THE IMPORTANCE OF FLOODPLAIN FORESTS IN THE CONSERVATION AND MANAGEMENT OF NEOTROPICAL MIGRATORY BIRDS IN THE MIDWEST

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ABSTRACT.— Floodplain forests of the Central Forest Region of the Upper Midwest are found primarily on the floodplains of large rivers and include at least 12 forest cover types (species groups). Birds breeding in floodplain forests are affected by extensive variation in latitude, climate, hydrology, forest succession, and change caused by anthropogenic disturbances. New information from two recent studies, one on the Upper Mississippi River and one on the Cache River in southern Illinois, indicates that floodplain forest bird communities differ in species composition and in relative abundance from adjacent upland habitats. High abundances of some species are found in the floodplain and species, such as the prothonotary warbler, brown creeper, yellow-billed cuckoo, yellow-bellied sapsucker, and great crested flycatcher, show a clear preference for floodplain forests. A few species, such as the red-shouldered hawk and prothonotary warbler are dependent on these forests. Studies of nesting success indicate that, for some species, nest success may be higher in the floodplain than in the uplands. Floodplain birds face threats from large-scale loss of forest habitats and their constituent natural levees, backwater sloughs, and oxbow lakes. Conservation efforts should focus on restoring degraded floodplains and maintaining high tree species diversity and wide corridors. To accomplish this, the underlying hydrodynamics which support a diverse floodplain forest habitat may need to be restored. Large, contiguous tracts of floodplain and adjoining upland forests should be maintained where they exist and restored in other locations. Large tracts are needed to reduce the effects of cowbird parasitism and predation and provide some high quality habitat for area-sensitive neotropical migratory birds (NTMBs) in agricultural landscapes where small, scattered forest fragments are the rule. The removal of known cowbird feeding areas within and adjacent to forests will also likely reduce brood parasitism. Primary and secondary cavity nesters make up a significant part of floodplain forest bird communities and managers should give high priority to providing an abundant supply of dead trees and snags. Future research efforts should examine the importance of floodplain forests in maintaining populations of neotropical migrants, especially birds experiencing population declines in adjacent uplands.

INTRODUCTION

The floodplain forests found along the network of major rivers of the Upper Midwestern United States have long provided breeding, migration, and wintering habitat for millions of birds. These forests and their associated wetlands have become increasingly important because of wetland and forest losses throughout the region. Large floodplain forests are distinctive features of the landscape and as dynamic habitats, exposed to frequent disturbances, they provide scarce resources for some species of birds that are less common or absent in adjacent upland habitats. We review the available literature on floodplain forest birds focusing on NTMBs and the breeding bird assemblages of floodplain forests of major

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rivers in the Upper Midwest. Because so little published information is available about Midwestern floodplain forest birds, we include summaries of data collected in two recent studies from the Cache River in southern Illinois and the Upper Mississippi River in Minnesota, Wisconsin, and Iowa. Full reports of methodology and analyses of these data are being published separately. Our purpose in summarizing this information is to provide a current perspective on Midwestern floodplain forest bird communities and to identify conservation and management needs.

This paper is organized according to the following sections: (1) Dynamics and structure of forests associated with large rivers in the Midwest, (2) The floodplain forest bird community, (3) Potential threats to floodplain forest-nesting birds, and (4) Conservation and management of floodplain forest birds.

DYNAMICS AND STRUCTURE OF FORESTS ASSOCIATED WITH LARGE RIVERS IN THE MIDWEST

The floodplain forests of the Upper Mississippi, much of the lower Missouri, and parts of the Ohio River systems can be grouped into two major forest types (Eyre 1980) (fig. 1). The elm-ash-cottonwood type occupies most of the floodplains of this region (referred to by Eyre as the Central Forest Region) (see Appendix A for scientific names of trees and shrubs). During the last century, as a result of flood control, irrigation, and other water projects, the elm-ash-cottonwood group has expanded westward in distribution along riparian corridors of the Great Plains (Knopf and Scott 1990). This expansion of eastern floodplain forests is responsible for an influx of eastern bird species into eastern Colorado (Knopf 1986).

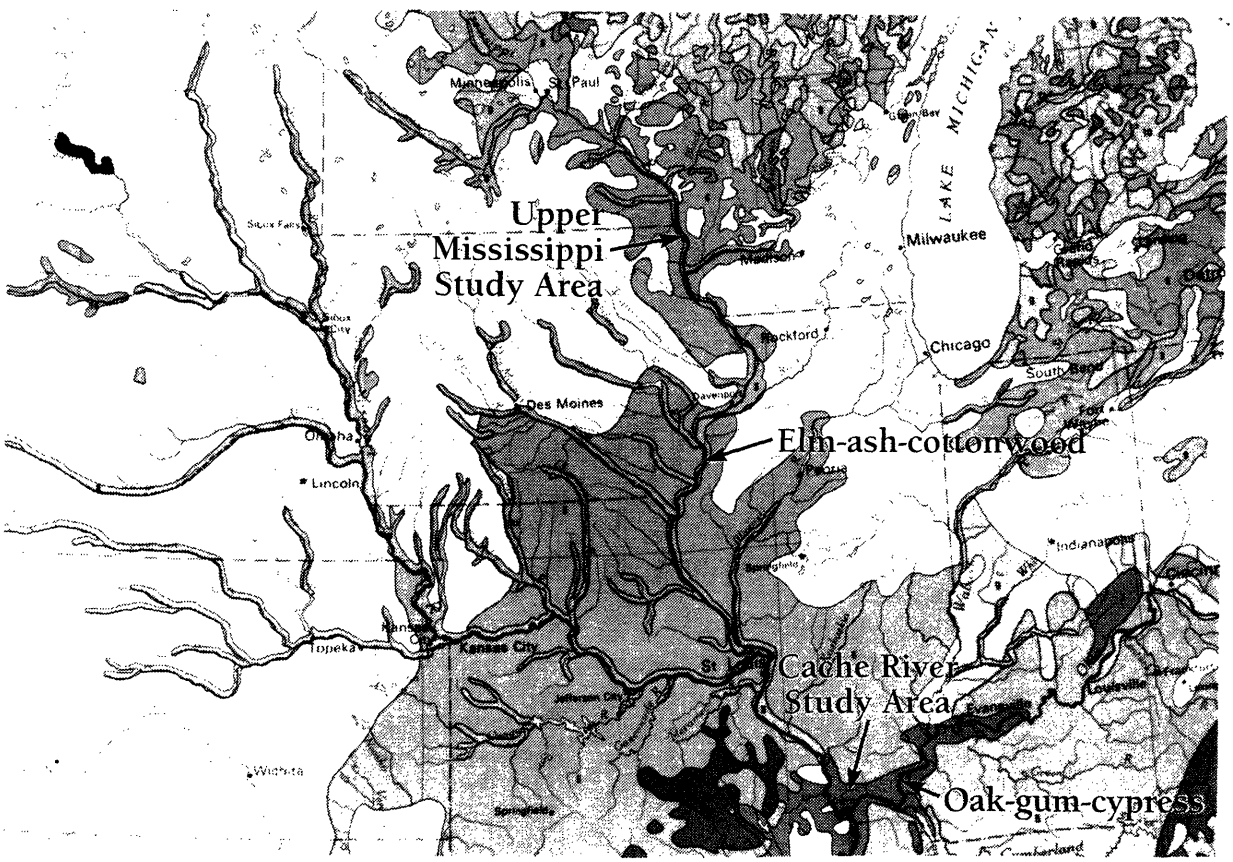

Figure 1.—*Major floodplain forest types (oak-gum-cypress and elm-ash-cottonwood) of the Central Forest Region of the United States. Elm-ash-cottonwood forests are bordered by either oak-hickory forest types (dark shading) or tallgrass prairie (no shading). Excerpted from national Atlas of Major Forest Types with an original scale of 1:7,500,000 (Eyre 1980).*

The oak-gum-cypress forest type of the lower Mississippi River alluvial plain extends into the Central Forest Region for a short distance north of Cairo, Illinois on the Mississippi and up the Ohio River into southern Indiana. The Cache River in southern Illinois enters the Ohio near its junction with the Mississippi and is in a transition zone between the elm-ash-cottonwood and the oak-gum-cypress forest types.

Each of these two general forest types contains 12 or more cover types (species groups) named for the tree species that are dominant in basal area within a stand. The elm-ash-cottonwood type includes: silver maple-American elm, river birch-sycamore, hackberry-American elm-green ash, willow, and cottonwood cover types. The oak-gum-cypress forest type includes: pin oak-sweetgum, swamp chestnut oak-cherrybark oak, sugarberry-American elm-green ash, sycamore-sweetgum-American elm, black willow, and bald cypress-water tupelo. Various species of oak, hickory, pecan, and maple are important associated species in most of these cover types. The composition of forest tree communities changes along latitudinal and climatic gradients, but on a local scale, diversity within a floodplain tree community is influenced by the elevation profile of the river channel from bank to bank. Plant species distributions arise from different tolerances to flooding, with the most tolerant species dominating the lowest elevations. Trees adapted to drier conditions are found on levees and the higher terraces adjacent to the rivers. Plant distributions also depend upon seed survival and dispersal dynamics (Yeager 1949; Hosner 1958, 1960; Galatowitsch and McAdams 1994). Trees with seeds that disperse by wind (cottonwood, silver maple) colonize more readily than trees with larger seeds that depend upon water or animal dispersal (oaks). Seedlings are often more sensitive to the effects of flooding than adult trees.

Large river fluvial dynamics (movements of sediment influenced by river hydrology) create an interspersion of forests, side channels, backwater sloughs, oxbow lakes, and marsh habitats (Malanson 1993) (fig. 2). This mix of habitats may remain stable over periods of 50-100 years within a region, but the location of habitat patches is dynamic because of erosion and land-building associated with fluvial processes (Kupfer and Malanson 1993). Flooding is a natural, periodic disturbance that strongly influences the species composition, size and shape of forested land in the floodplain. Over geologic time, the Mississippi River has served as a corridor for the gradual "migration" of tree species responding to climatic changes, especially the pecan (Bettis *et al.* 1990). The corridor may prove an important north-south link for tree species migration in the event of global warming.

According to the river-continuum concept, riverine forests are connected hydrologically, chemically, and biotically to each other and the larger upland matrix via transport of water and nutrients from uplands to the floodplain and downstream (Naiman *et al.* 1993, Johnson *et al.* 1995). Upstream forests are also connected to downstream forests via water flow. Therefore, riverine processes such as sedimentation (which can ultimately lead to development of forests) are closely tied to land use practices and disturbances to natural land cover in uplands adjacent to and upstream from a particular floodplain forest. In addition, contaminants from agricultural or industrial sources can move through these systems via water flow, especially under flood conditions. Thus, floodplain forests play a critical role in filtering nutrients and sediment and act as a buffer against potential effects on water quality of rivers from disturbances in upland portions of their watersheds (Peterjohn and Correll 1984, Brinson 1990). According to the flood pulse concept, periodic flooding (usually annual) is the most important hydrologic feature of large rivers (Johnson *et al.* 1995). Flood pulses extend the river onto the floodplain and directly affect nutrient availability and aquatic organisms (Junk *et al.* 1989, Power *et al.* 1995). Because some floodplain birds use aquatic insects and fish as sources of food, it is likely that flood pulses are important for them as well.

The complex interplay of these dynamic forces likely plays a major role in maintaining high biodiversity in floodplain corridors (Naiman *et al.* 1993). Riverine trees generally have greater basal area, higher biomass, and more biomass production than adjacent upland forests (Brinson 1990). Plant species richness can vary with the size of the river, with higher richness in the larger rivers than in the tributaries (Nilsson *et al.* 1994). However, within a

Figure 2.—*Aerial view of the Upper Mississippi River floodplain showing multiple channels, backwaters, marshes, forests, and adjacent uplands (left side of highway). The city of LaCrosse, Wisconsin is in the upper background of the photo.*

given floodplain, the number of tree species increases from the most frequently flooded and wetter soils near the main channel to the less frequently flooded soils at higher elevations of the floodplain (Brinson 1990). Species richness of aquatic invertebrates can increase with stream size (Minshall *et al.* 1985). Bird abundance increased with the width of riparian forests in Texas (Dickson *et al.* 1995). Riverine forests in both humid and arid environments, generally support more avian species than do adjacent uplands in the same geographic region (Lugo *et al.* 1990).

THE FLOODPLAIN FOREST BIRD COMMUNITY

Migration and Dispersal

Floodplain forests can have a profound influence on the local and regional bird community by functioning as a dispersal and migration corridor for forest-dependent species, especially in landscapes otherwise devoid of trees, such as the western United States (Knopf and Samson 1994). This may also apply to large areas of the Midwest, where row-crop agriculture dominates the landscape. Emlen *et al.* (1986) described the elm-ash-maple forest of the Upper Mississippi Valley as "...one of the longest north-south stretches of relatively uniform vegetation on the North American Continent."

The importance of the Mississippi River and its tributaries as important migration corridors for birds such as waterfowl is well known (Bellrose 1976). Floodplain forests of this river system may also provide important migratory corridors for neotropical birds that feed and rest in riverine habitats. Data collected by the U.S. Fish and Wildlife Service on the Upper Mississippi River Wildlife and Fish Refuge and the Mark Twain National Wildlife Refuge indicate that NTMBs consistently use the floodplain forests during migration in both fall and spring. In 1993, 150 species of birds were identified in Pools 4-8 during spring migration, 20 percent of all birds counted were NTMBs (Schumacher 1993).

Breeding

In Iowa, floodplain forests host a larger number of breeding bird species than upland forest, cropland, shrubland, or marsh (Best *et al.* 1995). Floodplain forests also rank very high in providing primary breeding habitat for Midwestern bird species experiencing population declines such as the cerulean warbler, prothonotary warbler, Louisiana waterthrush, and northern waterthrush (Thompson *et al.* 1993).

Breeding birds in floodplain forests include species that occupy a wide variety of habitat types, including species that specialize on early successional habitats created by flood disturbances. Floodplains provide habitat for some birds that are uncommon or absent from adjacent upland habitats such as prothonotary warblers and red-shouldered hawks (Murray and Stauffer 1995). In some cases, large trees and snags are more common in floodplains than in adjacent uplands and provide better habitat structure for cavity-nesting species (Renken and Wiggers 1993). The connection of floodplain forests with uplands may play an important role during the breeding season, by buffering isolation effects (Decamps *et al.* 1987) and influencing rates of species turnover (Gutzwiller and Anderson 1987).

Few studies have focused on birds breeding in floodplain forests in the Midwest. Emlen *et al.* (1986) surveyed 12 study sites on the Mississippi River between Cairo, Illinois and St. Paul, Minnesota in June 1979, and correlated latitude, habitat and other environmental factors with population densities for 43 species. The bird community changed in a predictable manner over latitudinal gradients with ecologically similar species replacing each other based on climatic affinities. Concern has been raised about the effects on the bird community from fragmentation and loss of these floodplain forests due to lock and dam construction, agriculture, and urban development (Knutson 1995, Grettenberger 1991). Forest fragmentation has been shown to lead to loss of bird species from upland forests (Robbins *et al.* 1989). Studies of Midwestern riparian bird communities demonstrate high bird diversity present in these habitats. A study of the St. Croix River floodplain, a northern Wisconsin tributary of the Mississippi, showed high species richness, with as many as 155 birds breeding in or near the corridor (Mossman 1991). Small and Hunter (1989) found no differences in abundance or species richness between forest-river edges and the forest interior. Best and Stauffer (1980) detected no differences in nesting

outcome for birds breeding in upland and floodplain woodlands in Iowa but indicated that habitat structure and predation were important factors affecting nest success.

Cache River, Illinois Case Study

This ongoing research by Jeffrey Hoover of the floodplain forests of the Cache River watershed in Southern Illinois includes data provided by Scott Robinson (Illinois Natural History Survey) from a study conducted in the nearby upland forests of the Trail of Tears State Forest in Southern Illinois. The Cache River watershed, located in the southern tip of Illinois, is a breeding, wintering, and migratory habitat for over 200 bird species. The plant communities found in this watershed include barrens, upland and floodplain hardwood forests, and cypress swamps. Some large (> 1,000 ha) blocks of forest habitat remain along sections of the Cache River, which still flows unconstrained through a broad floodplain with natural levees and backwaters. An ambitious forest acquisition and restoration effort encompassing 60,000 contiguous acres of land is now underway in the Cache River watershed.

The composition of the floodplain forest of the Cache River is diverse. Many species of trees are present in the tracts of floodplain forest in this area. The most common trees include oaks (white, Shumard, black, pin, cherrybark, swamp chestnut), maples (black, red, silver, sugar), hickories (shagbark, bitternut, mockernut, pignut, shellbark), American elm, sweetgum, sugarberry, and American hornbeam. Wet areas are composed of baldcypress, water tupelo, and buttonbush. The shrub layer includes spicebush, blackhaw, swamp holly, pawpaw, and greenbrier.

The Trail of Tears State Forest is less complex and diverse than the Cache River floodplains and is dominated by oak-hickory forests (red and white oak) on the hillsides, ridge tops, and coves, with younger mixed hardwoods (e.g., sugar maple, and tuliptree), in wider ravines. The topography of this forest is very uniform and consists of narrow (≤ 50 m wide) ridges and narrow ravines ranging from 800-2,500 m in length. The forest constitutes part of the eastern extent of the Ozark mountains.

Data from the Cache River floodplain forest were collected in 1993 and 1994 and data from the Trail of Tears State Forest were collected from 1990-1992. Presence and abundance of all breeding birds were monitored using standard point-count methods (Hutto *et al.* 1986). Point counts included distance estimates, vocalization type (song versus call) and compass direction for all species seen and/or heard during 6-minute periods. Only birds present within 70 m of the census points were considered for this analysis. A total of 1,495 points were censused in floodplain forest and 1,703 in upland forest. The number of species and relative abundances (mean number of individuals per 10 70-m radius census points) of NTMBs in floodplain and upland forest were compared.

To examine the effect of corridor width on the bird community, birds were censused in 14 forested corridors within the Cache River project area from 20 May to 30 July 1993 and 1994. All of the forested corridors included in this analysis were adjacent to or were bisected by flowing water. The width of forested corridors was determined by averaging the width (in meters) of the corridor at each end of the area that was censused, and the width at two points between each end that were equidistant from each other and the ends. All intensive study plots in which nesting success was quantified were censused 3 times. In these plots, points were located at 150 m intervals. These study plots were designed to sample the small (<100 ha) tracts entirely and to sample representative 100-150 ha portions of the larger tracts.

Nesting success of breeding birds was also monitored in these studies. Nests were located and monitored at 2 to 3 day intervals until they were no longer active. Daily predation rates were calculated for each species using the Mayfield (1975) index. Statistical comparisons of predation levels were made using the program CONTRAST (Hines and Sauer 1989). The frequency of brood parasitism by the brown-headed cowbird was also documented. We compared the daily predation rate and frequency of brood parasitism between floodplain and upland forest for three species of NTMBs (Kentucky warbler, wood thrush, and Acadian flycatcher) that were common in both forest types.

A total of 33 species of NTMBs were identified during point counts in the floodplain and upland forests combined (table 1). The hooded

warbler was the only species present in the uplands not present in the floodplains, although the worm-eating warbler was only present along bluffs adjacent to the floodplain. More species were detected in the floodplain forest (32) than in the upland forest (25). Based on the censuses, seven species occurred only in floodplains (chimney swift, eastern kingbird, eastern phoebe, yellow warbler, prothonotary warbler, American redstart, orchard oriole, and northern oriole); only the prothonotary warbler was common. Some of these species may be present only in the floodplains because they require habitat features not found in the uplands. For example, chimney swifts used large, hollow trees for nesting sites. Eastern phoebes built nests along the steeper banks of the Cache River and along some of the bluffs that overlook the river. The more abundant prothonotary warbler prefers flooded forests and numerous snags with natural cavities for nesting. The American redstart preferred forest-water edges.

Table 1.—*Relative abundances of neotropical migrant songbirds in floodplain and upland forest habitats in southern Illinois.*

Species	Number of individuals per 10, 70-m radius census points	
	Floodplain (1993-1994) (1495 census points)	Upland (1990-1992) (1703 census points)
Yellow-billed cuckoo	4.17	1.62
Chimney swift	2.13	—
Ruby-throated hummingbird	1.65	1.10
Eastern kingbird	0.007	—
Great-crested flycatcher	3.37	2.76
Eastern wood-pewee	7.69	9.23
Eastern phoebe	0.03	—
Acadian flycatcher	19.6	11.0
Blue-gray gnatcatcher	9.60	7.37
Gray catbird	0.19	0.02
Wood thrush	3.18	3.26
Red-eyed vireo	3.21	6.17
Yellow-throated vireo	2.09	1.97
White-eyed vireo	1.14	1.50
Northern parula	3.27	1.26
Yellow-throated warbler	0.61	0.38
Prothonotary warbler	5.12	—
Black and white warbler	0.007	0.02
Cerulean warbler	0.47	0.21
American redstart	0.15	—
Yellow warbler	0.013	—
Worm-eating warbler	0.03	6.88
Hooded warbler	—	0.67
Kentucky warbler	2.91	5.80
Common yellowthroat	1.44	0.01
Yellow-breasted chat	0.23	0.02
Louisiana waterthrush	0.38	0.56
Ovenbird	0.03	2.04
Orchard oriole	0.06	—
Northern oriole	0.07	—
Summer tanager	0.85	2.05
Scarlet tanager	0.57	3.62
Indigo bunting	6.39	2.38
Total neotropical migrants	79.4	71.9

Riverine edge habitats are created by flood waters gradually changing the course of the river, causing it to meander back and forth across the floodplain over time (Kupfer and Malanson 1993). Flooding can also weaken root systems of trees, leading to tree-fall gaps. River edges, particularly where the Cache still flows relatively unconstrained, are favorite habitat for the cerulean warbler. The dense cane stands along the river provide potential habitat for the Swainson's warbler (extirpated since 1992), should it return to Illinois. Forest edges with shrubs provide excellent habitat for the indigo bunting and white-eyed vireo.

Species more abundant in the uplands than in floodplains were the eastern wood-pewee, worm-eating warbler, red-eyed vireo, Kentucky warbler, scarlet tanager, summer tanager and ovenbird (table 1). In the floodplain forest, the Acadian flycatcher, blue-gray gnatcatcher, prothonotary warbler, yellow-billed cuckoo, northern parula, and indigo bunting were most abundant. Water levels throughout the Cache River floodplains vary greatly from place to place and fluctuate over the course of the breeding season (J.P. Hoover, data on file). The ground nesting substrate in floodplains is occasionally and unpredictably under water, limiting habitat availability for ground-nesting and ground-foraging species. This may be the reason ground nesters like the ovenbird, worm-eating and Kentucky warbler are more abundant in upland forests. Worm-eating warblers are also associated with moderately steep forested slopes that border the floodplain in a few places. Kentucky warblers are common in the floodplains, but depend on natural levees and areas of higher ground adjacent to the river, where soil has been deposited by spring floods over the years, for nesting and foraging habitat. Without these levees, Kentucky warblers would likely become rare or disappear. Natural flooding is needed to maintain this special type of habitat. A total of about 80 NTMBs per 10 census points in floodplain and 72 in upland forest habitat were found.

Sufficient numbers of nests were obtained to compare predation rates between upland and floodplain forests for 3 species. Daily predation rates did not differ for the Kentucky warbler or for the wood thrush (table 2). Daily predation rate estimates were 4.35 percent for the Kentucky warbler and 3.95 percent for the wood thrush. These daily rates result in overall predation rates for the nesting period of 62 percent for the Kentucky warbler and 65 percent for the wood thrush. However, the daily predation rate was significantly lower ($P<0.05$, CONTRAST) for Acadian flycatchers nesting in floodplain forests than in upland forests (table 2). Overall rates of predation for Acadian flycatcher nests were 61 percent for floodplain and 76 percent for upland forests.

Table 2.—*Daily predation rates for birds nesting in floodplain and upland forest habitats in southern Illinois.*

Species	Daily predation rate (%) ± SD (exposure days)	
	Floodplain (1993-1995)	Upland (1990-1992)
Kentucky warbler	4.4 ±0.69 (871)	4.3 ±0.82 (607)
Wood thrush	3.7 ±0.33 (3280)	4.2 ±0.56 (1301)
Acadian flycatcher	3.4 ±0.24 (5787)	5.1 ±0.49 (2030)

The frequency of brood parasitism was not different for the Kentucky warbler ($X^2 = 0.84$, df=1, $P>0.1$), wood thrush ($X^2 = 1.58$, df=1, $P>0.1$), and the Acadian flycatcher ($X^2 = 1.09$, df=1, $P>0.1$) (table 3). Floodplain and upland forests of southern Illinois are fragmented by agriculture which provides feeding areas for cowbirds. There are few places (if any) in the forests of Illinois that are far enough away from cowbird feeding areas to prevent brood parasitism. Recent studies in Illinois and Missouri show that cowbirds moved an average of 1.2 km and a maximum of 3.2 km between feeding and breeding areas (Thompson 1994). However, they were capable of moving 10 km or more in a day. A large-scale restoration project such as the Cache River Bioreserve could create blocks of forest extensive enough to reduce the current levels of parasitism. The rates of nest predation and brood parasitism found here are consistent with rates found for these species throughout Illinois (Brawn and Robinson 1996).

Table 3.—*Levels of brood parasitism for birds nesting in floodplain and upland forest habitats in southern Illinois.*

Species	Percentage of nests parasitized (n)	
	Floodplain (1993-1995)	Upland (1990-1992)
Kentucky warbler	36 (87)	43 (75)
Wood thrush	89 (238)	84 (108)
Acadian flycatcher	38 (365)	33 (169)

The correlation for species richness of NTMBs with floodplain corridor width was significant and positive (fig. 3: r^2=0.64, F=21.1, P=0.0006). From a management perspective, data from the Cache River study point to the following relationships: Increasing the width of forested corridors will increase species richness, especially for NTMBs. Additional data indicate that increasing corridor width will increase species richness, with most of the beneficial effect occurring between 200 and 600 m (Robinson and Hoover 1995). The increase in species richness in very wide corridors comes largely from the addition of a transition zone between floodplain and upland forests where increased diversity of vegetation favors a higher diversity of birds. The presence of flowing water in a tract of forest also increases species richness by attracting water birds and species such as the prothonotary warbler that nest at the interface of forest and water.

Results from the first 2 years of the Cache River study suggest that the largest tracts of floodplain forest have the highest diversity and abundance of migrant songbirds, and also contain area-sensitive species such as the cerulean warbler (J.P. Hoover and S.K. Robinson, data on file). Preliminary results also suggest that nesting success of songbirds may be better in wide floodplain forest corridors than in narrow ones (L. Chapa, Illinois Natural History Survey, pers. comm.). This implies that restoration of large blocks of unfragmented floodplain forest along the Cache River will greatly benefit NTMBs in southern Illinois.

Upper Mississippi River Case Study

This study was conducted by Melinda Knutson in the floodplain forests of the Upper Mississippi River from Winona, Minnesota to Prairie du Chien, Wisconsin (Knutson 1995). Census methods were similar to those used in southern Illinois, except point counts were done in 50 m-radius circles for 10 minute periods. For comparisons, data are taken from 700 point counts in the floodplains and 179 in the uplands in 1993 and 1994. Differences in the distribution of counts of individual species (classes of 0, 1, and $\geq$ 2) between uplands and lowlands were tested with chi-square analyses. Additional studies included a pilot study of nesting success conducted in 1992 and an artificial nest study conducted in 1993 and 1994. Methods in the nest success study were similar to those used in the Illinois study. In the artificial nest study, artificial nests containing 2 bobwhite quail eggs were placed about 2.5 m from the ground in trees 25, 50, 100, and 200 m from forest-water edges in the floodplain. The artificial nests were designed to simulate some features of American redstart nests, one of the most common lower canopy nesters in these forests. After 6 days, disturbances (loss or destruction of eggs) were recorded. Large (196-226 ha) and small (70-159 ha) forest tracts were compared, along with distance from edge. Four hundred thirty-one nests, evenly divided between large and small forest tracts were monitored over the 2 years.

Forests in this region are dominated by silver maple, followed by smaller components of green ash, American elm, swamp white oak, cottonwood, and hackberry (fig. 3). The hardwood community (oak, hickory, and walnut), found on slightly drier sites, has been greatly reduced since presettlement times. Surveyor's records indicate that prior to European settlement cottonwood and black willow were more dominant than they are now (Moore 1988). They represent the pioneer community of the floodplain, with seedlings regenerating on open substrates like sand or mud flats. River dynamics have been constrained by the locks and dams since the 1930's, the location of the mature forests has stabilized, and these species have declined (Yin and Nelson 1995). However, mean water levels and the height and severity of flooding have also increased, lead-

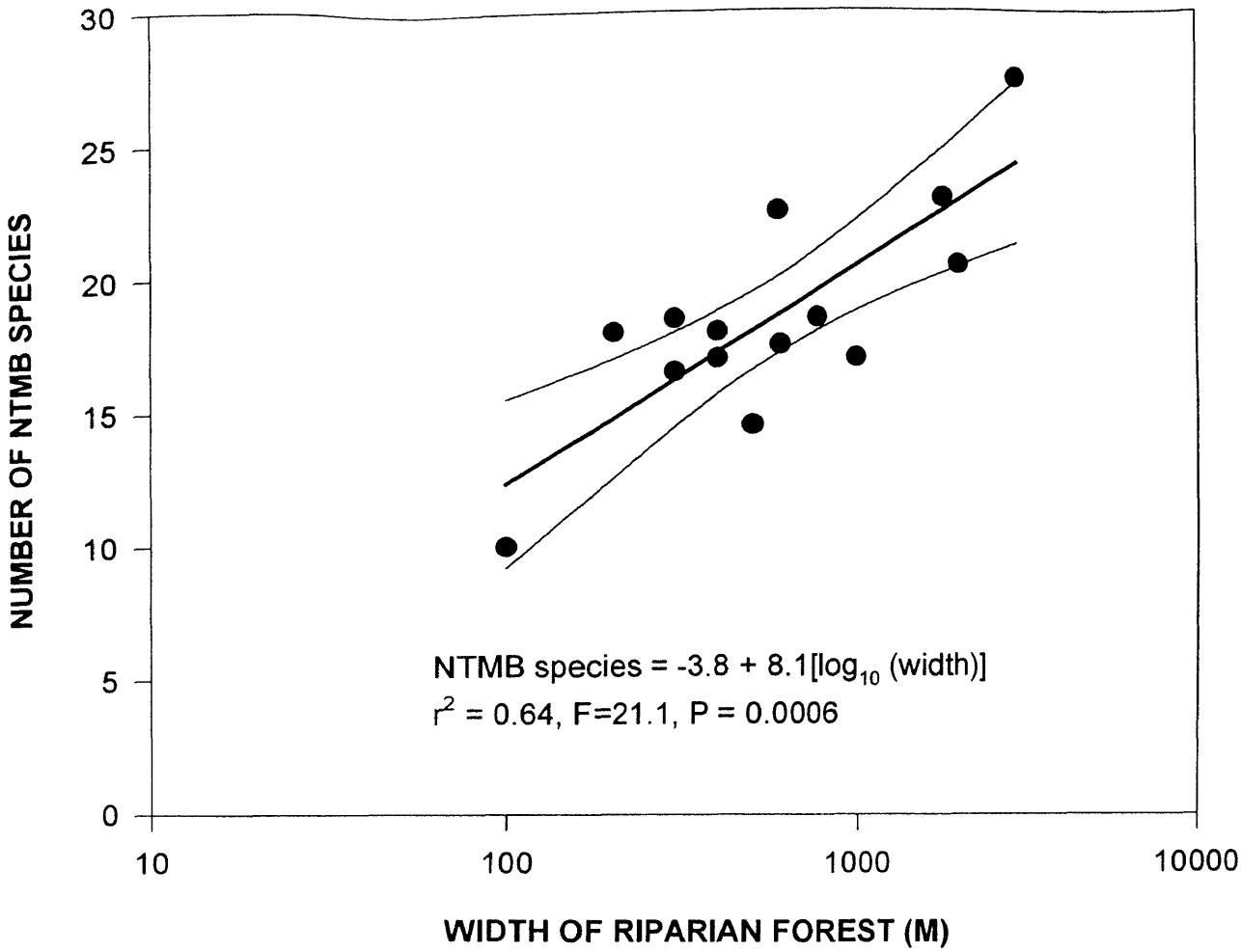

Figure 3.—*Correlation of the number of neotropical migratory bird species (y-axis) with $\log_{10}$ corridor width (x-axis) of riparian forest, Cache River, southern Illinois, 1993-1994. The regression line and 95 percent confidence intervals are shown.*

ing to silver maple dominance. Silver maple is more tolerant of flooded conditions than its former co-dominants, American elm and green ash. Hardwoods and other floodplain species, such as hackberry, cannot tolerate long periods of inundation and the new higher water levels (Yeager 1949; Hosner 1958, 1960; Jones *et al.* 1994; Nelson *et al.* 1994; Yin *et al.* 1994). Tree species composition and the natural disturbance cycles have changed as a result of the locks and dams, and these habitat changes may have affected the bird community. Unfortunately, only anecdotal information is available about the bird community prior to the Emlen *et al.* (1986) work in the 1970's.

Knutson detected 84 species of birds during the breeding season, of which 56 are NTMBs. Twenty of the 84 species are cavity-nesters, including seven woodpecker species. Woodpeckers are an important component of the bird community because they create nest holes for secondary cavity nesters, including NTMBs such as the prothonotary warbler, great crested flycatcher, chimney swift, tree swallow, and house wren. Cavity nesters are a conspicuous component of the bird community in the floodplain because of the availability of numerous large standing snags.

A total of 47 species of NTMBs were present in the floodplain, of which 4 (killdeer, cliff swallow, veery, golden-winged warbler, and white-throated sparrow) were not present in uplands. Knutson detected 52 species in upland forests, of which 9 were not found in floodplain forests (turkey vulture, cliff swallow, mourning

warbler, black-and-white warbler, Louisiana waterthrush, Kentucky warbler, rufous-sided towhee, vesper sparrow, and chipping sparrow).

Relative abundances of all birds and total numbers of NTMBs were almost twice as high in the Upper Mississippi River floodplain than in the adjacent uplands (table 4). The most abundant NTMBs in floodplain forests were American redstart, house wren, great crested flycatcher, northern oriole, prothonotary warbler, warbling vireo, and common yellowthroat. The most abundant NTMBs species in upland forests were the ovenbird, red-eyed vireo, rose-breasted grosbeak, scarlet tanager, cerulean warbler, and blue-winged warbler.

Abundance of most floodplain birds did not vary with the amount of forest within 800 m of the census plot. This was true even for American redstarts and blue-gray gnatcatchers, species found to be area-sensitive (show a positive relationship between probability of occurrence, abundance, and size of forest tract) in some upland studies (Stauffer and Best 1980, Temple 1986). The yellow-billed cuckoo, red-bellied woodpecker, yellow-bellied sapsucker, hairy woodpecker, white-breasted nuthatch, and brown creeper were area-sensitive in floodplain forests (Knutson 1995). Knutson's (1995) study included 1993, a year of major flooding for the entire upper Midwest. She examined the effect of the flood on the bird community and found that the relative abundance of some species (blue jay, house wren, and common yellowthroat) was lower the year of the flood and the breeding season following the flood.

In the pilot nest success study, Mayfield nest success (Mayfield 1975) for the American redstart was 25.1 percent (S.E.=8.7 percent, N = 23), prothonotary warbler was 17.7 percent (S.E.=7.5 percent, N = 24), house wren was 34.8 percent (S.E.=10.7 percent, N = 30), and American robin was 15.8 percent (S.E. = 10.4 percent, N = 13) (M. Knutson and E. Klaas, data on file). These estimates are similar to rates of nest survival found by Robinson (1992) in Illinois (about 20 percent for NTMBs).

Contrary to many similar studies, in the artificial nest study, large forest tracts had higher predation rates than small forest tracts (52.3 vs. 36.3 percent). There was no significant difference in predation rates among nests placed 25, 50, 100, or 200 m from the forest edge. Calculated artificial nest "survival", derived from observed predation rates in 1993-1994, was similar to natural nest survival for several species for the same study area in 1992. Nest losses did not differ among several habitat variables such as tree species composition, canopy cover, and shrub cover measured at the nest sites.

Species of Management Concern in Floodplain Forests

Based on the two case studies above, NTMBs of high management concern (mean score $\geq$ 3.0 based on Thompson *et al.* 1993) that are closely associated with floodplain forests include the cerulean warbler, prothonotary warbler, Acadian flycatcher, yellow-billed cuckoo, yellow-breasted chat, and great crested flycatcher. NTMBs of medium management concern (mean score of 2.0 -3.0 based on Thompson *et al.* 1993) that are closely associated with floodplain forests include the American redstart, chimney swift, northern oriole, indigo bunting, yellow-throated warbler, gray catbird, least flycatcher, warbling vireo, northern parula, and common yellowthroat. Wide riparian corridors can increase species richness. The fact that floodplain forests are not usually found in large, contiguous stands, but are naturally linear and interspersed by sloughs, oxbow lakes, and marsh habitats does not seem to have serious negative effects on species presence/absence or abundance. Indeed, total bird abundance in floodplain forests was higher than in upland forests. More data on reproductive success from other Midwestern locations is needed to assess how successfully some species are reproducing themselves across the landscape. High predation rates for wood thrushes indicate that this species is at high risk for population declines.

POTENTIAL THREATS TO FLOODPLAIN FOREST-NESTING BIRDS

Floodplain Forest Loss and Fragmentation

Most temperate rivers in the world are constrained from their natural fluvial dynamics by dams or other impoundments (Dynesius and

Table 4.—*Relative abundances of bird species during the breeding season in floodplain and upland forests of the Upper Mississippi River, Winona, MN to Prairie du Chien, WI (1993-1994).*

Species	Number of individuals per 10, 50-m radius census points		
	Floodplain (700 points)	Upland (179 points)	P-value[1]
Turkey vulture	—	0.17	0.008
Red-tailed hawk	0.01	0.06	0.366
Red-shouldered hawk	0.06	0.06	0.599
Killdeer	0.04	—	1.000
Mourning dove	0.30	0.11	0.426
Black-billed cuckoo	0.04	0.06	1.000
Yellow-billed cuckoo	0.87	0.17	0.006
Chimney swift	0.20	0.06	1.000
Ruby-throated hummingbird	0.04	0.11	0.270
Belted kingfisher	0.11	0.11	0.736
Yellow-bellied sapsucker	5.21	1.12	<0.0001
Northern flicker	1.67	1.12	0.339
Eastern wood-pewee	5.69	4.08	0.013
Acadian flycatcher	0.09	0.78	<0.0001
Least flycatcher	0.17	0.06	0.765
Willow flycatcher	0.00	0.11	0.041
Eastern phoebe	0.06	0.22	0.059
Great crested flycatcher	7.90	2.01	<0.0001
Eastern kingbird	0.01	0.06	0.366
Tree swallow	1.56	0.06	<0.0001
Northern rough-winged swallow	0.00	0.34	0.204
Cliff swallow	—	0.11	0.204
Brown creeper	0.53	0.22	0.320
House wren	12.64	2.46	<0.0001
Blue-gray gnatcatcher	4.54	3.91	0.054
Veery	0.20	—	0.258
Wood thrush	0.07	1.45	<0.0001
American robin	7.34	2.96	<0.0001
Gray catbird	3.27	2.18	0.131
Cedar waxwing	0.09	0.22	0.031
Yellow-throated vireo	1.80	1.84	0.158
Warbling vireo	5.93	0.22	<0.0001
Red-eyed vireo	1.99	4.86	<0.0001
Blue-winged warbler	—	0.89	<0.0001
Golden-winged warbler	0.01	—	1.000
Yellow warbler	1.26	0.45	0.018
Cerulean warbler	0.26	1.01	0.0001
American redstart	21.30	4.19	<0.0001
Prothonotary warbler	6.10	0.06	<0.0001
Ovenbird	0.10	5.36	<0.0001
Louisiana waterthrush	—	0.17	0.008
Kentucky warbler	—	0.22	0.002
Mourning warbler	—	0.06	0.204
Common yellowthroat	3.21	0.95	<0.0001
Scarlet tanager	0.07	2.68	<0.0001
Rose-breasted grosbeak	1.29	3.91	<0.0001

(table 4 continued on next page)

(table 4 continued)

Species	Number of individuals per 10, 50-m radius census points		
	Floodplain (700 points)	Upland (179 points)	P-value[1]
Rufous-sided towhee	—	1.23	<0.0001
Indigo bunting	0.09	1.34	<0.0001
Chipping sparrow	—	0.11	0.041
Vesper sparrow	—	0.11	0.041
Song sparrow	8.50	0.61	0.0001
Swamp sparrow	0.03	0.11	0.186
White-throated sparrow	0.03	—	1.000
Brown-headed cowbird	3.96	3.85	0.022
Northern oriole	6.29	2.91	<0.0001
American goldfinch	0.86	2.35	<0.0001
Total neotropical migrants	115.79	63.87	

[1]Probability of obtaining the same or greater difference in the distribution of counts of 0, 1, or ≥2 individuals at each census point between upland and lowland habitats, given the null hypothesis of no difference.

Nilsson 1994). The long-term ecological results of these constraints, such as changes in tree species composition and reduced wildlife habitat, are still under study (Hunt 1988). The results of flood control and other engineering changes to the Lower Mississippi River floodplain have been dramatic. About 80 percent of the original Lower Mississippi River floodplain forests have been lost and the cumulative impacts of the changes in this system are substantial (Gosselink *et al.* 1990). The bird community has also changed in response to these land use changes (Fredrickson 1980, Burdick *et al.* 1989). Species richness and population densities of both wintering and breeding birds have declined with cumulative losses of forest area.

The lock and dam system on the Upper Mississippi River has resulted in a different flow regime than prior to impoundment (Grubaugh and Anderson 1988, 1989; Sparks 1995; Wlosinski *et al.* 1995). Water levels are generally higher over the entire year, flood pulses are higher, and periods of very low flow formerly common in the fall have been eliminated. These human-induced changes in river hydrology have caused major changes in the vegetative cover of the floodplain (Hunter *et al.* 1987; Johnson 1992, 1994; Yin and Nelson 1995). As the navigation dams were constructed during the 1930s, floodplain forests immediately above the dams were cleared prior to flooding. Remaining forests located on higher ground or just below the dams gradually changed in species composition to include species tolerant of flooding and wet conditions. It may take years to detect impacts of hydrologic changes on forests. On the Upper Mississippi River, the forest community has become less diverse and the dominance of silver maple has increased since presettlement times (Moore 1988, Yin and Nelson 1995). Early successional stands of cottonwood and willow have been virtually eliminated and elm, ash, hackberry, oak, and sweetgum are less dominant than in the presettlement forests.

Uplands in the Midwest were formerly covered by either tallgrass prairie or oak-hickory forests maintained by fire. Most of the original area of these natural vegetation types in the central Midwest has been converted to agriculture. In addition, many rivers have been altered by artificial levees constructed to protect large areas of the floodplain from flooding. The forests on lands protected from flooding have been converted to agriculture and urban development. Rivers are dynamic systems, and vegetation and bird communities are likely dynamic as well. Changes in flood frequency and duration of flooding imposed by upstream impoundment (as has occurred on the Upper Missouri, Platte, and Kansas Rivers) can lead to dramatic changes in tree species composition, forest cover, and structure (Knopf and Scott 1990, Knopf and Samson 1993).

In a comparison of floodplain land use before and after European settlement and lock and dam impoundment, Nelson *et al.* (1994) found that 56 percent of the presettlement floodplain at the confluence of the Illinois and Mississippi Rivers was forested, while only 35 percent of the floodplain was forested in 1975. In the Illinois counties of Johnson and Pulaski (the site of the Illinois study), most of the forest is floodplain or swamp forest located within an agricultural matrix. These two counties have experienced significant reductions in forest acreage since 1820 (Iverson 1989). The amount of forest in Johnson County decreased from 92,000 ha to 37,400 ha between 1820 and 1985 (a 59 percent reduction). In Pulaski County, the amount of forest decreased from 53,500 ha to 12,400 ha between 1820 and 1985 (a 77 percent reduction).

Agriculture

Birds living in landscapes dominated by agriculture are subject to a number of threats. Floodplain birds face potential risks from agricultural chemicals used in adjacent upland habitats. These risks are intensified because of the close connection between riparian forests and adjacent croplands. No NTMB species in North America is known to be at risk of extinction because of contaminants. However, individuals and, in some cases, populations may be seriously affected either through direct mortality, decreased reproductive success, or degradation of feeding habitat. Levels of most persistent contaminants in the United States have declined in recent years due to clean-up efforts and control of the release of chemicals (Schmitt and Bunck 1995). Recent work on the Upper Mississippi River (Custer, in press) suggests that organochlorine, mercury, and selenium concentrations in great blue heron eggs were not elevated and have declined since the 1970's (Nosek and Faber 1984). Organophosphorus (OP) and carbamate insecticides, which are less persistent in the environment, are frequently used in agriculture, rangelands, and silvicultural areas (Gard and Hooper 1995) and these compounds continue to cause wildlife mortality (Glaser 1995).

Modern agricultural practices such as drainage and channelization of streams change the hydroperiod of floods by speeding water flow into streams and rivers after rains (Lugo *et al.* 1990). Some of these practices have contributed to major flooding on the Mississippi River in the last 25 years (Belt 1975, Interagency Floodplain Management Review Committee 1994). Agricultural practices that ignore principles of soil conservation lead to accelerated rates of soil erosion. Indirectly, agriculture contributed to the creation of locks and dams on many large rivers by creating demand for quick transport of crops on barges (McLeod 1990, U.S. Army Corps of Engineers 1995). Maintenance of barge traffic requires constant dredging of rivers and dumping of dredge spoil, often in forested areas. The combined effects of changed hydroperiods, high sedimentation rates, and the presence of locks and dams has had profound effects on floodplain habitats in the Upper Mississippi River (Wlosinski *et al.* 1995, Yin and Nelson 1995). These diverse agricultural influences on riparian systems continue to create ecosystem stress and could affect populations of forest-nesting birds in the future (Grubaugh and Anderson 1989, Robinson and Marks 1994).

CONSERVATION AND MANAGEMENT OF FLOODPLAIN FOREST BIRDS

Much of the current management of floodplain forests is, by necessity, adaptive management (Walters and Holling 1990). This involves implementing the best available management option, monitoring the biotic community responses, and changing management options as needed. The U.S. Army Corps of Engineers has been inventorying and mapping thousands of acres of floodplain forest on the Upper Mississippi for over a decade (G. Swenson, U.S. Army Corps of Engineers, Rock Island District, pers. comm.). Their foresters are concerned that the present extensive stands of mature silver maple are even-aged and a healthy distribution of younger trees is missing. As these forests mature, there is evidence that they may be replaced by shrub-scrub habitats, with delayed regeneration of forests. To counteract this predicted outcome, the Corps is harvesting 5 to 10 ha plots from forest stands on a planned 80 to 100 year rotation in the Rock Island District, Illinois. Cutting is done about every 5 years within a stand. A few large trees are left in each clear-cut for use by wildlife and to provide a seed source. Eagle roosts and red-shouldered hawk nests are avoided in planning these cuts. The

Corps is evaluating the effects of their clearcuts on breeding birds by conducting point counts annually.

Biologists from the Fish and Wildlife Service and the National Biological Service have drafted *The Great River Flyway: The Management Strategy for Migratory Birds on the Upper Mississippi River*. The goal of this plan is "...to ensure that habitat quality and availability on the Upper Mississippi River are sufficient to support and enhance optimum populations of migratory birds." The process outlined in this document is presented as a prototype for adaptive management at the landscape scale. The plan provides a logical approach for assessing ecosystem status through the use of species information, habitat definitions, and multi-scale digital land-cover data. The development of databases needed to manage Upper Mississippi River habitats to maintain populations of birds in an ecosystem context are far from complete. But the technology and a plan is available, and the implementation of this plan will help unify floodplain management of birds on the Upper Mississippi River.

Healthy populations of floodplain forest birds obviously require adequate habitat. The research summarized here indicates that floodplain forests provide a different type of habitat than upland forests, as demonstrated by differences in presence/absence and abundance of different bird species. Floodplain forests support higher abundances of birds than upland habitats, in some cases nearly double the abundance. Patterns of area-sensitivity are also different. Changes in flood frequency, duration, or depth imposed by impoundment can lead to changes in tree species composition and alterations in the overstory and understory structure of the forest. For example, large areas of mud flats and sand bars are needed for adequate regeneration of cottonwood and willow. With sustained high water levels created by locks and dams, these habitats remain underwater and little seedling establishment takes place. If these changes are large-scale and unidirectional, they could adversely affect species richness and relative abundance of some floodplain forest-nesting species. For example, species preferring the habitat structure provided by silver maples will likely increase on the Upper Mississippi River and those requiring the structure and/or mast provided by cottonwood, elm, and oak will likely decline. Work is ongoing to define the species associations with these forest types.

Adaptive forest management plans should seek to achieve a healthy age distribution and species diversity of floodplain trees. This might include extensive reforestation on reclaimed agricultural land. If possible, some large standing forests should be selected and preserved as old-growth forests. Regeneration of trees from existing seed sources surrounding clear cuts has not been totally successful. Clearings quickly become overgrown with dense stands of vines and herbaceous vegetation that prevent the establishment of tree seedlings. Control of herbaceous vegetation includes herbicide application, mowing, and disking. Natural forest openings over much of the Upper Mississippi River are dominated by reed canary grass, an aggressive grass which shades out shrub and tree seedlings. Regeneration of floodplain forests will require innovative techniques to control reed canary grass and allow tree seedlings to mature. Restoration of "natural" hydrodynamic patterns, to the greatest possible extent, is the approach most likely to succeed in large scale restoration of floodplain ecosystems. Locks and dams on the Mississippi and Illinois Rivers will remain into the foreseeable future. But, property damage resulting from the flood of 1993 and future major floods may stimulate reclamation of some areas to function as floodplain again. Providing continuous floodplain forest habitat along the Mississippi River and other large river corridors may prove especially important for NTMBs during migration, especially where the corridor crosses intensive agricultural areas devoid of forest cover. Areas like this are found in Illinois and southern Iowa. Regeneration of floodplain forests is being considered in other locations around the world where negative effects of river control measures are acute (Zinke and Gutzweiler 1990). Waterfowl and wading birds are being used to assess the success of restoration of floodplain habitats on the Kissimme River, Florida (Weller 1995). Predicted responses to restoration are an increase in species diversity and relative abundance.

Active management (tree planting, control of invasive plants, manipulation of water levels) of existing and restored forests may be necessary to maximize habitat values as long as

some of the forces which degraded these ecosystems (locks and dams, high sedimentation rates, channelization) remain. Forest management plans that include tree cutting to encourage forest regeneration should also provide standing snags for cavity-nesters. Cutting should be designed to minimize fragmentation of the remaining forests as little as possible because some species, such as cerulean warblers, likely require large areas of mature trees. Emphasis should be placed on restoring and maintaining wide floodplain forests. On small- to medium-sized rivers these forests should be at least 200 m wide; on larger rivers forests should be at least 600 m to several kilometers in width. Larger forests and corridors will increase species richness and potentially reduce brood parasitism by increasing the distance between breeding and feeding areas for cowbirds and also by diluting the parasitism with increased host abundances. The removal of known cowbird feeding areas within or adjacent to floodplain forests will also likely reduce brood parasitism. Management actions such as establishment and maintenance of riparian buffer strips high in the watershed could capture sediment and agricultural chemicals at their source and prevent movement into larger-order rivers, benefitting both aquatic and terrestrial wetland species (Peterjohn and Correll 1984).

Natural levees have high species diversity and high nesting success, and may serve as a refuge for ground-foraging and ground-nesting species during flood events. The restoration of natural flood pulses will help to create or maintain these levees. Restoring natural flood pulses should also reduce flash floods that can destroy nests and decrease sudden low flows that can expose nests to predators such as raccoon (*Procyon lotor*) and mink (*Mustela vison*). Upland forests adjacent to floodplain forests may serve as a refuge for ground-foraging and/or ground-nesting species, especially during a year of frequent or high flooding.

It may be possible to predict the composition and structure of the future floodplain forests based on current hydrodynamic information, observations of change already occurring, and our knowledge of vegetation tolerances to flooding. Forest composition and structure could be important factors in determining the composition of the future bird community. More research is needed to understand how hydrologic changes will drive successional processes in these forests and how forest change will influence the regional bird community.

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Appendix A

Common and scientific names of plant species used in text.

Common name	Scientific name
Alder	*Alder* spp.
Ash, green	*Fraxinus pennsylvanica*
Baldcypress	*Taxodium distichum*
Birch, river	*Betula nigra*
Blackhaw	*Viburnum prunifolium*
Buttonbush	*Cephalanthus occidentalis*
Cane	*Harundinaria gigantea*
Cottonwood	*Populus deltoides*
Elm, American	*Ulmus americana*
Grass, reed canary	*Phalaris arundinaceae*
Greenbrier (catbrier)	*Smilax* spp.
Hackberry	*Celtis occidentalis*
Hickory	*Carya* spp.
Bitternut	*Carya cordiformis*
Mockernut	*Carya tomentosa*
Pignut	*Carya glabra*
Shagbark	*Carya ovata*
Shellbark	*Carya laciniosa*
Hornbeam, American	*Carpinus caroliniana*
Maple	*Acer* spp.
Red	*Acer rubrum*
Silver	*Acer saccharinum*
Sugar	*Acer saccharum*
Oak	*Quercus* spp.
Black	*Quercus velutina*
Cherrybark	*Quercus falcata pagodifolia*
Northern red	*Quercus rubra*
Pin	*Quercus palustris*
Shumard	*Quercus shumardii*
Swamp chestnut	*Quercus michauxii*
Swamp white	*Quercus bicolor*
White	*Quercus alba*
Pawpaw	*Asimina triloba*
Pecan	*Carya illinoensis*
Poison ivy	*Toxicodendron radicans*
Possumhaw (Swamp holly)	*Ilex decidua*
Spicebush	*Lindera benzoin*
Sugarberry	*Celtis laevigata*
Sweetgum	*Liquidambar styraciflua*
Sycamore	*Platanus occidentalis*
Tuliptree	*Liriodendron tulipifera*
Tupelo, river	*Nyssa aquatica*
Walnut, black	*Juglans nigra*
Willow, black	*Salix nigra*