Biological Inventory Report for the Sonoran Desert Network: 2002

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Cover photos (left to right):

1) Common Collared lizard (*Crotophytus collaris*) at Saguaro National Park East. Photo by Dave Prival, 2001.
2) Black bear (*Ursus americanus*) at infrared-triggered camera at Fort Bowie National Historical Park, 2002.
3) Mexican poppy (*Eschscoltzia mexicana*) and non-native filaree (*Erodium cicutarium*) at Saguaro National Park West. Photo by Brian Powell, 2001.
4) Worm-eating warbler (*Helmitheros vermivorus*), a rare migrant in Arizona, at Tumacacori National Historical Park. Photo by Brian Powell, 2000.

List of Tables, Appendices, and Figure

EXECUTIVE SUMMARY

This is the second report summarizing the methods of data collection and results from the biological Inventory and Monitoring (I&M) Program for the National Park Service Sonoran Desert Network (SODEN) of parks. The survey effort during 2002 was the second full season where we surveyed intensively for most taxa at five parks in Arizona and New Mexico: Casa Grande Ruins National Monument (CAGR), Saguaro National Park East (SAGU-E) and West (SAGU-W), Tonto National Monument (TONT), and Tumacacori National Historical Park (TUMA) in Arizona and Gila Cliff Dwellings National Monument (GICL) in New Mexico. In addition, we did limited surveying ("scouting") at three parks that were initially scheduled for surveys beginning in 2003: Chiricahua National Monument (CHIR), Fort Bowie National Historic Site (FOBO), and Tuzigoot National Monument (TUZI).

We collected specimens representing 346 species of plants at six parks in 2002. We found the most new plant species at GICL (96) and the fewest at SAGU-E (1). We found 11 species of amphibians and 50 reptiles at seven parks and 192 species of birds at eight parks. At TUMA we found eight species of fish (four non-native). We found 29 species of small terrestrial mammals in five parks and 26 species of medium or large mammals at nine parks. We netted bats at two parks and found 11 species.

We found a number of new species compared to our 2001 effort including the second record in Arizona of wild marigold (*Tagetes minuta)*, an non-native species assigned "class 'A' noxious weed" status in California (CDFA 2003). Also, we found 3 new species of bats at SAGU-E including the Western red bat, a Wildlife Species of Special Concern in Arizona (AGFD 2003).

This annual report, similar to the 2001 report, does not provide an exhaustive analysis of the data. Rather, we present data in a format that will immediately benefit park managers and interpreters; the results for most taxa are expressed as a derivation of relative abundance. For most taxa we discuss results by describing general patterns of species richness among and within parks, and note species of interest. At the time of this writing we are organizing our databases and will begin writing final reports for parks that have completed inventory efforts (CAGR, GICL, SAGU, and TUMA). Final reports will provide parks with a more comprehensive analysis and description of the plants and vertebrates found in their parks. Although our inventory efforts have been among the most comprehensive to date, inventories are an ongoing and there will be a need to continue to collect observations and voucher specimens for species that were (inevitably) missed during this effort.

Table 1. Summary of field inventories in SODEN parks visited, 2002.

	Taxon					
Park	Plants	Amphibians	Reptiles	Birds	Fish	Mammals
Casa Grande National Monument	✓	✓	✓	✓		✓
Chiricahua National Monument[a]	✓	✓	✓	✓		✓
Fort Bowie National Historic Site[a]	✓			✓		
Gila Cliff Dwellings National Monument	✓	✓	✓	✓		✓
Saguaro National Park	✓	✓	✓	✓		✓
Tonto National Monument	✓	✓	✓	✓		✓
Tumacacori National Historical Park	✓	✓	✓	✓	✓	✓
Tuzigoot National Monument[a]		✓	✓			

[a] Park originally scheduled to receive surveys in 2003. See section in report relevant to taxa for type and duration of surveys.

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We thank a core group of dedicated field biologists who persevered through difficult conditions, day in and day out, to collect a wealth of data: James MacAdam, Meg Quinn, and Patty West (plants); Dan Bell and Kevin Bonine (amphibians and reptiles); Gabe Martinez (birds); Neil Perry (terrestrial mammals); Ronnie Sidner (terrestrial mammals and bats). Field assistance was also provided by Emily Bennett, Philip Brown, Cindy Bush, Russell Davis, Michael Olker, Andy Schultz, Chuck Schade, Christina Souza, Patina Thompson, and David Ward. William Norris at Western New Mexico University and Dale Zimmerman provided technical assistance in identifying plants from GICL.

We are thankful to the following people, many of whom never ventured into the field, but whose office tasks made the field effort possible: Debbie Angell, Andy Hubbard, Colleen McClain and Lindsay Norpel. Special thanks to Lisa Carder for her many months of hard work on all aspects of the project.

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We are also grateful to George Binny and Roy Ross, Rick Mohr and Phelps Dodge Corporation for allowing us access to their lands adjacent to TUMA-M and TUZI, respectively.

A big thank you goes to the board of directors of the NPS Sonoran Desert Network I&M Program for their vision and continued support.

Thanks to everyone for your invaluable contributions!

INTRODUCTION

The primary mission of the U.S. National Park Service (NPS) is to protect some of America's greatest natural and cultural resources and to conserve them for future generations (NPS 1988). However, many parks have suffered environmental degradation, both directly as a result of management decisions inside the parks (National Research Council 1992), and indirectly due to land use changes outside of park boundaries. These changes often affect the numbers, diversity, or distribution of species in the parks.

The NPS and other federal and state agencies have often been criticized for their failure to prevent, or even recognize, the loss of species from public lands. These shortcomings are clearly shown by studies which report high extinction rates of mammals (Newmark 1995), amphibians (Drost and Fellers 1996), and plants (Drayton and Primack 1995, Turner et al. 1995) in parks, and are implicit in inventories and studies of park biodiversity (e.g., Cox and Franklin 1989, Debinski and Brussard 1994, Stohlgren et al. 1995).

Basic biological information, including complete plant and animal species lists, is missing for most parks. As of 1994, more than 80% of national parks did not have complete inventories of major taxonomic groups (Stohlgren et al. 1995). Inventory data is particularly lacking for smaller parks and for parks created to protect cultural resources, but which also include considerable natural resources. Responding to criticism that it lacked basic knowledge of natural resources within parks, NPS initiated its Inventory and Monitoring (I&M) Program in the early 1990s. The program was established to increase scientific research in national parks and detect long-term changes in biological or physical resources (NPS 1992).

Species inventories in national parks are important for a number of reasons. Intuitively, species lists are useful for interpretation and for public 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, trails and prescribed fires).

Species inventories are also important for long-term monitoring. Good inventories provide both the basis for making monitoring decisions, such as which species and parameters to monitor, and offer data for long-term monitoring of biological community characteristics such as species richness and distribution. Inventories can also be used to identify those species and communities that are most appropriate to monitor for changes in abundance, demographic structure, or other individual or community parameters.

The purpose of our program is to complete basic inventories for vascular plants and vertebrates in the Sonoran Desert Network (SODEN) of 11 parks in southern Arizona and southwestern New Mexico. From March 2000 to present we have been compiling data on plants and vertebrates at most of these parks. In December 2000, we evaluated the quality of data collected up to that point, identified information gaps, and determined priorities for field sampling for parks. At that time we also produced the initial draft of our study plan (Davis and Halvorson 2000).

The goals of the inventory program are:

1. Compile historical data on all species of vascular plants and vertebrates believed to occur in SODEN parks. Data are found in a number of formats, including museum records, voucher specimens, previous studies, and park databases. As we continue to collect data we will input them into the appropriate NPS databases.
2. Complete field inventories with the goal of documenting at least 90% of all species of vascular plants and vertebrates estimated to occur in each park.
3. Gather inventory information using standardized techniques and repeatable designs so that our efforts can be repeated in the future to detect long-term changes in the distribution and abundance of species.
4. Provide park personnel with products that are useful for interpretation and management, including species lists, status assessments, and GIS-based distribution maps for species of interest.
5. Work closely with the monitoring personnel to assist them in developing protocols and a framework for monitoring plants and vertebrates.

This biological inventory report is the second in a series of reports that tracks our progress toward reaching these goals.

PARK INFORMATION

We completed field inventories in five parks in the SODEN in 2002. In addition, we began inventories in three parks that were originally scheduled to begin receiving inventories in 2003. Parks are shown in Figure 1 and park climate data are found in Table 2. Two parks, SAGU and TUMA have two and three units, respectively. For this report we treated each unit separately.

Note that we did not initiate inventories in two parks within the SODEN; Montezuma Castle National Monument and Organ Pipe Cactus National Monument have received biological inventories, and were not included in the study plan.

Casa Grande Ruins National Monument

Casa Grande Ruins National Monument (CAGR) protects the Casa Grande and other ruins of the ancient Hohokam culture. It was the first designated prehistoric and cultural site in the U.S. (1892) before becoming a national monument in 1918. The park contains desert scrub vegetation with scattered mesquite woodland remnants. CAGR has a base elevation of 430 m and little topographic relief. The rural lands once surrounding the park are now being developed as the town of Coolidge, Arizona grows.

Chiricahua National Monument

Chiricahua National Monument (CHIR) was established in 1924. Although preservation of geologic resources was the impetus to create the monument, the importance of the natural setting and cultural attributes was recognized. The biota are a blend of the Sonoran and Chihuahuan Deserts and represent the Mexican Highland section of the Basin and Range Biogeographical Province. The natural environment includes oak and coniferous forests and woodlands, canyons with erosion-sculpted rock formations, riparian corridors, chaparral hillsides, and grasslands. Human presence has included the prehistoric Mogollon culture, Chiricahua Apaches, military, and ranchers. Surrounding land uses remain mostly ranching and farming.

Coronado National Memorial

Coronado National Memorial (CORO) on the southern end of the Huachuca Mountains, is bounded on the south by the international border. It was established in 1952 to commemorate the 16th Century Spanish expedition through the area led by Francisco Vasquez de Coronado. Madrean woodlands of evergreen oak, pinyon pine and alligator juniper cover most of the Memorial but give way to mesquite savannas, mixed grass-agave grasslands, and near monocultures of exotic grasses in the formerly grazed areas on lower outwash plains and bajadas. Riparian vegetation including Arizona sycamore and seep willow occur near small springs and seeps, and along riparian areas.

Fort Bowie National Historic Site

Fort Bowie National Historic Site (FOBO) was established in 1972 to preserve the ruins of Fort Bowie, which was constructed in 1862 and served as a focal point of military operations against Geronimo and other Chiricahua Apaches. The diversity of vegetation is due to the integration of the Sonoran and Chihuahuan Desert biotic communities. The vegetation communities at FOBO are: riparian woodlands, grasslands, and desert scrub. Permanent water from springs, which were a primary factor in selecting the Fort's location, are particularly important to wildlife.

Gila Cliff Dwellings National Monument

Establish in 1907 and located in the highlands of western New Mexico, Gila Cliff Dwellings National Monument (GICL) is surrounded by the Gila National Forest and extensive wilderness areas. The park was established to protect well-preserved 13th century cliff dwellings. The park consists of two units, the larger cliff dwellings unit and the TJ ruins unit, located a short distance from the visitors center. Vegetation communities include Madrean evergreen woodland, pine forests and riparian associations along West Fork Gila River and a small tributary canyon.

Saguaro National Park

Saguaro National Park (SAGU) was established in 1933 to protect saguaro cacti (*Carnegiea gigantea*) on the lower slopes of the Rincon Mountains (Rincon Mountain District; SAGU-E). The Tucson Mountain District (SAGU-W), west of Tucson, was added in 1961 because of alarm about the lack of saguaro recruitment in SAGU-E. SAGU-W consists chiefly of Sonoran desert uplands and SAGU-E contains five life zones: Sonoran desert uplands, grasslands, oak woodlands, pine forests, and mixed conifer forests. The greatest natural resource issue at SAGU is urban expansion adjacent to its boundaries; Tucson is one of the fastest growing cities in the United States and some development now touches park boundaries. For the purposes of this report, we addressed each District separately.

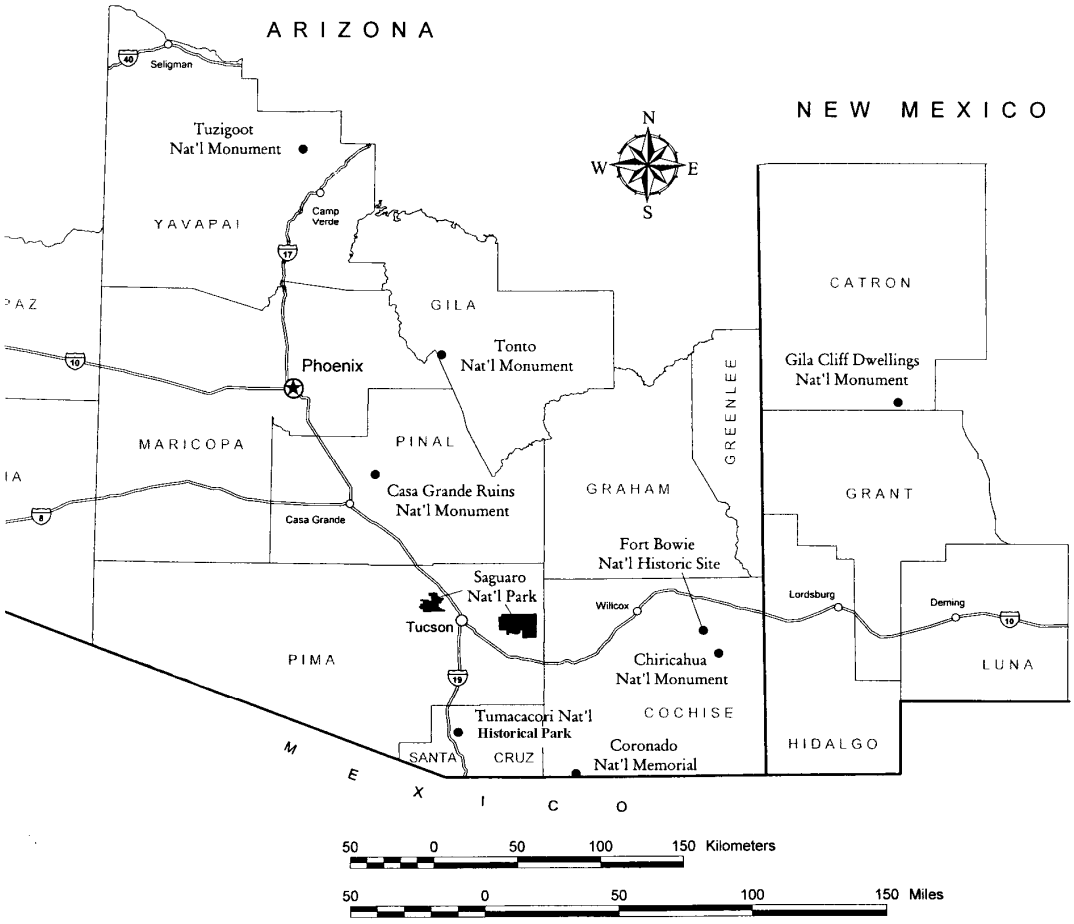

Figure 1. Map of Sonoran Desert Network parks receiving biological inventory in 2002.

Table 2. Climate information and physical characteristics of SODEN parks receiving University of Arizona biological inventories, 2000-2002.

Park	Mean daily temperature in July (˚ C)	Mean daily temperature in January (˚ C)	Mean Annual Precipitation (cm)	Park Size (ha)	Elevation Range (m)
CAGR[a]	32.6	9.2	18.9	191	431 – 436
CHIR[b]	23.5	6.2	50.2	4,852	1,570 – 2,385
CORO[a]	24.5	7.5	52.8	1,923	1,433 – 2,347
FOBO[b]	28.2	7.7	27.3	404	1,417 – 1,600
GICL[a]	21.2	1.4	41.1	216	2,027 – 2,079
SAGU				41,300	610 – 2,621
SAGU-E – low elevation[c]	30.2	10.9	33.1		
SAGU-E – high elevation[d]	18.1	1.4	79.3		
SAGU-W[c]	30.7	11.9	34.4		
TONT[a]	29.7	7.2	40.5	453	695 – 1,219
TUMA[a]	26.5	7.3	40.9	19[e]	994 – 1,097
TUZI[a]	27.8	6.1	30.1	17[f]	1,024 – 1,036[e]

[a] Arizona and New Mexico climate reports (2002).
[b] Summary from Western Regional Climate Center, prepared by The Arizona Department of Commerce, Communications Division (2002).
[c] Arizona and New Mexico climate reports (2002). Data from Sabino Canyon in the adjacent Santa Catalina Mountains.
[d] Arizona and New Mexico climate reports (2002). Data from Palisades Ranger Station in the adjacent Santa Catalina Mountains.
[e] Not including legislated expansion area adjacent to Mission Unit.
[f] Not including proposal expansion area, which is located adjacent to TUZI, is owned by Phelps Dodge Corporation.

Tonto National Monument

Tonto National Monument (TONT), established in 1907, was set aside to protect two prehistoric Salado cliff dwellings and associated sites. TONT consists mainly of Sonoran desert upland vegetation communities, with some localized spring-fed riparian vegetation. The park is surrounded by USFS land. Recent improvements in recreational facilities at neighboring Roosevelt Lake continue to increase visitation to the Tonto Basin.

Tumacacori National Historical Park

Tumacacori National Historical Park (TUMA-M) was established in 1908 to preserve the San José de Tumacacori Mission which was established in 1691. In 1990 the nearby mission ruins of Guevavi (established in 1691; TUMA-G) and Calabasas (established in 1756; TUMA-C) were added to the park. Sonoran desert riparian scrub and some mesic riparian communities along the Santa Cruz River (SCR), inhabit the three units. The SCR adjacent to TUMA-M has perennial water because of a wastewater treatment facility located a few kilometers upstream of the area. In 2002 a bill passed the U.S. Congress that allows for the acquisition of privately-held lands adjacent to TUMA-M, thereby increasing the size of the unit by 1400%. Most of these new lands contain the biologically-rich riparian area along the SCR.

Tuzigoot National Monument

Tuzigoot National Monument (TUZI) was established in 1939 and contains the ruins of one of the largest pueblos built by the Sinaguas who inhabited the area from 1100 to 1400 AD. The site is located in the transition zone between the Upper Sonoran life zone and the true Sonoran Desert. The park is hoping to acquire adjacent Tavasci Marsh (an old oxbow of the Verde River) and a short section of the Verde River. We chose to conduct surveys at Tavasci Marsh and adjacent areas in anticipation of this acquisition.

SPATIAL SAMPLING DESIGNS

In the 2001 report we described stratified random and random designs for SAGU-E and SAGU-W, respectively. Although these designs have strength in drawing inference to larger areas (e.g., the entire park), we found that randomly selected survey locations were often extremely difficult to get to and typically had low species richness and abundance, particularly of small mammals and reptiles. Given these meager rewards, we considered the cost of sampling with these designs to be prohibitive. In consideration of budgetary constraints, we scaled back our sampling efforts at SAGU. To develop complete species lists, we instead focused our efforts on areas that had not been previously surveyed, and on locations likely to posses relatively species-rich communities (e.g., riparian areas). Below is a brief discussion of the two spatial sampling designs that we used during 2002 for all parks.

Preferential Selection of Study Sites

Most parks contain unique areas requiring special surveys for most taxa. Riparian areas, cliffs, rocky outcrops and ephemeral pools were likely to be missed if we located our study sites only in random areas. Yet these areas are biodiversity "hotspots" and are therefore crucial to sample to complete species inventories. We preferentially selected study areas based on our knowledge of the taxa and parks. An important statistical consequence of this design is that the results of these surveys do not apply outside of the areas sampled.

Complete Coverage

For small parks it was possible to survey the entire area for certain taxa without selecting study sites. From a sampling design perspective this is an ideal situation in that there are no issues about inference; the entire "universe" (i.e., the park) is covered.

PLANTS

METHODS

We surveyed for plants through the use of general searches in areas that were likely to contain the most new plants. Often these searches involved searching part or all of a park; at all parks except CHIR, FOBO, and SAGU we attempted to visit the entire park, unit, or area of interest using a systematic walking pattern. We surveyed specifically to complete species lists for the parks.

Vouchers and Identification

We collected plant specimens for species that had not been collected in the parks previously or which could not be identified in the field for identification at the UA Herbarium. At the site of plant specimen collection, we recorded flower color (if applicable), UTM coordinates, and vegetation community associations. We identified all specimens according to the ITIS (Integrated Taxonomic Information System 2002), the most current web-based authority for plant nomenclature. We used the UA herbarium for identifying and accessioning plants.

RESULTS

We collected specimens of 346 species (434 species including duplicates among parks) in 2002 (Table 3). We typically collected two specimens of each species, one of which was deposited in the UA collection. The other is currently held by I&M. We collected the most species at CHIR (136), and fewest at CAGR (6), the most new species at GICL (98) and fewest at SAGU-E (1). Of these new species, 7% were non-native. Thirty-eight percent of new species at TUMA-M were non-native including wild marigold (*Tagetes minuta*), an exotic from South America that has only once previously been reported in Arizona (ASU herbarium staff, pers. com.).

The percentage of collections new to the park was highest at CAGR (83%) and GICL (90%), where little botanical work has been done. In other parks, the percentage of plants that were new was relatively low (3-13%). This preliminary assessment of plants previously undocumented for parks is based on a variety of sources, including studies that did not collect voucher specimens to substantiate the lists and are thus unreliable. A more complete review of plant collections from each park will be available in the final reports to each parks.

Table 3. Summary of preliminary results from plant specimen collecting by park unit, 2002.

Park	Number of species collected	Number of new records for the park	Number of new records that are non-native	Percentage of new records that are non-native	Appendix
CAGR	6	5	0	0	B
CHIR	136	5	1	20	C
FOBO	109	3	0	0	D
GICL	109	98	4	4	E
SAGU-E	10	1	0	0	F
TUMA-M	64	8	3	38	G
Totals	**434**	**120**	**8**	**7**	

AMPHIBIANS AND REPTILES

METHODS

We surveyed for amphibians and reptiles (herps) using five survey techniques or designs at seven parks between June and September, 2002 (Table 4). We combine reporting for amphibians and reptiles in this report because we surveyed for both phylogenetic classes using the same techniques. Most of our surveys were not constrained in time or area, which increased flexibility, maximized the crew's ability to survey more locations, and allowed us to target areas likely to have new species. Our goal in 2002 was to augment the extensive herp surveys we conducted in 2001, and we targeted species and search areas accordingly.

We anticipated placing special emphasis on ephemeral breeding amphibians that generally become active at the start of the monsoon rains, which were poor in 2001 and may have contributed to the relatively low number of amphibian detections in last year's inventory effort.

In 2002 we surveyed all parks we had visited in 2001 (CAGR, GICL, SAGU, TONT, TUMA), and made brief "reconnaissance" visits to TUZI (one visit) and CHIR (two visits).

For all survey methods, we recorded weather information (temperature, relative humidity, percent cloud cover, wind speed, and an overall description of the conditions). For methods other than pitfall trapping and road cruising we recorded species, time of observation, method used to locate the animal (visual, auditory, scanning with binoculars, moving cover, using mirror, or other), groundcover category of the area where the animal was located (bare ground, vegetation, rock, edifice, burrow, or water), sex and age (if known). All detections were geo-referenced using hand-held GPS units.

Table 4. Summary of survey methods and supplemental documentation type for herps by park unit, 2002.

	Park Unit									
Survey or documentation type	CAGR	CHIR	GICL	SAGU-E	SAGU-W	TONT	TUMA-C	TUMA-G	TUMA-M	TUZI
Incidental observations	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Pitfall traps	✓		✓		✓				✓	
Plot surveys	✓		✓							
Road cruising	✓	✓	✓	✓	✓					
Special-area searches	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Voucher photographs	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Voucher specimens	✓	✓	✓	✓				✓	✓	✓

Special-area Surveys

In an effort to maximize efficiency and probability of detecting species not found in 2001, we relied heavily on special-area surveys, which we used on a more limited basis in 2001 (Powell et al. 2002). We designed special-area surveys to enable us to search areas that we determined, based on our experience, were likely to have high species richness, abundance, or species of interest. These surveys were not constrained in time or area.

Special areas selected were often located in major canyons and riparian areas, but our selection criteria varied among parks because of differences in scale and habitat features. For example, at

SAGU-E and -W we targeted major drainages, at CAGR we focused on depressions likely to retain rainwater, and at CHIR we prioritized grasslands and rocky slopes.

Plot Surveys

We visited several locations at CAGR (6 plots) and GICL (5 plots) where we conducted plot surveys in 2001 (Powell et al. 2002). Surveys were limited to 90 minutes at CAGR and 60 minutes at GICL.

Incidental Observations

When we were not conducting a formal survey, we recorded each herp we encountered with associated GPS coordinates, time, and weather conditions. We also recorded the route we were taking when we saw the individual.

Pitfall Traps

We maintained one pitfall trap array at each of four parks: CAGR (100m north of the park entrance road and approximately 600m west of the park entrance), SAGU-W (west of Sandario Road and south of Manville Road), TUMA-M (proposed park-expansion land near the Santa Cruz River) and GICL (floodplain of the West Fork Gila River).

We constructed traps using four 5-gallon buckets. We placed three buckets 8m away from a central bucket in a horizontal plane at angles of about 120 degrees (Gibbons and Semlitsch 1981). We buried the buckets in the ground so that the lip of each bucket was at ground level, then dug a shallow trench connecting each of the three outside buckets to the central bucket. We placed a "drift fence" consisting of a 7.6 m by 46 cm piece of aluminum flashing in each trench, filled in the trench, and supported each wall with rebar.

An animal encountering one of the drift fences would turn right or left to go around it. Upon reaching the end of the fence, the animal would fall into the bucket and would be unable to escape.

We typically opened the pitfall traps around sunset, then checked and closed the traps with tight-fitting lids early the next morning, but at SAGU and GICL we maintained traps during the day on several occasions. We erected cover boards a few inches above the buckets which helped to keep the animals shaded in the morning or during day trapping. We used wire mesh funnel traps at the midpoint of each side of each drift fence at TUMA and GICL. We trapped 4 nights at CAGR, 25 nights at TUMA, 2 days and 23 nights at SAGU-W, 4 days and 22 nights at GICL.

Summary analysis of pitfall data consists of "minimum number" of each species; because we did not mark captured animals, we cannot determine whether subsequent captures of the same species were new individuals or "re-captures". Minimum number was determined by comparing age, sex, and distinguishing marks among all individuals captured, or by summing the number of individuals found in traps simultaneously.

Road-cruising Surveys

We used road-cruising surveys at CHIR (entrance road, all maintenance and residence roads), GICL (from the visitors center to the Cliff Dweller Canyon trailhead), SAGU-E (Loop Road) and SAGU-W (Kinney, Hohokam, and Golden Gate Roads). Road cruising involves driving slowly

along a road after sunset and watching the road and shoulder for animals. During these surveys we recorded the same weather information noted in other surveys. When we encountered an animal we recorded species, time observed, the mileage from the start point of the survey, and whether the animal was alive or dead.

Voucher Specimens and Photographs

Prior to field work, we collected records of voucher specimens from several parks and the UA collection to create a list of species that had already been collected from each park. When we found a species that was not on the voucher list or we found a dead animal in reasonable condition, we usually turned it into a specimen. We deposited voucher specimens in the UA reptile and amphibian museum collection. For each voucher specimen, we recorded the species, where and when it was collected, weather conditions and brief habitat description, and collector.

We photographed, using slide film, every herp species at each park that we were able to capture. We recorded the same information for each voucher photograph that we recorded for voucher specimens. We labeled each slide to indicate the species, date, park, and name of the photographer. We selected between one and three slides as official voucher photographs for each species in each park.

RESULTS

Unfortunately, according to the National Climatic Data Center (NCDC), one of Arizona's worst monsoon-season droughts on record coincided with our field work (NCDC 2003). The combined lack of moisture and unusually high temperatures may have adversely affected our results, particularly with regard to detection of amphibian species.

Summing results from all methods (special-area and incidental surveys, pitfall trapping and road cruising), we found 50 species of reptiles and 11 species of amphibians during the 2002 field season (Tables 5 and 6, respectively). We found the highest number of reptile species at SAGU-E (27), the highest abundance of reptiles at CAGR (389), highest species richness of amphibians at SAGU-E (7), and highest abundance of amphibians at GICL (369). The total number of "herps" found was highest at CAGR (634). These differences are not surprising given the diversity of biotic communities in SAGU-E and the high number of a few species of lizards, toads, and frogs at CAGR and GICL. The lowest species richness and number of individuals in each category was found in TONT, TUMA-C, or TUMA-G, which is to be expected given the limited search area and time spent in these units.

The most abundant reptile species were the tiger whiptail lizard at CAGR, SAGU-W, TONT and TUZI, the mountain spiny lizard at CHIR, the ornate tree lizard at GICL, the Clark's spiny lizard at SAGU-E, and the Sonoran spotted whiptail lizard at TUMA-C, -G and -M (Table 5).

The most abundant amphibian species were the Couch's spadefoot at CAGR, the canyon treefrog at CHIR, the Arizona toad at GICL, the Colorado River toad and the Couch's spadefoot at SAGU-W, the Couch's spadefoot at SAGU-E, TUMA-C and TUMA-M, the Couch's spadefoot and the Mexican spadefoot at TUMA-G, and the non-native American bullfrog at TUZI. As in 2001, we found no amphibians at TONT (Table 6).

There was no reptile species common to all eight parks, though the ornate tree lizard was found in all except CAGR. Thirteen reptile species were unique to single park units (Table 5). The Couch's spadefoot toad, found at six of the park units, was the most widespread amphibian encountered in our survey, and five amphibian species were found in only one park unit (Table 6).

Comparing results from 2002 with those from 2001, we found the same number of amphibian species (11), and slightly fewer reptile species (50, down from 52). One of these amphibians and four reptile species were found in CHIR, which was not surveyed in 2001. Our surveys were more efficient in 2002; within 33% of the number of individuals found in 2001 we detected 96% of the number of species (Powell et al. 2002).

In 2002 we found several species not detected in the same parks in 2001 (Tables 5, 6; Powell et al. 2002). These include 3 species of reptiles at GICL, 1 species of amphibian and 1 reptile at SAGU-E, 3 reptiles at SAGU-W, 9 reptiles at TONT, and 2 reptiles at TUMA-M, 2 amphibians at CAGR. Percentage of these "new" herp species ranged from 0 (TUMA-M) to 82 at TONT. Because of the excellent herp inventory completed at TONT by Don Swann (Swann et al. 1996), we spent little time there in 2001 or 2002. TONT received scant monsoon rains during Swann's surveys (Don Swann, pers. comm.), and our hope both in 2001 and 2002 had been to document amphibian species he had not found.

We found several species never documented in these parks before: Plains threadsnake at CHIR; Clark's spiny lizard, ringneck snake, and narrow-headed garter snake at GICL; Sonoran whipsnake and Sonoran coralsnake at SAGU-W; Western patch-nosed snake at TUMA-C and -G; Western threadsnake at TUZI.

Although in 2002 we detected nearly the number of species that we found in 2001, many species were not found including 1 species of reptile each at CAGR and GICL, 11 reptiles at SAGU-E, 2 species of amphibian and 8 reptiles at SAGU-W, 4 reptiles at TONT, 3 species of amphibian and 2 of reptile at TUMA.

Observations made by Inventory crews surveying for other taxa contributed significantly to our findings in 2002, documenting an additional 20 species not found in the same park unit by our herp crew. In many cases these observations were made by technicians with little background in herpetology but were substantiated by photographs or with detailed descriptions. Such observations illustrate the important role that can be played by park staff in continuing to develop species lists.

In the coming months we will analyze data from each survey technique and present these in the final reports to each park. These analyses will give managers and interpreters a more precise estimate of the relative abundance of herp species in their parks.

We took 39 official voucher photographs of herps at all parks. CHIR had the most species with voucher photographs (Tables 5, 6). We are in the process of scanning these slides, and the digital images will be available for use by park personnel.

Table 5. Relative frequency (%) of observations of reptiles by park unit, 2002. Frequencies were calculated using total numbers of individuals from all sampling methods. Underlined numbers indicate that we obtained specimen or photographic vouchers. Informal incidental observations (●) were documented by volunteers or technicians surveying for other taxa. Cells with "+" indicate species not found in 2001 surveys.

			Percent Relative Frequency of Observations by Park Unit									
Order Family	Scientific name	Common name	CAGR	CHIR	GICL	SAGU-E	SAGU-W	TONT	TUMA-C	TUMA-G	TUMA-M[a]	TUZI
Testudines												
Emydidae	*Terrapene ornata*	ornate box turtle		1							●	
Kinosternidae	*Kinosternon sonoriense*	Sonora mud turtle				4						4
Testudinidae	*Gopherus agassizii*	desert tortoise				6						
Squamata												
Teiidae	*Cnemidophorus exsanguis*	Chihuahuan spotted whiptail		4	19							
	Cnemidophorus sonorae	Sonoran spotted whiptail		2		8	2	4	46	43	67	
	Cnemidophorus tigris	tiger whiptail	60			2	38	47				38
	Cnemidophorus uniparens	desert grassland whiptail		1							10	4
Anguidae	*Elgaria kingii*	Madrean alligator lizard		2	●							
Gekkonidae	*Coleonyx variegatus*	Western banded gecko	1			2	1					
Helodermatidae	*Heloderma suspectum*	Gila monster				2	1	●				
Iguanidae	*Callisaurus draconoides*	zebra-tailed lizard				2	17	2				
	Cophosaurus texanus	greater earless lizard				2						5
	Crotaphytus collaris	common collared lizard			●	●						2
	Dipsosaurus dorsalis	desert iguana					1					
	Holbrookia maculata	common lesser earless lizard				4	8			4	2	
	Phrynosoma hernandesi	greater short-horned lizard		1		●						
	Phrynosoma solare	regal horned lizard					1				1	
	Sceloporus clarkii	Clark's spiny lizard		3	+●	18	7		23	4	4	7
	Sceloporus jarrovii	mountain spiny lizard		63								
	Sceloporus magister	desert spiny lizard	2			2	6	2				5
	Sceloporus poinsettii	crevice spiny lizard			5							
	Sceloporus undulatus	Eastern fence lizard			28						4	
	Sceloporus virgatus	striped plateau lizard		5								
	Urosaurus graciosus	long-tailed brush lizard	3									
	Urosaurus ornatus	ornate tree lizard		2	41	14	3	6	23		9	9
	Uta stansburiana	common side-blotched lizard	31			2	7	33				25
Leptotyphlopidae	*Leptotyphlops dulcis*	Plains threadsnake		1								
	Leptotyphlops humilis	Western threadsnake					1					2
Viperidae	*Crotalus atrox*	Western diamond-backed rattlesnake				2	4	2		40	2	
	Crotalus lepidus	rock rattlesnake		5								
	Crotalus molossus	black-tailed rattlesnake		3	1	6	1	2				
	Crotalus scutulatus	Mojave rattlesnake	1									
	Crotalus tigris	tiger rattlesnake				4	●					
	Crotalus viridis	Western rattlesnake				●						
Colubridae	*Diadophis punctatus*	ringneck snake			+●	+●						

Order / Family	Scientific name	Common name	Percent Relative Frequency of Observations by Park Unit									
			CAGR	CHIR	GICL	SAGU-E	SAGU-W	TONT	TUMA-C	TUMA-G	TUMA-M[a]	TUZI
Columbridae	*Hypsiglena torquata*	nightsnake		2			1			4	1	
	Lampropeltis getula	common kingsnake	1			●		●				
	Lampropeltis pyromelana	Sonoran mountain kingsnake		1		●						
	Masticophis bilineatus	Sonoran whipsnake		1		2	+●					
	Masticophis flagellum	coachwhip	1			●	1				1	
	Masticophis taeniatus	striped whipsnake			1							
	Pituophis catenifer	gophersnake	1	1	1							
	Rhinocheilus lecontei	long-nosed snake	1				1					
	Salvadora grahamiae	Eastern patch-nosed snake		1	●	●						
	Salvadora hexalepis	Western patch-nosed snake							+8	+4		
	Thamnophis cyrtopsis	black-necked gartersnake		5	2	16						
	Thamnophis elegans	terrestrial gartersnake			2							
	Thamnophis rufipunctatus	narrow-headed garter snake			+1							
	Trimorphodon biscutatus	Western lyresnake		2			+●					
Elapidae	*Micruroides euryxanthus*	Sonoran coralsnake				2	+1	+2		+4		
Number of individuals			**389**	**198**	**265**	**50**	**140**	**294**	**49**	**13**	**28**	**56**
Species richness			**10**	**20**	**15**	**27**	**22**	**11**	**4**	**7**	**11**	**10**
Percentage of species new in 2002			**0**	**NA**	**20**	**4**	**14**	**82**	**25**	**29**	**0**	**NA**
Number of species with photo vouchers			**1**	**16**	**1**	**0**	**1**	**1**	**1**	**2**	**2**	**4**

[a] TUMA-M sightings include proposed expansion area

Table 6. Relative frequency (%) of observations of amphibians by park unit, 2002. Frequencies were calculated using total numbers of individuals from all sampling methods. Underlined numbers indicate that we obtained specimen or photographic vouchers. Informal incidental observations (●) were documented by volunteers or technicians surveying for other taxa. Cells with "+" indicate species was not found in 2001 surveys.

			Percent Frequency of Observations by Park Unit									
Family	Scientific name	Common name	CAGR	CHIR	GICL	SAGU-E	SAGU-W	TONT	TUMA-C	TUMA-G	TUMA-M[a]	TUZI[a]
Ambystomatidae	*Ambystoma tigrinum*	tiger salamander		14								
Pelobatidae	*Scaphiopus couchii*	Couch's spadefoot	+68			41	50		83	50	47	
	Spea multiplicata	Mexican spadefoot		14		1			17	50	2	
Bufonidae	*Bufo alvarius*	Colorado River toad	28			35	50					
	Bufo cognatus	Great Plains toad	+4	14		1						
	Bufo microscaphus	Arizona toad			55							
	Bufo punctatus	red-spotted toad				9						
	Bufo woodhousii	Woodhouse's toad									13	
Hylidae	*Hyla arenicolor*	canyon treefrog		57	4	8						
Ranidae	*Rana catesbeiana*	American bullfrog[b]			41						38	100
	Rana yavapaiensis	lowland leopard frog				6						
Number of individuals			**57**	**7**	**369**	**104**	**2**	**0**	**6**	**2**	**95**	**9**
Species richness			**3**	**4**	**3**	**7**	**2**	**0**	**2**	**2**	**4**	**1**
Percentage of species new in 2002			**67**	**NA**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**NA**
Number of species with photo vouchers			**2**	**3**	**1**	**0**	**0**	**0**	**2**	**0**	**1**	**0**

[a] TUMA-M and TUZI sightings include proposed expansion areas

[b] Non-native species

BIRDS

METHODS

We surveyed for birds during the 2002 field season using three methods: variable circular-plot method at "permanent" and "reconnaissance" sites for diurnal birds, nocturnal surveys for owls and nightjars, and incidental observations for all species. We chose to concentrate our efforts during the breeding season for two reasons. First, breeding habitat plays a key role in the lifecycle of animals. Second, and most importantly from a monitoring perspective, the distribution of birds is temporally and spatially patchy during the non-breeding season due to the lack of territoriality and heterogeneity of food resources. However, during the breeding season birds maintain territories, thereby increasing our precision in estimating parameters of interest in monitoring such as abundance or density. It is important to note, however, that our survey period includes peak migration time for most species, thereby adding many species to our lists.

Variable Circular-plot Method: Diurnal Surveys

Permanent Transects. To survey for diurnal birds, we used the variable circular-plot method (VCPM; Reynolds et al. 1980, Buckland et al. 1993). Table 7 shows the location and description of the 13 "permanent" transects (81 points) that we surveyed in 2002. At each transect we established between 4 and 12 points, with a minimum of 250 m between points.

A crew of three observers surveyed from early April to late July, the period of peak breeding activity for most species in southern Arizona. To account for the later onset of breeding at higher elevations (at GICL and SAGU-E), we began surveying low-elevation areas first and moved to progressively higher elevations as conditions permitted. We varied the number of visits to each transect (Table 7) but maintained a minimum of ten days between surveys. On each visit, we alternated observers and the order in which we surveyed points along a transect to minimize bias by observer, time of day, and direction of travel.

We began bird surveys a few minutes before sunrise and concluded no later than four hours after sunrise, or when bird activity decreased markedly. We did not survey during gusty winds, when the average wind speed exceeded approximately 15 kph or when precipitation was heavier than an intermittent drizzle.

We recorded a number of environmental variables before we began each transect: wind speed (Beaufort scale), recent rain, temperature (ºC), humidity and cloud cover. After arriving at a point, we waited one full minute before beginning the count to allow birds to resume their normal activities. During the "active" period we counted birds for eight minutes and identified birds to species. We then recorded the exact distance (in meters) to each bird (often with the aid of laser range finders), time of detection (measured in one-minute intervals beginning at the start of the active period), and, if known, the sex and age class (adult or juvenile) of the bird(s). When observed, we recorded breeding behavior. We did not estimate distances to birds that were flying. We recorded an individual as a "repeat" if we recorded it on a previous point in the transect. If we detected a species during the "passive" count period (between the eight-minute counts) we recorded its distance to the nearest point.

Reconnaissance Transects. We used a modified version of "permanent" transects to survey areas that we would only be able to visit once during the season. Table 7 describes the location of 20 reconnaissance transects from 2002. Reconnaissance transects were identical to permanent transects except that counts at each point were shorter in duration (five minutes), and points were further apart (400 – 500 m) to enable us to cover more ground.

Table 7. Summary of bird surveys by park unit, 2002.

Survey Type / Park Unit	Transect Name or Location	Total Points	Number of Visits
Permanent VCPM			
CAGR	CAGR	12	4
GICL	Riparian - West Fork Gila River	6	6
	Uplands - near ruins	6	5
SAGU-E	Lower Rincon Creek	8	7
	Upper Rincon Creek	4	5
	Box Canyon	7	5
	Happy Valley Saddle	6	2
	Rincon Peak	4	2
	Loma Verde Creek	5	3
TONT	Riparian area	6	5
	Uplands- above upper ruins	4	4
TUMA-M	Mission and adjacent lands	8	7
TUMA-C and -G	Calabasas/Guevavi units	5	5
Reconnaissance VCPM			
CHIR	Bonita Canyon	9	1
CORO	Coronado Peak	3	1
FOBO	Siphon Canyon	9	1
SAGU-E	Bridal Wreath Falls	7	1
	Broadway Trailhead	8	1
	Chiminea Canyon	6	1
	Deer Head Springs	5	1
	Douglas Spring	4	1
	Freeman Road	8	1
	Freeman Wash	5	1
	Italian Spring	8	1
	Juniper Springs	5	1
	Loma Verde Wash	8	1
	Madrona Canyon	7	1
	Manning Camp	8	1
	Mica Mountain Trail	4	1
	North Slope Trail	8	1
	Upper Juniper Basin	5	1
SAGU-W	Camino del Cerro Wash	3	1
	Picture Rocks Wash	3	1
Nocturnal			
CAGR	Main Road	4	2
CHIR	Main Road	4	1
GICL	Main Road	4	3
SAGU-E	Loop Road	6	2
	Rincon Creek	4	1
	Manning Camp	4	1
	Box Canyon	3	1
	Juniper Basin		1
	Italian Spring	2	1
	Spud Rock Spring		1
SAGU-W	Golden Gate	6	2
	Loop Road	6	1
TONT	Riparian area	6	2
TUMA-M	Mission and adjacent lands	3	2
TUMA-C and -G	Calabasas/Guevavi units	2	2

Tape-playback for Owls

To inventory for owls we used tape-playbacks (Bibby et al. 1992) whereby we broadcast a recording of the species of interest using a megaphone setup (compact disc player and broadcaster). The owl recordings were from commercially available CDs (Peterson's Western Birds and Stokes Field Guide to Bird Songs - Western edition). Although we did not broadcast calls of nightjars, we recorded them when we heard them during owl surveys.

We established at least one owl survey transect along a road or trail at each park (Table 7). Owl call points were a minimum of 300 m apart and the number of points varied from three to six per transect. As with the VCPM surveys, we began surveying in the low-elevation transects early in the season and moved to progressively higher transects as conditions permitted. We also alternated observers and direction of travel along transects. We began surveys 45 minutes after sunset.

At each point, we began with a three-minute "passive" listening period when we broadcast no calls. We then broadcasted recordings of from four to six owl species, for a two-minute "active" period. During active periods, we broadcasted owl calls for 30 seconds followed by a 30-second listening period. This pattern was repeated two times for each species. We played recordings of owls, in order, from the smallest to the largest-sized species so that smaller species would not be inhibited by the "presence" of larger predators or competitors (Fuller and Mosher 1981). For example, at SAGU-W, we broadcasted for elf, Western screech, burrowing, and common barn owls in that order. We excluded great horned owl from the broadcast because of their aggressive behavior toward other owls. We did not broadcast for cactus-ferruginous pygmy owls or Mexican spotted owls, two endangered species currently monitored by the NPS.

During the count period, we used a flashlight to scan nearby vegetation for visual detections. If we detected a bird during the three-minute passive period, we recorded in which portion of the passive

period (1st, 2nd, and/or 3rd minute) the bird was detected, the type of detection (aural, visual or both), and the distance to the bird. If a bird was detected during any of the active periods, we recorded when each bird was detected during four 30-second intervals and the type of detection (aural, visual or both). Individuals that we detected at more than one point along a transect were marked as "repeats." We did not survey when winds exceeded 3 on the Beaufort scale (13-19 kph) or when precipitation was heavier than an intermittent drizzle.

Incidental Observations

When we encountered a species of interest, a species in an unusual location or observed breeding behavior outside of formal surveys, we recorded the location, time of detection, and (if known) the sex and age class of the bird.

Breeding Observations

When possible we recorded all observations that are considered to be confirmation of breeding by the North American Ornithological Atlas Committee (NORAC 1990). We classified each observation into one of nine categories: adults carrying nesting material, nest building, distraction display, used nest, fledged young, occupied nest, carrying food, adults feeding young, or adults carrying a fecal sac.

Winter Bird Surveys

We surveyed from October 2002 through January 2003 at eight park units for winter birds: CAGR, CORO, FOBO, CHIR, SAGU-E, and TUMA-C, -G, and -M. We surveyed selected areas at each park in the attempt to record species that would not be found during the breeding bird surveys. Although not in the original study proposal, we felt it was necessary to include these counts in order to reach our goal of documenting 90% of species present. Detailed methods and results from these surveys will be included in the final reports to parks.

RESULTS

Bird survey results for all species and parks appear in Table 8. We found 192 species in nine park units during 2002, from April 1 through September 1. Of the five park units with permanent VCPM stations (Table 7) in 2001, SAGU-E had the most species (135) and CAGR had the fewest (53). Given the elevational gradient and corresponding diversity of habitat types at SAGU-E compared to other parks (particularly CAGR) we would expect this pattern. We found two species (mourning dove and ash-throated flycatcher) in all nine park units visited throughout the 2002 season and 38 species that were found in only a single park unit. Three of those species (long-eared owl, Lucifer's hummingbird and Mexican chickadee) were found FOBO, CORO and CHIR, respectively, using reconnaissance VCPM in park units not surveyed in 2001.

We found 24 species during 2002 surveys that we did not find in 2001 (all parks combined) whereas we found 18 species during 2001 that we did not find in 2002. The percent of new species found in 2002 at parks surveyed in both years varied considerably among parks, from 10% at GICL and SAGU-E to 43% at TONT, 36% at CAGR and 31% at TUMA. Documentation of these additional species clearly illustrates the importance of surveying in multiple years.

We recorded 223 observations of breeding behavior in 69 species. The number of species with breeding observations ranged from 2 at CORO to 43 at SAGU-E.

Table 8. Frequency of detections (%) of bird species by park unit, April-September 2002. Percent frequencies are derived from variable circular-plot method (VCPM) counts and nocturnal surveys, and are averaged for all points in the park unit or strata (see text for descriptions of study areas). Incidental sightings are noted with (●). Underlined numbers indicate that breeding behavior by one or more individuals (or pairs) of that species was observed in the park. For GICL, SAGU-E and TONT incidental and breeding records are noted only in the "Total" or "Riparian" column. For CHIR, CORO, and FOBO data are based on one "Reconnaissance" survey to each park (see Table 7). Cells with "+" indicate species not found in 2001 surveys.

			Percent Relative Frequency of Detections by Park													
							GICL Transect		SAGU-E Elevation Stratum					TONT Transect		
Order Family	Common Name	Scientific Name	CAGR	CHIR	CORO	FOBO	Uplands	Riparian	Low[a]	Mid[b]	High[c]	SAGU-E Total	SAGW[d]	Riparian	Upland	TUMA
Ciconiiformes																
Ardeidae	great blue geron	*Ardea herodias*						6								+6
	great egret	*Ardea alba*	+●													
Threskiornithidae	white-faced Ibis	*Plegadis chihi*														+●
Cathartidae	turkey vulture	*Mycteria americana*						8	3			2	8	16		5
	black vulture	*Coragyps atratus*														1
Anseriformes																
Anatidae	black-bellied whistling duck	*Dendrocygna autumnalis*														1
	mallard	*Anas platyrhynchos*						6								1
	common merganser	*Mergus merganser*						8								
Falconiformes																
Accipitridae	Northern harrier	*Circus cyaneus*	+3													
	sharp-shinned hawk	*Accipiter striatus*										●				
	Cooper's hawk	*Accipiter cooperii*				11			5	5		4		13		4
	Northern goshawk	*Accipiter gentilis*									2	●				
	common black-hawk	*Buteogallus anthracinus*						●				+●				
	Harris's hawk	*Parabuteo unicinctus*	+●										8			
	gray hawk	*Asturina nitida*							2			+2				26
	Swainson's hawk	*Buteo swainsoni*	+3													+●
	zone-tailed hawk	*Buteo albonotatus*		●					1	5		1	●			
	red-tailed hawk	*Buteo jamaicensis*	●			11			4	5	1	4	8	3	6	
	golden eagle	*Aquila chrysaetos*		●									●			
Falconidae	Merlin	*Falco columbarius*												+●		
	American kestrel	*Falco sparverius*	18					8	3			2	●	10		
	peregrine falcon	*Falco peregrinus*				11						●		+●		+1
	prairie falcon	*Falco mexicanus*	3													
Galliformes																
Phasianidae	wild turkey	*Meleagris gallopavo*						3								
Odontophoridae	Montezuma quail	*Cyrtonyx montezumae*			●			●		9		1				
	Gambel's quail	*Callipepla gambelii*	66	●		33			49			36	38	45		10
Charadriiformes																
Charadriidae	killdeer	*Charadrius vociferus*						3								4
Scolopacidae	spotted sandpiper	*Actitis macularia*						3								

Order / Family	Common Name	Scientific Name	Percent Relative Frequency of Detections by Park													
							GICL Transect		SAGU-E Elevation Stratum					TONT Transect		
			CAGR	CHIR	CORO	FOBO	Uplands	Riparian	Low[a]	Mid[b]	High[c]	SAGU-E Total	SAGW[d]	Riparian	Upland	TUMA
Columbiformes																
Columbidae	rock dove	*Columba livia*	8		●											
	band-tailed pigeon	*Columba fasciata*		●				●	1		5	1				●
	white-winged dove	*Zenaida asiatica*	11	11	33	100			89	14	2	66	92	26	13	50
	mourning dove	*Zenaida macroura*	92	11	33	44	29	53	62	14	1	46	46	29	13	46
	Inca dove	*Columbina inca*	●													5
	common ground-dove	*Columbina passerina*														18
Cuculiformes																
Cuculidae	yellow-billed cuckoo	*Coccyzus americanus*														8
	greater roadrunner	*Geococcyx californianus*	+3		33				2		1	2	8			9
Strigiformes-Nocturnal Surveys[e]																
Tytonidae	barn owl	*Tyto alba*	25						8			+4		+17		20
Strigidae	Western screech-owl	*Otus kennicottii*		25					42	40		28	22	+17		60
	whiskered screech owl	*Otis trichopsis*		25						20		4				
	great horned owl	*Bubo virginianus*						●	33			16				
	elf owl	*Micrathene whitneyi*							92	20		48	72	67		+10
	burrowing owl	*Athene cunicularia*	25													
	spotted owl	*Strix occidentalis mexicana*									●	●				
	long-eared owl	*Asio otus*				●										
Caprimulgiformes-Noturnal Surveys[e]																
Caprimulgidae	lesser nighthawk	*Chordeiles acutipennis*	13						●			●	●			
	common poorwill	*Phalaenoptilus nuttallii*	●						17			8	28	17		+10
	whip-poor-will	*Caprimulgus vociferus*								20	38	4				
Apodiformes																
Apodidae	white-throated swift	*Aeronautes saxatalis*		●				●		5	1	1	8	3	25	
	Vaux's swift	*Chaetura vauxi*														+●
Trochilidae	Lucifer's hummingbird	*Calothorax lucifer*			●											
	broad-billed hummingbird	*Cynanthus latirostris*							12			9				13
	black-chinned hummingbird	*Archilochus alexandri*	●			33	4	3	13	5		10		13	6	16
	Anna's hummingbird	*Calypte anna*	18							9		1	8			
	Costa's hummingbird	*Calypte costae*	+5						3			2		10		+3
	calliope hummingbird	*Stellula calliope*						●								
	broad-tailed hummingbird	*Selasphorus platycercus*		11			11	11	3		13	4	●	+6	6	+1
	rufous hummingbird	*Selasphorus rufus*						●	2			1				
Coraciiformes																
Alcedinidae	belted kingfisher	*Ceryle alcyon*						+●	1			●				

Order / Family	Common Name	Scientific Name	Percent Relative Frequency of Detections by Park													
							GICL Transect		SAGU-E Elevation Stratum					TONT Transect		
			CAGR	CHIR	CORO	FOBO	Uplands	Riparian	Low[a]	Mid[b]	High[c]	SAGU-E Total	SAGW[d]	Riparian	Upland	TUMA
Piciformes																
Picidae	acorn woodpecker	*Melanerpes formicivorus*		56				28		9	19	4				
	Gila woodpecker	*Melanerpes uropygialis*	21						72			52	92	+39		*74*
	red-naped sapsucker	*Sphyrapicus nuchalis*		●								+●				
	ladder-backed woodpecker	*Picoides scalaris*		●		22			26			19		23	19	31
	hairy woodpecker	*Picoides villosus*		●			14	14		14	28	7				
	Arizona woodpecker	*Picoides arizonae*		11								●				
	Northern flicker	*Colaptes auratus*		11			18	44	1	5	18	5				6
	gilded flicker	*Colaptes chrysoides*	+29						9			6	15		6	+1
Passeriformes																
Tyrannidae	rose-throated becard	*Pachyramphus aglaiae*														+●
	Northern beardless-tyrannulet	*Camptostoma imberbe*							1			1				14
	olive-sided flycatcher	*Contopus cooperi*													+6	
	greater pewee	*Contopus pertinax*									19	4				
	Western wood-pewee	*Contopus sordidulus*	3	33			14	25	1	9	32	8		3		6
	willow flycatcher	*Empidonax traillii*										+●				●
	gray flycatcher	*Empidonax wrightii*	+3						1			1				+3
	Pacific-slope flycatcher	*Empidonax difficilis*												+6		1
	buff-breasted flycatcher	*Empidonax fulvifrons*										●				
	cordilleran flycatcher	*Empidonax occidentalis*					18		1		36	7				●
	black phoebe	*Sayornis nigricans*						8	2			2				1
	Say's phoebe	*Sayornis saya*	+3		●	●	7							10		6
	vermilion flycatcher	*Pyrocephalus rubinus*							6			4				18
	dusky-capped flycatcher	*Myiarchus tuberculifer*		56	33				3	5	25	7				20
	ash-throated flycatcher	*Myiarchus cinerascens*	34	67	33	33	21	11	16	32	7	16	23	48	13	19
	brown-crested flycatcher	*Myiarchus tyrannulus*				●			60	14		45	23	23	19	34
	sulphur-bellied flycatcher	*Myiodynastes luteiventris*									5	1				+●
	Cassin's kingbird	*Tyrannus vociferans*		33	33	56		6	9	5	1	8				25
	Western kingbird	*Tyrannus verticalis*	13		●				3			2		+●		8
Laniidae	loggerhead shrike	*Lanius ludovicianus*	8							9		1				
Vireonidae	Bell's vireo	*Vireo bellii*						3	55			39		84		46
	gray vireo	*Vireo vicinior*													+31	
	Hutton's vireo	*Vireo huttoni*		11						5	6	2				
	warbling vireo	*Vireo gilvus*					11	39	1		9	2		3		1
	yellow-throated vireo	*Vireo flavifrons*												+●		
	plumbeous vireo	*Vireo plumbeus*		22			21	6		9	41	8		+3		+3
	Cassin's vireo	*Vireo cassinii*												+3		+1
Corvidae	Steller's jay	*Cyanocitta stelleri*		●			21	31			23	4				
	Mexican jay	*Aphelocoma ultramarina*		67						23	12	4				
	Western scrub-jay	*Aphelocoma californica*			33	33	7	22		14		1		+3	13	
	pinyon jay	*Gymnorhinus cyanocephalus*						17				+●				

Order / Family	Common Name	Scientific Name	Percent Relative Frequency of Detections by Park													
							GICL Transect		SAGU-E Elevation Stratum					TONT Transect		
			CAGR	CHIR	CORO	FOBO	Uplands	Riparian	Low[a]	Mid[b]	High[c]	SAGU-E Total	SAGW[d]	Riparian	Upland	TUMA
Corvidae	common raven	*Corvus corax*	5	11			21	11	5	5		4		16		14
Alaudidae	horned lark	*Eremophila alpestris*	13													
Hirundinidae	purple martin	*Progne subis*						17	20			15	31			
	violet-green swallow	*Tachycineta thalassina*		22	33		39	33	1	5	17	4		+●		+1
	Northern rough-winged swallow	*Stelgidopteryx serripennis*					4					+●	+8	+●		9
	bank swallow	*Riparia riparia*														+1
	cliff swallow	*Petrochelidon pyrrhonota*	8												+6	3
	barn swallow	*Hirundo rustica*					+4									4
Paridae	mountain chickadee	*Poecile gambeli*					7				25	5				
	Mexican chickadee	*Poecile scateri*		●												
	bridled titmouse	*Baeolophus wollweberi*		56			7	6	2	5	7	3				16
	juniper titmouse	*Baeolphus ridgwayi*		●				●								
Remizidae	verdin	*Auriparus flaviceps*	8			56			72			52	62	45		25
Aegithalidae	bushtit	*Psaltriparus minimus*		22			18	6		5	12	3			+13	
Sittidae	red-breasted nuthatch	*Sitta canadensis*									7	1				
	white-breasted nuthatch	*Sitta carolinensis*		44			11			14	35	8				1
	pygmy nuthatch	*Sitta pygmaea*					4	3			15	3				
Certhiidae	brown creeper	*Certhia americana*		11							9	2				
Troglodytidae	cactus wren	*Campylorhynchus brunneicapillus*	32		67	56			66	32		51	69	48	69	+1
	rock wren	*Salpinctes obsoletus*		11	33		11					●		19	25	
	canyon wren	*Catherpes mexicanus*		33		22	36	17	9		9	8	●	65	25	
	Bewick's wren	*Thryomanes bewickii*		56	33	33	11	3	43	45	13	38		19		71
	house wren	*Troglodytes aedon*					4	64	1	9	27	7		10		3
Regulidae	ruby-crowned kinglet	*Regulus calendula*							1			+1	+●			
Sylviidae	blue-gray gnatcatcher	*Polioptila caerulea*	+●	●		●	11		3	23	7	6	15	16	13	+4
	black-tailed gnatcatcher	*Polioptila melanura*				11			13			9	15	35	38	+3
Turdidae	Western bluebird	*Sialia mexicana*						3			4	1				
	Townsend's solitaire	*Myadestes townsendi*						+3								
	Swainson's thrush	*Catharus ustulatus*														+●
	hermit thrush	*Catharus guttatus*									23	4	+●			
	American robin	*Turdus migratorius*		22			36	67		5	14	3				
Mimidae	gray catbird	*Dumetella carolinensis*						+3								
	Northern mockingbird	*Mimus polyglottos*	8			44		3	3	14		3	●		+13	5
	curve-billed thrasher	*Toxostoma curvirostre*	+3	●		11			47			34	62	●		10
	crissal thrasher	*Toxostoma crissale*				22			3	9		+3				
Sturnidae	European starling	*Sturnus vularis*	18													3
Ptilogonatidae	phainopepla	*Phainopepla nitens*							11	5		8		6		54
Peucedramidae	olive warbler	*Peucedramus taeniatus*					4		1		18	4				
Parulidae	Northern parula	*Parula americana*														+1
	orange-crowned warbler	*Vermivora celata*	+3					+●	1		9	2	●			+1
	Nashville warbler	*Vermivora ruficapilla*	+3						1							+●
	Virginia's warbler	*Vermivora virginiae*	+3				4	42	2		8	3		+13		

Order / Family	Common Name	Scientific Name	Percent Relative Frequency of Detections by Park													
							GICL Transect		SAGU-E Elevation Stratum					TONT Transect		
			CAGR	CHIR	CORO	FOBO	Uplands	Riparian	Low[a]	Mid[b]	High[c]	SAGU-E Total	SAGW[d]	Riparian	Upland	TUMA
Parulidae	Lucy's warbler	*Vermivora luciae*							48			34		23		54
	yellow warbler	*Dendroica petechia*						3	8			6		13		21
	yellow-rumped warbler	*Dendroica coronata*	+3				7		1		23	5		3		1
	black-throated gray warbler	*Dendroica nigrescens*		22			11		2	14	24	7	●	+●		+3
	Townsend's warbler	*Dendroica townsendi*									6	1		6	6	
	Grace's warbler	*Dendroica graciae*		●			4				33	6				
	Northern waterthrush	*Seiurus noveboracensis*														+●
	Macgillivray's warbler	*Oporornis tolmiei*					4	3	2			+2	+●	+3		+1
	common yellowthroat	*Geothlypis trichas*					4									11
	Wilson's warbler	*Wilsonia pusilla*	●				4	11	9		5	7	8	16	6	+14
	red-faced warbler	*Cardellina rubrifrons*		●			4				27	5				
	painted redstart	*Myioborus pictus*		11			50	17			11	2				
	yellow-breasted chat	*Icteria virens*					7	47				+●		3		56
Thraupidae	hepatic tanager	*Piranga flava*		33	33		7	8		5	30	6				
	summer tanager	*Piranga rubra*				33			13			9		10		45
	Western tanager	*Piranga ludoviciana*					36	25	3	5	53	12		+13	13	6
Emberizidae	green-tailed towhee	*Pipilo chlorurus*						8	12			9	8	+6	6	3
	canyon towhee	*Pipilo fuscus*		11		22		3	28	18		22	23	42	56	5
	Abert's towhee	*Pipilo aberti*							17			12		10		11
	spotted towhee	*Pipilo maculatus*		56	67		43	89	1	36	46	12			6	
	rufous-winged sparrow	*Aimophila carpalis*							21			15	8			18
	rufous-crowned sparrow	*Aimophila ruficeps*			33	11			2	32		5		16	44	5
	chipping sparrow	*Spizella passerina*							4	5		3		+3		1
	Brewer's sparrow	*Spizella breweri*	29						7			5		+3		+4
	black-chinned sparrow	*Spizella atrogularis*	+●	11							1	●			6	
	vesper sparrow	*Pooecetes gramineus*	3													
	lark sparrow	*Chondestes grammacus*						3	4			3				3
	black-throated sparrow	*Amphispiza bilineata*				●			18			13	23	35	44	8
	song sparrow	*Melospiza melodia*														21
	Lincoln's sparrow	*Melospiza lincolnii*						+6	1			+1				+1
	white-crowned sparrow	*Zonotrichia leucophrys*	+5					+3				●		+●		4
	dark-eyed junco	*Junco hyemalis*										+●				
	yellow-eyed junco	*Junco phaeonotus*		●							38	7				
Cardinalidae	Northern cardinal	*Cardinalis cardinalis*				67			51			37		52	6	48
	pyrrhuloxia	*Cardinalis sinuatus*							9			6	38			+1
	black-headed grosbeak	*Pheucticus melanocephalus*		22			21	50	3	9	26	8		+6	6	5
	blue grosbeak	*Guiraca caerulea*				11		8	16			11	+8			16
	lazuli bunting	*Passerina amoena*						●	1					+3		●
	indigo bunting	*Passerina cyanea*						●								●
	varied bunting	*Passerina versicolor*							8			6	●			6
Icteridae	yellow-headed blackbird	*Xanthocephalus xanthocephalus*						+●								
	red-winged blackbird	*Agelaius phoeniceus*	29													3

			Percent Relative Frequency of Detections by Park													
							GICL Transect		SAGU-E Elevation Stratum					TONT Transect		
Order Family	Common Name	Scientific Name	CAGR	CHIR	CORO	FOBO	Uplands	Riparian	Low[a]	Mid[b]	High[c]	SAGU-E Total	SAGW[d]	Riparian	Upland	TUMA
Icteridae	Brewer's blackbird	*Euphagus cyanocephalus*						14								1
	great-tailed grackle	*Quiscalus mexicanus*	37													14
	bronzed cowbird	*Molothrus aeneus*	+●													
	brown-headed cowbird	*Molothrus ater*	3	11		22	7	22	27	18	6	23	38	29		53
	hooded oriole	*Icterus cucullatus*				56			2			2		29		6
	Scott's oriole	*Icterus parisorum*		●	67	22			1	36	5	5	8	6	50	
	Bullock's oriole	*Icterus bullockii*	3					6	1			●		+6		8
Fringillidae	house finch	*Carpodacus mexicanus*	47	11	33	●		●	41	9		30	46	13		35
	red crossbill	*Loxia curvirostra*					4									
	lesser goldfinch	*Carduelis psaltria*		22				14	18	5		14				35
Passeridae	house sparrow	*Passer domesticus*	18										+●			5
Species richness			**53**	**52**	**21**	**33**	**45**	**72**	**91**	**51**	**58**	**135**	**47**	**71**	**33**	**103**
Number of species with breeding observations			**7**	**6**	**2**	**6**	**-**	**7**	**-**	**-**	**-**	**43**	**4**	**-**	**18**	**14**
Number of breeding records			**14**	**9**	**2**	**6**	**-**	**28**	**-**	**-**	**-**	**101**	**9**	**-**	**32**	**22**
Number of new species not found during 2001			**19**	**NA**	**NA**	**NA**		**9**[f]				**13**	**9**		**34**[f]	**32**
Percent of new species found during 2002			**36**	**NA**	**NA**	**NA**		**10**[f]				**10**	**19**		**43**[f]	**31**

[a] Transects visited in 2002: Upper and Lower Rincon Creek, Box Canyon, and Loma Verde Creek; Reconnaissance surveys at: Broadway, Chiminea, Freeman Road and Wash, Loma Verde Wash, and Madrona Canyon; Nocturnal surveys at Box Canyon, Loop Road and Rincon Creek.

[b] Reconnaissance surveys at: Bridal Wreath Falls, Deer Head Springs, Douglas Springs, Juniper Springs, and Upper Juniper Basin; Nocturnal Surveys at Italian Springs and Juniper Basin.

[c] Transcets visited in 2002: Happy Valley Saddle and Rincon Creek; Reconnaissance surveys for Manning Camp, Mica Mountain Trail, and North Slope Trail; Nocturnal Surveys at Manning and Spud Rock Springs.

[d] Reconnaissance surveys at Bajada, Picture Rocks Wash, and Camino de Cerro Wash; Nocturnal Surveys at Golden Gate and Loop Roads.

[e] Derived from nocturnal surveys.

[f] Calculated using all species found at both transects.

FISH

We surveyed for fish in the Santa Cruz River (SCR) and Tumacacori Slough (TS; referred to as Cospar Slough in other references) adjacent to TUMA-M. We surveyed on two occasions, once in the spring and again in the fall, as in 2001.

METHODS

Survey Areas

Santa Cruz River

On May 13 and November 12, 2002, we surveyed along the main channel of the SCR. We surveyed from 30 m north from the confluence of the SCR and TS to about 25 m south of Santa Gertrudis Lane. We chose this stretch of river because of the excellent fish habitat and because most of the area would be included in a future land acquisition (see park description on page 7). We randomly chose one side of the river from which to begin surveying, then surveyed from the stream margin to the midline, concentrating on areas likely to shelter fish (e.g., stream margins and in-stream obstructions). We surveyed about 100 m of stream, skipped 150 m of stream, then surveyed another 100 m of stream, alternating sides of the river. We repeated this pattern until finished.

Tumacacori Slough

On May 15 and November 14, 2002, we surveyed along TS from its confluence with the SCR and proceeded upstream to the headwaters of TS. We surveyed about 50 m of stream, skipped 50 m, then surveyed another 50 m of stream, repeating this pattern until finished. We used electrofishing for the first 50 to 100 m, and dip-nets for the rest of the slough. The latter method was chosen to optimize sampling efficiency while minimizing potential injury to the endangered Gila topminnow.

Survey Methods

We captured fish using a backpack electrofisher (Smith-Root 12-B POW) with pulsed DC, a pulse width of 60 Hz, frequency of 6 ms, and voltage of 300 V. At TS, we also used long-handled dip nets with 4mm mesh (Dauble and Gray 1980). We identified captured fish to species, classified them as juvenile or adult, and sexed them when possible. We returned all fish to the general area from which they were captured. We had a field crew of three conduct all surveys.

RESULTS

We found eight species of fish during the four days of sampling along the SCR and TS adjacent to TUMA-M in 2002 (Table 9). The most abundant species in the SCR in May was the longfin dace, and in November both Gila topminnow and Western mosquitofish. In TS, the abundant species were the longfin dace during May, but in November the overwhelming majority of captures were Western mosquitofish.

Species richness was high (8) in May in TS, but was low (3) during both sampling periods in the SCR and in November in TS. The later drop in species richness at TS was likely due to the

severe spring and summer drought, which resulted in the drying of many of the large pools which had contained native Cypriniformes (suckers) and non-native Perciformes (perch, bass and bluegill) during the May sampling event.

We found the same species in each location in 2001 and 2002.

Table 9. Results of fish surveys adjacent to TUMA-M, 2002. Relative abundance (RA) is expressed as a percent of the total catch (TC) for all species on that date. Vouchered species are underlined.

			Tumacacori Slough				Santa Cruz River			
			15 May		14 Nov.		13 May		12 Nov.	
Order Family	Scientific Name	Common Name	TC	RA	TC	RA	TC	RA	TC	RA
Cypriniformes										
Cyprinidae	*Agosia chrysogaster*	longfin dace	211	53	10	1	524	72	11	7
Cypriniformes										
Catostomidae	*Catostomus insignis*	Sonora sucker	12	3						
	Catostomus clarkii	desert sucker	1	>1						
Cyprinodontiformes										
Poeciliidae	*Poeciliopsis occidentalis*	Gila topminnow	46	12	90	14	79	11	79	48
	Gambusia affinis	western mosquitofish[a]	122	31	567	85	122	17	73	45
Perciformes										
Centrarchidae	*Micropterus salmoides*	largemouth bass[a]	1	>1						
	Lepomis macrochirus	bluegill[a]	2	>1						
	Lepomis cyanellus	green sunfish[a]	1	>1						
Species richness			8		3		3		3	

[a]Non-native species.

TERRESTRIAL MAMMALS

We surveyed for mammals using four techniques: live trapping, infrared-triggered photography, incidental or direct observation, and collection/documentation of sign.

METHODS – SMALL MAMMALS

We trapped for rodents at CAGR, CHIR, GICL, SAGU-E, and TONT between April and November, 2002.

General Trapping Methods

We used Sherman live traps baited with oatmeal and peanut butter to capture rodents in all parks surveyed. Traps were preferentially placed at each station to maximize success (e.g., alongside a fallen tree). As a precaution against cold nighttime temperatures we added polyester batting and dug small trenches for the traps and covered them with ground litter, leaving only the entry exposed. All traps were checked by late morning to protect animals from daytime high temperatures.

We identified animals using standard measurements and overall appearance. We recorded species, sex, age class, reproductive condition, weight, and measurements for right-hind foot, tail, ear, and head and body, and marked each individual with a permanent marker to identify recaptures.

Most of the trap arrangements (n = 36 grids, 73%) were 50 m by 50 m; 5 rows with 5 traps each and uniform 12.5 m spacing among traps. Four grids combined two of these to form a 50 m by 100 m grid, and nine others were linear arrangements placed along a drainage or other targeted landform. The number of stations in the latter category ranged from 5 to 24, typically with 12.5 m spacing. At one grid (in the TONT riparian area) we used double trap placement at each station. We recorded location of the southwest corner of each grid or line with a Garmin GPS unit, and described vegetation and habitat characteristics at each grid or trap line.

We opened traps for one to four nights in a session and re-visited only one grid (at GICL), which we trapped monthly from April through September. We trapped in all habitat types at CAGR and GICL; in the riparian at TONT; at low elevation riparian areas, grasslands, and rocky slopes at CHIR; and at Rincon Creek, Douglas Springs, and Juniper Basin at SAGU-E.

Voucher Specimens

Because of subtle variations in pelage color patterns and overlapping external measurements among species, we occasionally euthanized individuals and prepared them as vouchers to verify identification and serve as museum specimens. All specimens were prepared according to standardized techniques and placed in the UA mammal collection.

METHODS – MEDIUM AND LARGE MAMMALS

We used three techniques to identify and document medium and large mammals: infrared-triggered cameras, collection or documentation of sign and incidental direct observation of animals.

Infrared-triggered Cameras

We used one infrared-triggered camera each at CAGR, FOBO, SAGU-W and TUMA-M, and two each at GICL and CHIR. We placed cameras in washes or other travel corridors, and near water sources at FOBO and SAGU-W. We baited sites with commercial scent lures. We checked cameras approximately every two weeks to change film and batteries and ensure their proper function. On the first exposure of every new roll of film, we photographed a placard documenting the date and camera location.

Incidental Observations and Sign

Field crews surveying for all taxa recorded UTM coordinates of mammal sightings and recorded, collected or photographed sign (tracks, scat, or remains). Only animals positively identified to species are included here.

Voucher Specimens

In addition to the small mammals collected during trapping efforts, we collected carcasses (from natural mortality or road kill), skulls, and other bones to serve as voucher specimens when possible.

RESULTS – SMALL MAMMALS

We found 26 species of small mammals in 3,593 trap nights, and an additional 3 species incidentally, in the five park units surveyed during the 2002 field season (Table 10). The sites with the highest and lowest species richness were CHIR and TONT, respectively, and the areas with the highest and lowest richness *per trap night* were CHIR and SAGU-E, respectively. The number of trap nights at each unit varied from 160 at TONT to 1205 at SAGU-E. The areas with the highest and lowest trap success were TONT and CHIR, and the units with the highest and lowest variability in trap success were SAGU-E and TONT, respectively. We found white-throated woodrat in all parks but one (TONT), and 14 species that were unique to a single park.

These results show increased efficiency in comparison to accomplishments from our 2000-2001 season (Powell et al. 2002); in 2002 we documented 4 species more than in the combined 2000-2001 seasons, and did so in less than half (43%) of the number of trapnights. This difference was likely due to a change in strategy from predominantly randomly placed plots in previous years to exclusively non-random placement in 2002. Trapping at CHIR and CAGR (not trapped in 2000-2001) yielded 9 species not found at other parks, but trapping in 2000-2001 at TUMA and SAGU-W (not trapped in 2002) produced nine species not found in other parks during those years. We also found 8 species in 2002 that were not found in the same park units in 2000-2001: rock squirrel, Botta's pocket gopher, deer mouse, rock mouse, and Mexican vole at GICL; desert pocket mouse, fulvous harvest mouse and Merriam's kangaroo rat at SAGU-E. Percentage of new species captured varied by park from zero (TONT) to 45 (GICL). The non-native house mouse was found only at CHIR. Although not listed in Table 10, volunteers did trap and photograph a shrew (likely desert shrew, *Notiosorex crawfordi*) in the herp pitfall array at TUMA-M.

There were several species captured in 2000 and 2001 that we did not encounter in 2002: cliff chipmunk, brush mouse, and white-throated woodrat at TONT; desert shrew and house mouse at GICL; desert shrew, Harris' antelope ground squirrel, Arizona gray squirrel, Western harvest mouse, and deer mouse at SAGU-E.

Documentation of different species each year illustrates the difficulty in finding all species in a given year, and thus the importance of conducting surveys in multiple years.

Also unique to the 2002 season was our effort to trap monthly at a single grid (at GICL). We visited this grid from April through September, and in these six sessions documented a total of six species. However, only two of these (brush mouse and Western harvest mouse) were found in all six months; two (Mexican vole and deer mouse) in only two months, and one (Mexican woodrat) was only found in one month. The woodrat and vole were not found on any other grid at GICL.

Table 10. Frequency (%) of captures of small mammal species, by park unit, from trapping efforts in 2002[a]. Relative abundance was scaled to reflect adjusted trap effort[b] but trap success[c] was not; neither measure included recaptures. Number of grids and season trapped varied by park unit[d], and were trapped only once[e]. Incidental sightings (●) are not included in summary statistics other than species richness. Species not detected in 2000 or 2001 are indicated by "+". Species for which we obtained vouchers are underlined.

			Park Unit				
Family	Scientific Name	Common Name	CAGR	CHIR	GICL	SAGU-E	TONT
Sciuridae	*Spermophilus variegatus*	rock squirrel			+●	●	
	Spermophilus tereticaudus	round-tailed ground squirrel	3				
	Eutamias dorsalis	cliff chipmunk			2	1	
	Sciurus aberti	Abert's squirrel				●	
Geomyidae	*Thomomys bottae*	Botta's pocket gopher			+●	●	
Heteromyidae	*Perognathus flavus*	silky pocket mouse		9			
	Perognathus amplus	Arizona pocket mouse	6				
	Chaetodipus penicillatus	desert pocket mouse	36			+29	
	Chaetodipus intermedius	rock pocket mouse		4		22	
	Chaetodipus baileyi	Bailey's pocket mouse				6	56
	Chaetodipus hispidus	hispid pocket mouse		23			
	Dipodomys spectabilis	banner-tailed kangaroo rat	1				
	Dipodomys merriami	Merriam's kangaroo rat	49	4		+7	
Muridae	*Reithrodonomys montanus*	Plains harvest mouse		1			
	Reithrodontomys megalotis	Western harvest mouse			25		
	Reithrodontomys fulvescens	fulvous harvest mouse				+2	
	Peromyscus eremicus	cactus mouse		1		7	44
	Peromyscus maniculatus	deer mouse	3	1	+3		
	Peromyscus boylii	brush mouse		25	49	13	
	Peromyscus truei	piñon mouse			2		
	Peromyscus difficilis	rock mouse		2	1		
	Baiomys taylori	pygmy mouse		2			
	Onychomys torridus	Southern grasshopper mouse	2	4			
	Neotoma albigula	white-throated woodrat	1	4	17	7	
	Neotoma mexicana	Mexican woodrat			1		
	Sigmodon arizonae	Arizona cotton rat		10		1	
	Sigmodon ochrognathus	yellow-nosed cotton rat		7		5	
	Microtus mexicanus	Mexican vole			+2		
	Mus musculus	house mouse[f]		4			
Species richness			**8**	**15**	**11**	**14**	**2**
Percentage of species new to 2002			**NA**	**NA**	**45**	**21**	**0**
Sum relative abundance			**0.45**	**0.15**	**0.19**	**0.13**	**0.74**
Unadjusted trap effort (# of trapnights)			**480**	**863**	**885**	**1205**	**160**
Mean trap success			**0.38**	**0.11**	**0.14**	**0.14**	**0.61**
Co-efficient of variation[g] in mean trap success			**0.500**	**0.623**	**0.618**	**0.835**	**0.225**

[a] Percentages can be multiplied by "Sum relative abundance" to obtain relative abundance for a given species in a park unit.

[b] Adjusted trap effort = (total # of trap nights x total # of traps) - (total # of sprung traps x 0.5) (Beauvais and Buskirk 1999). Spacing (typically 12.5 m) and number of traps (typically 25) varied among grids.

[c] Trap success = # of captures / # of traps set

[d] CAGR = 9 grids trapped April or September, CHIR=11 grids in October or November, GICL=8 grids in one or more months April-September, SAGU-E = 17 grids April or September, TONT = 4 grids in September

[e] With exception of one plot at GICL, which was trapped monthly from April to September

[f] Non-native species

[g] CV = standard deviation/mean; a measure of the variability represented by the mean

RESULTS – MEDIUM AND LARGE MAMMALS

We observed or otherwise detected a total of 26 medium- and large-sized mammal species at all parks surveyed (Table 11). We obtained 259 photographs from infrared-triggered cameras, documenting 18 species at CAGR, CHIR, FOBO, GICL, SAGU-W, and TUMA-M. With all methods combined, there was no species common to all of these units, but gray fox was found at seven of the 11 park units. Badger and desert cottontail were found only at CAGR; wapiti (elk), beaver, and muskrat only at GICL; ringtail and antelope jackrabbit only at SAGU-E; Western spotted skunk only at SAGU-W; and opossum, housecat and raccoon only at TUMA-M. Highest overall species richness (23) was found at SAGU-E and lowest (1) was shared by TUMA-C and CORO. In each park where we placed cameras we obtained photographs of mammals unidentifiable to species, or of birds. Most notable of these were 15 slides of cottontails (desert cottontail [*Sylvilagus audubonii*] or Eastern cottontail [*S.floridanus*] at CAGR, and 28 slides of unidentifiable rodents (likely packrat species) at GICL.

Based on Trailmaster results, the highest and lowest species richness was found at FOBO and CAGR, respectively. The highest and lowest richness of identifiable mammals photographed, scaled by number of photos taken, was at TUMA-M and CAGR, respectively. The most common medium/large mammal found in CAGR was the black-tailed jackrabbit, at CHIR the gray fox, at FOBO the coati, at GICL both gray fox and coati, at SAGU-W the gray fox, and at TUMA-M the collared peccary. Considering these camera results alone, species richness (10) and number of photographs taken (102) were greatest at FOBO, suggesting a remarkable diversity of mammals for a relatively small (400-hectare) "cultural resource" park.

Also of importance is documentation of non-native species in parks: feral dogs in CAGR, FOBO and TUMA-M, housecats in TUMA-M, and domestic cows in CORO, FOBO (both of which incorporate grazing allotments), SAGU-E, TUMA-M, and TUZI (all three of which attempt to exclude cows; presence at TUMA-M and TUZI was documented in expansion areas).

We found three more species in 2002 than in 2001 overall, and documented four more species more than in 2001 through use of remote cameras. This latter increase may be due to a higher number of photos taken (82 additional photos) and our expanded use of cameras in 2002; we placed Trailmaster setups in twice the number of parks we had in 2001. Within park units, there were several species we found in 2001 that we did not encounter in 2002: 6 species at GICL, 8 at SAGU-W, and 2 at TUMA-M (Table 11; Powell et al. 2002). However, we also documented 15 species in 2002 that we had not found in 2000-2001 at the same parks: 7 species at TUMA, 4 at SAGU-E, 2 at SAGU-W, and 2 at GICL. Percentage of species new to our park inventory lists in 2002 ranged from zero (in 5 parks) to 27 (TUMA). This high variability of species detection again underscores the value of having surveyed for these animals in multiple years.

Table 11. Relative frequency (%) of mammal species[a] documented using infrared-triggered cameras and incidental observations, 2002. Incidental observations (●) are from direct observation, tracks or other sign. Species not found in 2000 or 2001 are indicated by "+". Species for which we obtained vouchers are underlined.

			Park										
Order Family	Scientific Name	Common Name	CAGR	CHIR	CORO	FOBO	GICL	SAGU-E	SAGU-W	TONT	TUMA-M[b]	TUMA-C	TUZI[b]
Didelphimorphia													
Didelphidae	*Didelphis marsupialis*	opossum									7		
Carnivora													
Canidae	*Canis latrans*	coyote						●			+●		
	Canis familiaris	feral dog	●			1					●		
	Urocyon cinereoargenteus	gray fox		70		6	6	●	68	●	+●		
Ursidae	*Ursus americanus*	black bear		●		4		●			+●		
Felidae	*Felis concolor*	mountain lion		3		11	2	●					
	Felis silvestris	house cat									20		
	Lynx rufus	bobcat				6	2	●	+3	●			
Mephitidae	*Mephitis macroura*	hooded skunk				1	+●				7		
	Mephitis mephitis	striped skunk		3		17	6	●					●
	Conepatus mesoleucus	hog-nosed skunk		3				+●	5				
	Spilogale gracilis	Western spotted skunk							3				
Mustelidae	*Taxidea taxus*	badger	●										
Procyonidae	*Procyon lotor*	raccoon									+27		
	Nasua narica	coati				30		●					
Bassariscidae	*Bassariscus astutus*	ringtail						+●					
Rodentia													
Castoridae	*Castor canadensis*	beaver					●						
Muridae	*Ondatra zibethica*	muskrat					+●						
Lagomorpha													
Leporidae	*Sylvilagus auduboni*	desert cottontail	●										
	Lepus alleni	antelope jackrabbit						+●					
	Lepus californicus	black-tailed jackrabbit	22					●					
Artiodactyla													
Bovidae	*Bos taurus*	domestic cow			●	●		+●			+●		●
Tayassuidae	*Pecari tajacu*	collared peccary		●		14	4	●	3		33		
Cervidae	*Odocoileus virginianus*	white-tailed deer		●				●	+●	●	+●		●
	Odocoileus hemionus	mule deer				9	●	●		●		●	
	Cervus elaphus	wapiti (elk)					4						
Other animals photographed (%)			**78.2[c]**	**6.7**		**2**	**65.3**		**20**		**6.7**		
Total number of pictures			**23**	**30**	**0**	**102**	**49**	**0**	**40**	**0**	**15**	**0**	**0**
Species richness			**4**	**7**	**1**	**11**	**10**	**15**	**6**	**4**	**11**	**1**	**3**
Percentage of species new in 2002			**0**	**NA**	**NA**	**NA**	**0**	**0**	**3**	**0**	**27**	**0**	**NA**

[a] >1 individual may be present in each slide; frequencies given represent number of slides for each species

[b] TUMA-M and TUZI include proposed expansion areas.

BATS

METHODS

We concentrated our survey effort in areas that were most likely to have bats, primarily mesic riparian areas and roost sites.

Roosts

We visited four roosts that were known or likely to have bats (Table 12). Once at a roost, we observed bats with the aid of infrared-filtered light and night-vision equipment or red-filtered light. When bats were present, we worked quickly to identify them to species, but if there were no bats we used a bright light to search for and collect skeletal material.

Table 12. Date and location of bat netting by park unit, 2002. See table 13 for results

Park Unit	Date(s) of Visit	Location	Abbreviation	Roost (R) or Net (N) site
GICL	6/22, 8/27	West Fork Gila River	WFG	N
	6/20-21	Cliff Dweller Canyon	CDC	N
	8/28-29	Lower Scorpion Campground	LSC	N
SAGU-W	7/23	Gould Mine	GM	R
	1/28	Wild Horse Mine	WHM	R
	2/27	Yuma Mine	YM	R
SAGU-E	5/4	Deer Creek	DC	N
	5/23	Tanque Verde Ridge	TVR	R
	8/13, 9/30	Lower Rincon Creek	LRC	N
	8/21	Madrona Ranger Station	MRS	N

Mist Netting

Because insectivorous bats congregate at water sites in the desert, we set mist nets over six aquatic sites (Table 12). We used three net sizes (5-meter, 9-meter, or 12-meter) depending on the site and set nets singly or stacked depending on conditions. We set all nets directly over water.

For each bat captured, we recorded time of capture, species and sex. When appropriate, we recorded relative age, reproductive condition, forearm length, mass, body condition, toothwear, presence of parasites and other measurements. We determined whether individuals were adult, subadult (by closure of epiphyses), or juvenile (by appearance). We determined age by an estimation of tooth wear. For females, we recorded reproductive condition as pregnant (palpation for fetal bones), currently lactating (mammary gland with milk), previous evidence of lactation (misshapen or scarred nipples), or nulliparity (non-use of nipples). We determined reproductive condition for males by degree of swelling of testes or the presence of black epididymides. We recorded genera of parasites when known. We marked all captured bats with a temporary, non-lethal marker to prevent counting the same individual more than once in the same evening.

We used sonar detectors (Anabat and/or QMC Mini) at all sites to aid in determining bat presence/absence and relative activity as compared to the visual or mist-net results. We listened passively for the call of pallid bats, the only species of bat in southern Arizona and New Mexico that can be definitively identified by its directive call.

Voucher Specimens and Photographs

When appropriate, we collected individuals and prepared specimens as skin and skull vouchers which were deposited in the UA mammal collection. We often took photo vouchers and collected bones from caves.

RESULTS

We found a combined total of 15 or 16 species of bats at all sites at GICL and SAGU during 2002 (Table 13). Lower Rincon Creek in SAGU-E had the highest species richness of any site with 11 species. We also netted three new species for the park at Lower Rincon Creek (downstream of Madrona Ranger Station): hognose bat, Western red bat, and Townsend's big-eared bat.

We also found several species that we had not located in 2001: California (and/or Western) small-footed bat and big free-tailed bat at GICL, and hognose bat at SAGU-E. This resulted in a high percentage of new species for 2002; 29% at GICL and 33% at SAGU-E. There were also a few species captured in 2001 that we did not find in 2002; Western pipistrelle bat in SAGU-W, lesser long-nosed bat, fringed bat, and silver-haired bat in SAGU-E, and silver-haired bat in GICL.

The big brown bat was the most widespread species of bat recorded; we found it at four locations in two parks. The Brazilian free-tailed bat was the most abundant with 20 individuals captured at two sites at GICL.

Table 13. Results of bat surveys by park unit, 2002. Cells with "+" indicate species not found in 2001. See Table 12 for descriptions of study areas.

		Number of Bats									
		GICL			SAGU-E				SAGU-W		
Family Scientific name	Common Name	WFG	CDC	LSC	DC	TVR	LRC	MRS	GM	WHM	YM
Phyllostomidae											
Macrotus californicus	California leaf-nosed bat										18
Choeronycteris mexicana	hognose bat						+1				
Vespertilionidae											
Myotis auriculus	Southwestern bat			1	2						
Myotis californicus and/or ciliolabrum	California and/or Western small-footed bat[a]	+1			3		2				
Myotis lucifugus	little brown bat	6	1	2							
Myotis velifer	cave bat						2		3	2	
Myotis volans	long-legged bat						1				
Eptesicus fuscus	big brown bat		3	1	2		4				
Lasiurus cinereus	hoary bat		2				3				
Lasiurus blossevillii	Western red bat						+1				
Plecotus townsendii	Townsend's big-eared bat						+1				
Antrozous pallidus	pallid bat						+1				
Molossidae											
Tadarida brasiliensis	Brazilian free-tailed bat	9	11				1				
Nyctinomops macrotis	big free-tailed bat		+1								
Nyctinomops femorosaccus	pocketed free-tailed bat						1				
Species richness per site		**3**	**5**	**3**	**3**	**0**	**11**	**0**	**1**	**1**	**1**
Species richness per park				**7**				**12**			**2**
Percentage of species new in 2002				**29**				**33**			**0**

[a] May be one or both species of *Myotis (M. californicus* and/or *M. ciliolabrum)*. At the time of writing, we are waiting for specimen identification.

DATABASE EFFORTS

Overview

Existing information on vertebrates and vascular plants in SODEN parks is stored in many locations, including park and regional files and natural history museums. From these sources we gathered data for GIS themes, voucher specimens and photographs, and observation records. We entered data directly into NPS databases or sent them to the Natural Resource Information Division of the Inventory and Monitoring Program in Fort Collins, Colorado. The quantity and quality of existing inventory information varied greatly among parks and taxa. For example, Organ Pipe Cactus National Monument had very detailed records for all taxonomic groups, while no information was available for most taxa at GICL and TUMA. Currently, we are updating our databases and are working with regional NPS database managers to complete our goal of compiling all existing information on vascular plants and vertebrates that occur in network parks. We anticipate that this work will be ongoing throughout the duration of the project.

Access Database

We created Microsoft Access databases (for all taxa) for entry, retrieval, and analysis of data from the entire inventory effort. This database will revert to the monitoring program at the completion of the project and be available to park personnel.

NPSpecies

NPSpecies is the National Park Service's database program for updating and maintaining information about the occurrence, abundance and status of species in all national park units. NPSpecies has been an integral component of our efforts for compiling information on plants and animals in SODEN parks. At the time of this writing, we have added over 13,000 records to the NPSpecies database using species lists from published articles, reports, collections, voucher specimens, natural history collections, and ANCS+ databases from each park.

PROJECT COMPLETION SCHEDULE

We will use the following schedule as a guide for completing inventories and entering, analyzing, and reporting data. Timing of surveys may change due to personnel availability, weather, and/or budgetary restrictions.

April-October 2003

- Field work
  Birds: CORO, CHIR, FOBO, TONT, TUZI
  Herps: CHIR, TUZI
  Mammals: TUZI
  Plants: CHIR, FOBO, TUMA, TUZI, MOCA

October 2003-March 2004

- Compile, enter and summarize data on all new inventories
- Distribute 2003 annual report
- Develop 2004 field schedule

March-October 2004

- Field work
  Birds: CORO, CHIR, FOBO, TUZI
  Herps: CHIR, TUZI

October 2004-March 2005

- Compile, enter and analyze data on all new inventories
- Complete final reports to parks with complete inventories
- Final report due March 31, 2005

PRODUCTS FROM THE INVENTORY PROGRAM

In addition to annual reports, which are brief descriptions of the study methods and results, we will also provide each park with a customized Final Report. These reports will contain more detail than annual reports and will include reviews of past inventories, detailed maps of study areas and distribution of species of interest, detailed analysis of results, and reviews of the efficacy of our inventory effort. We welcome input from park personnel on other needs that they have for the data generated from this program.

Finally, because our approach to inventories is unique in the southwest, and perhaps the country, we will submit our findings and methods for publication in peer-reviewed scientific journals.

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Appendix A. Summary of abbreviations that appear in the document.

Abbreviation	Full name
ASU	Arizona State University
CAGR	Casa Grande Ruins National Monument
CHIR	Chiricahua National Monument
CESU	Desert Southwest Cooperative Ecosystem Studies Unit
CORO	Coronado National Memorial
FOBO	Fort Bowie National Historic Site
GICL	Gila Cliff Dwellings National Monument
GPS	Global positioning system
I&M	Inventory and Monitoring Program
NPS	National Park Service
SAGU	Saguaro National Park to include Saguaro East (SAGU-E) and Saguaro West (SAGU-W)
SCR	Santa Cruz River
SODEN	Sonoran Desert Network
TONT	Tonto National Monument
TUMA	Tumacacori National Historical Park, including Calabasas (TUMA-C), Guevavi (TUMA-G), and Main Mission (TUMA-M)
TS	Tumacacori Slough
TUZI	Tuzigoot National Monument
UA	University of Arizona
USFWS	United States Fish and Wildlife Service
VCPM	Variable circular-plot method

Appendix B. List of plants collected at Casa Grande Ruins National Monument, 2002. Species in bold were previously undocumented in the park.

Family	Genus	Species	Synonym[a]
Asclepiadaceae	*Funastrum*	*cynanchoides*	
Asteraceae	*Acourtia*	*nana*	*Perezia nana*
	Pectis	*papposa*	
Euphorbiaceae	*Euphorbia*	*micromera*	*Chamaesyce micromera*
	Euphorbia	*polycarpa*	*Chamaesyce polycarpa*
Lamiaceae	*Teucrium*	*cubense*	

[a] Synonyms are from the Integrated Taxonomic Information System (IT IS 2002)

Appendix C. List of plants collected at Chiricahua National Monument, 2002. Species in bold were previously undocumented in the park; shaded species are non-native.

Family	Genus	Species	Synonym[a]
Amaranthaceae	*Amaranthus*	*graecizans*	*Amaranthus albus, Amaranthus blitoides*
	Gomphrena	*sonorae*	
	Gomphrena	*nitida*	
	Aristolochia	***watsonii***	***Aristolochia porphyrophylla***
Asteraceae	*Acourtia*	*thurberi*	
	Artemisia	*ludoviciana*	
	Artemisia	*carruthii*	
	Aster	*commutatus*	*Symphyotrichum falcatum*
	Baccharis	*thesioides*	
	Bidens	*heterosperma*	
	Brickellia	*betonicifolia*	
	Brickellia	*grandiflora*	
	Brickellia	*eupatorioides*	
	Brickellia	*lemmoni*	
	Carminatia	*tenuiflora*	
	Ericameria	*laricifolia*	
	Erigeron	*neomexicanus*	
	Erigeron	*speciosus*	
	Eupatorium	*herbaceum*	*Ageratina herbacea*
	Gymnosperma	*glutinosum*	
	Helianthus	*ciliaris*	
	Heterosperma	*pinnatum*	
	Hymenothrix	*wrightii*	
	Hymenoxys	*microcephala*	
	Melampodium	*longicorne*	
	Perityle	*cochisensis*	
	Pseudognaphalium	*canescens*	
	Senecio	*flaccidus*	
	Solidago	*missouriensis*	
	Stevia	*serrata*	
	Tagetes	*micrantha*	
	Verbesina	*longifolia*	
	Viguiera	*cordifolia*	
	Viguiera	*dentata*	
Brassicaceae	*Arabis*	*perennans*	
	Erysimum	*capitatum*	
Caryophyllaceae	*Arenaria*	*lanuginosa*	
	Drymaria	*leptophylla*	
	Drymaria	*fendleri*	*Drymaria glandulosa*
	Silene	*laciniata*	
Chenopodiaceae	*Chenopodium*	*graveolens*	
Convolvulaceae	*Ipomoea*	*costellata*	
Crossosomataceae	*Apacheria*	*chiricahuensis*	
Cyperaceae	*Bulbostylis*	*capillaris*	
Equisetaceae	*Equisetum*	*hiemale*	
	Equisetum	*laevigatum*	
Euphorbiaceae	*Acalypha*	*lindheimeri*	*Acalypha phleoides*
	Euphorbia	*brachycera*	
	Euphorbia	*cuphosperma*	
	Euphorbia	*serpyllifolia*	*Chamaesyce serpyllifolia*
	Euphorbia	*bilobata*	
	Euphorbia	*exstipulata*	

Family	Genus	Species	Synonym[a]
	Tragia	*ramosa*	
Fabaceae	*Calliandra*	*humilis*	
	Chamaecrista	*nictitans*	
	Crotalaria	*pumila*	
	Dalea	*versicolor*	
	Dalea	*albiflora*	
	Desmodium	*batocaulon*	
	Desmodium	*procumbens*	
	Galactia	*wrightii*	
	Lathyrus	*graminifolius*	
	Lotus	*plebeius*	
	Oxytropis	*lambertii*	
Hydrangeaceae	*Fendlerella*	*utahensis*	
Lamiaceae	*Hedeoma*	*hyssopifolia*	
	Hedeoma	*dentata*	
	Hedeoma	*oblongifolia*	
	Salvia	*subincisa*	
	Trichostema	*arizonicum*	
Liliaceae	*Echeandia*	*flavescens*	
Lythraceae	*Cuphea*	***wrightii***	*Cuphea wrightii, Parsonsia wrightii*
Malvaceae	*Sida*	*abutifolia*	
Nyctaginaceae	*Mirabilis*	*albida*	
	Mirabilis	*linearis*	
Onagraceae	*Epilobium*	*californicum*	*Epilobium ciliatum*
Oxalidaceae	*Oxalis*	*stricta*	
Poaceae	*Aristida*	*schiedeana*	
	Blepharoneuron	*tricholepis*	
	Bothriochloa	*barbinodis*	
	Bouteloua	*gracilis*	
	Bouteloua	*curtipendula*	
	Bouteloua	*hirsuta*	
	Brachiaria	*arizonica*	
	Bromus	*ciliatus*	
	Bromus	*anomalus*	
	Cenchrus	*spinifex*	*Cenchrus spinifex*
	Digitaria	*sanguinalis*	
	Elymus	*elymoides*	
	Elymus	*arizonicus*	
	Eragrostis	*intermedia*	
	Eragrostis	*pectinacea*	
	Eragrostis	*mexicana*	
	Eragrostis	*cilianensis*	
	Eragrostis	*lehmanniana*	
	Eriochloa	*acuminata*	
	Heteropogon	*contortus*	
	Leptochloa	*dubia*	
	Lycurus	*setosus*	
	Lycurus	*setosus*	
	Muhlenbergia	*asperifolia*	
	Muhlenbergia	*emersleyi*	
	Muhlenbergia	*polycaulis*	
	Muhlenbergia	*glauca*	
	Muhlenbergia	*texana*	
	Muhlenbergia	*rigida*	

Family	Genus	Species	Synonym[a]
	Muhlenbergia	*rigens*	*Epicampes rigens, Muhlenbergia marshii, Muhlenbergia mundula*
	Muhlenbergia	*sinuosa*	
	Muhlenbergia	*wrightii*	
	Panicum	*bulbosum*	
	Piptochaetium	*fimbriatum*	
	Piptochaetium	*pringlei*	
	Schizachyrium	*cirratum*	
	Schizachyrium	*sanguineum*	
	Setaria	*leucopila*	
	Setaria	*grisebachii*	
	Sorghastrum	*nutans*	
	Sporobolus	*airoides*	
	Sporobolus	*contractus*	*Sporobolus cryptandrus*
	Trachypogon	*secundus*	*Trachypogon spicatus*
Polemoniaceae	*Ipomopsis*	*macombii*	
	Ipomopsis	*multiflora*	
Polygonaceae	*Eriogonum*	*polycladon*	
	Eriogonum	*wrightii*	
Pteridaceae	*Pellaea*	*atropurpurea*	
Ranunculaceae	*Aquilegia*	*triternata*	
Rubiaceae	*Galium*	*microphyllum*	
	Galium	*wrightii*	
	Houstonia	*wrightii*	
Santalaceae	*Comandra*	*umbellata*	
Scrophulariaceae	*Brachystigma*	*wrightii*	
	Castilleja	*austromontana*	
	Castilleja	*tenuiflora*	
	Penstemon	*linarioides*	
	Scrophularia	*parviflora*	
Solanaceae	*Physalis*	*pubescens*	

[a] Synonyms are from the Integrated Taxonomic Information System (IT IS 2002)

Appendix D. List of plants collected at Fort Bowie National Historic Site, 2002. Species in bold were previously undocumented in the park.

Family	Genus	Species	Synonym[a]
Acanthaceae	*Anisacanthus*	*thurberi*	
Aizoaceae	*Trianthema*	*portulacastrum*	
Amaranthaceae	*Froelichia*	*arizonica*	
	Guilleminea	*densa*	
Asclepiadaceae	*Asclepias*	*asperula*	
	Funastrum	*crispum*	
Asteraceae	*Baccharis*	*bigelovii*	
	Bahia	*absinthifolia*	
	Brickellia	*venosa*	
	Carminatia	*tenuiflora*	
	Chrysothamnus	*nauseosus*	*Ericameria nauseosa*
	Ericameria	*laricifolia*	
	Gymnosperma	*glutinosum*	
	Heterosperma	*pinnatum*	
	Krascheninnikovia	*lanata*	
	Parthenium	*incanum*	
	Pseudognaphalium	*canescens*	
	Psilostrophe	*tagetina*	
	Sanvitalia	*abertii*	
	Schkuria	*wislizenii*	
	Senecio	*flaccidus*	
	Stephanomeria	*pauciflora*	
	Tagetes	*micrantha*	
	Thelesperma	*megapotamicum*	
Brassicaceae	*Arabis*	*perennans*	
Chenopodiaceae	*Chenopodium*	*pratericola*	
Euphorbiaceae	*Acalypha*	*neomexicana*	
	Croton	*pottsii*	
	Euphorbia	***heterophylla***	***Euphorbia geniculata, Euphorbia prunifolia, Poinsettia geniculata, Poinsettia heterophylla***
	Euphorbia	*serrula*	*Chaemasyce serrula*
	Euphorbia	*serpyllifolia*	*Chaemasyce serpyllifolia*
	Euphorbia	*albomarginata*	*Chaemasyce albomarginata*
	Euphorbia	***exstipulata***	***Euphorbia exstipulata***
	Euphorbia	*bilobata*	
	Euphorbia	*revoluta*	*Chaemasyce revoluta*
Fabaceae	***Chamaechrista***	***nictitans***	
	Crotalaria	*pumila*	
	Dalea	*pringlei*	
	Dalea	*versicolor*	
	Dalea	*formosa*	
	Dalea	*candida*	
	Dalea	*wrightii*	
	Desmanthus	*cooleyi*	
	Desmodium	*neomexicanum*	
	Macroptilium	*gibbosifolium*	
	Phaseolus	*acutifolius*	
Lamiaceae	*Hedeoma*	*oblongifolia*	
	Salvia	*subincisa*	
	Trichostema	*arizonicum*	
Loasaceae	*Cevallia*	*sinuata*	
Malvaceae	*Sida*	*abutifolia*	

Family	Genus	Species	Synonym[a]
	Sphaeralcea	*laxa*	
Nyctaginaceae	*Boerhavia*	*purpurascens*	
	Boerhavia	*spicata*	
	Mirabilis	*linearis*	
	Mirabilis	*albida*	
Onagraceae	*Epilobium*	*californicum*	*Epilobium ciliatum*
Poaceae	*Aristida*	*adscensionis*	
	Aristida	*ternipes*	
	Bothriochloa	*barbinodis*	
	Bouteloua	*gracilis*	
	Bouteloua	*repens*	
	Bouteloua	*eriopoda*	
	Bouteloua	*curtipendula*	
	Bouteloua	*hirsuta*	
	Brachiaria	*arizonica*	*Urochloa arizonica*
	Chloris	*virgata*	
	Digitaria	*californica*	
	Echinochloa	*colonum*	
	Enneapogon	*desvauxii*	
	Eragrostis	*cilianensis*	
	Eragrostis	*lehmanniana*	
	Eragrostis	*curvula*	
	Eragrostis	*intermedia*	
	Eriochloa	*acuminata*	
	Erioneuron	*pulchellum*	*Dasyochloa pulchella*
	Erioneuron	*grandiflorum*	*Erioneuron avenaceum*
	Heteropogon	*contortus*	
	Leptochloa	*dubia*	
	Lycurus	*setosus*	
	Muhlenbergia	*rigens*	
	Muhlenbergia	*porteri*	
	Muhlenbergia	*arenicola*	
	Muhlenbergia	*fragilis*	
	Muhlenbergia	*emersleyi*	
	Panicum	*hirticaule*	
	Panicum	*obtusum*	
	Setaria	*grisebachii*	
	Setaria	*leucopila*	
	Sporobolus	*airoides*	
	Sporobolus	*cryptandrus*	
	Sporobolus	*contractus*	
	Tridens	*muticus*	
Polygalaceae	*Polygala*	*barbeyana*	
Polygonaceae	*Eriogonum*	*polycladon*	
	Portulaca	*umbraticola*	
	Talinum	*aurantiacum*	
Rubiaceae	*Diodia*	*teres*	
	Galium	*stellatum*	
	Galium	*wrightii*	
Rutaceae	*Thamnosma*	*texana*	
Scrophulariaceae	*Castilleja*	*lanata*	
	Maurandya	*antirrhiniflora*	*Maurandella antirrhiniflora*
	Mimulus	*guttatus*	
	Penstemon	*linarioides*	

Family	Genus	Species	Synonym[a]
Solanaceae	*Chamaesaracha*	*sordida*	
	Nicotiana	*obtusifolia*	
	Physalis	*solanaceus*	*Margaranthus solanaceus*
Sterculiaceae	*Ayenia*	*filiformis*	

[a] Synonyms are from the Integrated Taxonomic Information System (IT IS 2002)

Appendix E. List of plants collected at Gila Cliff Dwellings National Monument, 2002. Species in bold were previously undocumented in the park, shaded species are non-native.

Family	Genus	Species	Synonym[a]
Amaranthaceae	*Antennaria*	*microphylla*	*Antennaria bracteosa, Antennaria nitida, Antennaria parvifolia, Antennaria rosea, Antennaria solstitialis*
	Gomphrena	*sonorae*	
Apiaceae	*Pseudocymopterus*	*montanus*	*Cymopterus lemmonii, Pseudocymopterus tidestromii, Thaspium montanum*
Asclepiadaceae	*Asclepias*	*nyctaginifolia*	
Asteraceae	*Ageratina*	*herbacea*	*Eupatorium herbaceum*
	Artemisia	*carruthii*	*Artemisia kansana*
	Artemisia	*dracunculus*	*Artemisia dracunculoides, Artemisia dracunculoides, Artemisia glauca, Oligosporus dracunculus*
	Bahia	*dissecta*	*Amauria dissecta*
	Bidens	*bigelovii*	
	Bidens	*pilosa*	*Bidens odorata, Bidens pilosa*
	Bidens	*bigelovii*	
	Brickellia	*brachyphylla*	
	Brickellia	*eupatorioides*	
	Carminatia	*tenuiflora*	
	Cirsium	*grahamii*	
	Cosmos	*parviflorus*	*Coreopsis parviflora*
	Erigeron	*oreophilus*	*Erigeron delphiniifolius*
	Erigeron	*speciosus*	
	Heterosperma	*pinnatum*	
	Hymenothrix	*wrightii*	
	Lactuca	*serriola*	*Lactuca scariola*
	Machaeranthera	*gracilis*	
	Melampodium	*hispidum*	*Melampodium sericeum*
	Pectis	*filipes*	
	Pericome	*caudata*	
	Senecio	*flaccidus*	
	Senecio	*longilobus*	*Senecio flaccidus, Senecio douglasii, Senecio filifolius*
	Solidago	*wrightii*	
	Verbesina	*encelioides*	
	Viguiera	*dentata*	
	Viguiera	*longifolia*	*Heliomeris longifolia, Gymnolomia longifolia*
Boraginaceae	*Lithospermum*	*multiflorum*	
	Mertensia	*franciscana*	
Brassicaceae	*Lesquerella*	*gordonii*	
	Sisymbrium	*altissimum*	*Norta altissima*
Cactaceae	*Opuntia*	*macrorhiza*	
Capparaceae	*Polanisia*	*dodecandra*	
Caryophyllaceae	*Cerastium*	*viscosum*	
	Drymaria	*fendleri*	
Chenopodiaceae	*Chenopodium*	*graveolens*	*Chenopodium incisum, Teloxys graveolens*
Clusiaceae	*Hypericum*	*formosum*	

Family	Genus	Species	Synonym[a]
Convolvulaceae	*Ipomoea*	*costellata*	
	Ipomoea	*capillacea*	*Convolvulus capillaceus, Ipomoea muricata*
Cornaceae	*Cornus*	*stolonifera*	
Crassulaceae	*Sedum*	*cockerellii*	*Cockerellia cockerellii, Sedum griffithsii, Sedum wootonii*
Cucurbitaceae	*Echinopepon*	*wrightii*	*Elaterium wrightii*
Cyperaceae	*Eleocharis*	*parishii*	*Eleocharis disciformis, Eleocharis montevidensis,*
Euphorbiaceae	*Euphorbia*	*lurida*	
	Euphorbia	*heterophylla*	*Euphorbia geniculata, Euphorbia prunifolia, Poinsettia geniculata, Poinsettia heterophylla*
	Euphorbia	*bilobata*	
	Euphorbia	*serpyllifolia*	
	Tragia	*ramosa*	*Tragia angustifolia, Tragia nepetifolia, Tragia stylaris*
Fabaceae	*Calliandra*	*humilis*	
	Cologania	*angustifolia*	*Cologania longifolia*
	Dalea	*albiflora*	*Dalea ordiae, Petalostemon pilosulus*
	Dalea	*filiformis*	
	Dalea	*urceolata*	
	Desmodium	*neomexicanum*	*Meibomia neomexicana*
	Lathyrus	*graminifolius*	
	Lathyrus	*arizonicus*	*Lathyrus lanszwertii, Lathyrus leucanthus,*
	Macroptilium	*gibbosifolium*	*Macroptilium heterophyllum, Phaseolus heterophyllus,*
	Phaseolus	*acutifolius*	
	Rhynchosia	*senna*	
	Trifolium	*wormskioldii*	*Lupinaster wormskioldii, Trifolium fendleri, Trifolium fimbriatum, Trifolium heterodon, Trifolium involucratum, Trifolium kennedianum, Trifolium spinulosum, Trifolium willdenovii, Trifolium willdenowii*
	Vicia	*leucophaea*	
	Vicia	*americana*	
Geraniaceae	*Geranium*	*richardsonii*	
Grossulariaceae	*Ribes*	*leptanthum*	
Lamiaceae	*Hedeoma*	*oblongifolium*	
	Salvia	*reflexa*	*Salvia lancifolia*
	Salvia	*subincisa*	
Liliaceae	*Allium*	*cernuum*	
Malvaceae	*Anoda*	*cristata*	*Anoda acerifolia, Anoda cristata, Anoda lavaterioides, Sida cristata*
Nyctaginaceae	*Boerhavia*	*purpurascens*	
	Mirabilis	*albida*	*Allionia albida, Allionia bracteata, Allionia coahuilensis, Allionia grayana, Allionia pauciflora, Allionia pseudaggregata, Allionia rotata, Mirabilis albida, Mirabilis coahuilensis, Mirabilis dumetorum, Mirabilis entricha, Mirabilis grayana, Mirabilis oblongifolia, Mirabilis pauciflora, Mirabilis pseudaggregata, Mirabilis rotata, Oxybaphus albidus, Oxybaphus coahuilensis, Oxybaphus pauciflorus, Oxybaphus pseudaggregatus, Oxybaphus rotatus*
	Mirabilis	*pumila*	*Allionia pumila, Oxybaphus pumilus*
Onagraceae	*Epilobium*	*ciliatum*	

Family	Genus	Species	Synonym[a]
Oxalidaceae	*Oxalis*	*corniculata*	*Acetosella corniculata, Oxalis corniculata var. atropurpurea, Oxalis langloisii, Oxalis pusilla, Oxalis repens, Oxalis villosa, Xanthoxalis corniculata, Xanthoxalis langloisii, Xanthoxalis repens*
	Oxalis	*decaphylla*	*Oxalis grayi*
Poaceae	*Alopecurus*	*aequalis*	
	Bouteloua	*eriopoda*	*Chondrosum eriopodum*
	Bouteloua	*radicosa*	*Atheropogon radicosus*
	Echinochloa	*crus-galli*	
	Eragrostis	*mexicana*	
	Leptochloa	*dubia*	*Chloris dubia, Diplachne dubia*
	Muhlenbergia	*sinuosa*	
	Muhlenbergia	*mexicana*	
	Panicum	*pampinosum*	*Panicum capillare var. hirticaule, Panicum capillare, Panicum hirticaule*
	Piptochaetium	*fimbriatum*	*Stipa fimbriata*
	Setaria	*grisebachii*	
	Sporobolus	*cryptandrus*	*Agrostis cryptandra*
Polygalaceae	*Monnina*	*wrightii*	
	Polygala	*obscura*	*Polygala orthotricha*
Polygonaceae	*Polygonum*	*lapathifolium*	*Persicaria incarnata, Persicaria lapathifolia, Persicaria tomentosa, Polygonum incanum, Polygonum incarnatum, Polygonum lapathifolium, Polygonum nodosum, Polygonum oneillii, Polygonum pensylvanicum, Polygonum scabrum, Polygonum tomentosum*
	Polygonum	*convolvulus*	
	Rumex	*acetosella*	
Portulacaceae	*Portulaca*	*oleracea*	*Portulaca neglecta, Portulaca oleracea, Portulaca retusa*
	Talinum	*pulchellum*	*Talinum youngiae*
Pteridaceae	*Bommeria*	*hispida*	*Gymnopteris hispida*
	Selaginella	*underwoodii*	*Selaginella underwoodii var. dolichotricha*
Ranunculaceae	*Ranunculus*	*aquatilis*	*Batrachium aquatile, Ranunculus aquatilis, Ranunculus trichophyllus*
	Ranunculus	*uncinatus*	
	Ranunculus	*hydrocharoides*	
Rosaceae	*Malus*	*sp.*	
Rubiaceae	*Hedyotis*	*pygmaea*	*Houstonia wrightii, Hedyotis cervantesii, Hedyotis wrightii*
Saxifragaceae	*Heuchera*	*novomexicana*	
Urticaceae	*Parietaria*	*pensylvanica*	*Parietaria obtusa, Parietaria occidentalis*
Verbenaceae	*Verbena*	*hastata*	
Zygophyllaceae	*Kallstroemia*	*parviflora*	*Kallstroemia intermedia*

Appendix F. List of plants collected at Saguaro National Park- Rincon Mountain District (SAGU-E), 2002. Species in bold were previously undocumented in the park unit.

Family	Genus	Species	Synonym (ITIS)
Asteraceae	*Eupatorium*	*pauperculum*	
	Solidago	*wrightii*	
Boraginaceae	*Cryptantha*	*barbigera*	
Fabaceae	*Mimosa*	*aculeaticarpa*	
Hydrophyllaceae	*Eriodictyon*	*angustifolium*	
Oleaceae	*Fraxinus*	*anomala*	
Poaceae	*Agrostis*	*scabra*	
	Bromus	*anomalus*	
	Polypogon	*viridis*	
Rosaceae	*Rubus*	*arizonensis*	

[a] Synonyms are from the Integrated Taxonomic Information System (IT IS 2002)

Appendix G. List of plants collected adjacent to Tumacacori National Historical Park (Main Mission unit only), 2002. Species in bold were previously undocumented in the park unit; shaded species are non-native.

Family	Genus	Species	Synonym[a]	Notes
Acanthaceae	*Dicliptera*	*resupinata*		
	Elytraria	*imbricata*		
	Tetramerium	*nervosum*		
Apiaceae	*Conium*	*maculatum*		
	Hydrocotyle	*verticillata*		
Asteraceae	*Ambrosia*	*trifida*		
	Ambrosia	*confertiflora*		
	Artemisia	*ludoviciana*		
	Baccharis	*salicifolia*		
	Bidens	*laevis*		
	Conyza	*canadensis*		
	Helianthus	*annuus*		
	Heliomeris	*multiflora*	*Viguiera multiflora.*	
	Heliomeris	*longifolia*		
	Hymenoclea	*monogyra*		
	Melampodium	*longicorne*		
	Pseudognaphalium	*leucocephalum*		
	Senecio	*flaccidus*		
	Tagetes	*minuta*		**Second record in Arizona**
	Xanthium	*strumarium*		
Brassicaceae	*Rorippa*	*nasturtium-aquaticum*		
Chenopodiaceae	*Chenopodium*	*pratericola*		
Convolvulaceae	*Cuscuta*	*umbellata*		
Cucurbitaceae	*Echinopepon*	*wrightii*		
	Sicyosperma	*gracile*		
Cyperaceae	*Cyperus*	*odoratus*		
Equisetaceae	*Equisetum*	*laevigatum*		
Euphorbiaceae	*Acalypha*	*ostryifolia*		
	Chaemasyce	*hirta*		
	Croton	*texensis*		
Fabaceae	*Cassia*	*leptocarpa*		
	Chamaechrista	*nictitans*		
	Crotalaria	*pumila*		
	Desmodium	*neomexicanum*		
Loasaceae	*Mentzelia*	*aspera*		
Menispermaceae	*Cocculus*	*diversifolius*		
Moraceae	*Morus*	*microphylla*		
Nyctaginaceae	*Boerhavia*	*spicata*		
	Mirabilis	*longiflora*		
Onagraceae	*Ludwigia*	*repens*		
Passifloraceae	*Passiflora*	*mexicana*		
Pedaliaceae	*Proboscidea*	*parviflora*	*Martynia parviflora, Proboscidea crassibracteata*	
Phytolaccaceae	*Rivina*	*humilis*		
Pinaceae	*Pinus*	*eldarica*		
Plantaginaceae	*Plantago*	*major*		
Poaceae	*Bothriochloa*	*barbinodis*		
	Bouteloua	*rothrockii*		
	Cottea	*pappophoroides*		
	Digitaria	*sanguinalis*		
	Echinochloa	*crus-galli*		
	Paspalum	*dilatatum*		

Family	Genus	Species	Synonym[a]	Notes
	Setaria	*leucopila*		
	Setaria	*pumila*		
	Sorghum	*halepense*		
	Sporobolus	*cryptandrus*		
	Sporobolus	*airoides*		
Polygonaceae	*Eriogonum*	*polycladon*		
	Polygonum	*punctatum*		
	Rumex	*sp.*		
Portulacaceae	*Talinum*	*paniculatum*		
Simaroubaceae	*Ailanthus*	*altissima*		
Solanaceae	*Calibrachoa*	*parviflora*		
	Datura	*quercifolia*	*Datura ferox*	
	Nicotiana	*glauca*		

[a] Synonyms are from the Integrated Taxonomic Information System (IT IS 2002)