BIRDS OF REMNANT RIPARIAN FORESTS IN NORTHEASTERN WISCONSIN

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Recently much research has been focused on the effect of forest fragmentation on so-called "forest interior" bird species. Forest interior birds are dependent for breeding habitat on the central portions of large forest tracts; a decline in these species has been associated with a reduction in size and quality of remnant forests (Robbins 1979, Whitcomb et al. 1981, and others). Fragmentation creates a greater proportion of edge habitat, resulting in increased nest predation (Wilcove 1985) and brood parasitism (Brittingham and Temple 1983). Ranney et al. (1981) have described edge-related changes in forest vegetation.

Our study considers forest birds of Brown and Kewaunee counties in northeastern Wisconsin, where forested landscapes have been drastically altered over the last two hundred years. A few remnants of the original vegetation type occur in lands considered marginal for agriculture. We focus on those remnant forests that may be considered riparian because they adjoin a stream, river, or wetland.

Brown and Kewaunee counties once were covered entirely by northern mesic forest (Stearns and Kobringer 1975) and scattered areas of lowland black ash (*Fraxinus nigra*) or conifer swamps (Link and Frings 1980). Less than 16% of the original forest remains in Kewaunee County, while only 11% remains in Brown County (Wisconsin Department of Natural Resources 1968). Deforestation undoubtedly has altered the original forest bird assemblages. The great reduction and fragmentation of forests, in light of observations elsewhere in eastern North America, suggest that forest interior bird species in Brown and Kewaunee counties must be greatly reduced in numbers if they persist at all. We ask: "Which forest interior birds, if any, remain today in these riparian remnants?" If forest interior birds are found, we then ask: "Can those sites with forest interior species be distinguished consistently from sites in which these species are absent?"

METHODS

We identified remnant riparian forests from aerial photos and topographic maps. In these forests, we selected 38 survey points in Brown County (Table 1) and 20 points in Kewaunee County (within tracts of 100, 157, 178, 217 and 229 ha). For comparison, we chose 17 additional points in a larger forest (867 ha) in Kewaunee County. The Brown County riparian remnants reflect a gradient from early successional to moderately mature stands of northern mesic forest. The Kewaunee remnants represent lowland conifer (cedar) swamps or mixed coniferous-hardwood swamps. With the exception of the 867-ha site in Kewaunee County, none of our sites is part of a contiguous

forest larger than 250 ha; the Brown County sites, in particular, are considerably smaller. Each site was visited at least once during the peak avian breeding season (June through mid-July) of 1985. All visits were completed during calm, non-rainy weather between sunrise and 0900. We recorded all birds seen or heard from a central point during two consecutive 10-minute censuses. We surveyed 30 sites in Brown County and 16 in Kewaunee County (including sites in the larger forest) repeatedly during 1985 and 1986. Details of these extended studies will be reported elsewhere.

Table 1 Environmental Variables and Discriminant-Analysis *F* Ratios for Survey Points in Riparian Remnants of Brown County

Environmental variable	Mean (± std. dev.)	*F* Ratio (initial step)		
		Ovenbird	Wood Thrush	Ovenbird and/or Wood Thrush
Percent forested area within				
1000 m	16.3 ± 7.4	8.0	11.4	21.0
500 m	55.2 ± 19.4	20.1	5.5	18.1
250 m	29.3 ± 13.8	10.4	14.2	28.7
150 m	74.0 ± 20.4	12.2	0.6	5.3
Area of remnant (ha)	35.8 ± 26.7	5.0	9.7	16.1
Contiguous area (ha)	56.3 ± 39.6	3.7	8.3	10.9
Nonagricultural area (ha)	68.1 ± 43.7	1.8	7.6	7.5
Elevation above river (m)	4.4 ± 4.5	8.6	0.2	0.7
Distance to the edge (m)	100 ± 37	2.3	0.8	1.7
Forest length (m)	1153 ± 684	7.8	6.0	15.6
Forest width (m)	225 ± 100	3.8	1.5	3.5
Canopy closure (%)	81.7 ± 17.6	5.4	0.6	2.7
Ground cover (%)	46.2 ± 19.2	0.8	0.8	2.4
Heterogeneity (Roth 1976)				
Canopy	54.4 ± 13.1	1.7	0.2	0.9
Understory	56.1 ± 13.5	1.7	1.1	1.9
Shrub	74.3 ± 13.5	3.4	3.9	5.1
Height (m)				
Canopy	11.1 ± 2.8	1.1	0.6	2.3
Understory	3.7 ± 1.1	0.3	0.1	0.04
Shrub	10 ± 0.2	0.7	0.3	1.4
Basal area (m^2)				
Canopy	0.61 ± 0.31	0.2	1.7	0.03
Understory	0.0044 ± 0.006	0.4	0.7	0.02
Shrub	0.0039 ± 0.0023	0.3	1.7	1.0
Density (stem/m^2)				
Canopy	0.016 ± 0.077	0.1	0.2	0.02
Understory	0.044 ± 0.032	5.1	1.4	1.5
Shrub	0.150 ± 0.110	0.4	3.7	10.2

Vegetation was analyzed in detail for the Brown County sites; analysis of the Kewaunee sites is in progress. Five sample quadrats were evaluated near each Brown County survey point. At each quadrat we recorded data on canopy trees, understory trees (less than two-thirds the height of canopy but at least 2 m tall) and woody shrubs (<2 m tall) by using a modified point-centered quarter method (Cottam and Curtis 1956, James and Shugart 1970). Percentage ground cover and percentage canopy cover were also estimated (Hays et al. 1981). These data, in addition to a review of aerial photos, allowed us to estimate 27 environmental variables (Table 1). We used discriminant analysis to compare these habitat characteristics to the bird census results (Rice et al. 1983).

RESULTS

We found significant numbers of forest interior birds (Whitcomb et al. 1981) even in unexpectedly small riparian remnants. For example, a narrow (<120 m wide) riparian strip in Kewaunee County (not included in Table 2) was occupied by singing Ovenbirds and Black-and-white Warblers, two species considered by Whitcomb et al. (1981) to be sensitive to forest extent. Larger sites in Kewaunee County were inhabited by Winter Wren, Pileated Woodpecker, Veery, Wood Thrush, Brown Creeper, and other forest interior species (Table 2). Width of these riparian areas rarely exceeds 500 m, even though the total area of contiguous forest is greater than 100 ha. Forest birds of Kewaunee County riparian fragments did not precisely reflect bird assemblages in the larger forest tract (Table 2), yet only two species characteristic of lowland forests in Kewaunee County (Red-breasted Nuthatch and Broad-winged Hawk) were absent in the isolated fragments. The Red-shouldered Hawk (*Buteo lineatus*) and several other species probably inhabited many of these areas before settlement but today they are absent even in the 867-ha site. Fewer forest bird species were recorded in the drier riparian forests of Brown County, but several species sensitive to forest extent, such as the Ovenbird, Hairy Woodpecker, and Wood Thrush, were found consistently (Table 2).

A detailed study of remnant riparian forests in Brown County focused on the Ovenbird and the Wood Thrush, two forest interior species from the same foraging guild (ground-feeders). These birds were the species most commonly encountered in Brown County that are widely considered to be sensitive to forest extent. The 38 census points were grouped according to the presence or absence of these two species. Stepwise discriminant analysis identified habitat characteristics that are significantly associated with the presence or absence of either bird.

Percentage forest within 500 m of the census point was most significant in distinguishing sites inhabited by the Ovenbird. This single habitat characteristic provided enough information to classify 76.3% of the points correctly. Discriminant analysis based on presence or absence of the Wood Thrush provided similar results, although in this case the most important discriminating variable was the percentage forest within 250 m. From this variable alone, 72% of the cases could be classified correctly. These results,

Table 2 Forest Interior Birds of Riparian Fragments (<250 ha) and a Larger Forest (867 ha) in Northeastern Wisconsin in 1985

Species	Percentage occurrence		
	Kewaunee County		Brown County
	867 ha (17 points)	100-229 ha (20 points)	<100 ha (38 points)
Ovenbird (*Seiurus aurocapillus*)	88	75	26
Black-capped Chickadee (*Parus atricapillus*)	65	65	36
Hairy Woodpecker (*Picoides villosus*)	53	55	47
Winter Wren (*Troglodytes troglodytes*)	47	50	0
Red-eyed Vireo (*Vireo olivaceus*)	41	10	47
Pileated Woodpecker (*Dryocopus pileatus*)	29	25	0
Red-breasted Nuthatch (*Sitta canadensis*)	29	0	0
Black-and-white Warbler (*Mniotilta varia*)	29	40	0
Veery (*Catharus fuscescens*)	24	30	0
Wood Thrush (*Hylocichla mustelina*)	24	30	42
Scarlet Tanager (*Piranga olivacea*)	24	5	7
Brown Creeper (*Certhia americana*)	18	15	0
Eastern Wood Pewee (*Contopus virens*)	18	15	71
Broad-winged Hawk (*Buteo platypterus*)	12	0	0
White-breasted Nuthatch (*Sitta carolinensis*)	0	20	60

coupled with the species' less frequent occurrence overall, suggest that Ovenbirds are more sensitive than Wood Thrushes to forest fragmentation.

We also performed a discriminant analysis based on the presence/absence of either the Wood Thrush or the Ovenbird. If neither bird was present the point was grouped in the "absent" category and if one or both species were present the point was grouped in the "present" category. Percentage forested area within 250 m of the census point was selected by this analysis as the most important discriminating variable. Other significant variables included shrub density, shrub heterogeneity, average understory height, and forest type

(based on varimax factor analysis of tree species importance values). The latter variable differentiates mature forests from stands in earlier stages of succession. The discriminant function with all five variables correctly classifies the samples (those with one or both species versus those with neither species) in 94.7% of the cases.

DISCUSSION

Forest interior birds do indeed exist in riparian forest remnants of these highly modified landscapes. The Ovenbird, Winter Wren, and Pileated Woodpecker bred successfully in Kewaunee County remnants. More intensive studies (in progress) will be needed to determine the status of birds we observed, yet 11 of the 15 forest interior species in Kewaunee County (Table 2) were only slightly less frequent in outlying forest remnants than they were in the larger (867-ha) forest.

The Brown-headed Cowbird (*Molothrus ater*) has been implicated in decreased fledging success of forest interior birds in Wisconsin (Brittingham and Temple 1983). In Kewaunee County, Brown-headed Cowbirds were present in 20% of the smaller sites but were not recorded at all in the 867-ha site. The increased frequency of cowbirds in smaller forests may reduce the breeding success of birds in the smaller remnants.

Robbins (1979) suggested that contiguous forest areas of at least 2650 ha might be necessary to support a population of Ovenbirds and that at least 100 ha are needed for a viable Wood Thrush population. Brown and Kewaunee counties have no forest remnants larger than 2500 ha and few larger than 100 ha, yet, as we have shown, both species (and other sensitive species) are present. Perhaps the extensive forested areas remaining northwest and west of Brown and Kewaunee counties provide a regular source of colonists for populations in our riparian remnants. In other words, the local populations that we have studied might not be self-sustaining. Current studies of the Kewaunee County sites are attempting to resolve this uncertainty.

Another possibility, first implied by Bond (1957), is that moister sites are better able to sustain populations of forest interior birds than are drier upland sites. Whitcomb et al. (1981) observed that forest interior bird species often are more abundant in bottomlands or mesic habitats than they are in drier uplands. Upland sites are more prone to the inevitable drying effects of sun and wind following forest fragmentation. Riparian forest fragments, on the other hand, have a source of moisture and often sheltered slopes to counteract these effects. Thus, riparian remnants might better retain the mesic nature of original forests. Forest interior birds species may, therefore, persist in smaller tracts if the tracts are riparian.

Isolation may be another important element contributing to the decline of habitat-island populations (Whitcomb et al. 1981, Lynch and Whigham 1984). Because riparian forests tend to form corridors that promote movement between local populations, they may be important in maintaining genetic or demographic integrity of regional populations (Noss and Harris 1986). The "interconnectedness" of riparian forests in our study areas, despite relatively small forest sizes and high proportions of edge habitat, may be another explanation for the presence of species sensitive to forest extent.

Results from our investigations illustrate the complexity of the relationships between habitat extent, habitat quality, and bird distributions. Many species, like Ovenbirds, occur in a variety of forest habitats, yet their abundance varies locally. Ovenbirds and several other species seem to be more successful in the moister forests of Kewaunee County, for example, than they are in riparian forests of Brown County (Table 2). The opposite seems to be true for the Wood Thrush, Eastern Wood Pewee, and Red-eyed Vireo. Small areas of highly favorable habitat might be equivalent to larger areas of less favorable habitat. We suggest that riparian or lowland forests are indeed highly favorable for certain forest interior bird species. Hence, these birds might be able to persist in riparian areas that are smaller than their minimum habitable areas in upland forest types.

Changes in forest size may affect the quality of forest vegetation. Red-breasted Nuthatches are fairly common in the large (867-ha) lowland forest of Kewaunee County, yet they are replaced by White-breasted Nuthatches in smaller, more isolated tracts of otherwise similar habitat (Table 2). Red-breasted Nuthatches in northeastern Wisconsin typically occur in shady coniferous forests, whereas White-breasted Nuthatches seem to favor deciduous forests, which for much of the year are considerably more open than coniferous woods. In other words, fragmentation of lowland coniferous forests may create a relatively open forest environment, more suitable for species like the White-breasted Nuthatch. Perhaps other, more subtle interactions between habitat quality and habitat size will be revealed as more types of "habitat islands" are evaluated.

The fact that significant numbers of forest interior specialists still occur in riparian forest remnants of our study area suggests that it is not too late to preserve at least a part of the original forest interior avifauna in this region. Riparian forests, because of their relatively high levels of available moisture and perhaps because of their interconnectedness, might play a crucial role in preservation efforts. The preservation of maximum bird species diversity in these two counties and many like them requires protection of the regional variation in forest habitats. Riparian forests provide a significant system of these forest refugia and thus are vital to regional bird species diversity.

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Ovenbird and Wood Thrush

Sketch by Narca Moore-Craig