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The Role of the Wetland Reserve Program in Conservation Efforts in the Mississippi River Alluvial Valley

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Abstract

*The Mississippi River Alluvial Valley includes the floodplain of the Mississippi River from Cairo, Illinois, USA, to the Gulf of Mexico. Originally this region supported about 10 million ha of bottomland hardwood forests, but only about 2.8 million ha remain today. Furthermore, most of the remaining bottomland forest is highly fragmented with altered hydrologic processes. During the 1990s landscape-scale conservation planning efforts were initiated for migratory birds and the threatened Louisiana black bear (*Ursus americanus luteolus*). These plans call for large-scale reforestation and restoration efforts in the region, particularly on private lands. In 1990 the Food, Agriculture, Conservation and Trade Act authorized the Wetlands Reserve Program (WRP). The WRP is a voluntary program administered by the United States Department of Agriculture that provides eligible landowners with financial incentives to restore wetlands and retire marginal farmlands from agricultural production. As of 30 September 2005, over 275,700 ha have been enrolled in the program in the Mississippi River Alluvial Valley, with the greatest concentration in Louisiana, Arkansas, and Mississippi, USA. Hydrologic restoration is common on most sites, with open-water wetlands, such as moist-soil units and sloughs, constituting up to 30% of a given tract. Over 33,200 ha of open-water wetlands have been created, potentially providing over 115,000,000 duck-use days. Twenty-three of 87 forest-bird conservation areas have met or exceed core habitat goals for migratory songbirds and another 24 have met minimum area requirements. The WRP played an integral role in the fulfillment of these goals. Although some landscape goals have been attained, the young age of the program and forest stands, and the lack of monitoring, has limited evaluations of the program's impact on wildlife populations.* (WILDLIFE SOCIETY BULLETIN 34(4):914–920; 2006)

Key words

black bear, conservation, migratory birds, Mississippi Alluvial Valley, restoration, Ursus americanus luteolus, *Wetland Reserve Program, wetlands.*

The Wetland Reserve Program (WRP) is a voluntary program implemented by the Natural Resources Conservation Service (NRCS) in the United States Department of Agriculture. Under program guidelines, eligible landowners are provided financial incentives to restore wetlands and retire marginal farmlands from agricultural production. The WRP was first authorized in the 1990 Food, Agriculture, Conservation and Trade Act (commonly referred to as the 1990 farm bill) and has been renewed in subsequent farm bill legislation. According to the act, the Secretary of Agriculture "... in consultation with the Secretary of the Interior, shall place priority on acquiring easements based on the value of the easement for protecting and enhancing habitat for migratory birds and other wildlife" (United States Congress 1990). Depending on the type of easement secured, the government will pay all (permanent easements) or part of restoration costs and the landowner also will receive an easement payment (United States Natural Resources Conservation Service [USNRCS] 2004).

As of 2003 nearly 600,000 ha have been enrolled in WRP (USNRCS 2003). Most of the enrollments have been in the Mississippi River Alluvial Valley (MAV), which includes the floodplain of the Mississippi River extending from Cairo, Illinois, USA, through parts of 7 states to the Gulf of Mexico (Llewellyn et al. 1996). This region also supports major wildlife habitat-restoration programs and WRP is playing a critical role in the fulfillment of these large-scale conservation efforts (King and Keeland 1999, Schoenholtz et al. 2001). Our objectives in this paper are to discuss and evaluate the role of WRP in addressing large-scale conservation objectives in the MAV, and identify current and future challenges to these conservation efforts. We briefly summarize existing literature and draw on personal experiences and the knowledge of state coordinators of WRP in Louisiana, Mississippi, and Arkansas, USA, as well as several other state and federal NRCS staff involved with WRP.

Background

Understanding the form, behavior, and historical context of landscapes is a critical prerequisite to understanding ecosystems on several temporal and spatial scales (Swanson et al. 1988). The development of the MAV has been influenced by numerous processes including glaciation, climate, relative sea level, tectonism, and subsidence (Saucier 1994). Although the region was not directly glaciated during the Quantenary, it served as a sluiceway for melting glacial waters and glaciation was the single most important event to influence the structure and development of the region

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(Saucier 1994). Glacial influences on the quantity and quality of sediments and the spatial distribution of landforms have significantly affected plant and animal communities in the region, as well as the hydrologic sources and geomorphic setting of forested wetlands (Delcourt and Delcourt 1987, King et al. 2005, Klimas et al. 2005).

At one time the MAV supported innumerable sloughs, swales, oxbows, and other wetland features embedded in nearly 10 million ha of bottomland hardwood forest. This wetland ecosystem represented the largest tract of bottomland hardwood wetlands in North America. Although bottomland hardwoods commonly occur along river systems throughout the MAV and the southeastern United States (Wharton et al. 1982), not all bottomland hardwood wetlands in the MAV received overbank flows prior to flood control activities. Instead, precipitation and groundwater often were the dominant sources of floodwaters depending upon the geomorphic surface of a particular site (Klimas et al. 2005). Those sites that retain connection to river systems during overbank flows are highly productive, and the life cycles of a variety of fish and wildlife species are closely linked to the timing, depth, duration, and frequency of flooding (Lambou 1963, Junk et al. 1989, Heitmeyer 2006).

Historically many bottomland forests within the MAV were cleared, harvested, or used intensively by Native Americans and early settlers (Williams 1989, King et al. 2005), but these perturbations had few long-term impacts on this forest landscape and often were ephemeral changes to forest structure. Indeed, vast areas of bottomland hardwood forest remained within the MAV at the beginning of the twentieth century. Following a major flood in 1927, however, extensive levee development, channelization, and other flood-control measures altered the hydrologic and geomorphic processes that structure the system (Fredrickson 2005, King et al. 2005).

Floodplains are formed by the erosion and deposition of sediment (Leopold et al. 1964) and it is the rates and patterns of deposition that create diverse floodplain wetland communities (Wharton et al. 1982, Shankman 1993). Although humans have not eliminated ongoing geomorphic processes in the MAV, we have greatly altered the rate at which these processes occur (Saucier 1994). Historically, new wetlands were formed from channel migration and river scouring while other wetlands were concurrently filled with sediments. Extensive levee development and channelization has restricted channel migration, thereby reducing, or even eliminating, the rate of wetland formation. Simultaneously, increased wetland sedimentation resulting from altered land use, including channelization and agriculture, has hastened filling of many wetlands in the region (Kleiss 1996, Oswalt and King 2005, Pierce 2005).

Bottomland hardwood forests and other wetlands in the region have been affected by flood control and farm bill legislation (Fredrickson 2005). During the 1950s to 1970s, soybean prices reached all-time highs and the combination of publicly funded flood-control measures and the prevailing farm economies facilitated widespread forest clearing in the region for agriculture. During this period these wetland forests suffered losses exceeding 120,000 ha per year (MacDonald et al. 1979, National Research Council 1982, Wilen and Frayer 1990). By the 1980s only 2.8 million ha of the original 10 million ha remained and much of the remainder was highly fragmented and hydrologically altered (Rudis 1995, Fredrickson 1997). Importantly, this ecosystem was converted from a forested wetland system to one that is now dominated by agriculture with forested wetlands embedded within an agricultural matrix. Therefore, agricultural programs that affect production or conservation, such as farm bill legislation, can have a marked influence on fish and wildlife populations in the region.

Few baseline data exist for wildlife species in the region; however, wetland habitat functions have been severely disrupted (Fredrickson 1997). Most remaining large expanses of bottomland forests are subject to increased frequency and duration of flooding (Twedt and Loesch 1999) that has reduced biodiversity and likely contributed to the extirpation or extinction of some species (e.g., Bachman's Warbler [*Vermivora bachmanii*]; Remsen 1986). Loss of forest habitat has threatened other species, such as Louisiana black bear (*Ursus americanus luteolus*; U.S. Fish and Wildlife Service 1995). Relatively common species within the MAV also have been negatively impacted with population declines noted for of 21 of 31 (68%) species of Neotropical migratory birds with identifiable population trends from 1966–2003 (Sauer et al. 2005). Of these species 12 had significantly declining ($P < 0.1$) populations. Similarly, long-term declines in waterfowl habitat have resulted from flood control, drainage, and agricultural expansion (Reinecke et al. 1988).

Implementation of the North American Waterfowl Management Plan in 1986, and the subsequent development of the Lower Mississippi Valley Joint Venture (LMVJV) partnership, marked the beginning of a larger conservation effort to address wildlife needs at landscape scales and facilitated the development of quantitative restoration goals for breeding silvicolous songbirds, waterfowl, shorebirds, and black bear through separate and distinct conservation efforts (e.g., Partners in Flight, North American Waterfowl Management Plan, Black Bear Conservation Committee). More recently, the North American Bird Conservation Initiative has made a concerted effort to bring all management plans together to address population sustainability of all birds at the landscape scale. Although shorebird and other waterbird conservation plans have affected wetland management activities in the region, it is clear that restoration goals for waterfowl, breeding silvicolous songbirds, and the Louisiana black bear have had the greatest influence on restoration activities in the region.

Waterfowl conservation goals were based upon an energetic model that relates waterfowl daily energetic requirements to metabolizable energy outputs of each foraging habitat (e.g., rice, moist soil, bottomland hardwoods). These energetic demands were coupled with historical waterfowl distributions to establish "duck-use

Table 1. Areas of mature bottomland hardwood forest and recent reforestation on lands under state, federal, and private ownership (Wetlands Reserve Program [WRP]) within the Mississippi River Alluvial Valley (MAV), USA.

	Mature forest ownership (ha)[a]			Reforestation ownership (ha)		
State	**State**	**Federal[b]**	**Private**	**Federal[a,b]**	**Private[c]**	**Total**
Ark.	57,538	78,317	475,673	8,115	77,140	696,783
Ill.	0	222	4,836	35	NA	5,093
Ky.	4,050	428	13,331	13	5,312	23,134
La.[d]	134,856	44,643	942,703	12,550	87,854	1,223,941
Miss.	15,987	49,282	374,179	10,998	62,088	512,534
Mo.	6,683	5,429	34,218	0	35,712	82,042
Tenn.	13,343	9,904	25,991	927	7,673	57,838
Total	**232,457**	**188,225**	**1,870,931**	**32,638**	**275,779**	**2,601,365**

[a] Mature forest ownership and federal reforestation prior to 2001 was delineated from 2001 aerial photography. Federal reforestation subsequent to 2001 is based on data entered by United States Fish and Wildlife Service (USFWS) refuge staff into a Lower Mississippi Valley Joint Venture (LMVJV) database through Jan 2006. Data for mature forest ownership and federal reforestation provided by B. Elliott, United States Fish and Wildlife Service, LMVJV based on the LMVJV's interpretation of the MAV Bird Conservation Region.

[b] Federal ownership includes National Wildlife Refuges and National Forests.

[c] Private reforestation is the total hectares of land enrolled in the United States Department of Agriculture's WRP in the MAV through fiscal year 2005. Private reforestation data are from D. Difiore, United States Natural Resource Conservation Service, Washington, D.C., USA. Private reforestation estimate 'NA' indicates that accurate area figures for MAV region were unavailable.

[d] Louisiana totals and overall total include 1,335 ha of reforestation on state-owned lands. No other state had reported reforestation totals to the LMVJV as of Jan 2006.

day" habitat goals for each state within the MAV (Reinecke and Loesch 1996). These objectives were then allocated among 4 primary sources of habitat: 1) natural flooded areas, 2) public managed lands, 3) private lands managed inside a conservation program [e.g., WRP], and 4) private lands managed outside a conservation program (LMVJV Office, unpublished data). In Arkansas, Louisiana, and Mississippi, the foraging habitat objectives for private lands within a managed program, such as WRP, exceed 136,000,000 duck-use days. That is, foraging habitat (e.g., water management units) within private conservation programs are expected to provide sufficient energy resources (e.g., moist-soil plants) to support the daily energetic requirements of >136,000 ducks for 100 days (>136,000,000 use days for ducks) within these 3 states.

Habitat restoration goals for silvicolous birds were developed based on the goal of supporting source populations for all species of conservation concern in the region, including Swainson's warbler (*Limnothlypis swainsonii*), prothonotary warbler (*Protonotaria citrea*), cerulean warbler (*Dendroica cerulea*), and swallow-tailed kite (*Elanoides forficatus*; Twedt et al. 1999). A habitat goal was established to maintain or reforest >1.5 million ha of predominately mature, forested wetlands within 87 Bird Conservation Areas. They recommended that this forest area be distributed among 101 patches of contiguous forest as 13 patches >40,000 ha, 36 patches >8,000 ha, and 52 patches >4,000 ha. Habitat objectives established for silvicolous birds overlapped broadly with habitat objectives that targeted linkages among disjunct populations of black bear in the region.

Extensive tracts of bottomland hardwood forest occur on public lands in the region (Table 1). To achieve the broad-scale conservation goals identified in its conservation plans, however, extensive forested wetland restoration is needed. Although state wildlife management areas and federal national wildlife refuges are critical components of the restoration program in the MAV, about 83% of forest land is privately owned (Table 1) and private landowner participation is necessary to achieve identified conservation goals (Mueller et al. 2000).

The Wetland Reserve Program Niche

The advent of the WRP was timely and enrollments contributed immediately to conservation goals. Even so, WRP has continued to increase its effectiveness as our understanding of large-scale restoration has improved. As of fiscal year 2005, more than 275,700 ha have been enrolled in WRP in the MAV. The largest amount of restoration has occurred in Louisiana (87,854 ha), Arkansas (77,140 ha), and Mississippi (62,088 ha; Fig. 1; D. Difiore, NRCS,

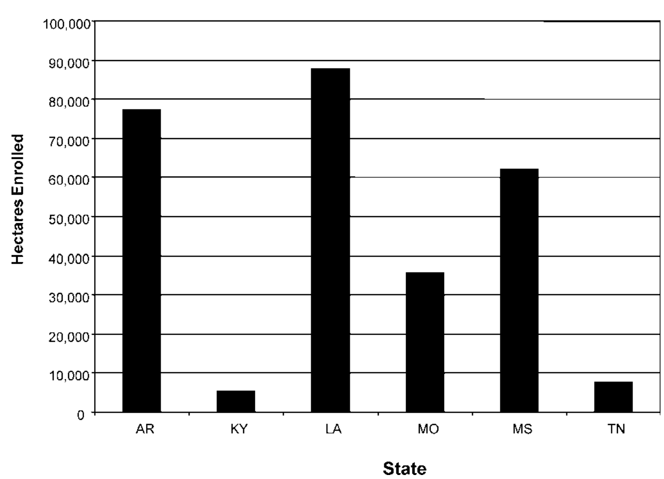

Figure 1. Total hectares of land enrolled in the United States Department of Agriculture's Wetland Reserve Program in the Mississippi River Alluvial Valley through fiscal year 2005. Data are from D. Difiore, United States Natural Resources Conservation Service, Washington, D.C., USA.

personal communication). A total of 89% of the easements are permanent; the remainder are 30-year easements. The program is immensely popular among landowners, as evidenced by several hundred landowners on waiting lists in Arkansas, Louisiana, and Mississippi.

Initial WRP efforts focused on restoring hard-mast tree species, with little regard for tree species diversity, placement in the landscape, or hydrologic restoration. King and Keeland (1999) reported that through 1997, oaks (*Quercus* spp.) represented 78% of planting stock on reforestation efforts in the MAV, including WRP. Researchers have encouraged practitioners to use fast-growing species to increase the rate of structural development within restored stands (Twedt and Best 2004). Rapid, vertical growth of pioneer tree species can result in colonization by forest-breeding songbird species in only a few years (Twedt et al. 2002). Hydrologic and edaphic conditions often limit the number and type of tree species that are suitable for a given site. Even so, the diversity of plantings has increased on recent restorations with as many as a dozen species planted on some sites.

To be successful (i.e., contribute to population sustainability), we believe restoration programs should strategically focus restoration activities (Scott et al. 2001). In the MAV initial restoration activities associated with WRP were haphazardly distributed across the landscape. Twedt and Uihlein (2005) introduced a spatially explicit prioritization model for reforestation that was subsequently refined (Twedt et al. 2006). This model used landscape metrics to target creation or additions to core forest habitat within increasingly forested landscapes and clearly showed the benefits of targeted restoration compared to random distribution of restoration efforts. Their efforts indicated that reforestation of the top 10% of lands based on their priority ranking system would increase the amount of core forest habitat by over 35 times relative to random distribution of restoration efforts.

Criteria used for ranking lands for potential WRP enrollment are not uniform across states. Currently, lands are weighted on a variety of characteristics related to wildlife habitat and wetland potential. In all states the potential for hydrologic restoration and uniqueness of existing wetland features comprise a maximum of 33–76% of the ranking score. Up to about one-third of the score in each state is based on restoration costs. In Louisiana the diversity of the site and water-quality considerations each comprise up to 6% of the total score, whereas the presence of threatened and endangered (T&E) species and potential use by waterfowl and shorebirds each represent up to 4%. Although only 1% of the total score is based upon its proximity to public lands, the T&E species component also captures proximity to conservation lands since it is based largely on proximity to critical habitat for the Louisiana black bear, which often is associated with public lands. In Arkansas up to 19% of the score is related to distance from public conservation lands, the property's location relative to bird conservation areas, and whether it adjoins contiguous forest.

Special project areas also have resulted in increased priority-ranking scores. For example, the recent rediscovery of the ivory-billed woodpecker (*Campephilus principalis*) in Arkansas resulted in a WRP appropriation of $1 million strictly for lands within a 12,146-ha zone around the rediscovery site. Similarly, in Louisiana the threatened status of the Louisiana black bear not only affects state-wide rankings, but it has also resulted in the establishment of a black bear project area to reconnect fragmented blocks of bottomland hardwood forest and facilitate dispersal among disjunct bear populations (R. Marcantel, NRCS, personal communication).

Early WRP efforts did not attempt to restore hydrologic functions (King and Keeland 1999). In this region socioeconomic constraints related to flood control and agricultural production prevent the reconnection of the river to the floodplain and constrain some on-site practices because of the potential to flood adjacent properties. Nevertheless, since 1997 WRP has integrated hydrologic restoration, or hydrologic management capabilities, into most WRP tracts. Implementing this practice increased costs from about $358–395/ha for tree planting only to about $741–1,158/ha for hydrologic restoration and tree planting. Nearly 100% of sites constructed since 1997 have some form of hydrologic restoration or management features, and many older sites have been revisited to add these features. On average, up to 30% of a given tract may consist of open-water wetlands such as moist-soil impoundments or wetlands created and restored through macro- and microtopographic restoration.

Initially, hydrologic restoration consisted almost exclusively of moist-soil impoundments, generally consisting of levees with water-control structures that allow managers to manipulate water levels to produce desired vegetation communities for target wildlife (Fredrickson and Taylor 1982, Nassar et al. 1993). Although moist-soil management is a critical component of waterfowl goals within the region and also benefits a wide variety of wetland-dependent wildlife, it can be costly, time-consuming, and it does not meet the needs of all wildlife species (Fredrickson 1997).

Macro- and microtopography restoration are the restoration of oxbows and temporary and seasonal wetlands, respectively. In Arkansas, which has the most diverse array of hydrogeomorphic conditions in the region (Saucier 1994), geomorphic maps, soil maps, and historical aerial photographs are used to identify former sloughs, swales, and other wetlands on the restoration tract. These wetland features are then either restored or created by using heavy equipment to sculpt depressions or to build levees that divert water into low-lying basins; these sites may or may not have water-control structures. This approach has been criticized by some as being too costly and of lower value to waterfowl than moist-soil impoundments because of the relative lack of control in producing annual plants. While initial costs may or may not be more expensive (i.e., site characteristics are important as to which is more expensive), over the long-term, costs actually will be lower than moist soil because of the passive nature of management. In fact, in Louisiana most landowners do not want moist-soil impoundments because of the labor-intensive and expensive maintenance costs (M. Nichols, NRCS, personal communication), which are amplified by Louisiana's long growing season. Instead, micro- and macrotopography, with and without water-control structures, are developed on sites to allow for both active and passive management on the vast majority of all the easements. In Arkansas most WRP tracts contain both moist-soil and micro- and macrotopography features (N. Childers, NRCS, personal communication). Although micro- and macrotopography sites may support fewer waterfowl per unit area, as they mature, these sites will provide habitats for many species of amphibians, secretive marsh birds, and other fish and wildlife species whose life-history requirements are not met by the early succession habitat conditions obtained through current management practices of moist-soil units.

Measures of Success

An evaluation of restoration success should be a key component in restoration projects to ensure that goals are being met in the most cost-effective manner (Wilson et al. 2005). Restoring vegetative cover usually will provide favorable conditions for native biota, but this assumption rarely is tested (Block et al. 2001). Since the goal of WRP is to protect and enhance habitat for wildlife, much of the focus has been on habitat restoration.

Lands enrolled in WRP have contributed to progress toward achieving landscape-scale habitat objectives: 50 of 87 forest-bird conservation areas have met or exceed core habitat objectives for either small (2,100 ha), medium (5,200 ha), or large (34,000 ha) patches. Twenty-three of these 50 areas have achieved their respective core goals, whereas 27 areas have met a minimum area requirement but still have "room to grow" toward their core area objective (B. Elliott, U.S. Fish and Wildlife Service, personal communication). Similarly, some waterfowl management goals have been achieved. Over 33,200 ha of open-water wetlands (e.g., moist-soil units, sloughs) have been restored (C. Manlove, Ducks Unlimited, personal communication), potentially providing 115,038,000 duck-use days (3,465 duck-use days per moist-soil ha).

At the local scale, less information is available. Individual projects are evaluated based upon the number of seedlings surviving 5 years postplanting; if tree density exceeds 309 stems per ha at that time, the restoration is deemed successful. Obviously, seedling survival does not equate to functional success of restoration; however, it may take 50–60 years or more before these sites develop attributes characteristic of mature forest stands. Most stands currently are <10 years old and habitat characteristics needed by many silvicolous species have not yet developed. As stands mature, snag and cavity development, increased inputs of woody debris and leaf litter, increased vertical and horizontal structure, and increased diversity of shrubs and understory plants are expected.

Similarly, most recently created micro- and macrotopographic wetlands lack the density and diversity of emergent and submergent plants that are expected to develop through time. Inadequate management of some moist-soil units also reduces their benefits to wintering waterfowl and other wetland-dependent wildlife. It currently is unknown how many duck-use days are actually being provided on WRP lands because some of these sites are not optimally managed. Although the effectiveness of WRP could be improved through better local management, WRP has substantially contributed toward meeting LMVJV wintering habitat acreage goals for waterfowl.

Restoring habitat for "migratory birds and other wildlife" is the ultimate goal of WRP; however, the young age of the program and forest stands, as well as the lack of monitoring, has limited the evaluation of program success from this perspective. Some research into wildlife and fish benefits of these stands has been conducted, although not all sites were WRP. Anecdotal observations indicate that waterfowl heavily utilize at least some tracts of WRP, but their use and the factors affecting use have not been quantified. Twedt et al. (2002) found that sites planted with eastern cottonwood (*Populus deltoides*), a fast-growing species, had more developed forest structure and supported a greater species richness of breeding birds and greater territory densities than on sites with slow-growing oak species. While avian species characteristic of scrub-shrub habitats and early succession forests were more common in the cottonwood sites, grassland birds were common in sites <10 years old that were planted with oaks. Similarly, Hamel (2003) also found twice as many species of birds during the winter in cottonwood stands than in stands of slower-growing trees.

Leao (2005) found that WRP sites also can provide important habitat for fish, provided the wetlands are connected to a river system during overbank flows. In as little as one year after restoration, wetlands supported levels of species diversity and richness that were comparable to that of reference wetlands. Restored wetlands, however, tended to support more generalist species, whereas the older reference wetlands supported more specialist species. In Arkansas only about 25% of WRP tracts are flooded by overbank or backwater flooding, whereas in Louisiana at least part of about 75% of tracts are flooded annually.

Data are lacking for most other groups of wildlife. Some telemetry data indicate that Louisiana black bears use WRP but the extent of use is still undetermined and will likely change as the stands mature (D. Telesco, Louisiana Black Bear Conservation Society, personal communication). Similarly, 2 unpublished studies indicate that WRP wetlands are rapidly colonized by anurans, but additional time is needed to identify habitat characteristics important to these species and to determine if reproduction is successful.

Future Challenges and Opportunities

The WRP is a relatively young program but it has had a tremendous impact on broad-scale conservation efforts in the MAV. Past challenges included simply developing techniques to plant trees. In the future the management of existing stands and wetlands to maximize benefits to migratory birds and other wildlife will be the primary challenge. Currently, forest management (i.e., harvest) is allowed on WRP tracts provided it is compatible with "protecting and enhancing habitat for migratory birds and other wildlife." However, because of the young age of the stands, only one request for harvesting has been made in Louisiana, Arkansas, and Mississippi. As WRP tracts mature, interest in timber harvest will undoubtedly intensify and questions regarding suitable forest management must be answered. If the goal is to achieve a specific stand composition and structure, how do we manage existing stands to achieve this goal? Can we achieve this goal through manipulation of the initial restored stand or should we be looking 2–3 stands into the future? What techniques and harvest intensities should be allowed on publicly protected lands? From a wetlands perspective, will maintenance costs of levees and water-control structures be maintained in future budgets? How can we improve wetland management on privately owned lands so that managed wetlands can better fulfill habitat objectives for the region? Finally, will ecological monitoring programs be implemented to allow for an in-depth evaluation of the benefits of various restoration and management strategies, and thereby provide input to improve existing restoration techniques and maximize wildlife benefits?

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Literature Cited

Block, W. A., A. B. Franklin, J. P. Ward, J. L. Ganey, and G. C. White. 2001. Design and implementation of monitoring studies to evaluate the success of ecological restoration on wildlife. Restoration Ecology 9:293–303.

Delcourt, P. A., and H. R. Delcourt. 1987. Long-term forest dynamics of the temperate zone: a case study of late-Quaternary forests in eastern North America. Springer-Verlag, New York, New York, USA.

Fredrickson, L. H. 1997. Managing forested wetlands. Pages 147–177 *in* M. S. Boyce and A. Haney, editors. Ecosystem management. Yale University, New Haven, Connecticut, USA.

Fredrickson, L. H. 2005. Contemporary bottomland hardwood systems: structure, function, and hydrologic condition resulting from two centuries of anthropogenic activities. Pages 19–35 *in* L. H. Fredrickson, S. L. King, and R. M. Kaminski, editors. Ecology and management of bottomland hardwood systems: the state of our understanding. University of Missouri-Columbia, Gaylord Memorial Laboratory Special Publication No. 10, Puxico, USA.

Fredrickson, L. H., and T. S. Taylor. 1982. Management of seasonally flooded impoundments for wildlife. U.S. Fish and Wildlife Service Resource Publication 148, Washington, D.C., USA.

Hamel, P. B. 2003. Winter bird community differences among methods of bottomland hardwood forest restoration: results after seven growing seasons. Forestry 76:189–197.

Heitmeyer, M. E. 2006. The importance of winter floods to mallards in the Mississippi Alluvial Valley. Journal of Wildlife Management 70: 101–110.

Junk, W. J., P. B. Bayley, and R. E. Sparks. 1989. The flood pulse concept in river-floodplain systems. Canadian Special Publication of Fisheries and Aquatic Science 106:110–127.

King, S. L., and B. D. Keeland. 1999. A survey and evaluation of reforestation of the lower Mississippi River alluvial valley. Restoration Ecology 7:348–359.

King, S. L, J. P. Shepard, K. Ouchley, J. A. Neal, and K. Ouchley. 2005. Bottomland hardwood forests: past, present, and future. Pages 1–17 *in* L. H. Fredrickson, S. L. King, and R. M. Kaminski, editors. Ecology and management of bottomland hardwood systems: the state of our understanding. University of Missouri-Columbia, Gaylord Memorial Laboratory Special Publication No. 10, Puxico, USA.

Kleiss, B. A. 1996. Sediment retention in a bottomland hardwood wetland in eastern Arkansas. Wetlands 16:321–333.

Klimas, C. V., R. D. Smith, R. T. Saucier, and J. Raasch. 2005. Hydrogeomorphic classification of forested wetlands in the Lower Mississippi Valley: implications for restoration and management. Pages 77–91 *in* L. H. Fredrickson, S. L. King, and R. M. Kaminski, editors. Ecology and management of bottomland hardwood systems: the state of our understanding. University of Missouri-Columbia, Gaylord Memorial Laboratory Special Publication No. 10, Puxico, USA.

Lambou, V. W. 1963. The commercial and sports fisheries of the Atchafalaya Basin floodway. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 17:256–281.

Leao, M. 2005. Fish utilization and diversity associated with created wetlands within the Lower White River Watershed, Arkansas. Thesis, University of Arkansas at Pine Bluff, USA.

Leopold, L. B., M. G. Wolman, and J. P. Miller. 1964. Fluvial processes in geomorphology. W. H. Freeman, San Francisco, California, USA.

Llewellyn, D. W., G. P. Shaffer, N. J. Craig, L. Creasman, D. Pashley, M. Swan, and C. Brown. 1996. A decision-support system for prioritizing restoration sites on the Mississippi River Alluvial Plain. Conservation Biology 10:1446–1455.

MacDonald, P. O., W. E. Frayer, and J. K. Clauser. 1979. Documentation, chronology, and future projections of bottomland hardwood habitat losses in the lower Mississippi Alluvial Plain. Volume 1. U. S. Fish and Wildlife Service, Washington, D.C., USA.

Mueller, A. J., C. R. Loesch, and D. J. Twedt. 2000. Development of management objectives for breeding birds in the Mississippi Alluvial Valley. Pages 12–17 *in* R. Bonney, D. N. Pashley, R. J. Cooper, and L. Niles, editors. Strategies for bird conservation: the Partners in Flight Planning Process. Proceedings of the 3rd Partners in Flight workshop, 1–5 October 1995, Cape May, New Jersey, USA. U.S. Department of Agriculture Forest Service Proceedings RMRS-P-16, Rocky Mountain Research Station, Ogden, Utah, USA.

Nassar, J. R., W. E. Cohen, and C. R. Hopkins. 1993. Waterfowl habitat management handbook for the Lower Mississippi River Valley. Mississippi State University Extension Service, Starkville, USA.

National Research Council. 1982. Impacts of emerging agricultural trends on fish and wildlife habitat. National Academy, Washington, D.C., USA.

Oswalt, S., and S. L. King. 2005. Channelization and floodplain forests: impacts of accelerated sedimentation and valley plug formation on floodplain forests of the Middle Fork Forked Deer River, Tennessee, USA. Forest Ecology and Management 215:69–83.

Pierce, A. R. 2005. Sedimentation, hydrology, and bottomland hardwood forest succession in altered and unaltered tributaries of the Hatchie River, Tennessee. Dissertation, University of Tennessee, Knoxville, USA.

Reinecke, K. J., R. C. Barkley, and C. K. Baxter. 1988. Potential effects of changing water conditions on mallards wintering in the Mississippi Alluvial Valley. Pages 325–335 *in* M. W. Weller, editor. Waterfowl in winter. University of Minnesota, Minneapolis, USA.

Reinecke, K. J., and C. R. Loesch. 1996. Integrating research and managment to conserve wildfowl (Anatidae) and wetlands in the Mississippi Alluvial Valley, U.S.A. Gibier Faune Sauvage, Game and Wildlife 13:927–940.

Remsen, J. V., Jr. 1986. Was Bachman's warbler a bamboo specialist? Auk 103:216–219.

Rudis, V. A. 1995. Regional forest fragmentation effects on bottomland hardwood community types and resource values. Landscape Ecology 10:291–307.

Saucier, R. T. 1994. Geomorphology and quaternary geologic history of the Lower Mississippi Valley. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi, USA.

Sauer, J. R., J. E. Hines, and J. Fallon. 2005. The North American Breeding Bird Survey, results and analysis 1966–2004. Version 2005.2. U.S. Geographical Service Patuxent Wildlife Research Center, Laurel, Maryland, USA. <http://www.mbr-pwrc.usgs.gov/bbs/bbs2004.html>. Accessed 2006 May 18.

Schoenholtz, S. H., J. P. James, R. M. Kaminski, B. D. Leopold, and A. W. Ezell. 2001. Afforestation of bottomland hardwoods in the lower Mississippi Alluvial Valley: status and trends. Wetlands 21:602–613.

Scott, T. A., W. Wehtje, and M. Wehtje. 2001. The need for strategic planning in passive restoration of wildlife populations. Restoration Ecology 9:262–271.

Shankman, D. 1993. Channel migration and vegetation patterns in the Southeastern Coastal Plain. Conservation Biology 7:176–183.

Swanson, F. J., T. K. Kratz, N. Caine, and R. G. Woodmansee. 1988. Landform effects on ecosystem patterns and processes. Bioscience 38:92–98.

Twedt, D. J., and C. Best. 2004. Restoration of floodplain forests for the conservation of migratory landbirds. Ecological Restoration 22:194–203.

Twedt, D. J., and C. R. Loesch. 1999. Forest area and distribution in the Mississippi Alluvial Valley: implications for breeding bird conservation. Journal of Biogeography 26:1215–1224.

Twedt, D. J., D. Pashley, W. C. Hunter, A. J. Mueller, C. Brown, and R. P. Ford. 1999. Partners in Flight Bird conservation plan for the Mississippi Alluvial Valley (physiographic area # 05). <http://www.blm.gov/wildlife/plan/MAV_plan.html>. Accessed 2006 Jan 30.

Twedt, D. J., and W. B. Uihlein III. 2005. Landscape level reforestation priorities for forest breeding landbirds in the Mississippi Alluvial Valley. Pages 321–340 *in* L. H. Fredrickson, S. L. King, and R. M. Kaminski, editors. Ecology and management of bottomland hardwood systems: the state of our understanding. University of Missouri-Columbia, Gaylord Memorial Laboratory Special Publication No. 10, Puxico, USA.

Twedt, D. J., W. B. Uihlein III, and A. B. Elliott. 2006. A spatially explicit decision support model for restoration of forest bird habitat. Conservation Biology 20:100–110.

Twedt, D. J., R. R. Wilson, J. L. Henne-Kerr, and D. A. Grosshuesch. 2002. Avian response to bottomland hardwood reforestation: the first 10 years. Restoration Ecology 10:645–655.

United States Congress. 1990. Food, Conservation, Agriculture, and Trade Act of 1990. S.2830. 101st Congress, Washington, D.C., USA. <http://icreport.loc.gov/cgi-bin/query/F?c101:1:./temp/~c101Fxg7c7:e722148:>. Accessed 2006 May 18.

United States Fish and Wildlife Service. 1995. Louisiana black bear recovery plan. U.S. Fish and Wildlife Service, Jackson, Mississippi, USA.

United States Natural Resources Conservation Service. 2003. WRP acres by state through FY2003. <http://www.nrcs.usda.gov/programs/wrp/2003_contractinfo/m7682.jpg>. Accessed 2006 Jan 30.

United States Natural Resources Conservation Service. 2004. Farm bill 2002: Wetland Reserve Program. <http://www.nrcs.usda.gov/programs/farmbill/2002/pdf/WRPFct.pdf>. Accessed 2006 Jan 30.

Wharton, C. H., W. M. Kitchen, E. C. Pendleton, and T. W. Sipe. 1982. The ecology of bottomland hardwood swamps of the Southeast: a community profile. U.S. Fish and Wildlife Service Biological Services Program FWS/OBS-81/37, Washington, D.C., USA.

Wilen, B. O., and W. E. Frayer. 1990. Status and trends of wetlands and deepwater habitats. Forest Ecology and Management 33/34:181–192.

Williams, M. 1989. Americans and their forests: a historical geography. Cambridge University, Cambridge, United Kingdom.

Wilson, R. R., J. M. Oliver, D. J. Twedt, and W. B. Uihlein III. 2005. Bottomland hardwood restoration in the Mississippi Alluvial Valley: looking past the trees to see the forest. Pages 519–532 *in* L. H. Fredrickson, S. L. King, and R. M. Kaminski, editors. Ecology and management of bottomland hardwood systems: the state of our understanding. University of Missouri-Columbia, Gaylord Memorial Laboratory Special Publication No. 10, Puxico, USA.

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