

Annual Biological Inventory Report Sonoran Desert Network

2003

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OVERVIEW

This report summarizes the results of field inventories during 2003 in five National Park Service units in southern Arizona. We surveyed for all taxonomic groups of vertebrates and vascular plants present in Chiricahua and Tuzigoot National Monuments, and selected taxonomic groups in Tonto and Montezuma Castle National Monuments, and Fort Bowie National Historic Site (Table 1).

Table 1. Summary of field inventories completed in Sonoran Desert Network national park units, by taxon group, in 2003.

Park	Abbreviation	Taxon group					
		Plants	Amphibians	Reptiles	Birds	Fish	Mammals
Chiricahua National Monument (NM)	CHIR	✓	✓	✓	✓		✓
Coronado National Memorial (NMem)	CORO				✓		
Fort Bowie National Historic Site (NHS)	FOBO	✓			✓		
Montezuma Castle National Monument (NM)	MOCA	✓					
Tonto National Monument (NM)	TONT	✓			✓		
Tuzigoot National Monument (NM)	TUZI	✓	✓	✓	✓	✓	✓

This biological inventory report is the third in a series of reports that tracks our progress toward reaching the following primary goals:

- Complete field inventories, documenting at least 90% of all species of vascular plants and vertebrates estimated to occur in each park.
- 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.

In this report we do not present detailed methods sections for all of our surveys, as these can be found in our previous annual reports (Powell et al. 2002, 2003). We do describe methods for three new survey techniques: modular plot surveys for plants, transects and time-area-constrained searches for reptiles and amphibians.

This is the final annual report for this project. The data in all annual reports will be presented in considerably more detail in final reports submitted to each park, which will be available according to the schedule presented in Table 2. The format for these final reports will be similar to Powell et al. (2004; *in press*).

Table 2. Schedule for submitting final inventory reports for Sonoran Desert Network National park units, 2004-2005. Reports are due on the first day of the month indicated.

Park	September	October	November	December	January	February	March	April
Casa Grande Ruins NM	Draft Final		Final					
Gila Cliff Dwellings NM		Draft Final		Final				
Coronado NMem				Draft Final		Final		
Saguaro NM				Draft Final		Final		
Fort Bowie NHS					Draft Final		Final	
Tuzigoot NM					Draft Final		Final	
Chiricahua NM						Draft Final		Final

PLANTS

We completed general botanizing surveys during 33 visits (survey field days, usually with two field technicians) to five network parks between 11 March and 28 May, 2003: four visits to Chiricahua NM, two visits to Fort Bowie NHS, twelve visits to Montezuma Castle NM, seven visits to Tonto NM, and ten visits to Tuzigoot NM. Survey frequency generally corresponded to the thoroughness of previous surveys; we spent the most time in parks with species lists that appeared to be least complete.

We completed modular plot work at Tonto NM ($n = 4$ plots), Tuzigoot NM ($n = 16$ plots), and Montezuma Castle NM ($n = 15$ plots) in 2003. This work was done in cooperation with Sonoran Desert Network Inventory and Monitoring program (I&M) staff, who developed the methods and protocol for use in multiple National Park Service units. We used these methods only to determine species presence, which we summarize below (Table 3) but the data may be used by I&M staff in the future as part of a long-term vegetation-monitoring program. The methods below describe field measurements (*italics indicate features illustrated in Fig. 1*) and suggest potential future data analysis.

Methods

Methods for general botanizing can be found in Powell et al. (2003), described as “general surveys”. For modular plots, we used a standardized, plot-based approach at all three parks in the spring of 2003. The basic survey unit was the 10 x 10 m *module*, two or four of which were joined to create a 10 x 20 m or 20 x 20 m *plot* (Fig. 1). We used two types of sampling at modular plots, with different objectives: 1) point-intercept transects to estimate frequency of plant species and ground cover types, and 2) nested plots, similar to Braun-Blanquet plots (Braun-Blanquet 1965), to estimate percent cover (spatial area occupied by the foliage of each plant species as viewed from above) for all plants and to calculate basal area (spatial area occupied by the main stem of each plant species) for trees.

We sited plots as follows: navigated to the northwest corner of each plot using Garmin Emap Geographic Positioning System (GPS) units; marked corner with a permanent rebar stake; used a Pathfinder GPS unit to obtain accurate UTM coordinates for the point; and used a compass and tape measure to define remaining module corners. Plot boundaries were aligned in cardinal directions (e.g., the west boundary was a north-south line). All plots were in a 2 x 2 (Fig. 1), or 1 x 2 arrangement of modules.

Point-intercept Transects

We bisected each module with a north-south *transect* (Fig. 1) that we measured using a 10-m tape measure marked at 10-cm increments. In each of three height categories (<0.5 m, 0.5–2 m and >2 m) we recorded the species of the first plant intercepted by a vertical line at each of 100 points located every 10 cm along the transect line. We created the vertical line with a laser pointer as often as possible, and otherwise visually estimated its position. If no plant was intercepted, we recorded “no plant.” We classified ground cover at each point according to the following categories: bare soil, loose rock, bedrock,

litter (senescent plant material that was detached from plants), or other (which was specified, e.g., “fallen tree limb”).

Braun-Blanquet Plots

We used a form of the Braun-Blanquet method (Braun-Blanquet 1965) to estimate percent cover for each species on all modules and *quadrats* (Fig. 1) in each of the height categories used for point-intercept transects. We estimated coverage at two scales: large (10 x 10 m; covering the entire module; $n = 4$ per plot) and small (1 x 1 m; in quadrats at opposite corners of the module; $n = 8$ per plot) (Fig. 1). To estimate percent cover by height category for each plant species in the modules or quadrats, we assigned the total coverage by each species to one of six cover classes based on visual estimation: “trace” (<1%), “1” (1–5%), “2” (6–25%), “3” (26–50%), “4” (51–75%), or “5” (76–100%). Because quadrats were nested within modules (Fig. 1), modules always contained all the plant species that were recorded in the quadrats. We recorded tree species in each module if the majority of the trunk was inside the module, and recorded basal diameter if it was >15 cm. For stems <15 cm basal diameter, we counted the number of stems but did not record basal diameter.

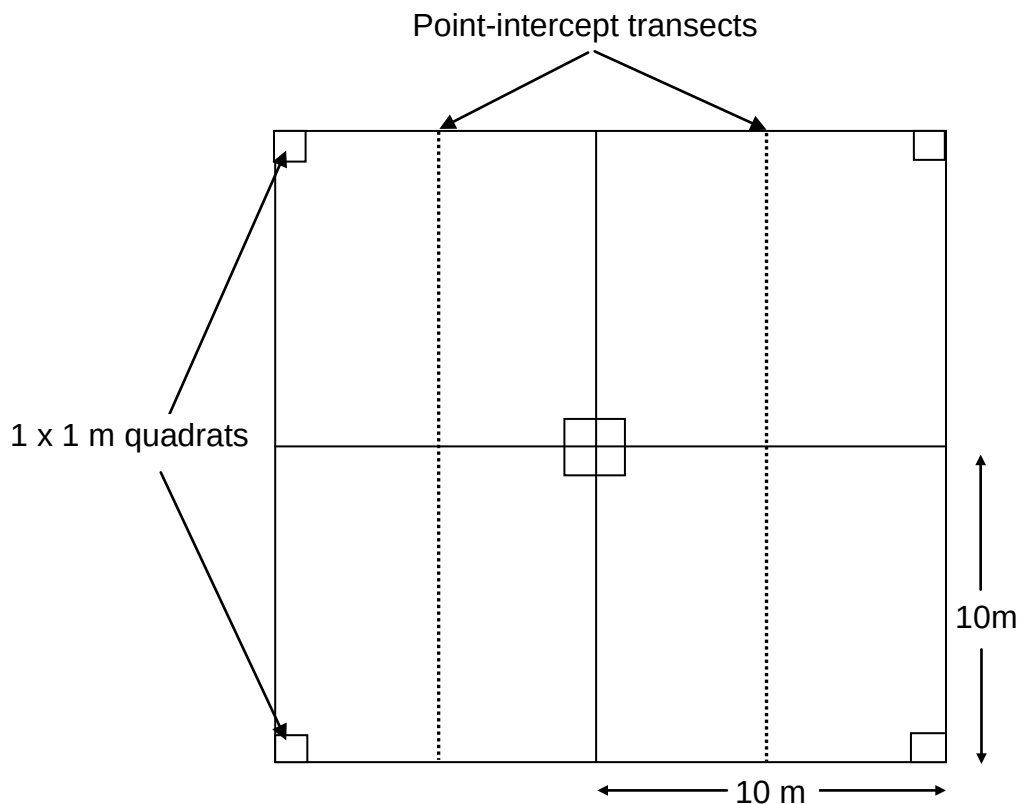


Figure 1. Typical modular plot layout: one 20 x 20 plot, four 10 x 10 m modules, eight 1 x 1 m quadrats, and four 10-m point-intercept transects; Montezuma Castle, Tonto, and Tuzigoot National Monuments, Arizona, 2003.

Results

We recorded a total of 380 species in five parks during plant inventories in 2003 (Table 3). Considering both field methods and not including specimens for which we

could not determine species (e.g., *Daucus* sp.), we recorded the most species at Tonto NM ($n = 158$), and fewer at Tuzigoot NM and Montezuma Castle NM ($n = 133$ and 132 , respectively) (Table 3). We recorded a similar number of species at Chiricahua NM ($n = 90$) and Fort Bowie NHS ($n = 93$).

Table 3. Number of plant specimens collected during general botanizing and modular plot surveys, and plant species observed on modular plots in Sonoran Desert Network national park units, Arizona, 2003.

Family	Genus	Species	Common name	Number of specimens collected					Observed on modular plots		
				CHIR	FOBO	MOCA	TONT	TUZI	MOCA	TONT	TUZI
Agavaceae	<i>Agave</i>	<i>americana</i>	American century plant	1							
	<i>Agave</i>	<i>chrysantha</i>	goldenflower century plant				1				
	<i>Agave</i>	<i>palmeri</i>	Palmer's century plant	1							
	<i>Agave</i>	<i>parryi</i>	Parry's agave	1	1						
	<i>Yucca</i>	<i>baccata</i>	banana yucca	1	1		1	1			X
	<i>Yucca</i>	<i>elata</i>	soaptree yucca	1			1		X		X
	<i>Yucca</i>	<i>schottii</i>	Schott's yucca	1							
Amaranthaceae	<i>Gomphrena</i>	<i>caespitosa</i>	tufted globe amaranth	1							
Anacardiaceae	<i>Rhus</i>	<i>aromatica</i>	fragrant sumac	1	1				X		
	<i>Rhus</i>	<i>microphylla</i>	littleleaf sumac		1						
	<i>Rhus</i>	<i>ovata</i>	sugar sumac				1				
	<i>Rhus</i>	<i>trilobata</i>	skunkbush sumac			1		1			
	<i>Rhus</i>	<i>virens</i>	evergreen sumac	1							
	<i>Toxicodendron</i>	<i>radicans</i>	eastern poison ivy	1	1						
	<i>Toxicodendron</i>	<i>radicans</i>	eastern poison ivy	1	1						
Apiaceae	<i>Bowlesia</i>	<i>incana</i>	hoary bowlesia				1			X	
	<i>Cymopterus</i>	<i>multinervatus</i>	purplenerve springparsley			1		1	X		
	<i>Daucus</i>	<i>pusillus</i>	American wild carrot				1		X		
	<i>Daucus</i>	sp.	wild carrot						X	X	
	<i>Lomatium</i>	<i>nevadense</i>	Nevada biscuitroot				1				
	<i>Yabea</i>	<i>microcarpa</i>	false carrot				1				
Asclepiadaceae	<i>Asclepias</i>	<i>asperula</i>	antelopehorns		1			1			
	<i>Funastrum</i>	<i>crispum</i>	wavyleaf twinevine	1							
	<i>Funastrum</i>	<i>cynanchoides</i>	fringed twinevine							X	
Asteraceae	<i>Acourtia</i>	<i>wrightii</i>	brownfoot				1		X		
	<i>Adenophyllum</i>	<i>porophylloides</i>	San Felipe dogweed				1				
	<i>Ambrosia</i>	sp.	ragweed				1			X	
	<i>Artemisia</i>	<i>ludoviciana</i>	white sagebrush		1		1	1	X	X	
	<i>Aster</i>	sp.	aster						X		
	<i>Baccharis</i>	<i>pteronioides</i>	yerba de pasmo	1		1					
	<i>Baccharis</i>	<i>salicifolia</i>	mule's fat					1			
	<i>Baccharis</i>	<i>sarothroides</i>	desertbroom		1		1	1			X
	<i>Baccharis</i>	sp.	baccharis species								X
	<i>Baileya</i>	<i>multiradiata</i>	desert marigold		1		1	1		X	X
	<i>Bebbia</i>	<i>juncea</i>	sweetbush				1			X	
	<i>Brickellia</i>	<i>atractylloides</i>	spearleaf brickellbush			1	1				
	<i>Carphochaete</i>	<i>bigelovii</i>	Bigelow's bristlehead	1							
	<i>Chaetopappa</i>	<i>ericoides</i>	rose heath	1		1					
	<i>Cirsium</i>	<i>neomexicanum</i>	New Mexico thistle		1		1			X	
	<i>Cirsium</i>	sp.	thistle						X		
	<i>Encelia</i>	<i>farinosa</i>	goldenhills				1			X	
	<i>Encelia</i>	<i>frutescens</i>	button brittlebush				1		X	X	
	<i>Ericameria</i>	<i>laricifolia</i>	turpentine bush	1	1		1			X	
	<i>Erigeron</i>	<i>concinus</i>	Navajo fleabane	1							
	<i>Erigeron</i>	<i>divergens</i>	spreading fleabane				1	1	X	X	
	<i>Erigeron</i>	<i>flagellaris</i>	trailing fleabane			1					
	<i>Filago</i>	<i>californica</i>	California cottonrose				1				
	<i>Gaillardia</i>	<i>pinnatifida</i>	red dome					1			

Family	Genus	Species	Common name	Number of specimens collected					Observed on modular plots		
				CHIR	FOBO	MOCA	TONT	TUZI	MOCA	TONT	TUZI
			blanketflower								
	<i>Gutierrezia</i>	<i>sarothrae</i>	broom snakeweed	1	1		1		X	X	X
	<i>Hymenoclea</i>	<i>monogyra</i>	singlewhorl burrobrush				1		X	X	
	<i>Isocoma</i>	<i>tenuisecta</i>	burroweed		1						
	<i>Lactuca</i>	<i>sp.</i>	lettuce						X		
	<i>Lasthenia</i>	<i>californica</i>	California goldfields				1				
	<i>Layia</i>	<i>glandulosa</i>	whitedaisy tidytips			1					
	<i>Machaeranthera</i>	<i>gracilis</i>	slender goldenweed				1				
	<i>Melampodium</i>	<i>leucanthum</i>	plains blackfoot				1	1	X		
	<i>Packera</i>	<i>neomexicana</i>	New Mexico groundsel	1							
	<i>Parthenium</i>	<i>incanum</i>	mariola		1				X		X
	<i>Perityle</i>	<i>saxicola</i>	Roosevelt Dam rockdaisy				2				
	<i>Porophyllum</i>	<i>gracile</i>	slender poreleaf							X	
	<i>Rafinesquia</i>	<i>californica</i>	California plumseed				1			X	
	<i>Rafinesquia</i>	<i>neomexicana</i>	New Mexico plumseed				1			X	
	<i>Rafinesquia</i>	<i>sp.</i>	California chicory							X	
	<i>Senecio</i>	<i>flaccidus</i>	Douglas' ragwort					1			
	<i>Senecio</i>	<i>flaccidus</i>	threadleaf ragwort					1			
	<i>Senecio</i>	<i>lemmonii</i>	Lemmon's ragwort				1			X	
	<i>Senecio</i>	<i>sp.</i>	ragwort							X	
	<i>Senecio</i>	<i>spartioides</i>	broomlike ragwort		1						
	<i>Sonchus</i>	<i>asper</i>	spiny sowthistle					1		X	
	<i>Sonchus</i>	<i>sp.</i>	sowthistle						X	X	
	<i>Stephanomeria</i>	<i>pauciflora</i>	brownplume wirelettuce				2		X	X	
	<i>Thymophylla</i>	<i>acerosa</i>	pricklyleaf dogweed					1	X		X
	<i>Thymophylla</i>	<i>pentachaeta</i>	five needle pricklyleaf					1	X		
	<i>Townsendia</i>	<i>strigosa</i>	hairy Townsend daisy			1		1			X
	<i>Uropappus</i>	<i>lindleyi</i>	Lindley's silverpuffs			1	1		X	X	
	<i>Verbesina</i>	<i>encelioides</i>	golden crownbeard	1							
	<i>Verbesina</i>	<i>rothrockii</i>	Rothrock's crownbeard		1						
	<i>Zinnia</i>	<i>acerosa</i>	desert zinnia		1						
Berberidaceae	<i>Mahonia</i>	<i>haematocarpa</i>	red barberry			1		1	X		X
Betulaceae	<i>Alnus</i>	<i>oblongifolia</i>	Arizona alder					1			
Bignoniaceae	<i>Chilopsis</i>	<i>linearis</i>	desert willow		1		1	1			
Boraginaceae	<i>Amsinckia</i>	<i>menziesii</i>	common fiddleneck					1	X	X	
	<i>Cryptantha</i>	<i>cinerea</i>	James' cryptantha	2							
	<i>Cryptantha</i>	<i>confertiflora</i>	basin yellow cryptantha			1		1			
	<i>Cryptantha</i>	<i>crassisejala</i>	thicksepal cryptantha	1		1		1			
	<i>Cryptantha</i>	<i>nevadensis</i>	Nevada cryptantha			1					
	<i>Cryptantha</i>	<i>pterocarya</i>	wingnut cryptantha		1						
	<i>Cryptantha</i>	<i>sp.</i>	cryptantha						X	X	X
	<i>Harpagonella</i>	<i>sp.</i>	grapplinghook						X		
	<i>Heliotropium</i>	<i>curassavicum</i>	salt heliotrope					1			
	<i>Lappula</i>	<i>occidentalis</i>	flatspine stickseed		1	2	1	4	X		
	<i>Lappula</i>	<i>occidentalis</i>	flatspine stickseed			1			X		
	<i>Lappula</i>	<i>sp.</i>	stickseed								X
	<i>Lithospermum</i>	<i>incisum</i>	narrowleaf stoneseed					1			
	<i>Pectocarya</i>	<i>recurvata</i>	curvenut combseed							X	
	<i>Plagiobothrys</i>	<i>arizonicus</i>	Arizona popcornflower	1			3				

Family	Genus	Species	Common name	Number of specimens collected					Observed on modular plots		
				CHIR	FOBO	MOCA	TONT	TUZI	MOCA	TONT	TUZI
Brassicaceae	<i>Plagiobothrys</i>	sp.	popcornflower						X		
	<i>Tiquilia</i>	<i>canescens</i>	woody crinklemat					1	X		X
	<i>Arabis</i>	<i>perennans</i>	perennial rockcress		1		1	1			
	<i>Brassica</i>	<i>tournefortii</i>	Asian mustard				1				
	<i>Capsella</i>	<i>bursa-pastoris</i>	shepherd's purse	1		1	1				
	<i>Chorispora</i>	<i>tenella</i>	crossflower			1		2	X		X
	<i>Descurainia</i>	<i>pinnata</i>	western tansymustard	1	1	3		3	X	X	X
	<i>Descurainia</i>	<i>sophia</i>	herb sophia					2			
	<i>Descurainia</i>	sp.	tansymustard						X		
	<i>Draba</i>	<i>cuneifolia</i>	wedgeleaf draba					2	X		X
	<i>Dryopetalon</i>	<i>runcinatum</i>	rockmustard	1							
	<i>Lepidium</i>	<i>lasiocarpum</i>	shaggyfruit pepperweed			1	1	1	X	X	X
	<i>Lepidium</i>	<i>montanum</i>	mountain pepperweed			2					
	<i>Lepidium</i>	<i>montanum</i>	mountain pepperweed					1			
	<i>Lepidium</i>	sp.	pepperweed						X		
	<i>Lepidium</i>	<i>virginicum</i>	medium pepperweed				1				
	<i>Lesquerella</i>	sp.	bladderpod						X		X
	<i>Lesquerella</i>	<i>tenella</i>	Moapa bladderpod		1			1			
	<i>Matthiola</i>	<i>longipetala</i>	night scented stock			1		1			
	<i>Schoenocrambe</i>	<i>linifolia</i>	flaxleaf plainsmustard		1						
	<i>Sisymbrium</i>	<i>altissimum</i>	tall tumbledustard				1	1			
	<i>Sisymbrium</i>	<i>irio</i>	London rocket		1		1	2	X	X	X
	<i>Streptanthus</i>	<i>carinatus</i>	lyreleaf jewelflower			1					
	<i>Thysanocarpus</i>	<i>curvipes</i>	sand fringeopod				1				
	<i>Thysanocarpus</i>	sp.	fringeopod							X	
Cactaceae	<i>Carnegia</i>	<i>gigantea</i>	saguaro				1				
	<i>Echinocereus</i>	<i>fendleri</i>	Leding's hedgehog cactus	1							
	<i>Echinocereus</i>	<i>fendleri</i>	pinkflower hedgehog cactus		1				X		
	<i>Echinocereus</i>	<i>rigidissimus</i>	rainbow hedgehog cactus								
	<i>Echinocereus</i>	<i>triglochidiatus</i>	kingcup cactus	1							
	<i>Escobaria</i>	<i>vivipara</i>	spinystar		1						
	<i>Ferocactus</i>	<i>wislizeni</i>	candy barrelcactus		1		1				
	<i>Opuntia</i>	<i>acanthocarpa</i>	buckhorn cholla				1			X	
	<i>Opuntia</i>	<i>bigelovii</i>	teddybear cholla				1				
	<i>Opuntia</i>	<i>chlorotica</i>	dollarjoint pricklypear	1							
	<i>Opuntia</i>	<i>engelmannii</i>	cactus apple		1						
	<i>Opuntia</i>	<i>leptocaulis</i>	Christmas cactus				1		X		X
	<i>Opuntia</i>	<i>macrocentra</i>	purple pricklypear		1						
	<i>Opuntia</i>	<i>phaeacantha</i>	tulip pricklypear						X		X
	<i>Opuntia</i>	<i>phaeacantha</i>	Mojave pricklypear		1						
	<i>Opuntia</i>	<i>spinosior</i>	walkingstick cactus	1	1						
	<i>Nemacladus</i>	<i>glanduliferus</i>	glandular threadplant		1						
	<i>Nemacladus</i>	<i>glanduliferus</i>	glandular threadplant				1	1			
	<i>Sambucus</i>	<i>nigra</i>	blue elderberry				2				
	<i>Sambucus</i>	sp.	elderberry							X	
Caryophyllaceae	<i>Herniaria</i>	<i>hirsuta</i>	hairy rupturewort				1				
	<i>Minuartia</i>	<i>douglasii</i>	Douglas' stitchwort				1				
	<i>Silene</i>	<i>antirrhina</i>	sleepy silene		1	1			X	X	
	<i>Stellaria</i>	<i>media</i>	common chickweed				1				

Family	Genus	Species	Common name	Number of specimens collected					Observed on modular plots		
				CHIR	FOBO	MOCA	TONT	TUZI	MOCA	TONT	TUZI
Celastraceae	<i>Canotia</i>	<i>holacantha</i>	crucifixion thorn				1		X		X
Chenopodiaceae	<i>Atriplex</i>	<i>canescens</i>	fourwing saltbush						X		X
	<i>Salsola</i>	<i>kali</i>	Russian thistle		1						
Commelinaceae	<i>Tradescantia</i>	<i>occidentalis</i>	prairie spiderwort				1				
Convolvulaceae	<i>Convolvulus</i>	<i>arvensis</i>	field bindweed		1						
	<i>Convolvulus</i>	<i>equitans</i>	Texas bindweed				1				
	<i>Evolvulus</i>	<i>nuttallianus</i>	shaggy dwarf morning-glory		1						
Crassulaceae	<i>Dudleya</i>	<i>collomiae</i>	Gila County liveforever				1				
Cucurbitaceae	<i>Marah</i>	<i>gilensis</i>	Gila manroot			1	1			X	
Cupressaceae	<i>Cupressus</i>	<i>arizonica</i>	Arizona cypress	1					X		
	<i>Juniperus</i>	<i>depeana</i>	alligator juniper	1							
	<i>Juniperus</i>	<i>monosperma</i>	oneseed juniper		1						
	<i>Juniperus</i>	<i>osteosperma</i>	Utah juniper						X		
	<i>Juniperus</i>	<i>sp.</i>	juniper								X
Cyperaceae	<i>Carex</i>	<i>chihuahuensis</i>	Chihuahuan sedge	1							
	<i>Carex</i>	<i>ultra</i>	Cochise sedge	1							
	<i>Eleocharis</i>	<i>sp.</i>	spikerush					1			
Elaeagnaceae	<i>Elaeagnus</i>	<i>angustifolia</i>	Russian olive					1			
Ephedraceae	<i>Ephedra</i>	<i>aspera</i>	rough jointfir				1				
	<i>Ephedra</i>	<i>viridis</i>	mormon tea					1	X		X
Equisetaceae	<i>Equisetum</i>	<i>laevigatum</i>	smooth horsetail					1			
Ericaceae	<i>Arbutus</i>	<i>arizonica</i>	Arizona madrone	1							
	<i>Arctostaphylos</i>	<i>pungens</i>	pointleaf manzanita	1	1						
Euphorbiaceae	<i>Chamaesyce</i>	<i>albomarginata</i>	whitemargin sandmat		1						
	<i>Chamaesyce</i>	<i>melanadenia</i>	squaw sandmat				1				
	<i>Chamaesyce</i>	<i>polycarpa</i>	smallseed sandmat			1		2			
	<i>Euphorbia</i>	<i>sp.</i>	spurge						X		
	<i>Euphorbia</i>	<i>spathulata</i>	warty spurge			1					
	<i>Tragia</i>	<i>ramosa</i>	branched noseburn		1						
Fabaceae	<i>Acacia</i>	<i>greggii</i>	catclaw acacia				1		X	X	X
	<i>Astragalus</i>	<i>allochrous</i>	halfmoon milkvetch					1			
	<i>Astragalus</i>	<i>calycosus</i>	Torrey's milkvetch			1		3			
	<i>Astragalus</i>	<i>lentiginosus</i>	freckled milkvetch			1		1			
	<i>Astragalus</i>	<i>newberryi</i>	Newberry's milkvetch					1			
	<i>Astragalus</i>	<i>nothoxys</i>	sheep milkvetch	2							
	<i>Astragalus</i>	<i>nuttallianus</i>	smallflowered milkvetch				1	2	X		X
	<i>Astragalus</i>	<i>sp.</i>	astragalus spp.						X		
	<i>Astragalus</i>	<i>tephrodes</i>	ashen milkvetch			1		1			
	<i>Caesalpinia</i>	<i>drepanocarpa</i>	sicklepod holdback					2			
	<i>Calliandra</i>	<i>eriophylla</i>	fairyduster		1						
	<i>Dalea</i>	<i>formosa</i>	featherplume						X		
	<i>Dalea</i>	<i>nana</i>	dwarf prairie clover		1						
	<i>Lathyrus</i>	<i>eucosmus</i>	bush vetchling			1					
	<i>Lathyrus</i>	<i>graminifolius</i>	grassleaf pea	1							
	<i>Lotus</i>	<i>corniculatus</i>	birdfoot deervetch			1					
	<i>Lotus</i>	<i>humistratus</i>	foothill deervetch			2	1				
	<i>Lotus</i>	<i>rigidus</i>	shrubby deervetch							X	
	<i>Lotus</i>	<i>sp.</i>	trefoil							X	
	<i>Lupinus</i>	<i>concinus</i>	scarlet lupine			1	1		X		
	<i>Lupinus</i>	<i>sp.</i>	lupine							X	
	<i>Lupinus</i>	<i>sparsiflorus</i>	Mojave lupine			1				X	

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				CHIR	FOBO	MOCA	TONT	TUZI	MOCA	TONT	TUZI
	<i>Lupinus</i>	<i>succulentus</i>	hollowleaf annual lupine				1			X	
	<i>Medicago</i>	<i>minima</i>	burr medick					1			
	<i>Medicago</i>	sp.	alfalfa						X		
	<i>Mellilotus</i>	<i>indicus</i>	annual yellow sweetclover				1				
	<i>Mimosa</i>	<i>aculeaticarpa</i>	catclaw mimosa		1				X		
	<i>Mimosa</i>	<i>dysocarpa</i>	velvetpod mimosa	1							
	<i>Parkinsonia</i>	<i>microphylla</i>	yellow paloverde				1				
	<i>Prosopis</i>	<i>glandulosa</i>	honey mesquite		1						
	<i>Prosopis</i>	<i>glandulosa</i>	western honey mesquite	1							
	<i>Prosopis</i>	<i>velutina</i>	velvet mesquite				1		X	X	X
	<i>Robinia</i>	<i>neomexicana</i>	New Mexico locust	1							
	<i>Senna</i>	<i>bauhinioides</i>	twinleaf senna						X		
	<i>Senna</i>	<i>covesii</i>	Coves' cassia				1				
	<i>Vicia</i>	<i>ludoviciana</i>	Louisiana vetch			1			X		
	<i>Quercus</i>	<i>arizonica</i>	Arizona white oak	1	1						
	<i>Quercus</i>	<i>dunnii</i>	Palmer oak	1				1			
	<i>Quercus</i>	<i>emoryi</i>	Emory oak	1	1						
	<i>Quercus</i>	<i>grisea</i>	gray oak		1						
	<i>Quercus</i>	<i>hypoleucoides</i>	silverleaf oak	2							
	<i>Quercus</i>	<i>pungens</i>	pungent oak		1						
	<i>Quercus</i>	<i>rugosa</i>	netleaf oak	2							
	<i>Quercus</i>	sp.	oak						X		
	<i>Quercus</i>	<i>toumeyii</i>	Toumey oak	1							
	<i>Quercus</i>	<i>turbinella</i>	Sonoran scrub oak					1			
Fouquieriaceae	<i>Fouquieria</i>	<i>splendens</i>	ocotillo	1	1		1				
Fumariaceae	<i>Corydalis</i>	<i>aurea</i>	scrambled eggs	1	1			1	X	X	
Garryaceae	<i>Garrya</i>	<i>wrightii</i>	Wright's silktassel	1	1						
Geraniaceae	<i>Erodium</i>	<i>cicutarium</i>	redstem stork's bill		1			1	X	X	X
	<i>Erodium</i>	<i>texanum</i>	Texas stork's bill				1	1	X		X
	<i>Geranium</i>	<i>carolinianum</i>	Carolina geranium				1			X	
Grossulariaceae	<i>Ribes</i>	<i>aureum</i>	golden currant					1			
Hydrophyllaceae	<i>Emmenanthe</i>	<i>penduliflora</i>	whisperingbells							X	
	<i>Eucrypta</i>	<i>chrysanthemifolia</i>	spotted hideseed				1				
	<i>Eucrypta</i>	<i>micrantha</i>	dainty desert hideseed					1			X
	<i>Phacelia</i>	<i>crenulata</i>	cleftleaf wildheliotrope		2			1	X	X	X
	<i>Phacelia</i>	<i>distans</i>	distant phacelia					1		X	
	<i>Pholistoma</i>	<i>auritum</i>	blue fiestaflower				1				
Juglandaceae	<i>Juglans</i>	<i>major</i>	Arizona walnut	1	1		1		X	X	
Juncaceae	<i>Juncus</i>	sp.	rush						X		X
Krameriaceae	<i>Krameria</i>	<i>erecta</i>	littleleaf ratany					2	X		X
Lamiaceae	<i>Hedeoma</i>	<i>nanum</i>	(no common name)			1		2			
	<i>Hedeoma</i>	<i>oblongifolia</i>	oblongleaf false pennyroyal		1	1	2		X		
	<i>Lamium</i>	<i>amplexicaule</i>	henbit deadnettle			1		1	X		X
	<i>Marrubium</i>	<i>vulgare</i>	horehound	1	1				X	X	
	<i>Salvia</i>	<i>columbariae</i>	chia		1			1		X	
Liliaceae	<i>Calochortus</i>	<i>flexuosus</i>	winding mariposa lily			1					
	<i>Calochortus</i>	<i>nuttallii</i>	sego lily				1				
	<i>Dasyllirion</i>	<i>wheeleri</i>	common sotol	1	1		1				
	<i>Dichelostemma</i>	<i>capitatum</i>	bluedicks	1					X		X

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				CHIR	FOBO	MOCA	TONT	TUZI	MOCA	TONT	TUZI
	<i>Nolina</i>	<i>microcarpa</i>	sacahuista	1	1		1	1			
	<i>Linum</i>	<i>puberulum</i>	plains flax					1			
Loasaceae	<i>Mentzelia</i>	<i>albicaulis</i>	whitestem blazingstar		1						
	<i>Mentzelia</i>	<i>multiflora</i>	Adonis blazingstar		1						
Malpighiaceae	<i>Janusia</i>	<i>gracilis</i>	slender janusia				1				
Malvaceae	<i>Malva</i>	<i>neglecta</i>	common mallow			1					
	<i>Sphaeralcea</i>	<i>ambigua</i>	desert globemallow				2			X	X
	<i>Sphaeralcea</i>	<i>parvifolia</i>	smallflower globemallow			1		3			
	<i>Sphaeralcea</i>	<i>sp.</i>	globemallow						X		
Moraceae	<i>Morus</i>	<i>microphylla</i>	Texas mulberry		2		1			X	
Nyctaginaceae	<i>Allionia</i>	<i>incarnata</i>	trailing windmills		1		1				
	<i>Anulocalis</i>	<i>leiosolenus</i>	southwestern ringstem					2			
	<i>Boerhavia</i>	<i>sp.</i>	boerhavia								X
	<i>Mirabilis</i>	<i>bigelovii</i>	wishbone-bush				1			X	
	<i>Mirabilis</i>	<i>coccinea</i>	scarlet four o'clock				1	1			
	<i>Mirabilis</i>	<i>multiflora</i>	Colorado four o'clock				1			X	
Oleaceae	<i>Forestiera</i>	<i>pubescens</i>	stretchberry					1	X		
	<i>Fraxinus</i>	<i>velutina</i>	velvet ash	1	1			1	X		
	<i>Menodora</i>	<i>scabra</i>	rough menodora				1				
Onagraceae	<i>Camissonia</i>	<i>californica</i>	California suncup							X	
	<i>Clarkia</i>	<i>epilobioides</i>	canyon clarkia				1				
	<i>Clarkia</i>	<i>purpurea</i>	winecup clarkia				1				
	<i>Gaura</i>	<i>coccinea</i>	scarlet beeblossom			1		1			
	<i>Oenothera</i>	<i>albicaulis</i>	whitest evening-primrose					1	X		X
	<i>Oenothera</i>	<i>brachycarpa</i>	shortfruit evening-primrose		1						
	<i>Oenothera</i>	<i>caespitosa</i>	tufted evening-primrose			1					
	<i>Oenothera</i>	<i>flava</i>	yellow evening-primrose					1			
	<i>Oenothera</i>	<i>primiveris</i>	desert evening-primrose	1			1				
Papaveraceae	<i>Argemone</i>	<i>pleiacantha</i>	southwestern pricklypoppy	1							
	<i>Eschscholzia</i>	<i>californica</i>	California poppy		1		1			X	
	<i>Platystemon</i>	<i>californicus</i>	creamcups				1				
Pinaceae	<i>Pinus</i>	<i>cembroides</i>	Mexican pinyon	1							
	<i>Pinus</i>	<i>edulis</i>	twoneedle pinyon	1	1						
	<i>Pinus</i>	<i>engelmannii</i>	Apache pine	1							
	<i>Pinus</i>	<i>leiophylla</i>	Chihuahuan pine	1							
	<i>Pinus</i>	<i>ponderosa</i>	ponderosa pine	1							
	<i>Pseudotsuga</i>	<i>menziesii</i>	Douglas-fir	1							
Plantaginaceae	<i>Plantago</i>	<i>ovata</i>	desert Indianwheat				1				
	<i>Plantago</i>	<i>patagonica</i>	woolly plantain	1	1	1	1		X		
	<i>Plantago</i>	<i>rhodosperma</i>	redseed plantain			1					
	<i>Plantago</i>	<i>sp.</i>	plantain						X	X	
Platanaceae	<i>Platanus</i>	<i>wrightii</i>	Arizona sycamore	1			1		X	X	
Poaceae	<i>Achnatherum</i>	<i>hymenoides</i>	Indian ricegrass			1					
	<i>Achnatherum</i>	<i>speciosum</i>	desert needlegrass				1				
	<i>Agrostis</i>	<i>scabra</i>	rough bentgrass	2							
	<i>Aristida</i>	<i>adscensionis</i>	sixweeks threeawn					1			

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				CHIR	FOBO	MOCA	TONT	TUZI	MOCA	TONT	TUZI
	<i>Aristida</i>	<i>purpurea</i>	purple threeawn						X	X	X
	<i>Aristida</i>	<i>sp.</i>	threeawn								X
	<i>Aristida</i>	<i>ternipes</i>	spidergrass						X		
	<i>Avena</i>	<i>fatua</i>	wild oat			1	1	1		X	
	<i>Bothriochloa</i>	<i>barbinodis</i>	cane bluestem						X		X
	<i>Bouteloua</i>	<i>curtipendula</i>	sideoats grama						X		
	<i>Bouteloua</i>	<i>eriopoda</i>	black grama						X		X
	<i>Bromus</i>	<i>carinatus</i>	California brome			2		4	X		
	<i>Bromus</i>	<i>catharticus</i>	rescuegrass	1							
	<i>Bromus</i>	<i>diandrus</i>	ripgut brome			1		1	X	X	X
	<i>Bromus</i>	<i>rubens</i>	red brome		1			1	X	X	X
	<i>Bromus</i>	<i>sp.</i>	brome						X		
	<i>Bromus</i>	<i>tectorum</i>	cheatgrass			3			X	X	
	<i>Cynodon</i>	<i>dactylon</i>	Bermudagrass								X
	<i>Dasyochloa</i>	<i>pulchella</i>	low woollygrass		1		1				
	<i>Elymus</i>	<i>elymoides</i>	squirreltail	1	1			1			
	<i>Elymus</i>	<i>glaucus</i>	blue wildrye				1			X	
	<i>Eragrostis</i>	<i>lehmanniana</i>	Lehmann lovegrass	1					X		
	<i>Erioneuron</i>	<i>pilosum</i>	hairy woollygrass			1					
	<i>Hesperostipa</i>	<i>neomexicana</i>	New Mexico feathergrass			1		1			
	<i>Hordeum</i>	<i>murinum</i>	smooth barley	1		1	1				
	<i>Hordeum</i>	<i>pusillum</i>	little barley				1				
	<i>Hordeum</i>	<i>sp.</i>	barley						X	X	X
	<i>Lamarckia</i>	<i>aurea</i>	goldentop grass				1				
	<i>Muhlenbergia</i>	<i>porteri</i>	bush muhly						X		X
	<i>Muhlenbergia</i>	<i>repens</i>	creeping muhly	1							
	<i>Muhlenbergia</i>	<i>virescens</i>	screwleaf muhly	1							
	<i>Pleuraphis</i>	<i>mutica</i>	tobosagrass			1		1	X		
	<i>Poa</i>	<i>bigelovii</i>	Bigelow's bluegrass				2				
	<i>Poa</i>	<i>fendleriana</i>	muttongrass	1		2		1	X		
	<i>Polypogon</i>	<i>monspeliensis</i>	annual rabbitsfoot grass				1	1			
	<i>Schismus</i>	<i>arabicus</i>	Arabian schismus					1			
	<i>Schismus</i>	<i>barbatus</i>	common Mediterranean grass			1					
	<i>Schizachyrium</i>	<i>sp.</i>	little bluestem						X	X	X
	<i>Sorghum</i>	<i>halepense</i>	Johnsongrass						X		
	<i>Sporobolus</i>	<i>contractus</i>	spike dropseed						X		
	<i>Sporobolus</i>	<i>cryptandrus</i>	sand dropseed				1				
	<i>Sporobolus</i>	<i>sp.</i>	dropseed						X		
	<i>Vulpia</i>	<i>microstachys</i>	Pacific fescue				1				
	<i>Vulpia</i>	<i>octoflora</i>	sixweeks fescue	1	1			1			
Polemoniaceae	<i>Eriastrum</i>	<i>diffusum</i>	miniature woollystar		1		1		X		
	<i>Eucrypta</i>	<i>sp.</i>	hideseed						X		
	<i>Gilia</i>	<i>flavocincta</i>	lesser yellowthroat gilia			1	2				
	<i>Gilia</i>	<i>flavocincta</i>	lesser yellowthroat gilia					1			
	<i>Gilia</i>	<i>mexicana</i>	El Paso gilia	1	1						
	<i>Gilia</i>	<i>ophthalmoides</i>	eyed gilia					1			
	<i>Gilia</i>	<i>sinuata</i>	rosy gilia				1				
	<i>Gilia</i>	<i>sp.</i>	gilia						X	X	

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				CHIR	FOBO	MOCA	TONT	TUZI	MOCA	TONT	TUZI
	<i>Ipomopsis</i>	<i>longiflora</i>	flaxflowered ipomopsis					1			
	<i>Ipomopsis</i>	<i>polycladon</i>	manybranched ipomopsis					2			
	<i>Linanthus</i>	<i>aureus</i>	golden linanthus		1						
	<i>Phlox</i>	<i>gracilis</i>	slender phlox				1				
	<i>Phlox</i>	<i>tenuifolia</i>	Santa Catalina Mountain phlox				1			X	
Polygalaceae	<i>Polygala</i>	<i>barbeyana</i>	blue milkwort					1			
	<i>Polygala</i>	<i>rusbyi</i>	Rusby's milkwort			2		1			
	<i>Polygala</i>	<i>scoparioides</i>	broom milkwort					1			
	<i>Chorizanthe</i>	<i>brevicornu</i>	brittle spineflower				1				
	<i>Eriogonum</i>	<i>deflexum</i>	flatcrown buckwheat					1			
	<i>Eriogonum</i>	<i>fasciculatum</i>	Eastern Mojave buckwheat				1	2		X	
	<i>Eriogonum</i>	<i>inflatum</i>	desert trumpet					1	X		
	<i>Eriogonum</i>	<i>trichopes</i>	little deserttrumpet			1					
	<i>Eriogonum</i>	<i>wrightii</i>	bastardsage		1						
	<i>Pterostegia</i>	<i>drymarioides</i>	woodland pterostegia				1				
	<i>Rumex</i>	<i>crispus</i>	curly dock					1			
	<i>Rumex</i>	sp.	dock						X		
Portulacaceae	<i>Calandrinia</i>	<i>ciliata</i>	fringed redmaids				2				
	<i>Claytonia</i>	<i>parviflora</i>	streambank springbeauty								X
	<i>Claytonia</i>	<i>perfoliata</i>	miner's lettuce				1			X	
Pteridaceae	<i>Cheilanthes</i>	sp.	lipfern								X
Ranunculaceae	<i>Anemone</i>	<i>tuberosa</i>	tuber anemone				1		X		
	<i>Clematis</i>	<i>ligusticifolia</i>	western white clematis				1				
	<i>Delphinium</i>	<i>parishii</i>	desert larkspur				1				
	<i>Ranunculus</i>	<i>aquatilis</i>	whitewater crowfoot					1			
	<i>Thalictrum</i>	<i>fendleri</i>	Fendler's meadow-rue	1							
Rhamnaceae	<i>Ceanothus</i>	<i>fendleri</i>	Fendler's ceanothus	1							
	<i>Ceanothus</i>	<i>greggii</i>	desert ceanothus					1			
	<i>Condalia</i>	<i>warnockii</i>	Warnock's snakewood		1						
	<i>Frangula</i>	<i>betulifolia</i>	beechleaf frangula	1							
	<i>Frangula</i>	<i>californica</i>	California buckthorn	1							
	<i>Ziziphus</i>	<i>obtusifolia</i>	lotebush		1		1		X	X	X
Rosaceae	<i>Cercocarpus</i>	<i>montanus</i>	alderleaf mountain mahogany	1	1						
	<i>Fallugia</i>	<i>paradoxa</i>	Apache plume	1							
	<i>Holodiscus</i>	<i>dumosus</i>	rockspirea	1							
	<i>Malus</i>	<i>pumila</i>	paradise apple					1			
	<i>Prunus</i>	<i>serotina</i>	black cherry	2							
	<i>Purshia</i>	<i>stansburiana</i>	Stansbury cliffrose			1					
	<i>Rubus</i>	<i>arizonensis</i>	Arizona dewberry				1				
	<i>Rubus</i>	<i>neomexicanus</i>	New Mexico raspberry	1							
	<i>Rubus</i>	sp.	blackberry							X	
Rubiaceae	<i>Galium</i>	<i>aparine</i>	stickywilly				2				
	<i>Galium</i>	<i>proliferum</i>	limestone bedstraw		1	1		1			
	<i>Galium</i>	sp.	bedstraw						X	X	
	<i>Galium</i>	<i>stellatum</i>	starry bedstraw				1				
Rutaceae	<i>Ptelea</i>	<i>trifoliata</i>	common hoptree		1	1					
	<i>Thamnosma</i>	<i>montana</i>	turpentinebroom					1			X
Salicaceae	<i>Populus</i>	<i>fremontii</i>	Fremont cottonwood	1				1			

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				CHIR	FOBO	MOCA	TONT	TUZI	MOCA	TONT	TUZI
	<i>Salix</i>	<i>gooddingii</i>	Goodding's willow					1			
Sapindaceae	<i>Dodonaea</i>	<i>viscosa</i>	Florida hopbush				1			X	
	<i>Sapindus</i>	<i>saponaria</i>	wingleaf soapberry		1						
Sapotaceae	<i>Sideroxylon</i>	<i>lanuginosum</i>	gum bully		1						
Scrophulariaceae	<i>Castilleja</i>	<i>aplegatei</i>	wavyleaf Indian paintbrush			2	1				
	<i>Castilleja</i>	<i>exserta</i>	exserted Indian paintbrush							X	
	<i>Keckiella</i>	<i>antirrhinoides</i>	snapdragon penstemon					1			X
	<i>Keckiella</i>	<i>antirrhinoides</i>	snapdragon penstemon				1				X
	<i>Linaria</i>	<i>dalmatica</i>	Dalmatian toadflax						X		
	<i>Maurandella</i>	<i>antirrhiniflora</i>	roving sailor		1		1	1			
	<i>Penstemon</i>	<i>eatonii</i>	Eaton's penstemon				1	1			
	<i>Penstemon</i>	<i>pseudospectabilis</i>	desert beardtongue	1		1					
	<i>Verbascum</i>	<i>thapsus</i>	common mullein	1					X		
	<i>Verbascum</i>	<i>virgatum</i>	wand mullein		1						
	<i>Veronica</i>	<i>anagallis-aquatica</i>	water speedwell			1					
Simaroubaceae	<i>Ailanthus</i>	<i>altissima</i>	tree of heaven					1			
Simmondsiaceae	<i>Simmondsia</i>	<i>chinensis</i>	jojoba				1			X	
Solanaceae	<i>Chamaesaracha</i>	<i>coronopus</i>	greenleaf five eyes			1		1			
	<i>Datura</i>	<i>wrightii</i>	sacred thorn-apple		1		1				
	<i>Lycium</i>	<i>pallidum</i>	pale desert-thorn					1	X		X
	<i>Lycium</i>	<i>sp.</i>	desert-thorn						X	X	
	<i>Nicotiana</i>	<i>obtusifolia</i>	desert tobacco		1		1	1		X	
Tamaricaceae	<i>Tamarix</i>	<i>chinensis</i>	five-stamen tamarisk								X
	<i>Tamarix</i>	<i>ramosissima</i>	saltcedar					1			
Ulmaceae	<i>Celtis</i>	<i>laevigata</i>	netleaf hackberry		1		1		X	X	
Urticaceae	<i>Parietaria</i>	<i>pennsylvanica</i>	Pennsylvania pellitory							X	
Urticaceae	<i>Parietaria</i>	<i>hespera</i>	rillita pellitory			2					
Verbenaceae	<i>Aloysia</i>	<i>wrightii</i>	Wright's beebush		1						
	<i>Glandularia</i>	<i>gooddingii</i>	southwestern mock vervain				1			X	
	<i>Glandularia</i>	<i>wrightii</i>	Davis Mountain mock vervain	1	1						
Vitaceae	<i>Vitis</i>	<i>arizonica</i>	canyon grape	1	1						
Zygophyllaceae	<i>Larrea</i>	<i>tridentata</i>	creosote bush		1		1		X		X
Number of species				90	93	67	134	112	94	66	47

FISH

We surveyed for fish during a two-day visit to Tuzigoot NM in May, 2003. No other parks in which we completed surveys this year (see Table 1) have fish.

Methods

We used electro-shocking techniques and seine nets (Dauble and Gray 1980) at a total of 8 sites in Tavasci Marsh and the Verde River. For details, see Powell et al. (2003).

Results

We recorded nine species of fish at eight sites (Table 4), all of which were non-native. The most widespread and frequently caught species was green sunfish.

Table 4. Number of sites at which each species was recorded, and number of individuals captured during fish sampling at eight sites in Tuzigoot National Monument, Arizona, May 2003.

Order	Family	Scientific name	Common name	Number of sites	Number of individuals captured
Siluriformes	Ictaluridae	<i>Ameiurus natalis</i>	yellow bullhead	1	1
Cypriniformes	Cyprinidae	<i>Cyprinella lutrensis</i>	red shiner	5	33
		<i>Cyprinus carpio</i>	common carp	2	2
Cyprinodontiformes	Poeciliidae	<i>Gambusia affinis</i>	western mosquitofish	2	15
	Ictaluridae	<i>Ictalurus punctatus</i>	channel catfish	1	1
Perciformes	Centrarchidae	<i>Lepomis cyanellus</i>	green sunfish	7	120
		<i>Lepomis macrochirus</i>	bluegill	4	4
		<i>Micropterus dolomieu</i>	smallmouth bass	5	20
		<i>Micropterus salmoides</i>	largemouth bass	2	4

AMPHIBIANS AND REPTILES

We surveyed for amphibians and reptiles at Chiricahua NM and Tuzigoot NM in 2003 using plot-based and non-plot-based visual-encounter walking surveys (Crump and Scott 1994), pitfall traps (Gibbons and Semlitsch 1981) and road cruising (Shaffer and Juterbock 1994) (Table 5). We focused surveys during the cooler morning, evening, and nighttime periods to maximize our chances of encountering snakes and amphibians which would be active during these times (Ivanyi et al. 2000). We opened pitfall traps primarily overnight and cruised roads in the evening and early nighttime hours. Field crews surveying for all taxon groups recorded incidental observations of amphibians and reptiles at all five parks.

Methods

We used road cruising and pitfall trap arrays (see Powell et al. 2003 for details), two types of plot-based surveys (time-area-constrained searches and transects), and one type of non-plot-based visual encounter survey (general surveys) to survey for amphibians and reptiles. Time-area-constrained searches (TACS) are similar to visual encounter surveys (Crump and Scott 1994), but were confined to 100 x 100 meter (1 ha) plots. These plots were placed non-randomly in areas of suspected high species richness, where uncommon species were suspected to occur, or in areas that appeared to be representative of the primary vegetation types in the park. These plots were surveyed in the morning or evening hours by a single observer for one hour, and all animals were recorded. The uniformity of these surveys allows comparison of parameter estimates (e.g., relative abundance, species richness) among plots or at the same plot through time.

Transects are 400 x 25 meter plots placed non-randomly, using the criteria described (above) for TACS. Transects were not time-constrained, and an observer could spend as much or as little time as necessary to document animals present. Transects were divided into four sections of 100 m each; search time and detections were recorded per section. Direction of travel was alternated between visits, and transects were surveyed in the morning or evening hours by a single observer. Transects were more flexible than TACS because although methods were otherwise similar, they were constrained in area but not in time. This additional flexibility allowed observers to adjust the amount of time spent in a given area based on conditions and the survey results. Search effort can be scaled in future analysis to adjust for variable search time, and results from transects can be compared with one another or with TACS (search area is equal), or tracked on any plots through time.

General surveys are also a type of visual-encounter survey but differ from plot-based surveys in that they are not constrained in area or time, thus they are one step more removed from the TACS method than are transects. Although the flexibility (lack of constraints) weakens the validity of comparing relative abundance and species richness values estimated with this method, the chances of locating uncommon species are higher, and the method indicates the general abundance of common species in areas that were not sampled with plot-based surveys. General surveys enabled us to search areas that, based on our field experience, were likely to have high species richness or species not

previously recorded. We used this method both as a low-intensity survey of large areas and as a high-intensity survey of small areas. General surveys provided more species distribution information than any other method. The observer defined the length and route of the survey, and more than one observer occasionally participated, though we were careful to record each animal only once.

Table 5. Survey effort for amphibians and reptiles at Sonoran Desert Network national park units, Arizona, 2003.

Park	Plot type	Plot name	Number of surveys or visits
Chiricahua NM	General surveys	--	31
	Road cruising	--	21
	Time and area constrained searches	ENT	5
	Time and area constrained searches	SSS	5
	Transect	EBO	5
	Transect	ENT	5
	Transect	SC	5
	Transect	SSS	5
	Pitfall array	--	97 ^a
Tuzigoot NM	General surveys	--	12
	Road cruising	--	16
	Time and area constrained searches	Cottonwood/mesquite	6
	Time and area constrained searches	Grass-shrub	4
	Time and area constrained searches	Open mesquite	4
	Transect	Monument grass-shrub	2
	Transect	Middle marsh	6
	Transect	North marsh	3
	Transect	South marsh	5
	Pitfall array	--	30 ^a

^a Number of nights that pitfall array was open; the array at Chiricahua NM was active from May to October, 2003.

Results

We recorded 23 species at both Chiricahua NM and Tuzigoot NM (Tables 6, 7). Field crews for other taxa made observations at Fort Bowie NHS, Montezuma Castle NM, and Tonto NM (Table 6). For Chiricahua and Tuzigoot National Monuments, each field method added at least one new species to the park list, though walking surveys consistently added the most species (Tables 6, 7).

Class Order Family	Scientific name	Common name	Survey Type								
			Walking surveys ^a		Road cruising		Incidental observations				
			CHIR	TUZI	CHIR	TUZI	CHIR	FOBO	MOCA	TONT	TUZI
Viperidae	<i>Trimorphodon biscutatus</i>	western lyre snake			6		1				1
	<i>Hypsiglena torquata</i>	night snake			5						
	<i>Crotalus atrox</i>	western diamond-backed rattlesnake		3		2			1		17
	<i>Crotalus lepidus</i>	rock rattlesnake	2		5		2				
	<i>Crotalus molossus</i>	black-tailed rattlesnake	2		11		1				1
Number of species			17	14	11	2	14	1	1	3	15

^a Data from general surveys, time-area-constrained searches, and transects.

^b Reported by Ruth Olsen, biological technician at Chiricahua NM

Table 7. Total number of animals caught in pitfall traps, Sonoran Desert Network national park units, 2003. Species in bold were recorded only in pitfall traps.

Taxon group	Scientific name	Common name	CHIR	TUZI
Amphibian	<i>Bufo cognatus</i>	Great Plains toad	7	
Reptile	<i>Phrynosoma hernandesi</i>	greater short-horned lizard	2	
	<i>Sceloporus magister</i>	desert spiny lizard		44
	<i>Sceloporus clarkii</i>	Clark's spiny lizard		9
	<i>Sceloporus undulatus</i>	eastern fence lizard		7
	<i>Uta stansburiana</i>	common side-blotched lizard		1
	<i>Urosaurus ornatus</i>	ornate tree lizard		4
	<i>Eumeces obsoletus</i>	Great Plains skink	11	
	<i>Cnemidophorus uniparens</i>	desert grassland whiptail		15
	<i>Cnemidophorus flagellicaudus</i>	Gila spotted whiptail		2
	<i>Cnemidophorus tigris</i>	western whiptail		6
	<i>Salvadora grahamiae</i>	mountain patch-nosed snake	1	
	<i>Thamnophis cyrtopsis</i>	black-necked garter snake	1	
	<i>Sonora semiannulata</i>	western ground snake		1
Mammal	<i>Chaetodipus hispidus</i>	hispid pocket mouse	1	
	<i>Notiosorex spp.</i>	unknown desert shrew ^a	2	1
	<i>Peromyscus maniculatus</i>	deer mouse		6
	<i>Reithrodontomys megalotis</i>	western harvest mouse		6
	<i>Thomomys bottae</i>	Botta's pocket gopher		5
Number of species			7	13

^a Genetic testing (which we did not do) is required to differentiate the Crawford's and Cockrum's desert shrews (Baker et al. 2003).

BIRDS

We surveyed for birds at five parks during the breeding season (April–July) in 2003.

Methods

We used two primary methods: variable circular plots for diurnal birds (Reynolds et al. 1980, Buckland et al. 1993) and taped-playback broadcasting for owls and other nocturnal birds (Bibby et al. 2002) (Table 8). We also recorded incidental observations, see Powell et al. (2003) for details related to each method.

Table 8. Survey effort by park and survey type, Sonoran Desert Network national park units, 2003.

Park	Survey type	Transect name	Number of visits in 2003
Chiricahua NM	Nocturnal	Owl	8
	Nocturnal	Rhyolite	1
	Nocturnal	Upper Road	2
	VCP	Bonita	5
	VCP	Rhyolite	5
	Reconnaissance VCP	Hunt	1
	Reconnaissance VCP	Jessie James Canyon	1
	Reconnaissance VCP	Natural Bridge Trail	1
	Reconnaissance VCP	Picket	1
	Reconnaissance VCP	Upper Rhyolite	1
	Reconnaissance VCP	Whitetail Pass	1
Coronado NMem	Nocturnal	Owl	6
	VCP	Riparian	5
	VCP	Wash	4
	Reconnaissance VCP	Crest Trail	1
Fort Bowie NHS	Nocturnal	Owl	2
	VCP	Siphon Canyon	5
Tonto NM	Nocturnal	Owl	4
	VCP	Riparian	5
Tuzigoot NM	Nocturnal	Owl Recon	1
	VCP	East	6
	VCP	West	6

Results

We recorded a total of 179 species at five parks in 2003, ranging from 37 species at Tonto NM to 112 at Coronado NMem and 113 at Chiricahua NM (Table 9). The number of species recorded at Fort Bowie NHS and Tuzigoot NM was intermediate (73 and 90 species, respectively; Table 9).

Table 9. Total number of bird detections by species across all survey types, Sonoran Desert Network national park units, Arizona, 2003.

Order	Family	Scientific name	Common name	Park				
				CHIR	CORO	FOBO	TONT	TUZI
Anseriformes	Anatidae	Anas platyrhynchos	mallard					5
		Anas cyanoptera	cinnamon teal					1
Galliformes	Odontophoridae	Callipepla gambelii	Gambel's quail	13	1	49		279
		Cyrtonyx montezumae	Montezuma quail	17	9			
Podicipediformes	Podicipedidae	Podilymbus podiceps podiceps	pied-billed grebe					4
Ciconiiformes	Ardeidae	Ardea herodias	great blue heron					13
		Butorides virescens	green heron					6
		Nycticorax nycticorax	black-crowned night-heron					4
	Threskiornithidae	Plegadis chihi	white-faced ibis					16
	Cathartidae	Cathartes aura	turkey vulture	10	39	5		5
Falconiformes	Accipitridae	Haliaeetus leucocephalus	bald eagle					2
		Circus cyaneus	northern harrier		4	2		3
		Accipiter striatus	sharp-shinned hawk		2		2	1
	Falconidae	Accipiter cooperii	Cooper's hawk	9	10	6		10
		Buteo swainsoni	Swainson's hawk		1			
		Buteo albonotatus	zone-tailed hawk	2	1			1
		Buteo jamaicensis	red-tailed hawk	1	9	5		9
		Aquila chrysaetos	golden eagle	1	1	1		
		Falco sparverius	American kestrel	1	7			4
		Falco peregrinus	peregrine falcon	1	1			1
		Falco mexicanus	prairie falcon	1	1			
Gruiformes	Rallidae	Rallus limicola limicola	Virginia rail					23
		Porzana carolina	sora					19
		Gallinula chloropus	common moorhen					15
Charadriiformes	Charadriidae	Charadrius vociferus	killdeer					3
Columbiformes	Columbidae	Patagioenas fasciata	band-tailed pigeon	1				
		Zenaida asiatica	white-winged dove	17	30	50		
		Zenaida macroura	mourning dove	14	24	17	2	162
		Columbina passerina	common ground-dove	2				
Cuculiformes	Cuculidae	Geococcyx californianus	greater roadrunner	2	15	1	1	1
Strigiformes	Tytonidae	Tyto alba	barn owl	1				
		Megascops kennicottii	western screech-owl	6	7			5
	Strigidae	Megascops trichopsis	whiskered screech-owl	10	10			
		Bubo virginianus	great horned owl		2		1	3
		Glaucidium gnoma	northern pygmy-owl	6	2			
		Micrathene whitneyi	elf owl	12	13	1	16	
		Strix occidentalis lucida	Mexican spotted owl	1				
Caprimulgiformes	Caprimulgidae	Chordeiles minor	common nighthawk					1
		Phalaenoptilus nuttallii	common poorwill	7	6	4	1	
		Caprimulgus vociferus	whip-poor-will	9	3			
Apodiformes	Apodidae	Aeronautes saxatalis	white-throated swift	33	34	1		
		Cynanthus latirostris	broad-billed hummingbird		1			
	Trochilidae	Eugenes fulgens	magnificent hummingbird	4	1			
		Calothorax lucifer	Lucifer's hummingbird		2			
		Archilochus alexandri	black-chinned hummingbird	6	6	5		18
		Calypte anna	Anna's hummingbird		3			
		Calypte costae	Costa's hummingbird				1	1
		Stellula calliope	calliope hummingbird		1			
		Selasphorus platycercus	broad-tailed hummingbird	3	3	2		
		Selasphorus rufus	rufous hummingbird	2	3			
Coraciiformes	Alcedinidae	Ceryle alcyon	belted kingfisher					7
Piciformes	Picidae	Melanerpes formicivorus	acorn woodpecker	22	6			

Order	Family	Scientific name	Common name	Park				
				CHIR	CORO	FOBO	TONT	TUZI
		Melanerpes uropygialis	Gila woodpecker		1			63
		Picoides scalaris	ladder-backed woodpecker	3	9	11		11
		Picoides villosus	hairy woodpecker	1				
		Picoides arizonae	Arizona woodpecker	13	12			
		Colaptes auratus	northern flicker	28	13			8
		Colaptes auratus red-shafted	red-shafted flicker	2				
Passeriformes	Tyrannidae	Camptostoma imberbe	northern beardless-tyrannulet	8				
		Contopus pertinax	greater pewee	4	1	1		
		Contopus sordidulus	western wood-pewee	26	3	3		
		Empidonax hammondi	Hammond's flycatcher		7			
		Empidonax wrightii	gray flycatcher	3	3	2	1	1
		Empidonax oberholseri	dusky flycatcher		1		1	
		Empidonax occidentalis or difficilis	western flycatcher		4			1
		Empidonax fulvifrons pygmaeus	buff-breasted flycatcher	1				
		Sayornis nigricans	black phoebe					7
		Sayornis saya	Say's phoebe	2			4	11
		Myiarchus tuberculifer	dusky-capped flycatcher	58	22			1
		Myiarchus cinerascens	ash-throated flycatcher	52	38	38		22
		Myiarchus tyrannulus	brown-crested flycatcher			3		28
		Myiodynastes luteiventris	sulphur-bellied flycatcher	3	10			
		Tyrannus vociferans	Cassin's kingbird	51	17	30		41
		Tyrannus verticalis	western kingbird		1	9	1	54
	Laniidae	Lanius ludovicianus	loggerhead shrike		7		1	
	Vireonidae	Vireo bellii	Bell's vireo		2	8	11	10
		Vireo vicinior	gray vireo				6	
		Vireo plumbeus	plumbeous vireo	25	5			
		Vireo cassinii	Cassin's vireo		1			
		Vireo plumbeus or V. cassinii	solitary vireo type		2			
		Vireo huttoni	Hutton's vireo	26	10			
		Vireo gilvus	warbling vireo	3	4	1		
	Corvidae	Cyanocitta stelleri	Steller's jay	3	2			
	Emberizidae	Melospiza lincolni	Lincoln's sparrow	1		1		1
	Corvidae	Aphelocoma californica	western scrub-jay	1	5	11		3
		Aphelocoma ultramarina	Mexican jay	149	88			
		Corvus corax	common raven	7	10	8		19
	Hirundinidae	Tachycineta bicolor	tree swallow					1
		Tachycineta thalassina	violet-green swallow	36	5			23
		Stelgidopteryx serripennis	northern rough-winged swallow					147
		Petrochelidon pyrrhonota	cliff swallow					22
		Hirundo rustica	barn swallow		1	1		2
	Paridae	Poecile sclateri	Mexican chickadee	2				
		Baeolophus wollweberi	bridled titmouse	53	25			
		Baeolophus ridgwayi	juniper titmouse	8				
	Remizidae	Auriparus flaviceps	verdin	5	11	22	3	15
	Aegithalidae	Psaltiriparus minimus	bushtit	36	40	2		3
	Sittidae	Sitta carolinensis	white-breasted nuthatch	17	1			
	Certhiidae	Certhia americana	brown creeper	13				
	Troglodytidae	Campylorhynchus brunneicapillus	cactus wren	14	10	30		
		Salpinctes obsoletus	rock wren	1	1			5
		Catherpes mexicanus	canyon wren	33	7	2		4
		Thryomanes bewickii	Bewick's wren	84	85	19		42
		Troglodytes aedon	house wren	2	2	1		
		Cistothorus palustris	marsh wren					1
	Regulidae	Regulus calendula	ruby-crowned kinglet	19	20	7		

Order	Family	Scientific name	Common name	Park				
				CHIR	CORO	FOBO	TONT	TUZI
	Sylviidae	<i>Poliophtila caerulea</i>	blue-gray gnatcatcher	1	2	1	3	
		<i>Poliophtila melanura</i>	black-tailed gnatcatcher				5	1
	Turdidae	<i>Sialia mexicana</i>	western bluebird	4	1			
		<i>Sialia currucoides</i>	mountain bluebird	5	2			
		<i>Myadestes townsendi</i>	Townsend's solitaire	13	2	1	1	
		<i>Catharus guttatus</i>	hermit thrush	5	5	1	1	
		<i>Turdus migratorius</i>	American robin	25		1		
	Mimidae	<i>Mimus polyglottos</i>	northern mockingbird	4	2	20		9
		<i>Toxostoma bendirei</i>	Bendire's thrasher	1		1		
		<i>Toxostoma curvirostre</i>	curve-billed thrasher		7	2		
		<i>Toxostoma crissale</i>	Crissal thrasher	2	7	4	2	9
	Sturnidae	<i>Sturnus vulgaris</i>	European starling					1
	Ptilonotidae	<i>Phainopepla nitens</i>	phainopepla		2	4	1	169
	Peucedramidae	<i>Peucedramus taeniatus</i>	olive warbler	1				
	Parulidae	<i>Vermivora celata</i>	orange-crowned warbler	1	2	2		1
		<i>Vermivora virginiae</i>	Virginia's warbler	3	3		1	
		<i>Vermivora luciae</i>	Lucy's warbler	1	5	1	3	18
		<i>Dendroica petechia</i>	yellow warbler	1			1	1
		<i>Dendroica coronata</i>	yellow-rumped warbler	3		1		
		<i>Dendroica coronata auduboni</i>	Audubon's warbler	13	2			
		<i>Dendroica nigrescens</i>	black-throated gray warbler	57	22			
		<i>Dendroica townsendi</i>	Townsend's warbler	4	4			
		<i>Dendroica occidentalis</i>	hermit warbler	1				
		<i>Dendroica graciae</i>	Grace's warbler	10				
		<i>Geothlypis trichas</i>	common yellowthroat					86
		<i>Wilsonia pusilla</i>	Wilson's warbler	3	5	5		3
		<i>Cardellina rubrifrons</i>	red-faced warbler	3				
		<i>Myioborus pictus</i>	painted redstart	16				
		<i>Icteria virens</i>	yellow-breasted chat				1	37
	Thraupidae	<i>Piranga flava</i>	hepatic tanager	28	4			
		<i>Piranga rubra</i>	summer tanager	2		10		21
		<i>Piranga ludoviciana</i>	western tanager	6	3	8		1
	Emberizidae	<i>Pipilo chlorurus</i>	green-tailed towhee	1	4	7		
		<i>Pipilo maculatus</i>	spotted towhee	56	25	4	1	1
		<i>Pipilo fuscus</i>	canyon towhee	16	12	26	2	1
		<i>Pipilo aberti</i>	Abert's towhee				3	56
		<i>Aimophila cassinii</i>	Cassin's sparrow		1			
		<i>Aimophila texana</i> or <i>botterri</i>	Botteri's sparrow		8	1		
		<i>Aimophila ruficeps</i>	rufous-crowned sparrow	15	34	5	1	
		<i>Spizella passerina</i>	chipping sparrow	39	107	2	1	
		<i>Spizella breweri</i>	Brewer's sparrow			5	2	1
		<i>Spizella atrogularis</i>	black-chinned sparrow	6				
		<i>Pooecetes gramineus</i>	vesper sparrow		21	28		
		<i>Chondestes grammacus</i>	lark sparrow		3			1
		<i>Amphispiza bilineata</i>	black-throated sparrow	2	2	12	4	2
		<i>Ammondramus savannarum</i>	grasshopper sparrow			2		
		<i>Ammondramus bairdii</i>	Baird's sparrow			1		
		<i>Melospiza melodia</i>	song sparrow		1			64
		<i>Zonotrichia leucophrys</i>	white-crowned sparrow	1		2	1	1
		<i>Junco hyemalis</i>	dark-eyed junco		2			
		<i>Junco hyemalis mearnsi</i>	pink-sided junco	4		1		
		<i>Junco hyemalis dorsalis</i>	gray-headed junco	9	3			
		<i>Junco hyemalis oregonus</i>	Oregon junco	2	1			
		<i>Junco phaeonotus</i>	yellow-eyed junco	6				

Order	Family	Scientific name	Common name	Park					
				CHIR	CORO	FOBO	TONT	TUZI	
	Cardinalidae	Cardinalis cardinalis	northern cardinal	1		52	2	41	
		Cardinalis sinuatus	pyrrhuloxia			1			
		Pheucticus melanocephalus	black-headed grosbeak	48	12	2		2	
		Passerina caerulea	blue grosbeak		4	2		29	
		Passerina amoena	lazuli bunting		2			6	
	Icteridae	Agelaius phoeniceus	red-winged blackbird					313	
		Sturnella magna lilianae	eastern meadowlark		12				
		Sturnella neglecta	western meadowlark		1				
		Euphagus cyanocephalus	Brewer's blackbird					1	
		Quiscalus mexicanus	great-tailed grackle					56	
		Molothrus aeneus	bronzed cowbird			2			
		Molothrus ater	brown-headed cowbird	6	9	11		73	
		Icterus cucullatus	hooded oriole			23	2	12	
		Icterus bullockii	Bullock's oriole	2		10	1	52	
		Icterus parisorum	Scott's oriole	58	34	2	2	1	
		Fringillidae	Carpodacus cassinii	Cassin's finch	1				
			Carpodacus mexicanus	house finch	11	14	15		83
			Carduelis pinus	pine siskin	1				
			Carduelis psaltria	lesser goldfinch	8	3			28
		Number of species				113	112	73	37

MAMMALS

We used folding Sherman traps in grids to trap small mammals (White et al. 1983), at Tuzigoot NM in January 2003 and made incidental observations of mammals at other parks. For details of these methods, see Powell et al. (2003). We also captured some small mammals incidentally in pitfall trap arrays (which were established for capture of amphibians and reptiles; see Powell et al. 2003 for methods) at Chiricahua NM and Tuzigoot NM.

Results

We trapped seven species in trapping grids (Table 10) and five species in the pitfall array (Table 8) at Tuzigoot NM, and recorded incidental observations for 17 species at all five parks (Table 10). Number of incidental observations ranged from one species at Fort Bowie NHS to ten species at Chiricahua NM (Table 10).

Table 10. Number of small mammals captured, by species, in Sherman traps at Tuzigoot National Monument, and number of incidental observations at other Sonoran Desert Network national park units, Arizona, 2003.

Order	Family	Scientific name	Common name	Trapping	Survey type				
					Incidental observations				
				TUZI	CHIR	CORO	FOBO	TONT	TUZI
Didelphimorphia									
	Felidae	<i>Didelphis virginiana</i>	Virginia opossum			1			
Carnivora									
	Ursidae	<i>Ursus americanus</i>	American black bear		1				
	Procyonidae	<i>Procyon lotor</i>	northern raccoon						1
		<i>Nasua narica</i>	white-nosed coati				1		
		<i>Bassariscus astutus</i>	ringtail		1				
	Mustelidae	<i>Lontra canadensis sonora</i>	southwestern river otter						1
		<i>Mephitis species</i>	unknown skunk		2				
	Canidae	<i>Canis latrans</i>	coyote			2			
		<i>Urocyon cinereoargenteus</i>	common gray fox		1	1			
	Felidae	<i>Puma concolor azteca</i>	mountain lion		1				2
Rodentia									
	Sciuridae	<i>Spermophilus variegatus</i>	rock squirrel		1				
		<i>Ammospermophilus harrisi</i>	Harris' antelope squirrel						1
		<i>Sciurus nayaritensis chiricahuae</i>	Chiricahua fox squirrel		1				
	Geomyidae	<i>Thomomys bottae</i>	Botta's pocket gopher						1
	Heteromyidae	<i>Dipodomys ordii</i>	Ord's kangaroo rat	5					
	Muridae	<i>Reithrodontomys megalotis aztecus</i>	western harvest mouse	3					
		<i>Peromyscus species</i>	unknown white-footed mouse	36					
		<i>Peromyscus eremicus eremicus</i>	cactus mouse	13					
		<i>Peromyscus maniculatus</i>	deer mouse	1					
		<i>Peromyscus boylii</i>	brush mouse	1					
		<i>Neotoma albigula</i>	western white-throated woodrat	1					
Lagomorpha									
	Leporidae	<i>Sylvilagus audubonii</i>	desert cottontail		1				
Artiodactyla									
	Tayassuidae	<i>Pecari tajacu</i>	collared peccary		2			5	
	Cervidae	<i>Odocoileus virginianus</i>	white-tailed deer		10	1			2
Number of species				7	10	4	1	1	6

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