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Authors: Dave Prival and Matt Goode

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A Herpetological Inventory of Chihuahuan Desert National Parks

DAVE PRIVAL* AND MATT GOODE

*Desert Southwest Cooperative Ecosystem Studies Unit,
School of Natural Resources, University of Arizona, Tucson, AZ 85721*

*Correspondent: *deprival@yahoo.com*

ABSTRACT—We conducted an inventory of amphibians and reptiles in six U.S. national parks within the Chihuahuan Desert in 2003 and 2004. Using a combination of foot searches, road cruising, pitfall and turtle traps, and incidental observations, our field technicians and park staff documented 13,610 amphibians and reptiles within these parks. The most diverse park we surveyed was Big Bend National Park in Texas, where we documented 59 species. The least diverse park was White Sands National Monument in New Mexico, where we documented 28 species. Our inventory data can be used to monitor species composition, species richness, changes in species distribution, and changes in relative abundance of amphibians and reptiles within each park. We recommend that future monitoring programs focus primarily on changes in species distribution and relative abundance.

The primary mission of the National Park Service (NPS) is to "…conserve the scenery and natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations" (National Park Service 1916). Although this mission has been in place for 90 years, few parks have conducted thorough inventories of their natural resources, and even fewer have attempted to conduct any kind of monitoring to determine whether management practices conflict with their primary mission (Stohlgren et al. 1995).

A reasonable first step toward conserving natural resources in parks, therefore, is to simply document these natural resources within each park. In 1999, Congress directed NPS to take this first step and inventory the vascular plants and vertebrates (i.e., mammals, birds, reptiles, and amphibians) that inhabit each park with significant natural resources (National Park Service 1999).

As part of this nationwide effort, the Chihuahuan Desert Network (Fig. 1) of the NPS entered into a cooperative agreement with the School of Natural Resources at the University of Arizona to conduct a two-year inventory of amphibians and reptiles in six network parks—Amistad National Recreation Area, Texas (AMIS), Big Bend National Park, Texas (BIBE), Carlsbad Caverns National Park, New Mexico (CAVE), Fort Davis National Historic Site, Texas (FODA), Guadalupe Mountains National

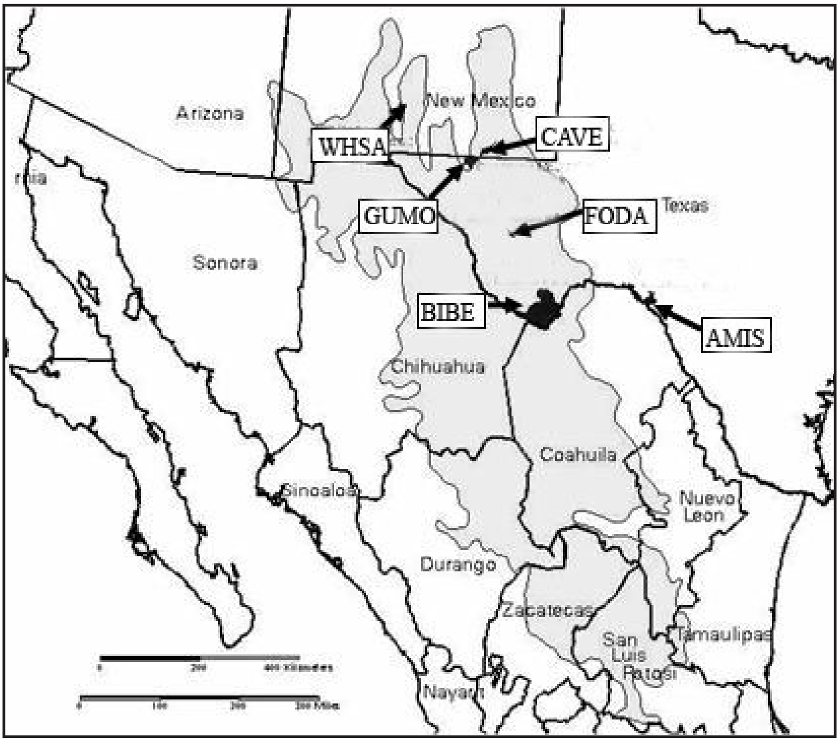

Fig. 1—Map showing locations of the national parks in the Chihuahuan Desert ecoregion that were included in the inventory – Amistad National Recreation Area (AMIS), Big Bend National Park (BIBE), Carlsbad Caverns National Park (CAVE), Fort Davis National Historic Site (FODA), Guadalupe Mountains National Park (GUMO), and White Sands National Monument (WHSA).

Park, Texas (GUMO), and White Sands National Monument, New Mexico (WHSA). This inventory took place from May through September, 2003, and June through September, 2004.

The Chihuahuan Desert is the most diverse ecoregion in the U.S.A. (Ricketts et al. 1999), and the number of endemic species is among the highest in the world (Olson and Dinerstein 1998). We expected reptile and amphibian diversity to be high, although reliable species lists did not exist for most parks, and little information was available regarding the distribution of herpetofauna, including species of special conservation concern. Baseline information is essential to guide decisions regarding the use of particular areas for interpretive, recreational, or other purposes, and to allow for the development of effective monitoring programs and adaptive management.

A stated goal of the NPS national inventory effort is to document 90% of all vertebrate and vascular plant species occurring in every park in the United States

(National Park Service 1999). Because many reptile and amphibian species are inconspicuous, secretive, well camouflaged, present in very low densities, and/or concealed and inactive for most of the year, documenting 90% of all species in any park is extremely difficult. In effect, our goal was simply to document as many reptile and amphibian species as possible within each park. However, to determine how close we came to documenting 90% of the species in each park, we compared our findings with lists of species we believe are likely to occur in each park based on previous sightings, museum records, species range maps, expert opinion, and habitat preferences. Relatively current field guides were available for Texas (Dixon 2000; Werler and Dixon 2000), New Mexico (Degenhardt et al. 1996), and the eastern (Conant and Collins 1998) and western United States (Stebbins 2003), which greatly aided in development of potential species lists for parks. We supplemented this information with data from nine museum collections to develop our potential species lists (California Academy of Sciences [San Francisco, CA]; Field Museum of Natural History [Chicago, IL]; Museum of Comparative Zoology [Harvard University, Cambridge, MA]; Museum of Southwestern Biology [University of New Mexico, Albuquerque, NM]; Museum of Vertebrate Zoology [University of California, Berkeley, CA]; Sul Ross State University Collection [Alpine, TX]; Texas Cooperative Wildlife Collection [Texas A&M University, College Station, TX]; University of Texas at El Paso Collection [El Paso, TX]; Peabody Museum of Natural History [Yale University, New Haven, CT]). It is important to note, however, that voucher specimens collected from these parks are likely spread throughout dozens of institutions, and a thorough nationwide search for museum specimens was beyond the scope of this project. Also, determining whether or not a voucher was collected from within a park boundary can be difficult, especially for the more recently established and smaller parks, and the landscape of one park (AMIS) has changed dramatically since the construction of Amistad Dam in 1969, so some guesswork was involved in determining what species are likely to occur in each park.

Our secondary objective was to map the distributions of all species we found within each park, because these data have potential for use in future monitoring efforts. Finally, we set out to obtain an index of relative abundance for reptile and amphibian species in all parks based on encounter rates, which may also prove important for monitoring efforts.

In this paper we document the results of our inventory. We describe the methods used for finding amphibians and reptiles and documenting their presence and distribution, the results of our surveys on a park-by-park basis, and present options for future monitoring efforts.

Methods—*Field Crews*—To accomplish our objectives, a four-person crew conducted inventory efforts in all six parks during May to September, 2003. In 2004, we utilized a different approach to maximize the likelihood of finding the remaining, infrequently active species we did not find in 2003. In 2004, we stationed one biological technician in each park (except FODA, which was surveyed by the technician stationed at BIBE, and CAVE, which hired its own technician) and a crew leader coordinated their activities. Following a week of intensive training at GUMO in June, technicians surveyed AMIS from July to September, BIBE and FODA from June to September, GUMO from June to August, and WHSA from June to September.

Our work was supplemented by assistance from park personnel and volunteers. Separate funding was obtained by CAVE to hire technicians in 2003 and 2004 to conduct herpetological surveys at the park. In addition, a volunteer from Sul Ross State University in Alpine, Texas surveyed FODA on our behalf during 2003. An NPS-supported technician was hired at WHSA to run pitfall traps in the park. Staff at GUMO and AMIS ran pitfall traps.

Study Areas—Amistad National Recreation Area, located in Val Verde County, Texas, is located at the junction of three biogeographic provinces—the Chihuahuan Desert, Edwards Plateau, and Tamaulipan Thornscrub (Brown 1994). The park was established to provide recreation at Amistad Reservoir, which began to fill in 1969 following construction of Amistad Dam. The park covers 23,680 ha, most of which are typically inundated, and includes the lower 39 km of the Devils River, the lower 22.5 km of the Pecos River, and 119 km of the Rio Grande. The reservoir affects or potentially could affect all of the riverways in the park and the immediately surrounding lands up to an elevation of 349 m. For the most part, the park boundary is the 349 m contour line. Most parklands consist of steep limestone cliffs along the river corridors, but the park also includes 996 ha of relatively level land within "hunt areas." During the 2003 season, reservoir levels were lower than usual due to drought. Water elevations at the dam ranged from approximately 322 to 328 m above sea level, giving us a maximum of 21 to 27 vertical meters of search area. The reservoir level was dramatically higher in 2004, rising to approximately 335 m above sea level and significantly reducing our potential search area.

Big Bend National Park, located in Brewster County, Texas, was by far the largest park we surveyed, covering 324,357 ha. This immense park contains many of the vegetation types found in the Chihuahuan Desert bioregion and ranges from a low point at about 549 m along the Rio Grande to a high point of about 2,378 m in the

Chisos Mountains. This park has received more attention from herpetologists than the other five parks in the network. Therefore, we focused most of our efforts on three mountain ranges that have been rarely visited, if visited at all, by herpetologists. These mountain ranges were the Sierra Quemada, located just south of the Chisos Mountains; the Sierra del Caballo Muerto, located on the eastern edge of the park; and the Mesa de Anguila, located in the southwest corner of the park. All three of these mountain ranges are dry, exposed, and rocky with little or no water, and are logistically challenging to survey, which explains why they had not received much attention from other herpetologists.

Carlsbad Caverns National Park, located in Eddy County, New Mexico, includes 18,934 ha of steep limestone hills and canyons in addition to the caves for which it was established. Ranging from 1,096 to 1,988 m elevation, this park has little permanent water except at Rattlesnake Spring. The Rattlesnake Spring unit is located near the Black River and is not continuous with the rest of the park.

Fort Davis National Historic Site, located in Jeff Davis County, Texas, covers just 192 ha in the Davis Mountains. This small park, established to protect fort ruins, includes steep cliffs, rocky hills, flat desert-scrubland, and a cottonwood grove, all within an elevation range of 1,488 to 1,591 m.

Guadalupe Mountains National Park covers 34,986 ha of Culberson and Hudspeth counties, Texas. The park includes the highest point in Texas at 2,667 m, mid-elevation hills, one of the most well-developed riparian areas in the region, and low desert and sand dunes around the park's lowest point at 1,105 m.

White Sands National Monument covers 58,191 ha in Otero and Doña Ana counties, New Mexico. The park protects about 50% of the world's largest gypsum sand dune field. Although most of the park consists of sand dune, there is a strip of desert scrub and a large playa on the west side. The park ranges in elevation from 1,186 to 1,255 m.

Weather—All of the parks were experiencing long-term drought conditions at the beginning of this study in May, 2003. However, the southern parks (AMIS, BIBE, and FODA) received significant rainfall during the summer of 2003, whereas the northern parks (CAVE, GUMO, and WHSA) remained extremely dry.

In 2004, all of the parks received significant rainfall during the summer. The greatest difference in weather between the two years probably occurred at CAVE, where the nearby town of Carlsbad, New Mexico received over 4.5 times as much rainfall during March to September, 2004, as during the same period in 2003 (National Weather Service 2004).

Search Methods—The bulk of our inventory effort consisted of foot searches. However, we also utilized road cruising, pitfall traps, turtle traps, and recorded data for every reptile and amphibian we saw incidentally. We also attempted to collect at least one voucher specimen, and associated tissue sample, of each species in each park. Generally we focused our search efforts on areas of high reptile and amphibian diversity, while also covering as many areas of each park as possible in order to document species distributions. At BIBE, however, due to the size of the park and the fact that many of the most diverse areas are already well known herpetologically, we focused our efforts primarily on three mountain ranges that had not been previously surveyed.

Foot Searches—Foot searches involved surveying pre-defined areas during periods when amphibians and reptiles were most likely to be active. Generally, we conducted foot searches between 0730 and 1200 h to document diurnal snakes and lizards, and between 1800 and 2400 h to document amphibians and nocturnal snakes and lizards. Actual start and end times varied depending upon time of sunrise/sunset, weather, and the elevation of the search area.

During a similar inventory of Sonoran Desert national parks in 2001 (Prival et al. 2001, unpubl. report, National Park Service, Sonoran Desert Network, Tucson, Arizona), we initially used randomly placed plots to survey for amphibians and reptiles. In theory, this approach is desirable from a statistical perspective, because it allows for inferences to be drawn to the entire park from a randomly selected sample, therefore being more useful in a monitoring context. However, we learned that this is a highly ineffective method for conducting inventories in parks (unless those parks are very small and homogenous), because amphibians and reptiles are not randomly distributed. As a result, using a randomized approach results in expending a great deal of time and effort to reach inaccessible places where, in most cases, diversity and relative abundance are low.

Therefore, during this study we focused our efforts on areas we believed were most likely to support high diversity or rare species, based upon our extensive past experience surveying for reptiles and amphibians in the southwestern U.S. We concentrated largely on canyons and riparian areas, but attempted to make sure that all habitat types within each park were represented in searches. We varied our search areas as much as possible to increase our distribution data without compromising our primary goal of documenting as many species as possible.

Occasionally we searched trails during foot searches, but most of the time we searched off-trail. In addition to simply looking around as we walked, we looked under rocks and logs and used mirrors and flashlights to illuminate crevices. Whenever cover was moved, we replaced it exactly as found.

During each search, we recorded the name of the area, start and end times, and weather (air temperature at 1.5 meters, relative humidity, and cloud cover) at the beginning and end of the search. We also recorded the boundaries of the search area in such a way that the same area could be searched again in the future.

Whenever we found a reptile or amphibian, we recorded species, subspecies (if identifiable), time, habitat (dry canyon bottom, slope, ridgetop/peak, flats, riparian, cliff wall, sand dune, lake, or cave), substrate (ground, vegetation, rock, structure, burrow, water, under cover, or crevice), and age (adult/juvenile or neonate/hatchling). In 2004, we added "terrace" to the habitat category and "road" to the substrate category as options.

We also recorded the location of every reptile and amphibian found using a Global Positioning System (GPS) unit. Our crew recorded all of this information into PDAs using a datasheet created in Pendragon Forms (v. 3.2), which could be downloaded into a laptop, reducing the likelihood of input and transcription errors. This method of collecting data also greatly reduced time spent on data entry, which enabled us to spend more time conducting surveys.

Unfortunately, recording our data directly onto computers did cause a problem at AMIS in 2004, where we lost 14 person-days of data (approximately 10% of the total person-days at AMIS) when a park computer crashed. We were able to reconstruct snake data from memory, but lost many lizard and amphibian observations. We also lost an unknown number of person-days at WHSA in 2004, possibly due to a long delay between recording data and downloading it onto a computer. Fortunately, no data regarding new species for either park were lost.

Incidental Observations—To supplement our other search methods, we obtained data for every reptile and amphibian we saw in a park while we were not conducting a formalized search. For example, we often observed animals when we were en route to a search area, walking around the housing area, or enjoying a hike on a day off. These animals were recorded as "incidentals." We recorded the same information about each animal, including UTM coordinates, as described above in the "Foot Searches" section.

Road Cruising—Road cruising involves slowly driving along a road at night in order to find amphibians and nocturnal snakes and lizards. During road cruising surveys, we recorded the names of the roads driven, start and end times, number of miles driven, and weather (air temperature at 1.5 meters, relative humidity, and cloud cover) at the beginning and end of the survey. Whenever we found a reptile or amphibian, we recorded the species, subspecies (if identifiable), time, whether the animal was dead or alive (or, in 2004, injured), and UTM coordinates. In general, we did not spend a great deal of time road cruising due to a lack of suitable roads in most parks and in order to obtain better distribution data.

Pitfall Traps—Pitfall traps are used to capture small amphibians and reptiles, and although they don't usually capture large numbers of animals, they can be especially useful for finding nocturnal, secretive animals and fossorial species. A pitfall trap array consists of four 5-gallon buckets, each completely sunken into the ground. The buckets are connected by low walls (each approximately 10 meters in length) constructed of silt fencing, such that three of the buckets connect to a central bucket in a triangular configuration (Jones 1986). Placing the silt-fencing wall in the ground involves digging a shallow (ca. 15 cm) trench and then using stakes to secure the wall in place. Animals running or crawling across the ground come to one of the walls and turn left or right. Whichever way they turn, they reach an open bucket into which they fall.

Turtle Traps—At AMIS, we occasionally used turtle traps to document turtle species living in the reservoir. We staked hoop traps into shallow water with PVC pipe and baited the traps with sardines to attract and capture turtles. These traps were checked daily when in use and rebaited as needed.

Vouchers—One of the most important aspects of our inventory was the collection of voucher specimens. A worthwhile inventory requires that specimens be collected and deposited at an institution where they will be properly stored and managed and data will be freely available to researchers and managers. Otherwise, there is no proof that the species actually occurred in the park, because it could have been misidentified in the field. Photographs rarely suffice as vouchers, because they often do not show all of the characteristics one needs to examine to identify a species or subspecies correctly, and photographs do not keep as well in storage as an actual specimen (Simmons 2002).

Specimens also provide important data regarding reproduction, diet, health, and morphology. We collected genetic material from most specimens during specimen preparation, which provided us with DNA that can be used to examine a variety of population level questions, as well as phylogenetic relationships within and between species.

Although voucher specimens of some species have been collected in the past in most of the parks we surveyed, we attempted to collect a complete set of vouchers for this inventory—one voucher of each species for each park. One reason for this is that vouchers collected from parks in the past are spread throughout many institutions, and therefore it is difficult to determine which species have already been collected.

More importantly; however, we wanted to provide a snapshot in time of all the species present in the six parks during 2003 and 2004. Just because a species was found in the park 5, 10, 50, or 100 years ago doesn't mean that it is still present now. The vouchers we collected will serve as a permanent record of the parks' herpetological diversity during these two years, and this information will be important for future monitoring efforts.

We arranged to store all of the vouchers we collected at the Museum of Southwestern Biology (MSB), University of New Mexico in Albuquerque (except for amphibians from BIBE, which were given to Texas A&M University as part of a separate study). The vouchers we placed at MSB are property of the National Park Service, but are on permanent loan to MSB.

Nomenclature—Species and common names often change as new information becomes available, and not all sources agree on what animals should be called. We have chosen the list of names published by the Society for the Study of Amphibians and Reptiles as our standard (Crother et al. 2000; Crother et al. 2003). When these names differ from those used in the Peterson's Field Guide series (Stebbins 2003 for New Mexico parks; Conant and Collins 1998 for Texas parks), we include the old names in the park species lists in parentheses. In some instances, we were unable to differentiate between subspecies in some or all locations. In these cases, we do not recognize subspecies for the taxon in this paper.

Results—In 2003, we spent 62 person-days at AMIS, 79 at BIBE, 157 at CAVE, 51 at FODA, 79 at GUMO, and 27 at WHSA for a total of 455 person-days in the field. In 2004, we spent 72 person-days at AMIS, 52 at BIBE, 54 at CAVE, 18 at FODA, 74 at GUMO, and 15 at WHSA, for a total of 285 person-days in the field.

Our foot search effort, including technicians at CAVE and FODA, is detailed in Table 1. The 2003 field season (May 5 to September 29) was significantly longer than the 2004 field season (June 14 to September 16) due to budgetary constraints.

We conducted four road-cruising surveys at AMIS (73.4 total road-miles), 36 at BIBE (2,794.1 total road-miles), 73 at CAVE (2,260.7 total road-miles), 16 at GUMO (501.1 total road-miles), and two at WHSA (44.5 total road-miles). No road-cruising surveys were conducted at FODA due to the absence of paved roads.

In 2003, we installed three pitfall trap arrays at AMIS, three arrays at CAVE, two arrays at FODA, two arrays at GUMO (one with only two walls instead of the usual three), and five arrays at WHSA (two with only one wall). At two of the WHSA arrays, we used funnel traps in addition to the pitfall buckets. In 2004, we installed two more arrays at GUMO. Traps were checked every day they were open.

Table 1—Foot search effort for all six Chihuahuan Desert national parks from 2003 to 2004.

Park	Number of Foot Searches	Number of Person-hours	Average Number of Hours per Search
AMIS*	> 204	> 576.1	2.8
BIBE	128	447.1	3.5
CAVE	271	733.5	2.7
FODA	105	298.7	2.8
GUMO	208	824.5	4.0
WHSA*	> 50	> 137.3	2.7

* Because 14 person-days of data were lost at AMIS, and an unknown number of person-days were lost at WHSA, actual search effort was significantly higher than indicated here.

The AMIS traps were checked 33 times, the CAVE traps 120 times, the FODA traps 36 times, the GUMO traps 125 times, and the WHSA traps 84 times. At GUMO and WHSA, not all traps were checked each time. We checked the turtle traps at AMIS 38 times.

In total, we documented 13,610 amphibians and reptiles within the six parks during 2003 and 2004. Broken down by search method, we recorded 9,596 animals during foot searches, 2,836 incidental observations, 658 road-cruising observations, 513 captured in pitfall and funnel traps, and seven turtles captured in traps. We collected 302 of these animals as voucher specimens.

In total, we documented 45 species at AMIS, 59 at BIBE, 46 at CAVE, 29 at FODA, 48 at GUMO, and 28 at WHSA. Below, we present our results for each park.

Amistad National Recreation Area

Amistad National Recreation Area Species List—We found 3,874 amphibians and reptiles at AMIS representing 45 species, including 9 frogs and toads, 15 lizards, 17 snakes, and 4 turtles (Appendix 1). We include Berlandier's Tortoise (*Gopherus berlandieri*) as documented even though we did not find a live animal in the park, just two scutes (small plates) from a shell.

One of these species, the Southwestern Fence Lizard (*Sceloporus cowlesi*) was just described recently. It was split off from the Eastern Fence Lizard (*S. undulatus*) based on genetic evidence (Leache and Reeder 2002). The Southwestern Fence Lizard is basically identical in appearance to another recently described species, the Prairie Lizard (*S. consobrinus*). In fact, no morphological differences have been published; one must use range to identify the species. Because AMIS is between the published ranges for the two species, it is possible that the animals we identified as Southwestern Fence Lizards will turn out to be Prairie Lizards once additional genetic work has been published.

Four of the species found, the Texas Horned Lizard (*Phrynosoma cornutum*), Texas Indigo Snake (*Drymarchon melanurus erebennus*), Trans-Pecos Black-headed Snake (*Tantilla cucullata*), and Berlandier's Tortoise, are Texas state-threatened. We did not find any federally listed amphibians or reptiles, nor did we expect to.

We found one non-native lizard species, the Mediterranean House Gecko (*Hemidactylus turcicus*). This Eurasian gecko has been widely introduced, both intentionally and accidentally, into many urban areas in the southern United States. The species has apparently expanded its range into AMIS within the last 28 years. LoBello (1976) noted that the species had been collected in nearby Ciudad Acuña in Mexico, and that there was a "possibility that it may eventually establish itself near the immediate reservoir." Indeed, we found large numbers of the species at Black Brush Point and in Evans Canyon. Typically, these geckos are found on buildings near lights, where insects attracted to the lights make easy prey. However, at AMIS we found them on cliff faces far from artificial illumination. Although the species is clearly invading natural areas of the park, it does not pose an obvious threat to the native gecko at AMIS, the Texas Banded Gecko (*Coleonyx brevis*), which typically forages on the ground, not on vertical walls favored by the Mediterranean House Gecko. However, the two species may compete in some more subtle way.

<u>Species Accumulation Curve</u>—Fig. 2 shows the rate at which we found new species during our entire survey effort (not including park staff observations). After reaching a plateau at the end of the 2003 field season, we had a strong start in 2004, finding six species during the first nine days that we did not find during the previous season. For the rest of the 2004 season, we found few species that we did not also find in 2003. We surveyed for a total of 134 person-days, but found no new species after 106 person-days. This species curve is not affected by the missing data from the 2004 field season.

<u>Undocumented Species</u>—Our list of species reasonably likely to occur in the park that we did not find is based on LoBello (1976), Werler and Dixon (2000), our incomplete set of museum records, and our assessment of whether a significant amount of suitable habitat still exists within the park for species known from the area prior to the construction of Amistad Dam. According to our estimates, there are probably ten species of amphibians and reptiles inhabiting the park that we did not find, including one lizard and nine snakes. This means that there are likely 55 species in the park in total, of which we documented 82%.

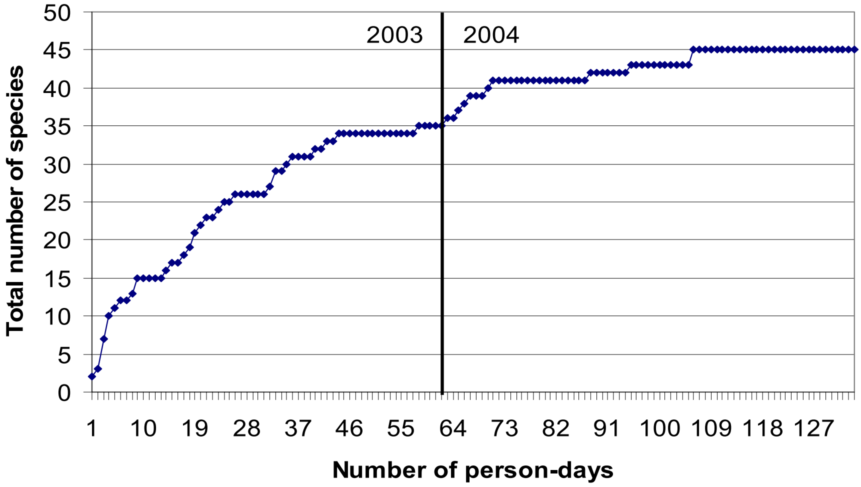

FIG. 2—Species accumulation curve for amphibians and reptiles from 2003-2004 at Amistad National Recreation Area. This graph illustrates the rate at which we found new species over the two years of the study combined

Because AMIS is essentially a narrow strip of land around the reservoir and adjoining rivers, it is likely that some of the species we did not document do not inhabit the park permanently, but just pass through from time to time. Many of the records from the area are old, and because the reservoir has drastically altered virtually every aspect of the parklands (mostly in a negative way as far as herpetological diversity is concerned), many species previously present may no longer occur in the park. This, combined with the lack of previous intensive surveys in the park, means that one should not place too much confidence in our 55 species estimate. Undocumented species expected to occur at AMIS are listed in Appendix 1.

Big Bend National Park

Big Bend National Park Species List—We found 2,259 amphibians and reptiles at BIBE representing 59 species, including 9 frogs and toads, 21 lizards, 26 snakes, and 3 turtles (Appendix 1).

Four of the species found, the Texas Horned Lizard, Reticulate Banded Gecko (*Coleonyx reticulatus*), Trans-Pecos Black-headed Snake, and Texas Lyresnake (*Trimorphodon biscutatus vilkinsonii*), are considered threatened by the state of Texas We did not find any federally listed amphibians or reptiles at BIBE.

We found two non-native species, the Mediterranean House Gecko and American Bullfrog (*Rana catesbeiana*). The Mediterranean House Gecko, described above, was found on structures near lights. One native gecko at BIBE, the Texas Banded Gecko, typically forages on the ground, not on vertical walls favored by the Mediterranean House Gecko. The other native gecko at BIBE, the Reticulate Banded Gecko, prefers cliff crevices, so there may be direct competition if the Mediterranean House Gecko invades natural areas, as it has at AMIS.

American Bullfrogs, a highly invasive species native to the eastern United States, were intentionally introduced to western states by state wildlife agencies during the twentieth century. Due to their enormous appetites, generalist diet, and large adult body size, these frogs have become a severe threat to many native species, in particular leopard frogs and gartersnakes (Rosen and Schwalbe 1995).

Species Accumulation Curve—Fig. 3 shows the rate at which we found new species during our entire survey effort at BIBE. Again, park staff observations are not included. We found the first 24 species within 16 days. After that, the rate at which we found new species declined. However, we continued to find new species during the entire course of the survey, never reaching an obvious asymptote.

Undocumented Species—According to the BIBE Amphibians and Reptiles Checklist (Dayton 2002), there are probably 69 species found in the park. Although our primary goal at BIBE was to survey the three remote mountain ranges we visited, rather than conduct a complete inventory of the park, we still wanted to document as many of the park's species as possible.

According to the list, ten species occur in the park that we did not find, including one toad, one salamander, one lizard, four snakes, and three turtles. In total, assuming that the park list is correct, we documented 86% of the park's amphibian and reptile species. The list of undocumented potential species for BIBE is in Appendix 1.

Carlsbad Caverns National Park

Carlsbad Caverns National Park Species List—We found 3,575 amphibians and reptiles at CAVE representing 46 species, including 8 frogs and toads, 15 lizards, 20 snakes, and 3 turtles (Appendix 1).

We found one New Mexico state-endangered species, the Gray-banded Kingsnake (*Lampropeltis alterna*), and two New Mexico state-threatened species, the Mottled Rock Rattlesnake (*Crotalus lepidus lepidus*) and the Rio Grande Cooter (*Pseudemys gorzugi*). We did not find any federally listed amphibians or reptiles at CAVE.

We found one non-native species, the American Bullfrog. This species is described in the BIBE section. We only found these frogs in Rattlesnake Spring.

Species Accumulation Curve—Fig. 4 shows the rate at which we found new species

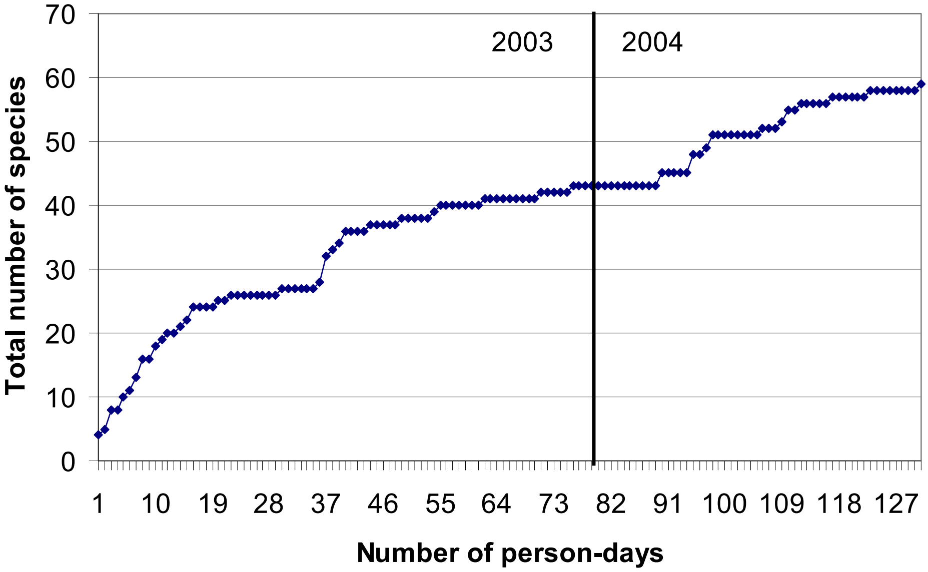

FIG. 3—Species accumulation curve for amphibians and reptiles from 2003 through 2004 at Big Bend National Park. This graph illustrates the rate at which we found new species over the two years of the study combined.

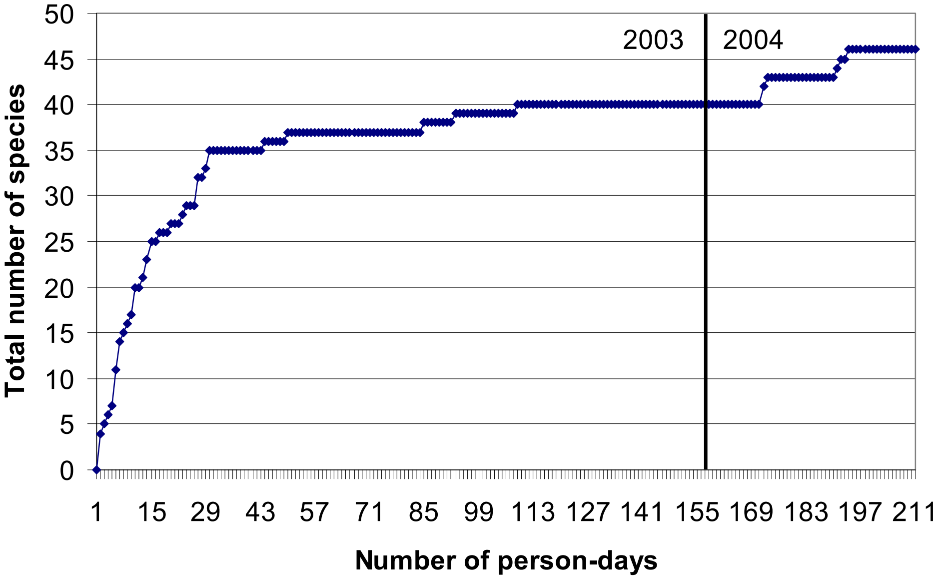

FIG. 4—Species accumulation curve for amphibians and reptiles from 2003 through 2004 at Carlsbad Caverns National Park. This graph illustrates the rate at which we found new species over the two years of the study combined.

during our entire survey effort. Park staff observations are not included, but data collected by park-supported technicians are included. We found the first 35 species within 30 person-days. After that, the rate at which we found new species declined. However, we found new species at a moderate rate in 2004 after a long lull in 2003.

Undocumented Species—According to a list compiled by Roemer (2002, unpubl. report, Carlsbad Caverns National Park, Carlsbad, New Mexico), 49 species have been documented at CAVE. However, we believe that one of these species, the Big Bend Patch-nosed Snake (*Salvadora hexalepis deserticola*) probably does not occur in the park because the next closest specimen of the species was collected over 161 km away (Degenhardt et al. 1996). The only record of the snake (CAVE 2115) is from the most highly visited area of the park. Most likely, the individual collected from the park was released by a visitor. Another species, Blanchard's Cricket Frog (*Acris crepitans blanchardi*) is thought to have been extirpated from the park (Roemer 2002, in litt.).

In 2003, we found two species that had not previously been documented—the Mexican Hog-nosed Snake (*Heterodon nasicus kennerlyi*) and Texas Long-nosed Snake (*Rhinocheilus lecontei tessellatus*). Also, Roemer's (2002, in litt.) list does not include Hernandez's Short-horned Lizard (*Phrynosoma hernandesi hernandesi*), which was apparently observed (though not documented) in the park in 1990 (Roemer 2002, in litt.), bringing the total number of species to 50.

According to the list, four species occur in the park that we did not find, including one lizard, two snakes, and one turtle. In total, assuming that the park list is correct (as modified above), we documented 92% of the park's amphibians and reptiles. The list of undocumented potential species at CAVE is in Appendix 1.

Fort Davis National Historic Site

Fort Davis National Historic Site Species List—We found 1,161 amphibians and reptiles at FODA representing 29 species, including 5 frogs and toads, 12 lizards, 11 snakes, and 1 turtle (Appendix 1).

One of the species found, the Texas Horned Lizard, is Texas state-threatened. We did not find any federally listed or non-native amphibians or reptiles.

Species Accumulation Curve—Fig. 5 shows the rate at which we found new species during our entire survey effort at FODA, including data from a Sul Ross State University volunteer. We found the first 23 species within 24 days. After that, the rate at which we found new species began to level off. We found new species in 2004 at about the same rate as at the end of 2003.

Undocumented Species—Determining the number of species inhabiting FODA is extremely difficult. FODA is a very small park (192 ha), so it probably is a permanent

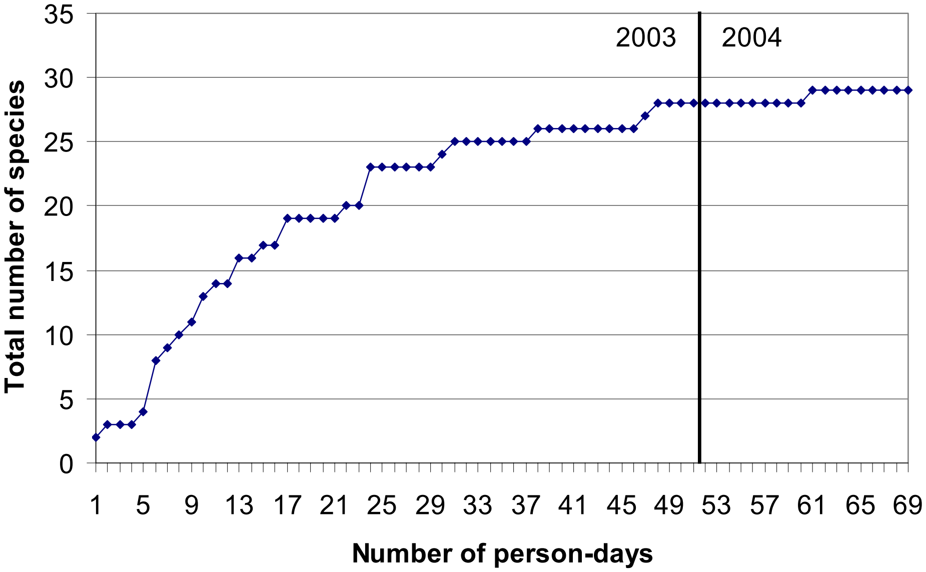

FIG. 5—Species accumulation curve for amphibians and reptiles from 2003 through 2004 at Fort Davis National Historic Site. This graph illustrates the rate at which we found new species over the two years of the study combined

home to few species. However, it is also part of the extremely diverse Davis Mountains, so many species probably move through the park.

The undocumented species listed in Appendix 1 include species that may occur in the park at least occasionally, but that we did not find this year. This list is based primarily on range maps and our conjecture regarding whether the species is likely to occur in the habitat types available in the park. In all likelihood, some of the species we list as undocumented potentials in Appendix 1 inhabit the park permanently, some visit the park only rarely, and some are never in the park. However, it is difficult to differentiate between groups without long-term surveys.

The list of undocumented species includes four frogs and toads, one salamander, four lizards, eleven snakes, and one turtle. If all of these species really occur at FODA, then there are a total of 51 species in the park, of which we documented 57%. Again, our estimate of 51 species should be viewed as highly suspect. The shape of the species curve suggests that we were in fact much closer to our 90% documentation target than our undocumented species list indicates.

Guadalupe Mountains National Park

Guadalupe Mountains National Park Species List—We found 1,931 amphibians and reptiles at GUMO representing 48 species, including 7 frogs and toads, 18 lizards, 21 snakes, and 2 turtles (Appendix 1).

The Texas Horned Lizard and Hernandez's Short-horned Lizard are Texas state-threatened. We did not find any federally listed amphibians and reptiles or non-native species.

Species Accumulation Curve—Fig. 6 shows the rate at which we found new species during our entire survey effort at GUMO. The figure does not include pitfall data recorded by park staff. The rate at which we found new species leveled off after 65 person-days with 44 species documented. We found only four additional species during 2004, mostly right at the end of the field season.

Undocumented Species—Based on a list compiled by Grace (1980) and locality data found in Werler and Dixon (2000), there are probably seven species of amphibians and reptiles in GUMO that occur in the park that we did not find, including one toad, one salamander, one lizard, and four snakes. If this estimate is correct, there are 55 species of amphibians and reptiles in GUMO, and we found 87% of them. A list of undocumented potential species is in Appendix 1.

White Sands National Monument

White Sands National Monument Species List—We found 810 amphibians and reptiles at WHSA representing 28 species, including 6 toads, 10 lizards, 11 snakes, and 1 turtle (Appendix 1).

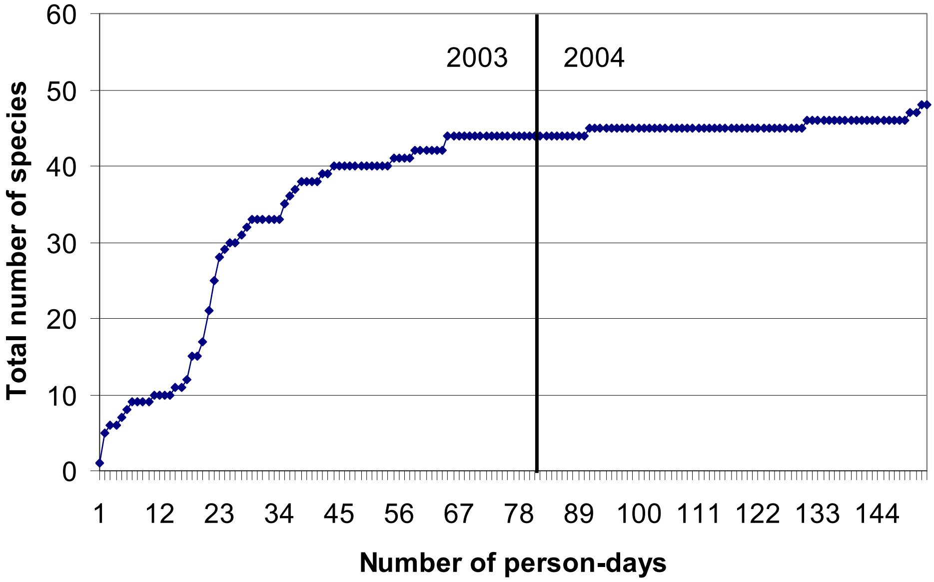

FIG. 6—Species accumulation curve for amphibians and reptiles from 2003through 2004 at Guadalupe Mountains National Park. This graph illustrates the rate at which we found new species over the two years of the study combined.

We did not find any New Mexico state listed, federally listed, or non-native amphibians or reptiles at WHSA.

Species Accumulation Curve—Fig. 7 shows the rate at which we found new species during our entire survey effort. The figure does not include data collected by park staff. We continued to find new species throughout the survey periods. It is possible that we finally reached a plateau after 40 person-days when we had documented 28 species, but is also possible that we would continue to find new species with additional search effort.

We had great difficulty accessing the desert scrub portion of WHSA along the west boundary (where most of the remaining species are probably found), because it is necessary to cross White Sands Missile Range to reach the area. We were only allowed to enter the missile range by notifying the military far in advance and had to be accompanied by park personnel at all times. Due to the long, irregular search periods required for herpetofauna survey work and the many other higher priority responsibilities of park personnel, these requirements severely hampered our efforts in this part of the park.

Undocumented Species—Prior to our survey, two herpetologists with extensive experience in the area (J. Johnson, University of Texas at El Paso, and D. Burkett,

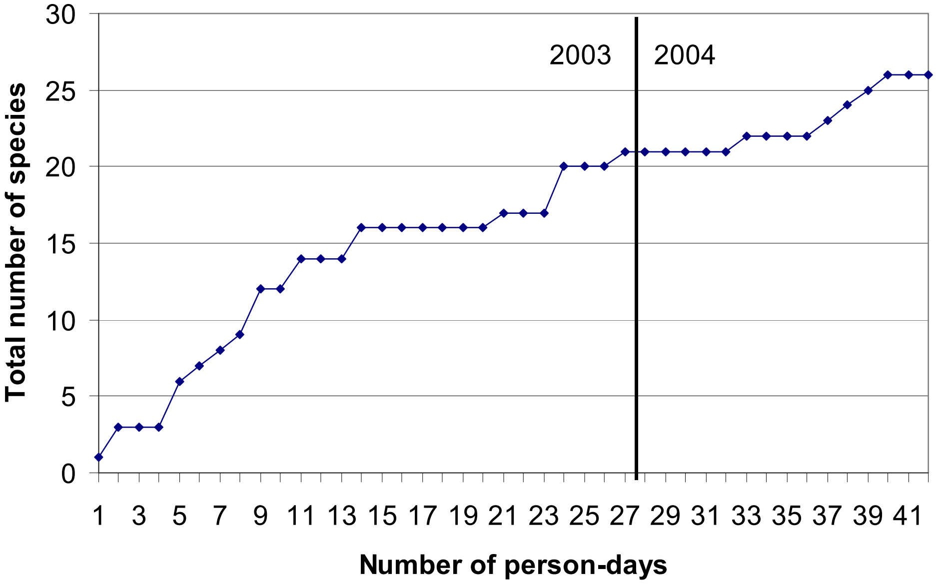

FIG. 7—Species accumulation curve for amphibians and reptiles from 2003 through 2004 at White Sands National Monument. This graph illustrates the rate at which we found new species over the two years of the study combined.

White Sands Missile Range) provided written comments on the existing WHSA list of amphibians and reptiles, giving us a good baseline of potentially occurring species from which to work. We excluded a few species from their list because we do not believe suitable habitat exists in the park.

The list of undocumented species that are likely to occur in the park includes one salamander, four lizards, and five snakes (Appendix 1). If this list is accurate, there are 38 species inhabiting the park, of which we documented 74%.

Discussion—The most important function of an inventory is that it provides a snapshot of the species present in an area at a given point in time. However, this information loses its value over time unless repeat surveys are conducted to examine potential changes to the community of interest (Morrison et al. 2001). Changes in the herpetofaunal communities of these parks may occur as a result of climate change, urbanization surrounding the park, drought, non-native species invasion, wildland fire, or other factors. There are several parameters that could be monitored, including species composition, species richness, species distribution, and relative abundance. We use our two years of data to examine the advantages and disadvantages of each approach below.

Strategy 1: Monitoring Species Composition—The species list itself serves as a baseline for what species were present in 2003 and 2004. However, due to the secretive nature of many reptiles and amphibians, as well as their sporadic activity patterns, monitoring species composition may not be a simple task. This approach would only work if you could count on finding the same species each time. However, during both 2003 and 2004, we found species that we did not find in the other year in five out of the six parks (Table 2).

We do not believe it is likely that any species were permanently extirpated from any of the parks between 2003 and 2004, or that new species colonized any of the parks during our study. Therefore, Table 2 indicates that if an intensive inventory is conducted in a park in a given year, the data can indicate that 13 to 36% of the species have either colonized or been extirpated from the park since the previous inventory even if there is no actual change in species composition.

Although it is true that search effort was not equal during both years of our study, we found a greater number of unique species in the year with less search effort in 33% of the parks, indicating that search effort alone cannot account for these annual differences.

Table 2—Apparent changes in species composition during study. This table lists the number of species found in each year that were not found in the other year of the survey. It also lists the number of species found in both years (i.e., the more "reliable" species), what percentage these reliable species comprise of the total species found, and the apparent percent change in species composition between the two years.

	No. of species found in 2003 only	No. of species found in 2004 only	No. of species found in both years	% of reliable species out of total species found	Apparent % change in species composition
AMIS	7	9	29	64.4%	35.6%
BIBE	3	15	41	69.5%	30.5%
CAVE	0	6	40	87.0%	13.0%
FODA	6	1	22	75.9%	24.1%
GUMO	10	3	35	72.9%	27.1%
WHSA	10	0	18	64.3%	35.7%

Weather conditions are clearly a major factor in the success of a herpetological inventory in a given year. For example, we found six species at CAVE in 2004 that we did not find in 2003, but did not find any species in 2003 that we did not also find in 2004. Most likely, this is partly because 2003 was a dry year, whereas 2004 was wet. However, at GUMO, located just south of CAVE, we had the opposite trend—in 2003 we found ten species that we did not find in 2004, but only found three species in 2004 that were not found the previous year.

Therefore, simply comparing wet years to wet years and dry years to dry years is not likely to make comparing annual species lists a more reliable monitoring method. The skill of the researchers involved, natural population level fluctuations, pure luck, and other factors that may be difficult to identify and impossible to account for are likely to always skew species lists from year to year. As such, a simple comparison of species lists over the years is unlikely to reliably indicate whether the herpetological community is changing or remaining stable.

Another option is to just monitor the reliable species—those that can always be documented in an inventory. This means conceding that the rare species (the species most likely to be extirpated) cannot be monitored. There are two important things to keep in mind if this option is selected. First, the reliable species make up a smaller percentage of the total than it seems. For example, at GUMO, 72.9% of the species we found were documented in both years (hence, reliable), but we did not document 100% of the species. If our estimate that we documented 87% of the species in the park is correct, then just 63.4% of the park's species could be considered reliable.

Therefore, over 1/3 of the park's herp species could theoretically be wiped out before the species being monitored are affected (assuming that the rare species are likely to be extirpated before the common species).

Second, the number of reliable species will decrease with every inventory until a plateau is reached, even if the species composition does not change. This is because many of the reliable species from our study are based on observations of just one or a few individuals each year. It doesn't require much bad luck to miss one individual in a given inventory, so these relatively rare reliable species will prove unreliable as inventories continue, until only the most common species remain.

Using GUMO as an example again, let us assume that over time, species will only be reliably documented if we found more than five individuals during each of our two survey years. Those species for which we found five individuals or less in a season are likely to be overlooked during some inventory down the line just by chance. This reduces the number of reliable species from 35 to 15, so now we are just monitoring 27% of the species likely to occur in the park. A series of repeated inventories could probably succeed in determining whether these 15 species remain present in the park or not. However, we are monitoring the 15 species that are probably the least likely to be extirpated. Table 3 indicates how many species could be monitored in each park using these same criteria.

Strategy 2: Monitoring Species Richness—Another strategy is to monitor species richness, the number of species present. By monitoring the number of species found during a survey period, rather than the species themselves, one rare species can essentially substitute for another rare species, which should reduce the natural variation between surveys. We can use our data to compare how apparent species richness changed between years in our survey (Table 4).

It is unlikely that there was any real, long-term change in species richness in any of the parks during our two year study. Therefore, the apparent percent change in Table 4 illustrates the error that would result if one attempted to monitor species richness using these two years of data. As predicted, monitoring species richness seems to be more reliable than monitoring species composition. On average, species composition changed by 27.7% between years, whereas species richness changed by 19.5%. Nonetheless, clearly there can be dramatic apparent annual fluctuations in species richness even if there is no actual change.

Of course, there should be less error in estimating variation in either species composition or species richness if several years of data are pooled and then compared with other data sets that also consist of several years of pooled data. However, as Tables

Table 3—Long-term reliable species. Long-term reliable species are defined as those species for which we found >5 individuals during each year. Because we are uncertain of the total number of species present in some parks, we calculate these long-term reliables as a percentage both of the number of species we actually found and the number of species we listed as likely to occur.

	No. of long-term reliable species	% of total species found	% of total species likely to occur
AMIS	16	35.6%	29.1%
BIBE	20	33.9%	29.0%
CAVE	19	41.3%	38.0%
FODA	10	34.5%	19.6%
GUMO	15	31.2%	27.3%
WHSA	6	21.4%	15.8%

Table 4—Apparent changes in species richness during study. This table lists the total number of species found each year, as well as the apparent percent change in species richness between 2003 and 2004.

	Total no. of species found in 2003	Total no. of species found in 2004	Apparent % change in species richness between 2003 and 2004
AMIS	36	38	+ 5.6%
BIBE	44	56	+ 27.3%
CAVE	40	46	+ 15.0%
FODA	28	23	- 17.9%
GUMO	45	38	- 15.6%
WHSA	28	18	- 35.7%

2 and 4 demonstrate, there can be very large apparent annual fluctuations, so many years of data would have to be pooled in order to reduce the error to an acceptable level.

Strategy 3: Monitoring Species Distribution—A third monitoring strategy is to use maps of the locations of individuals of each species to monitor distribution. One would expect that prior to extirpation, there should be a detectable change in the distribution of a given species. For example, if the range of a species that was widespread in 2003 becomes very limited by 2013, we would suspect that this species is in some trouble. Monitoring distribution could be particularly effective for documenting the effects of climate change on herpetofauna, because we can predict that most species are likely to move to higher elevations as the climate warms.

As such, species that are typically found only within a certain elevational range in a park are likely to be the best candidates for using distribution monitoring to detect changes in the herpetofauna community.

An advantage to monitoring species distribution instead of species composition or species richness is that changes in distribution may give advance warning that a species is in trouble, whereas the other methods just tell you when a species that was formerly present becomes absent, by which time it may be too late to implement any conservation measures for that species.

However, species distribution does have the same disadvantage as the other monitoring methods—it will probably only be possible to monitor changes in distribution of common or highly visible species. If rare species are not found in an area they used to be found in or suddenly appear in a new area, it is likely that they were just overlooked in some of the inventories.

An additional disadvantage of monitoring species distribution is that there may be natural fluctuations as populations have good years and bad years, so it is possible that a range extension or contraction may just be a normal event and not a cause for concern. However, since long-term herpetological studies are rare, and very little information is available regarding small-scale changes in distribution over time of various species, several years of monitoring will be required before any natural fluctuation patterns can be identified.

Strategy 4: Monitoring Relative Abundance—Another tool that can be used for monitoring is relative abundance. We recorded every reptile and amphibian we saw in each park during 2003 and 2004. We can use these data to calculate which species are common relative to other species. Although these data are biased toward areas we searched, we covered enough of each park that any major shifts in relative abundance should be apparent through monitoring. It will be important to standardize the survey design for monitoring if relative abundance is monitored. The data are also biased toward conspicuous species, although that bias should be the same in all surveys, so this should not be a problem for monitoring.

As with other monitoring strategies, monitoring relative abundance is only likely to be possible with common species. One way to monitor relative abundance is to rank species in terms of abundance and compare ranks. Table 5 lists the number of species with the same rank in each year among the top ten most abundant species each year, the number of species that were among the top five species in both years, and the number of species that were among the top ten in both years. Unlike the other parameters considered for monitoring, relative abundance actually did change at

Table 5—Similarities in relative abundance between 2003 and 2004. Species were ranked in terms of relative abundance for each year. The first column shows how many species had the same rank both years, only considering the 10 most abundant species for each year (maximum value possible = 10). The second column shows how many species were among the top 5 most abundant in both years (maximum value possible = 5), and the third column shows how many were among the top 10 in both years (maximum value possible = 10).

Park	No. of species with same rank both years		No. of species in top 5 both years		No. of species in top 10 both years	
	All herps	Reptiles only	All herps	Reptiles only	All herps	Reptiles only
AMIS	2	2	3	4	9	9
BIBE	1	1	3	4	8	8
CAVE	0	0	2	3	5	9
FODA	2	3	4	4	9	9
GUMO	2	0	4	3	8	9
WHSA	1	3	2	4	6	7

some parks between 2003 and 2004. The most apparent difference was in amphibian populations, which may be dramatically larger or smaller from one year to the next depending upon precipitation. However, since we are more interested in monitoring long-term trends than natural annual fluctuations, we will need to find a way of using relative abundance in such a way that these fluctuations do not affect the data if we are going to monitor relative abundance.

Table 5 indicates that a simple comparison of rank is not going to be very useful for monitoring, since few species retain the same rank in consecutive years. However, it may be more useful to look at whether common species remain common. So, we could look at how many of the five most common species are the same each year, or how many of the ten most common species are the same each year.

Table 5 indicates that while the top five most common species may change from year to year, the top ten are relatively stable. At every park except CAVE and WHSA, eight or nine species remained in the top ten each year. One reason this number is not higher is that amphibian populations fluctuate so dramatically. So, if we just look at reptiles instead, we can achieve a more stable top ten list. Nine of the species are in the top ten both years in four of the six parks, and eight are in the top ten in both years in one other. At WHSA, only seven reptile species were in the top ten both years, but this may be a function of the relatively small sample size at WHSA. Also, the number of species within the top ten at all parks should be much more consistent if the same areas are monitored each time.

A disadvantage of monitoring relative abundance in this way is that once again, we are only monitoring the most common species (in this case, the ten most common). However, an advantage of monitoring relative abundance over monitoring species composition or species richness is that you may be able to detect trends while there is still time to do something about it. For example, if a species that has been consistently among the ten most common drops off the top ten list for a few years, it will tell you that this species may be becoming more rare and you should look into it. In contrast, by the time the species drops entirely off the species list, it may be too late for conservation measures.

Implementing a Monitoring Program—We have to recognize that we will not be able to monitor rare species, at least not at a park-wide level. Instead, we are only likely to be able to detect changes in common and/or conspicuous species. Obviously, this is not ideal, because in most cases we would expect the rare species to be at a greater extirpation risk than the common species.

Of the four monitoring strategies outlined, we recommend creating a monitoring program that will emphasize the ability to detect changes in distribution and relative abundance rather than species composition or species richness, because distribution and relative abundance are more likely to provide information on important community-level changes in time to take conservation measures. Species composition and richness should also be recorded, but these parameters are less likely to indicate that something bad is happening until it is too late.

In order to monitor any of these aspects—species composition, species richness, distribution, or relative abundance—additional surveys will need to be carried out. When designing monitoring surveys for reptiles and amphibians, assuming that funds and manpower are in short supply (as expected), one faces two options.

The first option is to set up monitoring plots or transects that can be repeated every year, several times a year. In theory this could be accomplished by as few as one or two people working one or two days a week during the active season, depending on the size of the areas to be monitored.

Although randomly placed plots or transects would allow the greatest level of inference to the rest of the park, a completely randomized approach will probably not be feasible with the limited resources likely to be available, because reptiles and amphibians are not randomly distributed. In order to have any power to detect change, plots and transects will have to be placed in areas of high reptile and amphibian abundance and/or diversity. Potential areas can be identified from our distribution maps. Plots or transects may be able to be randomly placed within these areas for slightly greater inferential power.

Because randomization will not be feasible in most parks, it will not be possible to use plots or transects to monitor herpetofauna on a park-wide or region-wide basis using this approach. However, it should be possible to detect significant changes in species richness, distribution, or relative abundance within areas that are particularly favorable to reptiles and amphibians. Changes observed in these areas may serve as a warning that something may be occurring park-wide.

In addition, the distribution of common species within the park can be monitored relatively easily if long transects (i.e., several kilometers in length) are occasionally surveyed each year. Most parks have a trail system that could be used as an easily repeatable transect. Although, again, the results will only apply to the area surveyed, because the transects will not be randomly located, changes observed could serve as a warning that something is happening park-wide that warrants closer investigation. For parks with significant elevational gradients (such as BIBE and GUMO), distribution transects should include all elevations.

The second option is to save the money that would have been spent on a limited annual monitoring effort and instead conduct a complete herpetological inventory every five to ten years. Any inventory should run for at least two summers in order to reduce the chance that an abnormally dry or wet year will greatly influence the results. If conducted in approximately the same way each time, using approximately the same methods, one should be able to compare distribution and relative abundance between inventories, and species composition and richness by comparing pooled inventories.

The advantage to this approach is that large parts of each park can be surveyed, so you will have a much better idea of which species have changed distributions, if any. The large number of individuals and species recorded during an inventory also makes statistical comparisons of species richness and relative abundance more robust than may be possible with annual monitoring.

The main disadvantage is that a lot can happen in ten years, and it may take several inventories to identify any major trends, by which time it will likely to be too late to do anything about them. Also, if one inventory occurs during two wet years and another during two dry years, it may be difficult to draw conclusions from the results.

Regardless of which methods are chosen for monitoring, we hope that the baseline data we have acquired regarding the current status of the herpetofauna of the national parks of the Chihuahuan Desert will assist park managers to ensure that future generations will have the same opportunities we have had to enjoy the region's incredible and diverse array of wildlife.

We would like to give special thanks to those who did the sweating and bleeding on this inventory—James Borgmeyer, Brett DeGregorio, Adrienne Dreyfus, Allison Ebner, Dave Furphy, Dan Moen, Ian Murray, Chris Newsom, Barry Stephenson, Mike Swink, Chris Teske, and Mike Woolman. We thank our park contacts for doing all they could to make this project a success—Rick Slade at AMIS, Raymond Skiles at BIBE, Dave Roemer at CAVE, John Heiner at FODA, Fred Armstrong at GUMO, and Bill Conrod at WHSA.

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Appendix 1—Species Lists. The following list shows the taxa found during the 2003 and 2004 inventory within each of the six Chihuahuan Desert national parks. We also list species we believe are likely to occur within each park but that we did not find. Parks are ordered roughly from northwest to southeast. Scientific names from Conant and Collins (1998) and Stebbins (2003) are in parentheses when they differ from our nomenclature.

X = Found in the park during the 2003 and 2004 inventory.
? = Not found during the 2003 or 2004 inventory, but the taxon is likely to occur in the park based upon past records (cited in manuscript), species distribution, and our assessment of suitable habitat.

Taxon	WHSA	CAVE	GUMO	FODA	BIBE	AMIS
AMPHIBIANS						
Order Anura: Frogs & Toads						
Family Bufonidae (True Toads)						
Bufo cognatus Great Plains Toad	X	X	X	?		
Bufo debilis debilis Eastern Green Toad						X
Bufo debilis insidior Western Green Toad	X	X	?		X	
Bufo nebulifer Gulf Coast Toad (*Bufo valliceps valliceps*)						X
Bufo punctatus Red-spotted Toad	X	X	X	X	X	X
Bufo speciosus Texas Toad		X	X		X	X
Bufo woodhousii australis Southwestern Woodhouse's Toad				?		
Family Hylidae (Treefrogs)						
Acris crepitans blanchardi Blanchard's Cricket Frog						X
Hyla arenicolor Canyon Treefrog				X	X	
Family Leptodactylidae (Tropical Frogs)						
Eleutherodactylus guttilatus Spotted Chirping Frog (*Syrrhophus guttilatus*)					X	
Eleutherodactylus marnockii Cliff Chirping Frog (*Syrrhophus marnockii*)						X

APPENDIX 1—*continued*

Taxon	WHSA	CAVE	GUMO	FODA	BIBE	AMIS
Family Microhylidae (Narrow-mouthed Toads)						
Gastrophryne olivacea Great Plains Narrow-mouthed Toad				X	X	X
Family Pelobatidae (Spadefoot Toads)						
Scaphiopus couchii Couch's Spadefoot	X	X	X	X	X	X
Spea bombifrons Plains Spadefoot	X		X	?		
Spea multiplicata Mexican Spadefoot	X	X	X	?	?	
Family Ranidae (True Frogs)						
Rana berlandieri Rio Grande Leopard Frog		X	X	X	X	X
Rana catesbeiana American Bullfrog (non-native)		X			X	
ORDER URODELA: Salamanders						
Family Ambystomatidae (Mole Salamanders)						
Ambystoma tigrinum mavortium Barred Tiger Salamander	?		?	?	?	
REPTILES						
ORDER SQUAMATA: Lizards & Snakes						
Suborder Lacertilia: Lizards						
Family Anguidae: Alligator Lizards						
Gerrhonotus infernalis Texas Alligator Lizard (*Gerrhonotus liocephalis infernalis*)					X	
Family Gekkonidae: Geckos						
Coleonyx brevis Texas Banded Gecko		X	X	X	X	X
Coleonyx reticulatus Reticulate Banded Gecko					X	
Hemidactylus turcicus Mediterranean House Gecko (non-native)					X	X

Appendix 1—*continued*

Taxon	WHSA	CAVE	GUMO	FODA	BIBE	AMIS
Family Iguanidae (Iguanas & Allies)						
Cophosaurus texanus scitulus Chihuahuan Greater Earless Lizard	?	X	X	X	X	
Cophosaurus texanus texanus Texas Greater Earless Lizard						X
Crotaphytus collaris Eastern Collared Lizard	X	X	X	X	X	X
Gambelia wislizenii Long-nosed Leopard Lizard	X		X		X	
Holbrookia maculata Common Lesser Earless Lizard	X		X	X		
Phrynosoma cornutum Texas Horned Lizard	?	X	X	X	X	X
Phrynosoma hernandesi hernandesi Hernandez's Short-horned Lizard (*Phrynosoma douglasii hernandesi*)		?	X	?		
Phrynosoma modestum Round-tailed Horned Lizard	X	X	X	?	X	X
Sceloporus cowlesi Southwestern Fence Lizard (*Sceloporus undulatus consobrinus*)	X	X	X	X	X	X
Sceloporus magister bimaculosus Twin-spotted Spiny Lizard	X		?		X	
Sceloporus merriami annulatus Big Bend Canyon Lizard					X	
Sceloporus merriami merriami Merriam's Canyon Lizard						X
Sceloporus olivaceus Texas Spiny Lizard				?		X

Appendix 1—*continued*

Taxon	WHSA	CAVE	GUMO	FODA	BIBE	AMIS
Sceloporus poinsettii poinsettii Northern Crevice Spiny Lizard		X	X	X	X	X
Urosaurus ornatus schmidti Big Bend Tree Lizard		X	X	X	X	X
Uta stansburiana Common Side-blotched Lizard	X	X	X		X	
FamilyPolychrotidae: Anoles						
Anolis carolinensis Green Anole (non-native)					?	
Family Scincidae: Skinks						
Eumeces multivirgatus epipleurotus Variable Skink	X	X				
Eumeces obsoletus Great Plains Skink		X	X	X	X	X
Eumeces tetragrammus brevilineatus Short-lined Skink				X	X	X
Family Teiidae: Whiptail Lizards						
Aspidoscelis exsanguis Chihuahuan Spotted Whiptail (*Cnemidophorus exsanguis*)	?	X	X	X		
Aspidoscelis gularis gularis Texas Spotted Whiptail (*Cnemidophorus gularis gularis*)		X		X		X
Aspidoscelis gypsi Little White Whiptail (*Cnemidophorus inornatus*)	X					
Aspidoscelis inornata heptagramma Trans-Pecos Striped Whiptail (*Cnemidophorus inornatus heptagrammus*)		X	X	?	X	X
Aspidoscelis inornata llanuras Plains Striped Whiptail (*Cnemidophorus inornatus*)						

Appendix 1—*continued*

Taxon	WHSA	CAVE	GUMO	FODA	BIBE	AMIS
Aspidoscelis marmorata Marbled Whiptail (*Cnemidophorus marmoratus*)	X		X		X	?
Aspidoscelis neomexicana New Mexico Whiptail (*Cnemidophorus neomexicanus*)	?					
Aspidoscelis septemvittata septemvittata Big Bend Spotted Whiptail (*Cnemidophorus septemvittatus septemvittatus*)					X	
Aspidoscelis tesselata Common Checkered Whiptail		X	X	?	X	
Suborder Serpentes: Snakes						
Family Colubridae: Colubrid Snakes						
Arizona elegans elegans Kansas Glossy Snake			X		X	
Arizona elegans philipi Painted Desert Glossy Snake	X					
Bogertophis subocularis subocularis Trans-Pecos Ratsnake		X	X	?	X	?
Diadophis punctatus Ring-necked Snake		X	X	?	X	X
Drymarchon melanurus erebennus Texas Indigo Snake (*Drymarchon corais erebennus*)						X
Elaphe bairdi Baird's Ratsnake				?	X	X
Elaphe emoryi Great Plains Ratsnake		X	X	?	X	?
Gyalopion canum Chihuahuan Hook-nosed Snake		X	X		X	
Heterodon nasicus kennerlyi Mexican Hog-nosed Snake		X	X			

Appendix 1—*continued*

Taxon	WHSA	CAVE	GUMO	FODA	BIBE	AMIS
Heterodon nasicus nasicus Plains Hog-nosed Snake	?					
Hypsiglena torquata janii Texas Nightsnake	X	X	X	X	X	X
Lampropeltis alterna Gray-banded Kingsnake		X	?	?	?	?
Lampropeltis getula splendida Desert Kingsnake	X	?	?		?	
Lampropeltis triangulum Milksnake				?	?	
Masticophis flagellum testaceus Western Coachwhip	X	X	X	X	X	X
Masticophis taeniatus Striped Whipsnake	?	X	X	X	X	X
Nerodia erythrogaster transversa Blotched Watersnake		?			X	?
Nerodia rhombifer rhombifer Northern Diamond-backed Watersnake						X
Pituophis catenifer Gophersnake (*Pituophis melanoleucus*)	X	X	X	X	X	X
Rhinocheilus lecontei tessellatus Texas Long-nosed Snake	X	X	X		X	X
Salvadora grahamiae grahamiae Mountain Patch-nosed Snake		X	X	X	X	
Salvadora grahamiae lineata Texas Patch-nosed Snake						X
Salvadora hexalepis deserticola Big Bend Patch-nosed Snake (*Salvadora deserticola*)	?				X	

APPENDIX 1—*continued*

Taxon	WHSA	CAVE	GUMO	FODA	BIBE	AMIS
Salvadora hexalepis deserticola Big Bend Patch-nosed Snake (*Salvadora deserticola*)	?				X	
Sonora semiannulata semiannulata Variable Groundsnake	?	X	X	X	X	?
Tantilla cucullata Trans-Pecos Black-headed Snake (*Tantilla rubra cucullata/diabolica*)				?	X	X
Tantilla hobartsmithi Smith's Black-headed Snake		X	X	X	X	X
Tantilla nigriceps Plains Black-headed Snake	X		?	?		
Thamnophis cyrtopsis cyrtopsis Western Black-necked Gartersnake	?	X	X	X	X	
Thamnophis cyrtopsis ocellatus Eastern Black-necked Gartersnake						?
Thamnophis marcianus marcianus Marcy's Checkered Gartersnake		X		?	X	?
Thamnophis proximus Western Ribbonsnake						X X
Trimorphodon biscutatus vilkinsonii Texas Lyresnake						
Family Elapidae: Coralsnakes & Allies						
Micrurus tener tener Texas Coralsnake (*Micrurus fulvius tener*)						X
Family Leptotyphopidae: Threadsnakes						
Leptotyphlops dissectus New Mexico Threadsnake (*Leptotyphlops dulcis*)		X	X	X	?	

Appendix 1—*continued*

Taxon	WHSA	CAVE	GUMO	FODA	BIBE	AMIS
Leptotyphlops dulcis Texas Threadsnake						X
Leptotyphlops humilis segregus Trans-Pecos Threadsnake	X		X		X	
Family Viperidae: Vipers & Pitvipers						
Agkistrodon contortrix pictigaster Trans-Pecos Copperhead				?	X	X
Crotalus atrox Western Diamond-backed Rattlesnake	X	X	X	?	X	X
Crotalus lepidus lepidus Mottled Rock Rattlesnake		X	X	X	X	?
Crotalus molossus molossus Northern Black-tailed Rattlesnake		X	X	X	X	?
Crotalus scutulatus scutulatus Northern Mohave Rattlesnake			?		X	
Crotalus viridis viridis Green Prairie Rattlesnake	X		X			
Sistrurus catenatus edwardsii Desert Massasauga						
ORDER TESTUDINES : Turtles						
Family Emydidae : Cooters, Sliders, Box Turtles, and Allies						
Pseudemys gorzugi Rio Grande Cooter		X				X
Terrapene ornata Ornate Box Turtle	X	X	X	X	?	
Trachemys gaigeae gaigeae Big Bend Slider					X	
Trachemys scripta elegans Red-eared Slider (non-native at BIBE)	X				?	X
Family Kinosternidae: Mud Turtles						
Kinosternon flavescens Yellow Mud Turtle						

APPENDIX 1—*continued*

Taxon	WHSA	CAVE	GUMO	FODA	BIBE	AMIS
Family Testudinidae: Tortoises						
Gopherus berlandieri Berlandier's Tortoise (non-native at BIBE)					?	X
Family Trionychidae : Softshell Turtles						
Apalone spinifera emoryi Texas Spiny Softshell					X	X