Mississippi Alluvial Valley Forest Conversion: Implications for Eastern North American Avifauna

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Abstract: Because bottomland forests of the lower Mississippi Alluvial Valley (MAV) are valuable as breeding, wintering, and en-route habitat during migration, we investigated the impact of changing land uses in the MAV on avian abundance and diversity at the local and continental scales. Checklist inventories from 5 studies conducted in the MAV during 1985–1992 confirmed that bird species that occur in the MAV represent a substantial proportion of the entire avifauna of eastern North America (ENA). Of 236 landbird species reported for ENA, 200 (85%) occur in the MAV; we recorded 149 landbird species (63%). The frequency distribution of population trends as determined from Breeding Bird Surveys (BBS) varied significantly among species according to migratory status, geographic area, and habitat. Neotropical migrant landbird (NTMB) and temperate species were much more likely to show population declines than increases in the MAV. Woodland species exhibited fewer declines than expected in the MAV and ENA. However, analysis of population trends may be biased because populations of some species significantly declined prior to the establishment of the BBS.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 47:460–469

Bottomland hardwood forests contribute numerous natural resource values to landscapes across the southern United States (Wharton et al. 1982). An estimated 13 million ha (Putnam et al. 1960) of bottomland forests once was distributed throughout the southern United States. The Mississippi River alluvial plain originally supported 8.5 million ha of forested wetlands (Creasman et al. 1992), but 6.8 million ha of these bottomland forests (80%; Turner et al. 1981) were converted to agriculture or cleared for development by 1978 (MacDonald et al. 1979, Rudis and

Birdsey 1986). So extensive has been this reduction that southern forested wetlands have become an "endangered ecosystem" (Ernst and Brown 1989).

Most of the attention related to consequences of fragmentation and isolation of bottomland hardwood forest has focused on local or regional faunal impoverishment (e.g., Burdick et al. 1989, Harris 1989). However, the faunal significance of converting 80% of Mississippi floodplain forests (52% of all southern bottomland forests) to an agricultural or urbanized landscape may extend well beyond the immediate environs of the lower Mississippi Alluvial Valley (MAV). Our objective is to demonstrate the extensive contribution that floodplain forests of the MAV make to avifaunal diversity in eastern North America. We document the reduction of forested wetlands in the MAV, quantify seasonal use of floodplain forests by birds, and discuss the changes in local and continental populations associated with loss of floodplain forest within the MAV.

Financial support was provided by the State of Tennessee Governor's Safe Growth Team, U. S. Army Corps of Engineers Waterways Experiment Station, USDA Forest Service, Southern Forest Experiment Station, Vicksburg Research Station, USDI Fish and Wildlife National Wetlands Research Center, and Memphis State University. Additional support was provided by the Ecological Services Division, Tennessee Department of Conservation. We are grateful to the following for their assistance in obtaining and compiling observations from the many bird surveys: R. Abernathy, R. Allan, D. Arbour, V. Bates, D. Clippard, R. Cooper, M. Greene, J. Hestir, D. Hinebaugh, P. Kalla, D. Kendricks, Jr., K. Leiper, T. McCarthey, J. McGuiness, D. Pierce, M. Schaefbauer, J. Shippee, D. Twedt, D. Wiedenfeld, J. Wilson, R. Wilson, and C. Woodson. Technical assistance was provided by E. Buckner, R. Dimmick, and H. DeSelm. We appreciate the cooperation of Anderson-Tully Company, in particular, M. Staten's logistic assistance. We thank D. Pashley, R. Cooper, W. C. Hunter, and D. Twedt for comments that ultimately improve this paper.

Methods

We estimated trends and timing of land use changes in the MAV by compiling data from several studies that have estimated extent of forest land in the MAV at different times. MacDonald et al. (1979), Turner et al. (1981), and McWilliams and Rosson (1990) were particularly useful compilations.

We compiled avifaunal data from 5 original sources: line-transect and point count surveys from a 3-year study (1985–87) in west Tennessee bottomlands (Durham et al. 1988, Ford 1990); point counts from a 2-year study (1991–1992) on Delta Experimental Forest, Mississippi (Smith 1991); a point-count survey (N = 82) stratified among 3 habitat types at 9 localities across 3 regions of the MAV during spring 1992 (Smith et al. 1993); point counts from a 2-year study (1992–1993) examining the influence of fragmentation on species distribution and abundance among stratified-random sites throughout the MAV (Twedt pers. comm.); and daily checklists of birds recorded during nest searches and monitoring

(1992–1993) of 3 50-ha grids located on 2 Tennessee and 1 Arkansas sites (Hamel and Cooper 1993). The composite species list from these works is our empirical list of MAV avifauna.

We composed a master list of species from the Breeding Bird Survey (BBS) 1966–1989 (U.S. Dep. Int. Fish Wildl. Serv., unpubl. data) and information from range maps of individual species (Peterson 1980, Hamel 1992). This list comprises species found in eastern North America (ENA) as well as those for the MAV, and includes species for which population trend information is available. The states and Canadian provinces included in the Eastern Region of the BBS (sensu Robbins et al. 1986) compose the ENA. The MAV is not a part of the ENA as thus defined, so that MAV and ENA trends in the BBS are derived from independent data sets. We accepted the assignments of species to groups presented by Peterjohn and Sauer (1993) for our comparisons, except for the determination of neotropical migratory birds (NTMB) for which we used the list compiled for the Southeastern Management Working Group of the Neotropical Migratory Bird Conservation Program (cf. Hamel 1992). Estimates of centers of abundance and regions of significant population were taken from W. C. Hunter (pers. commun.). We assumed a trend was stable unless it differed from O at $P = 0.05$, regardless of type II error. This method of examining trends is conservative in the sense that it requires statistical significance of change regardless of the sacrifice of power involved. Copies of the master and empirical lists of species used in this paper are available from the senior author.

We considered the master ENA list to be the universe of species in eastern North America, and conducted comparisons between the empirical MAV list and the ENA list. To evaluate the impact of conversion of bottomland forests on bird populations, we examined population trends from BBS counts in the MAV and ENA during the period 1966–1989. We used an approach similar to that of Sauer and Droege (1992) and compared the proportions of species that experienced significant increases or declines or were not estimated.

We tested hypotheses arising from these comparisons using X^2 statistics. Our tests began with multiple contingency table tests of mutual independence. Where null hypotheses of independence were rejected, we proceeded with tests of partial independence (Zar 1984). We accepted $P = 0.05$ as our criterion for significance testing of Type I errors, and estimated the power of our analyses using the procedures of Cohen (1988).

Results and Discussion

Land Use Change in the Mississippi Alluvial Valley Study Region

Accurate historical data on MAV forests are scanty. Several authors reported that preColombian floodplain forests occupied 9 to 10 million ha within the MAV alone (Fredrickson 1979, Turner et al. 1981, Harris 1984). Presumably because of access to waterways and the productive soils of associated floodplains, southern bottomland forest landscapes were very attractive settlement areas. With the advent of dependable drainage technologies, extensive conversion of MAV forest lands to other uses began. By 1937, about 50% of the forest lands in the MAV had undergone conversion; an additional 2.7 million ha were altered between 1937 and 1978 (MacDonald et al. 1979). McWilliams and Rosson (1990) indicated that 2.2 million ha of South Central Coastal Plain bottomland forests were converted to agricultural uses between 1934–1990. Nearly all of these changes occurred in the MAV, and the largest decreases occurred in the 1940s and 1960s to early 1970s (McWilliams and Rosson 1990). Between 1960 and 1978, total floodplain forest area in the southeastern United States decreased by 175,000 ha annually.

Less than 25% of the original MAV bottomland hardwood forest remains (U.S. Fish and Wildl. Serv. 1978, Forsythe and Garth 1980). Less than 0.01% (about 500 ha) of pre-settlement bottomland forest habitat in the MAV has not experienced significant anthropogenic disturbance (W. P. Smith, unpubl. data). Most of the remaining forests have undergone a variety of timber harvests; for example, 56% of the MAV batture was in commercial forest land by 1974 (Sternitzke 1975). Management imposed on existing tracts will almost certainly intensify to meet the increasing demands for hardwood products (Murphy 1975, Barton 1986).

Using presence/absence data to reflect avifaunal composition, or BBS surveys to derive population trends, are subject to imprecisions inherent in qualitative data. For example, documenting the regular occurrence of various species, in particular migrating transients, provides little information about the importance of a region in providing critical resources for survival and reproduction. We share the apprehension of several authors about the use of BBS data because of inherent biases and uncertainties associated with conducting roadside surveys and using observers with different levels of ability and experience (e.g., Geissler and Noon 1981, James et al. 1990, James et al. 1992). Nevertheless, BBS data are the only continent-wide survey of bird populations; we believe their use can lead to important hypotheses and insights. We feel that our use of these data was appropriate for illustrating broad, general relationships and the potential far-reaching implications of continued alteration or removal of bottomland forest habitats within the MAV. We caution against drawing inferences beyond the strict, intended application in this paper.

Species Composition and Population Trends

Our master list of ENA species included 236 landbirds; 200 (85%) occur in the MAV at some time of the year. Of 200 landbird species that use the MAV, 101 are NTMB, and 121 breed in the MAV. Of 98 ENA species requiring forest habitats, 47 breed in the MAV.

Our surveys of MAV bottomland forest birds revealed 175 species; 149 species are landbirds. Sixty-five are permanent residents, 23 winter residents, 44 summer residents, and 36 transients. The remaining 7 species are short-distance migrants whose winter and breeding ranges include southern and northern parts of the MAV, respectively. Some 70 species (all landbirds) require forest habitat; 42 of these species breed in the MAV. Eighty-one species in the empirical sample are NTMB.

Population trends, migratory status, and geographic area (Table 1) were not mutually independent among species on the master list of ENA birds (X^2 = 38.3, df = 10, $P < 0.001$; Zar 1984:72). We further rejected hypotheses of partial independence among these 3 variables (for migratory status: $X^2 = 17.6$, df =10, $P < 0.001$; for region: $X^2 = 28.8$, df = 7, $P < 0.001$; for trend: $X^2 = 37.8$, df = 9, $P < 0.001$). Population trends, geographic area, and designation of species as woodland species were also not mutually independent ($X^2 = 48.8$, df = 10, $P < 0.001$). We further rejected hypotheses of partial independence among these 3 variables (for woodland use: $X^2 = 29.6$, df = 7, $P < 0.001$; for region: $X^2 = 29.7$, df = 7, $P < 0.001$; for trend: $X^2 = 48.6$, df = 9, $P < 0.001$).

Patterns of population trend differed between the MAV and ENA ($X^2 = 20.9$, df = 3, $P < 0.001$). Generally, relatively more species increased (14%) and fewer species could not be estimated (20%) in ENA (Table 1) as compared to the MAV (3% and 38%, respectively). Examination of the tests for partial independence showed that the woodland species and NTMB with unestimated trends contributed disproportionately to regional differences; in each case unestimated trends were more likely among MAV birds and constant trends were more likely in ENA than among MAV birds.

We therefore tested the hypothesis that population trend and species status (combination of woodland use status and NTMB status) were independent among MAV breeding birds. This test to determine whether the ability of BBS data to determine a trend was less among MAV forest NTMB was equivocal. We could not reject the null hypothesis of no relationship ($X^2 = 3.7$, df = 3, $P < 0.30$), but the power of the test was very low ($w = 0.1742$ [Cohen 1988:216], power $[1-\beta] = 0.36$). Identical proportions to ours in a test with power = 0.90 produced a X^2 with $P = 0.01$. We suspect, based upon the extensive reduction of MAV forests and the timing of the preponderance of reductions prior to the start of the BBS, that forest birds and forest NTMB in particular are not well estimated by the BBS in the MAV. Nevertheless, during 1966–1989 MAV species were 6 times more likely to

Table 1. Number of temperate or neotropical migrant, woodland, or nonforested landbird species of the lower Mississippi Alluvial Valley (MAV) and eastern North America (ENA) that have experienced significant ($P < 0.05$) population increases (+), or declines (-), or have remained stable (ø) during 1966–1989[a].

Species group	Geographic region							
	MAV				ENA			
	0	+	-	?	0	+	-	?
Temperate	24	2	12	23	46	21	27	32
Neotropical migrant	23	2	12	23	65	11	13	13
Total	47	4	24	46	111	32	40	45
Woodland	21	0	4	22	61	14	9	11
Nonforested	26	4	20	24	50	18	31	34
Total	47	4	24	46	111	32	40	45

[a] Population trends taken from Breeding Bird Survey 1966–1989 (U.S. Fish and Wildl. Serv. 1978).

decrease than increase. The high incidence of unestimable trends itself is evidence of the change in the MAV from a primarily forested to a primarily agricultural landscape.

Johnston and Hagan (1992) reported differences in population trends between resident and NTMB species of eastern deciduous forests. Generally, NTMB populations showed significant declines across most sites in the 1960s and 1970s, with fewer declining populations in the 1980s. Residents, however, showed stable populations, or an equivalent number of decreasing and increasing populations across sites during all decades. Significant positive correlations in population trends were reported between NTMB and resident populations at several sites suggesting that both groups may have been affected by similar factors or processes (Johnston and Hagan 1992).

Previous population trend analyses have produced contradictory results depending upon the scale or type of analysis (Robbins et al. 1989, Johnston and Hagan 1992, Sauer and Droege 1992). Depending upon the scale or type of analysis, the same species or groups of species have been reported as increasing, decreasing or stable (James et al. 1992). Both James et al. (1992) and Sauer and Droege (1992) emphasized the importance of analyzing individual strata or physiographic areas.

Analyses of population trends in physiographic areas support our contention that a substantial portion of the MAV avifauna has been undergoing significant decline. There were 39 landbird species from the MAV that showed evidence of decline in the physiographic areas where the species has been detected most frequently (W. C. Hunter unpubl. data). The most recent population trend analyses (W. C. Hunter 1994) revealed that 49% of all NTMB landbird species in the MAV exhibited significant ($P < 0.10$) declines. Moreover, 28% of temperate migrants (i.e., short-distance migrants plus category B Neotropical Migratory Species [Hamel 1992:M3]) and 25% of residents in the MAV also showed significant declines.

Implications for Continental Diversity

Our list of species is 1 estimate of the MAV contribution to maintenance of continental avian diversity: 151 of 236 ENA landbird species were recorded in MAV, including 98 of 121 breeding MAV landbirds. For 17 landbirds (including 7 woodland species) that were recorded in our surveys, the MAV represents the center of abundance; it supports significant populations of another 24 landbird species (including 13 woodland species).

A less obvious contribution of the MAV is through providing critical resources during migration (Moore and Simons 1992, Kuenzi et al. 1993). About two-thirds of the forest breeding bird species of ENA are NTMB. During May the most abundant species on study grids in the MAV are often such transient species as Swainson's thrush or Tennessee warbler (P. B. Hamel, unpubl. data). Most landbirds among NTMB that breed in ENA undertake a nonstop flight across the Gulf of Mexico each spring and fall (Buskirk 1980). Suitable en route habitat where migrants can safely and rapidly replenish energy reserves is critical to a successful migration (Moore and Simons 1992:345).

Conversion of historical migratory habitat within the MAV has likely impacted the survival or breeding success of migrants in several ways (Moore and Simons 1992). In addition to the obvious consequences of total habitat reduction, fragmentation of habitat has probably influenced the quality of remaining fragments as stopover habitat. The patchiness of en route habitat influences habitat selection and access to needed resources (Moore and Simons 1992). Impacts of competition for limited resources (Moore and Yong 1991) and of predation, 2 critical aspects of successful migration, are significantly influenced by habitat availability and suitability.

Given the extent of bottomland forest conversion in the MAV, we expected that a greater proportion of species would exhibit significant population declines (Table 1). At least 2 explanations exist as to why this did not occur. The first and simplest explanation is that no change has occurred because bottomland forest habitats are not necessary habitats for these species. The second explanation is that current datasets are inadequate either to determine historical changes that have already occurred or to monitor current population declines.

The distribution of forested acreage is an important determinant of avian habitat suitability (e.g., Robbins et al. 1989). Local changes in abundance, size, and distribution of forest tracts have influenced populations of breeding birds in many temperate regions (Askins and Philbrick 1987, Holmes and Sherry 1988). Most of the recent population declines across ENA were associated with woodland breeding species (Sauer and Droege 1992).

The second and perhaps more plausible explanation is that population trends derived from BBS surveys and our analysis were biased because of limitations in the population trend data. Undoubtedly, some MAV species may have exhibited declines before the BBS began in 1966. Carolina parakeet, ivory-billed woodpecker, and Bachman's warbler, for example, have long been extirpated from the MAV. Species that have experienced steep declines may no longer effectively be sampled by BBS counts in the MAV because of infrequent encounters. This will necessarily underestimate the number of declining species because it is the least abundant species that will be excluded from BBS analysis or because there is insufficient statistical power to detect a significant change for those that meet the minimum criterion but still yield small and highly varying numbers. Indeed, encounter rates for 46 landbird species from the MAV were too low to permit estimation of population trends in the MAV from BBS data; 22 of these landbirds are woodland species.

An outstanding value of bottomland forests is provision of wildlife habitat (Forsythe and Roelle 1990). Today, remnant bottomland forests in the MAV are scattered as fragments and have experienced at least one rotation of intensive land management. Conversion and subsequent loss and fragmentation of bottomland forests has negatively impacted seasonal and resident wildlife populations throughout the MAV (Reinecke et al. 1989). We now expect these remnant patches of forest to be source areas that produce supplies of resources that support viable populations of Neotropical migratory birds, temperate residents, and transients for all of North America. This may be an extraordinary expectation of any system, even one as productive as the MAV. We believe that compelling evidence exists to warrant concern over the potential and conceivable reduction of avian diversity linked to land use within the MAV.

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