

Response of Breeding Bird Communities to Restoration of Hardwood Bottomlands

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Abstract: Much of the original hardwood bottomland in the Mississippi Alluvial Valley is converted to crop lands. Land management agencies began restoring hardwood bottomland because of its importance to wildlife. To provide an initial evaluation of progress toward restoration, we used point counts to compare bird communities among plantations of 0 to 4, 7 to 15, and 21 to 27 years in age with natural sawtimber stands (>50 years in age) in the southern Delta region of Mississippi in 1994 and 1995. Mean number of species per point (species richness) increased with stand age ($P < 0.05$). Mean total abundance did not differ among age classes. Relative to bird communities of natural sawtimber forest at Yazoo National Wildlife Refuge and Delta National Forest, respectively, Morisita's index of similarity was 85.4% and 74.3% for 21- to 27-year-old plantations, 41.9% and 35.0% for 7- to 15-year-old plantations and 4.6% and 2.6% for 0- to 4-year-old plantations. Plantations in the 21- to 22- and 7- to 15-year-old age classes supported a substantial portion of the potential forest bird community, but still lacked area-sensitive and certain late-successional species. Plantations in the youngest age class were dominated by 2 abundant species, red-winged blackbird (*Agelaius phoeniceus*) and dickcissel (*Spiza americana*). Nevertheless, young plantations provide temporary habitat for regionally declining grassland bird species. Management prescription that mimic natural succession such as mixed plantings or thinning might enhance the restoration effort and promote earlier colonization by mature forest birds.

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Hardwood bottomland is the primary forested wetland along river drainages in the southeastern United States. Historically, one of the largest expanses of hardwood bottomland in the southeast was the Mississippi Alluvial Valley (MAV), which once contained almost 10 million ha of nearly unbroken forested wetland. Today, 80% of the original forested wetland in the MAV is converted to agriculture. Most remaining tracts of forested wetland, including seasonally flooded hardwood bottomland, are relatively small and highly fragmented (Creasman et al. 1992). Although forested wetland continues to be destroyed or altered by channel and levee developments, these losses must now be mitigated (Kusler 1986).

When compared with other forest types, hardwood bottomland has particularly diverse avian communities (Pashley and Barrow 1993). Regardless, breeding bird surveys indicate that many species of forest birds are declining in the MAV, especially species that winter in the neotropics. For example, hardwood bottomland in the MAV provides essential breeding habitat for 22 mature forest, neotropical migrant species. Of these, 7 species are believed to be in decline, along with 6 forest edge species (Hunter et al. 1993). Area-sensitive bottomland forest birds that are of special management concern in the MAV include Swainson's warbler (*Limnothlypis swainsonii*, which may require >4,000 ha for viable breeding populations of 500 pairs), the cerulean warbler (*Dendroica cerulea*, >8,000 ha) and the American swallow-tailed kite (*Elanoides forficatus*, >20,000 ha; Mueller *in press*). These species serve as flagships to focus management attention on restoring large blocks of forest. Additionally, hardwood bottomlands serve as migration corridors and stop-over habitat for many neotropical and short-distance migrant birds. The hardwood bottomland ecosystem in the southeast is identified as requiring highest conservation priority (Hunter et al. 1993).

Public, private, and interagency groups have identified protection and restoration of hardwood bottomland in the MAV as a major goal (Myers 1994). This surge of interest in restoration of hardwood bottomland has generated a need for information on how current restoration projects are affecting wildlife populations and at what age plantations begin to meet habitat requirements of bottomland species. The purpose of this study is to provide a preliminary evaluation of the progress of existing restoration sites in the MAV through a time-specific assessment of breeding bird populations in various-aged plantations and natural sawtimber bottomland hardwood forest. Although we did not assess avian reproduction, occupancy of a stand is a necessary precondition to reproduction and provides a measure of potential habitat quality. If we assume that mature stands of bottomland hardwood are the objective, then existing stands can serve as a point of reference to evaluate plantation communities. Our study is based on the premise that the degree to which bird communities in plantations match those in natural sawtimber stands is an index to the degree to which the hardwood bottomland ecosystem has been restored at those sites.

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Methods

The study was conducted on Yazoo National Wildlife Refuge (Washington County), Lake George Wildlife Management Area (Yazoo County), and Delta National Forest (Sharkey County) in west-central Mississippi. These areas are all within

the Mississippi Alluvial Plain physiographic province, with soils and hydrology largely influenced by the dynamics of the Mississippi River. Yazoo NWR is 4,800 ha in size and consists of a mosaic of share-cropped agricultural fields, moist-soil units, sloughs, bayous, and small lakes with open water and aquatic herbs and shrubs, forested wetlands including seasonally flooded hardwood bottomland and intermittently drained cypress swamps, and a number of bottomland hardwood restoration plantations from 0 to 27 years in age. Lake George WMA is 3,200 ha in size and was cleared for agriculture in the late 1960s. This WMA was recently purchased by the U.S. Army Corps of Engineers to mitigate wetland losses from the construction of the Tennessee-Tombigbee Waterway. Since 1991 the Corps has afforested (i.e., planted trees on previously nonforested land) approximately 400 ha annually, with each plantation being 10 to 300 ha in size. Edges between plantations consisted mainly of narrow drainage ditches of willow (*Salix* spp.) and cottonwood (*Populus deltoides*). Red oaks such as cherrybark oak (*Quercus pagoda*), Nuttall oak (*Q. nuttallii*), water oak (*Q. nigra*) and willow oak (*Q. phellos*) were the most common trees planted in restoration sites at Yazoo and Lake George. Volunteer species included green ash (*Fraxinus pennsylvanica*), sweetgum (*Liquidambar styraciflua*), sugarberry (*Celtis laevigata*), common persimmon (*Diospyros virginiana*), and honeylocust (*Gleditsia triacanthos*). Delta National Forest is 24,000 ha in size and consists of primarily mature hardwood bottomland, but adjacent forested properties increase the block size to 36,000 ha. Major forest associations at Delta National Forest were overcup oak (*Q. lyrata*)-bitter pecan (*Carya aquatica*), sugarberry-American elm (*Ulmus americana*)-green ash and sweetgum-Nuttall oak-willow oak.

We conducted point counts in stands ranging from first year plantings to mature forest in 1994 and 1995. In 1994, we censused 31 points in 0- to 3-year-old plantations at Lake George WMA, 9 points in 7- to 14-year-old plantations at Yazoo NWR, 3 points in 21- to 26-year-old plantations at Yazoo NWR, and 18 points in naturally regenerated sawtimber stands at Delta National Forest. In 1995, we censused 12 points in 1- to 4-year-old plantations at Lake George WMA, 7 points in 22- to 27-year-old plantations at Yazoo NWR, 11 points in natural sawtimber stands at Delta National Forest, and 15 points in natural sawtimber stands at Yazoo NWR. These age groupings include every available plantation age in the study areas. Sawtimber stands at Delta National Forest and Yazoo NWR were 50 to >200 and 50 to 100 years old, respectively. We were constrained from achieving a greater number of points in 7- to 15- and 21- to 27-year-old plantations because of their low availability in the landscape; however, we sampled all available stands in these age classes that met point count criteria. We located points ≥ 100 m from edge and ≥ 250 m apart (Ralph et al. 1993). In 1994, points were censused 4 times each from 3 June to 15 July. In 1995, points were sampled once from 3 June to 15 July. Birds observed ≥ 150 m from or flying over the point were not included in the analyses. Data from 1994 were averaged over the 4 censuses for each point. In 1995, natural sawtimber stands at Yazoo NWR and Delta National Forest were considered separate treatments because they exist in different landscape contexts.

We compared measures of relative abundance and species richness among treat-

ments with analysis of variance (ANOVA) for each year. We analyzed years separately because many stands were not censused in both years. We used Fisher's LSD multiple comparison procedure for pairwise comparisons when ANOVA's were significant ($P < 0.05$). In 1994, 0- to 3-year-old plantation points located >125 m from edge were compared with ANOVA to points located ≤ 125 m from edge to determine if proximity to edge affected mean species richness or total abundance. We compared similarity of bird communities among treatments with Morisita's (1959) similarity index for the combined 1994 and 1995 data of species relative abundance.

Results and Discussion

In 1994, mean number of bird species (species richness) differed among age classes, except between 7- to 14- and 21- to 26-year-old plantations; number of species increased with stand age. In 1995, mean species richness was lowest in 1- to 4-year-old plantations, but did not differ among other age classes (Table 1). Mean abundance of birds did not differ between treatments in 1994 or 1995. Low sample sizes in 21- to 27- and 7- to 15-year-old plantations may have provided insufficient power to detect differences. In 0- to 3-year-old plantations in 1994, we observed more species on average at points within 125 m of an edge than at points >125 m from an edge ($F = 8.58$; $df = 29, 1$; $P = 0.0066$); however, total abundance did not differ ($F = 1.79$; $df = 29, 1$; $P = 0.1908$) and community similarity between edge and interior points was 96.3%.

Table 1. Mean total abundance and species richness of birds observed/point at Delta National Forest, Lake George Wildlife Management Area, and Yazoo National Wildlife Refuge in 1994 and 1995.

	Year	
	1994	1995
Total abundance	11.81 (0.22) ^{a,b}	13.29 (0.56) ^c
Species richness	6.06 (0.29) ^d	7.46 (0.43) ^e
Natural sawtimber (Yazoo NWR)	--	8.67 (0.56) A ^f
Natural sawtimber (Delta NF)	8.84 (0.32) A ^f	9.36 (0.75) A
21- to 27-year-old plantations	6.75 (0.66) B	9.00 (0.00) A
7- to 15-year-old plantations	6.56 (0.32) B	8.00 (0.44) A
0- to 4-year-old plantations	4.24 (0.17) C	3.50 (0.31) B

^a Standard errors in parentheses.

^b Failed to reject H_0 : age classes did not differ with respect to mean total abundance of birds in 1994 ($F = 1.91$; $df = 57, 3$; $P = 0.1380$) therefore multiple comparisons were not performed.

^c Failed to reject H_0 : age classes did not differ with respect to mean total abundance of birds in 1995 ($F = 0.30$; $df = 43.4$; $P = 0.8742$) therefore multiple comparisons were not performed.

^d Rejected H_0 : age classes did not differ with respect to mean bird species richness in 1994 ($F = 66.80$; $df = 57, 3$; $P = 0.0001$) and multiple comparisons were performed.

^e Rejected H_0 : age classes did not differ with respect to mean bird species richness in 1995 ($F = 18.70$; $df = 43, 4$; $P = 0.0001$) and multiple comparisons were performed.

^f Values with like letters in a column are not significantly different ($P < 0.05$) with respect to mean bird species richness according to Fisher's LSD multiple comparisons.

Relative to natural sawtimber stands at Yazoo NWR and Delta National Forest, Morisita's index of similarity was 4.6% and 2.6%, respectively, for 0- to 4-year-old plantations (Table 2). Young plantations were dominated by 2 species that were absent or rare in natural sawtimber stands (red-winged blackbirds and dickcissels) and had low numbers of birds in common with natural sawtimber stands, contributing to the low similarity score. Young plantations did provide temporary habitat for some regionally declining grassland bird species (Hunter et al. 1993), including dickcissels and northern bobwhite (*Colinus virginianus*). Plantations 7 to 15 years in age were 41.9% similar to natural sawtimber at Yazoo NWR and 35.0% similar to natural sawtimber at Delta National Forest. Plantations 21 to 27 years in age were 85.4% similar to natural sawtimber at Yazoo NWR and 74.3% similar to natural sawtimber at Delta National Forest. These age classes had many species in common with natural sawtimber stands, contributing to their relatively high similarity scores; however, much of the similarity may be attributed to high abundance of many habitat generalists, including the Carolina wren (*Thryothorus ludovicianus*) and northern cardinal (*Cardinalis cardinalis*). Although abundant in natural sawtimber stands, these species do not require late-successional or forest interior conditions (Hamel 1992). The older plantations still lacked certain species that are considered area-sensitive or require late-successional forest, such as Swainson's warbler and yellow-throated vireo (*Vireo flavifrons*, Hamel 1992). Natural sawtimber stands at Yazoo NWR were 80.3% similar to those at Delta National Forest, less similar than to 21- to 27-year-old plantations at Yazoo NWR; thus, landscape context may limit community composition of natural stands and maturing plantations, regardless of its effect on total abundance or species richness.

Generally, the highest priority species (Mueller *in press*) were found in greatest abundance in natural sawtimber stands (Table 3). The conservation value, defined by abundance of high priority species, of plantations increases with plantation age, with the highest conservation value found in natural sawtimber stands at Delta National

Table 2. Morisita similarity matrix comparing bird community composition among all age classes of plantations and natural sawtimber at Delta National Forest, Lake George Wildlife Management Area, and Yazoo National Wildlife Refuge in 1994 and 1995.

	Plantations			Natural sawtimber	
	0-4 years old	7-15 years old	21-27 years old	Delta NF	Yazoo NWR
0- to 4-year old plantations	1.000				
7- to 15-year-old plantations	0.655	1.000			
21- to 27-year-old plantations	0.129	0.574	1.000		
Natural sawtimber Delta NF	0.026	0.350	0.743	1.000	
Natural sawtimber Yazoo NWR	0.046	0.419	0.854	0.803	1.000

Table 3. Mean number of individuals of each species observed/point in each age class at Delta National Forest, Lake George Wildlife Management Area, and Yazoo National Wildlife Refuge in 1994 and 1995^a.

PIF Score	Species	Plantations			Natural sawtimber	
		0-4 years old	7-15 years old	21-27 years old	Delta NF	Yazoo NWR
30 ^b	Swainson's warbler	0.00	0.00	0.00	0.19	0.00
28 ^c	Prothonotary warbler	0.00	0.00	0.07	0.68	0.47
27 ^c	Mississippi kite	0.00	0.00	0.00	0.00	0.07
26 ^c	Yellow-billed cuckoo	0.04	0.23	1.00	0.72	0.40
25 ^c	Orchard oriole	0.00	0.05	0.00	0.00	0.00
25 ^c	Painted bunting	0.02	0.00	0.00	0.00	0.00
25 ^c	White-eyed vireo	0.00	0.23	0.13	0.93	0.13
24 ^c	Acadian flycatcher	0.00	0.00	0.00	1.28	0.40
24 ^c	Eastern wood-pewee	0.00	0.00	0.00	0.21	0.13
24 ^c	Great crested flycatcher	0.08	0.05	0.00	0.00	0.27
24 ^c	Northern parula	0.00	0.00	0.20	0.11	0.00
24 ^c	Red-headed woodpecker	0.00	0.00	0.00	0.06	0.07
24 ^c	Wood thrush	0.00	0.02	0.33	0.35	0.53
23 ^d	Yellow-breasted chat	0.08	1.28	0.00	0.01	0.00
22 ^d	Dickcissel	3.31	0.88	0.00	0.00	0.00
22 ^d	Red-shouldered hawk	0.00	0.00	0.00	0.20	0.00
22 ^d	Ruby-throated hummingbird	0.03	0.05	0.00	0.00	0.07
21 ^d	Blue-gray gnatcatcher	0.00	0.00	0.07	0.32	0.37
21 ^d	Kentucky warbler	0.00	0.00	0.00	0.14	0.33
21 ^d	Northern bobwhite	0.44	0.12	0.00	0.00	0.00
21 ^d	Red-eyed vireo	0.00	0.00	0.07	0.11	0.20
21 ^d	Summer tanager	0.00	0.07	0.27	0.07	0.67
21 ^d	Yellow-throated vireo	0.00	0.00	0.00	0.16	0.00
20 ^d	Carolina chickadee	0.00	0.05	0.40	0.59	0.40
20 ^d	Indigo bunting	0.09	1.09	0.67	0.51	0.33
20 ^d	Red-bellied woodpecker	0.00	0.16	0.40	0.65	1.47
19 ^d	Carolina wren	0.02	0.28	1.93	1.63	2.13
19 ^d	Common yellowthroat	0.29	0.60	0.00	0.00	0.00
19 ^d	Tufted titmouse	0.01	0.07	0.33	0.37	0.60
18 ^c	Barred owl	0.00	0.00	0.00	0.01	0.00
18 ^c	Common grackle	0.05	0.16	0.00	0.00	0.00
18 ^c	Pileated woodpecker	0.00	0.00	0.07	0.48	0.20
17 ^c	Northern rough-winged swallow	0.01	0.00	0.00	0.00	0.00

Forest. Although observed at several points in the large forested block of Delta National Forest, the single highest priority species, Swainson's warbler, was never observed in the less extensive forest at Yazoo NWR, even though we sampled every forested location there that met point count criteria. Thus, our data support Mueller's (in press) estimate concerning area sensitivity of Swainson's warblers, which suggests they require a forested block of >4,000 ha. Regardless, other high-priority, area sensitive species, like prothonotary warblers (*Protonotaria citrea*), great crested flycatchers (*Myiarchus crinitis*), summer tanagers (*Piranga rubra*), pileated woodpeckers (*Dryocopus pileatus*), Kentucky warblers (*Opornis formosus*), eastern wood-pewees

Table 3. *continued*

PIF Score	Species	Plantations			Natural sawtimber	
		0-4 years old	7-15 years old	21-27 years old	Delta NF	Yazoo NWR
16 ^e	Brown-headed cowbird	0.00	0.14	0.07	0.02	0.07
16 ^e	Eastern meadowlark	0.74	0.07	0.00	0.00	0.00
16 ^e	Northern cardinal	0.17	1.53	2.47	1.36	1.93
16 ^e	Northern mockingbird	0.07	0.00	0.00	0.00	0.00
16 ^e	Rufous-sided towhee	0.04	0.07	0.20	0.00	0.07
15 ^e	Mourning dove	0.27	0.72	0.13	0.17	0.27
15 ^e	Hairy woodpecker	0.00	0.00	0.00	0.00	0.20
14 ^e	Blue jay	0.02	0.47	0.60	0.15	0.33
14 ^e	Downy woodpecker	0.00	0.02	0.33	0.22	0.40
14 ^e	Killdeer	0.09	0.00	0.00	0.00	0.00
14 ^e	White-breasted nuthatch	0.00	0.00	0.00	0.01	0.00
12 ^f	Red-winged blackbird	6.01	2.81	0.20	0.00	0.07
10 ^f	Barn swallow	0.02	0.00	0.00	0.00	0.00
9 ^f	Red-tailed hawk	0.00	0.00	0.00	0.01	0.00
- ^g	Bobolink	0.01	0.00	0.00	0.00	0.00
- ^g	Fox sparrow	0.00	0.02	0.00	0.00	0.00
- ^g	Great egret	0.02	0.14	0.53	0.10	0.00
	Unknown bird ^h	0.10	0.19	0.53	0.70	0.27

^aData from 1994 were averaged over 4 censuses per point before combining with 1995 data, which consist of 1 census per point.

^bSwainson's warbler is considered by Partners in Flight as of "extremely high concern, most vulnerable and likely in need of immediate management and/or monitoring attention" in the Mississippi Alluvial Valley (Mueller *in press*, Hunter 1993).

^cThese species are considered by Partners in Flight of "very high concern, more vulnerable and likely in need of management and/or monitoring attention."

^dThese species are considered by Partners in Flight of "high concern, average vulnerability or relative degree of vulnerability unknown but likely in need of at least monitoring attention."

^eThese species are considered by Partners in Flight of "moderate concern, less vulnerable and possibly in need of monitoring attention."

^fThese species are considered by Partners in Flight of "low concern, least vulnerable and not likely needing any attention at this time."

^gThese species are not scored by Partners in Flight for the MAV.

^hCould not be identified at time of census.

(*Contopus virens*), and yellow-billed cuckoos (*Coccyzus americanus*), were observed in Yazoo NWR natural sawtimber stands, and prothonotary warblers, great crested flycatchers, summer tanagers and yellow-billed cuckoos were observed in 21- to 27-year old plantations (also at Yazoo NWR), contradicting Mueller's estimates for these birds. Although we did not assess reproduction or productivity for birds in this study, and cannot determine whether these individuals contributed to viable breeding populations, we did encounter several yellow-billed cuckoo and prothonotary warbler nests at Yazoo NWR. Still, the area and landscape context of afforested sites will influence their ability to support certain species. As restoration proceeds on former agricultural land, many area-sensitive species may begin to find suitable habitat in a natural sawtimber-plantation sawtimber habitat mosaic.

Two management prescriptions that might accelerate the restoration of hardwood bottomland sites are mixed plantings and thinning. Currently, the primary spe-

cies planted for restoration are oaks, because they provide mast as food for wildlife and are commercially valuable when mature. Furthermore, oaks may be difficult to establish otherwise, because seed sources are often too far away for natural dispersal. Unfortunately, oaks grow slower than other hardwood bottomland species like cottonwood and sycamore (*Platanus occidentalis*), delaying the time it takes for the plantation to develop vertical structure and other natural forest conditions. We suggest that plantings of a combination of fast-growing and slower-growing species could accelerate colonization by forest birds. Furthermore, since soil conditions were greatly perturbed and seed banks depleted in former agricultural fields, their properties are more similar to sand bars than recent clear cuts within existing forest (J. D. Hodges, Miss. State Univ. pers. commun.). Therefore, we believe afforesting sites with early-successional tree species would more closely mimic primary succession as it occurred on these sites (Hodges and Switzer 1979), perhaps facilitating restoration of ecological processes. Incorporating a fast-growing vertical component within the interior of plantations would provide song perches and nesting cover for birds, especially in the youngest plantations where tall woody cover only occurs at plantation edges. Forest management once oaks become established, such as thinning, will help maintain vertical structure and diversity of woody species. Research is underway in the region to investigate the feasibility of mixed plantings for wildlife habitat and timber revenue potential (B. D. Leopold, Miss. State Univ., pers. commun., J. Hodges, Miss. State Univ., pers. commun.).

A second prescription that may enhance avian habitat in established plantations is thinning at approximately 20 to 25 years after establishment. The canopies in 21- to 27-year-old plantations were completely closed, except in areas where plantings had failed (Nuttle and Burger, unpubl. data); thus, there was little ground or midstory vegetation, reducing structural diversity and subsequently the number of bird species in the plantations. Plans are currently underway to thin the 27-year-old plantations on Yazoo NWR (L. Dorris, Yazoo NWR, pers. commun.). Should thinning produce the desired effect on vegetation in these plantations, application of this treatment to other afforested sites, as they reach canopy closure, could have a significant positive impact across the MAV. Further research on how these prescriptions will affect the bird communities inhabiting these stands will help to understand avian community succession in hardwood bottomland restoration sites.

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