Vertebrate wildlife and habitat relationships in an urban park setting: Papago Park, Phoenix, Arizona

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Abstract

An inventory of floral and vertebrate faunal communities was completed at Papago Park, a fragmented parcel of Sonoran desertscrub within urbanized east-central Phoenix, Arizona. The inventory was completed to delineate habitat types, estimate relative abundance and species composition of vertebrate wildlife, examine their relationship to vegetation parameters, and infer changes in ecological condition in the Park over time. Seven vegetation associations were identified in the Park, with the majority of the area consisting of creosote bush-bursage-paloverde association. Floral composition consisted primarily of native plant species, although introduced and near-native species were locally common in developed portions of the Park. The highest density of native birds occurred in native xeroriparian habitat, while areas with relatively high proportions of exotic plant species were dominated by exotic bird species. The density of small mammals was highest at the base of rock outcrops. Black-tailed jackrabbits occurred at relatively high densities in open habitats, while cottontail rabbits were associated with dense vegetation types. The highest density of small reptiles (lizards) occurred in xeroriparian habitats. Significant positive correlations were found between native vegetation volume and total wildlife density, native vegetation volume and native bird density, native plant species richness and total wildlife species richness, and native plant species richness and native bird species richness. A comparison to historical data for Papago Park suggests that avian species composition is relatively unchanged over time. Comparison to wildlife communities in similar but less fragmented Sonoran desertscrub habitat suggests that other wildlife groups (e.g. reptiles and small mammals) at Papago Park have become depauperate over time. Factors associated with urbanization surrounding the Park have likely changed plant species composition, relative abundance, and wildlife communities.

INTRODUCTION

With human population growth and the associated expansion of urban areas, there is increasing interest in the effects of urbanization on native wildlife communities, both from theoretical and applied management perspectives. Primary effects of urbanization on wildlife, cited by researchers, include habitat modification (Minton 1968; Gavareski 1976; Dickman and Doncaster 1987; Bolger et al. 1991; Morrison and Scott 1994) and fragmentation (Oxley et al. 1974; Gavareski 1976; Bolger et al. 1991). Changes in plant species composition and structure can negatively affect habitat quality (Morrison and Scott 1994) and reduce individual fitness (Bolger et al. 1991). Fragmentation of natural habitats may lead to the local extinction of some species, particularly those that occur at low densities, due to low recolonization rates, increased predation by natural and feral predators and competitors, and other environmental and stochastic factors (Wilcove 1985; Bolger et al. 1991; Morrison and Scott 1994). In Sonoran desertscrub habitats in the southwestern United States, the density and species richness of wildlife is affected by the amount of native vegetation (Mills 1989), vegetation structure (Christensen 1997), housing density (Tweit and Tweit 1986; Germaine 1995), and connectivity to natural habitats (Germaine 1995).

This study describes and analyzes plant and wildlife communities at Papago Park, a fragment of Sonoran desertscrub within an urban setting. Specific objectives are to (1) describe and to characterize the density and species richness of wildlife relative to vegetation parameters and (2) to compare wildlife density and species richness at Papago Park to that recorded

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historically and to an area of similar, but relatively unfragmented habitat.

METHODS

Study Area

Papago Park consists of 476 ha of open space and developed facilities located in southeast Phoenix, Maricopa County, Arizona. Elevation in the study area ranges from 400 m to 550 m above mean sea level. In addition to natural open space, the Park also includes bicycle and pedestrian trails, paved roads, fishing lagoons, athletic facilities, picnic areas, a municipal golf course, botanical gardens, zoo, stadium, sports complex, and museum. The majority of the study area is surrounded by residential, commercial, and recreational development. Papago Park is not directly connected to any larger natural desert areas.

In general, plant communities at Papago Park are transitional between Lower Colorado River and Arizona Upland Sonoran Desertscrub (Brown 1994). A total of 7 distinct vegetation associations occur: (1) Creosotebush (*Larrea tridentata*)-Bursage (*Ambrosia deltoidea*)-Palo Verde (*Cercidium* spp.) (CBP, 70% of vegetated areas of the Park); (2) Creosotebush-Bursage-Palo Verde-Saguaro (*Carnegiea gigantea*) (CBPS, 20%); (3) Creosotebush-Bursage (CB, 8%); (4) Palm (*Washingtonia filifera*)-Cottonwood (*Populus fremontii*)-Willow (*Salix gooddingii*)(PCW, <2%); (5) Mesquite (*Prosopis velutina*)-Palo Verde-Ironwood (*Olneya tesota*) (MPI, <1%); (6) Salt Cedar (*Tamarix ramosissima*)-Mixed Deciduous Scrub (SC-mix, <1%);and (7) Salt Cedar (SC, <1%).

Birds

A survey transect, 12 km-long, was established in the Park along which wildlife surveys were conducted. Birds surveys were conducted along the survey transect in the spring (29 April, and 1, 6, 8 May), summer (10, 11, 12 June), and fall (4, 26, 27 September, and 22 October) of 1997. They also took place in the winter (14 and 25 January, and 12 and 27 February) of 1997-1998. Birds were identified to species by sight and/or sound and their distance from the transect line was estimated to the nearest 5 m, to a maximum distance of 100 m on either side of the transect. For narrow linear habitats or small habitat patches, total counts of birds within the patch were completed. Total species richness was calculated as the total number of species encountered in a particular habitat type during the study period. Total bird density was calculated for each habitat type by dividing the total number of birds recorded during all 4 seasons by the effective survey area. For narrow, linear habitats and small patches the effective survey area was calculated as the total patch or habitat area. For the remaining areas, density was calculated as the number of birds within the distance intervals from the transect in which most detections occurred.

Mammals

Nocturnal trapping was conducted for rodents in 7 of the 8 habitat types identified, with trapping intensity within a habitat type based roughly on its areal extent within the Park. A total of 400 trap-nights were surveyed between 28 October and 31 October 1997. Approximately 100 Sherman live traps were set each of 4 consecutive nights along traplines at 15-20 m intervals. They were baited with rolled oats, set, and checked early the following morning. Species composition of other, diurnally active, mammals was recorded opportunistically throughout the duration of the study.

Reptiles and Amphibians

Surveys for diurnal reptiles were conducted in late spring (3, 4, 5, and 9 June) and in late summer-early fall (9, 10, 26, and 27 September) of 1997. All reptiles encountered within 15 m of the 12-km survey transect were recorded, by species and by habitat type. Species richness was calculated as the total number of species encountered. Density of reptiles was estimated by dividing the number of individuals recorded within 15 m of the transect line by the effective survey area (length of the transect through a habitat type multiplied by the effective survey width, i.e., 30 m). Nocturnal reptile surveys were conducted in the early summer (21 and 25 June, and 1 and 22 July) and again in late summer and fall (26 August, and 8 and 9 September, and 28 October) of 1997 by driving Park roads and walking some of the trails and paths.

Vegetation Volume

Vegetation volume was measured using the pole-technique, a modified vertical line-intercept method (Mills et al. 1991). Vegetation volume transects were established at uniform intervals along the 12 km survey transect. A total of 94 transects were established and surveyed in 7 of the 8 identified habitat types.

Comparison with Historical and Contemporary Studies

Bird species richness and composition recorded over a 3-day period from 10 June to 12 June 1997 were compared to that recorded over a 5-day period from 30 May to 4 June 1917 (Swarth 1920). At that time, Papago Park (Papago Saguaro National Monument) was relatively undisturbed and unfragmented, and located outside the urbanized area of Phoenix (Gart 1996).

Results were compared to data collected from a less fragmented area of Sonoran desertscrub, located in the foothills of the McDowell Mountains, 33 km northeast

of Papago Park (Christensen 1997). Species richness of birds, diurnal reptiles, and small mammals (rodents) were compared between these study areas based on a calibrated level of effort and data collected at approximately the same time of year and in similar habitat types.

Differences in species richness between Papago Park and (1) historic data and (2) data collected at the McDowell Mountains site were qualitatively compared; sample size was either insufficient or complete data sets were not available to test for statistical significance.

Data Analysis

Both total bird density, native bird density, and diurnal reptile density were compared over all habitat types at Papago Park by analysis of variance (ANOVA), using mean density per season as replicates. The differences between each of the habitat types were investigated using Tukey's multiple comparison test. Differences in species richness between habitats were not tested, due to inherent bias associated with differences in the total area of each habitat surveyed. Density and species richness of small mammals was not compared between habitat types due to relatively small sample size and lack of replicates.

RESULTS AND DISCUSSION

Birds

A total of 80 bird species were recorded in Papago Park over the study period (Table 1). Eighteen species were associated predominantly with aquatic habitat provided by the fishing lagoons in the east-central portion of the park. Forty-eight species were resident breeding birds, breeding either in the Park or in the vicinity. The remainder were transients (spring and or fall migrants) or winter visitors. Three common exotic species occur in the Park: Rock Dove (*Columba livia*), European Starling (*Sturnus vulgaris*), and House Sparrow (*Passer domesticus*). These species were primarily found in developed areas of the Park. Great-tailed Grackles (*Quiscalus mexicanus*) and Inca Doves (*Columbina inca*) have expanded their range recently from Mexico. They are also primarily associated with developed areas and are referred to here as "near-native" species.

Total bird density varied significantly (overall ANOVA, $F=43.35$, $p \ll 0.001$, Figure 1A) among habitat types surveyed, with highest densities occurring in PCW and MPI, and the lowest densities in CBP and CB. High bird densities in PCW were partially due to the high abundance of exotic and near-native bird species. Other researchers have found non-native and near-native birds to be dominant in urbanized environments having exotic vegetation and have suggested that this type of vegetation is a more suitable resource for these species (Beissinger and Osborne 1982; Mills et al. 1989; Germaine 1995).

When near-native and exotic species are eliminated from the analysis, native bird density also varies significantly among habitat types (overall ANOVA, $F=27.02$, $p \ll 0.001$, Figure 1A). In contrast to total bird density, native bird density was highest in MPI and SC-mix and lowest in CBP and CB. Except for MPI and SC-Mix, PCW had higher bird densities compared to other habitats. This is likely due to the presence of water that attracts native birds from surrounding habitats.

The relative abundance of bird species also varies among habitat types. PCW and SC show relatively high degrees of dominance (most of the bird density contributed by a few species); while other habitats display somewhat more evenness (bird species contribute more evenly to the total density). In PCW, the avian community is strongly dominated by exotic and non-native species, particularly Rock Doves, Great-tailed Grackles, and House Sparrows. MPI showed similar total bird densities, however, the avian community is dominated by native species.

Both total bird species richness and native bird species richness were similar among habitat types. Total and native bird species richness were similar between CBP, CBPS, CB, PCW and MPI habitats and higher than those in SC and SC-mix habitats (Figure 1B). CBP had the highest species richness, while SC had the lowest. Statistical comparison of species richness among habitats is confounded by differences in the total areas surveyed (James and Rathbun 1981). Generally, larger areas have greater numbers of species. Although CBP had the highest species richness, it also represented the largest area surveyed. It is likely that if equal size areas of all habitat types were surveyed, MPI and CBPS would have significantly higher species richness than CBP.

Mammals

A total of 11 species of diurnal and nocturnal mammals were recorded during surveys (Table 2). A total of 4 species were recorded during nocturnal small mammal trapping. The desert pocket mouse (*Perognatus pennicilatus*) was the most frequently trapped species, followed by the cactus mouse (*Peromyscus eremicus*). One Harris' antelope ground squirrel (*Ammospemophilus harrisi*) was trapped. Arizona cotton rats (*Sigmodon arizonae*) are fairly abundant along a stand of cattails at one of the fishing lagoons. Rock outcrops had the highest percent trap success (64.5%, n=2), while salt cedar-mixed deciduous and scrub habitat had the lowest (17%, n=1). Trap success across the other habitat types was fairly similar, ranging from 22% to 31%. The high numbers

along rock outcrops may be credited to the high density of shrubs, other vegetation, and shelter sites. Hafner (1977) found rodent population densities to be correlated with shrub density. Low densities of small mammals in the SC-mix habitat may be due to several factors. Szaro and Belfit (1983) speculated that pocket mice were absent from riparian areas due to inadequate soil conditions for burrowing (loose sand), absence of shrub and herbaceous species used as food resources, and a high water table and irregular flooding events.

Reptiles and Amphibians

A total of 11 species of reptiles and amphibians were recorded in Papago Park during diurnal and nocturnal surveys (Table 3). Diurnal reptile density varied significantly by habitat type (overall ANOVA, F=16.86, p«0.001). MPI had significantly higher diurnal reptile densities than all other habitat types. There was no significant difference in reptile densities between CBP, CBPS, CB, SC, SC-mix, or PCW habitats. Overall reptile densities consisted primarily of western whiptails (*Cnemidophorous tigris*), the most abundant reptile species in the Park. Chuckwallas (*Sauromalus obesus*) were observed only on rock outcrops. Desert iguanas (*Dipsosaurus dorsalis*) were seen only in CB habitat north of the botanical gardens.

Vegetation Volume

Vegetation volume differed significantly among some of the habitat types in Papago Park, both when total vegetation volume (native and exotic plants) was compared (overall ANOVA, F=3.58,p=0.002) and when vegetation volume of native species only was compared (overall ANOVA, F=3.4, p=0.003, Figure 2). Total vegetation volume was not significantly different among MPI, SC, SC-mix, or PCW; however, it was significantly higher in these habitats than in CBP, CBPS, and CB. When only native vegetation volume is considered, there were no significant differences among MPI, PCW, and SC-mix, but these 3 habitat types had higher vegetation volume than CBP, CBPS, CB, and SC.

Results of correlation analyses between vegetation volume and wildlife parameters are summarized in Table 4. Total vegetation volume was significantly correlated with total wildlife density (R^2=0.57, p=0.04, Figure 3A). Although statistically significant, this correlation is relatively weak and is primarily attributable to bird densities. Native vegetation volume was significantly correlated with native bird density (R^2=0.64, p=0.02, Figure 3B). Furthermore, native plant species richness was significantly correlated with both total wildlife species richness (R^2=0.68, p=0.02, Figure 3C) and native bird species richness (R^2=0.78, p=0.005, Figure 3D). The positive relationship between the density and species richness of vegetation and that of wildlife is consistent with the findings of other researchers (Mills et al. 1989; Germaine 1995; Christensen 1997).

Comparison with Historical and Contemporary Studies

A similar number of bird species was found at Papago Park in 1917 compared to 1997. A total of 30 species were recorded at each of these times. However, 4 of these species recorded in 1997 were exotic or near-native species (Great-tailed Grackle, Inca Dove, Rock Dove, and European Starling). Species recorded during the 1917 survey which were not recorded at Papago Park in the 1997 study were the Burrowing Owl (*Athene cunicularia*) and Arizona Crested (Brown-crested) Flycatcher (*Myiarchus tyrannulus*). Burrowing Owls are not known to occur in the Park at this time, although there is an active re-introduction program underway north of the Park. Brown-crested Flycatchers were reported during an Arizona Breeding Bird Atlas Survey in 1993, but were believed to be migrants or transients. Apparent loss of this species as a breeding bird may be related to the loss of saguaros, evidenced by historical photographs from the 1920's and 1940's, and the lack of recruitment of this species in most areas of the Park. Species richness of birds and lizards was similar between Papago Park and the McDowell Mountains site, although species richness of mammals appears to be lower at Papago Park (Figure 4). Other studies also suggest that birds and lizards are less affected by habitat fragmentation than other wildlife. Gavareski (1976) found that a large park with natural vegetation supported a high diversity of birds, comparable to that found in a control area outside the urban influence. Similarly, researchers have found that low density residential development can maintain natural diversity of birds if native vegetation is retained or used in landscaping (Mills et al. 1989; Tweit and Tweit 1986). Relatively high population densities of lizards may make this group less prone to local extinction compared to larger wildlife species. Bolger et al. (1991) found that species with higher population densities persist longer in fragmented habitats. Loss of small mammals in fragmented habitats has been found by other researchers (Morrison et al. 1994; Germaine 1995) and may be due to lower population densities and inability to recolonize areas. Heavily traveled roads surrounding Papago Park may effectively isolate mammal populations by preventing movement to and from adjacent natural areas. Lower numbers of larger mammal species at Papago Park compared to the McDowell Mountain site may be due to low population densities and lack of movement corridors that have resulted in local extinction, and/or habitat differences between these areas.

CONCLUSIONS

Density and species richness of wildlife at Papago Park varied among the habitat types present. Highest bird densities were found in a primarily non-native vegetation type associated with recreational ponds and in native xeroriparian habitats. In the former, high bird densities were partially due to high abundance and dominance of exotic and near-native species and the presence of surface water. Rock outcrops had the highest density of small mammals. Lizard densities were significantly higher in xeroriparian habitats and similar among all other habitats. Total vegetation volume was higher in xeroriparian and riparian habitats compared to upland habitats. Significant positive correlations were found between total vegetation volume and total wildlife density, native vegetation volume and native bird density, native plant species richness and total wildlife species richness, and native plant species richness and bird species richness. A comparison with historical wildlife data from a less fragmented and less urbanized area suggests that birds and lizards in Papago Park have been relatively unaffected by urbanization and fragmentation, while mammal species have become depauperate.

ACKNOWLEDGMENTS

This study was funded by the Arizona Game and Fish Department Heritage Fund and administered by the City of Phoenix Parks, Recreation, and Library Department. We would like to thank the Department and the City for their assistance. We are grateful to Kerry Christensen for use of comparative data from the McDowell Mountain site. This study was completed under contract by SWCA, Inc. Environmental Consultants.

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Table 1. Bird species recorded at Papago Park, Phoenix, Arizona.

Pied-billed Grebe
Double-crested Cormorant
Great Blue Heron
Green Heron
Black-crowned Night Heron
Canada Goose
Mallard
Northern Pintail
Northern Shoveler
Gadwall
American Wigeon
Ring-necked Duck
Ruddy Duck
Turkey Vulture
Sharp-shinned Hawk
Cooper's Hawk
Harris' Hawk
Red-tailed Hawk
American Kestrel
Prairie Falcon
Gambel's Quail
Common Moorhen
American Coot
Killdeer
Rock Dove
White-winged Dove
Mourning Dove
Inca Dove
Yellow-headed Parrot
Greater Roadrunner
Western Screech-owl
Great Horned Owl
Lesser Nighthawk
White-throated Swift
Black-chinned Hummingbird
Anna's Hummingbird
Belted Kingfisher
Gila Woodpecker
Ladder-backed Woodpecker
Gilded Flicker
Ash-throated Flycatcher
Cassin's Kingbird
Western Kingbird
Violet-green Swallow
Northern Rough-winged Swallow
Cliff Swallow
Verdin
Cactus Wren
Rock Wren
Ruby-crowned Kinglet
Blue-gray Gnatcatcher
Black-tailed Gnatcatcher
Northern Mockingbird
Bendire's Thrasher
Curve-billed Thrasher
American Pipit
Phainopepla
Loggerhead Shrike
European Starling
Orange-crowned Warbler
Yellow Warbler
Yellow-rumped Warbler
MacGillivray's Warbler
Wilson's Warbler
Green-tailed Towhee
Abert's Towhee
Chipping Sparrow
Brewer's Sparrow
Black-throated Sparrow
White-crowned Sparrow
Dark-eyed Junco
Red-winged Blackbird
Great-tailed Grackle
Bronzed Cowbird
Brown-headed Cowbird
Northern Oriole
House Finch
Lesser Goldfinch
House Sparrow
Say's Phoebe

Table 2. Mammals recorded at Papago Park in Phoenix, Arizona

Scientific Name	Common Name
Ammospermophilus harrisii	Harris' antelope squirrel
Canis latrans	Coyote
Lepus californicus	Black-tailed jack rabbit
Perognathus penicillatus	Desert pocket mouse
Peromyscus eremicus	Cactus mouse
Pipistrellus hesperus	Western pipistrelle
Spermophilus tereticaudus	Round-tailed ground squirrel
S. variegatus	Rock squirrel
Sigmodon arizonae	Arizona cotton rat
Sylvilagus audubonii	Desert cottontail
Urocyon cinereoargenteus	Gray fox

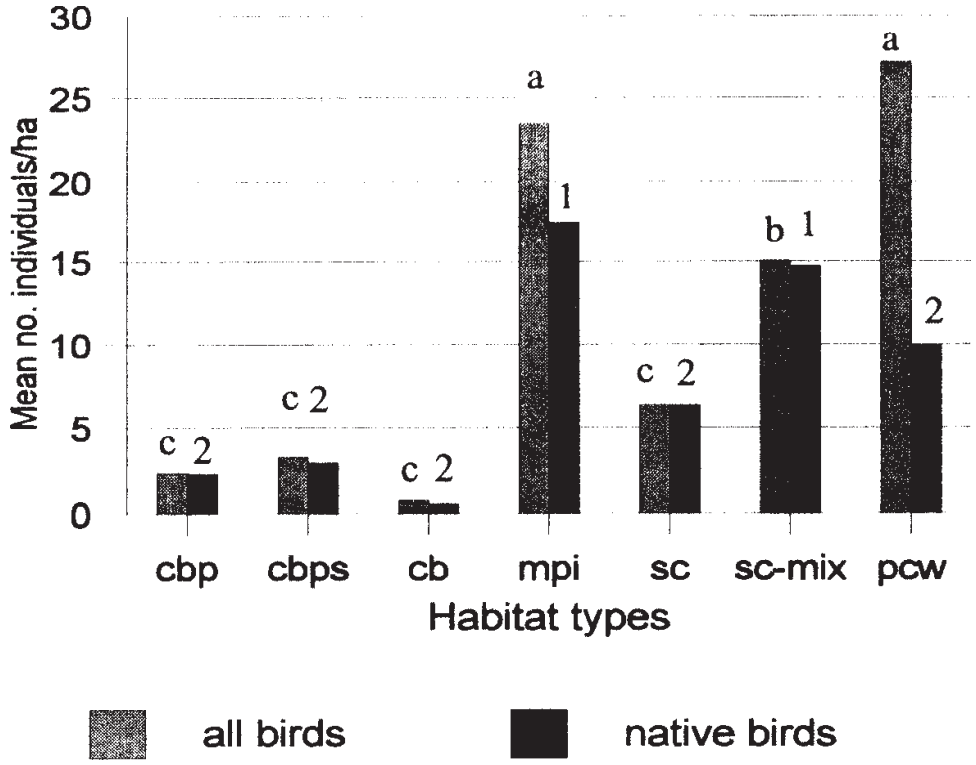
Table 3. Reptiles and amphibians recorded at Papago Park in Phoenix, Arizona.

Scientific Name	Common Name
Bufo woodhousei	Woodhouse toad
Callisaurus draconoides	Zebra-tailed lizard
Cnemidophorus tigris	Western whiptail
Coleonyx variegatus	Western banded gecko
Dipsosaurus dorsalis	Desert iguana
Kinosternon sonoriense	Sonoran mud turtle
Masticophis flagellum	Coachwhip snake
Pituophis melanoleucus	Gopher snake
Sauromalus obesus	Chuckwalla
Sceloporus magister	Desert spiny lizard
Scaphiopus couchii	Couch's spadefoot toad
Uta stansburiana	Side-blotched lizard

Table 4. Summary of correlation analyses among vegetation and wildlife variables in Phoenix, Arizona.

Independent variable	Dependent variable	Multiple correlation coefficient (R^2)	p-value	significance
Total veg. volume	Total wildlife density	0.57	0.04	*
Total veg.volume	Total wildlife spp. richness	0.02	0.77	ns
Native veg. volume	Total wildlife density	0.54	0.05	*
Native veg. volume	Total wildlife spp .richness	0.02	0.77	ns
Native plant spp.richness	Total wildlife density	0.10	0.24	ns
Native plant spp.richness	Total wildlife spp. richness	0.68	0.02	*
Total veg. volume	Total bird density	0.66	0.02	*
Total veg. volume	Total bird spp. richness	0.14	0.41	ns
Native veg. volume	Native bird density	0.64	0.02	*
Native veg. volume	Native bird spp. richness	0.05	0.63	ns
Native plant spp. richness	Native bird density	0.16	0.37	ns
Native plant spp. richness	Native bird spp. richness	0.78	0.005	*
Total veg. volume	Total diurnal reptile density	0.12	0.22	ns
Total veg. volume	Total diurnal reptile spp. richness	0.02	0.75	ns
Native veg. volume	Total diurnal reptile density	0.04	0.67	ns
Native veg. volume	Total diurnal reptile spp. richness	0.005	0.88	ns
Native plant spp. richness	Total diurnal reptile density	0.53	0.06	ns
Native plant spp. richness	Total diurnal reptile spp. richness	0.0006	0.96	ns

(A)



(B)

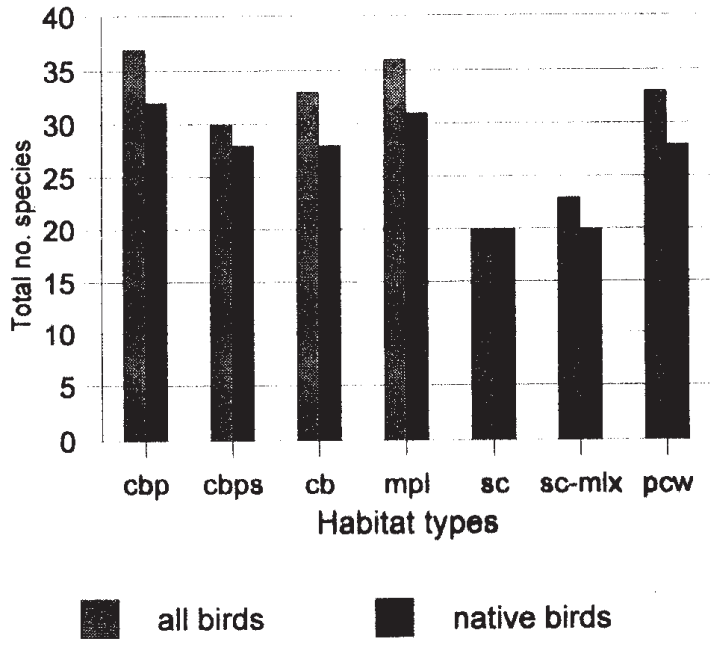


Figure 1. Mean densities (A) of all birds and native birds in habitat types at Papago Park. Different letters denote statistically significant differences between density of all birds, while different numbers denote statistically significant differences between density of native birds between habitat types. Mean species richness (B) of all birds and native birds in habitat types at Papago Park

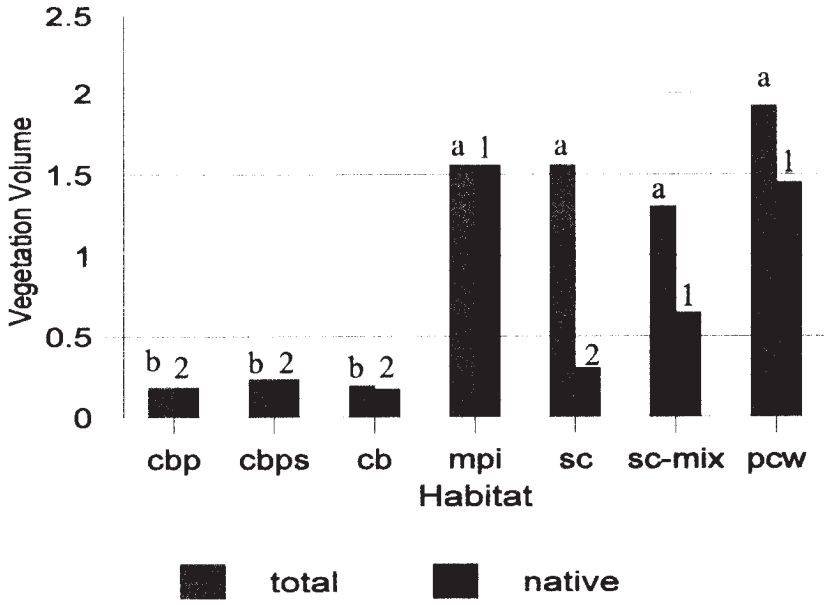


Figure 2. Mean vegetation volume of all plant species and native plant species in habitat types at Papago Park. Different letters denote statistically significant differences in vegetation volume of all plant species, while different numbers denote statistically significant differences in vegetation volume of native plant species between habitat types.

(A)

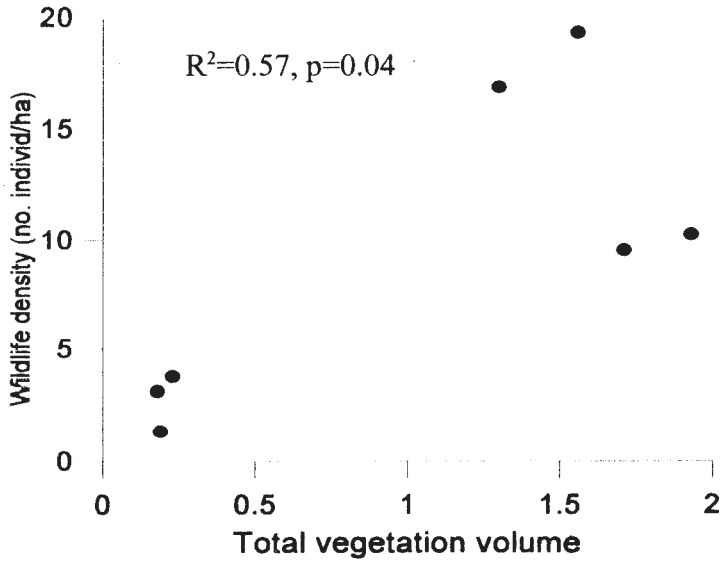
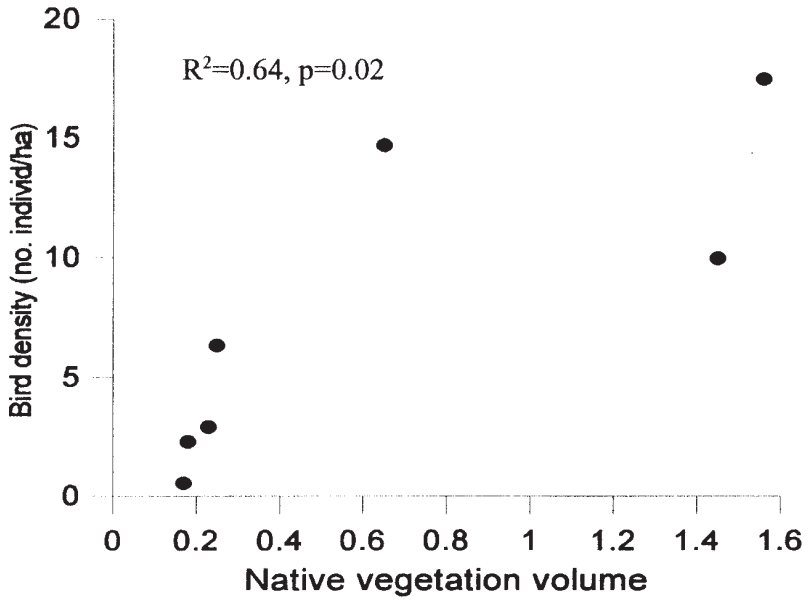


Figure 3. Relationships between (A) total vegetation volume and total wildlife density, (B) native vegetation volume and native bird density, (c) native plant species richness and total wildlife species richness, and (D) native plant species richness and native bird species richness at Papago Park.

(B)



(C)

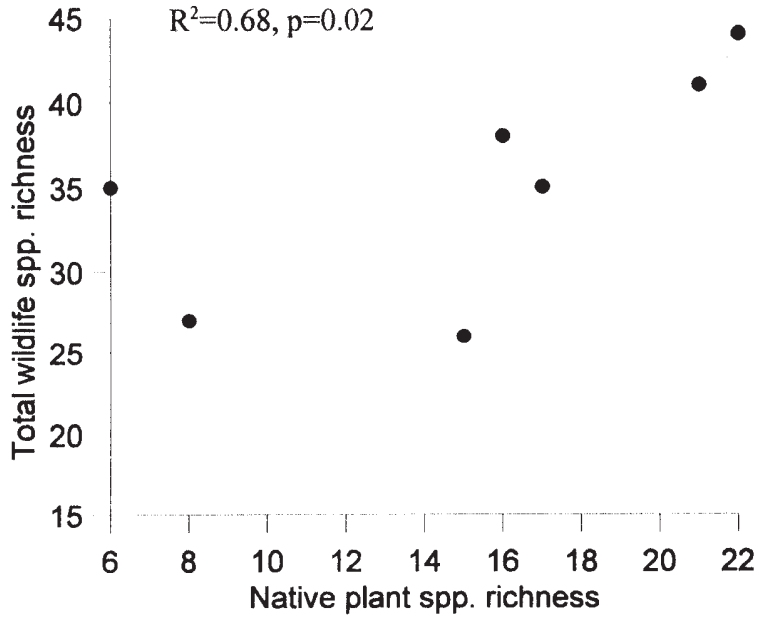


Figure 3. (Cont) Relationships between (A) total vegetation volume and total wildlife density, (B) native vegetation volume and native bird density, (c) native plant species richness and total wildlife species richness, and (D) native plant species richness and native bird species richness at Papago Park.

(D)

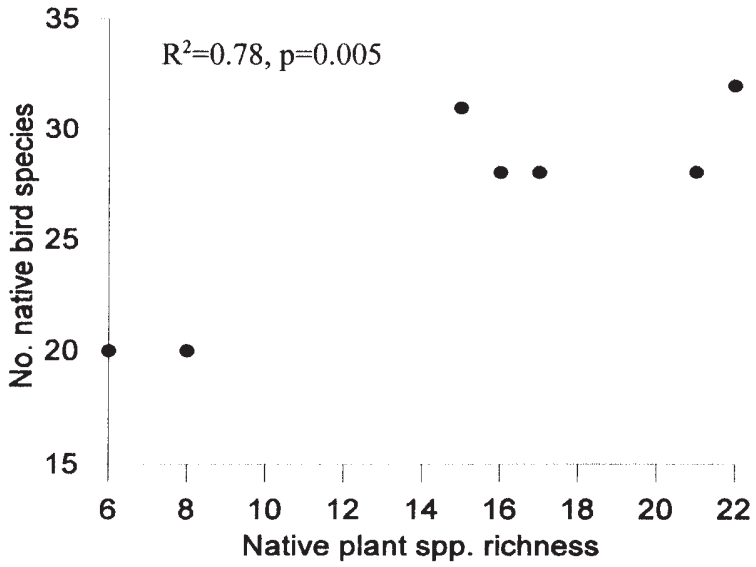


Figure 3. (Cont) Relationships between (A) total vegetation volume and total wildlife density, (B) native vegetation volume and native bird density, (c) native plant species richness and total wildlife species richness, and (D) native plant species richness and native bird species richness at Papago Park.

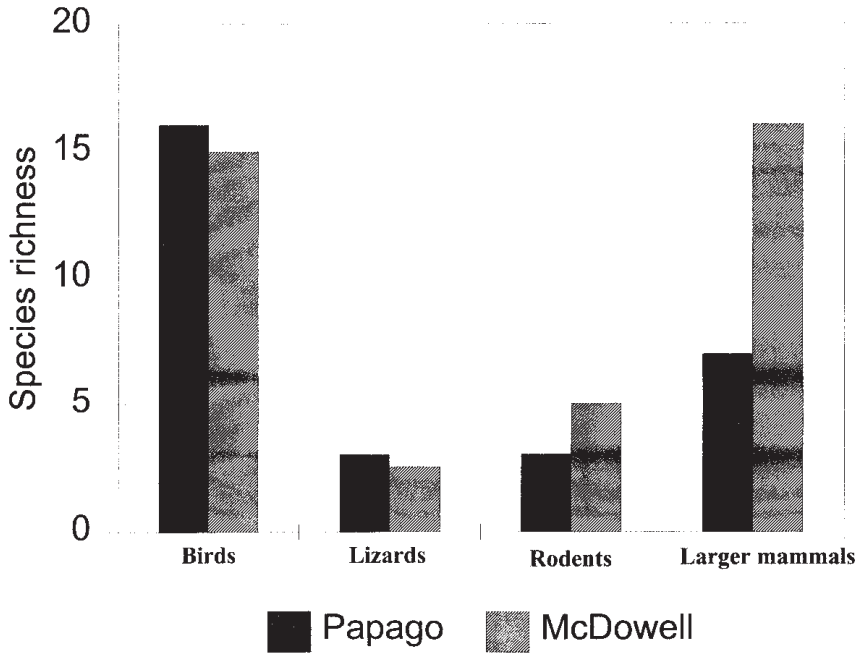


Figure 4. Comparison of bird, lizard, rodent, and larger mammal species richness among Papago Park and the McDowell Mountains site.