		Empidonax oberholseri	dusky flycatcher						X						
		Empidonax occidentalis or difficilis	western flycatcher					X							
		Sayornis nigricans	black phoebe					X	X						
		Sayornis saya	Say's phoebe	1			4	X	X	X					
		Myiarchus tuberculifer	dusky-capped flycatcher	1											
		Myiarchus cinerascens	ash-throated flycatcher	101				X	X	X					
		Myiarchus tyrannulus	brown-crested flycatcher	3			5	X	X						
		Tyrannus vociferans	Cassin's kingbird	75			5	X	X						
		Tyrannus verticalis	western kingbird	14			1	X	X						
	Laniidae	*Lanius ludovicianus*	loggerhead shrike		1			X	X	X	SC	X			
	Vireonidae	*Vireo vicinior*	gray vireo					X	X						
		Vireo plumbeus	plumbeous vireo	2			2	X							
		Vireo huttoni	Hutton's vireo				1								
		Vireo gilvus	warbling vireo	3			4	X	X						
	Corvidae	*Cyanocitta stelleri*	Steller's jay		2			X							
		Aphelocoma californica	western scrub-jay	48	33		1	X	X	X					
		Aphelocoma ultramarina	Mexican jay	1				X	X						
		Gymnorhinus cyanocephalus	pinyon jay					X	X						

				UA survey method				Observed or documented			Conservation designation				
Order	Family	Scientific name	Common name	VCP	Line transect	Noc-turnal	Incid-ental	R&J	FI	AE	ESA[a]	USFS[b]	AZ[c]	AZ PIF[d]	U.S. FWS[e]
Passeriformes	Corvidae	*Nucifraga columbiana*	Clark's nutcracker					X							
		Corvus cryptoleucus	Chihuahuan raven					X	X	X					
		Corvus corax	common raven					X	X						
		Corvus sp.	unknown raven	11	2		1								
	Alaudidae	*Eremophila alpestris*	horned lark						X	X					
	Hirundinidae	*Tachycineta thalassina*	violet-green swallow	5				X							
		Stelgidopteryx serripennis	northern rough-winged swallow					X	X						
		Petrochelidon pyrrhonota	cliff swallow					X	X						
		Hirundo rustica	barn swallow				2	X							
	Paridae	*Baeolophus wollweberi*	bridled titmouse	1	11			X	X						
		Baeolphus ridgwayi	juniper titmouse	3	2		1	X	X						
	Remizidae	*Auriparus flaviceps*	verdin	40	10		1	X	X						
	Aegithalidae	*Psaltriparus minimus*	bushtit	11	28			X	X	X					
	Sittidae	*Sitta carolinensis*	white-breasted nuthatch					X	X						
	Certhiidae	*Certhia americana*	brown creeper		1			X							
	Troglodytidae	*Campylorhynchus brunneicapillus*	cactus wren	120	18		4	X	X	X					
		Salpinctes obsoletus	rock wren	9	3		1	X	X						
		Catherpes mexicanus	canyon wren	7			2	X	X						
		Thryomanes bewickii	Bewick's wren	118	11		2	X	X						
		Troglodytes aedon	house wren	2				X							
	Regulidae	*Regulus calendula*	ruby-crowned kinglet	15	32		1	X	X						
	Sylviidae	*Polioptila caerulea*	blue-gray gnatcatcher	4			1	X	X						
		Polioptila melanura	black-tailed gnatcatcher	1			1		X	X					
	Turdidae	*Sialia mexicana*	western bluebird		27		1	X	X						
		Sialia currucoides	mountain bluebird					X	X						
		Myadestes townsendi	Townsend's solitaire		4		1	X	X						
		Catharus ustulatus	Swainson's thrush					X							
		Catharus guttatus	hermit thrush		1		4	X	X						
		Turdus migratorius	American robin	1	39		1	X							
	Mimidae	*Mimus polyglottos*	northern mockingbird	116	10		2	X	X						
		Oreoscoptes montanus	sage thrasher					X	X						

				UA survey method				Observed or documented			Conservation designation				
Order	Family	Scientific name	Common name	VCP	Line transect	Noc-turnal	Incid-ental	R&J	FI	AE	ESA[a]	USFS[b]	AZ[c]	AZ PIF[d]	U.S. FWS[e]
Passeriformes	Mimidae	*Toxostoma bendirei*	Bendire's thrasher				1	X	X	X					
		Toxostoma curvirostre	curve-billed thrasher	9	2		1	X	X	X					
		Toxostoma crissale	crissal thrasher	33	16	1	4	X	X	X					X
	Sturnidae	*Sturnus vulgaris*	European starling					X							
	Motacillidae	*Anthus rubescens*	American pipit						X						
	Bombycillidae	*Bombycilla cedrorum*	cedar waxwing		12			X	X						
	Ptilogonatidae	*Phainopepla nitens*	phainopepla	17	16		2	X	X						
	Parulidae	*Vermivora celata*	orange-crowned warbler				3	X	X						
		Vermivora ruficapilla	Nashville warbler					X	X						
		Vermivora virginiae	Virginia's warbler					X							
		Vermivora luciae	Lucy's warbler	17			1	X	X					X	
		Dendroica petechia	yellow warbler						X						
		Dendroica coronata	yellow-rumped warbler	4	3			X	X						
		Dendroica nigrescens	black-throated gray warbler	4	1			X	X						
		Dendroica townsendi	Townsend's warbler	1				X	X						
		Dendroica occidentalis	hermit warbler						X						
		Seiurus noveboracensis	northern waterthrush					X							
		Oporornis tolmiei	MacGillivray's warbler					X	X						
		Geothlypis trichas	common yellowthroat					X							
		Wilsonia pusilla	Wilson's warbler	8			5	X	X						
	Parulidae	*Icteria virens*	yellow-breasted chat					X							
	Thraupidae	*Piranga rubra*	summer tanager	34			2	X	X						
		Piranga ludoviciana	western tanager	7			3	X	X						
	Emberizidae	*Pipilo chlorurus*	green-tailed towhee	9	34		1	X	X						
		Pipilo maculatus	spotted towhee	7	52			X							
		Pipilo fuscus	canyon towhee	86	40		7	X	X	X					
		Aimophila cassinii	Cassin's sparrow						X						
		Aimophila texana or botterrii	Botteri's sparrow	1				X							
		Aimophila ruficeps	rufous-crowned sparrow	49	1			X	X						
		Spizella passerina	chipping sparrow	3	83			X	X						
		Spizella breweri	Brewer's sparrow	2	51		3	X	X						

				UA survey method				Observed or documented			Conservation designation				
Order	Family	Scientific name	Common name	VCP	Line transect	Noc-turnal	Incid-ental	R&J	FI	AE	ESA[a]	USFS[b]	AZ[c]	AZ PIF[d]	U.S. FWS[e]
Passeriformes	Emberizidae	*Spizella atrogularis*	black-chinned sparrow	2	5		1	X	X						
		Passerculus sandwichensis	savannah sparrow					X	X						
		Pooecetes gramineus	vesper sparrow		33		2	X	X						
		Melospiza lincolnii	Lincoln's sparrow		6		1	X	X						
		Chondestes grammacus	lark sparrow					X	X						
		Amphispiza bilineata	black-throated sparrow	115	12	1	6	X	X	X					
		Calamospiza melanocorys	lark bunting					X	X						
		Ammodramus savannarum	grasshopper sparrow				3		X						
		Ammodramus bairdii	Baird's sparrow				1				X		X		
		Passerella iliaca	fox sparrow					X	X						
		Melospiza melodia	song sparrow					X	X						
		Zonotrichia albicollis	white-throated sparrow					X							
		Zonotrichia leucophrys	white-crowned sparrow		134		2	X	X	X					
		Junco hyemalis	dark-eyed junco	X	X			X	X						
		Junco hyemalis mearnsi	pink-sided junko[f]	1	2										
		Junco hyemalis dorsalis	gray-headed junco[f]		2			X							
		Junco hyemalis oreganus	Oregon junco[f]		4										
		Junco phaeonotus	yellow-eyed junco					X							
	Cardinalidae	*Cardinalis cardinalis*	northern cardinal	124	13	1	4	X	X						
		Cardinalis sinuatus	pyrrhuloxia	1	1			X	X						
		Pheucticus ludovicianus	rose-breasted grosbeak					X	X						
		Pheucticus melanocephalus	black-headed grosbeak	12			1	X		X					
		Passerina caerulea	blue grosbeak	6			1	X	X						
		Passerina amoena	lazuli bunting	1				X	X						
		Passerina ciris	painted bunting					X	X						
	Icteridae	*Sturnella magna lilianae*	eastern meadowlark				1	X	X						
		Sturnella neglecta	western meadowlark					X	X						
		Euphagus cyanocephalus	Brewer's blackbird						X						
		Quiscalus mexicanus	great-tailed grackle						X						
		Molothrus aeneus	bronzed cowbird	1			1	X	X						
		Molothrus ater	brown-headed cowbird	56			2	X	X						

				UA survey method				Observed or documented			Conservation designation				
Order	Family	Scientific name	Common name	VCP	Line transect	Noc-turnal	Incid-ental	R&J	FI	AE	ESA[a]	USFS[b]	AZ[c]	AZ PIF[d]	U.S. FWS[e]
Passeriformes	Icteridae	*Icterus cucullatus*	hooded oriole	44			5	X	X	X					
		Icterus bullockii	Bullock's oriole	26			2	X							
		Icterus parisorum	Scott's oriole	26				X	X						
	Fringillidae	*Carpodacus mexicanus*	house finch	54	4		2	X	X						
		Carduelis pinus	pine siskin		1			X	X						
		Carduelis psaltria	lesser goldfinch	3	6		1	X	X						
		Coccothraustes vespertinus	evening grosbeak					X							
	Passeridae	*Passer domesticus*	house sparrow					X							

[a] "SC" = "Species of Concern"; "C" = Candidate for listing under the Endangered Species Act, U.S. Fish and Wildlife Service. (in HDMS 2004)
[b] "Sensitive Species"; U.S.D.A. Forest Service (HDMS 2004).
[c] "Wildlife of Special Concern"; Arizona Game and Fish Department (HDMS 2004).
[d] "Priority species"; Arizona Partners in Flight (Latta et al. 1999).
[e] "Species of Conservation Concern"; U.S. Fish and Wildlife Service (HDMS 2004).
[f] We include observations of these subspecies in the appendix because field crew members occasionally made the distinction.

Appendix D. Mammals recorded at Fort Bowie NHS by University of Arizona inventory personnel (UA) and/or documented/observed by other researchers: Roth (1976; ROH), Petryszyn (1999; PZN), Herman-Reese (unpublished data; HR), Swann et al. (2001; SEA), Krebbs (2005; KRB), or specimens located in the UA mammal collection (UAMC). Species in bold-faced type is non-native.

Order Family	Scientific name	Common name	UA	UAMC	ROH	PZN	HR	SEA	KRB
Insectivora									
Soricidae	*Notiosorex crawfordi*	Crawford's desert shrew			X				
Chiroptera									
Phyllostomidae	*Choeronycteris mexicana*	Mexican long-tongued bat		X	X				
	Leptonycteris curasoae yerbabuenae	lesser long-nosed bat		X	X				
Vespertilionidae	*Myotis occultus*	Arizona myotis							X
	Myotis auriculus	southwestern myotis							X
	Myotis velifer	cave myotis		X	X				X
	Myotis thysanodes	fringed myotis		X	X				X
	Myotis californicus	California myotis							X
	Myotis volans	long-legged myotis							X
	Myotis ciliolabrum	western small-footed myotis							X
	Pipistrellus hesperus	western pipistrelle		X	X				
	Eptesicus fuscus	big brown bat		X					
	Antrozous pallidus	pallid bat		X	X				
Carnivora									
Ursidae	*Ursus americanus*	American black bear	X				X		
Procyonidae	*Procyon lotor*	northern raccoon			X				
	Nasua narica	white-nosed coati	X		X		X		
	Bassariscus astutus	ringtail			X		X		
Mustelidae	*Taxidea taxus*	American badger			X			X	
	Mephitis macroura	hooded skunk	X						
	Spilogale gracilis	western spotted skunk			X				
	Mephitis mephitis	striped skunk	X		X		X		
	Conepatus mesoleucus	white-backed hog-nosed skunk	X		X				
Canidae	***Canis familiaris***	**feral dog**	X						
	Canis latrans	coyote	X		X		X	X	
	Urocyon cinereoargenteus	common gray fox	X		X		X	X	
Felidae	*Lynx rufus*	bobcat	X		X		X	X	
	Puma concolor	mountain lion	X				X	X	
Rodentia									
Sciuridae	*Spermophilus variegatus*	rock squirrel	X		X		X	X	
	Spermophilus tereticaudus	round-tailed ground squirrel		X					
	Ammospermophilus harrisii	Harris' antelope squirrel		X	X			X	
	Neotamias dorsalis	cliff chipmunk		X	X			X	
Geomyidae	*Thomomys bottae*	Botta's pocket gopher		X	X				
Heteromyidae	*Perognathus flavus flavus*	silky pocket mouse		X	X		X		
	Perognathus amplus	Arizona pocket mouse					X		
	Chaetodipus penicillatus	Sonoran Desert pocket mouse		X	X	X	X		
	Chaetodipus intermedius	rock pocket mouse		X	X		X		
	Chaetodipus baileyi	Bailey's pocket mouse		X	X		X		
	Chaetodipus hispidus	hispid pocket mouse		X	X		X		
	Dipodomys spectabilis	banner-tailed kangaroo rat		X	X				
	Dipodomys ordii	Ord's kangaroo rat		X	X		X		
	Dipodomys merriami	Merriam's kangaroo rat			X	X	X		

Order Family	Scientific name	Common name	UA	UAMC	ROH	PZN	HR	SEA	KRB
Rodentia									
Heteromyidae	*Reithrodontomys megalotis megalotis*	western harvest mouse					X		
	Reithrodontomys fulvescens	fulvous harvest mouse		X	X				
	Peromyscus eremicus	cactus mouse		X	X		X		
Muridae	*Peromyscus maniculatus*	deer mouse		X	X		X		
	Peromyscus leucopus	white-footed mouse		X					
	Peromyscus boylii	brush mouse		X	X		X		
	Baiomys taylori	northern pygmy mouse					X		
	Onychomys leucogaster	northern grasshopper mouse		X	X		X		
	Onychomys torridus	southern grasshopper mouse		X	X	X	X		
	Neotoma albigula	western white-throated woodrat		X	X	X	X	X	
	Sigmodon hispidus	hispid cotton rat		X	X		X		
Erethizontidae	*Erethizon dorsatum*	North American porcupine						X	
Lagomorpha									
Leporidae	*Lepus alleni*	antelope jackrabbit		X	X				
	Lepus californicus	black-tailed jackrabbit	X	X	X			X	
	Sylvilagus audubonii	desert cottontail			X			X	
Artiodactyla									
Tayassuidae	*Pecari tajacu*	collared peccary	X		X		X	X	
Cervidae	*Odocoileus hemionus*	mule deer	X		X		X	X	
	Odocoileus virginianus	white-tailed deer			X			X	

Appendix E. List of voucher specimens collected from Fort Bowie NHS. See Table 1.1 for list of collections that were queried for specimens.

Group	Common name	Field collection numbers	Collection[a]	Date	Primary Collector
Reptile	eastern collared lizard	12578, 12579	CAS	08/02/1950	H. K. Gloyd
		022207	USNM	05/22/1894	A. K. Fisher
		12578-16024, 12579-16025	CAS	08/02/1950	H. K. Gloyd
	Clark's spiny lizard	12586, 12587, 125867-160323	CAS	08/02/1950	H. K. Gloyd
	ornate tree lizard	12636-16082	CAS	08/02/1950	H. K. Gloyd
	Chihuahuan spotted whiptail	40890	UCO	07/22/1970	R. L. Holland
	western diamond-backed rattlesnake	022194	USNM	UNKN	A. K. Fisher
Bird	Swainson's hawk	3366, 3367, 3368	UCB	05/25/1894	F. H. Fowler
		68829	UCB	05/18/1936	A. H. Miller
	red-tailed hawk	3359, 3360, 3361, 3362	UCB	04/17/1893	F. H. Fowler
	greater roadrunner	3388, 3389, 3390, 3391	UCB	04/10/1893	F. H. Fowler
	Say's phoebe	3425, 3426	UCB	04/11/1893	F. H. Fowler
	ash-throated flycatcher	78819	UCB	05/22/1894	F. H. Fowler
	loggerhead shrike	3500, 3501, 3502, 3503, 3504, 3505, 3506	UCB	04/01/1893	F. H. Fowler
	western scrub-jay	3441, 3442, 3443, 3444	UCB	04/05/1893	F. H. Fowler
	Chihuahuan raven	3457, 3458, 3459	UCB	05/11/1893	F. H. Fowler
	horned lark	3435, 3436, 3437, 3438, 3439, 3440	UCB	04/22/1893	F. H. Fowler
	bushtit	3461	UCB	05/03/1894	F. H. Fowler
	cactus wren	3463, 3464, 3465, 3466, 3467, 3468, 3469, 3471, 3472, 3473, 3474, 3475	UCB	04/01/1893	F. H. Fowler
	black-tailed gnatcatcher	78882	UCB	04/13/1894	F. H. Fowler
	Bendire's thrasher	3489	UCB	04/15/1894	F. H. Fowler
	curve-billed thrasher	12573, 12573	UA	UNKN	UNKN
	crissal thrasher	3483, 3484, 3486	UCB	04/05/1893	F. H. Fowler
	canyon towhee	3534, 3535, 3536	UCB	04/13/1893	F. H. Fowler
	black-throated sparrow	3544, 3545	UCB	04/21/1893	F. H. Fowler
	white-crowned sparrow	78975	UCB	05/15/1894	F. H. Fowler
	black-headed grosbeak	78931	UCB	05/15/1894	F. H. Fowler
	hooded oriole	3519	UCB	05/28/1894	F. H. Fowler
Mammal	Sandborn's long-nosed bat	23523	UA	09/22/1976	E. L. Roth
	Mexican long-tongued bat	23506	UA	09/22/1976	E. L. Roth
	cave myotis	23503, 23504	UA	08/08/1976	E. L. Roth
		23621, 23622, 23623	UA	08/08/1976	T. & P. Vaughan
	fringed myotis	23522	UA	09/22/1976	E. L. Roth
	western pipistrelle	23502	UA	08/08/1976	E. L. Roth
	big brown bat	23505	UA	09/22/1976	E. L. Roth
	pallid bat	23501	UA	08/08/1976	E. L. Roth
	round-tailed ground squirrel	23461, 23462	UA	09/23/1976	E. L. Roth
	Harris' antelope squirrel	23241, 23493, 23498	UA	10/18/1975	E. L. Roth
	cliff chipmunk	23475, 23485, 23520, 23643	UA	10/18/1975	E. L. Roth
	Botta's pocket gopher	23472, 23478, 23473	UA	09/24/1976	E. L. Roth
	Sonoran Desert pocket mouse	23242, 23243, 23244, 23245, 23246, 23247, 23248, 23481, 23482, 23484, 23490, 23508, 23514, 23518, 23524, 23525	UA	10/18/1975	E. L. Roth
	rock pocket mouse	23249, 23480, 23495, 23497, 24065	UA	10/18/1975	E. L. Roth
		23641	UA	11/01/1975	P. L. Dods
		23732	UA	08/29/1976	G. S. Mills
		24041	UA	08/07/1976	T. P. Vaughan
	Bailey's pocket mouse	23463, 23499, 23513, 23730	UA	09/23/1976	E. L. Roth
	hispid pocket mouse	23466, 23469, 23470	UA	09/24/1976	E. L. Roth

Group	Common name	Field collection numbers	Collection[a]	Date	Primary Collector
Mammal	banner-tailed kangaroo rat	23456, 23457	UA	09/23/1976	E. L. Roth
	Ord's kangaroo rat	23458, 23459	UA	09/23/1976	E. L. Roth
	Merriam's kangaroo rat	23228—23240, 23460, 23474, 23483, 23489, 23507, 23512, 23731	UA	10/18/1975	E. L. Roth
	fulvous harvest mouse	23467	UA	09/24/1976	E. L. Roth
	cactus mouse	23258—23266, 23476, 23477, 23491, 23496, 23500, 23509, 23515, 24064	UA	10/18/1975	E. L. Roth
	deer mouse	23521, 23527	UA	10/31/1975	E. L. Roth
	white-footed mouse	23486, 23526	UA	11/02/1975	E. L. Roth
	brush mouse	23267, 23479, 23511, 23517, 23642, 23743, 23744	UA	10/18/1975	E. L. Roth
	northern grasshopper mouse	23464	UA	09/23/1976	E. L. Roth
	southern grasshopper mouse	23250—23257, 23468, 23488, 23510	UA	10/31/1975	E. L. Roth
	western white-throated woodrat	23487, 23492, 23494, 23516, 23519, 23639, 23640, 23644, 24042, 24043, 24043	UA	11/02/1975	E. L. Roth
	hispid cotton rat	23471	UA	09/24/1976	E. L. Roth
	antelope jackrabbit	23465	UA	09/23/1976	E. L. Roth
	black-tailed jackrabbit	23439	UA	10/19/1975	E. L. Roth

[a] CAS = Chicago Academy of Sciences; USNM = U.S. National Museum; UCO = University of Colorado; UCB = University of California, Berkeley; UA = University of Arizona

Appendix F. Summary of vegetation characteristics measured at bird survey stations, Fort Bowie NHS, 2004. See Appendix A for list of common names of plants.

Transect Station	Category	Species	Mean density
Butter-field 1	Subshrub	*Gutierrezia sarothrae*	33.69
		Haplopappus laricifolius	67.39
		Isocoma tenuisecta	89.85
		Prosopis velutina	11.23
		Sideroxylon lanuginosum	22.46
	Shrub	*Rhus microphylla*	5.19
		Haplopappus laricifolius	5.19
		Opuntia spinosior	5.19
		Prosopis velutina	23.36
		Dasylirion wheeleri	2.60
		Nolina microcarpa	2.60
		Sideroxylon lanuginosum	7.79
	Tree	*Rhus microphylla*	2.69
		Juniperus monosperma	0.67
		Juniperus osteosperma	0.67
		Prosopis velutina	8.75
		Celtis reticulata	0.67
	Cavity	*Juglans major*	2.38
		Celtis reticulata	0.79
2	Subshrub	*Yucca baccata*	121.36
		Gutierrezia sarothrae	40.45
		Haplopappus laricifolius	121.36
		Isocoma tenuisecta	161.82
		Opuntia spinosior	80.91
		Arctostaphylos pungens	121.36
		Mimosa biuncifera	80.91
		Nolina microcarpa	40.45
	Shrub	*Yucca baccata*	22.40
		Haplopappus laricifolius	22.40
		Juniperus monosperma	22.40
		Arctostaphylos pungens	89.60
		Mimosa biuncifera	22.40
		Prosopis velutina	201.60
		Quercus emoryi	44.80
		Dasylirion wheeleri	22.40
	Tree	*Juniperus deppeana*	3.46
		Juniperus osteosperma	6.93
		Prosopis velutina	20.78
		Quercus emoryi	24.24
		Pinus edulis	6.93
		Celtis reticulata	6.93
	Cavity	*Juniperus deppeana*	1.96
		Quercus emoryi	4.58
		Pinus edulis	3.27
3	Subshrub	*Agave palmeri*	39.66
		Yucca baccata	39.66
		Haplopappus laricifolius	79.32
		Isocoma tenuisecta	19.83
		Opuntia engelmannii	19.83
3	Subshrub	*Opuntia spinosior*	19.83
		Arctostaphylos pungens	118.98
		Dasylirion wheeleri	19.83
		Nolina microcarpa	39.66
	Shrub	*Arctostaphylos pungens*	153.35
		Mimosa biuncifera	19.17
		Prosopis velutina	57.51
		Quercus arizonica	19.17
		Quercus emoryi	57.51
		Quercus sp.	19.17
		Nolina microcarpa	57.51
	Tree	*Juniperus osteosperma*	1.85
		Arctostaphylos pungens	1.85
		Prosopis velutina	1.85
		Quercus arizonica	1.85
		Quercus emoryi	27.67
		Pinus edulis	1.85
	Cavity	*Juniperus osteosperma*	2.01
		Quercus arizonica	2.01
		Quercus emoryi	24.13
		Quercus sp.	2.01
4	Subshrub	*Agave palmeri*	31.66
		Yucca baccata	63.33
		Haplopappus laricifolius	348.31
		Arctostaphylos pungens	63.33
		Prosopis velutina	94.99
		Dasylirion wheeleri	31.66
	Shrub	*Yucca baccata*	9.91
		Arctostaphylos pungens	39.63
		Prosopis velutina	59.44
		Quercus emoryi	19.81
		Dasylirion wheeleri	9.91
		Nolina microcarpa	59.44
	Tree	*Juniperus monosperma*	4.05
		Prosopis velutina	10.13
		Quercus emoryi	26.34
	Cavity	*Quercus arizonica*	1.66
		Quercus emoryi	19.90
5	Subshrub	*Gutierrezia sarothrae*	88.61
		Haplopappus laricifolius	443.07
		Arctostaphylos pungens	88.61
		Dasylirion wheeleri	132.92
		Nolina microcarpa	132.92
	Shrub	*Yucca baccata*	16.80
		Juniperus deppeana	16.80
		Juniperus monosperma	16.80
		Arctostaphylos pungens	100.80
		Prosopis velutina	16.80
		Quercus arizonica	16.80
		Quercus emoryi	16.80

Transect Station	Category	Species	Mean density
5	Shrub	*Dasylirion wheeleri*	117.60
		Nolina microcarpa	16.80
	Tree	*Juniperus monosperma*	4.92
		Quercus arizonica	4.92
		Quercus emoryi	7.87
		Garrya flavescens	1.97
	Cavity	*Juniperus monosperma*	0.63
		Quercus arizonica	1.90
		Quercus emoryi	6.96
		Quercus sp.	1.90
6	Subshrub	*Yucca baccata*	2.85
		Haplopappus laricifolius	14.23
		Opuntia spinosior	1.42
		Arctostaphylos pungens	1.42
		Mimosa biuncifera	1.42
		Quercus emoryi	4.27
		Nolina microcarpa	2.85
	Shrub	*Agave palmeri*	14.56
		Arctostaphylos pungens	58.22
		Mimosa biuncifera	29.11
		Prosopis velutina	72.78
		Quercus emoryi	14.56
		Nolina microcarpa	101.89
	Tree	*Juniperus monosperma*	11.25
		Prosopis velutina	3.75
		Quercus emoryi	22.50
	Cavity	*Quercus emoryi*	5.54
		Quercus sp.	0.40
7	Subshrub	*Yucca baccata*	139.84
		Baccharis sarothroides	69.92
		Haplopappus laricifolius	559.34
		Opuntia spinosior	139.84
		Arctostaphylos pungens	209.75
		Mimosa biuncifera	69.92
		Nolina microcarpa	209.75
	Shrub	*Yucca baccata*	14.99
		Juniperus monosperma	14.99
		Arctostaphylos pungens	44.97
		Mimosa biuncifera	14.99
		Prosopis velutina	29.98
		Nolina microcarpa	179.86
	Tree	*Juniperus monosperma*	6.49
		Prosopis velutina	2.60
		Quercus emoryi	16.87
	Cavity	*Juniperus monosperma*	0.61
		Quercus arizonica	1.82
		Quercus emoryi	6.06
		Quercus sp.	0.61
8	Subshrub	*Agave palmeri*	123.43
		Haplopappus laricifolius	617.13
		Mimosa biuncifera	431.99
		Dasylirion wheeleri	61.71
	Shrub	*Agave palmeri*	1.46
		Juniperus monosperma	2.91

Transect Station	Category	Species	Mean density
8	Shrub	*Mimosa biuncifera*	10.19
		Prosopis velutina	4.37
		Dasylirion wheeleri	2.91
		Nolina microcarpa	7.28
	Tree	*Juniperus monosperma*	6.00
		Prosopis velutina	1.50
		Quercus arizonica	2.25
		Quercus emoryi	4.50
		Garrya flavescens	0.75
	Cavity	*Juniperus deppeana*	0.24
		Quercus arizonica	0.94
		Quercus emoryi	2.83
Siphon Canyon			
1	Subshrub	*Agave palmeri*	172.80
		Yucca baccata	691.19
		Chrysothamnus nauseosus	172.80
		Gutierrezia sarothrae	345.59
		Haplopappus laricifolius	518.39
		Parthenium incanum	518.39
		Juniperus osteosperma	172.80
		Mimosa biuncifera	172.80
		Garrya flavescens	172.80
		Nolina microcarpa	172.80
		Sideroxylon lanuginosum	345.59
	Shrub	*Rhus microphylla*	170.36
		Haplopappus laricifolius	56.79
		Juniperus osteosperma	56.79
		Mimosa biuncifera	113.58
		Prosopis velutina	56.79
		Quercus arizonica	113.58
		Quercus turbinella	170.36
		Garrya flavescens	113.58
		Sapindus saponaria	56.79
		Sideroxylon lanuginosum	170.36
		Celtis reticulata	56.79
	Tree	*Juniperus monosperma*	8.13
		Juniperus osteosperma	8.13
		Prosopis velutina	8.13
		Quercus arizonica	4.07
		Quercus turbinella	8.13
		Fouquieria splendens	8.13
		Garrya flavescens	12.20
		Sapindus saponaria	4.07
		Sideroxylon lanuginosum	12.20
		Celtis reticulata	8.13
	Cavity	*Juniperus monosperma*	2.15
		Juniperus osteosperma	4.31
		Quercus arizonica	8.62
		Quercus sp.	2.15
		Juglans major	2.15
		Fraxinus velutina	10.77
		Celtis reticulata	2.15
2	Subshrub	*Unknown species*	81.73
		Gutierrezia sarothrae	81.73

Transect Station	Category	Species	Mean density
2	Subshrub	*Haplopappus laricifolius*	163.46
		Isocoma tenuisecta	245.19
		Opuntia engelmannii	81.73
		Opuntia spinosior	163.46
		Prosopis velutina	81.73
		Sideroxylon lanuginosum	572.10
		Celtis reticulata	163.46
	Shrub	*Rhus microphylla*	237.17
		Baccharis sarothroides	79.06
		Opuntia engelmannii	158.12
		Prosopis velutina	474.34
		Sideroxylon lanuginosum	474.34
		Celtis reticulata	158.12
	Tree	*Rhus microphylla*	4.19
		Juniperus monosperma	8.39
		Prosopis velutina	29.36
		Fouquieria splendens	8.39
		Sideroxylon lanuginosum	20.97
		Celtis reticulata	12.58
	Cavity	*Juniperus monosperma*	4.66
		Prosopis velutina	1.55
		Quercus arizonica	2.33
		Juglans major	0.78
		Celtis reticulata	4.66
3	Subshrub	*Rhus microphylla*	29.36
		Brickellia sp.	88.08
		Gutierrezia sarothrae	117.44
		Haplopappus laricifolius	29.36
		Isocoma tenuisecta	117.44
		Opuntia engelmannii	58.72
		Opuntia spinosior	58.72
		Datura meteloides	58.72
		Celtis reticulata	29.36
	Shrub	*Unknown species*	6.01
		Rhus microphylla	6.01
		Haplopappus laricifolius	18.02
		Chilopsis linearis	24.02
		Opuntia spinosior	12.01
		Prosopis velutina	18.02
		Sideroxylon lanuginosum	6.01
		Lycium pallidum	6.01
		Celtis reticulata	24.02
	Tree	*Rhus microphylla*	16.68
		Chilopsis linearis	16.68
		Prosopis velutina	20.02
		Juglans major	3.34
		Celtis reticulata	10.01
	Cavity	*Chilopsis linearis*	5.38
		Prosopis velutina	2.69
		Quercus emoryi	1.35
		Juglans major	5.38
3	Cavity	*Celtis reticulata*	4.04
4	Subshrub	*Brickellia sp.*	41.67
		Gutierrezia sarothrae	20.84

Transect Station	Category	Species	Mean density
4	Subshrub	*Haplopappus laricifolius*	31.26
		Opuntia spinosior	20.84
		Ephedra sp.	10.42
		Sideroxylon lanuginosum	83.35
	Shrub	*Rhus microphylla*	105.49
		Brickellia sp.	70.32
		Prosopis velutina	35.16
		Sideroxylon lanuginosum	140.65
	Tree	*Rhus microphylla*	20.93
		Prosopis velutina	34.88
		Juglans major	6.98
		Sideroxylon lanuginosum	27.90
		Celtis reticulata	48.83
	Cavity	*Chilopsis linearis*	11.21
		Prosopis velutina	3.74
		Juglans major	3.74
		Sideroxylon lanuginosum	3.74
		Celtis reticulata	44.86
5	Subshrub	*Anisacanthus thurberi*	15.71
		Rhus microphylla	31.42
		Brickellia sp.	47.13
		Chrysothamnus nauseosus	15.71
		Gutierrezia sarothrae	15.71
		Isocoma tenuisecta	47.13
		Parthenium incanum	31.42
		Prosopis velutina	47.13
		Garrya flavescens	15.71
		Sideroxylon lanuginosum	31.42
		Lycium pallidum	15.71
	Shrub	*Rhus microphylla*	4.43
		Brickellia sp.	2.22
		Chilopsis linearis	2.22
		Prosopis velutina	13.30
		Sideroxylon lanuginosum	15.52
		Celtis reticulata	4.43
		Larrea tridentata	2.22
	Tree	*Chilopsis linearis*	3.07
		Juniperus monosperma	1.54
		Prosopis velutina	10.75
		Fouquieria splendens	3.07
		Sideroxylon lanuginosum	9.22
		Celtis reticulata	3.07
	Cavity	*Chilopsis linearis*	3.08
		Prosopis velutina	3.08
		Juglans major	6.16
		Celtis reticulata	10.78
6	Subshrub	*Brickellia sp.*	34.33
		Chrysothamnus nauseosus	45.77
		Parthenium incanum	22.89
		Opuntia engelmannii	34.33
		Opuntia spinosior	22.89
		Juglans major	11.44
		Sideroxylon lanuginosum	45.77
		Lycium pallidum	11.44

Transect Station	Category	Species	Mean density
6	Shrub	*Rhus microphylla*	15.12
		Chrysothamnus nauseosus	90.72
		Chilopsis linearis	30.24
		Atriplex canescens	45.36
		Prosopis velutina	15.12
		Nolina microcarpa	15.12
		Sideroxylon lanuginosum	75.60
		Lycium pallidum	15.12
	Tree	*Rhus microphylla*	9.33
		Chilopsis linearis	32.65
		Juniperus monosperma	4.67
		Prosopis velutina	13.99
		Fouquieria splendens	9.33
		Juglans major	4.67
		Condalia warnockii	4.67
		Celtis reticulata	13.99
	Cavity	*Chilopsis linearis*	1.39
		Juniperus monosperma	0.35
		Juglans major	1.39
		Pinus edulis	0.35
		Sideroxylon lanuginosum	0.35
		Celtis reticulata	2.44
7	Subshrub	*Rhus microphylla*	41.00
		Baccharis sarothroides	20.50
		Brickellia sp.	20.50
		Haplopappus laricifolius	20.50
		Opuntia engelmannii	20.50
		Juniperus osteosperma	20.50
		Acacia greggii	61.50
		Morus microphylla	41.00
		Ziziphus obtusifolia	20.50
		Ptelea trifoliata	20.50
		Sideroxylon lanuginosum	41.00
		Lycium pallidum	20.50
		Celtis reticulata	61.50
	Shrub	*Rhus microphylla*	88.51
		Baccharis sarothroides	59.00
		Acacia greggii	118.01
		Ziziphus obtusifolia	88.51
		Sideroxylon lanuginosum	118.01
		Celtis reticulata	118.01
	Tree	*Rhus microphylla*	15.73
		Juniperus monosperma	3.15
		Fouquieria splendens	3.15
		Morus microphylla	3.15
		Sideroxylon lanuginosum	3.15
		Celtis reticulata	25.17
7	Tree	*Juniperus osteosperma*	0.60
		Juglans major	2.97
		Fraxinus velutina	1.19
		Populus fremontii	1.19
		Celtis reticulata	3.57

Transect Station	Category	Species	Mean density
8	Subshrub	*Brickellia sp.*	20.16
		Gutierrezia sarothrae	20.16
		Haplopappus laricifolius	120.96
		Opuntia engelmannii	120.96
		Acacia greggii	20.16
		Mimosa biuncifera	20.16
		Prosopis velutina	20.16
		Fouquieria splendens	20.16
		Sideroxylon lanuginosum	40.32
	Shrub	*Unknown species*	12.77
		Agave palmeri	12.77
		Brickellia sp.	12.77
		Opuntia engelmannii	25.55
		Acacia greggii	51.09
		Mimosa biuncifera	25.55
		Prosopis velutina	12.77
		Quercus arizonica	12.77
		Fouquieria splendens	12.77
		Nolina microcarpa	12.77
		Sideroxylon lanuginosum	63.86
	Tree	*Acacia greggii*	3.17
		Prosopis velutina	6.34
		Quercus arizonica	6.34
		Quercus turbinella	3.17
		Fouquieria splendens	25.34
		Sideroxylon lanuginosum	15.84
		Celtis reticulata	3.17
	Cavity	*Quercus arizonica*	5.27
		Juglans major	1.76
		Fraxinus velutina	8.79
		Celtis reticulata	5.27

Appendix F, part 2

	Litter		Bare Ground		Rock	
Transect	Mean	SD	Mean	SD	Mean	SD
Butterfield	30	18.4	68	18.2	1	3.1
	50	29.0	51	30.1	4	5.0
	36	23.5	55	22.4	11	15.0
	35	15.7	61	16.5	7	9.2
	29	22.0	43	18.7	27	14.9
	29	12.1	64	18.5	6	9.4
	52	23.3	47	22.7	3	4.7
	22	16.4	76	16.0	6	7.6
Siphon Canyon	55	24.2	33	19.2	9	8.8
	52	27.5	41	24.6	7	12.3
	59	27.4	38	20.9	4	7.5
	40	32.6	60	32.1	1	3.1
	60	34.3	37	31.2	5	11.0
	28	22.7	62	24.6	8	10.7
	58	32.1	25	24.8	16	25.0
	29	26.2	49	33.4	22	18.2

Appendix G. Most abundant bird species at each transect and season based on data published in Russell and Johnson (1976) and the UA inventory. Relative abundance (RA) estimates from Russell and Johnson are number of individuals per transect kilometer whereas RA estimates for the UA effort are the mean number of individuals per transect station or section, including flyovers and birds seen > 75 m or > 100 m from stations or sections, respectively. See methods section for community descriptions. Species in bold-faced type are species that are not found on the corresponding list of the most common species by season. Relative abundance estimates are for showing abundance ranks and cannot be compared between studies because of different methods of data collection.

		Study			
		Russell and Johnson		UA	
Community	Season	Species	RA	Species	RA
Mesquite-grasslands	Breeding	Gambel's quail	4.3	mourning dove	1.9
		black-throated sparrow	2.7	black-throated sparrow	1.8
		canyon towhee	1.7	**turkey vulture**	1.7
		cactus wren	1.3	canyon towhee	1.3
		mourning dove	0.8	Gambel's quail	1.1
		Mexican jay	**0.6**	**white-winged dove**	1.1
		violet-green swallow	0.6	ash-throated flycatcher	1.1
		verdin	0.5	cactus wren	1.1
		Wilson's warbler	0.5	**Bewick's wren**	1.0
		western tanager	0.4	**northern mockingbird**	0.6
		ash-throated flycatcher.	0.4	**rufous-crowned sparrow**	0.6
	Non-breeding	chipping sparrow	11.0	**bushtit**	1.2
		Brewer's sparrow	9.9	chipping sparrow	1.0
		black-throated sparrow	6.0	**western bluebird**	0.8
		white-crowned sparrow	3.7	white-crowned sparrow	0.7
		Gambel's quail	2.6	**bridled titmouse**	0.4
		canyon towhee	2.4	canyon towhee	0.4
		dark-eyed junco	2.4	**phainopepla**	0.3
		cactus wren	0.7	**western scrub-jay**	0.3
		ladder-backed woodpecker	0.7	**ruby-crowned kinglet**	0.3
Oak-juniper woodland	Breeding	Gambel's quail	5.1	mourning dove	2.4
		Mexican jay	1.7	**black-throated sparrow**	1.5
		western scrub-jay	1.5	Bewick's wren	1.2
		mourning dove	1.5	ash-throated flycatcher	0.8
		cactus wren	0.7	**canyon towhee**	0.7
		rufous-crowned sparrow.	0.7	Gambel's quail	0.7
		Bewick's wren	0.6	**brown-headed cowbird**	0.6
		violet-green swallow	0.6	**northern mockingbird**	0.6
		northern cardinal	0.5	rufous-crowned sparrow	0.6
		black-chinned hummingbird	0.5	cactus wren	0.5
		ash-throated flycatcher	0.4	**white-winged dove**	0.5
	Non-breeding	Gambel's quail	5.4	Gambel's quail	3.3
		chipping sparrow	4.2	white-crowned sparrow	2.6
		white-crowned sparrow	4.2	chipping sparrow	1.2
		dark-eyed junco	4.2	Brewer's sparrow	0.7
		Brewer's sparrow	1.5	spotted towhee	0.4
		western scrub-jay	1.5	**black-throated sparrow**	0.2
		mourning dove	1.0	ruby-crowned kinglet	0.2
		canyon towhee	0.8	western scrub-jay	0.2
		cactus wren	0.8	cactus wren	0.2
		ruby-crowned kinglet	0.8	canyon towhee	0.2
		spotted towhee	0.6	**crissal thrasher**	0.2
		Bewick's wren	0.6	**northern flicker**	0.2
Wash-riparian	Breeding	**black-chinned hummingbird**	5.8	Gambel's quail	1.9
		northern cardinal	4.6	white-winged dove	1.4

		Study			
		Russell and Johnson		UA	
Community	Season	Species	RA	Species	RA
Wash-riparian	Breeding	mourning dove	3.6	northern cardinal	1.2
		white-winged dove	2.8	mourning dove	1.1
		cactus wren	2.7	**Cassin's kingbird**	0.9
		Gambel's quail	2.1	cactus wren	0.9
		canyon towhee	2.0	**Bewick's wren**	0.8
		verdin	1.8	**northern mockingbird**	0.8
		hooded oriole	1.8	canyon towhee	0.8
Non-breeding		**northern cardinal**	6.6	white-crowned sparrow	3.0
		chipping sparrow	6.0	**American robin**	1.8
		white-crowned sparrow	5.8	**vesper sparrow**	1.8
		dark-eyed junco	5.3	spotted towhee	1.8
		canyon towhee	3.9	Brewer's sparrow	1.7
		spotted towhee	3.7	chipping sparrow	1.3
		Brewer's sparrow	3.5	canyon towhee	1.1
		Gambel's quail	3.1	Gambel's quail	1.1
		cactus wren	2.9	**green-tailed towhee**	1.1
		curved-bill thrasher	2.0	**western scrub-jay**	1.1

Appendix H. Number of Trailmaster photos and total number of individuals of each species. Data from Herman-Reese (unpublished data), Fort Bowie NHS, 2000–2001.

Group	Common name	Number of photographs	Total number of individuals photographed	
Reptile	western diamond-backed rattlesnake	1	2	
Bird	white-winged dove	1	2	
	mourning dove	3	3	
	greater roadrunner	1	3	
	Mexican jay	1	1	
	northern mockingbird	1	1	
	lark sparrow	28	>55	
	northern cardinal	1	1	
	pyrrhuloxia	3	3	
	Bullock's oriole	2	4	
Mammal	American black bear	36	37	
	white-nosed coati	8	9	
	ringtail		3	3
	striped skunk	2	2	
	coyote		3	3
	common gray fox	41	43	
	mountain lion	1	1	
	bobcat		2	2
	rock squirrel	1	1	
	mule deer		17	40

Appendix I. Photographic vouchers taken by University of Arizona inventory personnel, Fort Bowie NHS, 2002–2004.

Group	Common name
Reptile	greater earless lizard
	Gila monster
	green rat snake
Bird	common black-hawk
	mourning dove
	Bell's vireo
	canyon towhee
Mammal	American black bear
	white-nosed coati
	striped skunk
	hooded skunk
	feral dog
	common gray fox
	mountain lion
	bobcat
	collared peccary
	mule deer