Wilson Bull., 104(4), 1992, pp. 732–738

SHORT COMMUNICATIONS

Avian characteristics of an urban riparian strip corridor.—Riparian strip corridors bordered by agricultural fields and forest clear-cuts have a distinct, induced-edge habitat with greater density and diversity of birds and denser vegetation than large, contiguous forests (Ranney et al. 1981, Noss and Harris 1986, Temple 1986). No studies have determined if similar relationships exist for stream corridors in urban landscapes where habitat interfaces are different. The ability of urban corridors to maintain the ecological integrity of riparian systems is relatively unexplored (Adams and Dove 1989, Barrett and Bohlen 1991). This paper compares avian density, diversity, and richness of an urban stream corridor with that found along a stream system in a large rural habitat block.

Methods.—Our study was conducted on two areas in Alachua County, Florida: the urbanized Hogtown Creek and the rural San Felasco Hammock State Preserve. The predominant habitats in the Hogtown Creek corridor in western urbanized Gainesville are flatwoods and mesic hardwood hammocks. San Felasco is a 2500-ha preserve consisting mostly of mesic hardwood hammock and is located 8 km northwest of Gainesville. This park contains one of the largest undeveloped stands of mesic hammock in peninsular Florida. Study plots within the two study areas were located along the Hogtown Creek in 20–60 m wide (narrow) and 75–150 m wide (wide) naturally vegetated corridor segments. Criteria for selecting plots included (1) predominantly mesic hardwood hammock plant communities, (2) placed near streams with at least 20 m of natural forest vegetation width on one side, and (3) bordered on both sides by residential housing.

Potential control plots (San Felasco) were marked on a USGS topographical map within hardwood hammock communities along two creeks within the State Preserve at 150-m intervals. Of these, nine were selected randomly. No residential housing or man-made clearings were present within 500 m of control plots. Both study and control plots were circular with 50-m radii, and their centers were at least 150-m apart and 10 m from the edge of the creekbank. Study plots were located on the side that contained the widest area of natural forest, and control plots in San Felasco were randomly situated on either side of the creek. Six narrow and nine wide Hogtown plots and nine San Felasco plots were studied.

We sampled breeding birds from 23 April through 8 June in 1989 and 16 April through 31 May in 1990. Winter sampling was conducted from 13 December 1989 to 1 February 1990. During the breeding season of 1989, all plots were sampled six to nine times. Each plot was sampled eight times during the winter and breeding seasons of 1990. Sampling began at sunrise and ended approximately 3 h later on calm, clear mornings. Counts began at different plots each day to avoid time-of-day activity biases. After arriving at the plot a one-min equilibration period was followed immediately by an eight-min sampling period to detect and record birds seen and heard (Reynolds et al. 1980). Observations were made from the center of each plot. No bird detected outside the 50-m radius plot was counted.

Average density of birds (all species combined) per sampling period, average frequency of birds (all species combined), and average density of each species per sampling period were determined. Richness was the number of species that occurred on the plot during the study season. We measured bird species diversity per plot by using Brillouin's index (Pielou 1966, Magurran 1988). This index is preferred over the Shannon Diversity index when the assumption of random sampling is violated (Pielou 1966, Magurran 1988). Because some species may be more detectable than others, random sampling was not assumed and no comparisons between species were made (Blake and Karr 1987).

Circular plots of 0.031 ha (20-m diameter) were centered on bird sampling plots for vegetation sampling during the summer of 1989. Vegetation data were collected (Table 1).

TABLE 1
HABITAT MEASUREMENTS

Height and species of all trees ≥3 cm dbh
Height class, species, and canopy cover estimate of all woody stems <3 cm dbh and >0.5 m tall within two perpendicular, 2-m-wide, 20-m-long, x-shaped transects
Number of all woody stems <3 cm dbh and <0.5 m tall within two perpendicular 2-m-wide, 20-m-long transects
Count of all vine stems or vine leaves that intersect the centerline of the two perpendicular transects
Estimation of vertical structural diversity by recording the presence or absence of vegetation at height intervals of 0–0.3 m, 0.31–5 m, 5.1–10 m, and >10 m

Diversity of shrubs and trees was calculated with the Shannon-Weaver formula, and evenness (E) = Shannon index/log of the cumulative number of species (Magurran 1988).

We measured the percent coverage of vegetation types (Myers and Ewel 1990), including hardwood hammock, pine flatwoods, and percent cleared area by examining color infrared vertical photographs of the Hogtown Creek at a scale of 1:15,840. All San Felasco plots were in hardwood hammock communities. A 20-ha circle was drawn to scale (2-cm radius) on transparent material, and its center was aligned with the center of the bird census plot on the photograph. Areas covered by various vegetation types were outlined on the transparency using a fine-point felt-tipped pen. The transparency was then placed over a dot grid of 16 dots per square cm. Dots within an outlined vegetation patch were counted, and a percent of the total for each vegetation type was calculated.

Housing density in the vicinity of the plots was measured on a map by drawing a scaled 3-ha circle around the center of each plot, then counting the number of houses within each circle. The percent cover of vegetation type, housing density, and width comprised the development variables. Housing density was zero in San Felasco.

We compared habitat characteristics among plots using the non-parametric Kruskal-Wallis test (Hollander and Wolfe 1973). When a significant treatment effect ($P \leq 0.05$) was found, a non-parametric multiple-comparison test for unequal sample sizes was used to determine which treatments differed ($Q > 2.394$, $P \leq 0.05$; Hollander and Wolfe 1973, Zar 1984). We used the SAS multiple regression procedure (SAS Institute Inc. 1988) to determine which habitat variables explained most of the variation in bird community parameters and species densities. Any two variables that were highly and significantly correlated ($r \geq 0.70$, $P \leq 0.05$) were not used in the same regression model. The variable that produced a significant model with the highest r^2 was kept. No model included more than five independent variables.

We compared five bird community parameters and densities of 22 bird species among treatments with the Kruskal-Wallis test. When a significant treatment effect ($P \leq 0.05$) was found, a non-parametric multiple-comparison test for unequal sample sizes was used to determine which treatments differed ($Q > 2.394$, $P \leq 0.05$). To eliminate species that had a low frequency of occurrence, only those that were observed in at least 50% of the plots of any one treatment were tested. Before conducting the correlation and multiple linear regression analyses, variables were transformed to achieve normality using the Box-Cox transformation technique (Sokal and Rohlf 1981). The two Hogtown treatments were pooled for these analyses because only one significant difference in a species' density was found when tested separately.

TABLE 2

AVERAGES OF BIRD COMMUNITY PARAMETERS ALONG THE HOGTOWN CREEK AND IN SAN FELASCO HAMMOCK STATE PRESERVE, IN ALACHUA COUNTY FLORIDA, DURING 1989 AND 1990[a]

Variable	Treatment		
	Narrow	Wide	San Felasco
Spring			
Bird density	0.76 a	0.75 a	0.51 b
Bird species richness	11.91 a,b	10.66 a	12.66 b
Bird species diversity	0.77 a	0.74 a	0.87 b
Evenness	0.65 a	0.67 a	0.83 b
Bird frequency	0.39 a	0.37 a	0.33 a
Winter			
Bird density	0.78 a	0.76 a	0.44 b
Bird species richness	13.33 a	11.55 a	10.00 a
Bird species diversity	0.83 a	0.76 a	0.77 a
Evenness	0.64 a,b	0.63 a	0.74 b
Bird frequency	0.30 a,b	0.31 a	0.22 b

[a] Kruskal-Wallis multiple-comparison test for unequal sample sizes was used to determine differences. Values with identical letters were not significantly different from each other.

Results.—We detected fifty-three bird species. During spring, average density of birds was greater and bird species diversity and evenness were less in Hogtown Creek plots than in San Felasco (Table 2). Of nine resident species, five (American Crow [*Corvus brachyrhynchos*], Blue Jay [*Cyanocitta cristata*], Carolina Wren [*Thryothorus ludovicianus*], Northern Cardinal [*Cardinalis cardinalis*], and Red-bellied Woodpecker [*Melanerpes carolinus*]) had higher densities in one or both Hogtown Creek treatments than in San Felasco. One resident (Pileated Woodpecker [*Dryocopus pileatus*]) was more common in San Felasco than in wide plots (K-W test; $Q = 2.531$, $P = 0.04$). Of seven neotropical migrants, four (Acadian Flycatcher [*Empidonax virescens*], Hooded Warbler [*Wilsonia citrina*], Red-eyes Vireo [*Vireo olivaceus*], and Summer Tanager [*Piranga rubra*]) had higher densities in San Felasco. Acadian Flycatchers and Hooded Warblers were not detected in narrow plots, and Summer Tanagers were not detected in any plots along the Hogtown Creek.

During winter, bird density was greater in both Hogtown Creek plots compared to San Felasco ($Q = 3.776$, $P = 0.005$ and $Q = 3.104$, $P < 0.001$; Table 2). Evenness was greater in San Felasco than in wide plots ($Q = 2.417$, $P = 0.05$), but not greater than in narrow plots. Bird species diversity did not differ among treatments. Four species had significantly different densities between treatments and eight did not. Blue Jays, Northern Cardinals, and American Robins (*Turdus migratorius*) had higher densities in one or both Hogtown Creek study plots than San Felasco. The Yellow-rumped Warbler (*Dendroica coronata*) had higher densities in narrow than in both wide ($Q = 2.408$, $P = 0.05$) and San Felasco plots ($Q = 2.623$, $P = 0.03$). This was the only species comparison where a difference was found between the two Hogtown Creek treatments.

Only four habitat variables differed among treatments. Tree height diversity was greater in San Felasco than in either narrow or wide plots ($Q = 3.19$, $P = 0.004$ and $Q = 3.458$, $P = 0.002$, respectively). Tree density was greater in San Felasco than in narrow plots ($Q = 2.807$, $P = 0.016$). Species richness of shrubs in narrow plots was greater than in San Felasco

($Q = 2.803$, $P = 0.016$). Vine density was greater in the narrow treatment vs San Felasco ($P = 0.038$). Of the 21 significant regression models using spring data, tree characteristics were included in six models for Hogtown Creek and seven for San Felasco. Shrub variables were included in five Hogtown Creek models and seven San Felasco models. At least one development variable (width and housing density) contributed to five models in Hogtown Creek. Average r^2 values were greater in San Felasco (0.9782 ± 0.1827 SD) than in Hogtown Creek (0.5611 ± 0.2071 SD; $t = 4.87$, df = 19, $P < 0.001$). Of the 15 significant regression models found using winter data, tree characteristics and hardwood hammock cover each were included in five Hogtown Creek linear regression models. Width contributed to four, whereas housing density and shrub characteristics were included in two models each. Tree variables contributed to all six models in San Felasco. Again, average r^2 values were greater in San Felasco (0.9592 ± 0.0307 SD) than Hogtown Creek (0.6585 ± 0.1382 SD; $t = 5.185$, df = 13, $P < 0.001$).

Discussion.—The three most obvious factors that might explain at least some of the avian differences between San Felasco and Hogtown are vegetation dissimilarities, width of the urban corridor, and adjacent land use.

Sunlight can penetrate the less dense Hogtown forest and allow shade-intolerant shrubs and vines to persist. Naturally caused fires that reduce understory vegetation also have been suppressed for several decades in the urban corridor. The implications of these relationships is that urbanization may indirectly influence avian differences by directly affecting their habitats. For example, the understory in the Hogtown may be too dense for species such as Hooded Warblers that nest and forage close to the ground. Other urban studies have established relationships between bird species richness, diversity, density, and composition and vegetation variables in urban residential areas (Woolfenden and Rohwer 1969, Geis 1974, Beissinger and Osborne 1982, Goldstein et al. 1986). However, no previous investigations have focused on urban corridors.

All five species (Acadian Flycatcher, Hooded Warbler, Pileated Woodpecker, Red-eyed Vireo, and Summer Tanager) that had higher densities in San Felasco are insectivorous and are known to be sensitive to the size of isolated forest islands (Whitcomb et al. 1981). For example, Robbins et al. (1989) found that the diameter of forest patches which had a 50% probability of occurrence for Acadian Flycatchers was 437 m, Red-eyed Vireo 178 m, Summer Tanager 713 m, and Pileated Woodpecker 1449 m. Tassone (1981) reported that Acadian Flycatchers and Pileated Woodpeckers occurred infrequently in riparian strips less than 50 m wide in clear-cut areas. Stauffer and Best (1980) found that the minimum forested riparian width in which Red-eyed Vireos were found in an agricultural landscape was 40 m.

In our study, Acadian Flycatchers and Hooded Warblers were not found in narrow corridor segments (≤60 m), and Summer Tanagers were not recorded throughout the Hogtown Creek (≤150 m). Our data provide more evidence to support the ecological phenomenon that some Neotropical migrants are sensitive to habitat areas and widths. It is reasonable to believe that these widths are related somehow to the diameter of the species' home range which varies in response to food supply, age of the individual, population density, and other factors.

The five resident species (American Crow, Blue Jay, Carolina Wren, Northern Cardinal, and Red-bellied Woodpecker) with higher densities in the Hogtown Creek than in San Felasco consist of omnivores (three species), insectivores (one species), and granivores (one species), feed on or close to the ground, are found commonly in edge habitat, and are considered to be insensitive to the size of forest interior. The two short-distance migrants with higher densities in Hogtown Creek in winter, the American Robin and Yellow-rumped Warbler, also are edge species (Whitcomb et al. 1981).

The lack of avian and habitat differences between narrow and wide plots compared to the more frequent dissimilarities in these variables between the Hogtown and San Felasco suggests an inadequate range of widths studied. Although the ideal research design would include a larger continuum of sizes, local ordinances and development pressures tend to limit the variety of riparian widths available.

The importance of adjacent land use is illustrated by the fact that the development variables we measured were included in many significant regression models for the Hogtown Creek. Whitcomb et al. (1981) also found that the Acadian Flycatcher was more abundant in forests isolated by agricultural fields than those bordered by low-density suburban residential development. This suggests that the disturbance factors associated with residential housing may outweigh the habitat values of ornamental yard plantings. Several authors have reported that avian density and richness changes and fragment-sensitive forest species are replaced by edge species (Woolfenden and Rohwer 1969, Walcott 1974, Aldrich 1980, Beissinger and Osborne 1982, DeGraaf and Wentworth 1986, Gotfryd and Hansell 1986) in areas where natural forested habitats are replaced by mature suburbs.

Because the r^2 values for our Hogtown regression models were relatively low, we believe some unmeasured adjacent development variables were influencing bird-community parameters and individual-species' densities in this study area. There also may be a shift in importance from trees and shrubs in spring to development-associated variables in winter. Tilghman (1987) found that the density of adjacent buildings was one of four variables that accounted for much of the variation in bird species richness during winter in urban forest islands in Massachusetts. She speculated that the presence of bird feeders was responsible for this result.

As development continues to sprawl and alter natural landscapes, assessing impacts on local ecosystems becomes increasingly important. Habitat values of agricultural and urban landscapes must be taken into account to achieve regional goals of maintaining ecological integrity of natural systems (Schaefer et al. 1991). Lynch and Whitcomb (1978) reported that urban and suburban parks in the Washington, D.C. area failed as avifaunal preserves because from 1950 to 1970 many specialized, fragment-sensitive species were replaced by generalized residents.

At the local level, conservation strategies for forested riparian areas within urbanizing environments typically have been based only on flood control and water quality concerns (Zampella and Roman 1983, Barton et al. 1985, Budd et al. 1987). Consideration often is given to the recreational and educational opportunities they provide for local residents. Wildlife data such as presented in this paper also should be used to determine the consequences of various community greenspace options.

Acknowledgments.—The authors gratefully acknowledge the contributions of J. Smallwood in the study design and data analysis of this project. This is a Florida Agricultural Experiment Stations Journal Series No. R-01318.

LITERATURE CITED

ADAMS, L. W. AND L. E. DOVE. 1989. Wildlife reserves and corridors in the urban environment. National Institute for Urban Wildlife, Columbia, Missouri.

ALDRICH, J. W. 1980. Breeding bird populations from forest to suburbs after thirty-seven years. Atl. Nat. 33:8–9.

BARRETT, G. W. AND P. J. BOHLEN. 1991. Landscape ecology. Pp. 149–161 *in* Landscape linkages and biodiversity (W. E. Hudson, ed.). Island Press, Washington, D.C.

BARTON, D. R., W. D. TAYLOR, AND R. M. BIETTE. 1985. Dimensions of riparian buffer strips required to maintain trout habitat in southern Ontario streams. N. Amer. J. Fish. Manage. 5:364–378.

BEISSINGER, S. R. AND D. R. OSBORNE. 1982. Effects of urbanization on avian community organization. Condor 84:75–83.

BLAKE, J. G. AND J. R. KARR. 1987. Breeding birds of isolated woodlots: area and habitat relationships. Ecology 68:1724–1734.

BUDD, W. W., P. L. COHEN, AND P. R. SAUNDERS. 1987. Stream corridor management in the Pacific Northwest: I. Determination of stream corridor widths. Environ. Manage. 11:587–597.

DEGRAAF, R. M. AND J. M. WENTWORTH. 1986. Avian guild structure and habitat associations in suburban bird communities. Urban Ecol. 9:399–412.

GEIS, A. D. 1974. Effects of urbanization and type of urban development on bird populations. Pages 97–105 *in* Wildlife in an urbanizing environment (J. H. Noyes and D. R. Progulski, eds.). Univ. Mass., Amherst, Massachusetts.

GOLDSTEIN, E. L., M. GROSS, AND R. M. DEGRAAF. 1986. Breeding birds and vegetation: a quantitative assessment. Urban Ecol. 9:377–385.

GOTFRYD, A. AND R. I. C. HANSELL. 1986. Prediction of bird-community metrics in urban woodlots. Pages 321–326 *in* Wildlife 2000: modeling habitat relationships of terrestrial vertebrates (J. Verner, M. L. Morrison, and C. J. Ralph, eds.). Univ. of Wisconsin Press, Madison, Wisconsin.

HOLLANDER, M. AND D. A. WOLFE. 1973. Nonparametric statistical methods. John Wiley and Sons, New York, New York.

LYNCH, J. F. AND R. F. WHITCOMB. 1978. Effects of the insularization of the eastern deciduous forest on avifaunal diversity and turnover. Pp. 461–489 *in* Classification, inventory, and analysis of fish and wildlife habitat: proceedings of a national symposium (A. Marmelstein, ed.). U.S. Dept. Int., Fish and Wildl. Serv., FWS-78/76, Washington, D.C.

MAGURRAN, A. E. 1988. Ecological diversity and its measurement. Princeton Univ. Press, Princeton, New Jersey.

MYERS, R. L. AND J. J. EWEL. 1990. Ecosystems of Florida. Univ. Presses of Florida, Gainesville, Florida.

NOSS, R. F. AND L. D. HARRIS. 1986. Nodes, networks, and mums: preserving diversity at all scales. Environ. Manage. 10:299–309.

PIELOU, E. C. 1966. The measurement of diversity types of biological collections. J. Theor. Bio. 13:131–144.

RANNEY, J. W., M. C. BRUNER, AND J. B. LEVENSON. 1981. The importance of edge in the structure and dynamics of forest islands. Pp. 67–95 *in* Forest island dynamics in man-dominated landscapes (R. L. Burgess and D. M. Sharpe, eds.). Ecol. Stud. 41. Springer-Verlag, New York, New York.

REYNOLDS, R. T., J. M. SCOTT, AND R. A. NUSSBAUM. 1980. A variable circular-plot method for estimating bird numbers. Condor 82:309–313.

ROBBINS, C. S., D. K. DAWSON, AND B. A. DOWELL. 1989. Habitat area requirements of breeding forest birds of the middle Atlantic states. Wildl. Monogr. 103:1–34.

SAS INSTITUTE INC. 1988. SAS/STAT user's guide. SAS Institute Incorporated, Cary, North Carolina.

SCHAEFER, J. M., M. T. BROWN, R. HAMANN, AND J. TUCKER. 1991. A natural resources management and protection plan for the Econlockhatchee river basin. Pp. 145–150 *in* Proceedings of the symposium on wildlife conservation in metropolitan environments (L. W. Adams and D. L. Leedy, eds.). Natl. Inst. for Urban Wildlife, Columbia, Maryland.

SOKAL, R. R. AND F. J. ROHLF. 1981. Biometry. Second ed. W. H. Freeman, San Francisco, California.

Stauffer, D. F. and L. B. Best. 1980. Habitat selection by birds of riparian communities: evaluating effects of habitat alterations. J. Wildl. Manage. 44:1–15.

Tassone, J. F. 1981. Utility of hardwood leave strips for breeding birds in Virginia's central Piedmont. M.S. thesis, Virginia Polytechnic Institute and State Univ., Blacksburg, Virginia.

Temple, S. A. 1986. Predicting impacts of habitat fragmentation on forest birds: a comparison of two models. Pp. 301–304 *in* Wildlife 2000 (J. Verner, M. L. Morrison, and C. J. Ralph, eds.). Univ. Wisconsin Press, Madison, Wisconsin.

Tilghman, N. G. 1987. Characteristics of urban woodlands affecting winter bird diversity and abundance. For. Ecol. Manage. 21:163–175.

Walcott, C. F. 1974. Changes in bird life in Cambridge, Massachusetts from 1860 to 1964. Auk 91:151–60.

Whitcomb, R. F., C. S. Robbins, J. F. Lynch, B. L. Whitcomb, M. K. Klimkiewicz, and D. Bystrak. 1981. Effects of forest fragmentation on avifauna of the eastern deciduous forest. Pp. 125–205 *in* Forest island dynamics in man-dominated landscapes (R. L. Burgess and D. M. Sharpe, eds.). Springer-Verlag, New York, New York.

Woolfenden, G. E. and S. A. Rohwer. 1969. Breeding birds in a Florida suburb. Bull. Florida State Mus. 13:1–83.

Zampella, R. A. and C. T. Roman. 1983. Wetlands protection in the New Jersey Pinelands. Wetlands 3:124–133.

Zar, J. H. 1984. Biostatistical analysis. Prentice Hall, Inc., Englewood Cliffs, New Jersey.

Ruthe J. Smith and Joseph M. Schaefer, *Dept. Wildlife and Range Sciences, 118 Newins-Ziegler Hall, Univ. of Florida, Gainesville, Florida 32611-0430.* *Received 20 May 1991, accepted 20 April 1992.*

Wilson Bull., 104(4), 1992, pp. 738–743

The role of Marbled Murrelets in mixed-species feeding flocks in British Columbia.—Studies off the west coasts of Vancouver Island and the Queen Charlotte Islands indicate that Marbled Murrelets (*Brachyramphus marmoratus*) usually feed singly or in pairs (Carter 1984, Carter and Sealy 1990, Sealy 1973, 1975). Marbled Murrelets participated in mixed-species feeding flocks (Carter 1984; Carter and Sealy 1987, 1990; Chilton and Sealy 1987; Porter and Sealy 1981, 1982; Sealy 1973, 1975) but were not as prevalent as other species (Sealy 1973, Hoffman et al. 1981, Porter and Sealy 1981) and infrequently initiated the flock (Porter and Sealy 1982, Chilton and Sealy 1987). We describe events in a dense concentration of murrelets (Kaiser et al. 1991) in the more sheltered waters of the Strait of Georgia, east of Vancouver Island, where Marbled Murrelets were the major initiators and participants of mixed species feeding flocks.

Study area and methods.—The Okeover Inlet study area (50°5′N, 124°45′W) includes several small inlets and fiords on the southwestern coast of British Columbia (Fig. 1). It is sheltered from major Pacific storms by Vancouver Island and more locally by numerous small islands and peninsulas, creating a protected inshore habitat. The area is characterized by rugged, broken coastline, deep inlets and fiords and moderate tidal currents. Open sound, channel, inlet, and estuarine habitats were included within the study area. During the summer, the area had a resident population of about 370 Marbled Murrelets and 200 Glaucous-winged Gulls (*Larus glaucescens*) with respective densities of 10.4 and 5.6 birds km^{-2} (Kaiser et al. 1991, Campbell et al. 1990). Other fish-eating birds constituted less than 10% of summer observations.