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Forest area and distribution in the Mississippi alluvial valley: implications for breeding bird conservation

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Abstract

Knowing the current forest distribution and patch size characteristics is integral to the development of geographically defined, habitat-based conservation objectives for breeding birds. Towards this end, we classified 2.6 million ha of forest cover within the Mississippi Alluvial Valley using 1992 thematic mapper satellite imagery. Although historically this area, from southern Illinois to southern Louisiana, was dominated by forested wetlands, forest cover remains on less than 25% of the floodplain. Remaining forest cover is comprised of >38,000 discrete forest patches >2 ha. Mean patch area (64.1 ± 5.2 ha; $\bar{x} \pm$SE) was highly skewed towards small fragment size. Larger patches had a higher proportion of more hydric forest cover classes than did smaller patches which had a higher proportion of less hydric forest cover classes. Public lands accounted for 16% of remaining forested wetlands. Fewer than 100 forest patches exceeded our hypothesized habitat objective (4000 ha minimum contiguous forest area) intended to support self-sustaining populations of forest breeding birds. To increase the number of forest patches exceeding 4000 ha contiguous area, and thereby increase the likelihood of successful forest bird conservation, we recommend afforestation adjoining existing forest fragments ≥1012 ha and focused within designated Forest Bird Conservation Regions.

Keywords
Forested wetlands, bottomland hardwood forest, bird conservation, habitat assessment, Mississippi Valley.

Abstract

Que sabe las características actuales de la distribución y de la talla del fragmento del bosque es integral al desarrollo de los objetivos geográficamente definido, habitat basado de la conservación para criar pájaros. Hacia este extremo, clasificamos 2,6 millones de has de la cubierta del bosque dentro del valle aluvial de Mississippi usando 1992 imágenes basadas en los satélites del mapper temático. Aunque históricamente sigue habiendo esta área, de Illinois meridional a Louisiana meridional, fue dominada cerca bosques de maderas dura inundable, cubierta del bosque en menos que 25% del esta valle. La cubierta restante del bosque se abarca de los fragmentos discretos > 2 ha del bosque > 38 000. Área de fragmento malo (64,1 ± 5,2 ha; $\bar{x} \pm$SE) fue sesgado altamente hacia talla pequeña del fragmento. Fragmentos más grandes tenían una parte más elevada de clases más hídricas de la cubierta del bosque que fragmentos más pequeños que teníian una parte más elevada de clases menos hídricas de la cubierta del bosque. Las pistas públicas consideraron 16% de restante bosques inundable. Menos de 100 fragmentos del bosque excedieron nuestro objetivo presumido del habitat (4000 ha área contigua mínima del bosque) prevista para utilizar las poblaciones independientes económicamente del bosque que crían pájaros. Para aumentar el número de los fragmentos del bosque que exceden 4.000 has de área contigua, y de tal modo para aumentar la probabilidad de la conservación acertada del pájaro del bosque, recomendamos la repoblación forestal que el bosque existente colindante hace fragmentos de $\geq$1012 ha y que enfocado dentro de regiones señaladas de la conservación del pájaro del bosque.

Palabras clave
Bosque de maderas duras inundable, pájaros, conservación, valle alluvial de Mississippi.

INTRODUCTION

Bottomland hardwood forests occurred historically as a nearly contiguous land cover within the Mississippi Alluvial Valley (Putnam *et al.*, 1960) but by the late 1940s, less than 50% of this floodplain remained forested. Facilitated by flood control projects that altered the hydrology of the floodplain (Galloway, 1980), 2–3 million additional hectares of forested wetlands have been converted to agriculture since the 1940s (Forsythe, 1985). The remaining forests are highly fragmented by nonforest land cover with most forest patches $\leq$1012 ha (Rudis, 1995). In response to loss of bottomland forests throughout the south-eastern United States, the South-east Working Group of the interagency Neotropical Migratory Bird Conservation Program, also known as 'Partners in Flight' (HTTP://www.partnersinflight.org) identified bottomland hardwood forest as a habitat of regional concern (Hunter *et al.*, 1993). Increased forest edge, associated with small patch sizes, limits breeding opportunities for forest interior birds (Van Horn *et al.*, 1995) and enhances opportunities for detrimental nest predation and nest parasitism (Robinson, 1992). Additionally, forest fragmentation may ultimately limit forest bird distributions (Robbins *et al.*, 1989). However, the impact of fragment size is temper by the landscape context within which the fragments are found (Andrén, 1994; Robinson *et al.*, 1995; Fahrig, 1997). The injurious impacts associated with forest fragmentation in the sparsely forested landscape of the Mississippi Alluvial Valley may be of critical importance to bird conservation within this floodplain. Of twenty-four landbird species identified as in need of management or monitoring within this physiographic area, twenty are dependent on bottomland hardwood forests for breeding habitat (Hunter *et al.*, 1993; Mueller *et al.*, 1999).

Even with its forest area reduced and highly fragmented, the Mississippi Alluvial Valley retains strategic forested habitat for breeding birds. A conservation plan for forest breeding birds, developed under the auspices of Partners in Flight, has defined area-specific forested habitat patch requirements of > 4000 ha, > 8000 ha, and > 40,000 ha (Mueller, 1996). These patch sizes were derived based on the minimum areas required by three different suites of bird species to attain densities of $\geq$500 breeding pair within forest patches containing a mosaic of forest types. The underlying assumption of these hypothesized minimum area requirements is that the densities of breeding birds within these patches are sufficient to support source populations (i.e. populations where reproduction exceeds mortality) with little risk of local extinction (Mueller *et al.*, 1999). To assess the adequacy of current forest conditions in the Mississippi Alluvial Valley at meeting these hypothesized area-specific habitat requirements, we determined forest area, fragment size, and forest cover class using 30-m resolution Landsat thematic mapper imagery. The area of forest under public ownership was determined as a surrogate for the likelihood of continued forest protection. Our objectives were (1) to ascertain the current extent and distribution of forest in the Mississippi Alluvial Valley (2) to characterize the size and cover type of forest patches (3) to assess the adequacy of current forest conditions at meeting proposed habitat objectives for forest bird conservation, and (4) to assess forest ownership as a measure of the likelihood of continued protection of forests.

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METHODS

Land cover classification

We classified forested habitat within the Mississippi Alluvial Valley (Fig. 1) using 30-m resolution Landsat thematic mapper imagery from the spring (April–May) and fall (October) of 1992. Using supervised classification of 15 or 30 min quadrangles, technicians aided by aerial photography and topographic maps distinguished forest classes based on spectrally identified hydrology and crown density. Five broadly defined forest classes were identified: (1) 'bottomland hardwood forests' – that we assumed were not frequently inundated (2) 'flooded forests' – that we assumed were subject to regular but not prolonged inundation (3) 'swamp forests' – that we assumed to be subject to prolonged and frequent inundation (4) 'edge/open forests' – that included forest-nonforest ecotones and forests with open canopies that resulted in spectral signatures similar to forest edges, and (5) 'other forests' – such as pines, upland hardwoods, and orchards. Forest edges were classified as edge/open forests only when their spectral signatures did not allow classification as bottomland, flooded, or swamp

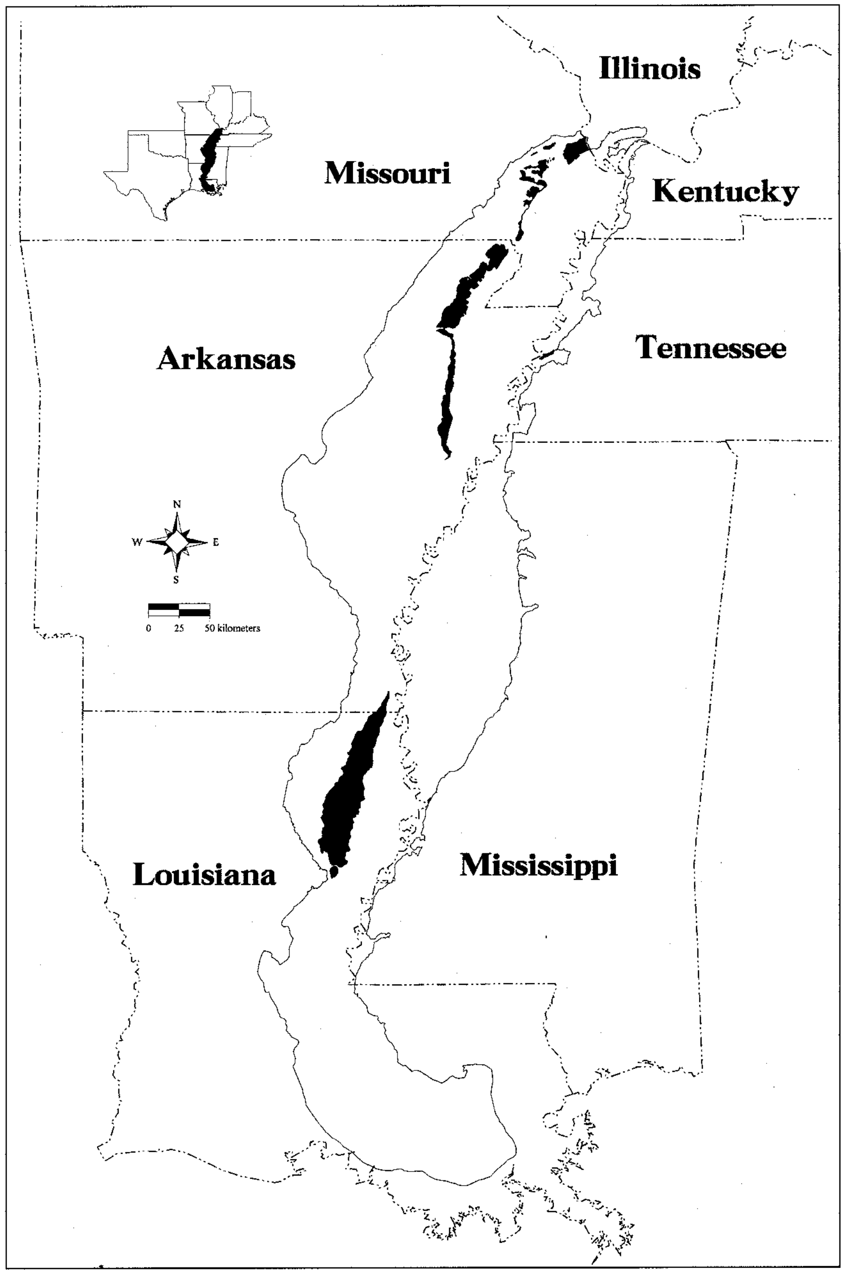

Figure 1 Mississippi Alluvial Valley in the southeastern United States as defined by alluvial deposits. Broken lines depict state boundaries, shaded areas are upland islands and ridges within the alluvial valley.

forests. After forest cover was classified, quadrangles were rejoined and area of each forest class determined within state boundaries. Additionally, within each state, we determined forest area on public lands dedicated to natural resource conservation (e.g. national wildlife refuges, state wildlife management areas, as well as state and national forests and parks).

We assessed the accuracy of our forest classification using vegetation assessment data from 623, 0.04-ha sample plots within 261 randomly located forest patches throughout the Mississippi Alluvial Valley. From one to three sample plots were obtained within a forest patch beginning at a random location and continuing at 250 m intervals toward the interior of the patch. These data were combined with forty-six additional sample plots within the Atchafalaya Basin of Louisiana. At each plot we assessed tree species and basal area following standardized techniques (James & Shugart, 1970). Forest cover type at each plot was determined from importance values calculated from species dominance and abundance. Additionally, we used 3875 USDA Forest Service, Forest Inventory and Analysis (FIA) plots systematically located throughout Arkansas, Louisiana, Mississippi, and Tennessee (Rudis, 1995; Rudis, 1996). Forest cover type for FIA plots was extracted from the associated FIA database. Forest cover types were assigned to one of our spectrally identified forest classes based on moisture requirements (Eyre, 1980; McWilliams &

Table 1 Total bottomland area (ha) and forested wetland area (ha) in the Mississippi Alluvial Valley determined from classified 1992 thematic mapper (TM) satellite imagery. (An additional 488,000 ha of upland habitat, including 146,000 ha of forest, occur within the Mississippi Alluvial Valley)

State	Total land area in Mississippi Alluvial Valley	Area of forest	% Forest	Swamp forest	Flooded forest	Bottomland hardwoods	Edge/open forests
Arkansas	3,763,004	722,488	19.0	94,499	119,649	301,001	115,991
Illinois	57,833	10,235	17.5	1685	1149	3794	3607
Kentucky	70,665	21,081	29.7	5242	3847	8213	3779
Louisiana	3,249604	1,254,824	36.4	357,331	286,441	405,224	153,953
Missouri	1,005,861	64,620	6.0	5465	9593	31,376	15,014
Mississippi	2,035,807	467,800	22.3	73,158	122,524	198,361	60,452
Tennessee	272,739	66,460	21.2	13,586	15,436	24,297	11,095
Total	10,456,513	2,608,508	24.9	551,966	559,639	973,266	364,891

Rosson, 1990:493). Swamp forest class included cypress (*Taxodium distichum*)/tupelo (*Nyssa aquatica*) and sweetbay (*Magnolia virginiana*)/tupelo/red maple (*Acer rubrum*) cover types (tree nomenclature follows Duncan & Duncan, 1988). Flooded forest class included four cover types: overcup oak (*Quercus lyrata*)/water hickory (*Carya aquatica*), sycamore (*Platanus occidentalis*)/pecan (*Carya illinoensis*)/American elm (*Ulmus americana*), willow (*Salix nigra*), and sugarberry (*Celtis laevigata*)/American elm/green ash (*Fraxinus pennsylvanica*) cover types. Bottomland hardwood forest class included three major cover types: sweetgum (*Liquidambar styraciflua*)/Nuttall oak (*Q. nuttallii*)/willow oak (*Q. phellos*), cottonwood (*Populus deltoides*), and swamp chestnut oak (*Q. michauxii*)/cherrybark oak (*Q. pagodaefolia*). We used a likelihood-ratio chi-square test to compare forest classes predicted from satellite imagery with actual forest classes from vegetation plots (Fienberg, 1977).

Forest patches

We delineated discrete forest patches after combining forest classes and applying a spatial filter (3 × 3) that filled small gaps and removed small forest fragments when they constituted ≤3 of 9 pixels. Filtering was intended to fill small openings and to join forest patches separated from other patches by distances of < 90 m that could conceivably be considered as contiguous patches. Also, narrow linear forest stretches are widespread in this region and provide tenuous links between disjoint forest patches. The filter we used tended to separate forest patches when linkages were very narrow (< 90 m). Finally, to reduce the likelihood of including specious forest patches (Keitt *et al.*, 1997), only patches that exceeded 2 ha were retained for further analyses. We then assessed the number of forest patches within each of the seven states comprising the Mississippi Alluvial Valley. Because historical changes in the course of the Mississippi River have resulted in oxbows and river cutoffs, small areas of some states were disjoined. However, forest patch boundaries were not constrained by these political boundaries. Therefore, we designated the Mississippi River as the state boundary when assessing the number of forest patches and their size. We quantified forest classes within forest patch size categories and used Mantel–Haenszel chi-square (Mantel, 1963) to test for linear association between forest class composition and forest patch area. We further contrasted habitat differences among patch size categories by using analysis of variance (ANOVA) to examine differences among forest classes on FIA plots and the area of the forest patches in which they were encountered.

RESULTS

Extent of forest

Forested habitat remains on 2.6 million ha (24%) of the Mississippi Alluvial Valley (Fig. 2a). Forest cover was greater in the south, where Louisiana had 36% of its Mississippi Alluvial Valley landbase in forests, than in the north, where Missouri retained only 6%. Over 50% of all forested wetlands were within Louisiana. Collectively, Louisiana, Arkansas, and Mississippi contained 94% of the Mississippi Alluvial Valley's forests (Table 1). Although the boundaries we used to define the Mississippi Alluvial Valley (Fig. 1) differed slightly from those previously used to obtain forest cover estimates (e.g. Frey & Dill, 1971; Rudis & Birdsey, 1986; McWilliams & Rosson, 1990), comparison with data from the most comparable boundaries (MacDonald *et al.*, 1979) suggests that forest loss within the Mississippi Alluvial Valley has slowed (Fig. 3).

In the Mississippi Alluvial Valley there are > 570,000 ha of public land managed, at least in part, for wildlife. Over 415,000 ha (72%) of this public land were forested wetlands (Table 2). Public ownership of forests was greatest in Tennessee and Illinois, where approximately 35% of all forested wetlands were on public land. Conversely, in Louisiana, 87% of forested wetlands remain in private ownership.

Accuracy assessment indicated our ability to classify forest from nonforest habitat was high with 95% (5% commission error, omission error was not estimated) of random plots and 86% (8% commission error, 6% omission error) of FIA plots classified correctly. We found a significant ($G^2 = 87.6$, d.f. $= 2$, $P < 0.001$) association between our predicted forest classes and actual forest classes (Table 3). However, only about 36% of

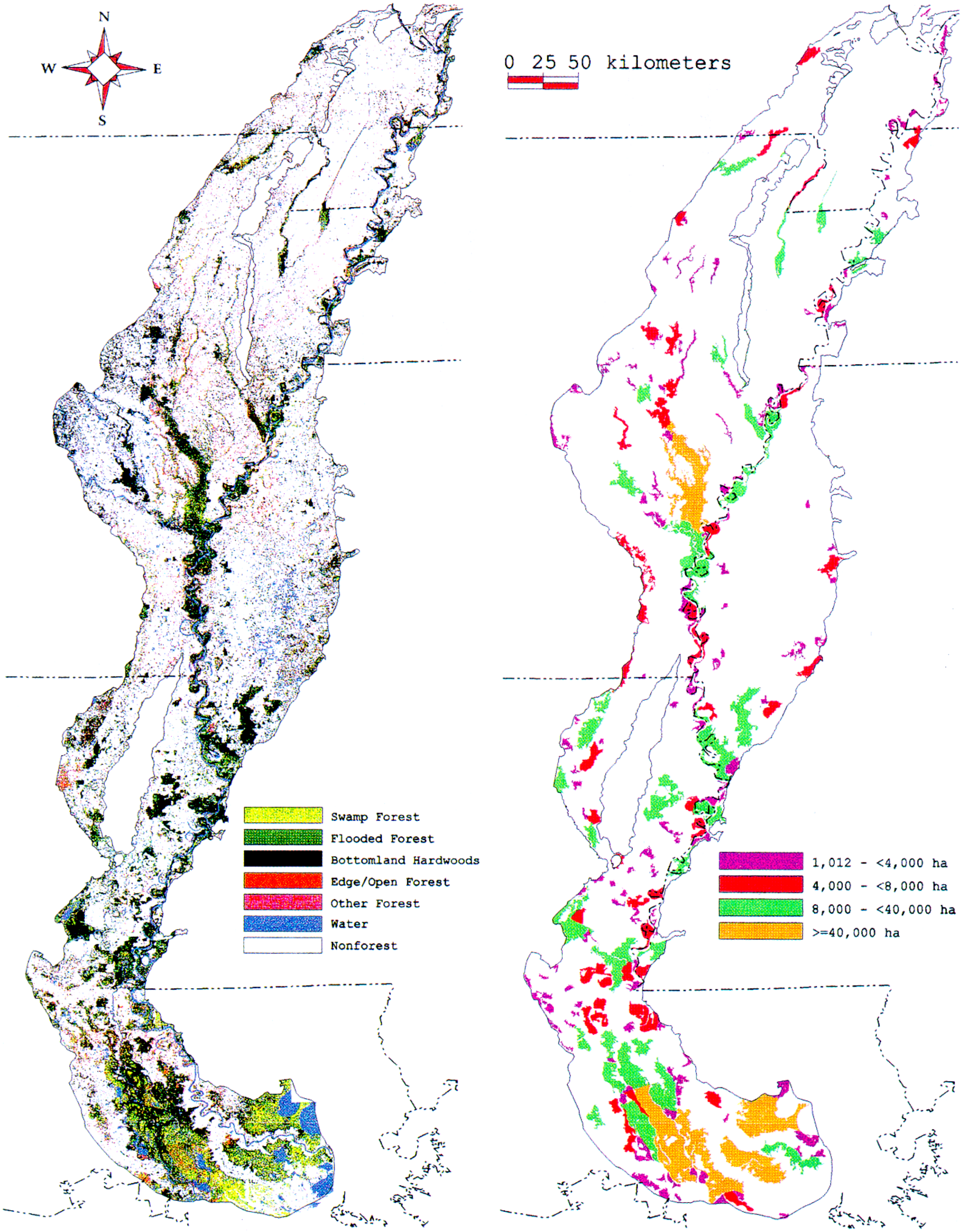

Figure 2 Forested habitat within the Mississippi Alluvial Valley as determined from classified 1992 thematic mapper (TM) satellite imagery: (a) distribution of forested wetland classes (left) and (b) location of forest patches, by size category (right). Forest patch size categories > 4000 ha follow recommendations of Mueller (1996). Broken lines depict state boundaries.

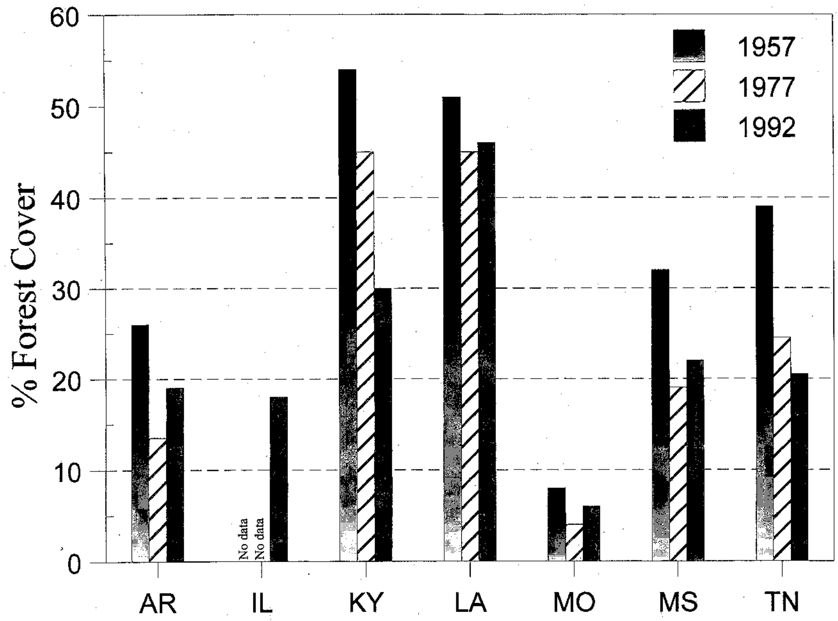

Figure 3 Temporal changes in the area (ha) of forested habitat in states comprising the Mississippi Alluvial Valley. Data for 1992 are from this study based on areas from Table 1. Data for 1957 and 1977 are from MacDonald *et al.* (1979) with areas reported as: Arkansas (3,207,880 ha), Kentucky (39,272 ha), Louisiana (3,396,968 ha), Mississippi (1,916, 364 ha), Missouri (913,460 ha), and Tennessee (212,200 ha).

Table 2 Area of public lands in the Mississippi Alluvial Valley that are managed, at least in part, for wildlife and the area forested wetland habitation on these public lands based on classified 1992 thematic mapper (TM) satellite imagery. (An additional 6472 ha of public land are in upland habitats within the Mississippi Alluvial Valley, 4995 ha of which are forested)

State	Area of public land (ha)	Forest area on public land (ha)	% of public land that is forested
Arkansas	174,031	145,236	83.5
Illinois	11,830	3615	30.6
Kentucky	7376	3581	48.5
Louisiana	224,572	160,147	71.3
Missouri	22,465	13,626	60.6
Mississippi	102,960	66,291	64.4
Tennessee	29,703	22,515	75.8
Total	572,937	415,011	72.4

actual forest classes were correctly identified (Table 3). We were better able to correctly classify bottomland hardwood forests (53%) whereas only 21% of flooded forests were correctly classified. Even so, field verification of 271 predicted flooded forest locations revealed 45% were correctly classified. Hence, our classification of satellite imagery at this scale was limited with respect to precisely distinguishing forest cover classes. Even so, because forest/nonforest classification is most crucial for the initial development of landscape level migratory bird conservation plans, these data were entirely suitable for our objectives.

Distribution of Forest Patches

A total of 38,316 forest patches > 2 ha were identified in the Mississippi Alluvial Valley (Table 4). The mean forest patch size was 64.1 ± 5.2 ($\bar{x} \pm SE$) with the distribution of forest patches highly skewed towards small patch sizes. As with total forest area, most large patches (204 of 264 patches ≥ 1012 ha) were in Arkansas or Louisiana (Table 4). Only ninety-eight

			Predicted forest class			
Source	Number of plots	Actual forest class	Bottomland hardwoods (BLH)	Flooded forest	Swamp forest	Edge/open forest
USDI	240	BLH	0.60	0.19	0.06	0.15
USDA	260	BLH	0.47	0.21	0.17	0.16
USDI	314	Flooded forest	0.53	0.21	0.08	0.19
USDA	258	Flooded forest	0.52	0.22	0.12	0.14
USDI	80	Swamp forest	0.44	0.16	0.19	0.21
USDA	127	Swamp forest	0.19	0.20	0.48	0.13
USDA	80	Upland forest	0.41	0.10	0.04	0.25

Table 3 Number of vegetation plots of four forest cover classes from 623 U.S. Department of Interior (USDI) sample plots (0.04 ha) and 274 U.S. Department of Agriculture (USDA), Forest Service, Forest Inventory and analysis plots (0.4 ha) from forests within the Mississippi Alluvial Valley and forest classification proportions from 1992 thematic mapper satellite imagery

Table 4 Size distribution of forest patches in the Mississippi Alluvial Valley calculated from 1992 thematic mapper (TM) satellite imagery

State	Mean area (ha)	2 – < 1012 ha	1012 – < 4000 ha	4000 – < 8000 ha	8000 – < 40,000 ha	≥ 40,000 ha	Maximum size (ha)
Arkansas	47	14,612	41	16	8	2	49,223
Illinois	28	317	1	0	0	0	1034
Kentucky	72	235	6	0	0	0	2230
Louisiana	110	10,891	78	25	23	4	91,656
Missouri	23	2476	6	1	0	0	6465
Mississippi	48	8590	22	11	5	0	38,707
Tennessee	60	926	5	2	1	0	9014
Total number of patches		38,047	159	55	37	6	
Total area (ha)		842,125	318,110	315,323	615,824	363,138	

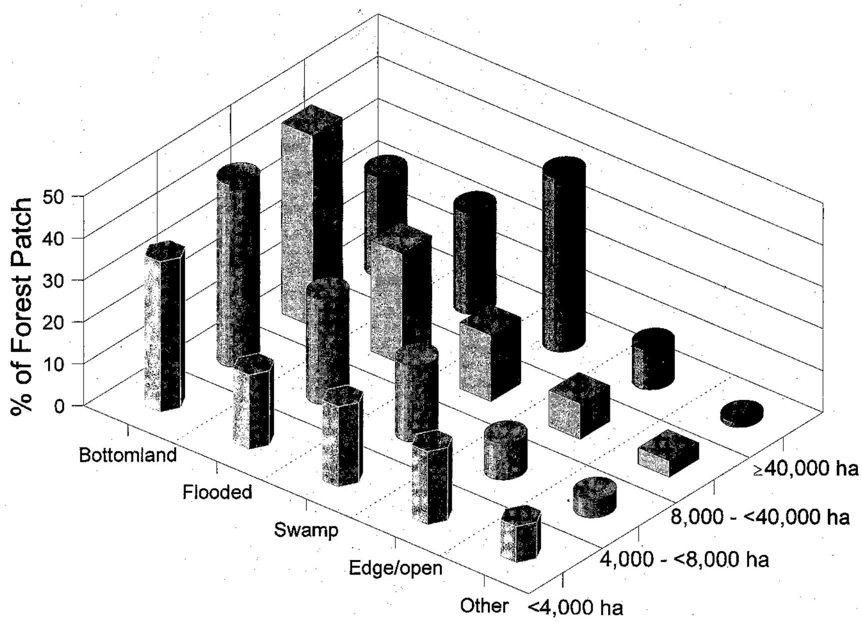

Figure 4 Distribution of forest classes within forest patch size categories in the Mississippi Alluvial Valley.

forest patches satisfied the proposed minimum size criterion for breeding birds established by Mueller (1996) – that is, being ≥4000 ha of contiguous forest. Of these patches, forty-three also met Mueller's mid-level criterion of ≥8000 ha, whereas only six patches met the highest level criterion of ≥40,000 ha. The effective size of some forest patches, however, was probably considerably larger than indicated due to the juxtaposition of patches. For example, several individually identifiable forest patches were nearly contiguous (Fig. 2b), being separated only by water channels or levees > 90 m wide. Grassed levees are conducive habitats for brown-headed cowbirds (*Molothrus ater*; bird nomenclature follows American Ornithological Union., 1997) and probably contribute to the potential negative impacts associated with forest fragmentation. However, waterways are probably neutral with respect to their influencing the affects of forest fragmentation. Thus, forest patches separated solely by waterways could be considered to be effectively joined for purposes of bird conservation. The effective area of multiple forest patches in the Atchafalaya River Basin, Louisiana and the lower White River Basin, Arkansas (Fig. 2b) would be markedly increased under these criteria. In addition, upland forests on valley bluffs or interior ridges, although not considered in this study, were often located adjacent to bottomland forests. Thus the total contiguous forest area of forest patches abutting forested ridges could also exceed the contiguous area criterion proposed by Mueller (1996).

Qualitative assessment of predicted forest class within 4 patch size categories revealed a significant association (Q_{MH} = 10.0, d.f. = 1, P = 0.02) between patch size category and forest cover class, with larger forest patches comprised of wetter forest classes (Fig. 4). Over one third of the forest area within the largest patch size category (≥40,000 ha) was classified as swamp forest, whereas drier bottomland hardwood forests comprised > 43% of forest patches between 4000 and 8000 ha. As expected based on their small size, forest patches < 4000 ha had a relatively high proportion of edge/open forest, reflecting their increased interface with nonforested habitat and increased likelihood of anthropogenic disturbance.

Although our relatively poor classification accuracy of forest classes makes assessment of the exact relationship between forest class and patch size dynamics suspect, we detected an identical relationship using FIA data. Indeed, we found significant differences ($F = 31.62$, d.f. $= 2$, $P = 0.01$) among swamp forest, flooded forest, and bottomland hardwood forest classes associated with 1538 FIA plots with respect to the patch size in which they were located. The mean patch size in which swamp forest cover class occurred was 19,619 ha (SE = 973). This area was greater than the mean 14,353 ha (SE = 572) forest patch in which flooded forests occurred, which was again greater than the mean 9165 ha (SE = 888) forest patch in which bottomland hardwood forests were encountered.

DISCUSSION

When compared to the results of previous forest inventories in the Mississippi Alluvial Valley, our classification of 1992 satellite imagery suggests that loss of forested habitat has slowed or been reversed. This conclusion is supported by recent analyses of data from USDA Forest Service's Forest Inventory and Analysis Units (McWilliams & Rosson, 1990; Rudis, 1993). McWilliams & Rosson (1990:492) attributed reduced forest loss to 'a shortage of drainable tracts, a general agricultural surplus, and depressed oil markets.' In addition, we suggest that much of the remaining forest is on land unsuitable for agriculture, 16% of remaining forest is publicly owned (Table 2), private timber corporations manage approximately 14% of the remaining forest (Rudis & Birdsey, 1986), and competitive timber prices and government incentives, such as the Wetland Reserve Program, have encouraged private landowners to plant or retain forests.

Even though most of the remaining forest patches in the Mississippi Alluvial Valley were small (99% are < 1012 ha), 53% of the forested wetland area (1.3 million ha) was in forest patches deemed suitable for breeding birds (i.e. ≥ 4000 ha). Although considering only Arkansas, Louisiana, Mississippi & Tennessee, Rudis (1995) found larger forest patches (> 1012 ha) were more prevalent in the southern Mississippi Alluvial Valley and smaller forest patches (≤ 1012 ha) were more common in northern parts of the Mississippi Alluvial Valley. Similarly, we found the mean patch size in Missouri was only 23 ha whereas it was 110 ha in Louisiana. In addition to small patch sizes, the total forested area in Missouri was also relatively small (6%).

Although larger and more abundant, forest patches in Louisiana tended to be comprised of more hydric forest classes. Indeed, 28% of Louisiana forests were classified as swamp forests whereas only 8% of Missouri forests were of the same wetness. Thus we concur with Rudis (1995), that throughout the Mississippi Alluvial Valley smaller forest patches are comprised of relatively more xeric forest classes and larger forest patches have a greater proportion of hydric forest habitat. This phenomena has import ramifications for bird conservation. Christman (1984) found decreased avian abundance and species richness with increased hydrologic regime within bottomland hardwood forests. Flooding during the breeding season obviously limits nests site selection for species, such as Kentucky warbler (*Oporornis formosus*), that nest on or near the ground. Similarly, foraging habitat for species that forage extensively in the rich undergrowth of bottomland forests is diminished when the hydrologic regime is prolonged. Additionally, some species of special concern, such as Swainson's warbler (*Limnothlypis swainsonii*) are notably less abundant in wetter forest classes (Hamel, 1992; Hunter *et al.*, 1993). Thus, retention of even large forest patches may not provide adequate habitat for some species if these forest patches are primarily swamp forest. Ensuring habitat heterogeneity, including a sufficient area of drier forest classes, within large bottomland forest patches is essential to provide habitat for diverse avian species (Freemark & Merriam, 1986).

Proactive conservation efforts, such as the designation of Forest Bird Conservation Regions (Pashley, 1999), benefit from knowledge of forest patch areas, their regional distribution, and their habitat quality. Once area requirements to support source populations of breeding forest birds are established, the number of forest patches (other habitat characteristics being equal) meeting these criteria can be determined. For example, if forest patches > 4000 ha are indeed sufficient to maintain avian populations, ninety-eight forest patches are currently available to support breeding populations within the Mississippi Alluvial Valley. However for those species requiring > 8000 ha of contiguous forest, only 43 forest patches currently support viable source populations in the Mississippi Alluvial Valley.

Afforestation is the primary management technique aimed at increasing breeding bird habitat in the Mississippi Alluvial Valley. Afforestation that results in progress toward the minimum contiguous forest areas proposed by Mueller (1996), by augmenting existing large (≥ 1012 ha) forest patches or reducing their edge to area ratio, better addresses avian habitat needs than does isolated afforestation or additions to small (< 1012 ha) forest patches. As an example, a vast drainage network of interconnected canals in south-east Missouri and north-east Arkansas has promoted extensive deforestation and supports intensive agriculture. This area has limited potential for sufficient afforestation to meet the needs of forest breeding birds. Conversely, parts of Arkansas (e.g. White River Basin), Louisiana (e.g. Tensas River Basin), and Mississippi (e.g. Yazoo River Basin) have large extant forest patches that are located in relatively close proximity. These adjacent forest patches could feasiblely be linked through comparatively modest afforestation efforts.

These data on the area and distribution of forest patches are being used to establish habitat objectives for forest birds in the Mississippi Alluvial Valley. One aim of this conservation effort is to identify Forest Bird Conservation Regions within which afforestation may be directed (Mueller *et al.*, 1999). Where possible, Wetland Reserve Program and other government incentive programs (Coreil *et al.*, 1997) should give priority to private-land conservation within these conservation regions. The forest-products industry has been an active participant in defining Forest Bird Conservation Regions, and managed corporate forests are crucial to retaining forested habitat in the Mississippi Alluvial Valley. Finally, afforestation through mitigation or acquisition by state or federal land management agencies should add to existing forested wetlands and, where possible, link existing large patches of forest. These conservation efforts will help to provide forested wetland habitat, in sufficiently large patches, to ensure continued source populations of breeding forest birds, thus safeguarding 'area-sensitive' species within the Mississippi Alluvial Valley.

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