

Assessment of the Bird Community along the Middle Reach of Rincon Creek, Saguaro National Park

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INTRODUCTION

In southern Arizona, riparian areas consisting of surface water and tall trees such as cottonwood (*Populus fremontii*) and sycamore (*Platanus wrightii*) comprise <0.5% of the landscape, yet support much of the region's bird species diversity (Knopf and Samson 1994, Skagen et al. 1998). Research in the southwestern U.S. has consistently shown that bird communities are more diverse in riparian areas than on adjacent sites (Carothers et al. 1974, Szaro and Jakle 1985, Strong and Bock 1990), which is due, in part, to the variety of microhabitats that riparian vegetation provide for nesting (Powell and Steidl 2002), cover, and foraging. Riparian trees provide an abundance of nest substrates for primary- (i.e., primarily woodpeckers) and secondary-cavity-nesting species (e.g., elegant trogon [*Trogon Elegans*], Lucy's warbler, and Bewick's wren). Riparian areas also provide water for birds to drink, and this vital resource is especially important in the arid southwest.

The need to identify important environmental features for birds has been heightened by the decline of many species in North America (Robbins et al. 1989) and the region (Sauer et al. 2003) in the last few decades. Riparian areas in the southwest are home to a disproportionate number of bird species, but these invaluable areas are decreasing in both size and quality (Rosenberg et al. 1991, Russell and Monson 1998). Therefore, it is no surprise that many bird species that rely solely on these rare and dwindling resources are themselves showing signs of regional population decline (Sauer et al. 2003). The need to identify and protect resources and areas that provide habitat for regionally rare species is becoming especially critical.

I conducted an inventory of birds along the middle reach of Rincon Creek in Saguaro National Park as part of a larger effort to document the biological and hydrological features of the area (see NPS 2004). The riparian vegetation component along Rincon Creek is highly variable, with some areas appearing to be degraded (i.e., dying trees) and other areas appearing to be in reasonable condition. Due to concern over the long-term health of the riparian area, park staff are interested in determining if the area is a unique resource for birds and if so, what are the species and resources of importance. Therefore, my goals were to:

- 1) Conduct standardized bird surveys along Rincon Creek and adjacent lands to compare species composition, and if possible, the resources being used.
- 2) Survey for yellow-billed cuckoo, a species of interest to managers.
- 3) Compare results of my surveys to other bird research in the park and adjacent lands and to two areas of high bird diversity in southern Arizona to evaluate the conservation value of the Rincon Creek area.

METHODS

I surveyed for birds along Rincon Creek in Saguaro National Park (Figs. 1, 2) from October 2003 to June 2004. I used four field methods: variable circular-plot counts for diurnal breeding birds, line transects for non-breeding season birds, tape-playback for yellow-billed cuckoos, and incidental observations for all birds in all seasons. I concentrated survey effort during the breeding season because bird distribution is relatively uniform at this time (due to territoriality among most landbird species; Bibby et al. 2002), which increases precision in estimating relative abundance and also enabled me to document breeding activity.

During both the breeding and non-breeding seasons, I surveyed two transects on the same morning- one riparian, one upland. One of my main goals was to compare bird communities between riparian and upland sites and therefore highlight differences in these communities. This approach was strengthened by eliminating the temporal element of the surveys; because I

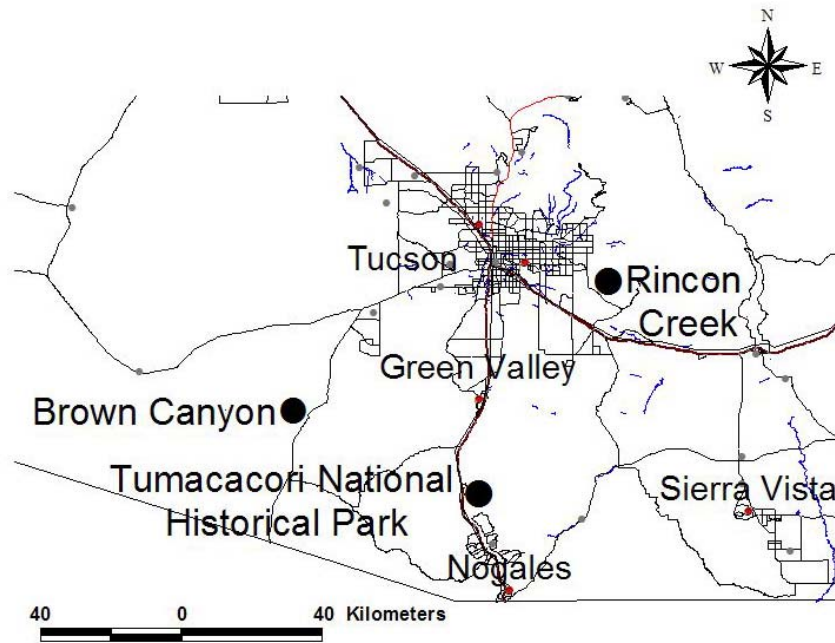


Figure 1. Map of southern Arizona showing location of Rincon Creek, Rincon Mountain District, Saguaro National Park; Brown Canyon in the Baboquivari Mountains; and Tumacacori National Historical Park (NHP) along the Santa Cruz River. Data from Brown Canyon and Tumacacori NHP are used to provide a regional context for evaluating the bird community of Rincon Creek (see page 8).

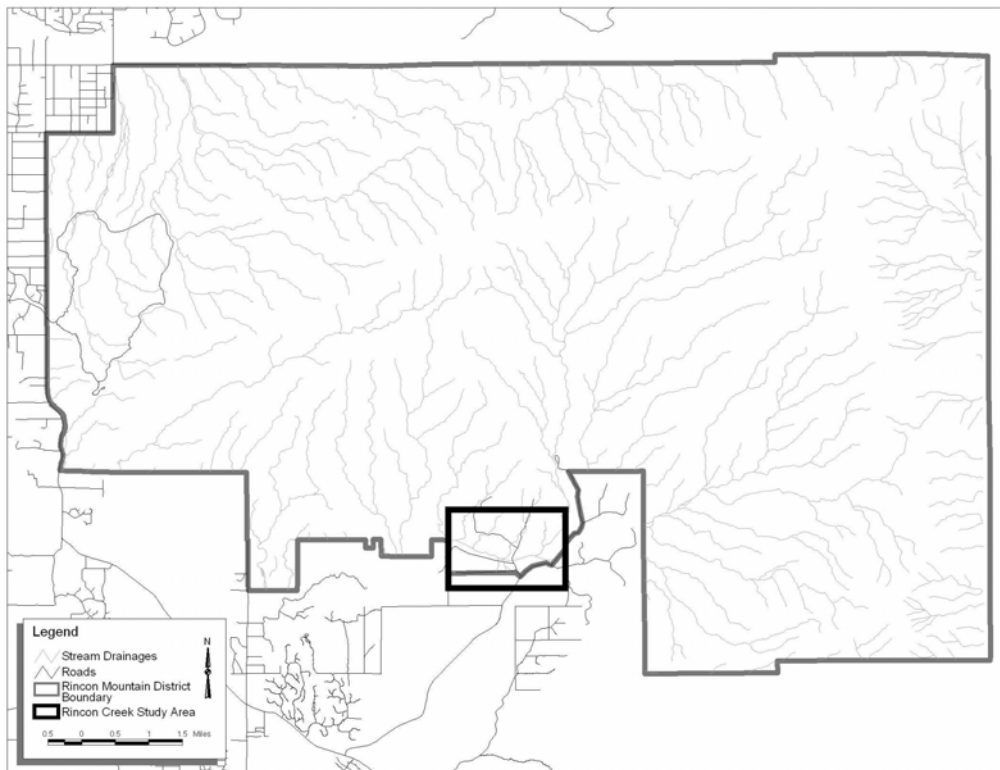


Figure 2. Location of the Rincon Creek study area, Saguaro National Park.

surveyed both transects on the same morning, the results reflect spatial differences in the bird communities, despite a difference in survey effort between riparian and upland transects.

The riparian and upland transects are structurally and floristically different. The upland area is typical of what is found in most places in the Rincon Mountain District of the park below 3,500 feet elevation; mixed cacti and palo verde (*Cercidum* sp.), velvet mesquite (*Prosopis velutina*) with a variety of shrubs such as acacia (*Acacia* sp.), mimosa (*Mimosa* sp.), and snakeweed (*Gutierrezia* sp.), and lycium (*Lycium* sp.). By contrast, the riparian area is dominated by tall Fremont cottonwood, Arizona sycamore, and netleaf hackberry (*Celtis reticulata*). In most places the riparian “zone” is only a single or a few trees in width on either side of the creek and the upland vegetation community borders these areas. The understory in the riparian zone is variable, with some open areas, and some areas with dense stands of acacia and velvet mesquite.

Breeding-season Surveys

Field Methods

I used the variable circular-plot method to survey for diurnally active birds during the breeding season (VCP; Reynolds et al. 1980, Buckland et al. 2001). Conceptually, these surveys are similar to traditional “point counts” (Ralph et. al 1995)¹ during which an observer spends a standardized length of time at one location (i.e., station) and records all birds seen or heard.

I established one transect (five stations) along the section of Rincon Creek which contained the most mesic riparian vegetation, and one transect (three stations) in an adjacent “upland” area that was parallel to the riparian transect (Fig. 3). The stations along Rincon Creek were a subset of the eight stations that were established by the UA inventory group for surveys along Rincon Creek in 2001 and 2002 (Powell et al. 2002, 2003). Stations along each transect were located a minimum of 250 m apart to maintain independence among observations at each station. I surveyed each station seven times from 19 April to 31 May 2004. Ideally, I should have started surveys approximately two weeks earlier, but high water in the creek and the resulting excessive noise prevented me from surveying in early April. On each visit to the area I alternated the order in which I surveyed transects and stations (along a transect) to minimize bias by time of day and direction of travel. I began surveys approximately 30 minutes before sunrise and concluded no later than four hours after sunrise. I did not survey when wind exceeded 15 km/h or when precipitation exceeded an intermittent drizzle.

I recorded a number of environmental variables at the beginning of each transect: wind speed (Beaufort scale), presence and severity of rain (qualitative assessment), air temperature (°F), relative humidity (%), and cloud cover (%). After arriving at a station, I waited for one minute before beginning the count to allow birds to resume their normal activities. I identified to species all birds seen or heard during an eight-minute “active” period. For each detection I estimated distance in meters (measured with laser range finder when possible or otherwise estimated), time of detection (measured in one-minute intervals beginning at the start of the active period), and the sex and/or age class (adult or juvenile), if known. I did not measure distances to birds that were flying overhead nor did I use techniques to attract birds (e.g., “pishing”). I made an effort to avoid double-counting individuals that had been recorded at previous stations. If I observed a species during the “passive” count period (between the eight-minute counts), which had not been recorded previously at a station on that visit, I recorded its distance to the nearest station.

¹ Point counts are limited in distance (usually to 50 m) and the distance to birds is not recorded. This method precludes calculation of density.

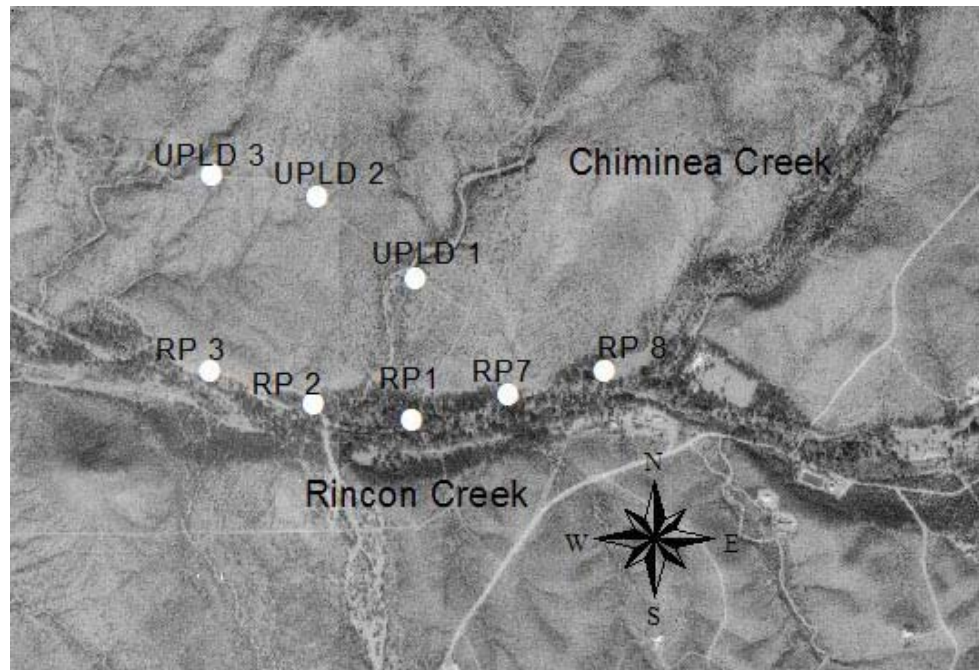


Figure 3. Location of breeding-season survey stations (“UPLD” = upland transect; “RP” = riparian transect) for birds along Rincon Creek, Saguaro National Park, 2004. See Appendix B for UTM coordinates.

Analysis

I calculated relative abundance of each species for each transect as the total number of detections at all stations and visits (including zero values), divided by effort (number of visits multiplied number of stations). I reduced the full collection of observations ($N = 1,054$) to a subset of data ($n = 630$) that was more appropriate for estimating relative abundance. I used only those detections that occurred ≤ 75 m from count stations (thereby excluding 375 observations) because detectability is influenced by conspicuousness of birds (i.e., loud, large, or colorful species are more detectable than others) and environmental conditions (dense vegetation can reduce likelihood of some detections). Truncating detections may reduce the influence of these factors (Verner and Ritter 1983). I also excluded observations of birds that were flying over the station (78 observations), birds observed outside of the eight-minute count period (61 observations), and unknown species (17 observations). Some observations met more than one of these criteria for exclusion from analysis.

Non-breeding Season Surveys

Field Methods

I used a modified line-transect method (Bibby et al. 2002) to survey for birds from October 2003 to April 2004. Line transects differ from station transects (such as those used in our breeding-season surveys) in that an observer records birds seen or heard while the observer walks a line, rather than stands at a station. The transect method is more effective during the non-breeding season because bird vocalizations are less conspicuous and frequent (Bibby et al. 2002).

I established one transect (seven sections) along Rincon Creek and one transect (four sections) in the upland, which ran parallel to the riparian transect (Fig. 4). As with the breeding-season surveys, the location of the transect was the same as that used by the UA inventory group, but unlike the breeding-season surveys, the non-breeding season transect used by the UA inventory

group also included the upland area. However, I omitted two sections used by the UA group because I felt their transect was too long to survey effectively in one morning.

The transect was broken into sections, the starting and stopping points of which corresponded with breeding-season stations. Sections were approximately 250 m in length. As with breeding-season surveys, I alternated direction of travel along transects to reduce bias by time of day, and did not survey during periods of excessive rain or wind (see breeding-season survey methods for details on weather restrictions). I began surveys about 30 minutes after sunrise and continued until I completed the transect. As with breeding-season surveys, I recorded weather conditions at the beginning and end of each survey. Prior to beginning a section, I recorded the section name (e.g., “A–B”) and the start time. I timed my travel so that I traversed each section in ten minutes, during which time I assigned all birds seen and/or heard into one of the following distance categories: ≤ 100 m, > 100 m, or “flyover.” When possible, I noted the sex and age class of birds. I recorded birds observed before or after surveys as “incidentals” (see section below), and I did not use techniques to attract birds (e.g., “pishing”).

Analysis

I calculated relative abundance of birds as per breeding-season surveys but excluded flyovers and birds observed >100 m from the transect line (total number of observations excluded from analysis was 40).

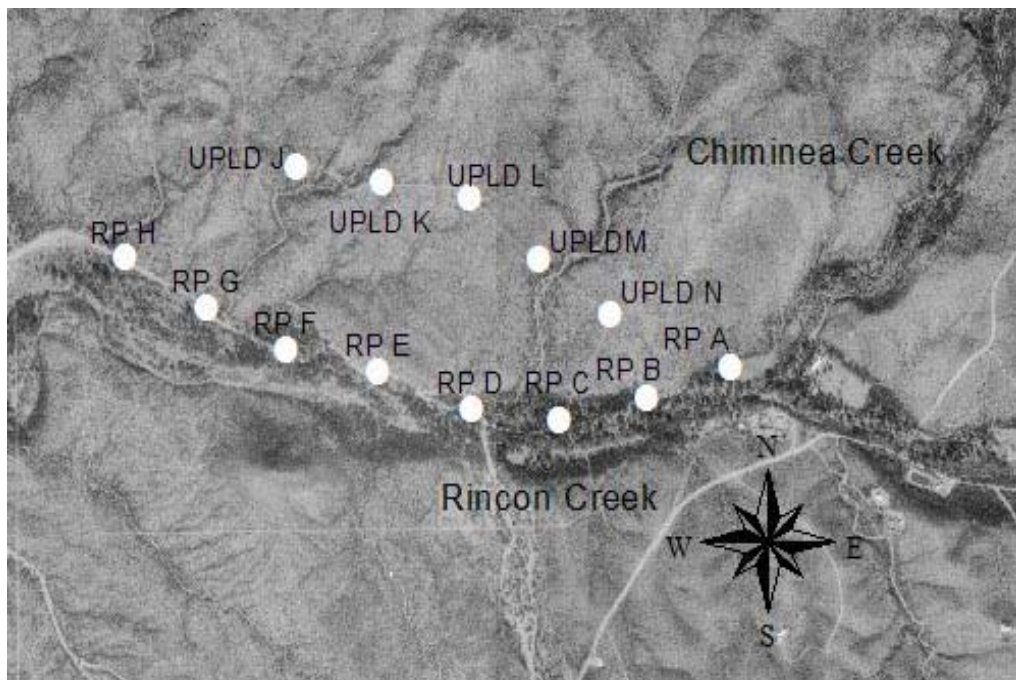


Figure 4. Start and stop locations of non-breeding-season survey sections (“UPLD” = upland transect; “RP” = riparian transect) for birds along Rincon Creek, Saguaro National Park, 2003 and 2004. See Appendix B for UTM coordinates.

Call-playback Surveys: Yellow-billed Cuckoo

The yellow-billed cuckoo is a species of interest to the park. In western North America, yellow-billed cuckoo were once found from southern British Columbia to Mexico and in most regions of California (Hughes 1999). However, cuckoos in the western U.S. have declined dramatically during the past 80 years and are now extirpated from much of their previous range. Population declines of the yellow-billed cuckoo have been linked to loss of riparian habitat in nesting areas due to (1) habitat inundation by reservoirs, (2) canalization for flood control, (3) conversion to agriculture and grazing, (4) urban development and 5) lowered water tables (Gaines and Laymon 1984, Laymon and Halterman 1987, 1989). The increasing loss and fragmentation of remaining habitat in Arizona make population persistence there uncertain.

I surveyed for yellow-billed cuckoos using a protocol adapted from the Arizona Game and Fish Department (Corman and Magill 2000), U.S. Geological Survey of the Colorado Plateau Field Station in Flagstaff, Arizona, and using information provided by Laymon (1998). A version of this protocol was used for statewide surveys in Arizona and California (Corman and Magill 2000).

I surveyed for yellow-billed cuckoos on two occasions (7 and 11 July 2004) along Rincon Creek. I spaced call stations approximately 150 m apart. At each station I broadcast a tape of the cuckoos' contact call (the "kowlp" call; from Colver et al. 1999) played on a portable compact disc player and broadcaster (Bibby et al. 2002). The tape was of five sets of "kowlp" calls with each set of calls was followed by 30 seconds of silence.

Incidental ObservationsField Methods

When I was not conducting formal surveys and encountered a species of interest, a species in an unusual location, or an individual engaged in breeding behavior, I recorded UTM coordinates (NAD 83), time of detection, and the sex and age class (if known) of the bird.

Analysis

I report frequency counts of incidental observations; I cannot calculate relative abundance (as for breeding- and non-breeding-season surveys) because I did not standardize effort for this survey type.

Breeding Observations

I searched for nests to confirm breeding in the area around Rincon Creek but did not actively search for nests in the upland vegetation community. I noted all breeding observations using the standardized classification system (NAOAC 1990), which characterizes breeding behavior into one of nine categories: adult carrying nesting material, nest building, adult performing distraction display, used nest, fledged young, occupied nest, adult carrying food, adult feeding young, or adult carrying a fecal sac. I made breeding observations during standardized and incidental surveys.

Analysis

I report frequency counts of breeding observations.

Summary of Other, Nearby Survey Efforts

To gain a more complete understanding of the bird community along Rincon Creek and surrounding areas, I summarize data collected by the UA inventory group for surveys that they completed in 2001 to 2003 (Powell et al. 2002, 2003, and unpublished data²). As indicated in the respective survey methods (above), many of the study sites for the surveys that I completed in 2003 and 2004 were identical to those surveyed earlier by the UA inventory group (Powell et al. 2002, 2003). I also summarize data from research that Powell (1999) completed at the Rocking K development and adjacent Saguaro National Park expansion area, located 5-10 km west of the Rincon Creek study area. The vegetation community in these areas is similar to the upland transect adjacent to Rincon Creek – mixed cactus and palo verde. Approximately one half of the stations that Powell (1999) surveyed were located adjacent to dry washes that were dominated by xeroriparian vegetation – dense stands of mesquite, acacia, and, in some cases, netleaf hackberry. With a few minor exceptions, the data-collection and the methods of analysis for all of the studies summarized in this report were the same. I also compare my species list at Rincon Creek to the research by Friederici (1998) in the park's expansion area.

To compare the breeding-season bird community at Rincon Creek to other areas of Saguaro National Park, I compared the number of species found at Rincon Creek to 27 other transects in the park that were surveyed in 2001 and 2002 (Powell et al. 2002, 2003, and unpublished data). Because of unequal survey effort among transects, I divided the survey effort (number of stations divided by number of visits) by number of species found during all surveys. Because I was interested in making comparisons at the transect level, I included observations made outside of the 8 minute count periods (but not incidental detections made outside of formal VCP surveys because sampling effort was not consistent), and bird flying overhead. I also included birds observed at unlimited distances from the stations (but rarely >300 m away).

Assessing Species Richness of the Bird Community at Rincon Creek

Inventory completeness and assessment of the species richness of an area can most easily be evaluated by examining the rate at which new species are recorded in successive surveys (i.e., species accumulation curves; Hayek and Buzas 1997). I graphed a species accumulation curve for both breeding-season survey transects (riparian and upland) along Rincon Creek to show intra-site differences. To put the results from Rincon Creek into a regional context, I graphed species accumulation curves for the riparian transect and two other areas of high bird diversity: Brown Canyon in the Baboquivari Mountains (Powell and Steidl, in prep) and a stretch of the Santa Cruz River at Tumacácori National Historical Site (Powell et al. 2004). Both areas are located within approximately 40 km of the border with Mexico (Fig. 1). The methods of data collection at these sites were similar to the methods used in this study. For all species accumulation curves, I randomized the order of the sampling periods to break up clusters of new detections that resulted from temporal conditions (e.g., spring migrants) independent of cumulative effort. I included observations of birds seen flying over the sites, birds seen > 75 m from the stations, and observations made outside of the 8 minute count period (except for Brown Canyon). To make the most meaningful comparisons among sites, I summarized the same number of count stations as used at Rincon Creek (five) from each site (station numbers 25, 26, 27, 28, and 29 from Brown Canyon; station numbers 4, 5, 6, 7, and 8 from the Santa Cruz River) and used a random subset of visits to those stations to closely match my survey effort at Rincon Creek (five stations with seven visits each).

² These data will be published in a final inventory report for Saguaro National Park.

Data Entry and Archiving

I entered field data into a Microsoft Access database that was created by the UA inventory group. Original data sheets will be archived at Saguaro National Park and I will retain copies. Copies of the Access database will be given to the park at the completion of the project.

RESULTS

I found 79 species of birds during 14 field days from October 2003 through July 2004 (Appendix A). I found the most species during breeding-season surveys (64 species) and fewer species during non-breeding season surveys (44 species). I did not find any yellow-billed cuckoos during two days of call-playback surveys. I found some species of conservation concern including Gila woodpecker, gilded flicker, Bell's vireo, crissal thrasher, and rufous-winged sparrow, all which are listed as "Birds of Conservation Concern" by the U.S. Fish and Wildlife Service (USFWS 2002). Also, Costa's hummingbird, gilded flicker, Lucy's warbler, and rufous-winged sparrow are considered species of interest by Arizona Partners in Flight (Latta et al. 1999). Finally, Bell's vireo is considered a "Sensitive" species by the U.S. Forest Service (HDMS 2004). European starling was the only non-native species that I found during my surveys.

Breeding-season Surveys

I found 64 species during 7 VCP surveys of both transects. Excluding birds that were seen >75 m from stations and flyovers, I was able to calculate relative abundance for 52 species (Table 1). The difference in species composition between the two transects was striking but expected; I observed more than twice as many species on the riparian transect as on the upland transect, and only observed two species on the upland transect that I did not observe on the riparian transect. The most abundant species on the upland transect were cactus wren, black-throated sparrow, Gambel's quail, and curve-billed thrasher (Appendix C). The most abundant species on the riparian transect were Gambel's quail, Lucy's warbler, white-winged dove, and Bewick's wren. Although the survey effort was skewed toward more stations in the riparian transect, this did not appear to affect the results; the number of new species being recorded on each consecutive survey appeared to be reaching an asymptote (Fig. 5). Of the 23 species in the uplands, only 7 were more common in the upland transect than in the riparian (Table 1). By contrast, of the 50 species in the riparian area, 45 were more common in the riparian transect than in the upland transect. Not surprisingly, I found a number of species on the riparian transect that have habitat requirements that are restricted to riparian vegetation, and which are regionally rare: summer tanager, yellow warbler, and varied bunting.

Non-breeding Season Surveys

I found 44 species during five non-breeding season surveys. Excluding birds that I observed flying overhead or were >100 m from the transect line, I was able to calculate relative abundance for 41 species (Table 2). The pattern of inter-community differences was similar to that of breeding-season surveys; I found more than twice as many species along the riparian transect as on the uplands transect and there were no species on the upland transect that was not observed on the riparian transect. The most abundant species on the upland transect did not change from the breeding season: cactus wren, black-throated sparrow, curve-billed thrasher, and Gambel's quail (Appendix C). However, the most abundant species on the riparian transect changed markedly between seasons: chipping sparrow, mourning dove, Gambel's quail, and Gila woodpecker.

Table 1. Number of observations (sum) and relative abundance (mean $\pm$ SE) of birds recorded within 75 m of count stations during breeding-season surveys, Rincon Creek area, Saguaro National Park, 2004. List excludes flyovers and observations made outside of the eight-minute count period. See Methods section for details on estimation of relative abundance and effort. See Appendix A for scientific names.

Common name	Transect					
	Riparian (n = 35)			Upland (n = 21)		
	Sum	Mean	SE	Sum	Mean	SE
Gambel's quail	69	1.97	0.576	12	0.57	0.657
red-tailed hawk	1	0.03	0.029			
white-winged dove	35	1.00	0.142	8	0.38	0.448
mourning dove	28	0.80	0.107	7	0.33	0.233
greater roadrunner				3	0.14	0.129
broad-billed hummingbird	1	0.03	0.029			
black-chinned hummingbird	3	0.09	0.048			
Costa's hummingbird	1	0.03	0.029			
Gila woodpecker	24	0.69	0.135	6	0.29	0.214
ladder-backed woodpecker	10	0.29	0.097	1	0.05	0.048
gilded flicker	3	0.09	0.048	2	0.10	0.090
northern beardless-tyrannulet	1	0.03	0.029			
gray flycatcher	1	0.03	0.029			
"western" flycatcher ^a	2	0.06	0.040			
vermillion flycatcher	10	0.29	0.077			
ash-throated flycatcher	8	0.23	0.072	5	0.24	0.290
brown-crested flycatcher	5	0.14	0.073	8	0.38	0.448
Cassin's kingbird	10	0.29	0.097			
Bell's vireo	20	0.57	0.131			
solitary vireo type	1	0.03	0.029			
curve-billed thrasher	7	0.20	0.080	11	0.52	0.362
western scrub-jay	1	0.03	0.029			
common raven	3	0.09	0.048			
purple martin	5	0.14	0.093			
bridled titmouse	1	0.03	0.029			
verdin	26	0.74	0.085	10	0.48	0.262
cactus wren	16	0.46	0.103	35	1.67	0.533
Bewick's wren	32	0.91	0.126			
northern mockingbird	1	0.03	0.029	1	0.05	0.048
European starling	1	0.03	0.029			
phainopepla	11	0.31	0.114	2	0.10	0.090
Lucy's warbler	68	1.94	0.174	6	0.29	0.214
yellow warbler	18	0.51	0.111			
Audubon's warbler	1	0.03	0.029			
Wilson's warbler	3	0.09	0.048	1	0.05	0.048
summer tanager	6	0.17	0.065			
canyon towhee	2	0.06	0.040	1	0.05	0.048
Abert's towhee	3	0.09	0.048			
rufous-winged sparrow	8	0.23	0.072	8	0.38	0.348
chipping sparrow	2	0.06	0.040	1	0.05	0.048
Brewer's sparrow	3	0.09	0.048	4	0.19	0.162
black-throated sparrow	6	0.17	0.065	21	1.00	0.500
Lincoln's sparrow	1	0.03	0.029			
white-crowned sparrow	3	0.09	0.086			
northern cardinal	22	0.63	0.117	3	0.14	0.129

Common name	Transect					
	Riparian (n = 35)			Upland (n = 21)		
	Sum	Mean	SE	Sum	Mean	SE
pyrrhuloxia				4	0.19	0.162
black-headed grosbeak	1	0.03	0.029			
blue grosbeak	2	0.06	0.040			
varied bunting	1	0.03	0.029			
brown-headed cowbird	3	0.09	0.048			
house finch	13	0.37	0.101			
lesser goldfinch	17	0.49	0.111			
Species richness	50			23		

^a Cordilleran or Pacific-slope flycatchers [*Empidonax difficilis*].

Incidental and Breeding Observations

I recorded incidental observations for 23 species, three of which I did not observe during other surveys: bronzed cowbird, warbling vireo, and lazuli bunting. I confirmed breeding for 18 species (Table 3) including species of conservation concern, including vermilion flycatcher, Bell's vireo, summer tanager, and yellow warbler.

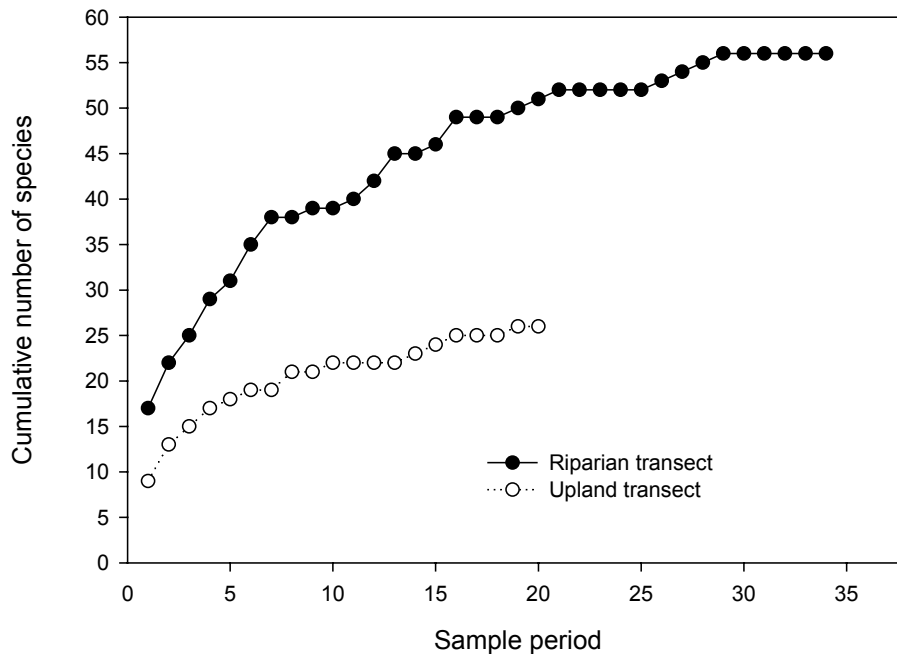


Figure 5. Species accumulation curves for detections from breeding-season bird surveys, riparian and upland transects, Rincon Creek area, Saguaro National Park, 2004. Each sample period represents one visit to a station. Sample periods were randomized to account for temporal and spatial spikes in species richness.

Table 2. Number of observations (sum) and relative abundance (mean $\pm$ SE) of birds recorded during non-breeding season surveys, Rincon Creek area, Saguaro National Park, 2003 and 2004. See Methods section for details on estimation of relative abundance. See Appendix A for scientific names.

Common name	Transect					
	Riparian (<i>n</i> = 35)			Upland (<i>n</i> = 20)		
	Sum	Mean	SE	Sum	Mean	SE
Gambel's quail	27	0.77	0.489	21	1.05	0.559
American kestrel	1	0.03	0.029	1	0.05	0.050
mourning dove	34	0.97	0.314	1	0.05	0.050
great horned owl	2	0.06	0.040			
Gila woodpecker	27	0.77	0.124	7	0.35	0.131
ladder-backed woodpecker	7	0.20	0.080	1	0.05	0.050
northern flicker	15	0.43	0.111	1	0.05	0.050
gilded flicker	4	0.11	0.068			
gray flycatcher	1	0.03	0.029			
plumbeous vireo	1	0.03	0.029			
Hutton's vireo	1	0.03	0.029			
curve-billed thrasher	22	0.63	0.109	25	1.25	0.250
crissal thrasher	1	0.03	0.029			
western scrub-jay	20	0.57	0.160	1	0.05	0.050
common raven	1	0.03	0.029			
bridled titmouse	2	0.06	0.057			
verdin	13	0.37	0.092	7	0.35	0.131
cactus wren	30	0.86	0.149	49	2.45	0.294
rock wren	1	0.03	0.029	5	0.25	0.099
Bewick's wren	15	0.43	0.094	4	0.20	0.092
house wren	4	0.11	0.068			
ruby-crowned kinglet	12	0.34	0.091			
black-tailed gnatcatcher	1	0.03	0.029	3	0.15	0.082
hermit thrush	1	0.03	0.029			
northern mockingbird	1	0.03	0.029			
phainopepla	2	0.06	0.040			
spotted towhee	3	0.09	0.048			
canyon towhee	7	0.20	0.090	6	0.30	0.128
Abert's towhee	8	0.23	0.092			
rufous-winged sparrow	6	0.17	0.087	7	0.35	0.150
chipping sparrow	79	2.26	1.151	8	0.40	0.400
Brewer's sparrow	9	0.26	0.138			
black-throated sparrow	7	0.20	0.090	25	1.25	0.331
Lincoln's sparrow	9	0.26	0.111			
savannah sparrow	2	0.06	0.040			
white-crowned sparrow	12	0.34	0.315			
dark-eyed junco	11	0.31	0.147			
northern cardinal	11	0.31	0.107	1	0.05	0.050
pyrrhuloxia	10	0.29	0.097	2	0.10	0.069
house finch	22	0.63	0.184	3	0.15	0.082
lesser goldfinch	14	0.40	0.184			
Species richness		41			20	

Table 3. Number of observations of each breeding behavior for birds along Rincon Creek, Saguaro National Park, 2004. Breeding behaviors follow standards set by NAOAC (1990). See Appendix A for scientific names.

Common name	Carrying nesting material	Nest building	Nest with eggs	Nest with young	Occupied nest	Recently fledged young	Adults feeding recently fledged young	Adults carrying food
red-tailed hawk					1	1		
mourning dove		1			1			
black-chinned hummingbird					1			
ladder-backed woodpecker								1
vermillion flycatcher		1				1		
ash-throated flycatcher	1							
Cassin's kingbird		1					1	
Bell's vireo		2						
common raven					1			
verdin		1						
Lucy's warbler			1					1
yellow warbler	1						1	
summer tanager						2	1	
Abert's towhee						1		
rufous-winged sparrow								1
black-throated sparrow				1		1		
house finch							1	1
lesser goldfinch		1						

Results of Other Survey Efforts

Considering all survey types in all seasons, the UA inventory group found a total of 117 species of birds in the vicinity of Rincon Creek³ (Appendix A; Powell et al. 2002, 2003 and unpublished data). This list includes many species of conservation concern including: grey hawk, common black hawk, peregrine falcon, and yellow-billed cuckoo. Boyle and Conway (2003) found a northern shrike near the Madrona Ranger Station in May 2003. Below I briefly summarize results from formal studies in the area and compare the results from those studies to what I found.

UA Inventory at Rincon Creek and Other Areas of the Park: Breeding-season Surveys

The UA group found a total of 66 species along Rincon Creek (within 75 m of stations along the riparian transect) during breeding-season surveys in 2001 and 2002 (Appendix D). They found 22 species during VCP surveys that I did not find including: grey hawk, common ground dove, belted kingfisher, and black phoebe. Conversely, I found seven species that were not found by the UA group including varied bunting.

Although comparing relative abundance scores among years is not recommended, there were some glaring differences among years (Table 1, Appendix D) most noticeably for brown-crested flycatcher between 2002 and 2004. In 2002, the UA inventory group found them to be one of the most abundant species (Appendix D), but I found them to be only slightly above the median for relative abundance (Table 1). This discrepancy may be explained by the low number of ash-throated flycatchers reported in 2002 and the fact that these two species are difficult to distinguish.

³ Includes surveys in Chimenea Creek, Madrona Creek, and the upper reach of Rincon Creek.

Of the 28 transects that the UA inventory group studied at both districts of Saguaro National Park in 2001 and 2002, Rincon Creek had the highest species richness (82 species; Appendix E). Box Canyon, another low-elevation riparian area, had the second-highest species richness (71 species), though survey effort was greater along Rincon Creek.

UA Inventory at Rincon Creek: Non-breeding-season Surveys

The UA group found 42 species during non-breeding season surveys, including 13 species that I did not find (Appendix F). Conversely, I found seven species that were not found by the UA inventory group. The most common species found by the UA group in the upland transect were similar to my effort (Table 2, Appendix C): black-throated sparrow, cactus wren, and Gambel's quail. However, the most abundant species along the riparian transect in 2002 (Gambel's quail, Gila woodpecker, lesser goldfinch, and rufous-winged sparrow) were different than the most abundant species in 2004 surveys (chipping sparrow, mourning dove, and cactus wren).

Rocking K and Expansion Area: Breeding-season Surveys

Powell (1999) found a total of 43 species within 75 m of bird stations during a study of the Rocking K ranch development and Saguaro National Park expansion area (Appendix G). Compared to the differences in species richness and composition between the upland and riparian bird communities in this study (Table 1) and that by Powell et al. (2002, 2003, unpublished data; Appendix D), the difference between the upland and xeroriparian stations were intermediate (Appendix G). Powell (1999) found a number of species that are riparian-associated including: Bell's vireo, Bewick's wren, and summer tanager. All of these species were not as abundant at xeroriparian stations as I found for the Rincon Creek transect (Table 1). Powell (1999) did not find any species that were not found in this survey effort.

Friederici (1998) found 58 species in the expansion area during mid-summer surveys in 1998 (Appendix A). He found no species that were not recorded by this or other survey efforts. He noted one sighting of a yellow-billed cuckoo during his surveys, though this individual was likely not nesting in the expansion area.

Regional Significance of Rincon Creek

A comparison of the species accumulation curves for Rincon Creek and two other areas of high species richness suggest that Rincon Creek has higher species richness than a comparable area in Brown Canyon and similar observed species richness to the Santa Cruz River at Tumacácori National Historical Park (Fig. 6). The graph also shows that, while the number of new birds being added to the Brown Canyon "list" appears to be reaching an asymptote, the communities along Rincon Creek and the Santa Cruz River continue to add new species.

DISCUSSION

Rincon Creek and its environs are home to an extraordinary diversity of birds and the community is regionally significant in terms of species richness and composition (Appendix A, Fig. 6). With a modest survey effort in the vicinity of the creek, there have been a total of 120 species observed, including many species of conservation concern (Appendix A). The creek itself, and the riparian vegetation that it supports, is responsible for this high diversity. I and others found that bird species richness along the creek is considerably greater than in the adjacent uplands (Tables 1 and 2; Appendices D and F) and other nearby areas (Fig. 6, Appendices A and E). Not only was species richness greater in the riparian area, but the complement of species was, in most cases, markedly different. While the upland areas seemed fairly stable in the abundance ranks of the most common species (both between studies and between seasons), the riparian area was

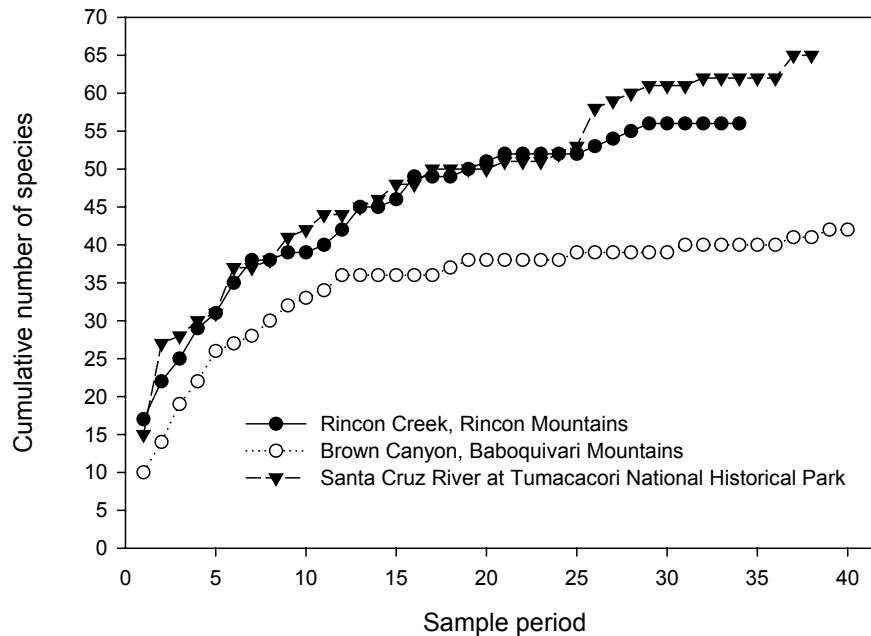


Figure 6. Species accumulation curves for detections from breeding-season bird surveys, Rincon Creek riparian transect (as from Fig. 5) 2004; Brown Canyon, Buenos Aires National Wildlife Refuge, Baboquivari Mountains, 1997–1998 (Powell and Steidl, in prep); and Santa Cruz River at Tumacacori National Historical Park, 2001–2002. Each sample period represents one visit to a station.

more variable, indicating a bird community that is more dynamic and, by extension, biologically more unique. The poor condition of some resources (e.g., trees) and the variability of available water in the riparian area may partially explain the occurrence and variability in relative abundance estimates; in some cases, birds may be drawn to the area to evaluate the resources and may not stay for long periods of time, or they may expand or reduce their home range size to accommodate for changing resources.

I found a number of species that are restricted to riparian areas in the southwest (Rosenberg et al. 1991) and which were consistent members of the bird community along Rincon Creek: Bell's vireo, Abert's towhee, summer tanager, and yellow warbler. This indicates that all of the habitat components needed for birds to settle and reproduce are present. Of the species for which we found nests, almost all of them nested in riparian trees such as cottonwood, ash, and netleaf hackberry. Riparian vegetation is preferred nesting habitat for a disproportionate number of species in many vegetation communities containing both riparian and adjacent vegetation types (Carothers et al. 1974, Bock and Bock 1984, Powell and Steidl 2000, Powell and Steidl 2002). Riparian vegetation often has greater volume and structure than vegetation on upslope areas and therefore could provide an abundance of well-concealed nest sites that offer protection from weather and predators (Whitmore 1975, Bock and Bock 1984).

This study, and those reviewed herein, were concerned with determining patterns of species richness and relative abundance between riparian and adjacent vegetation types. The *quality* of breeding habitat, however, can only be assessed using demographic measures (VanHorne 1983), such as reproductive success, which exerts strong selective pressures that ultimately affect selection of breeding habitat (Martin 1988). We have some anecdotal evidence that this area provides quality-breeding habitat for some species. Specifically, I and others (Powell et al.

unpublished data) found a number of nests and evidence of nesting success (through observation of recent fledglings) in the area. For example, of the nine Bell's vireo nests with eggs or nestlings that were found by Powell et al. (unpublished data), only one nest had a brown-headed cowbird egg. Brown-headed cowbirds pose a threat to many native birds because they are brood parasites (i.e., lay their eggs in the nests of other species), thereby reducing the productivity of host species, especially Bell's vireos in southern Arizona (Averill-Murray et al. 1999, Powell and Steidl 2000). During the breeding season, cowbirds prefer edge communities (Rothstein 1994), such as along Rincon Creek.

The relative lack of brown-headed cowbird eggs in the nests of Bell's vireo is consistent with the low numbers of observations of brown-headed cowbirds along Rincon Creek (Table 1, Appendices A, D, F, and G). Similarly, these studies found few observations of rock pigeon and European starlings, and no observations of house sparrows, all of which are non-native species of management concern. This low number of non-native species and individuals, especially European starling and house sparrow, is good news for native birds, especially secondary cavity-nesting species (e.g., Bewick's wren and Lucy's warbler), which do not compete well with these non-native species for nest sites.

The increase in construction of housing in the Rincon Valley will certainly cause an increase in the number of non-native bird species to the Rincon Creek area. Great-tailed grackle may become established as a result of development, and there may be an increase in the numbers of other human-adapted species (i.e., those that reach high densities in human-dominated landscapes; Mills et al. 1989, Germiane et al. 1998) such as mourning dove, and house finch, in addition to the non-native species mentioned earlier. These changes would most likely have negative impacts on the structure of the bird community and habitat quality for a number of sensitive species in the riparian area. In addition to changes in the bird community, development could change the plant and other vertebrate communities through an increase in non-native plant (thereby changing the function of the ecosystem) and increased harassment and mortality of native animals by free-roaming feral pets (Clarke and Pacin 2002). Finally, with development comes roads, which act as barriers to movement of wildlife because of direct mortality and modification of behavior (Kline and Swann 1997, 1998, Trombulak and Frissell 2000, Clark et al. 2001, Tigas et al. 2002, Cain et al. 2003).

Perhaps the most detrimental impact on the bird community from development in the Rincon Valley will be the accelerated withdrawal of groundwater from the basin. A reduction in water will change the availability of surface water, reduce the abundance of insects (the main source of food for most birds during the breeding season), and ultimately affect the health, abundance, and distribution of the tall riparian vegetation that is so important to the birds. In fact, the latter appears to be happening already; many cottonwood and sycamore trees are in poor health and this may have already affected the abundance of riparian-associated bird species. For example, with a healthy riparian forest, there is every reason to believe that the area would be nesting habitat for yellow-billed cuckoo, which nest approximately 20 km away in Cienaga Creek (Corman and Magill 2000).

RECOMMENDATIONS

Additional Research

The species list for Rincon Creek and surrounding areas will increase with additional survey effort. Therefore, I recommend, at the very minimum, to continue breeding-season surveys along Rincon Creek and adjacent upland sites. This will provide for continuity of data collection. The National Park Service (NPS), Sonoran Desert Inventory and Monitoring program (Hubbard et al. 2003) may provide funds for this undertaking, but at the time of this writing, no bird research is planned for the spring of 2005. I also recommend additional yellow-billed cuckoo surveys in early June; my surveys in July may have been too late because birds are not as responsive as earlier in the nesting season (personal observation).

This study, and past research that I reviewed, correlate measures of abundance and diversity to gross environmental features (i.e., vegetation type). An additional approach is to document the resources that are being used by riparian-obligate birds and compare those resources to the suite of resources that are available. Typically this involves documentation of nest or foraging sites compared to random areas (e.g., Powell and Steidl 2002). This approach pinpoints those environmental features that are most important and perhaps could be manipulated to meet management objectives.

An additional step would be to determine the quality of the breeding habitat along Rincon Creek for riparian-obligate and other birds. This approach is labor intensive but is important to determine if, as we suspect, the area is high-quality breeding habitat. Nest success of a few species could be monitored in order to alert managers to important demographic changes in the community. One obstacle to estimating nest success for the riparian-obligate species, however, will be sample size; the length of the middle reach of Rincon Creek is only about 1.5 km and the populations of target species (Bell's vireo, summer tanager, yellow-warbler, and Abert's towhee) may not be large enough to monitor nest success. A complementary approach would be to study additional areas in the region to determine larger-scale patterns of habitat quality.

Because the abundance and diversity of birds along Rincon Creek are tied so closely with the riparian trees, it is essential to map the location and condition of those trees. This project is currently not planned (Mark Briggs, personal communication) but could be accomplished relatively easily through photo points and detailed measurements and examination of all of the large trees. Once this task is accomplished, it is not inconceivable to undertake an experiment using supplemental irrigation (during times of drought) to determine the effects that this has on tree health.

Management Recommendations

The unique qualities of the bird community, especially the suite of riparian-obligate birds, warrants that this area be protected to ensure its long-term viability as habitat for riparian obligate birds. I suggest that park managers aggressively pursue the tools they need, such as funding for additional lines of research or acquisition of water rights, to maintain or enhance the health of the riparian system. Funding for this, and other related studies, clearly shows the management priority of enhancing the biological and hydrological integrity of Rincon Creek.

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Appendix A. List of bird species observed on this study (“Powell”), in the vicinity of Rincon Creek by the University of Arizona Inventory personnel from 2001–2003 (“I&M”; Powell et al. 2002, 2003, and unpublished data), and by Friederici (1998) in the adjacent expansion lands, Rincon Mountain District, Saguaro National Park. Number in column for Powell and I&M indicates total number of observations across all years and survey types and includes observations made > 75 m bird-survey stations; these numbers should not be used as measures of relative abundance. Emboldened species names are non-native and underlined species indicate that they are neotropical migrant species (Rappole 1995). Species names follow AOU (1998, 2003).

Order	Family	Scientific name	Common name	Powell	I&M	Friederici	Conservation designation by agency				
							U.S. Fish and Wildlife Service ^a	Bureau of Land Management ^b	U.S. Forest Service ^b	State of Arizona ^c	Arizona Partners in Flight ^d
Anseriformes	Anatidae	<u>Anas platyrhynchos</u>	mallard		3						
Galliformes	Odontophoridae	<u>Callipepla gambelii</u>	Gambel's quail	108	142	X					
Ciconiiformes	Cathartidae	<u>Cathartes aura</u>	turkey vulture	5	14	X					
Falconiformes	Accipitridae	<u>Accipiter striatus</u>	sharp-shinned hawk		1				S		
		<u>Accipiter cooperii</u>	Cooper's hawk	2	24						
		<u>Asturina nitida maxima</u>	gray hawk		5	X	SC	S	S	WSC	
		<u>Buteogallus anthracinus</u>	common black-hawk		1				S	WSC	P
		<u>Buteo albonotatus</u>	zone-tailed hawk		2	X					
		<u>Buteo jamaicensis</u>	red-tailed hawk	6	17	X					
	Falconidae	<u>Falco sparverius</u>	American kestrel	3	10	X					
Columbiformes	Columbidae	<u>Falco peregrinus</u>	peregrine falcon		1		SC, BCC			WSC	
		Columba livia	rock pigeon		1						
		<u>Patagioenas fasciata</u>	band-tailed pigeon		1						
		<u>Zenaida asiatica</u>	white-winged dove	85	200	X					
		<u>Zenaida macroura</u>	mourning dove	68	181	X					
Cuculiformes	Cuculidae	<u>Columbina passerina</u>	common ground-dove		4						
		<u>Coccyzus americanus</u>	yellow-billed cuckoo		1	X	C, BCC		S	WSC	P
		<u>Geococcyx californianus</u>	greater roadrunner	3	4	X					
Strigiformes	Tytonidae	<u>Tyto alba</u>	barn owl		1	X					
	Strigidae	<u>Megascops kennicottii</u>	western screech-owl		16	X					
		<u>Bubo virginianus</u>	great horned owl	4	17	X					
		<u>Micrathene whitneyi</u>	elf owl		44	X	BCC				
Caprimulgiformes	Caprimulgidae	<u>Chordeiles acutipennis</u>	lesser nighthawk	1	3	X					
		<u>Phalaenoptilus nuttallii</u>	common poorwill	1	17	X					
Apodiformes	Apodidae	<u>Aeronautes saxatalis</u>	white-throated swift		1						
	Trochilidae	<u>Cynanthus latirostris</u>	broad-billed hummingbird	2	19	X					
		<u>Archilochus alexandri</u>	black-chinned hummingbird	5	35	X					
		<u>Calypte costae</u>	Costa's hummingbird	1	5						P

				Conservation designation by agency							
Order	Family	Scientific name	Common name	Powell	I&M	Friederici	U.S. Fish and Wildlife Service ^a	Bureau of Land Management ^b	U.S. Forest Service ^b	State of Arizona ^c	Arizona Partners in Flight ^d
Apodiformes	Trochilidae	<i>Selasphorus platycercus</i>	broad-tailed hummingbird		3						
		<i>Selasphorus rufus</i>	rufous hummingbird		2						
Coraciiformes	Alcedinidae	<i>Ceryle alcyon</i>	belted kingfisher		3					WSC	
Piciformes	Picidae	<i>Melanerpes uropygialis</i>	Gila woodpecker	116	176	X	BCC				
		<i>Sphyrapicus nuchalis</i>	red-naped sapsucker		2						
		<i>Picoides scalaris</i>	ladder-backed woodpecker	24	64	X					
		<i>Colaptes auratus</i>	northern flicker	15	11						
		<i>Colaptes chrysoides</i>	gilded flicker	20	17	X	BCC				P
Passeriformes	Tyrannidae	<i>Camptostoma imberbe</i>	northern beardless-tyrannulet	2	10	X					
		<i>Contopus sordidulus</i>	western wood-pewee		5						
		<i>Empidonax traillii</i>	willow flycatcher		1					WSC	
		<i>Empidonax wrightii</i>	gray flycatcher	2							
		<i>Empidonax occidentalis</i> or <i>difficilis</i> ^e	western flycatcher	2	1						
		<i>Empidonax occidentalis</i>	cordilleran flycatcher		1						
		<i>Sayornis nigricans</i>	black phoebe		16	X					
		<i>Sayornis saya</i>	Say's phoebe		3	X					
		<i>Pyrocephalus rubinus</i>	vermillion flycatcher	15	28	X					
		<i>Myiarchus tuberculifer</i>	dusky-capped flycatcher	1							
		<i>Myiarchus cinerascens</i>	ash-throated flycatcher	45	76	X					
		<i>Myiarchus tyrannulus</i>	brown-crested flycatcher	24	134	X					
		<i>Tyrannus vociferans</i>	Cassin's kingbird	18	21	X					
		<i>Tyrannus verticalis</i>	western kingbird		9	X					
	Vireonidae	<i>Vireo bellii</i>	Bell's vireo	24	150	X	BCC			S	
		<i>Vireo plumbeus</i>	plumbeous vireo	1	1						
		<i>Vireo huttoni</i>	Hutton's vireo	1	1						
		<i>Vireo gilvus</i>	warbling vireo	1	4						
	Mimidae	<i>Toxostoma curvirostre</i>	curve-billed thrasher	74	90	X					
		<i>Toxostoma crissale</i>	crissal thrasher	1	5		BCC				
Passeriformes	Corvidae	<i>Aphelocoma californica</i>	western scrub-jay	18	9						
		<i>Corvus corax</i>	common raven	16	17	X					
	Hirundinidae	<i>Progne subis</i>	purple martin	10	54	X					P
		<i>Tachycineta thalassina</i>	violet-green swallow	4	4						
	Paridae	<i>Baeolophus wollweberi</i>	bridled titmouse	2	4						

Order	Family	Scientific name	Common name	Powell	I&M	Friederici	Conservation designation by agency				
							U.S. Fish and Wildlife Service ^a	Bureau of Land Management ^b	U.S. Forest Service ^b	State of Arizona ^c	Arizona Partners in Flight ^d
Passeriformes	Remizidae	<i>Auriparus flaviceps</i>	verdin	58	152	X					
	Troglodytidae	<i>Campylorhynchus brunneicapillus</i>	cactus wren	133	142	X					
		<i>Salpinctes obsoletus</i>	rock wren	6	7	X					
		<i>Catherpes mexicanus</i>	canyon wren	2	11	X					
		<i>Thryomanes bewickii</i>	Bewick's wren	60	129	X					
		<i>Troglodytes aedon</i>	house wren	3	11						
	Regulidae	<i>Regulus calendula</i>	ruby-crowned kinglet	11	17						
	Sylviidae	<i>Polioptila caerulea</i>	blue-gray gnatcatcher		5						
		<i>Polioptila melanura</i>	black-tailed gnatcatcher	4	13	X					
	Turdidae	<i>Sialia mexicana</i>	western bluebird	1	3						
		<i>Myadestes townsendi</i>	Townsend's solitaire	1							
		<i>Catharus guttatus</i>	hermit thrush	1	5						
		<i>Turdus migratorius</i>	American robin		2						
	Mimidae	<i>Mimus polyglottos</i>	northern mockingbird	4	4	X					
	Sturnidae	<i>Sturnus vulgaris</i>	European starling	5	3						
	Bombycillidae	<i>Bombycilla cedrorum</i>	cedar waxwing		4						
	Ptilonotidae	<i>Phainopepla nitens</i>	phainopepla	15	23	X					
	Parulidae	<i>Vermivora celata</i>	orange-crowned warbler		1						
		<i>Vermivora ruficapilla</i>	Nashville warbler		1						
		<i>Vermivora luciae</i>	Lucy's warbler	84	183	X					P
		<i>Dendroica petechia</i>	yellow warbler	20	25	X					
		<i>Dendroica coronata</i>	yellow-rumped warbler	3	7						
		<i>Dendroica nigrescens</i>	black-throated gray warbler		1						
		<i>Dendroica townsendi</i>	Townsend's warbler		1						
		<i>Oporornis tolmiei</i>	Macgillivray's warbler		1						
		<i>Wilsonia pusilla</i>	Wilson's warbler	4	15						
Passeriformes	Thraupidae	<i>Piranga rubra</i>	summer tanager	24	40	X					
		<i>Piranga ludoviciana</i>	western tanager	3	7						
	Emberizidae	<i>Pipilo chlorurus</i>	green-tailed towhee		9						
		<i>Pipilo maculatus</i>	spotted towhee	3	4						
		<i>Pipilo fuscus</i>	canyon towhee	16	52	X					
		<i>Pipilo aberti</i>	Abert's towhee	16	42	X					
		<i>Aimophila carpalis</i>	rufous-winged sparrow	27	65	X	BCC				P

Order	Family	Scientific name	Common name	Powell	I&M	Friederici	Conservation designation by agency				
							U.S. Fish and Wildlife Service ^a	Bureau of Land Management ^b	U.S. Forest Service ^b	State of Arizona ^c	Arizona Partners in Flight ^d
Passeriformes	Emberizidae	<i>Aimophila cassinii</i>	Cassin's sparrow		1						
		<i>Aimophila ruficeps</i>	rufous-crowned sparrow		2	X					
		<i>Spizella passerina</i>	chipping sparrow	18	12						
		<i>Spizella breweri</i>	Brewer's sparrow	11	8						
		<i>Spizella atrogularis</i>	black-chinned sparrow		4						
		<i>Poocetes gramineus</i>	vesper sparrow		3						
		<i>Passerculus sandwichensis</i>	savannah sparrow	2							
		<i>Chondestes grammacus</i>	lark sparrow	2	8						
		<i>Amphispiza bilineata</i>	black-throated sparrow	52	62	X					
		<i>Melospiza lincolni</i>	Lincoln's sparrow	8	10						
		<i>Zonotrichia leucophrys</i>	white-crowned sparrow	5	4						
		<i>Junco hyemalis</i>	dark-eyed junco	5	6						
	Cardinalidae	<i>Cardinalis cardinalis</i>	northern cardinal	58	114	X					
		<i>Cardinalis sinuatus</i>	pyrrhuloxia	17	12	X					
		<i>Pheucticus melanocephalus</i>	black-headed grosbeak	1	7						
		<i>Passerina caerulea</i>	blue grosbeak	8	38						
		<i>Passerina amoena</i>	lazuli bunting	1	9	X					
		<i>Passerina cyanea</i>	indigo bunting		3						
		<i>Passerina versicolor</i>	varied bunting	2	19	X					
	Icteridae	<i>Molothrus aeneus</i>	bronzed cowbird	1							
		<i>Molothrus ater</i>	brown-headed cowbird	10	44	X					
		<i>Icterus cucullatus</i>	hooded oriole	1	3	X					
		<i>Icterus bullockii</i>	Bullock's oriole		5	X					
		<i>Icterus parisorum</i>	Scott's oriole		5						
Passeriformes	Fringillidae	<i>Carpodacus mexicanus</i>	house finch	36	70	X					
		<i>Carduelis pinus</i>	pine siskin		1						
		<i>Carduelis psaltria</i>	lesser goldfinch	33	66						

^a SC = Species of conservation concern; C = Species that has been petitioned for threatened or endangered status. BCC = Bird of Conservation Concern for the Sonoran Desert. (USFWS 2002)

^b S = Sensitive species (HDMS 2004).

^c WSC = Wildlife species of species concern (HDMS 2004).

^d P = Arizona Partners in Flight (Latta et al. 1999).

^e Included in the number of species found for this study, but not for the overall number of species.

Appendix B. UTM (NAD 83) coordinates of stations and transect breaks and midpoints, Rincon Creek area, Saguaro National Park, 2003 and 2004.

Survey type	Description	Transect	Identifier	UTM X	UTM Y
Breeding-season (VCP)	Station location	Riparian ^a	1	535857	3554748
			2	535609	3554787
			3	535347	3554872
			7	536100	3554810
		Upland	8	536345	3554871
			1	535867	3555107
			2	535615	3555312
			3	535350	3555366
Non-breeding (line transect)	Section break starting/stopping point	Riparian ^a	A	536333	3554889
			B	536096	3554809
			C	535853	3554747
			D	535604	3554776
			E	535342	3554874
			F	535082	3554930
			G	534859	3555041
			H	534629	3555172
		Upland	J	535111	3555412
			K	535355	3555367
			L	535600	3555328
			M	535792	3555168
			N	535997	3555027
		Riparian ^a	A-B	536215	3554849
			B-C	535975	3554778
			C-D	535729	3554762
			D-E	535473	3554825
			E-F	535212	3554902
			F-G	534971	3554986
			G-H	534744	3555107
		Upland	J-K	535233	3555390
			K-L	535478	3555348
			L-M	535696	3555248
			M-N	535895	3555098

^a Called "Lower Rincon Creek" by Powell et al. (2002, 2003).

Appendix C. Ranking of the ten most abundant species, from each season and transect, based on relative abundance scores reported in Tables 1 and 2. See Appendix A for scientific names.

Season	Transect	Species	Relative abundance rank	Relative abundance score
Breeding	Riparian	Gambel's quail	1	1.97
		Lucy's warbler	2	1.94
		white-winged dove	3	1.00
		Bewick's wren	4	0.91
		mourning dove	5	0.8
		verdin	6	0.74
		Gila woodpecker	7	0.69
		northern cardinal	8	0.63
		Bell's vireo	9	0.57
		yellow warbler	10	0.51
	Upland	cactus wren	1	1.67
		black-throated sparrow	2	1.00
		Gambel's quail	3	0.57
		curve-billed thrasher	4	0.52
		verdin	5	0.48
		white-winged dove	6	0.38
		rufous-winged sparrow	6	0.38
		brown-crested flycatcher	6	0.38
		mourning dove	7	0.33
		Lucy's warbler	8	0.29
Non-breeding	Riparian	chipping sparrow	1	2.26
		mourning dove	2	0.97
		cactus wren	3	0.86
		Gila woodpecker	4	0.77
		Gambel's quail	4	0.77
		house finch	5	0.63
		curve-billed thrasher	5	0.63
		western scrub-jay	6	0.57
		northern flicker	7	0.43
		Bewick's wren	7	0.43
	Upland	cactus wren	1	2.45
		curve-billed thrasher	2	1.25
		black-throated sparrow	2	1.25
		Gambel's quail	3	1.05
		chipping sparrow	4	0.40
		Gila woodpecker	5	0.35
		verdin	5	0.35
		rufous-winged sparrow	5	0.35
		canyon towhee	6	0.3
		rock wren	7	0.25

Appendix D. Number of observations (sum) and relative abundance (mean $\pm$ SE) of birds recorded within 75 m of count stations during breeding-season surveys by University of Arizona Inventory personnel, Rincon Creek riparian transect, Saguaro National Park, 2001 and 2002 (Powell et al., unpublished data). List excludes flyovers and observations made outside of the eight-minute count period. See Methods section for details on estimation of relative abundance and effort. See Appendix A for scientific names.

Common name	2001 (n = 20)			2002 (n = 35)		
	Sum	Mean	SE	Sum	Mean	SE
Gambel's quail	13	0.65	0.196	38	1.09	0.427
Cooper's hawk				1	0.03	0.029
gray hawk				1	0.03	0.029
red-tailed hawk	1	0.05	0.050	1	0.03	0.029
white-winged dove	24	1.20	0.247	29	0.83	0.156
mourning dove	26	1.30	0.242	24	0.69	0.178
common ground-dove	1	0.05	0.050			
great horned owl	3	0.15	0.109			
broad-billed hummingbird	2	0.10	0.069	1	0.03	0.029
black-chinned hummingbird	5	0.25	0.123	4	0.11	0.055
Costa's hummingbird	1	0.05	0.050			
rufous hummingbird				2	0.06	0.040
belted kingfisher				1	0.03	0.029
Gila woodpecker	11	0.55	0.170	17	0.49	0.103
ladder-backed woodpecker	9	0.45	0.135	10	0.29	0.088
gilded flicker	2	0.10	0.100			
northern beardless-tyrannulet	1	0.05	0.050			
western wood-pewee				2	0.06	0.040
cordilleran flycatcher				1	0.03	0.029
black phoebe	1	0.05	0.050			
vermillion flycatcher	4	0.20	0.092	9	0.26	0.103
ash-throated flycatcher	19	0.95	0.223	4	0.11	0.068
brown-crested flycatcher	15	0.75	0.204	46	1.31	0.204
Cassin's kingbird	5	0.25	0.143	5	0.14	0.073
western kingbird	2	0.10	0.100	1	0.03	0.029
Bell's vireo	7	0.35	0.109	17	0.49	0.095
curve-billed thrasher	4	0.20	0.092	8	0.23	0.072
common raven	2	0.10	0.069			
purple martin	5	0.25	0.160	9	0.26	0.118
bridled titmouse				5	0.14	0.117
verdin	26	1.30	0.179	18	0.51	0.086
cactus wren	6	0.30	0.105	14	0.40	0.102
Bewick's wren	20	1.00	0.192	24	0.69	0.114
house wren				1	0.03	0.029
ruby-crowned kinglet				1	0.03	0.029
blue-gray gnatcatcher				2	0.06	0.040
black-tailed gnatcatcher				1	0.03	0.029
northern mockingbird				1	0.03	0.029
European starling	1	0.05	0.050			
phainopepla	2	0.10	0.069	1	0.03	0.029
orange-crowned warbler				1	0.03	0.029
Lucy's warbler	34	1.70	0.231	40	1.14	0.184
yellow warbler	4	0.20	0.092	9	0.26	0.075
yellow-rumped warbler	1	0.05	0.050			
Wilson's warbler	1	0.05	0.050	4	0.11	0.068
summer tanager	9	0.45	0.135	5	0.14	0.073

Common name	2001 (n = 20)			2002 (n = 35)		
	Sum	Mean	SE	Sum	Mean	SE
western tanager	1	0.05	0.050			
green-tailed towhee				1	0.03	0.029
canyon towhee	3	0.15	0.109	6	0.17	0.065
Abert's towhee	4	0.20	0.092	6	0.17	0.077
rufous-winged sparrow	3	0.15	0.082	10	0.29	0.088
chipping sparrow				3	0.09	0.086
Brewer's sparrow				1	0.03	0.029
lark sparrow				3	0.09	0.063
black-throated sparrow	5	0.25	0.160			
Lincoln's sparrow				1	0.03	0.029
northern cardinal	8	0.40	0.112	24	0.69	0.152
black-headed grosbeak	1	0.05	0.050	1	0.03	0.029
blue grosbeak	1	0.05	0.050	8	0.23	0.072
lazuli bunting	1	0.05	0.050			
indigo bunting	1	0.05	0.050			
brown-headed cowbird	4	0.20	0.092	4	0.11	0.068
hooded oriole				1	0.03	0.029
Bullock's oriole	2	0.10	0.069			
house finch	7	0.35	0.109	4	0.11	0.068
lesser goldfinch	9	0.45	0.235	16	0.46	0.161
Species richness		47			52	

Appendix E. Ratio of survey effort divided by number of species found at each transect for breeding-season surveys by University of Arizona Inventory personnel, Saguaro National Park, 2001 and 2002 (Powell et al., unpublished data). Survey effort is the number of stations multiplied by the number of visits. “Lower Rincon Creek” transect corresponds to the riparian transect of this study. Data includes flyovers and species seen between 8-minute count periods.

Unit	Plot type	Transect name	Number of species	Survey effort	Ratio
Saguaro West	Random	204	32	20	0.63
		212	33	16	0.48
		213	26	16	0.62
		238	30	16	0.53
		239	29	16	0.55
Saguaro East	Random	101	34	16	0.47
		106	42	16	0.38
		107	33	16	0.48
		111	37	16	0.43
		112	39	16	0.41
		113	34	16	0.47
		115	36	16	0.44
		120	38	16	0.42
		121	35	16	0.46
		125	39	16	0.41
		128	36	16	0.44
		130	35	16	0.46
		138	44	16	0.36
		139	37	16	0.43
		155	36	16	0.44
		189	32	16	0.50
		191	22	16	0.73
	Special area-low elevation	Lower Rincon Creek	82	87	1.06
Upper Rincon Creek		66	51	0.77	
Loma Verde Creek		48	23	0.48	
Box Canyon		71	63	0.89	
	Special area-middle elevation	Rincon Peak	49	24	0.49
Happy Valley Saddle		52	36	0.69	

Appendix F. Number of observations (sum) and relative abundance (mean $\pm$ SE) of birds recorded during non-breeding-season surveys by University of Arizona Inventory personnel, Rincon Creek area, Saguaro National Park, 2002 and 2003 (Powell et al., unpublished data). List includes flyovers and observations made at unlimited distances from the observer. See Appendix A for scientific names.

Common name	Transect					
	Riparian (n = 28)			Upland (n = 16)		
	Sum	Mean	SE	Sum	Mean	SE
Gambel's quail	26	0.93	0.493	18	1.13	1.125
Cooper's hawk	2	0.07	0.050			
red-tailed hawk	3	0.11	0.060			
American kestrel	1	0.04	0.036			
mourning dove	3	0.11	0.060	1	0.06	0.063
Gila woodpecker	26	0.93	0.199	2	0.13	0.085
red-naped sapsucker	1	0.04	0.036			
ladder-backed woodpecker	8	0.29	0.101	2	0.13	0.085
northern flicker	3	0.11	0.060			
red-shafted flicker	4	0.14	0.067			
gilded flicker	3	0.11	0.079	5	0.31	0.176
black phoebe	1	0.04	0.036			
Say's phoebe	1	0.04	0.036			
curve-billed thrasher	11	0.39	0.107	5	0.31	0.151
western scrub-jay	2	0.07	0.050			
verdin	16	0.57	0.149	6	0.38	0.180
cactus wren	15	0.54	0.131	24	1.50	0.329
rock wren	1	0.04	0.036	4	0.25	0.112
Bewick's wren	12	0.43	0.108	1	0.06	0.063
house wren	8	0.29	0.087			
ruby-crowned kinglet	18	0.64	0.172	2	0.13	0.085
black-tailed gnatcatcher				6	0.38	0.180
hermit thrush	2	0.07	0.050			
American robin	3	0.11	0.107			
cedar waxwing	12	0.43	0.429			
phainopepla	4	0.14	0.067			
green-tailed towhee	4	0.14	0.067			
spotted towhee	1	0.04	0.036			
canyon towhee	13	0.46	0.131	2	0.13	0.085
Abert's towhee	7	0.25	0.083			
rufous-winged sparrow	22	0.79	0.202	13	0.81	0.245
chipping sparrow	20	0.71	0.514	1	0.06	0.063
black-chinned sparrow	3	0.11	0.060			
vesper sparrow	4	0.14	0.085			
black-throated sparrow	18	0.64	0.422	26	1.63	0.676
Lincoln's sparrow	6	0.21	0.094			
dark-eyed junco	13	0.46	0.167			
northern cardinal	19	0.68	0.219			
pyrrhuloxia	5	0.18	0.090			
house finch	13	0.46	0.167	2	0.13	0.085
pine siskin	5	0.18	0.179			
lesser goldfinch	23	0.82	0.512			
Species richness		41			17	

Appendix G. Number of observations (sum) and relative abundance (mean $\pm$ SE) of birds recorded within 75 m of count stations during breeding-season surveys, Saguaro National Park East expansion area and Rocking k development, 1999 (data from Powell 2000). Flyovers and observations made outside of the eight-minute count period are excluded. See Methods section for details on estimation of relative abundance and effort. See Appendix A for scientific names.

Common name	Vegetation community					
	Uplands (n = 66)			Xeroriparian (n = 84)		
	Sum	Mean	SE	Sum	Mean	SE
Gambel's quail	12	0.18	0.083	83	0.99	0.212
American kestrel				1	0.01	0.012
white-winged dove	13	0.20	0.049	66	0.79	0.091
mourning dove	15	0.23	0.068	32	0.38	0.076
great horned owl				4	0.05	0.029
black-chinned hummingbird				1	0.01	0.012
Costa's hummingbird				2	0.02	0.017
Gila woodpecker	10	0.15	0.049	34	0.40	0.056
northern flicker	5	0.08	0.033	13	0.15	0.040
western flycatcher				2	0.02	0.017
ash-throated flycatcher	20	0.30	0.065	47	0.56	0.064
Bell's vireo				16	0.19	0.043
curve-billed thrasher	26	0.39	0.074	29	0.35	0.057
common raven				1	0.01	0.012
purple martin	2	0.03	0.021	22	0.26	0.080
verdin	17	0.26	0.054	72	0.86	0.068
cactus wren	46	0.70	0.089	61	0.73	0.068
canyon wren				1	0.01	0.012
Bewick's wren				9	0.11	0.034
black-tailed gnatcatcher	30	0.45	0.081	17	0.20	0.044
northern mockingbird	3	0.05	0.026	2	0.02	0.017
phainopepla	5	0.08	0.039	27	0.32	0.059
Lucy's warbler	1	0.02	0.015	70	0.83	0.072
Wilson's warbler				5	0.06	0.035
summer tanager				1	0.01	0.012
western tanager	1	0.02	0.015	5	0.06	0.026
green-tailed towhee	1	0.02	0.015	7	0.08	0.035
canyon towhee	9	0.14	0.043	12	0.14	0.048
Abert's towhee	2	0.03	0.021	2	0.02	0.017
rufous-winged sparrow				8	0.10	0.032
vesper sparrow	1	0.02	0.015			
black-throated sparrow	61	0.92	0.079	22	0.26	0.054
northern cardinal	10	0.15	0.054	58	0.69	0.078
pyrrhuloxia	5	0.08	0.039	5	0.06	0.026
black-headed grosbeak	2	0.03	0.021	4	0.05	0.023
lazuli bunting				1	0.01	0.012
varied bunting				7	0.08	0.030
bronzed cowbird	1	0.02	0.015			
brown-headed cowbird	33	0.50	0.102	38	0.45	0.084
hooded oriole				3	0.04	0.020
Scott's oriole	2	0.03	0.021	4	0.05	0.023
house finch	31	0.47	0.099	41	0.49	0.086
lesser goldfinch	1	0.02	0.015	1	0.01	0.012
Species richness		28			41	

