Turfgrass and Environmental Research Online

...Using Science to Benefit Golf

USDA Forest Service scientists compared a number of golf courses in the Albuqurque area with paired natural areas to see whether golf courses have the potential of acting as surrogate riparian habitats for Southwestern birds. They concluded that golf courses do have the potential to support riparian bird communities, but that their conservation potential can be enhanced through the addition of habitat complexity and structure utilizing native plants.

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PURPOSE

The purpose of *USGA Turfgrass and Environmental Research Online* is to effectively communicate the results of research projects funded under USGA's Turfgrass and Environmental Research Program to all who can benefit from such knowledge. Since 1983, the USGA has funded more than 290 projects at a cost of $25 million. The private, non-profit research program provides funding opportunities to university faculty interested in working on environmental and turf management problems affecting golf courses. The outstanding playing conditions of today's golf courses are a direct result of ***using science to benefit golf***.

Southwestern Golf Courses Provide Needed Riparian Habitat for Birds

Michele Merola-Zwartjes and John P. DeLong

SUMMARY

The goal of our study was to determine how the development of golf courses in the desert environment impacts the native bird community, and particularly to see whether golf courses have the potential of acting as surrogate riparian habitats for Southwestern birds. We compared the avian communities on five golf courses in the Albuquerque, New Mexico area (four traditional and one "naturalistic") to those of five paired natural areas that served as reference sites. Birds were surveyed using points counts during the breeding season over two years.

- In agreement with most other studies of urbanization effects, we found that bird abundance increased on four out of five golf courses.
- In contrast to many studies of urban birds, we found that total species richness and species diversity was higher on the golf courses in three out of five cases, and native species richness was higher on all five of the golf courses. Of the bird species unique to the golf course communities, 72% were riparian associates.
- Although they had high numbers of native species, most of the individuals on golf courses were relatively common generalist species, with one exception. The naturalistic golf course that was dominated by native vegetation had greater native bird species richness, diversity, and abundance when compared both to its reference site and all of the other courses.
- We conclude that golf courses do have the potential to support riparian bird communities, but that their conservation potential can be enhanced through the addition of habitat complexity and structure utilizing native plants.

Most studies of birds in urban areas have reported a decrease in avian species richness and/or diversity in association with urbanization, although density typically increases (3, 12, 18). However, Blair (5) found that although bird abundance and diversity did indeed decrease in highly developed areas, total species richness, diversity, and density increased at moderate levels of development, such as golf courses and residential areas with detached housing. He suggested that the increased heterogeneity of the habitat, in terms of both changes in vegetation and the introduction of structures, and the abundance and diversity of resources available to birds in such areas, may account for this trend. A few other studies have also reported an increase in bird species richness or diversity in areas characterized by relatively low levels of development (1, 22, 26).

In the southwestern U.S., the greatest diversity of breeding birds is normally found in riparian habitats; it is estimated that the bird diversity in riparian zones surpasses that of all other western habitat types combined (8, 21, 23, 37). In a region characterized by low rainfall and often sparse vegetation, riparian zones act as an oasis for both migratory and resident birds, offering a relative abundance of the critical elements of

Many species of swallow, including the barn swallow, were attracted to the open areas of turf on the golf course for foraging. The swallows were not observed on the reference sites during sampling. *Photo by Dave Menke, courtesy U.S. Fish and Wildlife Service*

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Relatively common and wide-ranging species, such as this American robin, tended to make up the majority of birds observed on most of the golf courses. P*hoto by Lee Karney, courtesy U.S. Fish & Wildlife Service.*

water, food, and cover (9, 45).

Natural riparian systems are quickly disappearing, however, in response to the demands of a growing human population on these areas for water, recreation, and development, as well as degradation due to factors such as flood control efforts and improper grazing practices (14, 24, 31). Estimates are that up to 95% of western riparian habitats have been lost or degraded over the past century, and many of the bird species associated with these systems have been extirpated or have experienced severe declines (11, 20, 25).

Most golf courses in the Southwest provide a combination of habitat characteristics that are reminiscent of the riparian systems used by western birds. They often have permanent water sources used either as water hazards or irrigation, or both. They have deciduous trees that provide cover, shade, nest sites, and food. Depending upon the extent, composition, and structure of the vegetation in out-of-play areas, golf courses may potentially offer rewarding foraging and/or nesting habitat for birds that utilize shrub habitats as well as those that forage on the turf or in the canopy. In his study over a range of urban gradients, Blair (5) found that avian species richness and density peaked on a golf course, and Terman (39) also reports on a golf course with high species richness and bird densities.

Given the extensive loss of riparian systems throughout the West and the potential similarity of habitats on golf courses to those of riparian areas, we were interested in determining whether golf courses might possibly serve as surrogate riparian habitats for breeding birds in the Southwest. We hypothesized that golf courses in the Southwest would not only have greater avian species richness and abundance when compared to the surrounding natural environment, but that the golf courses would also support a greater number of bird species normally associated with riparian areas.

The goals of our study were to determine: (1) how the presence of a golf course impacts the native bird community through comparisons of abundance, species richness, diversity, evenness and productivity between five golf courses and five undisturbed reference areas assumed to represent the original bird communities; (2) whether golf courses support high numbers of typically riparian bird species; and (3) if possible, identify those features of golf courses that are most conducive to supporting high numbers of native and riparian bird species.

Study Sites

Our study sites were five golf courses and five paired reference sites in the high desert region of Albuquerque, New Mexico. Courses were chosen to represent a range of vegetation types, course features (e.g., water sources), and landscape settings. The participating golf courses were the Albuquerque Country Club (ACC), Four Hills Country Club (FH), Paradise Hills Golf Club (PH), PaaKo Ridge Golf Club (PK), and University of New Mexico Championship Course (UNM).

The Albuquerque Country Club is located

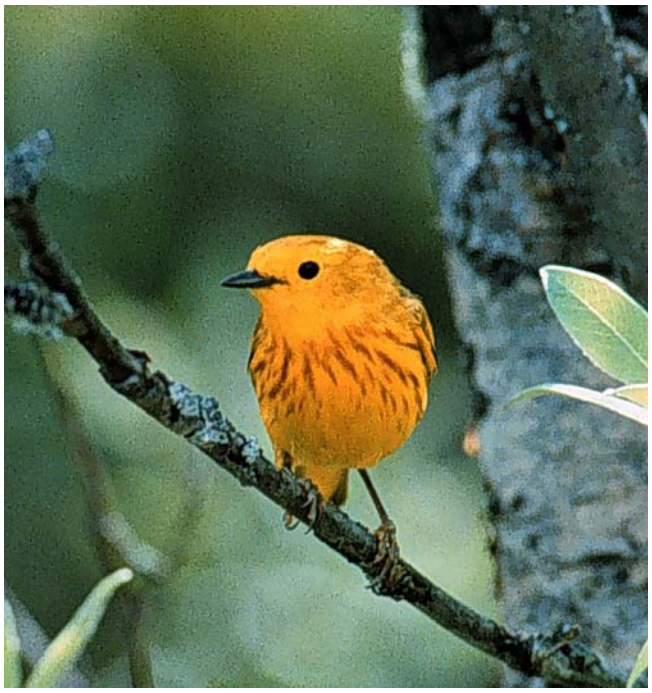
in a residential area of downtown Albuquerque, directly across from the riparian forest that lines the Rio Grande. Established in 1929, this 106-acre course is a traditional park-like course, consisting primarily of turfgrass with large, isolated trees between the fairways. There is no understory, and there are no natural areas or water hazards on this course, although an irrigation ditch runs along one side.

The Four Hills Country Club course, 153 acres in size, was established in 1957 in eastern Albuquerque, a residential area at the edge of the Sandia Mountain foothills. There are two large ponds on the course, only one of which is partially surrounded by typical riparian vegetation (e.g., cat-tails, *Typha spp.*; willows, *Salix spp.*). Most of the course is park-like in structure, but there are a few large out-of-play areas that are not maintained and that retain primarily native vegetation typical of this area (e.g., blue grama, *Bouteloua gracilis*; cholla cactus, *Opuntia imbricata*; rabbitbrush, *Chrysothamnus nauseosus*).

The Paradise Hills Golf Club was established in a residential area on Albuquerque's west mesa in 1963. This 133-acre course is primarily park-like in structure and has no remnant native vegetation or understory. It does, however, have one large pond partially surrounded by cat-tails and some large cottonwoods (*Populus spp.*).

PaaKo Ridge is the newest of the golf courses. The initial construction was completed in 2000 in the eastern foothills of the Sandia Mountains. This 217-acre course was constructed in the midst of expansive pinyon-juniper (*Pinus edulis-Juniperus monosperma*) woodlands. The surrounding area is largely undeveloped except for the low-density housing that is under construction in association with the PaaKo development. The PaaKo course makes maximum use of the natural topography and vegetation of the area. The only turf present on the course is on the fairways inserted between large areas of natural woodland. Three ponds were constructed on the PaaKo course and were just beginning to get some emergent vegetation growth around the perimeters toward the end of our study.

The UNM Championship Course was built in 1965 in southern Albuquerque. It is situated in a low-density industrial area near the airport. This 212-acre course has several large areas of remnant native vegetation characterized by various bunchgrasses and shrubs such as yucca (*Yucca spp.*), rabbitbrush, and fourwing saltbush (*Atriplex canescens*) between the more traditional park-like fairways separated by rows of trees. The UNM course also has two large ponds, each surrounded with riparian vegetation (cat-tails, willows, and large cottonwoods).



The yellow warbler is an example of a riparian specialist that was present on a golf course, but was not observed at any of the reference sites. *Photo courtesy of U.S. Fish and Wildlife Service.*

A paired reference site was selected for each golf course. Reference sites were nearby natural areas that reflected as much as possible the habitat conditions that would have been present prior to the construction of the comparison course. The purpose of these reference sites was to provide an avian community "baseline". Birds on the reference sites were assumed to represent the original bird community for its paired golf course.

For the Albuquerque Country Club, the Rio Grande floodplain forest protected in a City of Albuquerque Open Space area directly across the road from the course served as the reference site. This forest is dominated by large cottonwoods

The western tanager was one of the native species observed on several golf courses, but not on any of the paired reference sites in this study. *Photo by Gary Kramer, courtesy of U.S. Fish and Wildlife Service.*

with a dense understory. The Four Hills Open Space in the nearby foothills served as the reference site for the Four Hills Golf Course. This area was characterized by sparsely distributed pinyons and junipers amongst native grama grasses and shrubs and cacti such as rabbitbrush and cholla.

For Paradise Hills, we used the desert grasslands of the Boca Negra Open Space unit near Petroglyph National Monument. This area was characterized by desert bunchgrasses and scattered shrubs such as fourwing saltbush and sand sage (*Artemisia filifolia*) with occasional junipers. For PaaKo, nearby pinyon-juniper woodlands in the Cibola National Forest served as the reference site. For the UNM Championship Course, an extensive area of undeveloped, privately-owned lands directly across the freeway from the course served as the reference site. This area was primarily desert grassland with occasional small shrubs (e.g., fourwing saltbush, rabbitbrush).

With the exception of PaaKo, all reference sites were located within one km of their paired golf course. The PaaKo reference site was several kilometers from the course, but the terrain and habitat-type are largely uninterrupted between the two and they sit at approximately the same elevation.

Methods

Bird surveys

We conducted point counts at each site every three to four weeks during the breeding season from mid-April through July in 2001 and 2002. We have a total of eight counts for each site over the two-year period of the study. Counts at each golf course and its paired reference site were conducted on consecutive days whenever possible, and always within the same seven-day period.

Point count stations were established a minimum of 300 meters apart. Due to the size of the golf courses, this restricted the number of stations to five at each site. Counts began 15 minutes after sunrise and were completed by 10:00 a.m. We recorded all birds heard or seen within a five-minute period at each station, and recorded the distance to each bird detected. We estimated distances to the nearest meter and used laser rangefinders to calibrate and check our distance estimates. To minimize variability due to observer differences, the same two observers conducted all counts throughout the study.

Nest Boxes

We installed nest boxes on several of the sites to study the breeding bird community on the golf courses. Although this restricted our observations to cavity-nesting species, it was the most efficient method for determining which birds were actually breeding on the courses, as our access to the golf courses was extremely limited and did not allow time for conducting nest searches. We restricted nest boxes to those courses for which the paired reference sites would be expected to support native cavity-nesters. We did not install

nest boxes at PH or UNM due to the absence of trees or snags at their paired reference sites.

Eleven nest boxes (nine standard bluebird-size boxes and two wren-size boxes) were installed at each of six sites: ACC, FH, PK, and the three paired reference sites. Boxes were checked for activity weekly throughout the breeding season in 2001 and 2002. An observer noted the stage of nest construction, if any, the species occupying the box, the number of eggs present, number of nestlings present, the number of young presumed fledged, and any mortality or predation events. In the absence of evidence of predation, we assumed that young were successfully fledged if the box was empty and the young had been close to fledging at the last check.

Data Analysis

For our estimates of bird abundance, species richness, and composition, we used all individuals heard or seen within 100 meters of the observer. We did not treat individual points as independent observations at each site, but pooled all observations into a single count for each survey day. Numbers of individuals observed were averaged for each of eight surveys to derive an index of abundance (mean number of individuals observed per survey) for each site.

Species richness is the total number of species observed at each site over all eight surveys, since equal numbers of points at each site and equal numbers of surveys at each ensured equivalent sampling effort. Discussions of species composition include only the species observed during the point counts (i.e., from a total of eight surveys over two years, each survey representing a total effort of five five-minute point counts) and is not intended to represent the total avian community composition of a site.

We looked at the community composition of the courses by classifying the individuals observed in our samples into one of two categories, either "native" or "cosmopolitan/introduced" species. We considered a cosmopolitan species to be a bird that is widespread, abundant, and that frequently increases in association with human habitation. Non-native (introduced) is any species that originated outside of North America.

Species that we classified as cosmopolitan or introduced (the latter indicated by an asterisk) included: domestic duck*, ring-necked pheasant* (*Phasianus colchicus*), mourning dove (*Zenaida macroura*), rock dove* (*Columba livia*), American crow (*Corvus brachyrhynchos*), American robin (*Turdus migratorius*), European starling* (*Sturnus vulgaris*), Brewer's blackbird (*Euphagus cyanocephalus*), common grackle (*Quiscalus quiscula*), great-tailed grackle (*Quiscalus mexicanus*), brown-headed cowbird (*Molothrus ater*), house finch (*Carpodacus mexicanus*), and house sparrow* (*Passer domesticus*). For lack of a better term, the classification of "native" is intended to represent relatively more specialized native species.

We considered birds to be "riparian associates" if they were identified as such by either Krueper (24) or Cartron et al. (8). Species in this category are those that are frequently associated with riparian habitats in the southwestern U.S., particularly during the breeding season, but they are not necessarily riparian obligates. Species diversity was calculated using Shannon's Index. Shannon's Index and evenness were calculated for each survey and averaged over all eight surveys for each site. All means were compared using a

The ponds on the desert golf courses attracted birds such as this black-crowned night heron. *Photo by Lee Karney, courtesy U.S. Fish and Wildlife Service.*

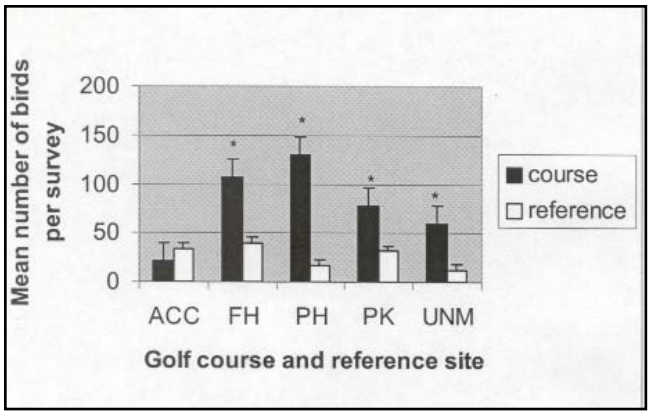


Figure 1. Index of abundance for all bird species on golf courses and reference sites, in terms of mean number of individuals detected per survey (± SE, n = 8 for all). An asterisk (*) denotes a significant difference between the abundance on a golf course and its paired reference site.

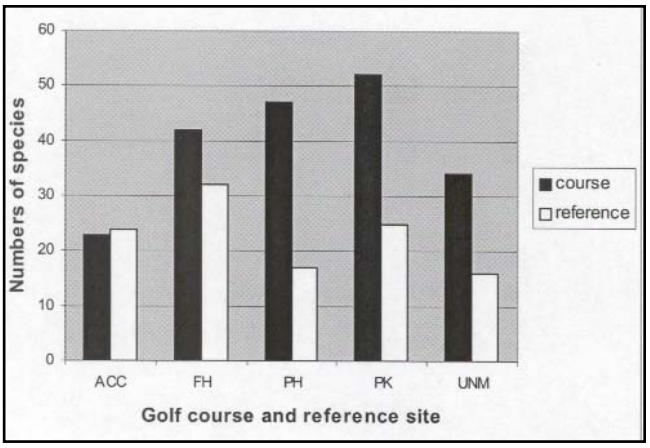


Figure 2. Species richness for all bird species on golf courses and reference sites. As survey effort was equivalent between all sites (n = 8), the total number of species observed was used for each site.

standard t-test. If variances were unequal, data were log-transformed to meet the assumptions of the test (all data are reported in their original form for ease of understanding).

Results

Avian Abundance

Birds were more abundant on golf courses than on their respective reference sites in four out of five cases (Figure 1). The exception was the Albuquerque Country Club, which did not differ from its reference site in index of abundance.

These results dispelled any concerns we may have had regarding possible bias in detectability of birds due to habitat differences between sites, as most of our reference sites were more open than the golf courses, yet we had more bird observations on the courses. In addition, for the Albuquerque Country Club, the only course with a reference site that was markedly more dense in vegetation than its paired course, we detected more birds on the reference site than at the course. Thus we believe that our results are conservative in their representation of differences between the golf courses and their reference sites.

Species Richness

Total species richness was greater on the golf course in four out of five cases (Four Hills, Paradise Hills, PaaKo, UNM; Figure 2). Only the Albuquerque Country Club had fewer bird species than its paired reference site. Native species richness (excluding cosmopolitan species) was higher at all five of the golf courses relative to their reference sites, although only marginally so at the Albuquerque Country Club (Figure 3).

Species Diversity

Three of the golf courses (Paradise Hills, PaaKo, and UNM) had greater diversity than their paired reference sites (Figure 4). There was no difference between diversity for the Four Hills course and its comparison area, and the reference site for the Albuquerque Country Club had greater diversity than the course.

Evenness

Three of five reference sites demonstrated greater evenness in the distribution of individuals among species than their paired golf courses (Figure 5). The reference sites for the Albuquerque Country Club, Four Hills, and

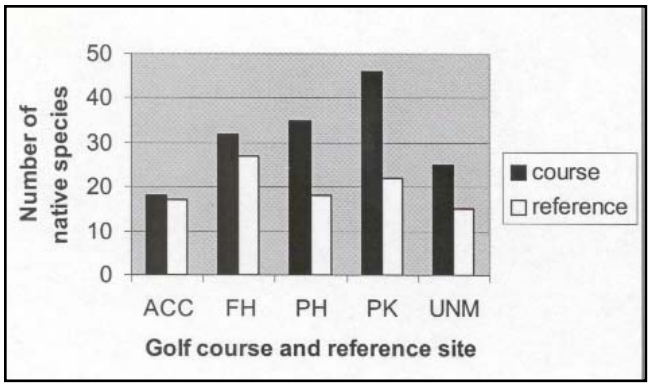


Figure 3. Species richness for all native bird species (all birds that we did not classify as cosmopolitan/introduced) on golf courses and reference sites. As survey effort was equivalent between all sites (n = 8), the total number of native species observed was used for each site.

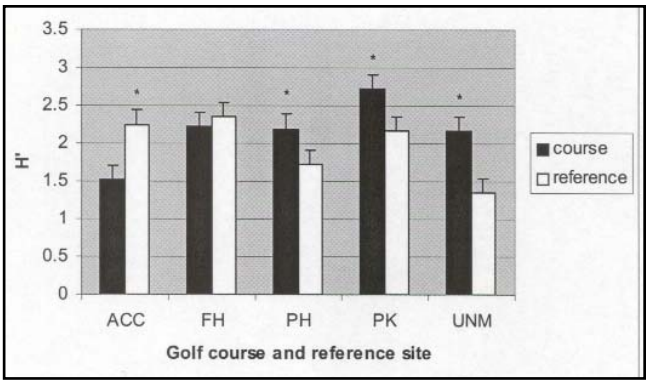


Figure 4. Shannon's Index of Diversity (H) for all golf courses and reference sites, based on the average diversity per count (± SE, n = 8 for all). An asterisk (*) denotes a significant difference between the abundance on a golf course and its paired reference site.

Paradise Hills all had greater evenness compared to the courses. Evenness did not differ between courses and reference sites for PaaKo and UNM

At three out of five golf courses, native birds were greatly outnumbered by representatives of either cosmopolitan or introduced bird species. Paradise Hills had the greatest overall index of abundance, but only 24% of the birds observed were native species (Figure 6). Four Hills and UNM also had relatively low proportions of native species (31% and 29% respectively), and at the Albuquerque Country Club 51% of the individuals observed were natives. The low representation of native species at these four courses differed from that observed at the PaaKo Ridge Golf Course, where native individuals made up 76% of the birds observed. The proportion of native species observed at reference sites exceeded that of the golf courses in all cases except that of PaaKo where there was no difference (Figure 6).

For all courses except the Albuquerque Country Club, the majority of bird species observed were either shared by the avian community on the golf course and its paired reference

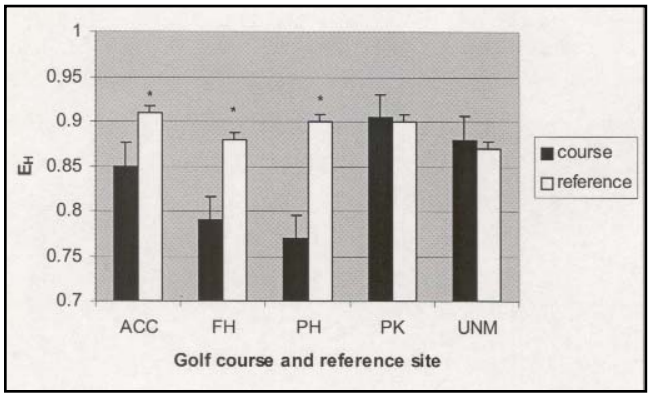


Figure 5. The evenness (E_H) of avian communities (equitable distribution of individuals across all species present) for all golf courses and reference sites, based on the average evenness per count (± SE, n = 8 for all). An asterisk (*) denotes a significant difference between the evenness on a golf course and its paired reference site.

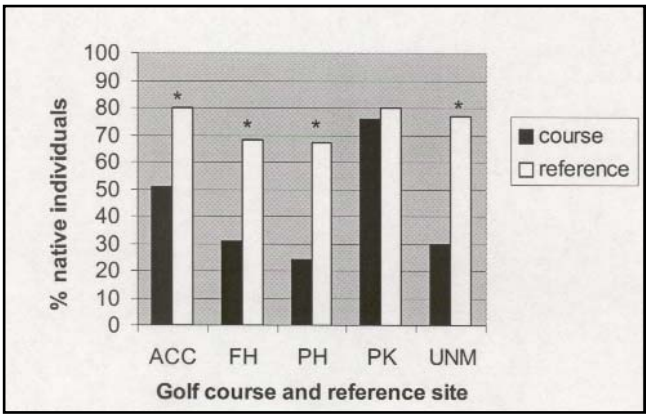


Figure 6. The proportion of the individuals observed in each survey that were native bird species (not cosmopolitan/introduced species, as identified in text). An asterisk (*) denotes a significant difference between the proportion of native species detected on a golf course and its paired reference site. A comparison across the five courses showed that the PaaKo Ridge Golf Course (PK) had a significantly greater proportion of native bird species in its avian community than the other courses.

Golf Course	Number of bird species (%)			Percent of individuals unique to golf courses	
	Unique to golf course	Shared	Unique to reference site	All riparian associates	Riparian associates without cosmpolitan/introduced species
Albuquerque Country Club	10 (30%)	13 (38%)	11 (32%)	40%	37%
Four Hills Country Club	23 (42%)	19 (34%)	13 (24%)	38%	14%
Paradise Hills Golf Club	36 (68%)	11 (21%)	6 (11%)	27%	19%
PaaKo Ridge Golf Club	27 (52%)	25 (48%)	0 (0%)	64%	49%
UNM Championship Course	25 (61%)	9 (22%)	7 (17%)	53%	29%

Table 1. Numbers and percent of all bird species that were observed only on the golf course, found on both the course and its paired reference site, or only on the reference site for all golf course-reference site pairs, and percent of individuals on golf courses that were riparian associate species (Table 2) based on breeding season point counts in 2001 and 2002 in the Albuquerque, New Mexico area.

site, or were found only on the golf course (Table 1). Four of five reference sites had some subset of the avian community that was unique, with the exception of PaaKo. In the latter case, the 25 species that were observed on the reference site were also observed on the golf course, and there were an additional 27 species that were observed only on the golf course. No species was unique to the reference site in this pairing.

We observed 65 species of birds on golf courses that were not detected on reference sites during our observations. These are species that we assume to have been added to the avian community of the golf course (Table 2). Most of the species that were unique to the golf course observations, 47 out of 65 species (72%), are birds that are considered riparian associates. The percentage of detected individuals that were riparian associates was 40.5% overall, ranging from 27% at Paradise Hills to 64% at PaaKo. A few species that are considered riparian associates also fall within our classification of cosmpolitan/introduced species (mallard, domestic duck, brown-headed cowbird, Brewer's blackbird, American robin). If these species are removed from the calculations, the percentage of individuals that were riparian associated species was 24.8% overall, ranging from 14% at Four Hills to 49% at PaaKo.

Several introduced and/or cosmopolitan species were also unique to golf course communities in our samples. Rock doves, American crows, European starlings, common grackles, great-tailed grackles, and house sparrows were all found on golf courses, but not in the reference sites. Seven native species of birds were observed on reference sites, but never detected on the golf courses: scaled quail (*Callipepla squamata*), burrowing owl (*Athene cunicularia*), crissal thrasher (*Toxostoma curvirostre*), black-throated sparrow (*Amphispiza bilineata*), Brewer's sparrow (*Spizella breweri*), western meadowlark (*Sturnella neglecta*), and Scott's oriole (*Icterus parisorum*) .

Nest boxes

Nest boxes were used at all three of the golf course-reference site pairs in both 2001 and 2002, with the exception of the Albuquerque Country Club golf course, which did not have any boxes utilized over the two years of the study (Table 3). Results were mixed in regard to breeding populations of cavity-nesting species on golf courses, and the non-use of the boxes at the Albuquerque Country Club reduced our sample size to just two courses. The PaaKo course had a high level of productivity in their nest boxes, producing 41 fledglings, all of native species, over the two seasons of our study. Productivity in terms of number of young fledged did not differ between PaaKo and its reference site. The total number of young produced at PaaKo was second only to the 43 fledglings produced at the Four Hills Country Club. However, all of the nest boxes at Four Hills were used by house sparrows, an introduced species.

Nest boxes at all three of the reference sites were occupied entirely by native species of

Common Name	Species	Common Name	Species
Pied-billed Grebe[b]	*Podilymbus podiceps*	**Yellow Warbler**[b]	*Dendroica petechia*
Black-crowned Night Heron[b]	*Nycticorax nycticorax*	Cedar Waxwing	*Bombycilla cedrorum*
Canada Goose[b]	*Branta canadensis*	**Wilson's Warbler**[a]	*Wilsonia pusilla*
Mallard[a,b]	*Anas platyrhynchos*	**Black-headed Grosbeak**	*Pheucticus melanocephalus*
American Wigeon[a,b]	Anas americana	**Blue Grosbeak**	*Guiraca caerulea*
Ruddy Duck[b]	*Oxyura jamaicensis*	Lark Sparrow	*Chondestes grammacus*
Domestic Duck[a,b]	species unknown	**Chipping Sparrow**	*Spizella passerina*
American Coot[a,b]	*Fulica americana*	**White-crowned Sparrow**	*Zonotrichia leucophrys*
Killdeer	*Charadrius vociferus*	**Lincoln Sparrow**[b]	*Melospiza lincolnii*
Spotted Sandpiper[a,b]	*Actitis macularia*	**Yellow-headed Blackbird**[b]	*Xanthocephalus xanthocephalus*
Cooper's Hawk	*Accipiter cooperi*	**Red-winged Blackbird**[a,b]	*Agelaius phoeniceus*
Swainson's Hawk	*Buteo swainsoni*	**Brewer's Blackbird** [a,b]	*Euphagus cyanocephalus*
American Kestrel	*Falco sparverius*	**Brown-headed Cowbird**	*Molothrus ater*
Rock Dove	*Columba livia*	Common Grackle[a,b]	*Quiscalus quiscula*
Broad-tailed Hummingbird	*Selasphorus platycercus*	Great-tailed Grackle[a,b]	*Quiscalus mexicanus*
Rufous Hummingbird	*Selasphorus rufus*	**Bullock's Oriole**[a,b]	*Icterus bullockii*
Northern Flicker	*Colaptes auratus*	**Western Tanager**[a]	*Piranga ludoviciana*
Downy Woodpecker[a,b]	*Picoides pubescens*	**Summer Tanager**	*Piranga rubra*
Hairy Woodpecker	*Picoides villosus*	House Sparrow	*Passer domesticus*
Western Kingbird	*Tyrannus verticalis*	**Pine Siskin**	*Carduelis pinus*
Ash-throated Flycatcher	*Myiarchus cinerascens*	**American Goldfinch**[a ,b]	*Carduelis tristis*
Western Wood-Pewee[a]	*Contopus sordidulus*	**Lesser Goldfinch**	*Carduelis psaltria*
Black Phoebe[b]	*Sayornis nigricans*	Evening Grosbeak[b]	*Coccothraustes verspertinus*
Say's Phoebe	*Sayornis saya*	Mountain Bluebird	*Sialia currucoides*
Dusky Flycatcher[b]	*Empidonax oberholseri*	**Yellow-rumped Warbler**[a]	*Dendroica coronata*
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	**Warbling Vireo**	*Vireo gilvus*
Cliff Swallow	*Hirundo pyrrhonota*	European Starling[a,b]	*Sturnus vulgaris*
Barn Swallow	*Hirundo rustica*	Curve-billed Thrasher	*Toxostoma curvirostre*
Violet-green Swallow	*Tachycineta thalassina*	**American Robin**	*Turdus migratorius*
American Crow	*Corvus brachyrhynchos*	Western Bluebird	*Sialia mexicana*
Mountain Chickadee	*Parus gambeli*	**Blue-Gray Gnatcatcher**	*Polioptila caerulea*
Bushtit	*Psaltriparus minimus*	**Ruby-crowned Kinglet**	*Regulus calendula*
White-breasted Nuthatch[a]	*Sitta carolinensis*		

[a] These species were identified in more than one golf course-reference site pair.

[b] This subset of species was observed on a golf course, but not on its paired reference site, nor on any of the other four reference sites.

Table 2. Bird species that were observed on golf courses, but not on their paired reference sites, based on sampling from breeding season point counts on five golf courses and five paired reference sites in 2001 and 2002 in the Albuquerque, New Mexico area. Species in bold are those that are often associated with riparian areas or wetlands (8, 24)

birds. The only species that we classified as a riparian associate to use a nest box for breeding on a golf course was the ash-throated flycatcher at PaaKo. Ash-throated flycatchers are not riparian obligates, however, and are very common nesters in more arid areas. Ash-throated flycatchers also nested at all three of the reference sites, as did several other native species (Table 3).

Discussion

Golf courses supported a greater number of birds than surrounding natural areas, a response that is common throughout studies of avian responses to urbanization 3, 12, 17, 19). In contrast to many such studies, we also found increased avian species richness on most of the

	ACC		FH		PK	
	Course	Reference	Course	Reference	Course	Reference
Nests Initiated						
2001	0	7	9	8	6	5
2002	0	4	10	4	10	10
Successful Nests[a]	(%)					
2001	na	67	67	100	75	67
2002	na	100	100	100	80	100
Number Fledged						
2001	na	7	19	12	13	10
2002	na	8	24	3	28	26
Total	na	15	43	15	41	36
Native Species	(%)					
2001	na	100[b]	0[c]	100[d]	100[e]	100[f]
2002	na	100	0	100	100	100

[a] We classified a nest as successful if it produced at least one fledgling.

[b] Boxes used by Ash-throated Flycatchers and Bewick's Wrens (*Thyromanes bewickii*)

[c] Boxes used by House Sparrows only.

[d] Boxes used by Ash-throated Flycatchers and Bewick's Wrens.

[e] Boxes used by Ash-throated Flycatchers, Western Bluebirds, and Mountain Bluebirds.

[f] Boxes used by Ash-throated Flycatchers, Bewick's Wrens, Western Bluebirds, and Juniper Titmice (*Baeolophus griseus*).

Table 3. Results of nest box comparisons from the Albuquerque Country Club (ACC), Four Hills Country Club (FH), and PaaKo Ridge Golf Club (PK) and their reference sites, based on monitoring of eleven nest boxes at each site in the years 2001 and 2002 in the Albuquerque, New Mexico area.

golf courses, as well as increased diversity (Figures 2, 4).

The increase in avian abundance on golf courses was to a large degree at the expense of more specialized native bird species, as has been witnessed in numerous other studies of urbanization effects (3, 4, 12, 26). We found that a relatively few widespread and abundant species made up the majority of individuals detected (including, but not limited to, house sparrows, house finches, common grackles, and European starlings), comprising from 69 to 76% of the individuals detected on three out of the five courses.

Although they had fewer species, the reference sites were composed primarily of native bird species, and these communities were more even in their distributions (Figures 5, 6). The PaaKo Ridge golf course was exceptional in several aspects, as it demonstrated greater species richness and diversity, and similar evenness, when

compared to its natural area reference site, and was the only course that did not have significantly fewer native individuals (Figure 6).

Species richness of native birds was greater on golf courses, in contrast to the results of many other studies of birds in urban environments (3, 12, 35, 41). This result held across all five of the courses we studied (Figure 3). The abundance of these native birds was not as great as that of cosmopolitan/introduced species, but golf courses supported numerous native bird species that were not components of the avian community in the surrounding natural areas. Of birds that were exclusive to our golf course observations, 54 (83%) were native species that we did not consider to be cosmopolitan or introduced species (Table 2).

We found strong support for our hypothesis that golf courses would provide habitat for riparian birds. Over 70% of the species observed exclusively on golf courses were riparian associates (Tables 1, 2). The numbers of individuals in this group were relatively low, particularly once we excluded those that are also considered cosmopolitan species (e.g., American robin). Still, 25% of the birds observed on golf courses were riparian associate species that were not represented in our samples of the surrounding natural area bird communities.

Our results add support to the hypothesis that avian species richness and/or diversity does not respond to urbanization in a linear fashion (7), but instead peaks at a level of intermediate disturbance or development (5, 22). At the higher levels of urbanization, most of the land area is dominated by buildings or paved areas, and any vegetation is primarily ornamental (3, 5, 16).

Golf courses, however, represent an intermediate level of development, in which most of the land area is still vegetated, some areas of native habitat may remain, and trees and ponds are common. Habitat diversity may actually increase under such a scenario, as structural diversity is added through changes in vegetation as well as the introduction of buildings and other structures that may serve as nest sites or perch sites, and openings are created for edge species (5, 12, 26).

Birds attracted to water sources on the golf courses, such as this yellow-headed blackbird, contributed to the greater species diversity found on desert golf courses. *Photo by James C. Leupold, courtesy U.S. Fish & Wildlife Service.*

Moderate levels of development may increase food resources for some guilds of birds; scavenging opportunities increase, and areas of lawn or turf are capable of supporting high numbers of ground foraging birds (13).

This potential increase in habitat diversity at low to moderate levels of development is particularly noticeable in the desert landscape. In general, there is a strong positive correlation between bird species diversity and habitat diversity (6, 27, 40), such that any increase in habitat diversity, particularly in a relatively simple landscape such as a desert, is likely to result in increased species richness (12).

The features added to the landscape during the development of a golf course often stand in sharp contrast to those of the desert environment. Courses may provide numerous shade trees, water sources, turf, structures, and vegetation types that are not available in the surrounding natural areas. Riparian-like habitats surrounding ponds on the course offer tall broad-leaved trees, multiple understory vegetation layers, and abundant water with emergent vegetation – all features that are absent from the desert habitat in the immediate area.

In conjunction with numerous out-of-play areas dominated by remnant native shrublands and expansive open areas of turf, the UNM

Championship Course provides a range of habitats that supports a wide variety of birds, including such diverse species as yellow warblers, spotted sandpipers, greater roadrunners (*Geococcyx californianus*), ash-throated flycatchers, northern rough-winged swallows, and American robins. Given this diversity of habitat types, it is hardly surprising that the UNM course had a greater number of species, including greater numbers of native species, than its comparison reference site. This contrast in habitat diversity associated with greater species richness was also apparent at the golf courses at Four Hills, Paradise Hills, and PaaKo.

The impact of a golf course on avian community composition in the desert environment appears to be very different from that of one that may be constructed, for example, in a forested area. In their comparison of an urban area with a reference site intended to represent the original bird community, Beissinger and Osborne (3) worked with a reference community in a climax beech-maple forest in Ohio, and Blair's (5) natural community was an oak woodland in California. Increased development in these communities led to a loss of canopy-foraging or bark-gleaning birds, since canopy trees were lost from the habitat. This is consistent with Batten's (2) observation that the loss of bird diversity is likely when development occurs in an area that had an initially high diversity of habitats.

This pond at the UNM Championship Course demonstrates how golf courses may provide habitats that are very similar in structure and composition to natural riparian habitats. Cottonwoods, willows, and cat-tails surround the water, providing habitat for a variety of bird species including red-winged blackbirds, black-crowned night herons, warbling vireos, yellow warblers, and western tanagers. Thirty-four species of birds were detected on this course, and 21 of these were riparian-associate species that were not found on the paired reference site.

By contrast, the addition of a golf course actually added this component of habitat diversity (high canopy trees) at three out of five of our study sites (Four Hills, Paradise Hills, and UNM), thereby attracting canopy species or bark-gleaners that would not otherwise be present in the avian community. Several of the species that decreased in response to urbanization in these other studies 3, 5) were species that we detected exclusively on the golf courses in our study, including northern flickers, white-breasted nuthatches, downy woodpeckers, cliff swallows, and western wood-pewees. The only course we studied that had less habitat complexity and structural diversity than its reference site, the Albuquerque Country Club, was also the only course that had lower bird abundance, species richness, and diversity. Our study suggests that in the structurally simple desert landscape, the additional resources and habitat complexity provided by golf courses result in increased avian abundance and species richness, including increased native species richness.

High numbers of birds do not necessarily reflect high quality habitat, however, nor can we assume that they represent self-sustaining populations (43). Many anthropogenic habitats have been found to function as ecological "sinks," even though they are utilized by large numbers of birds (32, 44). Measures of physiological condition or productivity would offer greater insight into the viability of riparian bird populations on golf courses.

Our limited attempt to measure productivity of birds nesting on golf courses offered some interesting observations, though our sample size was small. In particular, our data indicate that within our study sites, native cavity-nesting species are absent from traditional golf courses as resident breeders. Although source populations were close by, no native birds nested at either Four Hills or the Albuquerque Country Club over the

two years of our study. The only native cavity-nesters to use our nest boxes were at PaaKo. Native birds appear to be using these golf courses for foraging and other activities, but whether these courses are capable of supporting self-sustaining populations of native birds remains subject to further investigation.

It should be noted that although overall species richness and diversity increased on golf courses, the original native bird community nonetheless suffered negative consequences. At the four traditional golf courses – Albuquerque Country Club, Four Hills, Paradise Hills, and UNM – loss of species found in the native community ranged from 17 to 32%. This is somewhat lower than the 40% loss reported by Blair (5), but nonetheless these numbers represent the loss of a significant component of the desert bird community. Furthermore, seven species of desert specialists were excluded from golf course habitats altogether, including two species of management concern, the burrowing owl and black-throated sparrow (42), and a species that is experiencing population declines throughout its range, the western meadowlark (34).

Certain characteristics of the PaaKo Ridge golf course deserve attention, as this course was exceptional in both the abundance and diversity of native bird species. PaaKo is what Terman (39) calls a "naturalistic" golf course, one that retains "the native vegetation, land form, soils, and typical habitat units of a region." The course at PaaKo is based upon the natural topography of the Sandia foothills, turf is minimized, and the out-of-play areas are indistinguishable from the surrounding pinyon-juniper woodlands.

PaaKo was the only course that had greater abundance, species richness, diversity and comparable evenness of native species with its reference site; 76% of the individuals observed at this course were native species. No native species were excluded from the PaaKo course, and 27 species were added to the community (a few of these, however, were invasive species such as brown-headed cowbirds or Brewer's blackbirds). PaaKo was also the only course where we had native cavity-nesters using our nest boxes, and the productivity at the golf course was comparable to that of the comparison natural areas.

In addition to increased habitat diversity, the greater native species richness at PaaKo and the continued dominance of its avian community by native species is likely attributable to the extensive areas of undisturbed native vegetation on the course. Increased numbers of native bird species and the ability to exclude invasive avian species are associated with the amount of native vegetation present (17, 30). However, a potentially confounding factor is the undeveloped matrix that surrounds the PaaKo course. Some low-density housing has recently been constructed in association with the golf course, but, other than this, the landscape surrounding the course is largely undisturbed. The PaaKo course thus has an advantage in avoiding many of the cosmopolitan bird species that so frequently accompany urbanization, as it is currently isolated from such development.

Even though extensive areas of native vegetation remain on the course, the presence of houses adjacent to the course make the avian com-

The relatively simple habitat structure of the reference site for the UNM Championship Course can be deduced from this photograph. This undeveloped natural area, located directly across from the golf course, offers less for many bird species in terms of habitat diversity, complexity, and resources, which is reflected in lower overall species richness (16 species). However, this site did support some of the desert specialist species that were not detected on any of the golf courses in our study, including scaled quail and burrowing owls.

Unlike more traditional golf courses, the design of the course at PaaKo makes maximum use of the natural topography and native vegetation of the area. The area in turf is minimized, and fairways and ponds are surrounded by extensive stands of undisturbed woodlands, resulting in a course that provides a variety of habitats for high numbers of native bird species. PaaKo was the only golf course in our study to retain native cavity-nesting birds, and that had greater species richness and abundance of more specialized native birds than cosmopolitan and/or introduced species.

munity vulnerable to future incursions by increased numbers of "urban exploiter" species (15, 33). The PaaKo course may provide a valuable natural experiment in whether such a naturalistic course can maintain its ecological integrity over the long-term, as several thousand new homes are planned for future development not far from the course.

Summary

Golf courses in the high desert area of Albuquerque have the potential to support large numbers of native bird species. In addition, the resources and habitat diversity provided on these courses may mitigate to some extent the loss of riparian systems in the Southwest. These golf courses do not function as true riparian habitats, however, in terms of excluding invasive bird species (16). As presently constructed, most of

the traditional courses support large numbers of birds that are relatively widespread and abundant species, and that may even be considered pests or nuisance species (e.g., common grackles, European starlings).

The conservation value of golf course habitats in this desert region could be improved to support greater numbers of native birds and exclude more invasive exotics or pest species by increasing the complex vertical structure and diversity of plant species composition in the out-of-play areas on the courses, and in particular by increasing the extent and usage of native plants (16, 17, 30, 35). Such improvements, even on a very small, localized scale, have the potential to affect changes in bird species composition (10, 16), and golf courses that are dominated by native vegetation may support significant numbers of native bird species (39). The increased usage of native plants on golf courses would have the added benefit of lowering maintenance needs and reducing the strain on the limited water resources in the region, potentially lessening the increasingly volatile conflict between golf course irrigation requirements and diminishing water supplies in the desert (29, 38).

Whether golf course habitats in the desert have the potential to support viable populations of native and riparian species of birds remains to be tested. It is possible that even if improved, the habitat fragments on these courses may be too small and isolated to support some native species (35). At the very least, our data showing increased species richness of native birds, and particularly high numbers of riparian species on these courses, demonstrate that these golf courses may be capable of providing valuable stopover habitat for the numerous species of migratory birds that utilize riparian corridors in the Southwest.

The potential for desert golf courses to serve as surrogate riparian areas for these species has important conservation implications, as many migratory birds in the western U.S. are currently experiencing population declines associated with the loss of riparian habitats (11, 20, 25).

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