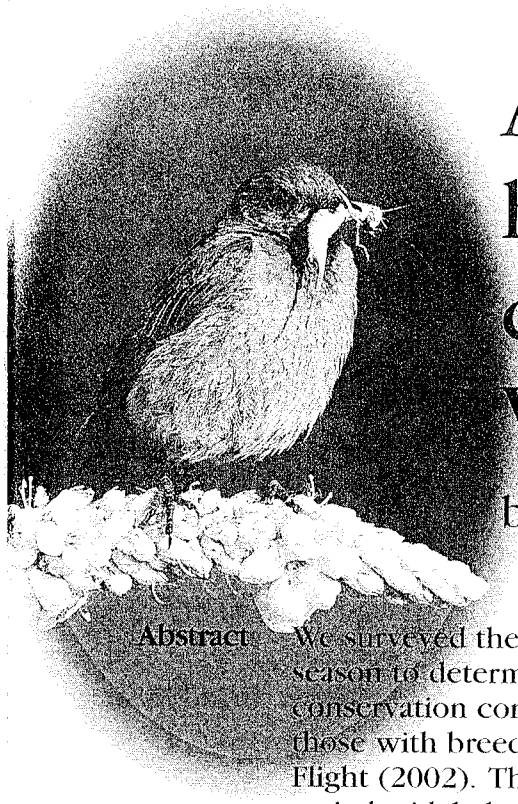


Are golf courses providing habitat for birds of conservation concern in Virginia?

by Joshua E. LeClerc and Daniel A. Cristol

Abstract We surveyed the avian communities of 87 golf courses during the 2002 breeding season to determine whether golf courses provided significant habitat for birds of conservation concern in Virginia. We defined birds of conservation concern as those with breeding priority scores ≥16 in our region, as classified by Partners in Flight (2002). The species richness and relative abundance of birds on golf courses varied widely, but in general, courses supported few birds of conservation concern. We found that a typical course had <7 species of conservation concern at a relative abundance of <2 birds of conservation concern per hectare. This compared unfavorably to richness and relative abundance values found at reference landscapes selected to represent the land that golf courses replaced in this region. Because some golf courses had >3 times as many species of conservation concern as others, we compared the land cover on the richest and most depauperate golf courses in an attempt to explain what attracted birds of conservation concern to some courses but not others. Proportions of forested land within the golf-course boundaries and within 1.5 km of the center of the course were the best predictors of a course's conservation value. Our results suggested that 1) regional planners should not expect typical golf courses to provide more habitat for birds of conservation concern than alternative land uses, including residential or agricultural uses; and 2) designers of golf courses in this region can increase the conservation value of courses by increasing the amount of forested land on the course.

Key Words bird, conservation concern, disturbance-dependent, early successional, golf-course design, land cover

opulations of many North American bird species are declining, in particular forest birds that migrate to the Neotropics and birds living in disturbance-dependent landscapes such as grassland and shrub-scrub (Hunter et al. 2001). As native vegetation communities are converted or degraded, it becomes increasingly important for managers to consider whether human-created landscapes have any potential to support declining bird species. In many rapidly developing suburban areas, golf courses provide a variety of created vegetation communities, some of which, at least superficially, resemble early-successional landscapes. Previous studies have found that

Authors' address: Department of Biology, Box 8795, College of William and Mary, Williamsburg, VA 23187, USA; e-mail for Daniel A. Cristol: dacris@wm.edu.

many golf courses provide important wildlife habitat (Green and Marshall 1987) and that bird diversity on golf courses can be higher than that in natural landscapes (Blair 1996). Our goal in the present study was to determine whether golf courses provide significant habitat for birds of conservation concern. Because golf courses are a created landscape, their conservation value can only be evaluated with reference to the native or anthropogenic landscapes they are replacing. Thus, we also surveyed a set of reference landscapes, and in this way compared bird communities of golf courses to those that would be present had the golf courses not been constructed. Because we expected to find great variation in the quality of bird habitat provided by different golf courses, we used land-cover data from satellite images to compare characteristics of courses supporting the most and the fewest birds of conservation concern.

We found that courses with both high richness and relative abundance of species of conservation concern were characterized by twice as much forest cover as golf courses of lower conservation value.

Methods

Bird surveys

Golf courses. We surveyed 87 of Virginia's approximately 360 golf courses (Golfcourse.com; 2003). We selected courses by geographic location, with no knowledge of their avian fauna, to provide a representative sample from each of the 3 major physiographic provinces in Virginia: Coastal Plain, Piedmont, and mountains (primarily Valley and Ridge with some Blue Ridge, and Appalachian Plateau). We conducted surveys from 1–16 June 2002, so all birds detected potentially were breeders, and migrants were not present in significant numbers. Surveys commenced at dawn (approximately 0530 EDT) and were completed by 1000 hours.

Observers recorded only those birds using the vegetation of the golf course or foraging actively in its airspace. We recorded birds as breeding units, such that we recorded a male, a female, a breeding pair, or an entire family group as a single unit. We did this to avoid inflation of the abundance estimate for early breeders.

We solicited observers (n=119) primarily through the Virginia Society of Ornithology and affiliated bird clubs and provided them with written instructions. A pair of observers surveyed each golf course, one with >10 years of experience identifying birds by song. At the tee of each hole on the golf course, observers conducted a 3-minute point count with a radius of 50 m (Verner 1985). Count circles fell entirely on property owned by the golf course and normally included areas beyond the edge of the maintained fairway, depending on course design. Observers did not record the distances to each bird detected.

Between point counts, observers walked the same route that golfers follow along the mowed fairway and recorded all birds detected within the boundaries of the golf course. Observers did not enter unmaintained areas during fairway counts but recorded birds detected at any distance unless they were outside of property owned by the golf course. A few golf courses required the use of carts, in which case observers drove between tee counts and stopped periodically to look and listen for birds on and adjacent to the fairway. Depending upon the size of the golf course, each survey consisted of 9 or 18 point counts at tees and the same number of fairway counts. We estimated relative abundance (see below) to correct for differences in golf-course size.

Reference landscapes. We selected 3 representative examples (1 in each physiographic province) of each of 9 common landscape types: early-successional forest, fragmented mature forest, intact mature forest, row crops, livestock pasture, annually mowed grassland, low-density suburban (housing lots ~5 ha), high-density suburban (lots <0.5 ha), and urban. These samples were used as reference points against which to compare golf-course bird communities because, in our experience, they represent landscape types most likely to have been present before golf-course construction in our region.

To simulate the methodology of the golf-course surveys, observers walked a winding path through these reference areas and stopped to conduct point counts every 400 m (length of a typical fairway). In this manner each reference survey consisted of 9 or 18 point counts with "fairway" counts in between. Otherwise, reference surveys followed the same methodology as described above for golf courses.

Land-cover analysis

To determine proportions of various land-cover types associated with golf courses, we analyzed digital orthophoto quarter quad (DOQQ) images of each golf course using Geographic Information Systems software (ArcView 3.2, Environmental Systems Research Institute, Inc., Redlands, Calif.). The area within each golf course was defined by an 8-sided polygon, digitized from

DOQQ images. We created a 250-m buffer around the golf-course polygon to define the buffer zone and created a 1.5-km buffer around the center point of the golf-course polygon to define the large surrounding area. We used these 3 polygons (golf course, buffer zone, and large surrounding area) as templates to define land-cover analysis areas in the National Land Cover Data 1992 data set (National Land Cover Characterization Project; 2003).

We determined the percent cover of each of 15 land-cover types defined by the National Land Cover Characterization Project, which for clarity can be grouped into 6 types: open water, herbaceous wetland, forest (subtypes: woody wetland, deciduous forest, evergreen forest, mixed forest, transitional), row crop, grassland (subtypes: pasture–hay, recreational grass), and developed (low-intensity residential, high-intensity residential, commercial–industrial–transportation, bare rock–sand–clay, quarries–strip mines–gravel pits). The currently available land-cover data for most of our region were from 1992 satellite images. Thus, using ground-truthing and records provided by course managers, we removed all courses from the land-cover analysis that were substantially altered after 1992, leaving 57 courses. We made no

Table 1. Species of conservation concern found on Virginia golf courses during 2002. The Partners In Flight (PIF) breeding priority scores were averaged across the 3 physiographic provinces in which study sites occurred (mid-Atlantic Coastal Plain, mid-Atlantic Piedmont, mid-Atlantic Ridge and Valley).

Species	Scientific name	Estimated birds/50-ha course		PIF breeding priority score
		Mean	Standard deviation	
green heron	*Butorides virescens*	1.14	3.03	18
yellow-crowned night-heron	*Nyctanassa violacea*	0.12	0.84	17
wood duck	*Aix sponsa*	0.49	4.55	16
American black duck [a]	*Anas rubripes*	0	0	21
bald eagle	*Haliaeetus leucocephalus*	0.08	0.53	16.7
sharp-shinned hawk [a]	*Accipiter striatus*	0	0	17.7
wild turkey	*Meleagris gallopavo*	0.16	0.92	17.7
northern bobwhite	*Colinus virginianus*	0.69	2.21	20
killdeer	*Charadrius vociferus*	1.54	2.99	16
laughing gull	*Larus atricilla*	1.38	7.28	16
royal tern [a]	*Sterna maxima*	0	0	17
common tern [a]	*Sterna hirundo*	0	0	17
Forster's tern [a]	*Sterna forsteri*	0	0	19
least tern	*Sterna antillarum*	0.04	0.38	18
black-billed cuckoo [a]	*Coccyzus erythropthalmus*	0	0	19
yellow-billed cuckoo	*Coccyzus americanus*	0.77	2.38	18.3
eastern screech-owl [a]	*Otus asio*	0	0	19.3
chimney swift	*Chaetura pelagica*	8.74	20.80	19
ruby-throated hummingbird	*Archilochus colubris*	0.45	1.85	18
belted kingfisher	*Ceryle alcyon*	0.28	1.11	17.7
red-headed woodpecker	*Melanerpes erythrocephalus*	0.12	0.65	18
red-bellied woodpecker	*Melanerpes carolinus*	5.41	5.60	16.3
northern flicker	*Colaptes auratus*	2.40	3.76	16
eastern wood-pewee	*Contopus virens*	4.19	6.53	20.7
Acadian flycatcher	*Empidonax virescens*	1.30	3.54	21.3
willow flycatcher [a]	*Empidonax traillii*	0	0	17.7
eastern phoebe	*Sayornis phoebe*	2.07	3.17	16.3
great crested flycatcher	*Myiarchus crinitus*	2.85	5.03	17.7
eastern kingbird	*Tyrannus tyrannus*	2.76	3.43	19
northern rough-winged swallow	*Stelgidopteryx serripennis*	0.61	2.24	17.7
barn swallow	*Hirundo rustica*	5.45	12.89	16.3
fish crow	*Corvus ossifragus*	3.78	7.88	16.3
Carolina chickadee	*Poecile carolinensis*	7.28	7.75	17.3
brown-headed nuthatch	*Sitta pusilla*	0.98	4.84	22.5
blue-gray gnatcatcher	*Polioptila caerulea*	3.17	5.63	16.3
wood thrush	*Hylocichla mustelina*	1.46	3.43	24.7
gray catbird	*Dumetella carolinensis*	4.92	11.33	19
brown thrasher	*Toxostoma rufum*	3.09	4.17	19.7
white-eyed vireo	*Vireo griseus*	0.93	3.47	19.7
blue-headed vireo	*Vireo solitarius*	0.20	1.90	16
yellow-throated vireo	*Vireo flavifrons*	0.57	1.93	22
warbling vireo	*Vireo gilvus*	0.20	1.56	17.3
northern parula	*Parula americana*	0.65	2.19	20.7
chestnut-sided warbler [a]	*Dendroica pensylvanica*	0	0	19
black-throated green warbler	*Dendroica virens*	0.08	0.76	17.7
yellow-throated warbler	*Dendroica dominica*	0.41	1.98	20.3
pine warbler	*Dendroica pinus*	2.48	4.95	18
prairie warbler	*Dendroica discolor*	0.28	1.23	24
cerulean warbler	*Dendroica cerulea*	0.08	0.76	26.3
black-and-white warbler	*Mniotilta varia*	0.33	2.33	18
American redstart	*Setophaga ruticilla*	0.08	0.76	16

(*Continued*)

[a] This species was recorded on a golf course fairway count, but not on a point count.

attempt to correct for changes in surrounding land cover (e.g., reduction in forest cover) between 1992 and 2002, and this undoubtedly limited the resolution of our analysis.

Table 1 (*continued*). Species of conservation concern found on Virginia golf courses during 2002. The Partners In Flight (PIF) breeding priority scores were averaged across the 3 physiographic provinces in which study sites occurred (mid-Atlantic Coastal Plain, mid-Atlantic Piedmont, mid-Atlantic Ridge and Valley).

Species	Scientific name	Estimated birds/50-ha course		PIF breeding priority score
		Mean	Standard deviation	
prothonotary warbler	*Protonotaria citrea*	0.12	0.84	22
ovenbird	*Seiurus aurocapillus*	1.87	5.63	17.3
Kentucky warbler	*Oporornis formosus*	0.04	0.38	24.3
common yellowthroat	*Geothlypis trichas*	1.38	3.02	17
hooded warbler	*Wilsonia citrina*	0.16	0.92	21
yellow-breasted chat	*Icteria virens*	0.61	2.30	19
summer tanager	*Piranga rubra*	0.73	2.42	16
scarlet tanager	*Piranga olivacea*	0.53	1.75	21
rose-breasted grosbeak [a]	*Pheucticus ludovicianus*	0	0	17.3
blue grosbeak	*Guiraca caerulea*	0.45	1.85	17
indigo bunting	*Passerina cyanea*	5.00	6.77	17.3
eastern towhee	*Pipilo erythrophthalmus*	3.58	6.46	20
chipping sparrow	*Spizella passerina*	14.51	15.54	16.3
field sparrow	*Spizella pusilla*	1.63	4.14	22.3
grasshopper sparrow	*Ammodramus savannarum*	0.28	1.64	19.3
eastern meadowlark	*Sturnella magna*	1.38	3.71	17.7
orchard oriole	*Icterus spurius*	1.50	3.60	18.7
Baltimore oriole	*Icterus galbula*	1.18	3.44	18.7

[a] This species was recorded on a golf course fairway count, but not on a point count.

Statistical analysis

We assumed that all birds reported on the surveys were potential breeders, with the exception of spotted sandpiper (*Actitis macularia*) and ring-billed gull (*Larus delawarensis*), which we eliminated because they are not known to breed in our region. Starting with the set of all 125 species detected, we eliminated from analyses those not of conservation concern in the study region. We considered a species to be of regional conservation concern if the Partners in Flight (PIF) (2002) total breeding priority score assigned to it averaged ≥16 across the 3 physiographic provinces in which most of our sites occurred (mid-Atlantic Coastal Plain, mid-Atlantic Piedmont, mid-Atlantic Ridge and Valley) (Table 1). We selected this arbitrary cut-off because it eliminated all non-native and suburban-adaptable species and minimized the number of native species classified as being of conservation concern despite exhibiting moderate or significant population increases on the Breeding Bird Surveys in ≥2 of the physiographic provinces in our region. Four species with increasing populations were "misclassified" as being of concern and were included in the analysis (wood duck [*Aix sponsa*], wild turkey [*Meleagris gallopavo*], red-headed woodpecker [*Melanerpes erythrocephalus*], fish crow [*Corvus ossifragus*]), while 3 species with decreasing populations failed to be classified as being of concern and were not included (yellow warbler [*Dendroica petechia*], red-winged blackbird [*Agelaius phoeniceus*], brown-headed cowbird [*Molothrus ater*]).

To determine how many birds of conservation concern occurred on golf courses and reference landscapes, we calculated the species richness and relative abundance of breeding units (i.e., males, pairs, or families). Species richness values included all species recorded in point counts and "fairway" counts at a site. We calculated relative abundance for each site by summing the number of breeding units detected on all of the tee counts and dividing this by the total area of the count circles (0.785 ha per tee). It should be noted that our methodology did not allow accurate assessment of absolute densities. We then summed the abundances of all species of conservation concern found on that course or reference site. For comparison with the golf courses, we combined the reference sites into 3 categories to achieve a sample of 9 sites in each category: forest, agricultural, and residential. These were compared to the golf courses using a nonparametric Kruskal-Wallis test with post-hoc comparisons (Siegel and Castellan 1988) because abundances were not normally distributed. Because golf courses superficially resemble open landscapes, we repeated this analysis, restricting it to species of conservation concern that are dependent on early-successional, disturbance-dependent landscapes. We classified a species as such if it was described as nesting outside of the forest canopy in ≥2 of 3 standard references (Harrison 1978, Farrand 1983, Ehrlich et al. 1988).

We were most interested in explaining the difference between golf courses with very high and very low conservation value for birds. To identify clusters of golf courses with similar conservation values, we used cluster analysis (JMP v. 3.2.1, SAS Institute, Cary, N.C.) to separate the courses along the relative abundance and richness axes. We then restricted our analysis of land cover

to the top and bottom clusters of the 3 identified (high: high relative abundance and high richness; low: low relative abundance and low richness). To identify potential explanatory variables, we compared the high and low golf-course clusters with respect to proportion of coverage by each of the 6 land-cover types (open water, herbaceous wetland, forest, row crop, grassland, and developed), using Wilcoxon tests because of non-normal distributions and increasing α to 0.10 (without correction for multiple tests) as a conservative criterion for exclusion. The subtypes of those land-cover types that differed between the high and low golf-course clusters were then used in a discriminant analysis as a way of testing which combination of subtypes could classify the most courses into the correct clusters. The discriminant analysis was adjusted to omit a given golf course from the function when attempting to classify that course. Throughout this paper means are accompanied by standard deviations.

Results

Considering all species, golf courses supported 38.4± 8.3 species/course (including fairways; range: 19–60 species/course). Restricting this analysis to species of conservation concern, species richness dropped to 17.7± 6.0 species/course (range: 7–31 species/course). Relative abundance of all species was 7.1±3.6 birds/ha (range: 2.6–20.3 birds/ha), which dropped to 2.2±1.2 birds/ha for species of conservation concern (range: 0.4–5.6 birds/ha). Another way of describing the occurrence of species of conservation concern on golf courses was with quartiles: 75% of courses had fewer than 23 species of concern, 50% had fewer than 17 species, and 25% had fewer than 13 species. Likewise, 75% had fewer than 2.8 birds/ha of conservation concern, 50% had fewer than 2.0 birds/ha, and 25% had fewer than 1.3 birds/ha. Table 1 provides a list of species of conservation concern found on golf courses and a crude estimate of the number of breeding units to be expected on a typical Virginia course.

Comparing golf courses to reference landscapes indicated that the relative abundance of birds of conservation concern was highest on the forested reference sites and lowest on the golf courses (Figure 1*a*). All 3 reference landscapes had higher mean abundances of birds than the golf courses, and there was a significant difference among groups (χ_3^2=9.6, P=0.02), but the only reference landscape that was significantly different from golf courses in post hoc comparisons was forest, which had 50% higher relative abundance of birds of conservation concern (difference in mean ranks: forest–golf course=34.05; agriculture–golf course=14.28; residential–golf course=5.16; critical value for post hoc comparisons=27.8).

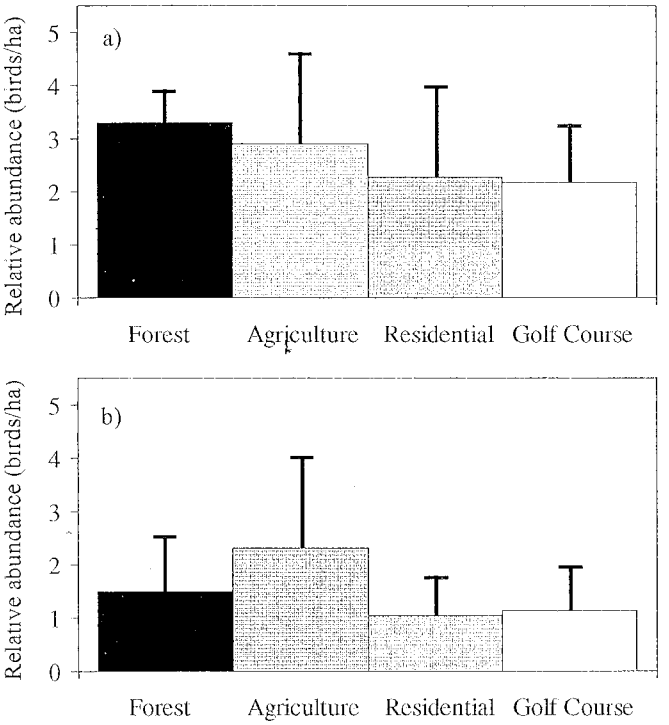


Figure 1. Mean and standard deviation of relative abundance of a) birds of conservation concern for golf courses (n = 87) and forested (n = 9), agriculture (n = 9), and residential (n = 9) reference sites in Virginia in 2002, and b) only those birds of conservation concern that are dependent on early-successional, disturbance-dependent landscapes.

Restricting this analysis to just those species of conservation concern that would seem most likely to benefit from golf courses (disturbance-dependent species) resulted in agricultural reference sites providing the greatest conservation value, approximately twice as high as that of golf courses (Figure 1*b*). Agriculture was the only reference habitat that was significantly different from golf courses in post hoc comparisons (difference in mean ranks: agriculture–golf course=28.03; forest–golf course =10.80; residential–golf course=–2.58; critical value for post hoc comparisons=27.8).

There was wide variation in how well golf courses supported birds of conservation concern. Cluster analysis identified 9 courses with the highest conservation value and 15 with the lowest (Figure 2), and we focused on explaining the differences between these 2 clusters of courses by comparing the proportion of each land-cover type for each type of course. Using an inclusive criterion for including variables, the only land-cover types that differed between the clusters were forest (at all 3 spatial scales: golf courses, 250-m buffer zones, and 1.5-km sur-

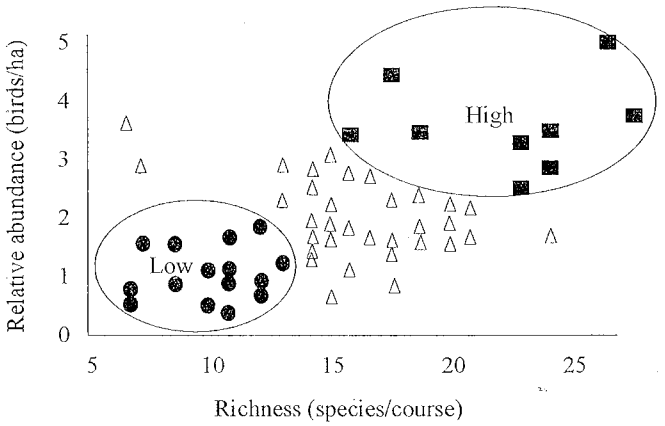


Figure 2. Results of cluster analysis for 57 Virginia golf courses used in the land-cover analysis (1992 land-cover data, 2002 bird data). Cluster labeled "high" had high numbers of bird species of conservation concern at high relative abundances; those labeled "low" had low richness and relative abundances of these species.

rounding areas; Table 2) and developed (buffer zone only; Table 2). Golf courses with high value for bird conservation had approximately twice the proportion of forest cover and had buffer zones with half as much development (Table 2). Using combinations of the land-cover subtypes, we found that a discriminant function including only the percent cover of deciduous, evergreen, mixed, and transitional forests on golf courses classified 75.0% of courses into their correct cluster (either high or low value for birds of conservation concern). Considering the land cover of the large surrounding area of each course (a circle with diameter 1.5 km that includes the golf course), a discriminant function using the same combination of forest subtypes correctly classified 83.3% of the courses. Including only the buffer zone, with proportion of the same forest subtypes plus woody wetland, the discriminant function correctly classified only 66.7% of the courses. The proportion of developed land in the buffer also differed between the clusters (Table 2), but using these subtypes as a discriminant function did not provide good predictive ability (58.3% correct). Thus, knowledge of the amount of area covered by forest, either on the course or in the larger surrounding area, would allow one to predict with a reasonable probability of success (75–83%) whether a course was among the best 9 or the worst 15 in terms of conservation value for birds. The other land-cover variables we measured did not provide comparable levels of predictive ability.

Table 2. Percent coverage by each land-cover type for the golf courses, 250-m buffers, and 1.5-km diameter surrounding circle on the courses with the lowest (n = 15) and highest (n = 9) conservation values in Virginia during 2002.

Land-cover type		Low value mean ± SD	High value mean ± SD	Z	P
Golf course	Open water	2.0 ± 2.1	3.0 ± 3.1	0.78	NS
Golf course	Wetland	1.0 ± 1.8	0.2 ± 0.4	0.25	NS
Golf course	Forest	18.4 ± 14.7	35.5 ± 23.8	1.85	0.06
Golf course	Grassland	57.7 ± 25.0	47.2 ± 24.2	0.78	NS
Golf course	Developed	15.4 ± 17.0	11.5 ±11.2	0.42	NS
Buffer zone	Open water	4.5 ± 5.5	4.4 ± 5.2	0.33	NS
Buffer zone	Wetland	2.5 ± 4.1	0.7 ± 0.9	0.24	NS
Buffer zone	Forest	34.5 ± 17.9	55.5 ± 25.4	1.91	0.06
Buffer zone	Row crop	5.4 ± 6.2	2.7 ± 2.9	0.57	NS
Buffer zone	Grassland	23.4 ± 19.6	24.7 ± 25.7	0.42	NS
Buffer zone	Developed	28.5 ± 20.8	11.6 ± 11.0	2.03	0.04
Surrounding	Open water	4.7 ± 6.3	4.8 ± 3.8	0.66	NS
Surrounding	Wetland	2.9 ± 4.4	0.6 ± 0.7	1.01	NS
Surrounding	Forest	35.6 ± 22.6	59.4 ± 16.8	2.03	0.04
Surrounding	Row crop	6.22 ± 8.2	3.8 ± 3.15	0.06	NS
Surrounding	Grassland	23.1 ± 17.4	20.34 ± 18.73	0.78	NS
Surrounding	Developed	27.5 ± 22.4	11.1 ± 7.8	1.37	NS

Discussion

Few of the bird species present on Virginia golf courses during the breeding season were of conservation concern. This was despite the fact that we used a liberal definition of conservation concern that included some widespread species with stable populations. If we had restricted consideration to those species of more urgent conservation concern, golf courses provided virtually no habitat. For example, we detected only 6 species with PIF breeding priority scores >22 on golf courses, and most were found on only a few courses (brown-headed nuthatch, *Sitta pusilla*, 8% of courses; wood thrush, *Hylocichla mustelina*, 41% of courses; prairie warbler, *Dendroica discolor*, 15% of courses; cerulean warbler, *D. cerulea*, 2% of courses; Kentucky warbler, *Oporornis formosus*, 2% of courses; field sparrow, *Spizella pusilla*, 30% of courses).

Relative abundance of birds of conservation concern was 50% higher on forested reference landscapes than on golf courses, and courses did not differ from residential or agricultural reference sites. Thus, while the golf courses we surveyed provided habitat for large numbers of birds, they presently are not augmenting bird conservation efforts because the landscapes they replace, whether natural or anthropogenic, support as many or more birds of conservation concern. Even for the subset of birds most likely to benefit from golf-course construction, those preferring early-successional, disturbance-dependent landscapes, golf courses did not have higher relative abundance than residential, forested, or agricultural land. These findings are conservative in that our survey method, in which we did not make corrections for

detectability, made it more likely for us to detect birds on the relatively open golf courses than in many of the reference landscapes, particularly early-successional forest.

There was enormous variation in species richness among courses, and species of high conservation concern did occur on some courses. Thus, there is potential for new golf courses to play a larger role in regional bird conservation if they are designed to resemble the courses that did provide habitat for species of conservation concern. We found that courses with both high richness and relative abundance of species of conservation concern were characterized by twice as much forest cover as golf courses of lower conservation value. The proportion of forest cover in a circle centered on the golf course with a diameter of 1.5 km was an even better predictor of the course's conservation value, indicating that a course's conservation value is influenced by landscape context as well as course design. Other land-cover variables were poor predictors of conservation quality at any of our spatial scales, whether they were considered alone or in multivariate analyses (LeClerc 2004).

Management implications

The public is deeply divided in its opinion of whether golf courses provide valuable wildlife habitat (Gange et al. 2003), and until recently few data have been available to resolve this question. We suggest that when a golf course replaces or displaces another landscape, even agricultural or suburban residential areas, there may be a negative impact on abundance of birds of conservation concern. In addition, one could speculate that the golf course may serve as a source population for suburban-adaptable species, which we and others found to make up a high proportion of the birds present (e.g., Moul and Elliott 1994, Blair 1996, Terman 1997). If true, the negative impact of a golf course on birds of conservation concern may radiate beyond the area of the course itself through competition between vulnerable native species and the suburban-adaptable species dispersing from the golf course. On the other hand, we found that a few courses supported relatively high numbers of birds of conservation concern, suggesting that carefully designed courses with high proportions of forest cover on or within 1.5 km of the course could play a role in regional bird conservation. It should be noted that forest is the dominant natural cover type in our study region, but golf courses nationwide are built in a wide variety of vegetation communities. The habitat needs of native species of conservation concern must be evaluated in the context of the region in question. For example, in a grassland region, increasing a golf course's forest cover would be detrimental to native grassland birds.

We did not account for size and shape of individual patches of cover type, which could have profound effects on their value for birds of conservation concern (e.g., thin strips of forest along fairways may have little value). Designers must consider the effects of patch metrics, as well as overall proportion of forest, when planning courses with bird conservation in mind. Further studies also are needed that directly examine the reproductive success of birds on golf courses and whether courses are providing stopover or wintering habitat for species of conservation concern. If golf courses are source populations for suburban-adaptable species that compete with species of conservation concern off of the course, and if they provide little or no habitat for species of conservation concern, regional bird conservation might, counterintuitively, be better served if courses were modified to provide less bird habitat. If, however, some golf-course designs provide habitat for successful reproduction by species of conservation concern, an effort should be made to educate the public on the importance of requiring these design features in new courses and, where practical, modifying existing courses.

Acknowledgments. We are grateful to the many keen observers and cooperative golf-course superintendents who made this study possible. The names of all 119 observers and the 87 golf courses surveyed are provided in LeClerc (2002). We thank T. Russell for assistance with the land-cover analysis. A. Rodewald and S. Gillihan provided careful reading and criticism of this manuscript.

Literature cited

Blair, R. B. 1996. Land use and avian species diversity along an urban gradient. Ecological Applications 6:506–519.

Ehrlich, P. R., D. S. Dobkin, and D. Wheye. 1988. The birder's handbook. Simon and Schuster, New York, New York, USA.

Farrand, J., Jr., editor. 1983. The Audubon Society master guide to birding. Alfred A. Knopf, New York, New York, USA.

Gange, A. C., D. E. Lindsay, and J. M. Schofield. 2003. The ecology of golf courses. Biologist 50:63–68.

Golfcourse.com: The Golf Magazine golf course guide. 2003. Golf Magazine. Available online at http://www.golfcourse.com (accessed 1 December 2003).

Green, B. H., and I. C. Marshall. 1987. An assessment of the role of golf courses in Kent, England in protecting wildlife and landscapes. Landscape and Urban Planning 14:143–154.

Harrison, C. 1978. A field guide to the nests, eggs, and nestlings of North American birds. Collins, Cleveland, Ohio, USA.

Hunter, W. C., D. A. Buehler, R. A. Canterbury, J. L. Confer, and P. B. Hamel. 2001. Conservation of disturbance-dependent birds in eastern North America. Wildlife Society Bulletin 29:440–455.

LeClerc, J. E. 2002. The 2002 golf course foray. Raven 73:3–43.

LeClerc, J. E. 2004. Bird conservation value of golf courses. Thesis, College of William and Mary, Williamsburg, Virginia, USA.

Moul, I. E., and J. E. Elliott. 1994. The bird community found on golf courses in British Columbia. Northwestern Naturalist 75:88–96.

National Land Cover Characterization Project. 2003. United States Geological Survey. Available online at http://landcover.usgs.gov/nationallandcover.asp (accessed 15 August 2003).

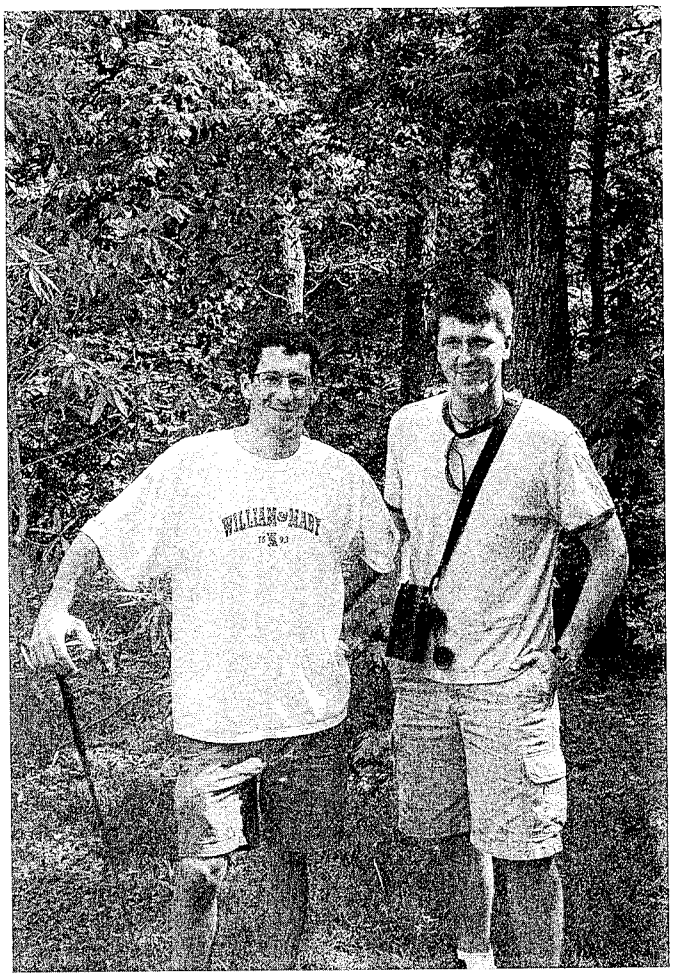
Partners in Flight Species Assessment Database. 2002. Rocky Mountain Bird Observatory. Available online at http://www.rmbo.org/pif/pifdb.html (accessed 13 October 2003).

Siegel, S., and N. J. Castellan, Jr. 1988. Nonparametric statistics for the behavioral sciences. Second edition. Mcgraw Hill, New York, New York, USA.

Terman, M. R. 1997. Natural links: naturalistic golf courses as wildlife habitat. Landscape and Urban Planning 38:183–197.

Verner, J. 1985. Assessment of counting techniques. Current Ornithology 2:247–302.

Josh LeClerc (right) is a GIS technician at the Center for Conservation Biology in Williamsburg, Virginia. He received a B.Sc. in biology from the College of William and Mary in 1999 and an M.A. in biology from William and Mary in 2004. His interests include music and bird conservation. ***Dan Cristol*** (left) is an associate professor in the Biology Department at the College of William and Mary. He earned his B.Sc. in natural resources at Cornell University and his Ph.D. in Biology from Indiana University. His research interests include the role of memory in migration, evolution and learning of foraging techniques, and conservation of birds in human-created landscapes.



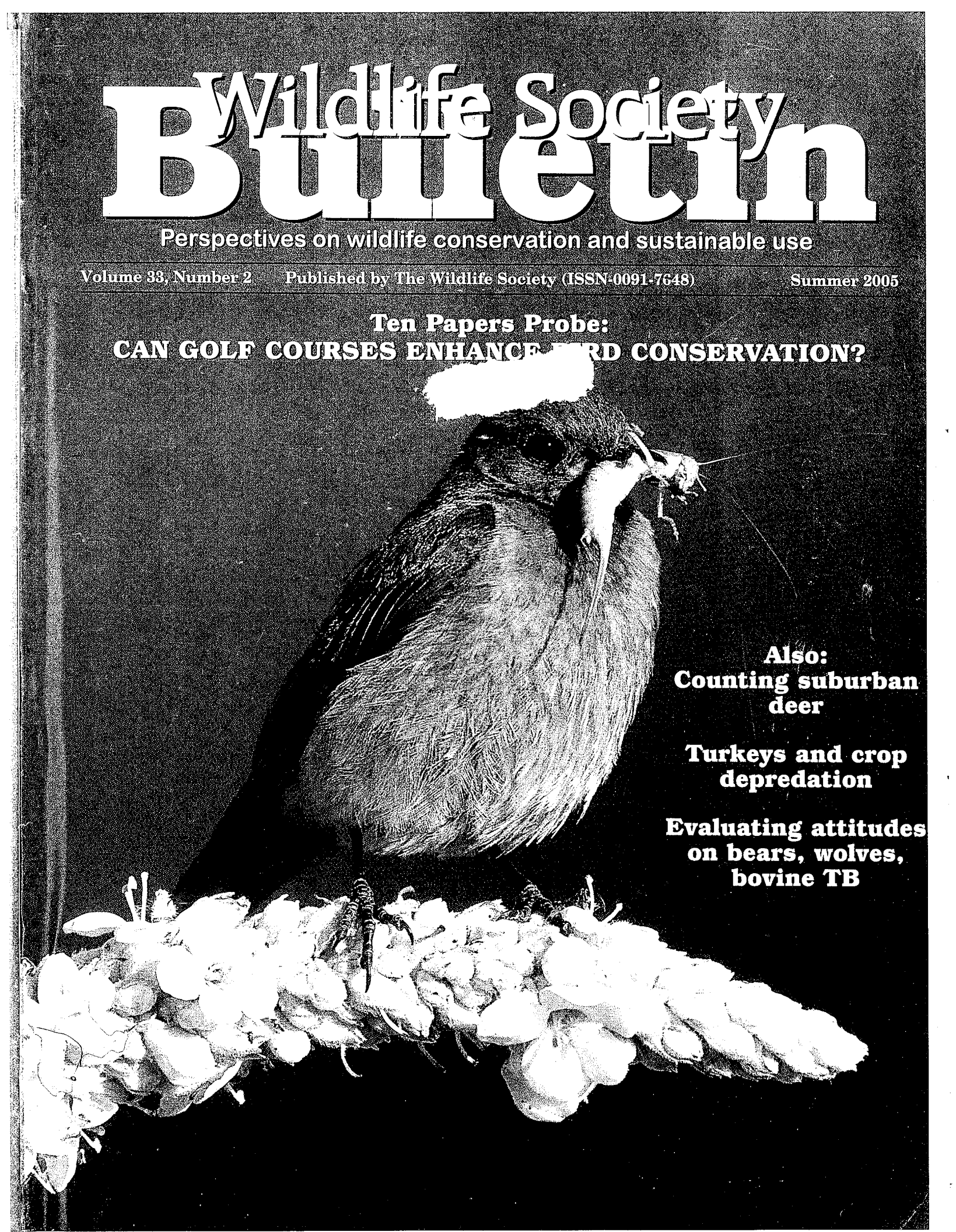
Special Section Associate Editor: *Rodewald*

Wildlife Society Bulletin

Perspectives on wildlife conservation and sustainable use

Volume 33, Number 2 Published by The Wildlife Society (ISSN-0091-7648) Summer 2005

Ten Papers Probe:
CAN GOLF COURSES ENHANCE WILDLIFE CONSERVATION?



Also:
Counting suburban deer

Turkeys and crop depredation

Evaluating attitudes on bears, wolves, bovine TB