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FINAL REPORT

REGIONAL ESTIMATES OF ECOLOGICAL SERVICES DERIVED FROM U.S. DEPARTMENT OF AGRICULTURE CONSERVATION PROGRAMS IN THE MISSISSIPPI ALLUVIAL VALLEY

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Table of Contents

List of Figures

List of Tables

Executive Summary

The Mississippi Alluvial Valley (MAV) is the Nation’s largest floodplain and this once predominantly forested ecosystem provided significant habitat for a diverse flora and fauna, sequestered carbon in trees and soil, and stored floodwater, sediments, and nutrients within the floodplain. This landscape has been substantially altered by the conversion of nearly 75% of the riparian forests, predominantly to agricultural cropland, with significant loss and degradation of important ecosystem services. Large-scale efforts have been employed to restore the forest and wetland resources and the U.S. Department of Agriculture (USDA) Wetlands Reserve Program (WRP) and Conservation Reserve Program (CRP) represent some of the most extensive restoration programs in the MAV. The objective of the WRP is to restore and protect the functions and values of wetlands in agricultural landscapes with an emphasis on habitat for migratory birds and wetland-dependent wildlife, protection and improvement of water quality, flood attenuation, ground water recharge, protection of native flora and fauna, and educational and scientific scholarship.

The degree to which these conservation practices can restore ecosystem functions and services is not well known. This project was initiated to quantify existing ecological services derived from USDA conservation practices in the MAV as part of the USDA Conservation Effects Assessment Project, Wetlands Component (CEAP-Wetlands). The U. S. Geological Survey (USGS), in collaboration with the USDA Natural Resources Conservation Service, the USDA Farm Service Agency, the U. S. Fish and Wildlife Service, and Ducks Unlimited, collected data on soils, vegetation, nitrogen cycling, migratory birds, and amphibians from 88 different sites between 2006 and 2008. Results from restored WRP sites were compared to baseline data from active agricultural cropland (AG) to evaluate changes in ecosystem services.

Biogeochemically Related Services: Carbon sequestration, Nutrient Retention, and Sediment Reduction

There were no significant differences between the AG and WRP sites in total carbon or denitrification potential likely due to the young age of the WRP sites. In nearly all forest ecosystems, most of the carbon is stored in tree biomass and the trees planted on the WRP sites are all less than 15 years old. Reduction in soil erosion was the most immediately measurable impact of converting AG to WRP and is a consequence of the effects of land cover on erosion processes. The reduction varied by soil textural class and ranged from 5.10 metric tons/ha/yr for silty clay soils to 9.35 metric tons/ha/yr for silt loam soils. Current similarities between AG and WRP sites will likely diverge over time and if the WRP sites continue on a trajectory towards fully functional BLH sites, then these conservation practices will significantly improve water quality and carbon storage on the landscape.

Biological Conservation, Sustainability, and Habitat Quality

Restoration practices included planting a narrow range of tree species on WRP resulting in greater species diversity in older, naturally regenerated forests (BLH) and a dominance of oak (*Quercus*) species on WRP sites. In WRPs, dominant species were Nuttall oak (*Q. texana*), green ash (*Fraxinus pennsylvanica*), water oak (*Q. nigra*), and willow oak (*Q. phellos*). In contrast, dominant trees in BLH were sweetgum (*Liquidambar styraciflua*), hackberry (*Celtis laevigata*), American elm (*Ulmus americana*), green ash, cedar elm (*U. crassifolia*), water hickory (*Carya aquatica*), and willow oak. The high density of oaks and the near absence of other important species suggest that the mature forests resulting from these planting practices will have a different species composition compared with the existing naturally regenerated forests.

There were improvements in wildlife habitat resulting from conservation practices on the WRP sites with significantly more migratory bird species, but not resident species, compared with

AG sites. Overall, 109 bird species were detected during the 2006 autumn migration season in AR and LA and 82 species were detected during the 2008 autumn migration season in MS. Results of the repeated measures analysis indicate that mean observed species richness varied over time by state and habitat type. Throughout the study period, BLH sites had greater mean species richness than WRP sites and AG fields. The differences between WRP sites and AG fields changed over the migration season. In LA, the mean species richness of AG sites was significantly greater than WRP sites during early migration; however, as the season progressed, the species richness of WRP sites increased and was significantly greater than AG sites during mid to late migration. The pattern was similar in the AR where the mean species richness of WRP sites was significantly greater than AG sites in early October. Increasing the diversity of species planted, while remaining cognizant of species-site requirements, will likely improve the habitat for both resident and migratory birds.

The MAV High Frequency Flood Model indicated that 69.7% to 77.7% of sampled easements in LA, AR, and MS were within the 0-24 month flood frequency class. The restoration of hydrologic conditions more typical of riparian forested wetlands resulted in higher probability of occurrences of frog species that require permanent water sources (e.g., American Bullfrog, Southern Leopard Frog) and more waterfowl habitat. More rigorous implementation and intensive management of water control structures could potentially increase an important measure of waterfowl habitat, duck energy days, by up to 60%.

Chapter I. Introduction

The ecosystems that dominated the Mississippi Alluvial Valley (MAV) prior to European colonization were floodplain forests and wetlands intimately connected to the Mississippi River and its tributaries. In their natural state, they were sinks for sediments and nutrients, provided temporary storage of floodwaters, stored significant amounts of carbon in tree biomass and soils, and provided extensive habitat for flora and fauna. Much of the MAV has been converted to other land uses, primarily agriculture, resulting in the loss of more than 75% of the riparian forests (Macdonald et al. 1979) with highly fragmented patches remaining (Twedt and Loesch 1999).

This land-use conversion and the resulting loss and degradation of ecosystem functions and services in the MAV are nearly unprecedented in both scale and scope. Ecosystem services are the benefits that people and societies derive from the natural processes that sustain ecosystems (Daily 1997). The recent Millennium Ecosystem Assessment (2003) identified four categories of ecosystem services: supporting (soil formation, nutrient cycling, and biodiversity), regulating (climate change, water quality, and flood storage), cultural (recreation, education), and provisioning (food, fiber, water). The conversion to agriculture has resulted in these areas becoming net sources of greenhouse gases and nutrients as opposed to net sinks under natural forests. Drainage and cultivation of the converted lands, expanded use of nitrogen (N) fertilizers (Galloway et al. 2003), and the loss of wetlands in the Mississippi River Basin (Mitsch et al. 2001; Lowrance et al. 1984), has resulted in increased NO_3 concentration in the Mississippi River (Donner 2004). Approximately 74% of the NO_3 load of the Mississippi River is currently contributed by agricultural run-off, and the increase in dissolved and particulate NO_3 levels is one of the major causes of extensive eutrophication and hypoxia in the northern Gulf of Mexico (Rabalais et al. 2002; Howarth et al. 2002).

The extensive alteration of the MAV requires landscape-scale rehabilitation and restoration in order to restore or replace the lost and degraded ecosystem services. Large-scale efforts are under way to restore former riparian habitats on both public (Federal wildlife refuges, State lands) and private lands. More than 26,000 ha of National Wildlife Refuges in the MAV have been reforested with many projects related to carbon storage. An additional 9.7 million ha of created wetlands and restored riparian forests in the entire Mississippi River Basin have been recommended in order to reduce NO_3 levels in rivers and streams and reduce the extent of the hypoxic zone in the Gulf of Mexico (Mitsch et al. 2001).

The USDA Wetlands Reserve Program (WRP) and Conservation Reserve Program (CRP) represent some of the most extensive restoration programs in the MAV. Reauthorization of the Wetlands Reserve Program in the 2002 Farm Security and Rural Investment Act (Farm Bill) increased acreage enrollment to 921,000 ha and funding by $1.52 billon (Zinn 2009). Nearly 235,000 ha of the total 808,000 ha of WRP lands enrolled by 2008 are located in Louisiana, Mississippi, and Arkansas (NRCS 2010). The objective of the WRP is to restore and protect the functions and values of wetlands in agricultural landscapes with an emphasis on habitat for migratory birds and wetland dependent wildlife, protection and improvement of water quality, flood attenuation, ground water recharge, protection of native flora and fauna, and educational and scientific scholarship. The CRP has similar goals and objectives including improving the quality of water, controlling soil erosion, and enhancing wildlife habitat.

The effectiveness of these conservation programs in achieving their goals and objectives, and thereby restoring ecosystem services, is not known for wetlands in the MAV. The USDA Conservation Effects Assessment Project, Wetlands Component (CEAP-Wetlands) was initiated in 2004 to quantify ecosystem services and document effects of conservation practices and programs on ecosystem services provided by wetlands in agricultural landscapes. The MAV was selected as one of eleven geographic areas to conduct a CEAP-Wetlands regional study, which resulted in a collaboration among the USDA Natural Resources Conservation Service, the USDA Farm Service Agency, the U. S. Geological Survey National Wetlands Research Center, the U. S. Fish and Wildlife Service, and Ducks Unlimited. The overall goal of this project was to quantify existing ecological services derived from USDA conservation practices in the MAV and develop indicators of wetland functions that can be used to quantify ecological services in the future.

This project occurred in two phases. The first was carried out in 2006-07 in the lower White/Cache River Basin (LWC), Arkansas and the Tensas River Basin (TRB), Louisiana. Using spatially explicit GIS data documenting the location of WRP and CRP easements supplied by Natural Resources Conservation Service (NRCS) and Farm Service Agency (FSA), sixteen study sites were randomly selected in each of three land use types: agricultural crop land (AG), former crop land afforested under the NRCS Wetlands Reserve Program (WRP), and natural bottomland hardwood forest (BLH). The BLH sites were selected from sites where existing records and on-site evaluations indicated that the overstory vegetation was at least 70 years old and naturally regenerated. Half of the study sites were located in the LWC (n=24) (Fig. I.1) and the other half in the TRB (n=24) (Fig. I.2). Each study site was > 40 ha in size and the plots within each study site were > 100 m from the habitat edge and > 400 m from a paved road. In order to analyze the effects of landscape attributes on restored ecosystem services, WRP plots were selected to maintain at least four kilometers between plots to avoid confounding landscape attributes. AG sites were in crop production during the study period with species including soybean, corn, milo, and cotton. The WRP sites were all planted between 1995 and 2004 primarily with combinations of oak species: Nuttall (*Quercus texana*), willow (*Q. phellos*), water (*Q. nigra*), overcup (*Q. lyrata*), pin (*Q. palustris*), Shumard (*Q.*

shumardii), cherrybark (*Q. pagoda*), and swamp chestnut (*Q. michauxii* (Table I.1). Other species planted included green ash (*Fraxinus pennsylvanica*), bald cypress (*Taxodium distichum*), sweet pecan (*Carya illinoinensis*), persimmon (*Diospyros virginiana*), sweetgum (*Liquidambar styraciflua*), hackberry (*Celtis laevigata*), and black gum (*Nyssa sylvatica*). All WRP sites had undergone some form of hydrologic restoration. In the TRB, Louisiana, all but two of the BLH sites occurred on public land in the Tensas River National Wildlife Refuge (NWR), Buckhorn Wildlife Management Area (WMA), and Big Lake WMA. In the LWC, Arkansas, all of the BLH sites were on public land (Cache River NWR and White River NWR).

The second phase of this study occurred in 2008 in the Yazoo River Basin (YRB), Mississippi (Fig. I.3). Thirty-three WRP easements were selected from a GIS data layer obtained from the NRCS in a stratified random design. As opposed to Phase One of the project, no data were collected in BLH or AG, with the exception of the amphibian surveys, which were conducted on both WRP and AG. Study sites were >40 ha in size and were at least 5 km apart to insure independence of landscape variables. Prior to establishing study plots within each WRP easement, an exclusion area (100-m buffer from the WRP boundary) was established to control edge effects. We also excluded areas not planted with trees (based on information from NRCS). The remainder of each WRP was stratified into swale and non-swale areas, using aerial photography. Twenty random points were generated per site using Hawth's Tools (Beyer 2004). The distribution of these points was stratified based on the proportion of the site in swale versus non-swale. If 75% of a site was mapped as non-swale and 25% as swale, then the distribution of random points was 15 and 5 respectively.

Planting dates ranged from 1994-2006 and the species planted on the YRB sites included oaks (Nuttall, willow, water, overcup, Shumard, cherrybark, swamp chestnut, and sawtooth (*Q.*

acutissima)), green ash, bald cypress, bitter pecan (*C. aquatica*), sweet pecan, persimmon, sweetgum, hackberry, sycamore (*Platanus occidentalis*), and water tupelo (*N. aquatica*) (Table I.1).

Chapter II. Biogeochemically Related Services:

Carbon sequestration, Nutrient Retention, and Sediment Reduction

Introduction

The restoration of ecosystem services that help regulate greenhouse gases by sequestering carbon and improve water quality by retaining nutrients and sediments is an important objective of many USDA conservation programs. Riparian forest buffers and forested wetlands are uniquely suited to mitigate the negative impacts of nonpoint source pollution and their nutrient and sediment retention benefits have been well documented (Peterjohn and Correll 1984, Lowrance et al. 1984, Gilliam 1994). Their landscape position and biogeochemical properties give them both the opportunity and mechanisms to alter pollutant loadings to aquatic ecosystems (Johnston 1991). Nitrogen (N) and phosphorus (P) have different chemical characteristics and different controls on their fate and transport. Phosphorus is primarily attached to sediments and removed by sedimentation and sorption processes (Sharpley et al. 2000). Denitrification is considered the primary NO_3-N removal mechanism in riparian buffers and forested wetlands (Pinay et al. 1993, Vellidis, et al. 2003). Anaerobic conditions induced by wetland hydrology are a prerequisite for microbial denitrifiers to use NO_3-N instead of oxygen in the denitrification process while pH, labile (microbially available) carbon source, NO_3-N availability, and temperature control the rate of denitrification (Tiedje 1982, Reddy and Patrick 1984). Conservation practices implemented to improve water quality have to affect the different processes responsible for N and P retention in order to connect those practices to ecosystem services.

The bottomland hardwood (BLH) forests of the MAV are characterized by hydrologic gradients ranging from permanently to briefly inundated (Faulkner and Patrick 1992). Small differences (<30 cm) in surface elevation results in considerable changes in soil saturation and redox processes which, in turn, alters biogeochemical processes controlling carbon storage, greenhouse gas (GHG) emissions, and nutrient retention, especially nitrate. Wetter, lower elevation sites have higher fluxes of CH_4 and N_2O and greater soil carbon contents than adjacent drier, higher elevation landscape positions consistent with known controls over relevant soil processes (Yu et al. 2008). Reforestation of once forested cropland is a key carbon mitigation strategy being implemented on both public and private lands. Restoration often involves some type of hydrologic restoration of drained wetlands creating a variety of hydrologic regimes, therefore, data are needed to quantify GHG emissions, carbon storage, and nutrient and sediment retention in both natural and restored wetlands relative to pre-restoration baselines (i.e., farmed or deforested).

The complex interactions of hydrology, soil type, nutrient loadings, and landscape position create the variability in specific ecosystem processes found in natural wetlands (even within a wetland class) and there is a wide range in reported nutrient retention rates due to differences in specific processes controlling those rates (Faulkner and Richardson 1989, Lowrance et al. 2006). Whiting and Chanton (2001) found a wide range of CO_2:CH_4 values for different North American wetlands with specific wetlands shifting between source and sink functions across 20, 100, or 500 year time horizons. The degree to which the biogeochemically related ecosystem services can be successfully restored on the landscape is a function of both this variability in site-specific attributes and the type and efficacy of the conservation practices.

Methods

Phase 1. At each site (8 each in BLH and WRP in each LWC and TRB river basin), the vegetation was sampled in five study plots (400 m^2 each) that were spaced at 75 m intervals along a transect (Fig. II.1). No vegetation plots were established in AG sites since they were planted with commercial crops. Transect location was based on a randomly located point and a randomly chosen azimuth within the stand. Study plot locations were intended to support the biological components of the overall study, rather than to provide an in-depth analysis of soil and vegetation variability across an entire site. The species, diameter at breast height (dbh, 140 cm above the soil surface), height, vigor, crown class and associated vines were recorded for every tree (≥ 10 cm dbh) within the plot. Tree heights were measured to the nearest decimeter with a laser rangefinder/hypsometer.

Two shrub subplots were centered 5 m from the center pole of each main plot, on opposite ends of a line perpendicular to the transect direction. On each shrub subplot, we recorded the species, diameter, vigor, and vines on each tree that was 2.5 cm or greater but less than 10 cm dbh. In addition, all seedlings and saplings (< 2.5 cm dbh) were tallied by size class. In these plots, we also recorded the number and size class of all river cane (*Arundanaria gigantia*) and palmetto (*Sabal minor*). Four herbaceous vegetation sub-plots, centered at 5 m from the main plot center pole, (either along the transect line or on a line perpendicular to the transect), were sampled within each main plot and the cover class of all herbaceous species observed.

Phase 2. In the Mississippi YRB, our objective was to better quantify the range of ecosystem responses to reforestation occurring on WRP easements as opposed to comparisons with different land uses. At each site, a total of 20 400-m^2 circular plots were randomly established, stratified into ridge and swale strata based on areal proportion as described above, and sampled for woody shrubs/trees. All stems ≥ 30 cm tall were recorded by species. Dbh measurements were collected on stems with a dbh ≥ 2.5 cm. Based on preliminary plot data, we determined that tree heights of planted trees on a given site were generally uniform. Therefore, it was not practical nor necessary to measure tree heights at every plot, so heights were measured to the nearest in 0.5 m interval at two random plots within each stratum (swale/non-swale). A total of 28 WRP sites were sampled entirely and an additional four other WRP sites were partially sampled (four plots each). Based on Phase 1 data and resource constraints with the more intensive sampling design, herbaceous data were collected on 2 sub-plots (1 m^2) within the main 400-m^2 plot. Since no natural forest stands were sampled in the YRB, we used data from the U.S. Forest Service's Forest Inventory and Analysis (FIA) program plots nearest to each of our study sites to characterize natural forest conditions in the region and to compare relative importance values of species on WRPs versus BLH.

The following data were collected or calculated for all sites in the LWC, TRB, and YRB during both phases of the study. Carbon storage in soil and trees was calculated based on site-specific vegetation and soils data and primary scientific literature. Carbon in tree, understory, and forest floor pools were calculated using site data and allometric equations (Jenkins et al. 2003, 2004). Soil carbon in the upper 10 cm was calculated directly from soil samples randomly collected within the vegetation study plots using a slide hammer soil corer with brass ring inserts at a depth of 0-10 cm. The brass rings enabled volumetric determination of soil bulk density. A subset of each sample was used to measure percent total carbon and nitrogen. These sub-samples were oven-dried (105 °C), ground through a 2-mm sieve, and pulverized. Between 40 and 45 mg of pulverized sample were analyzed for total carbon and nitrogen using a Thermo Finnigan® FlashEA 1112 Elemental Analyzer. Separate sub-samples from the original soil sample were air-dried at room temperature for particle size analysis. Percent sand, silt, and clay were determined gravimetrically following Burt et al. (1993).

Average annual soil erosion was calculated using the USDA's Revised Universal Soil Loss Equation (RUSLE). The official NRCS version of RUSLE2 Version 1.26.6.4 and associated database were downloaded from http://fargo.nserl.purdue.edu/rusle2_dataweb/RUSLE2_Index.htm. Climate data, soil data, and base management templates were downloaded from the website and then imported into RUSLE2. The template NRCS RUSLE Lite 101506 was used to calculate a single soil loss for one hillslope in one field. The soil type was chosen based on the site location; soil texture and percent sand, clay, and silt were changed based on data from the particle size analysis from each site. The slope length was left at the default setting of 150 ft for all the sites and the percent slope was determined from the SSURGO database for that particular county/parish (Soil Survey Staff 2009). The percent slope was extracted by soil type from the "wind erosion prediction system related attributes" report.

Three different base management templates were chosen based on NRCS zone location classification with guidance from Richard Aycock, NRCS. We assumed that single crop rotation was used for both the TRB and LWC agriculture fields. The template "Soybeans full season with weeds; SD Z38" was used for TRB agriculture fields and "Soybean, grain; SD, Z-42" for LWC agriculture fields as soybeans are the most common crop grown on marginal cropland, they are usually left fallow through winter, and are disk-tilled in the spring. Nothing was edited for the Louisiana template; however, the Arkansas template was edited by adding winter weeds for the mid-south. The same template from CMZ 38 was used for WRPs in all three states. The template chosen was "Hardwood trees, hand planted, mowed, subsoiled." The rest of the profile was kept at its default setting.

Denitrification potential was measured following the denitrification enzyme assay (DEA) procedure (Groffman and Tiedje, 1989; Ullah and Faulkner, 2006a). Field moist soils were thoroughly homogenized by hand and brought to room temperature overnight before incubation. A slurry was created in 150 mL serum bottles using 10 g of field moist soil with a 10 mg L^{-1} NO_3-N treatment solution and DI water control (no NO_3-N) with three replicate bottles per treatment. Each bottle was sealed with a rubber septa and foil cap, wrapped in aluminum foil, and purged with two cycles of O_2-free N_2 gas, one lasting five minutes and one lasting twenty, to create an anaerobic system. Approximately 10% of the headspace was removed and replaced with C_2H_2 gas. Samples were then placed on a rotary shaker at 125 rpm at ~25°C for 90 minutes. Gas samples were taken at 0, 30, 60, and 90 minutes and stored in labeled, evacuated, crimped gas vials. The gas samples were analyzed within one day on a Varian 3800 Gas Chromatograph equipped with an electron capture detector. Corrections were made for dissolved N_2O with the Bunsen's absorption coefficient and soil moisture content to report on a dry soil weight basis.

Total (above- and belowground) carbon storage data were analyzed using the non-parametric Kruskal-Wallis test. Soil carbon data were analyzed using simple one-way ANOVA's. Tukey's test was used to detect differences among groups. A simple linear regression was used to compare soil carbon and planting year. The DEA and soil erosion data were rank transformed and analyzed with two-way ANOVA. The significance level for all tests was $\alpha = 0.05$.

Results and Discussion

There was no difference in total carbon pools between the active crop land (AG) and restored forest (WRP), while the natural forest (BLH) sequestered the greatest amount of carbon ($p<0.001$) (Fig. II.2). Soil carbon (kg/ha) did not differ between swale and non-swale locations ($p=0.956$) in the YRB (Fig. II.3). These results suggest that either elevation is not important at this scale, or that the WRPs have not had sufficient time to recover from tillage practices and, therefore, differences are not yet detectable. When comparing land use by basin (e.g., TRB-AG, TRB-WRP, etc.), there was a significant difference between groups ($p<0.001$); however, the WRPs did not differ from the AG sites (Fig. II.4). When comparing carbon by land use (i.e., summing carbon across basins), total soil carbon was significantly different between each land use type with AG < WRP < BLH ($p<0.001$) (Fig. II.5). We used regression analysis to evaluate the effect of time since WRP restoration on soil carbon. For sites that were replanted or had multiple planting years, the mean planting year was used. If the planting year was unknown, the site was excluded from this analysis. There was a general trend of increasing soil carbon with increasing stand age ($p=0.051$) (Fig. II.6). Stand age and insufficient sample size are the likely causes for the statistically similar results for AG and WRP sites when states are not lumped.

Calculated sediment losses from erosion were significantly higher in the AG than the WRP sites ($p<0.001$) (Fig. II.7). The absolute amount varied by soil textural class, ranging from 5.10 metric tons/ha/yr for silty clay soils to 9.35 metric tons/ha/yr for silt loam soils. We did not have comparable loam and sandy loam data from AG sites to compare to our WRP data for those soil texture classes. The large reduction in sediment loss results from the conversion to perennial forest cover and the removal of disturbance from management actions (e.g., tilling, disking) associated with commodity crop production.

Potential denitrification rates in the AG and WRP sites, as measured by the denitrification enzyme assay (DEA), were similar in both control (no NO_3 added) and NO_3-amended treatments ($p=0.532$) (Fig. II.8). Higher potential denitrification rates in the BLH sites were observed when 10 mg L^{-1} NO_3 was added. These results are comparable to those reported in the literature documenting the high denitrification rates of forested wetlands (Lindau et al. 1994; Lowrance et al. 1984, 1995; Mitsch and Day 2006; Mitsch et al. 2001; Ullah and Faulkner 2006a) and the lower rates in active agricultural crop land and restored forested wetlands (Hunter and Faulkner 2001; Ullah et al. 2005; Ullah and Faulkner 2006b). At this time, it is not certain why restored forested wetlands have lower DEA values. The potential causes are those known controls over denitrification including differences in carbon availability to microbes, hydrologic regime, and denitrifier populations (Hunter and Faulkner 2001; Ullah and Faulkner 2006b; Faulkner and Hou, unpublished results).

Within the WRP sites, differences in potential denitrification rates among river basins and between NO_3 amended and control soil samples were highly significant ($p<0.001$) (Fig. II.9). The highest denitrification rates were observed in the YRB swale sites and likely result from both micro-site differences and recent flooding since more than half of these sites experienced back-water flooding in the spring of 2008.

Conclusions

Reduction in soil erosion was the most immediately measurable impact of converting AG to WRP and is a consequence of the large effects of land cover on erosion processes. It is not surprising that there were no significant differences between the AG and WRP sites in total carbon or denitrification potential given the young age of the WRP. In nearly all forest ecosystems, most of the carbon is stored in tree biomass and the trees planted on the WRP sites were all less than 15 years old at the time of sampling. It is also likely that as the WRP sites mature with appropriate wetland hydrology that the denitrifier populations and denitrification potential will more closely resemble that of mature, natural BLH. Additional future measurements of soil carbon will be necessary to determine if there is a similar temporal effect in soil carbon in swale and non-swale micro-sites. These current similarities between AG and WRP sites will be negated over longer time scales and watersheds with significant area in mature WRP will store more carbon and remove more nitrate than those with only active crop lands. Additional research beyond this project is required to experimentally determine the factors responsible for the differences in denitrification potential among the river basins. If the WRP sites continue on a trajectory towards fully functional BLH sites, then these conservation practices will significantly improve water quality and carbon storage on the landscape.

Chapter III. Biological Conservation, Sustainability, and Habitat Quality

Introduction

The large-scale conversion of forests to cropland in the MAV resulted in a significant loss of wildlife habitat (MacDonald et al. 1979). Birds are a conspicuous element of forest ecosystems and are widely appreciated for their game and non-game value. At least 70 species of birds breed regularly in forested wetlands of the MAV including about 30 species of nearctic-neotropical migrant landbirds. (Pashley and Barrow 1993). The MAV is also a continentally significant wintering area for North American waterfowl, and it is particularly important for mallards (*Anas platyrhyncos*), wood ducks (*Aix sponsa*), northern pintails (*Anas acuta*), gadwalls (*Anas strepera*) and green-winged teal (*Anas crecca*) (Reinecke et al. 1989). Waterfowl conservation plans often assume foraging habitat to be a limiting resource in migration and wintering areas. The Lower Mississippi Valley Joint Venture (LMVJV) has established conservation objectives, based on bioenergetic models, to provide enough foraging habitat to meet the energy requirement of approximately 4.3 million waterfowl that are expected to winter in the MAV annually (LMVJV Waterfowl Working Group Update 2007).

Bailey et al. (2006) recognized seven aquatic habitat types that are important to amphibians in the Southeastern U.S., of which the following are found within the MAV: (1) floodplain wetlands; (2) seasonal isolated wetlands and small ponds; (3) permanent wetlands; (4) small streams, springs and seeps; and (5) rivers and large streams. At least one of these five wetland types are considered "optimal" habitat for 96% of anurans and 76% of the salamanders found in the MAV (Bailey et al. 2006), thus emphasizing their importance to the persistence of amphibians in this region. A total of 25 species of anurans (frogs and toads) and 18 species of salamanders (27 and 11%, respectively, of all species of amphibians in the U.S.) are known to occur in the MAV (USGS ARMI National Atlas for amphibian distributions, http://www.pwrc.usgs.gov/armiatlas/ and the Global Amphibian

Assessment (http://www.globalamphibians.org/). Amphibians often represent a large and significant fraction of vertebrate biomass in freshwater and terrestrial habitats (Davic and Welsh 2004, Regester et al. 2006). Because amphibian reproduction is so tightly tied with the aquatic habitat, changes in hydrology is one of the biggest considerations for most species when evaluating the effects of conservation practices and programs in restoring habitat to suitable conditions for amphibians.

We used edaphic, vegetative, and morphological characteristics, at both the patch scale and landscape scale, and made direct measurements to evaluate the effects of WRP on the following species groups: neotropical migratory birds, waterfowl, and amphibians.

Methods

Vegetation and Flooding. The vegetation data collection described in Chapter II was used to evaluate wildlife habitat quality. Since plant community structure and function is controlled by flooding and inundation in the MAV, the spatial extent and frequency of flooding was needed. The MAV High Frequency Natural Flood Model was developed from a synthesis of river gauge data and the classification of satellite imagery. We used the river gauge data from the New Orleans, Vicksburg, Memphis, and Little Rock Districts of the United States Army Corps of Engineers as these districts cover the MAV. In total, we acquired and analyzed period of record (POR) data for 140 gauge stations throughout the MAV to determine appropriate dates for flood events of interest for each individual stream segment that coincided with the availability of Landsat satellite imagery and we used Landsat TM imagery to estimate the spatial extent of flood events.

We selected Landsat satellite images by taking all bank-full and over-bank stream stage records and comparing them with complete Landsat POR data since the launching of Landsat TM in 1982; this enabled us to identify 37 scenes capturing flood or near-flood events. From these scenes, we selected dates that captured approximately equal interval samples between the bank-full minimum and the over-bank maximum for each stream segment. Potential scenes were limited to winter (leaf-off) imagery to permit inclusion of flooded timber.

We then returned to the gauge data and modeled approximate flood stage-to-frequency relationships up to the 3-year flood event for those stations that had sufficient POR (>10 years of data). We used two frequency-modeling techniques to model high frequency events: (1) Peak Over Threshold (POT); and (2) Monthly Peaks Analysis (MPA). In POT frequency modeling, an event peak is logged each time that the data trend rises above and falls back below a specified threshold, in this case the bank-full stage. These loggings were analyzed to determine recurrence interval for the period recorded. In the MPA, a variation of the Annual Peaks method, maximum observed stage was logged for each month where sufficient record existed. The recurrence interval was then estimated from an ordered ranking of flood events for the period recorded.

We extracted water features from the imagery using both thresholding and unsupervised classification techniques as described above. In many instances, classified water features included water impounded through aquaculture or the common practice of winter flooding of agricultural fields. Many of these features were isolated from over bank floodwaters in one scene, but subsumed by flood waters at higher stages in other scenes. We developed an aquaculture layer that enabled us to mask these ponds. However, while some agricultural impoundments that clearly were isolated were removed, we note that many remain within the dataset and must be accounted for by end users of the model.

The Flood Frequency Model values represent expected recurrence interval in months from 6-36 months based upon the Monthly Peaks frequency analysis. No interpolation of values was performed, so only frequencies with which satellite imagery could be correlated are included. No approximations are made for non-observed stages or frequencies.

We examined data for 107 watersheds across the MAV for which adequate gauge data were available to model flood frequency comparing WRP easements to the Flood Frequency Model output. The remaining 180 watersheds lacked adequate gauge and/or POR data and were eliminated from the model. Only watersheds that had 8 or more observed discrete flood events delineated based on satellite imagery, where stage could be determined from gauge data archives, and where gauge data period of record was of sufficient length to model flood frequency were used in this analysis. We eliminated watersheds with 7 or less discrete flood events because our experience suggested they lacked enough observations to allow an adequate understanding of the surface extent of flooding within flood frequencies of interest within the watersheds. These inclusion criteria resulted in a subset of 61 of the 107 watersheds incorporated into the analysis that collectively had 783 observed discrete flood events. Herein, the 61 watersheds incorporated in the analysis are assumed to be representative of the range of conditions present in the excluded watersheds (n = 46), or watersheds where POR data was not available (n = 180).

We characterized flood frequency into eight categories: (1) Flood frequency 0–6 months, where discrete flood events were observed at least once every 6 months; (2) Flood frequency 7–12 months where discrete flood events were observed at least once every 7-12 months; (3) Flood frequency 13-18 months, where discrete flood events were observed at least once every 13-18 months; (4) Flood frequency 19–24 months, where discrete flood events were observed at least once every 19–24 months; (5) Flood frequency 25–36 months where discrete flood events were observed at least once every 25–36 months; (6) Flood frequency greater than 37 months, where discrete flood events were observed at least once, but not more than every 37 months; (7) No flooding, where flooding was not observed at any time on any satellite scenes used herein; and (8) Flooding observed, frequency unknown, where flooding was observed, but inadequate watershed POR data precluded determination of frequency. We then used ESRI ArcGIS Zonal Statistics tool to categorize each feature of the Lower Mississippi Valley Joint Venture (LMVJV) WRP Easement Data Set into one of these 8 classes.

Neotropical migratory birds. Variable-width line transects (Ralph et al. 1993) were used to obtain estimates of bird density, and species richness. In TRB and LWC, we sampled in three habitat types: BLH, WRP, and AG. Eight sites within each habitat were sampled per river basin for a total of 48 sites. A 300-m transect was sampled at each site once every 14 days from 3 September to 28 October 2006. Each site was sampled four times over the migration season and all three habitat types were sampled on each day of data collection. In the YRB, Mississippi, 29 WRPs were sampled using variable-width line transects. The sites were distributed over a 178-km north-south gradient in the delta region of Mississippi. A 300-m transect was sampled at each site once a week from 8 September to 25 October 2008 for a total of seven samples over the migration season. Air temperature and wind speed were monitored to insure that counts were only conducted when the air temperature was > 0^{o} C (Robbins 1981) and when wind speed was < 20 km/h. The first counts of the day began at official sunrise and the final counts of the day were completed within 5.5 h after official sunrise. At each site, observers walked the length of a 300-m transect at a moderate pace so that the entire transect length was covered in 30 min. Poles placed at 0m, 75m, 150m, 225m, and 300m helped maintain a consistent pace (ca. 100m per 10 minutes). All birds known to be distinct in time and space were recorded. A laser rangefinder was used to determine the distance from the observer to each detected bird, and an angle rule was used to record the bearing of the bird with respect to the transect line. Birds flying past the habitat (i.e. not foraging over) or in adjacent habitat were recorded, but were not used in the analyses. Technicians wore drab clothing to avoid detection biases

(Gutzwiller and Marcum 1997) and reversed the order in which sites were sampled to reduce time-of-day effects.

Bird species were divided into three migrant categories for analyses: resident species, nearctic-neotropical migrants, and temperate migrants. Resident (non-migratory) species status was confirmed with Birds of North America species accounts (http://bna.birds.cornell.edu/BNA). Nearctic-neotropical migrant landbirds were defined according to Finch (1991), with the exception of American Kestrel, Eastern Phoebe, Ruby-crowned Kinglet, Red-winged Blackbird, and Brown-headed Cowbird. The migratory status of these species was changed to temperate based on Birds of North America accounts. The remaining migrant landbirds were categorized as temperate migrants. The migratory status of waterbirds was defined according to DeGraaf and Rappole (1995) with supporting documentation from Birds of North America species accounts. The exception was the Mallard which was classified as a temperate migrant based on the Birds of North America account and regional knowledge of this species. Bird species richness was analyzed with repeated measures analysis of variance (Winer 1971) where the class variables were sample period, state, habitat type, and migrant category. False discovery rates were used *a posteriori* to identify significant class-level differences (Verhoeven et al. 2005). Differences are reported as significant at $P \leq 0.05$.

In addition to the line transects at WRP sites, eight additional CRP tracts within the TRB that were at least 100 acres in size were selected for a pilot study of a portable radar system for identifying bird use of active cropland, CRP, and native forest. The CRP tracts were located adjacent to or nearby agricultural land that was also ≥ 100 acres and all CRP tracts were at least 4 km apart. Each site was sampled four times during an eight week period in September and October, 2006. The radar unit collected data continuously from one hour before dusk until one hour after dawn. During these one-hour sampling periods, visual detections of birds with binoculars were recorded and 300 m variable-width line transects were completed in both the CRP and the agricultural field. All birds known to be distinct in time and space were recorded along the transects to help calibrate the radar results.

Waterfowl. In order to assess the effect of WRP on waterfowl foraging habitat, it is necessary to quantify the timing and spatial extent of flooding in the MAV, WRP hydrologic management, and the change in duck energy days (DEDs) resulting from converting cropland to WRP. A DED is defined as the amount of energy required by one mallard-size duck for one day. The winter period is assumed to be approximately 110 days.

Winter season imagery was selected based on the 120-day wintering period (November 1 – February 28) for waterfowl and the quality of the available Landsat Thematic Mapper (TM) data for paths and rows P24 R36 and P23 R34 through P23 R38. Imagery was acquired for each winter from 2000 through 2005. Our objective was to capture at least one cloud-free image per winter during the 120-day period. This was achievable partly because Landsat TM 5 and 7 were both operational and offered a combined eight-day repeat cycle increasing the likelihood of acquiring cloud-free images. When available, we tried to acquire imagery from dates between December 15 and January 31 that coincided with peak abundance of wintering waterfowl. We obtained satellite images from the USGS EROS Data Center, and had radiometric and geometric corrections performed by a contractor (Image Links, Melbourne, FL). Recent precipitation events had the potential to introduce error related to interpretation of flooded wetlands versus saturated soils. Therefore, we acquired daily precipitation values for 30 stations located throughout the MAV and analyzed them to ensure that no significant precipitation events occurred 3 days prior to image acquisition (Wax and Walker 1986).

The WRP hydrology management units and easements (WRP HMU) database was developed by Ducks Unlimited and was one of two feature datasets used to analyze contributions of WRP to the

LMVJV population-based foraging habitat objectives. We developed this data set from AUTOCAD files of the engineered units that were geo-referenced to provide spatial accuracy. When AUTOCAD files were not available, we obtained consent from participating landowners to individually map additional WRP hydrology units on their properties. The other feature dataset was the WRP Conservation Easement Database. This database is maintained and updated annually by the USFWS LMVJV office, Vicksburg, MS. We obtained the most current copy of this database to estimate spatial extent of land converted to flood-compatible uses.

We used remote sensing techniques to quantify the spatial extent of flooding within WRP HMUs, and also to develop point-in-time estimates of the areal extent of natural flooding in the MAV. Subsequently, we incorporated the results of the natural flood estimates into development of the Ducks Unlimited Flood Frequency Model for the MAV as detailed below.

We analyzed the results of our winter water classification efforts alongside the WRP HMU database using the Zonal Statistics function in ESRI ArcGIS to estimate what percentage of each unit is flooded at each winter's observation. We then determined the acreage of inundation for a particular unit or easement, and then summed those values across the subset of WRP hydrology units or easements analyzed for that year and factored the results into our foraging habitat estimates. This process was repeated for each winter period analyzed in accordance with the appropriate WRP HMUs and easements completed at that point in time in each of the three states, thereby providing a quantitative estimate of waterfowl foraging habitat value provided by WRP in Arkansas, Louisiana, and Mississippi during the winters of 2001-2005. For clarity, this analysis incorporates flooding on all WRP easements and HMUs in the WRP Conservation Easement Database and WRP Hydrology Unit Database, respectively, whereas the flood frequency analysis only incorporates WRP easements within watersheds where we had an adequate number of observations of discrete flood events as discussed below.

We surveyed NRCS State WRP coordinators via telephone to develop an estimate of total WRP easement acreage, and total WRP HMU acreage in Arkansas, Louisiana and Mississippi. Only Arkansas had data recorded by county regarding specific easement hectares and HMU hectares. However, based upon information provided by the WRP Coordinators, an estimated 49,000 ha of managed seasonal wetlands have been restored through the Wetlands Reserve Program by construction of HMUs. The WRP Coordinators generally could not provide an estimate of the actual number of HMUs created through WRP in each state. Typically the HMUs have levees and water control structures that enable landowners to manipulate water levels and practice moist soil management techniques. Variation in precipitation, construction design and other factors results in flooding of some fraction of the potential acres within HMUs in any given winter. Hence, herein we estimated the total area flooded for each year within a subset of WRP HMUs (n = 2,516 for 2001, n = 2,747 for 2002, n = 2,845 for 2003, and n = 2,862 for 2005) to quantify potential waterfowl foraging habitat values.

The vast majority of WRP HMUs are under some degree of moist soil management intensity. Moist soil management is generally defined as manipulation of flood periodicity and duration to mimic natural systems and promote decomposition of detritus and nutrient cycling to stimulate production of annual and perennial plants and invertebrates that provide high-energy, nutrient-rich foods for wintering waterfowl and other wetland wildlife (after Baldassarre and Bolen 2006). Moist soil management often is categorized as either active or passive, depending largely on the frequency of soil disturbances and intensity of water level manipulation. Wetlands under active moist soil management are those for which water levels are manipulated under a prescribed management plan, and wetland substrates are disturbed via disking on a 1 to 3-year interval. Wetlands under passive management are those where management activities are not planned or performed on any prescribed schedule, nor are they intensive. Passively managed wetlands rarely undergo managed draw downs, wetland substrates are infrequently (> every 3 years) disturbed using mechanical means, and plant succession is rarely set back via use of fire or other methods.

A complete characterization of management intensity of WRP HMUs has not been completed in the MAV. However, in 2003, we visited and inspected 578 WRP HMUs in Louisiana (n = 238) and Mississippi (n = 340). We performed inspections to (1) develop area polygons for the HMUs to include in the WRP Hydrology Management Unit database; (2) assess condition of infrastructure of HMUs; (3) qualitatively assess plant species composition within each HMU via ocular estimation; and (4) determine landowner management intensity for each HMU (Ducks Unlimited unpubl. report, 2003). During our inspections of WRP HMUs in Louisiana and Mississippi we assessed plant species composition as Satisfactory, Marginal, or Unsatisfactory and categorized management intensity as Active, Passive, or Unmanaged. Plant species composition and management categories were based on qualitative ocular estimates performed by a single observer (Ducks Unlimited, unpubl. data) using criteria presented in the Waterfowl Habitat Management Handbook (Nassar et al. 1993).

Reinecke and Kaminski (LMVJV Waterfowl Working Group Memorandum, 2007 Update) surveyed published literature and concluded that actively managed moist soil wetlands in the MAV on average have a waterfowl carrying capacity of 4,616 DEDs/ha. Kross et al. (2008) surveyed a series of actively and passively managed moist soil units on state and federal lands in the MAV and found they provided a combined average of 3,776 DEDs/ha. Gann and Brennan (2007) estimated that WRP wetlands in Arkansas provided 2,368 DEDs/ha. Hence, to estimate the contribution of WRP HMUs to LMVJV Waterfowl Foraging Habitat Objectives we assigned a foraging habitat value of 4,616 DEDs/ha for the Satisfactory/Active area. For the combined area deemed Marginal/Passive or Unsatisfactory/Unmanaged we assigned a value equal to 50% of the food energy produced by actively managed wetlands, or 2,308 DEDs/ha.

We estimated waterfowl foraging values of reforested areas based upon when trees mature and begin mast production. While some mast production has been noted in year 12 post-reforestation on some sites in the MAV, consistent mast production meaningful to wintering waterfowl typically begins about year 20 post-reforestation. We used the average percentage of seedlings of red oak and sweet and bitter pecan planted on WRP reforestation sites in Louisiana and Arkansas. This group of species is known to produce mast favored by waterfowl (Reinecke et al. 1989). For reforestation conducted from 2003 through 2007, 68% of seedlings planted on Louisiana WRP easements were comprised of mast-producing red oaks (60%), sweet pecan and bitter pecan (combined 8%). In Arkansas, 62% of planted seedlings were mast-producing species, including 54% red oaks and 8% sweet pecan. Herein, it is assumed that 65% of WRP sites were reforested with species that contribute mast as potential waterfowl food. Further, we assume that species composition of reforestation sites 20 years post-reforestation and beyond will not change significantly over time and is representative of species composition of seedling planted in reforestation efforts.

Reinecke and Kaminski (LMVJV Waterfowl Working Group Memo, 2007 Update) surveyed published and unpublished literature to gather estimates of mast production, invertebrate production, and seed production by annual and perennial herbaceous plants in forested wetlands. That information was summarized and used in development of LMVJV foraging habitat objectives (Loesch et al. 1994) and updated in 2007 (Reinecke and Kaminski, LMVJV Waterfowl Working Group Memo). Hence, we used those values herein to calculate the estimated foraging value of WRP reforestation sites 20 years post-reforestation. A forest stand comprised of 65% red oak/native pecan provides an estimated average of 274 DEDs/acre (Reinecke and Kaminski, LMVJV Waterfowl Working Group Memo).

Amphibians Phase 1. We focused on calling male anuran amphibians (frogs and toads) in the LWC and TRB in 2006 and 2007 because of the logistical feasibility (compared to non-calling salamanders) of locating, monitoring and enumerating these species. We placed automated recorders ("frogloggers") at each site to quantify the number of species of calling anurans (i.e., species richness) for each land-use treatment (AG, WRP, BLH). These froglogger units consisted of hand-held computers (personal digital assistants or PDAs), operated by software developed in-house to set up the recording parameters and to control recording events. Sound recordings were stored as .wav files on either a secure digital card or a compact flash card. All components were housed in water tight Hardigg Storm Cases lined with precut non-absorbent foam and mounted on a wooden stand approximately 1.5 m above the ground. Units were operated at sites continuously from March – June in 2006 and February – June in 2007 to capture "winter" breeding species (January-February), "spring" breeders (March-April) and "summer" breeders (May-June). Each field site was visited approximately every 20 days to retrieve stored data, check the equipment, and to replace the 12 v batteries. The stored data was returned to NWRC, downloaded to the NWRC computer network, and personnel trained in identifying anurans from calls listened to each stored recording and identified the species from the recorded calls.

We modeled anuran species occurrence by land-use category using the site occupancy model described by MacKenzie et al. (2002). One of the requirements for an occupancy analysis is that some number of samples greater than one is made at each site in a period of time short enough that it may be assumed the site is closed to changes in occupancy (MacKenzie et al. 2006). We therefore took the frog call data from the 9 weeks beginning 1 April 2007 and ending 2 June 2007 as our closed season of activity. We treated each week during this 9-week interval as a separate sample. Not all recording devices were working consistently during this period due to equipment malfunctions, so we only considered a site sampled during a week if it had at least one full 24-hr period of proper functioning during the week. This constraint meant that the number of repeat samples for each site varied from 2-9 (mean = 6.4). If a species was detected by the human listener during one of the sample weeks, the site was known to be occupied, and a 1 was put in the capture history for that species at that combination of site and sample. If the species was not detected during the week at a site, it was marked 0 in the capture history. Weeks without sufficient recordings to count as sampled were marked with a dash and treated as missing data (MacKenzie et al. 2006).

We modeled species occupancy (Ψ) and detection probability (p) using a single-season model in program PRESENCE (MacKenzie et al. 2002). We used information-theoretic methods based on Akaike's Information Criterion (AIC) to compare between two models (Burnham and Anderson 1998). The first model ($\Psi.p.$) assumed that probability of occurrence was constant across all sites, meaning there was no effect of land use (WRP, AG, or BLH) on occurrence of a species. The other model ($\Psi_{hab}p.$) included an effect of land use category on the probability of occurrence. Both models assumed p was constant across time and land use category. Occupancy rates are reported for only the species that had at least 30 detections out of the possible 300 site/sample combinations over the 9-week interval as those with less failed to reach numerical convergence in PRESENCE.

Amphibians Phase 2. A one person-hour, nighttime visual encounter survey (VES) and concurrent vocalization survey was conducted at each of 30 WRP and 20 AG sites in the YRB in 2008. Each site was surveyed three times within a 2-4 week period, with all 150 surveys occurring between 5 May 2009 and 4 August 2009. A minimum of two observers conducted each survey using high-powered headlamps to facilitate anuran observations. Relative humidity, wind speed and air temperature were measured at each survey with a pocket weather meter. We recorded water temperature and depth if water was present at the survey point.

In both WRP and AG land use categories, sites were selected that appeared likely to harbor anurans based on knowledge of amphibian natural history. Selected sites within WRP tracts were usually near water control structures or other water bodies, while selected AG sites were usually near a drainage ditch or canal within or adjacent to the agricultural field. The area within a 20-meter radius circle of the selected survey point was thoroughly searched for anurans. Species, age, sex, snout-to-urostyle length (SUL), substrate and perch height were recorded for each anuran observed. Anuran species' vocalizations were identified and assigned a calling intensity of 1–3 based on North American Amphibian Monitoring Program (NAAMP) protocols. While distant vocalizations were recorded, only those vocalizations heard within a 50-meter radius of the survey point were used in analyses.

Results and Discussion

Flooding Extent and Frequency. The MAV High Frequency Flood Model indicated that 69.7% to 77.7% of land within easements we sampled was within the 0-24 month flood frequency. The total number of easements sampled across all three states was 365, 420, 462, and 498 for 2001 through 2005, respectively (data for Mississippi only current through 2004). Approximately 69.7% to 77.7% of land enrolled in WRP across the three states appears to fall within the 0-24 month flood frequency (Table III.1). Changes in percentages among years are related to additions of new easements with differing amounts of acreage with differing flood frequencies. Additionally, some natural flooding would be expected to occur on approximately 77.3% to 85.0% of all land in the easements we sampled.

The model suggests that 15.0 to 22.7% of land enrolled would not be expected to flood, or at least we have never observed flooding on that land in our analysis of satellite imagery to date (Table III.1). Through 2005, the model indicates that 120,115 acres of 172,326 analyzed have a flood frequency of 0-24 months, and 125,672 acres were predicted by the model to have at least some natural flooding. Overall, the majority of land accepted into WRP appears to be within the high frequency flood interval elevations within the MAV portions of Arkansas, Louisiana and Mississippi.

From the standpoint of retiring frequently flooded, marginal agricultural land, enrollments in WRP appear to be well located in these three states. Given the large proportion of enrollments within the 24-month flood frequency and that the majority of WRP easements in these states are perpetual, these lands should provide significant wetland functions and ecosystem services as their plant communities mature.

Vegetation. Comparisons of species importance values (IV300) indicated differences between land use type (WRP and BLH). In WRPs, dominant species were Nuttall oak (*Quercus texana*), green ash (*Fraxinus pennsylvanica*), water oak (*Q. nigra*), and willow oak (*Q. phellos*) (Fig. III.1). In contrast, dominant trees in BLH were sweetgum (*Liquidambar styraciflua*), hackberry (*Celtis laevigata*), American elm (*Ulmus americana*), green ash, cedar elm (*U. crassifolia*), water hickory (*Carya aquatica*), and willow oak. The differences between land use types were not unexpected since the four dominant species observed in WRPs were the most commonly planted species on those sites.

In general, stem density, basal area, species richness, and diversity were all higher in the natural forest stands. Basal area was similar within land use types but was expectedly smaller in the WRP stands due to their young age (Fig. III.2). More variability was observed in stem density, but most of this variation was due to the smaller Sapling/Seedling class (≥ 0.3m in height and < 2.5cm dbh) (Fig.

III.3). In both land use types, stem density was greatest in the Sapling/Seedling size class and smallest in the Tree class (≥ 10cm dbh). Both species richness and diversity were higher in the BLH stands in the Tree class (Fig. III.4 and III.5), but the other size classes were not as consistent. Species richness in the two smaller size classes at LWC WRPs and TRB WRPs were noticeably smaller than the BLH sites; however, richness at the YRB WRPs for the Midstory (2.5cm ≤ dbh < 10cm) and Sapling/Seedling classes were more similar to the BLH stands. The diversity measurements for the Sapling/Seedling class were variable at the WRPs, but were all less than values observed at the BLH sites. The higher species richness and diversity values observed at the YRB WRPs versus the LWC and TRB WRPs is more likely due to the greater sampling intensity in YRB than real differences between the river basins.

We observed 56 species of trees and shrubs in the BLH stands and 35 species on the WRP sites in LWC and TRB (Table III.2). A total of 54 species were found on the WRP sites in YRB (Table III.2). Many species were found on both swale and non-swale (ridge) plots, but 14 species were only found on ridge plots compared to 4 species only found on swale plots. The most important species encountered on swale plots included green ash, Nuttall oak, willow oak, and water oak (Fig. III.6A). Similarly, on the ridge plots, the most important species were Nuttall oak, green ash, water oak, and willow oak (Fig. III.6B). The high importance of these four species on both swale and ridge plots is directly related to those species having been planted in the greatest quantities. However, since green ash is a heavily-seeded pioneer species that readily colonizes open areas, its high stem densities are likely a combination of planting and natural dispersal. These results are similar to those reported by Twedt (2004) for a range of reforestation sites in the MAV.

Over the course of this project, we detected 176 herbaceous species and 28 vine species in the 1-m^2 plots. Only 36 herbaceous species (15 unique) were observed on the BLH sites compared to the

161 species detected on the WRPs (140 unique). Despite these differences, mean percent herbaceous cover was similar between land use types (Fig. III.7).

<u>Neotropical migratory birds.</u> Overall, 109 bird species were detected over the 2006 autumn migration season in LWC and TRB (Table III.3). Of the total species detected, 46 species were detected in AG, 68 species were observed in WRP, and 66 species were detected in BLH. Many species (48.6%) occupied more than one habitat, while 5.5% were only found in AG, 14.7% were only detected in WRP, and 31.2% were only observed in BLH (Table III.4).

Results of the repeated measures analysis indicate that mean observed species richness varied over time by state and habitat type as shown by the significant sample period*habitat type*state interaction (Table III.5). Throughout the study period, BLH sites had greater mean species richness than WRP sites and AG fields (Fig. III.8). The differences between WRP sites and AG fields changed over the migration season. In the TRB, the mean species richness of AG sites was significantly greater than WRP sites during early migration (early September, $P = 0.009$) (Fig. III.8A). As the season progressed, the species richness of WRP sites increased and was significantly greater than AG sites during mid to late migration (early October, $P = 0.004$; late October, $P = 0.009$). The pattern was similar in the LWC where the mean species richness of WRP sites was significantly greater than AG sites in early October ($P = 0.008$) (Fig. III.8B).

Use of habitat types by migrant classes also varied over the migration season as demonstrated by the significant interaction between sample period, habitat type, and migrant class (Table III.5). Throughout the study period, the mean species richness of resident birds was significantly greater in BLH sites than in WRP sites and in AG sites (Fig. III.9A). The mean species richness of nearctic-neotropical migrants in BLH sites decreased from September to October, and was significantly greater than the richness of WRP sites and AG sites throughout September (Fig. III.9B). In WRP sites, the species richness of nearctic-neotropical migrants remained consistent from early September to early October. When the number of nearctic-neotropical migrant species in BLH sites decreased in early October, the specie richness of BLH and WRP sites became similar. The richness of both habitats was still significantly greater than the species richness of AG sites (P = 0.009 for both interactions). By late October, the species richness of nearctic-neotropical migrants was similar between the three habitat types.

As autumn migration progressed, the species richness of temperate migrants increased in BLH and WRP sites and remained similar over time in AG sites (Fig. III.9C). The species richness of temperate migrants was significantly greater in BLH sites than in AG sites throughout October (early October, P = 0.003; late October, P = <0.0001), and the species richness of WRP sites was greater than AG sites in late October (P = 0.0002).

In YRB, 82 species were detected over the 2008 autumn migration season (Table III.6). Of the total species detected, 16 were resident species, 39 species were nearctic-neotropical species, and 27 were temperate migrants.

Use of WRPs by migrant groups varied over the migration season. The mean species richness of residents remained consistent throughout the season while the species richness of nearctic-neotropical migrants gradually decreased from early September to late October (Fig. III.10). As autumn migration progressed, the species richness of temperate migrants increased in WRP sites.

Additional analyses will include using the 2008 (fall migration) species probability of occurrence and species richness metrics (from habitat occupancy modeling; 95% Bayesian Credible Intervals) to produce landscape-scale habitat relations models for migratory birds using WRPs in Mississippi. We will use habitat occupancy modeling for a comparison of species probability of occurrence and species richness across the vegetation gradient of sites sampled in Arkansas and Louisiana during fall migration 2006 (AG, WRP, and BLH).

Waterfowl. We calculated the total contribution of WRP to Lower Mississippi Valley Joint Venture (LMVJV) Foraging Habitat Objectives by summing the estimated contributions of hydrology management units (HMU) and the naturally flooded area on WRP easements. We also estimated the potential of WRP HMUs to provide additional foraging habitat if they were all Satisfactory-Active in terms of plant species composition and management intensity. This estimate assumes that 95% of the area within units is in the Satisfactory-Active category producing 4,616 Duck Energy Days (DEDs)/ha, and it assumes that 5% of each unit is managed to provide unharvested corn in the form of food plots producing 70,650 DEDs/ha (Reinecke and Kaminski, LMVJV Waterfowl Working Group; Table 1). Use of a limited amount of row crops for food plots currently is a permissible management practice under WRP guidelines for Mississippi. We used the estimated flooded area values from 2001- 2005 to provide for a consistent comparison between actual conditions and potential conditions.

Our sample of WRP HMUs provided a range of 5,991 ha to 10,503 ha of flooded potential foraging habitat in LA, AR, and MS (Table III.7) during the 4-year period. Most of this variation was caused by differences in annual precipitation and associated spatial extent of flooding. We found that approximately 95% of HMUs were managed passively or not managed at all, and that about 5% were actively managed. However, in terms of total area of WRP HMUs, we classified 41% of HMUs as Satisfactory-Active in terms of plant species composition and management, while 59% were Marginal-Passive/Unsatisfactory-Unmanaged with a large coverage of undesirable vegetation and consequently substantially lower waterfowl food production. Herein, we combined Marginal-Passive and Unsatisfactory-Unmanaged because conditions in both were not favorable for significant production of waterfowl foods and both categories were in immediate need of management action.

Collectively, the combined Marginal-Passive and Unsatisfactory-Unmanaged WRP HMUs provided 4.7% to 8.3% of the tri-state LMVJV foraging habitat objective (Table III.7). The net increase in potential foraging capacity resulting from restoration of marginal soybean agricultural land to emergent wetland ranged from 18.96 to 33.24 million DEDs (Table III.7).

Contributions of naturally flooded, reforested area within WRP easements to foraging habitat objectives were estimated for Arkansas, Louisiana and Mississippi (Table III.8). Landowner enrollment increased from 2001-2005 with sample size of WRP easements increasing from 228 to 342 in Arkansas , 447 to 652 in Louisiana, and 371 to 437 in Mississippi. Concurrently, the estimated acreage under easement increased from 32,907 to 49,432 ha in Arkansas, 45,141 to 67,919 ha in Louisiana and 37,186 to 45,125 ha in Mississippi. Flooded area within easements ranged from 10.8 to 45.3% in Arkansas, 10.5 to 21.0% in Louisiana and 12.2 to 39.2% in Mississippi. Reforested lands on WRP easements contributed from 1.5 to 5.3% of the foraging habitat objective in Arkansas, 3.7 to 5.5% in Louisiana and 5.1 to 13.6% in Mississippi with variation among years due largely to variation in annual precipitation. The net increase in potential foraging capacity resulting from restoration of marginal soybean agricultural land to reforested bottomland hardwoods ranged from 2.80 to 10.18 million DEDs in Arkansas, 3.93 to 5.75 million DEDs in Louisiana and 3.24 to 8.57 million DEDs in Mississippi. Collectively, WRP reforested lands provided 2.8 to 6.4% of the tri-state LMVJV foraging habitat objective which provided a net increase in potential foraging capacity from 9.98 to 22.92 million DEDs.

Amphibians Phase 1. The maximum number of amphibian species found was 12 in 2006, of which all occurred at BLH sites (Table III.9). The BLH sites had a mean species richness of 11.5;

however, mean species richness in the AG and WRP sites was 4.5 and 9.0, respectively. In 2006-2007, 11 species (*Acris blanchardi*, *Anaxyrus fowleri*, *Gastrophryne carolinensis*, *Hyla chrysoscelis*, *H. cinerea*, *H. squirella, Lithobates catesbeianus*, *L. clamitans*, *L. sphenocephalus*, *Pseudacris crucifer*, and *P. fouquettei*) were found in both WRP and BLH habitats.

Only 5 species met the minimum criteria of at least 30 detections during the sampling period for occupancy analysis (Table III.10). Information-theoretic model selection indicated that in four of the species the better model was Ψ_{hab}p., with almost no support (AIC weight) for Ψ*.p.*. In one species, the Green Treefrog, there was nearly equal support for both models. Aside from the ambiguity in the Green Treefrog, there was a large amount of evidence that there are different rates of occurrence of the five anuran species by land use category. Parameter estimates of Ψ were lowest at AG sites for all species except for the Southern Leopard Frog (Fig. III.11). The Cope's Gray Treefrog had an intermediate rate of occupancy in WRP, while the Green Treefrog had nearly equal rates of occupancy in WRP and BLH. Occupancy rates of American Bullfrogs and Southern Leopard Frogs were highest in WRP, while for Bronze Frogs, the highest rate of occupancy was in BLH.

The result that the majority of species found in BLH were also found in WRP indicates that patches undergoing restoration may be an important transitional habitat for those species that prefer an open canopy, vertical structure, and habitat heterogeneity. The preliminary findings indicate that conservation practices implemented to restore wetlands on lands enrolled in WRP can help alleviate the effects of agriculture-induced habitat loss on amphibian species richness in the MAV.

Our occupancy modeling results indicate that WRP sites were much more likely to be occupied by the five frog species than AG sites (Fig. III.11). BLH sites were much more likely to be occupied by Cope's Gray Treefrogs than WRP sites, but BLH sites were only slightly more likely to be occupied by Green Treefrogs and Bronze Frogs than WRP sites. Cope's Gray Treefrogs are generally forest dwelling frogs and tend to breed at sites near forested areas (Ritke et al. 1991), so it is possible that although WRP sites are an improvement over AG sites, Cope's Gray Treefrogs may require more forested areas to maximize occurrence. Model selection indicated that there was roughly equal support for the hypotheses that Green Treefrog occupancy is constant and different across land-use categories. The generalist nature of Green Treefrogs (Trauth et al. 2004) probably explains both the high rate of occupancy and the lack of support for a habitat effect on occurrence.

The American Bullfrog and the Southern Leopard Frog had the highest probability of occurrence in WRP (Fig. III.11). These species, along with the Bronze Frog clearly benefited from WRP relative to AG. These are highly aquatic species with tadpoles that require long time periods to metamorphosis, thus the presence of permanent water is critical habitat for these species (Trauth et al. 2004). It is likely that the hydrologic restoration that is conducted as part of the WRP restoration may provide exceptional habitat for these frog species, leading to high rates of occurrence in WRP relative even to forest habitat.

When interpreting the results of the occupancy modeling for the anuran species, it is important to remember that we are only monitoring vocalizations. Anurans call for various reasons, but the majority of calls are advertisement calls used by males to attract gravid females or to mediate aggression with other males (Gerhardt 1994). Not all species that occur in the study area are equally likely to be breeding and therefore vocalizing during the time period we used in our analysis. However, it seems likely that the species modeled may serve as indicators for the rest of the anuran community. Another important fact about calling anurans is they tend to vocalize from or very near a breeding site (Duellman and Trueb 1986), which for all of the species that occur in the study area is standing water (Dundee and Rossman 1989). Therefore the presence of water was likely very influential on the calling behavior of the species.

Although it is possible to include covariates to account for sources of heterogeneity in both Ψ and *p* in the model we used (MacKenzie et al. 2002), we did not. We had a relatively small number of sites per habitat stratum (MacKenzie et al. 2006), and therefore had little power to use site covariates for Ψ. Sampling occasion covariables would be very difficult to include because each "sample" in our analysis represents a composite of the recordings over a 7-night period. These recordings come from various nights and from various times of night, so it is impossible to define a covariate that describes each sampling occasion for comparison with other sampling occasions. We must therefore make the assumption that there is no unmodeled heterogenity in detection probabilities across sampling occasions at the different sites (MacKenzie et al. 2006).

Amphibians Phase 2. Over 1,000 observations of 11 anuran species were made by visual encounter surveys in WRP and AG sites, with ~75% of observations occurring in WRP sites (Table III.11). Six of the 11 species were infrequently seen, with two species having only a single observation. The most commonly observed anuran in both land use categories was the Southern Leopard Frog, *L. sphenocephalus*. All anuran species, with the exception of the true toads, *A. fowleri* and *A. americanus*, had a higher observation rate in WRP than AG sites.

When using both visual encounter and vocalization surveys to examine the proportion of sites where the given species was detected, or the naïve occupancy, WRP sites had an equal or higher naïve occupancy for all species with the exception of the American Toad, *A. americanus*, which had only a single observation at an AG site (Table III.12). Southern Leopard Frogs were found at all WRP sites and all but three of the AG sites. Commonly observed anurans such as Blanchard's Cricket Frog (*A. blanchardi*), the Green Treefrog (*H. cinerea*), and the American Bullfrog (*L. catesbeianus*) were encountered at nearly all WRP sites, but less than half of AG sites.

Conclusions

The greater tree species diversity of the BLH forest and the dominance of oak species on WRP are not surprising given the narrow range of species planted on WRP. The high density of oaks and the near absence of important species like water hickory, hackberry, flowering dogwood, sweetgum, cherrybark oak, and American elm suggest that the mature forests resulting from these planting practices will be very different from the existing naturally regenerated forests.

There were significant improvements in wildlife habitat resulting from the conservation practices on the WRP. Despite the predominance of primarily oak species planted on WRP sites, there were significantly more migratory bird species, but not resident species, compared with AG sites. Increasing the diversity of species planted while remaining cognizant of species-site requirements, will likely improve the habitat for both resident and migratory birds. The restoration of hydrologic conditions more typical of riparian forested wetlands resulted in higher probability of occurrences of frog species that require permanent water sources (e.g., American Bullfrog, Southern Leopard Frog) and more waterfowl habitat. More rigorous implementation and intensive management of water control structures could potentially increase duck energy days (DEDs) by up to 60%.

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Stelzer, T. Thigpen, P. Vasseur, and I. Wiggins. We are also grateful to the private land owners, U.S. Fish and Wildlife Service, and Louisiana Department of Wildlife and Fisheries for granting access to the study sites. We thank Patrick Megonigal, Camille Stagg, and Diane Eckles for thoughtful reviews. Statistical review was performed by D. Johnson. Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

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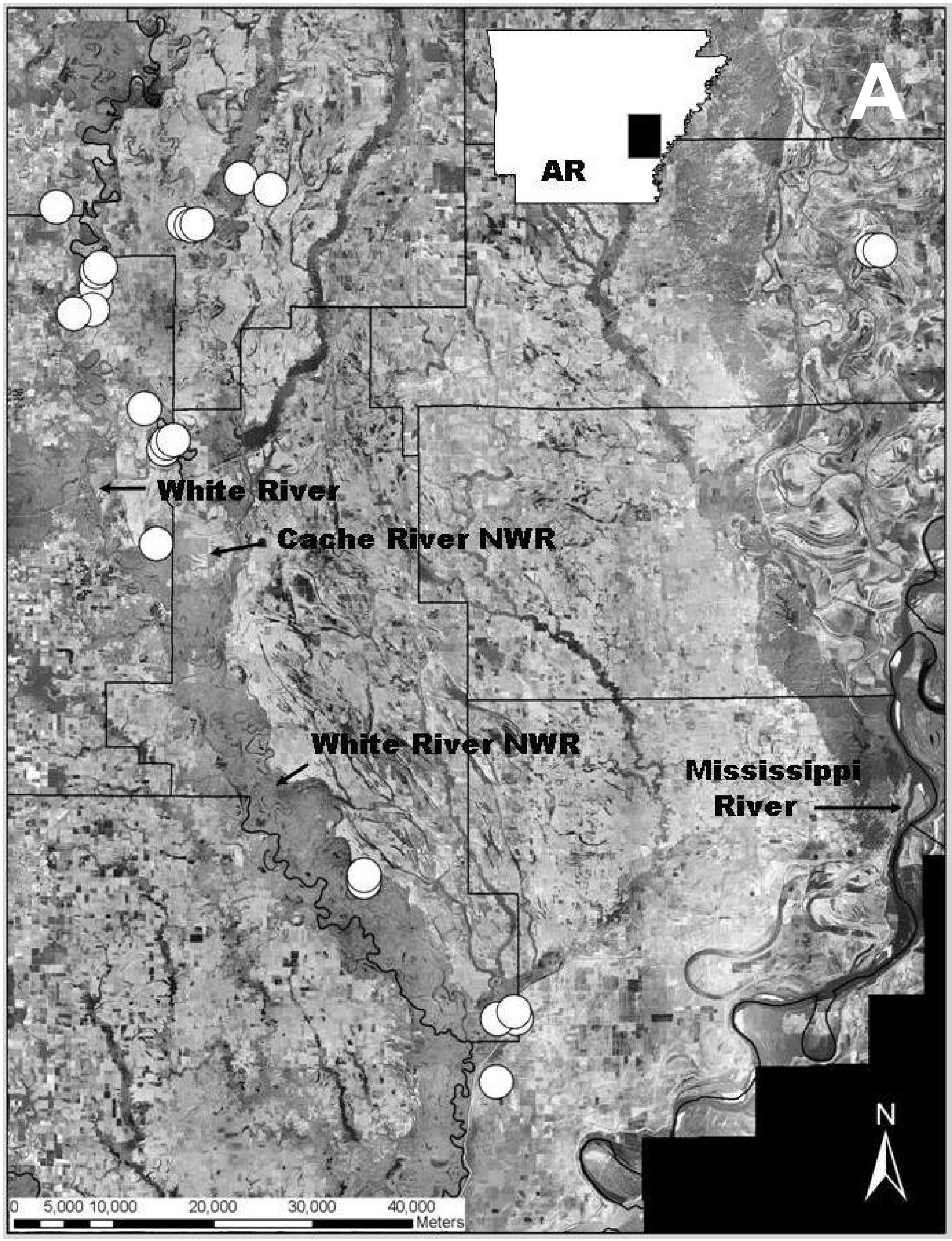

Figure I.1. Location of study sites in the Lower White/Cache River Basin (LWC), AR.

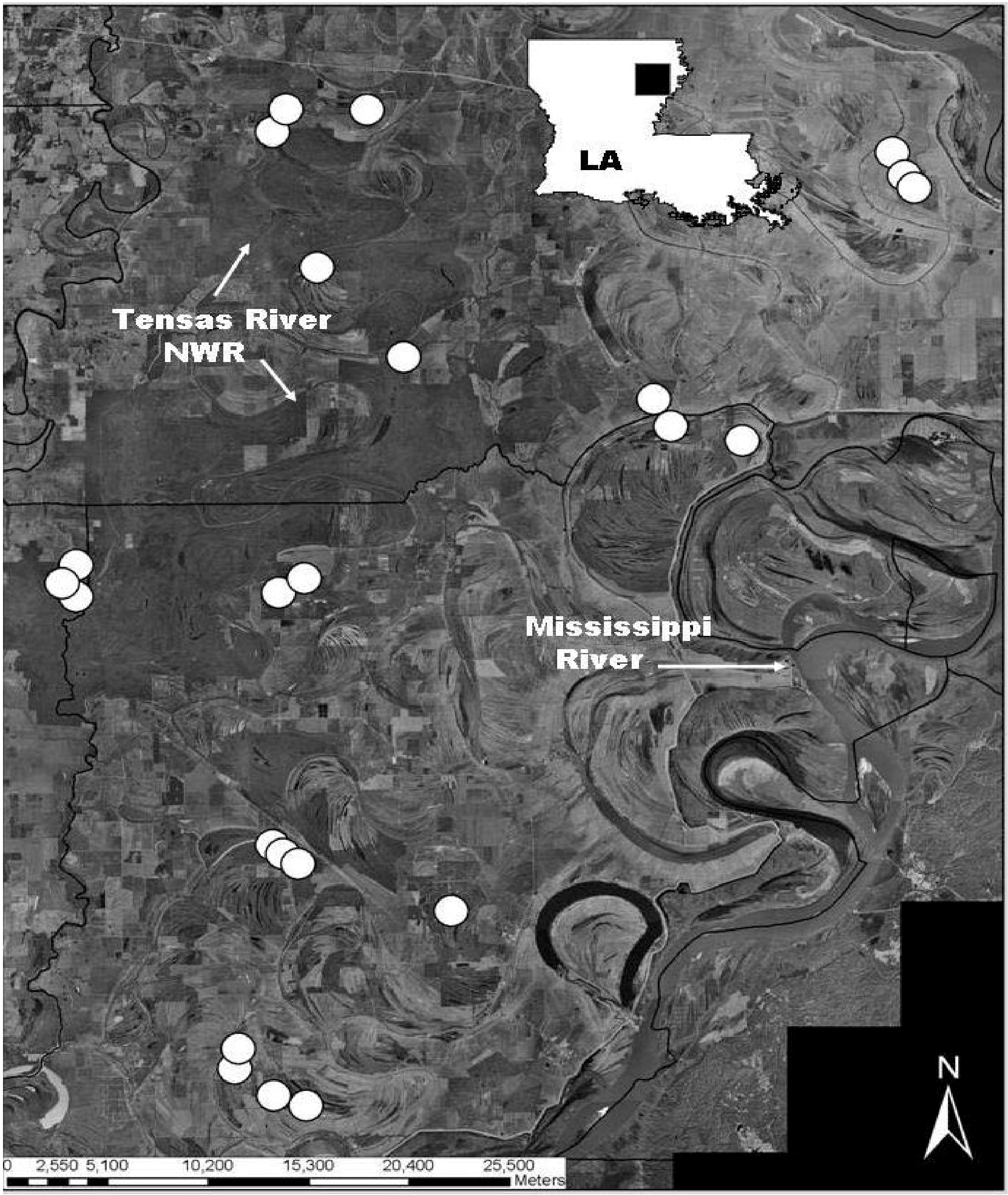

Figure I.2. Location of study sites in the Tensas River Basin (TRB), LA.

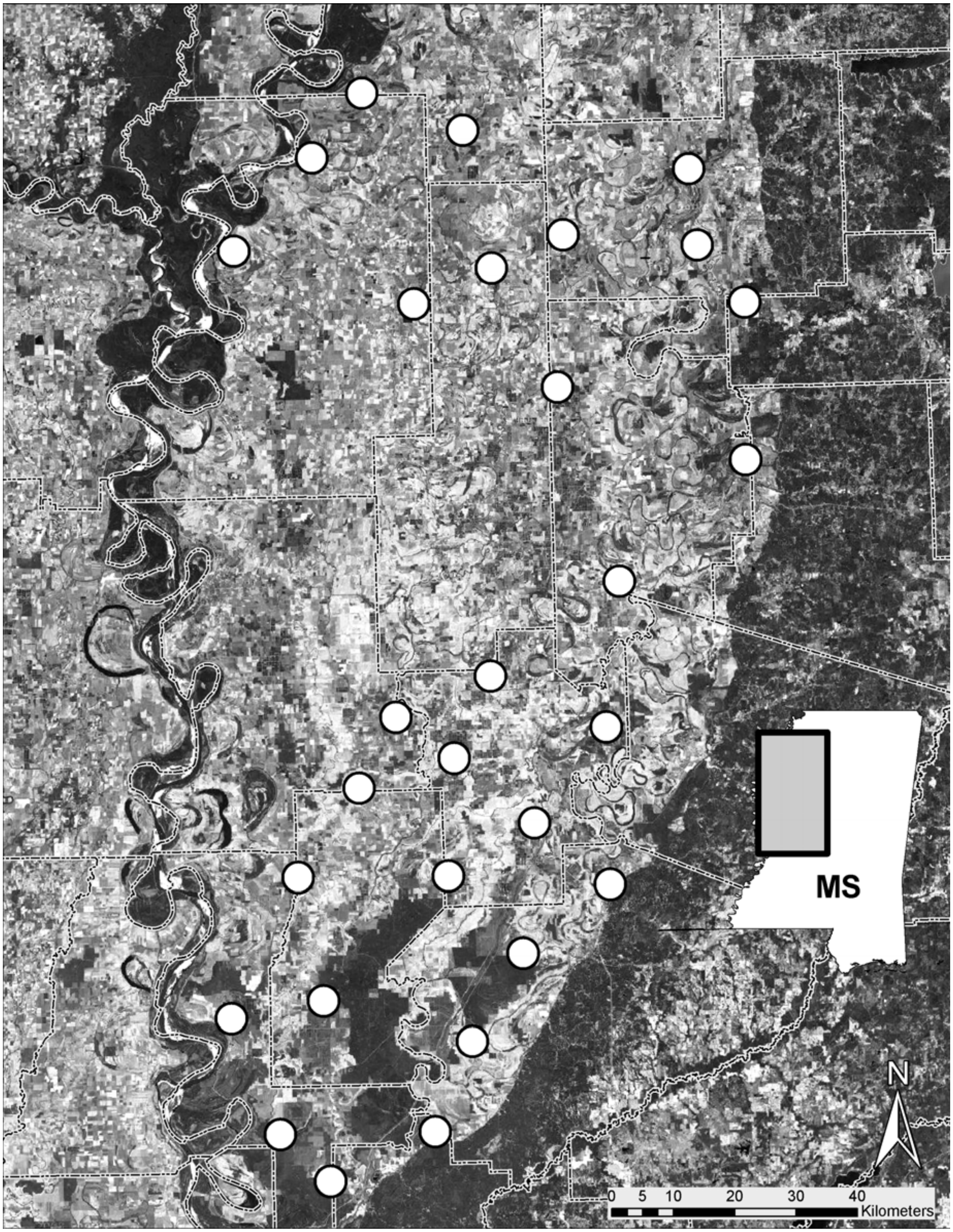

Figure I.3. Location of study sites in the Yazoo River Basin (YRB), MS.

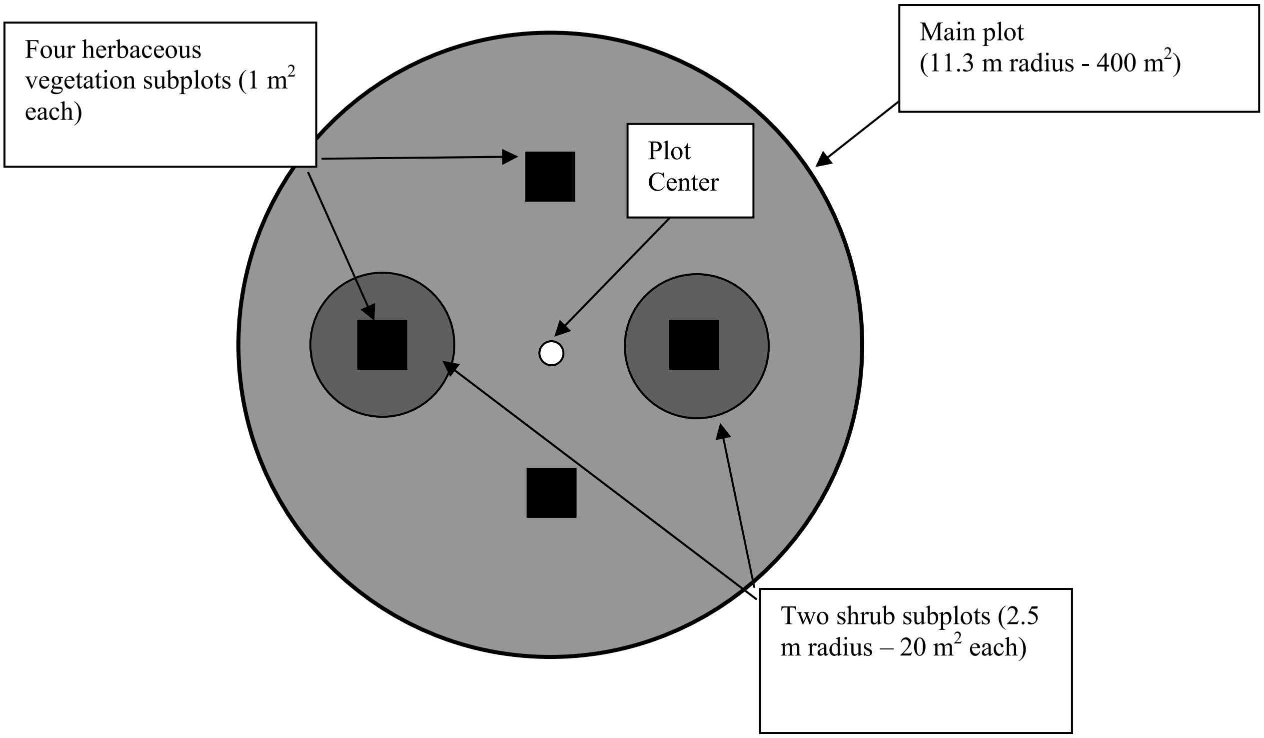

Figure II.1. Layout of vegetation sampling plots in Tensas River Basin (TRB), LA and Lower White/Cache River Basin (LWC), AR. The same 400 m^2 plot was used in Yazoo River Basin (YRB), MS, but only two herbaceous plots were sampled and no shrub-subplots were sampled. Instead, all trees and shrubs > 0.3m tall were surveyed in the main plot.

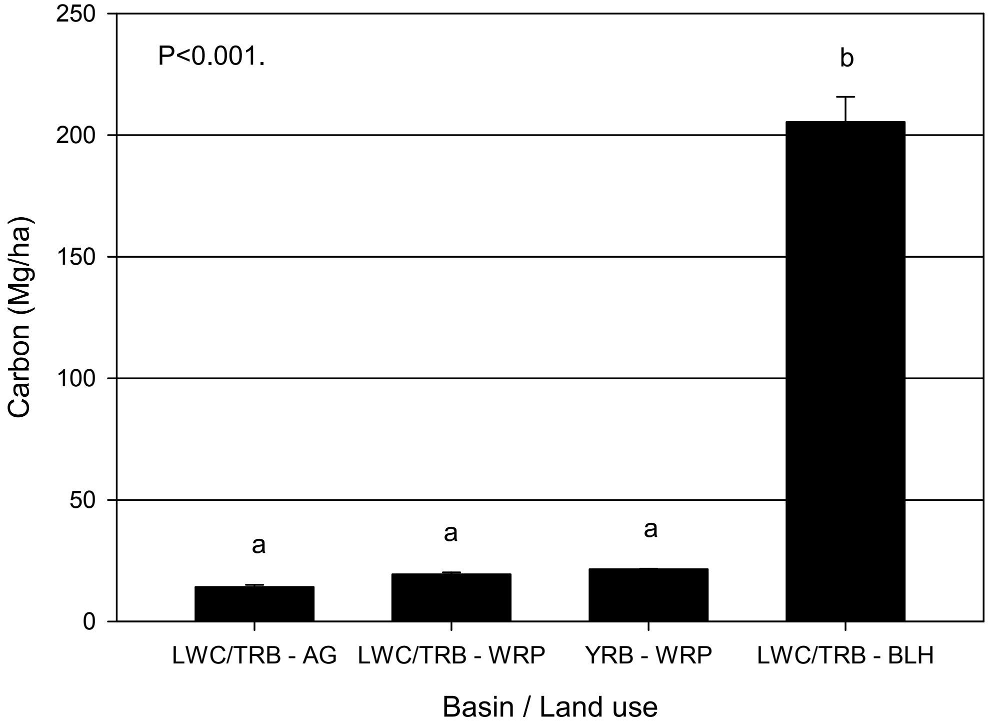

Figure II.2. Total carbon (Mg/ha) stored aboveground (tree, understory, and forest floor) and belowground (soil 0-10 cm depth) in active crop land (AG), Wetlands Reserve Program (WRP), and natural forest (BLH) sites in the Tensas (TRB), LA, Lower White/Cache (LWC), AR, and Yazoo (YRB), MS River Basins.

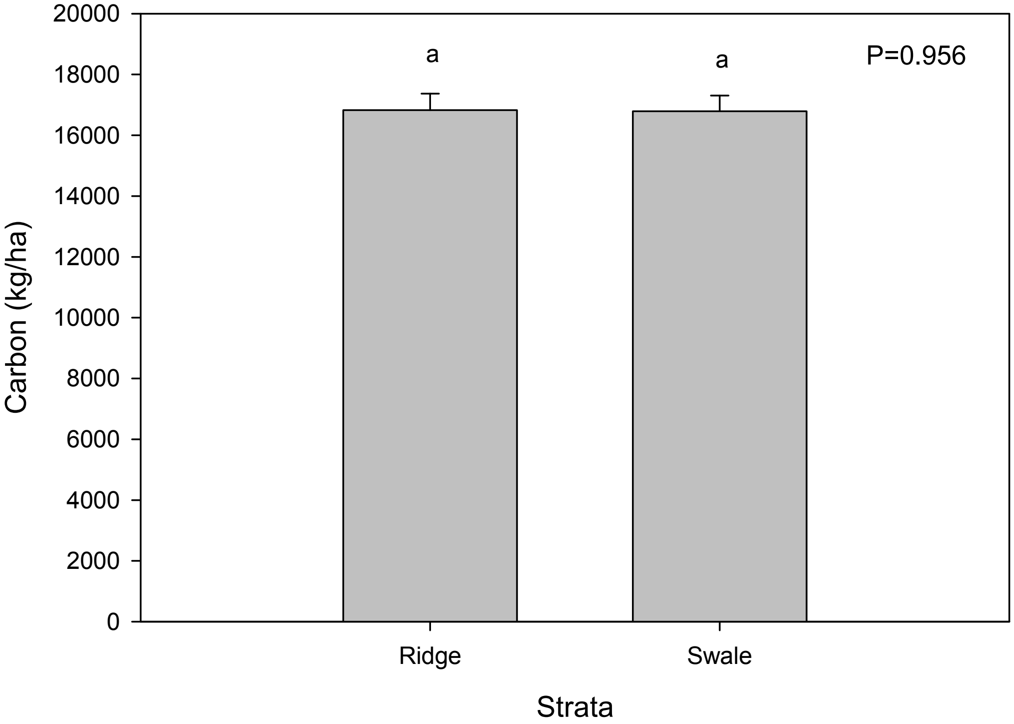

Figure II.3. Total soil carbon (kg/ha) in the Yazoo River Basin (YRB), Mississippi by ridge versus swale. Means with the same letter are not significantly different.

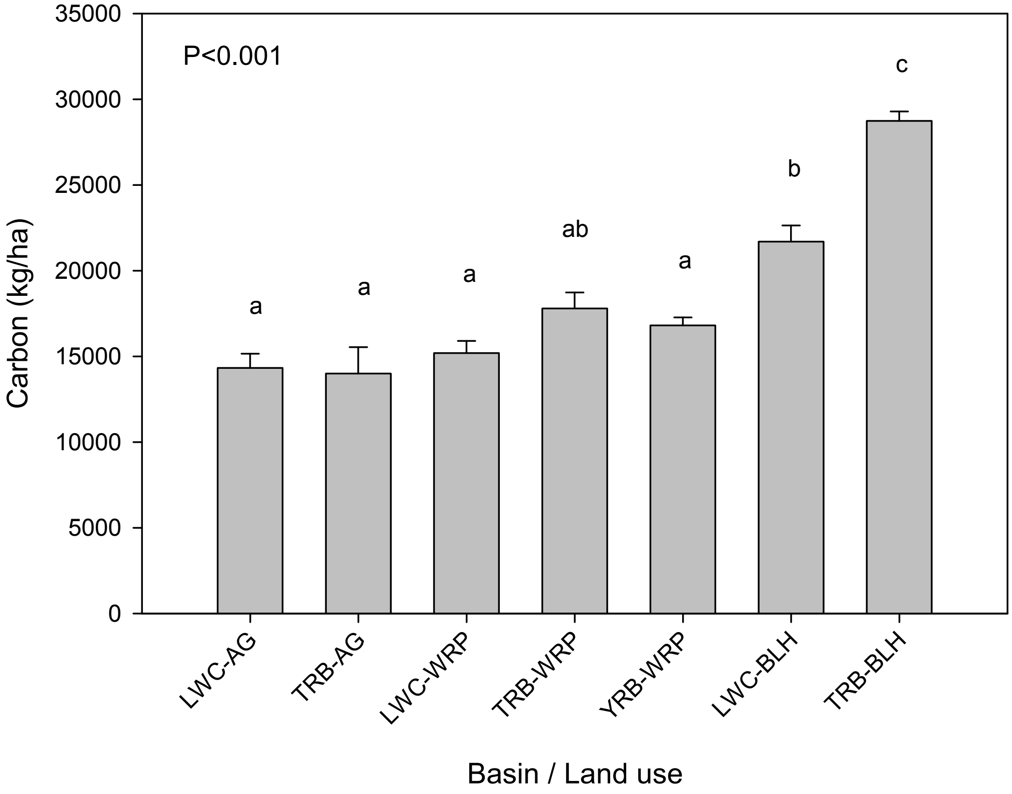

Figure II.4. Total soil carbon (kg/ha) in active crop land (AG), Wetlands Reserve Program (WRP), and natural forest (BLH) in the Tensas (TRB), LA, Lower White/Cache (LWC), AR, and Yazoo (YRB), MS River Basins. Means with the same letter are not significantly different.

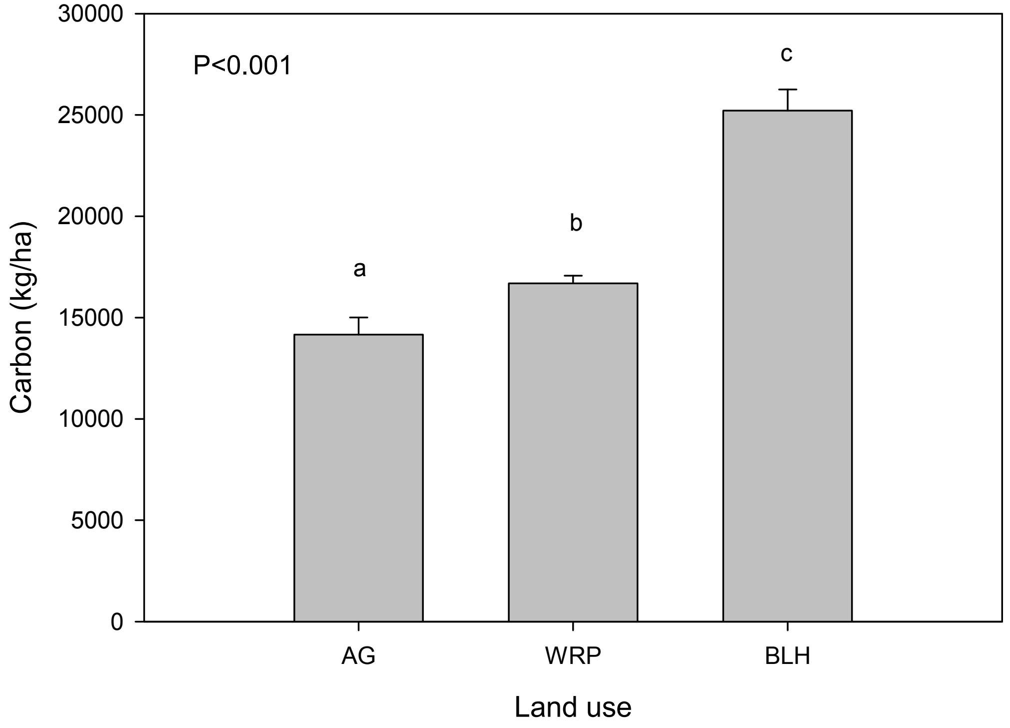

Figure II.5. Total soil carbon (kg/ha) in active crop land (AG), Wetlands Reserve Program (WRP), and natural forest (BLH) study sites with river basins combined. Means with different letters are significantly different at alpha = 0.05.

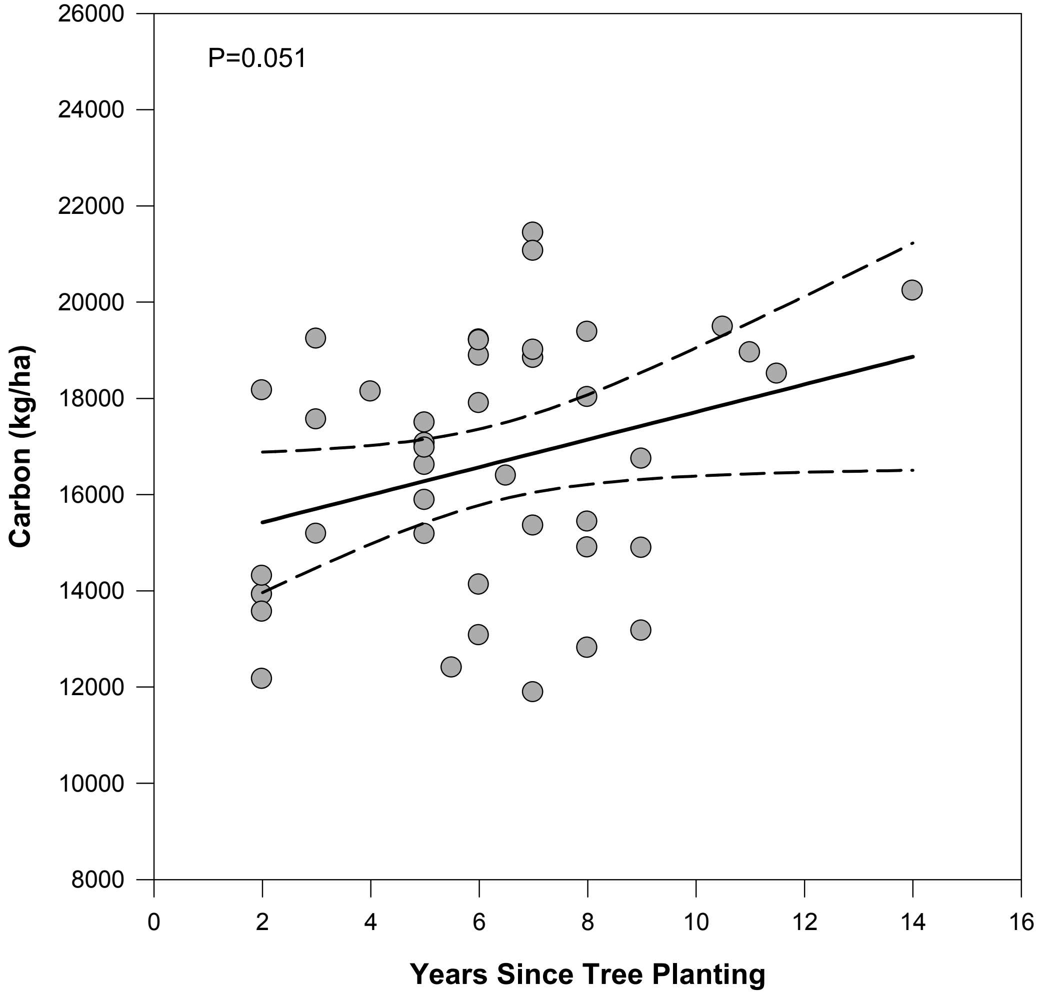

Figure II.6. Regression of total soil carbon (kg/ha) (0-10 cm below surface) plotted against the number of years since tree planting on the WRP sites (p=0.051). When planting date was unknown, the observation was excluded from the analysis.

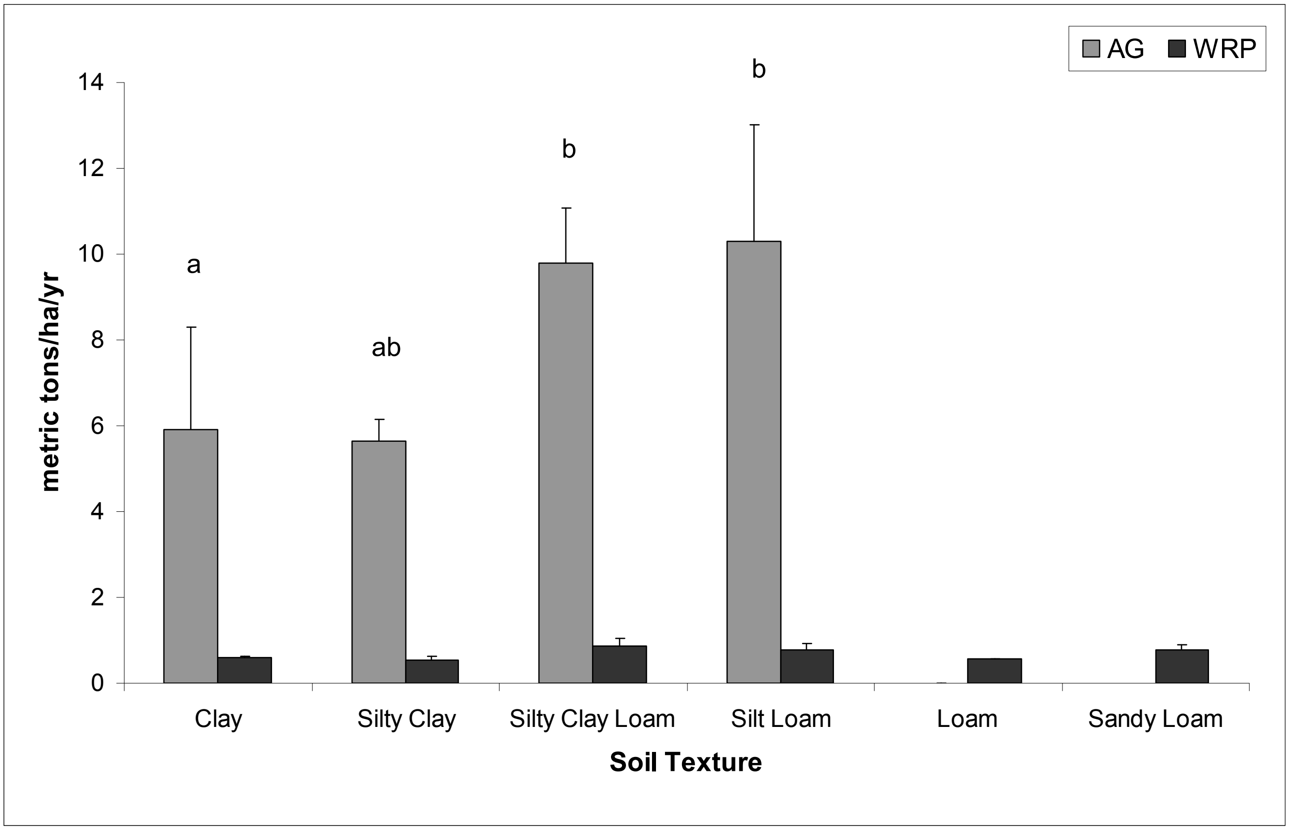

Figure II.7. Sediment erosion losses by soil texture class from active crop land (AG) and Wetlands Reserve Program (WRP) in the Tensas (TRB), LA, Lower White/Cache (LWC), AR, and Yazoo (YRB), MS River Basins. No loam or sandy loam soils occurred on the AG sites Erosion estimates were significantly lower for WRP sites than AG ($p<0.001$). Erosion rates were not consistent across soil texture classes ($p<0.001$). Letters depict texture comparisons only. Means with the same letter are not significantly different at alpha = 0.05.

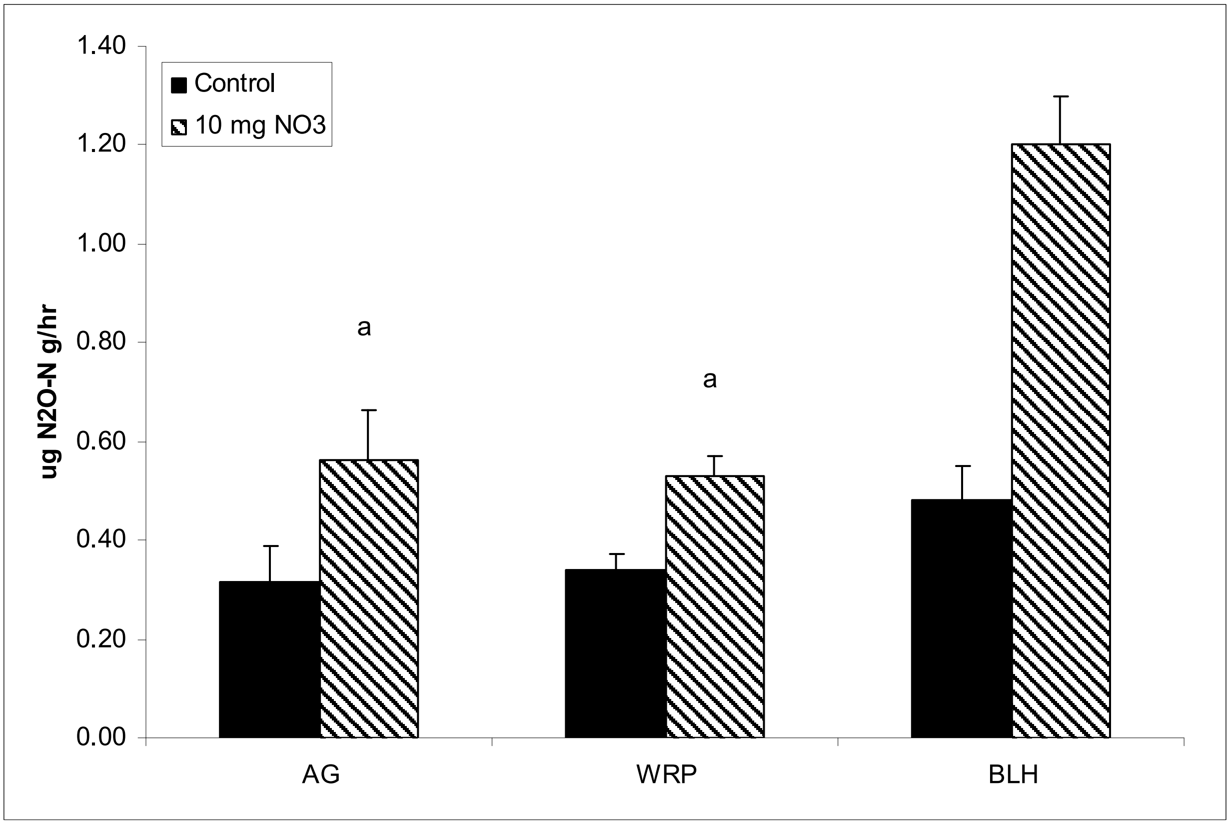

Figure II.8. Soil denitrification potentials for active crop land (AG), Wetlands Reserve Program (WRP), and natural forest (BLH) in the Tensas, LA, Yazoo, MS, and Lower White/Cache, AR River Basins. Denitrification data were not different between AG and WRP sites (p=0.532), but were different between nitrate amended and control samples (p=0.003) (Note: BLH data were not included in the comparisons). Letters depict land use comparisons only. Means with the same letter are not significantly different at alpha = 0.05.

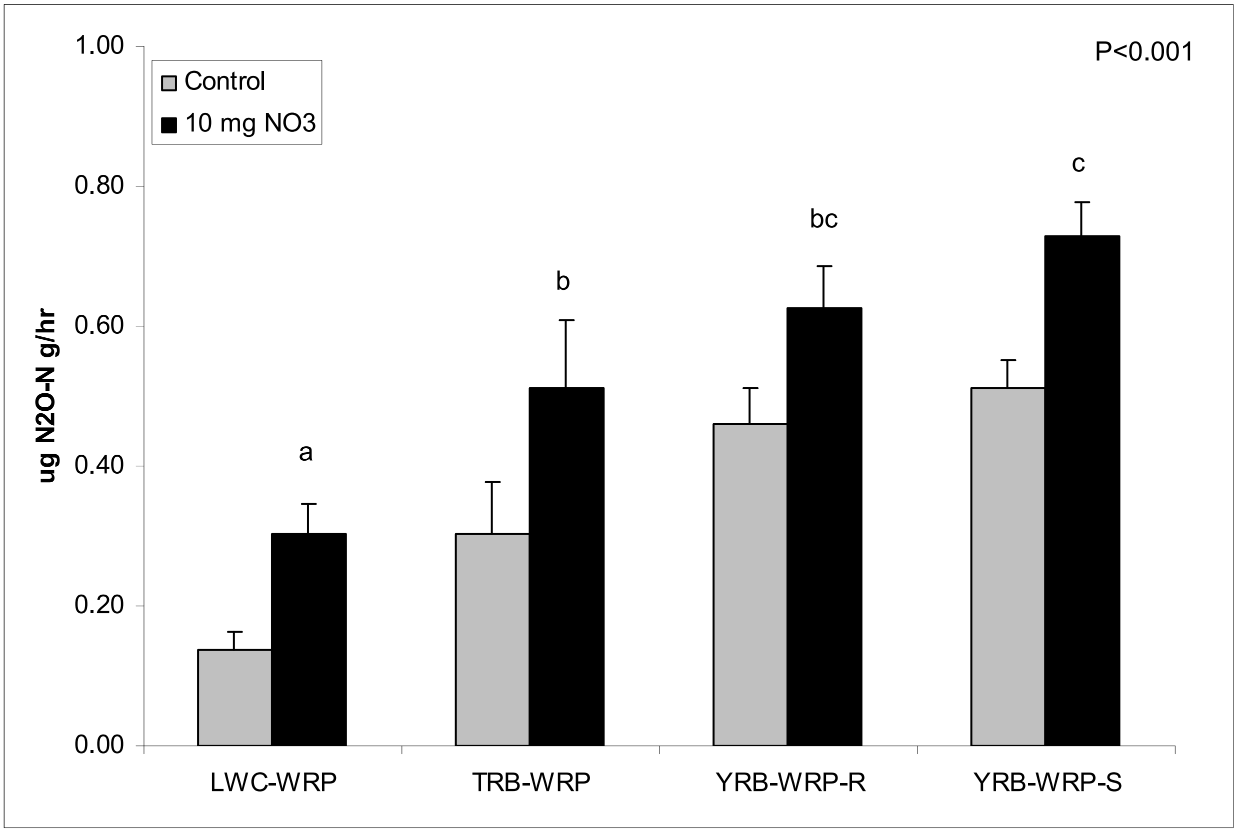

Figure II.9: Soil denitrification potentials for Wetlands Reserve Program (WRP) sites in the Tensas (TRB), LA, Yazoo (YRB), MS, and Lower White/Cache (LWC), AR River Basins. YRB sites are stratified into ridge (WRP-R) and swale (WRP-S). Letters only depict comparisons among basins. Means with different letters are significantly different at alpha = 0.05.

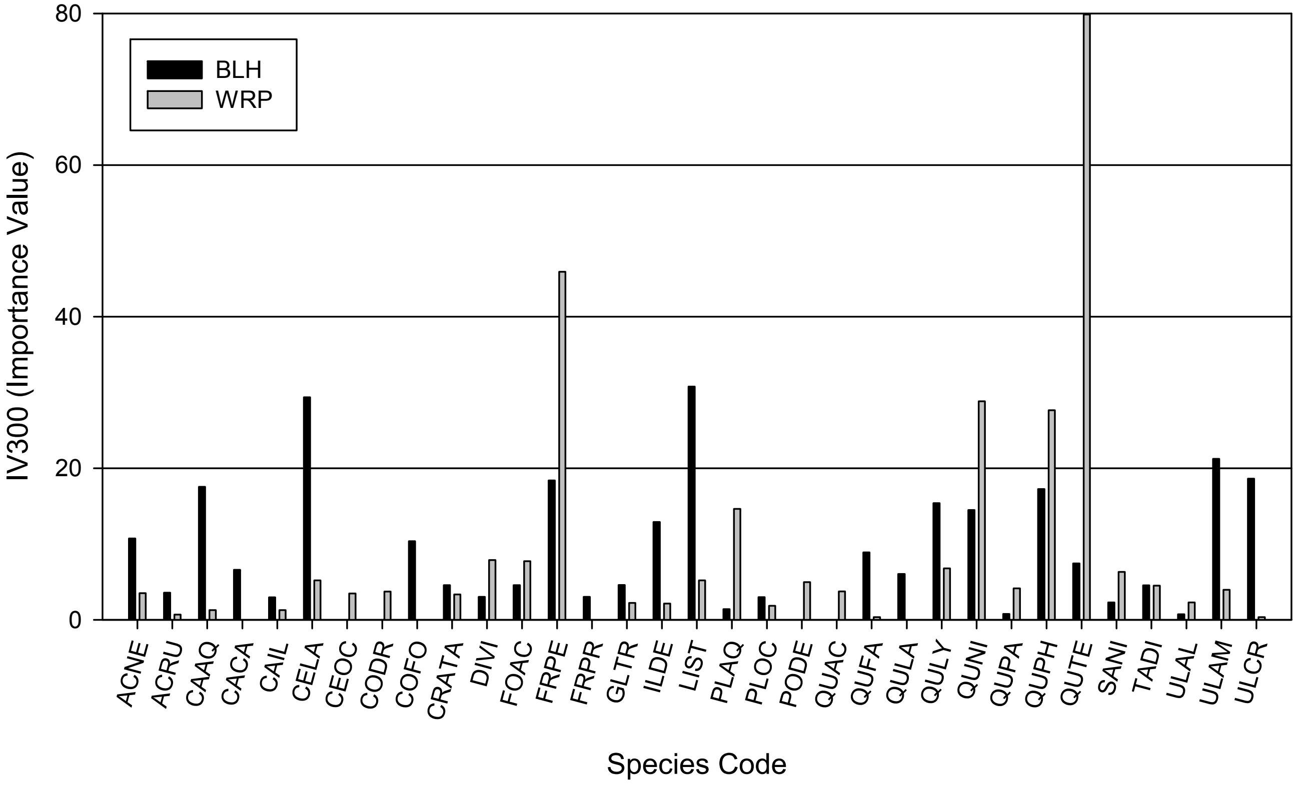

Figure III.1. Importance values (IV300) for tree species detected in the natural forest stands (BLH) and afforested stands (WRP). Species with IV300 < 3 were excluded from this graph. See Table III.13 for a description of the species codes.

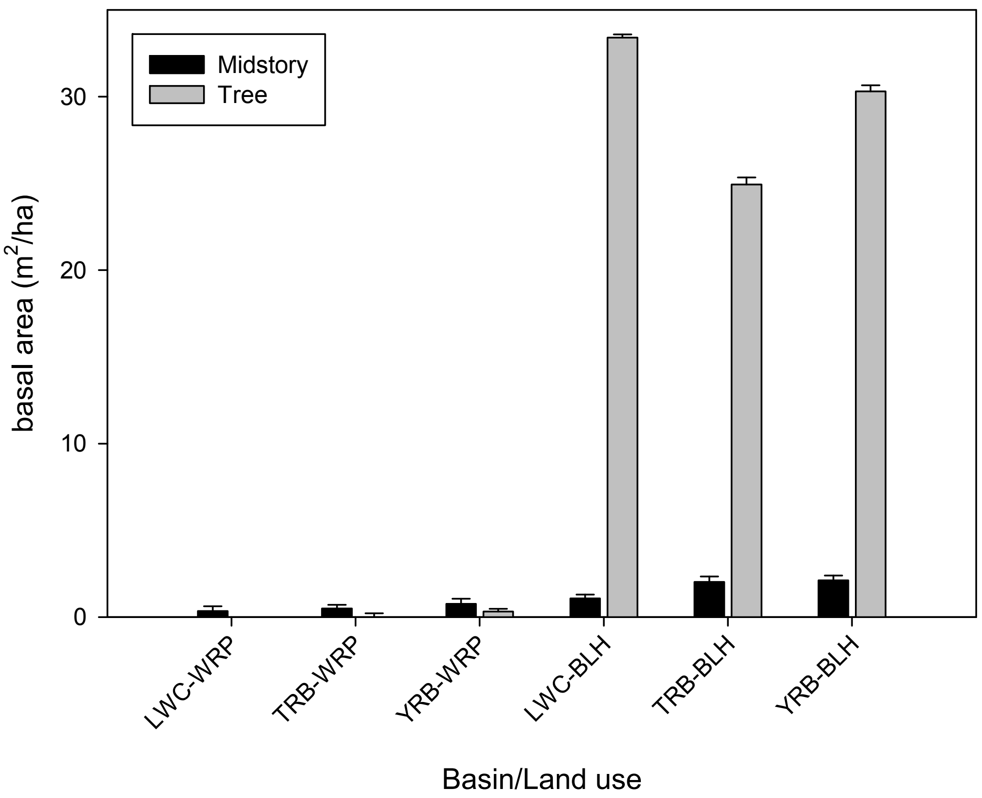

Figure III.2. Mean basal area (m^2/ha) of trees and shrubs by size class in Wetlands Reserve Program (WRP) and natural forest (BLH) in the Tensas (TRB), LA, Lower White/Cache (LWC), AR, and Yazoo (YRB), MS River Basins. Midstory class = 2.5cm ≤ dbh < 10cm, and Tree class = ≥ 10cm dbh. Note: BLH data for the YRB came from U.S. Forest Service Forest Inventory and Analysis (FIA) data.

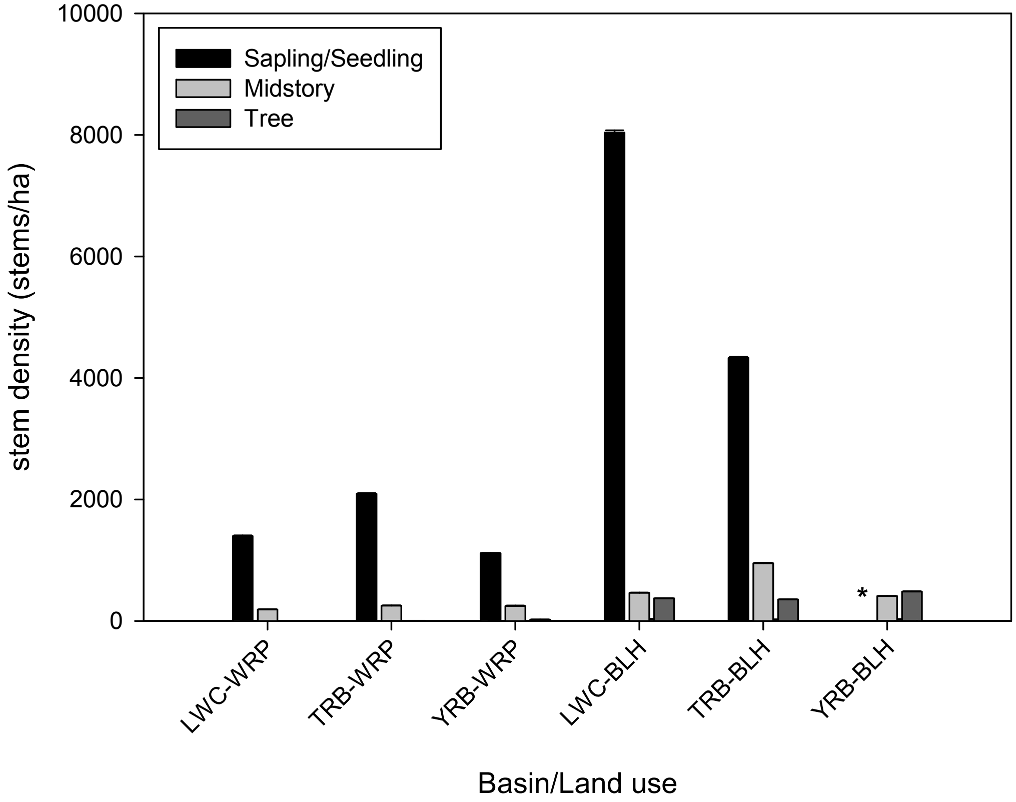

Figure III.3. Mean stem density (stems/ha) of woody species by size class in Wetlands Reserve Program (WRP) and natural forest (BLH) in the Tensas (TRB), LA, Lower White/Cache (LWC), AR, and Yazoo (YRB), MS River Basins. Sapling/Seedlings class = ≥ 0.3m in height and < 2.5cm dbh; Midstory class = 2.5cm ≤ dbh < 10cm; and Tree class = ≥ 10cm dbh. BLH data for the YRB came from U.S. Forest Service Forest Inventory and Analysis (FIA) data.

* indicates no sapling/seedling data available from FIA dataset.

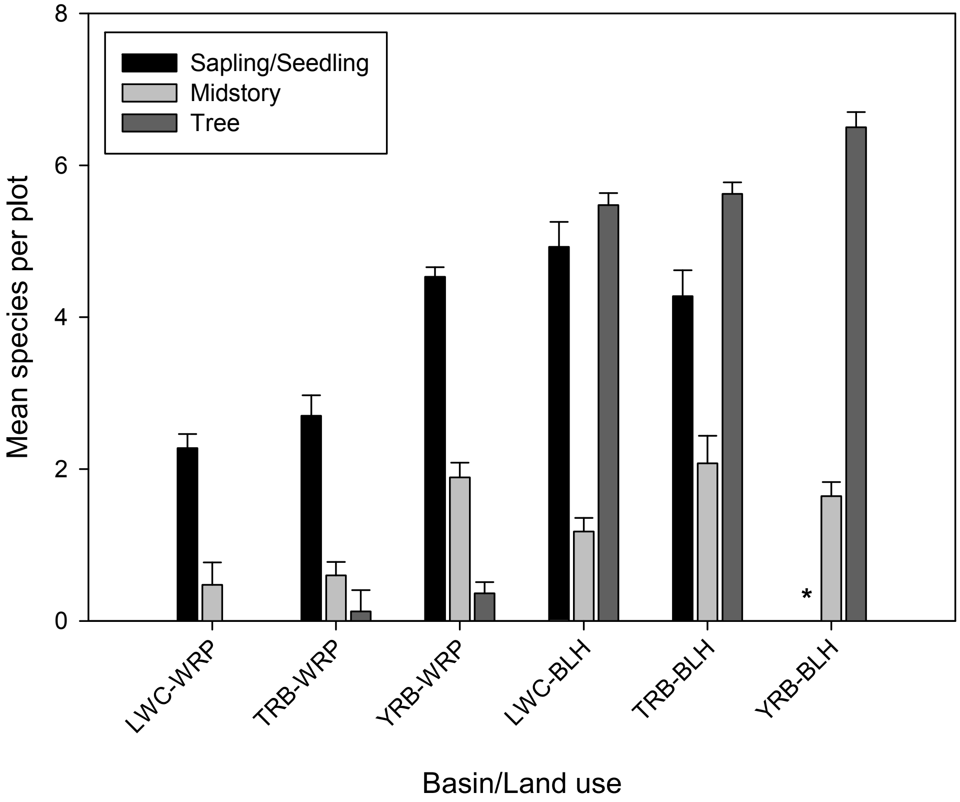

Figure III.4. Mean number of woody species detected per plot by size class in Wetlands Reserve Program (WRP) and natural forest (BLH) in the Tensas (TRB), LA, Lower White/Cache (LWC), AR, and Yazoo (YRB), MS River Basins. Sapling/Seedlings class = ≥ 0.3m in height and < 2.5cm dbh; Midstory class = 2.5cm ≤ dbh < 10cm; and Tree class = ≥ 10cm dbh. BLH data for YRB came from U.S. Forest Service Forest Inventory and Analysis (FIA) data.

* indicates no sapling/seedling data available from FIA dataset.

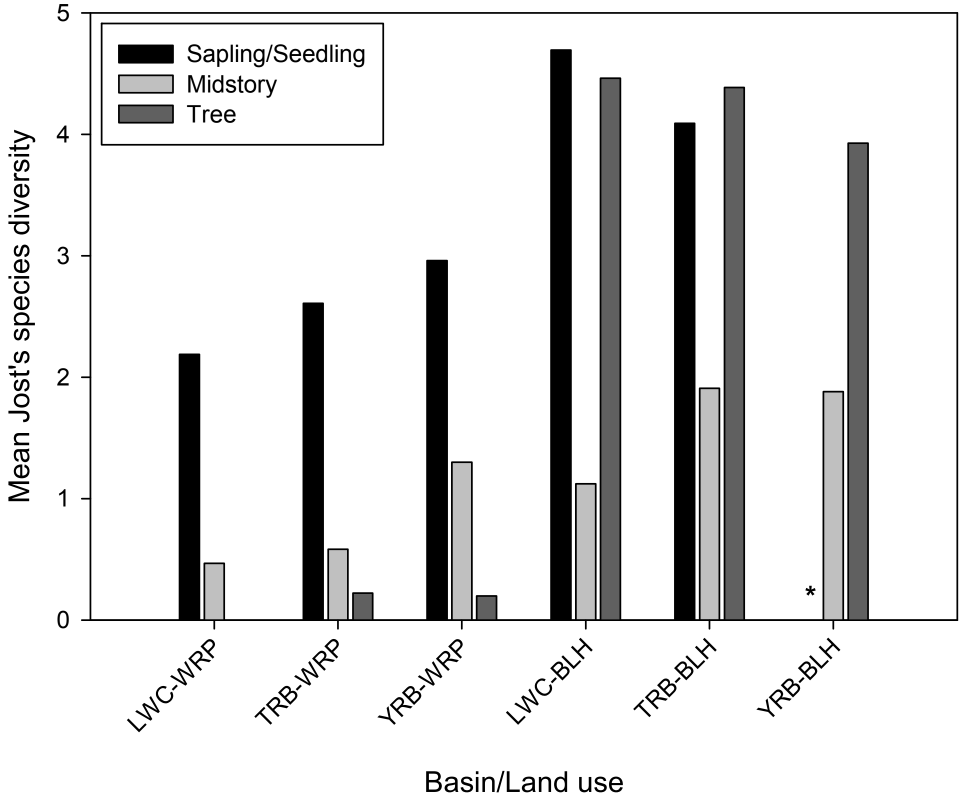

Figure III.5. Mean species diversity per plot using Jost's method for measuring diversity. Means presented by size class in Wetlands Reserve Program (WRP) and natural forest (BLH) in the Tensas (TRB), LA, Lower White/Cache (LWC), AR, and Yazoo (YRB), MS River Basins. Sapling/Seedlings class = ≥ 0.3m in height and < 2.5cm dbh; Midstory class = 2.5cm ≤ dbh < 10cm; and Tree class = ≥ 10cm dbh. BLH data for the YRB came from U.S. Forest Service Forest Inventory and Analysis (FIA) data.

* indicates no sapling/seedling data available from FIA dataset.

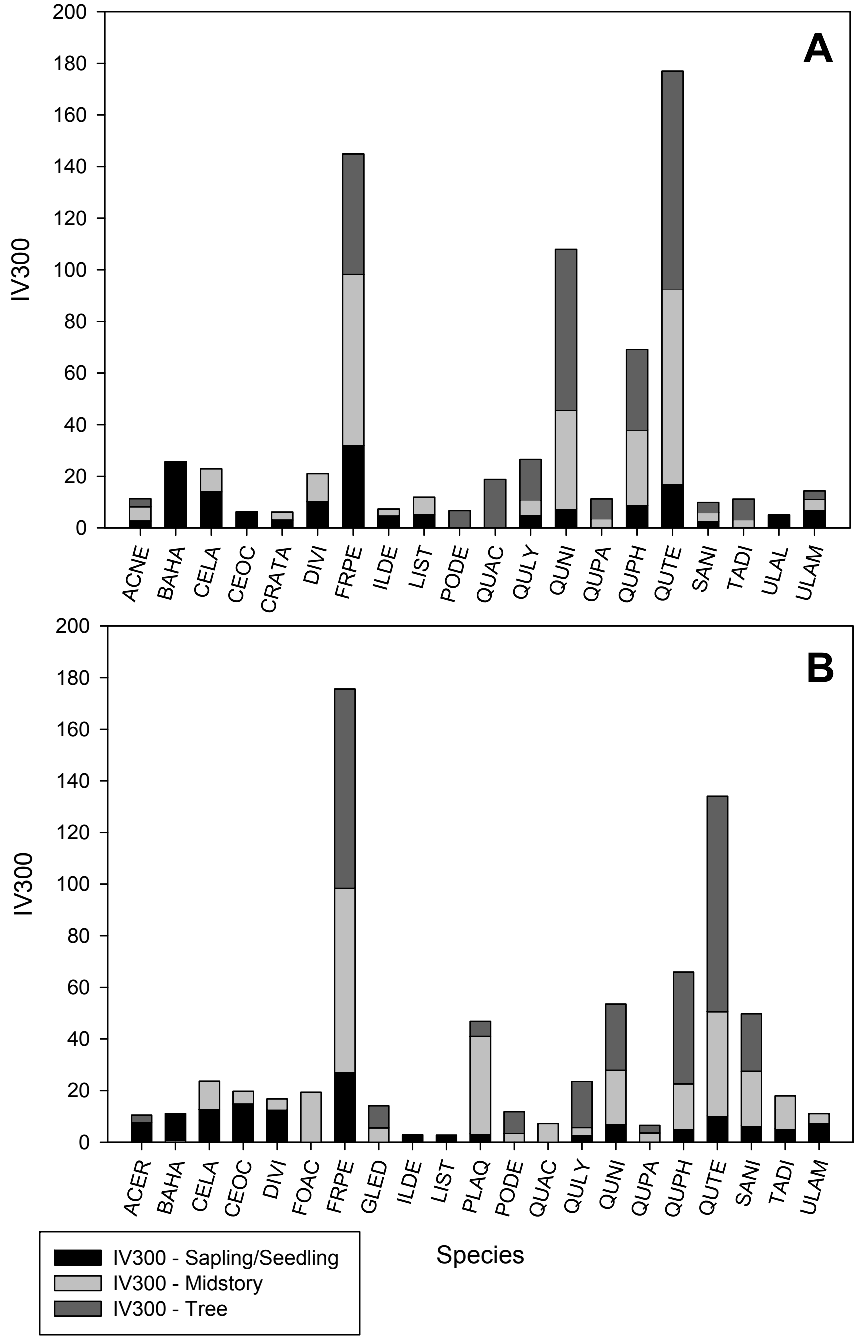

Figure III.6. Importance values (IV300) of trees and shrubs on WRPs in the Yazoo River Basin (YRB), MS by strata: (A) swale and (B) ridge. Sapling/Seedlings = ≥ 0.3m in height and < 2.5cm dbh; Midstory = 2.5cm ≤ dbh < 10cm; and Tree = ≥ 10cm dbh. See Table III.13 for a description of the species codes.

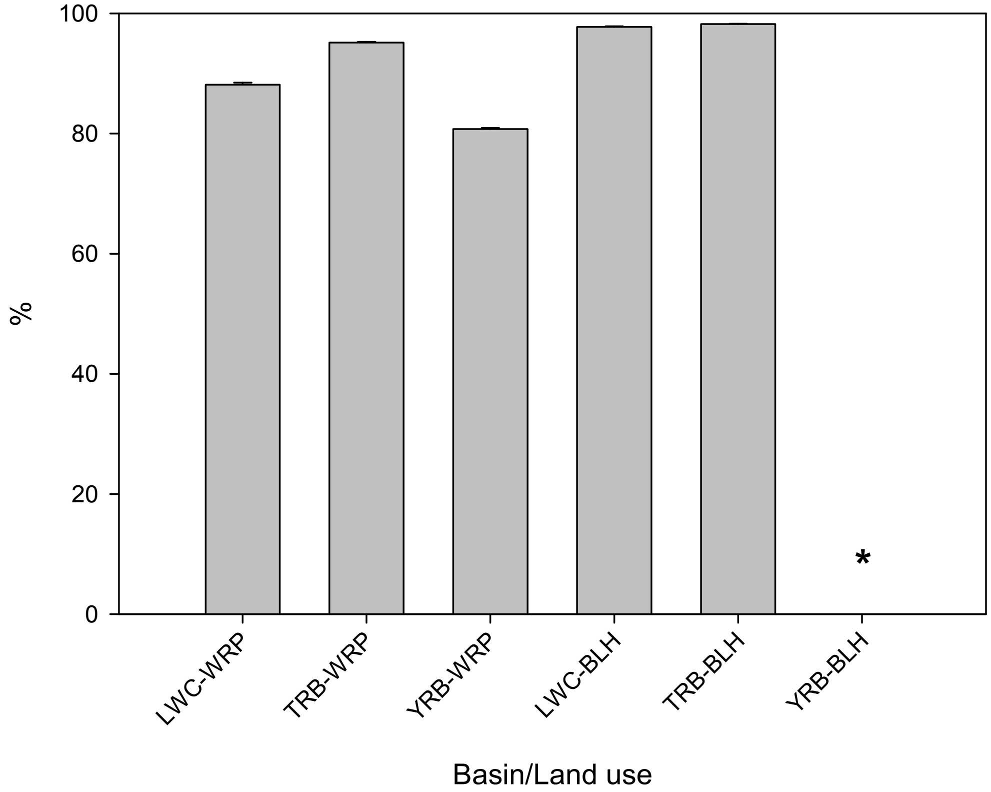

Figure III.7. Mean percent herbaceous cover in Wetlands Reserve Program (WRP) and natural forest (BLH) in the Tensas (TRB), LA, Lower White/Cache (LWC), AR, and Yazoo (YRB), MS River Basins.

* indicates no sapling/seedling data available from FIA dataset.

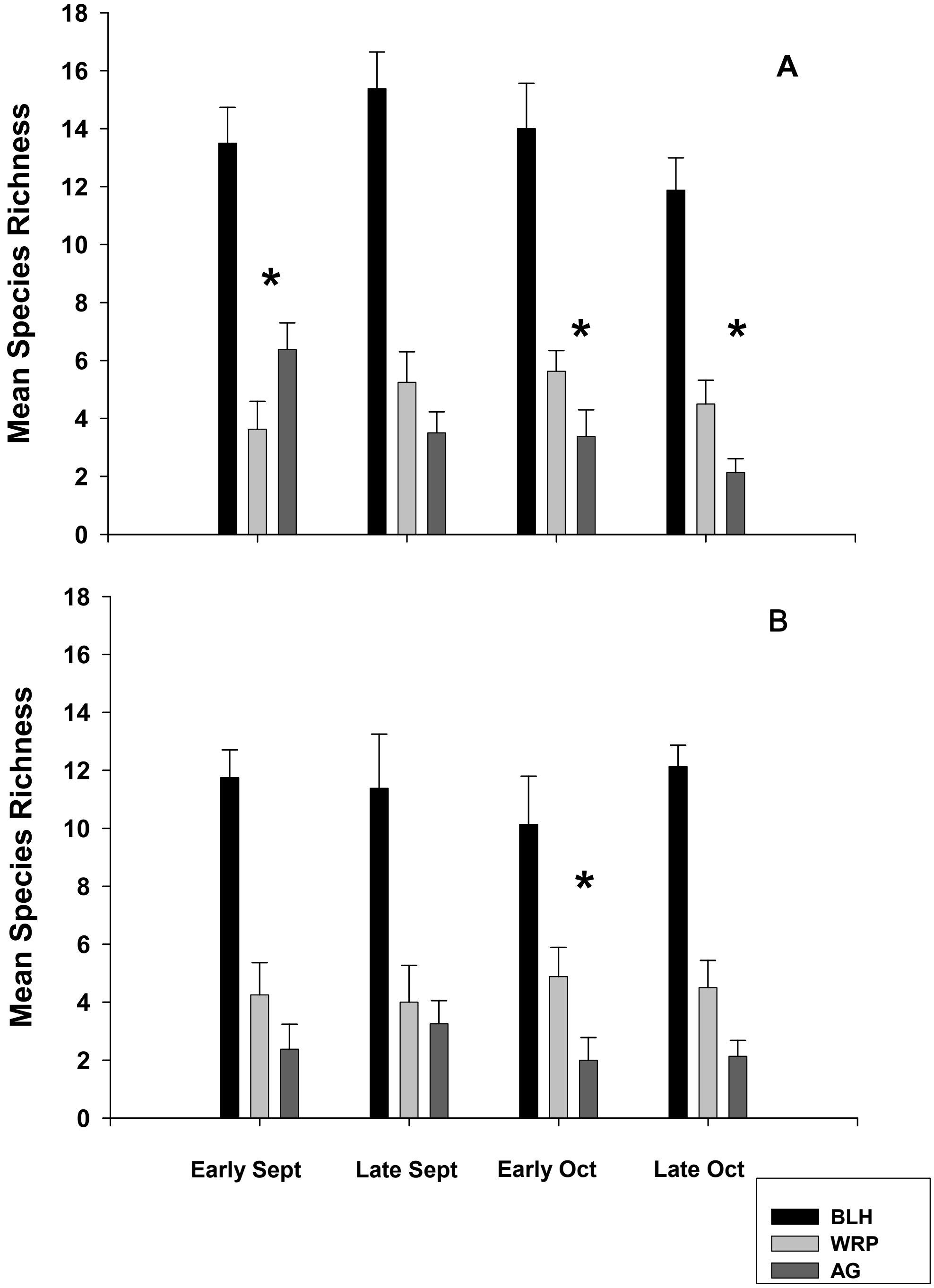

Figure III.8. Mean observed bird species richness (± SE) by habitat type (AG, WRP, and BLH) and sampling period in the Tensas, LA (A) and Lower White/Cache, AR (B) River Basins. Asterisk denotes significant difference between WRP sites and AG sites.

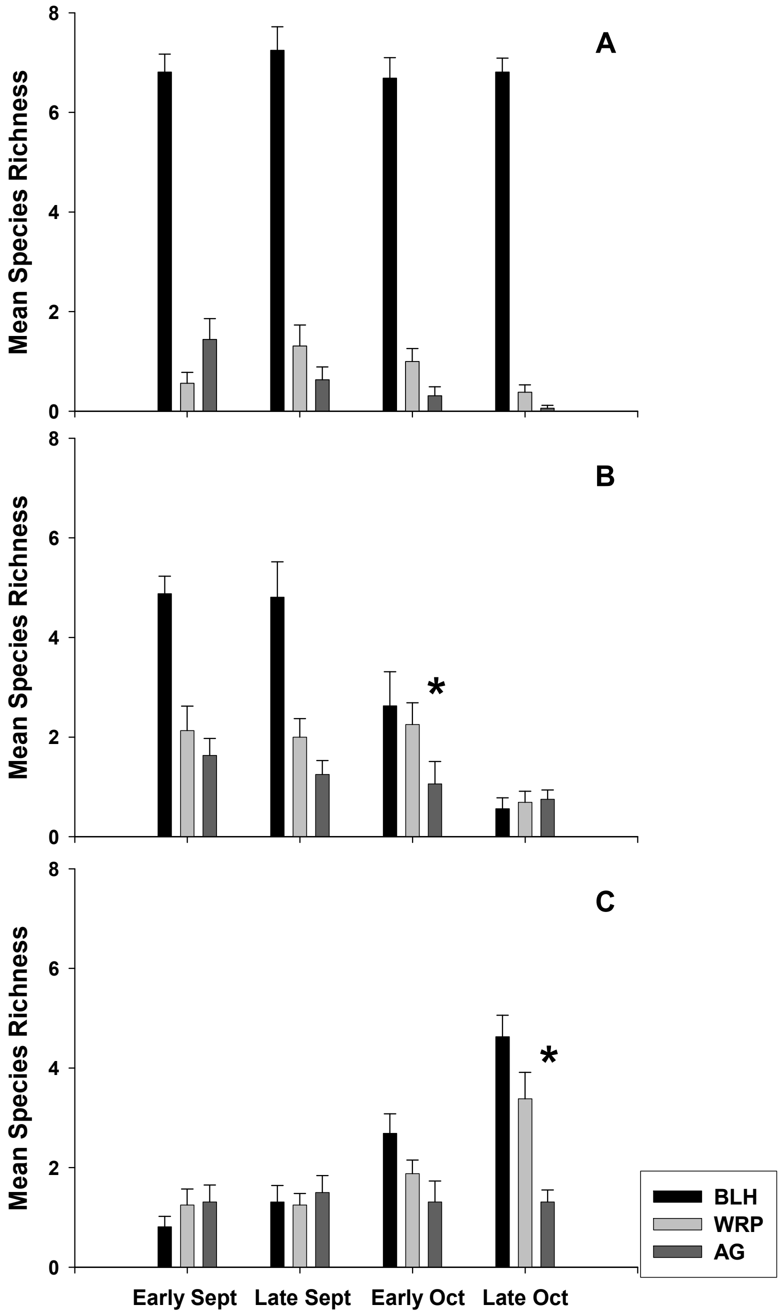

Figure III.9. Mean observed bird species richness (+ SE) in the Tensas, LA and Lower White/Cache, AR River Basins by habitat type (AG, WRP, BLH) and sampling period for resident species (A), nearctic-neotropical migrants (B), and temperate migrants (C). Asterisk denotes significant difference between WRP sites and AG sites.

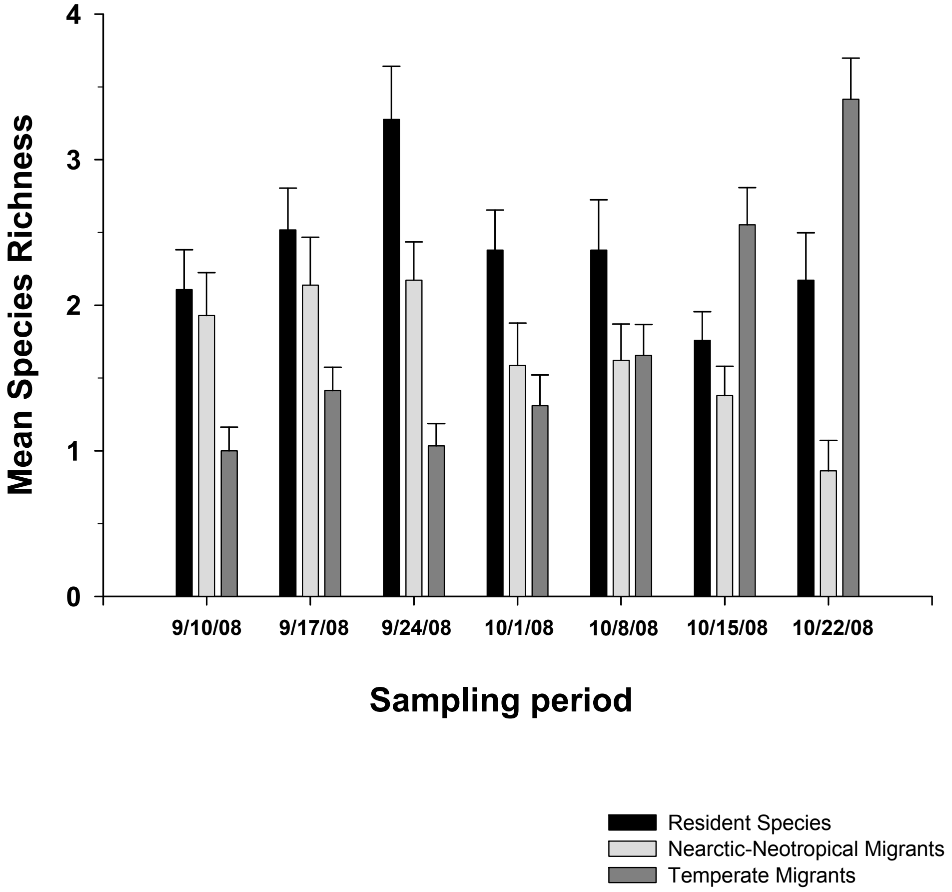

Figure III.10. Mean observed bird species richness (+ SE) in the Yazoo River Basin, Mississippi by sampling period for nearctic-neotropical migrants, resident species, and temperate migrants.

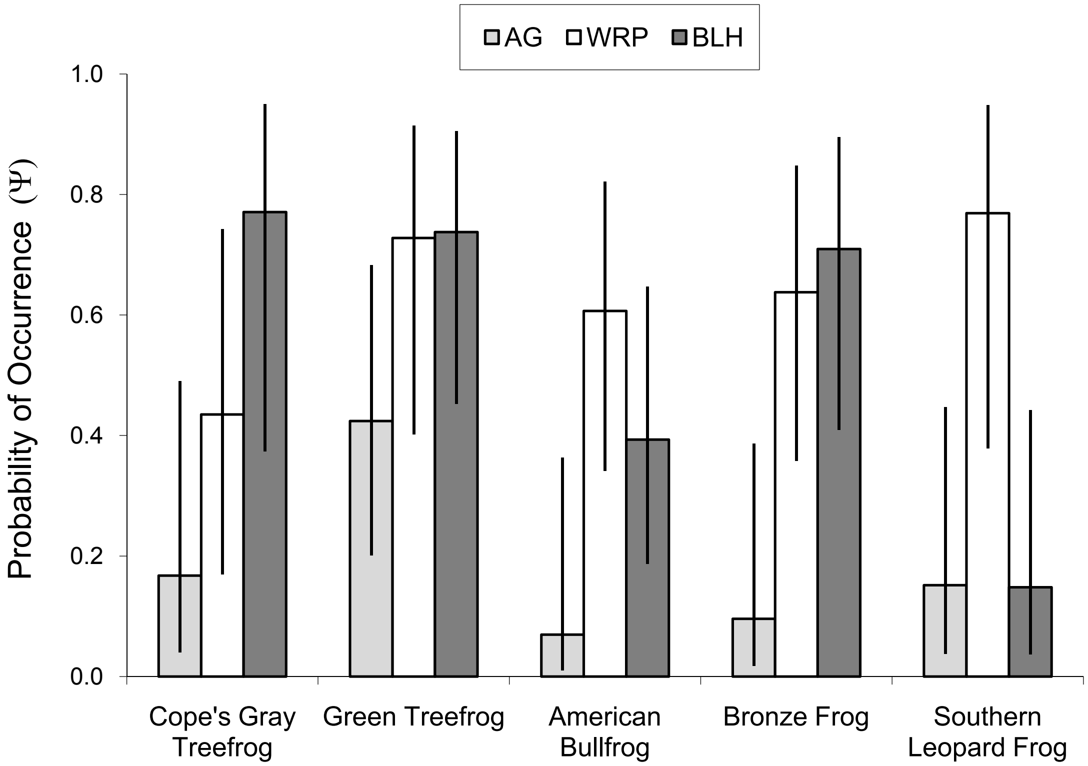

Figure III.11. Estimates of probability of occurrence, Ψ, in each of the 3 land-use categories: agriculture (AG), WRP, and forest (BLH). Error bars indicate the 95% confidence intervals for the estimates.

Table I.1. Summary information for the WRP easements. Variables include WRP size, tree planting date, species planted, and dominant soil map unit names. Planting information was collected from the NRCS field offices, except were noted. Soil mapping units were determined from the NRCS digital soil maps for each county/parish. See Table III.13 for a key to the tree species codes.

River basin	Site #	Size (ha)	Date planted	Tree species planted	Dominant soil mapping unit
TRB	1	173	Jan - 1995	QUPH, QUNI, QUTE, TADI, FRPE	Sharkey clay
TRB	2	339	Jan - 1999	QUPH, QUNI, QUTE, TADI, FRPE	Sharkey-Tunica complex, gently undulating
TRB	3	131	Jan - 1999	QUTE, QUPH, TADI, QUNI, QULY	Tensas-Sharkey clays, gently undulating
TRB	4	156	Feb - 1998	QUPH, QUTE, TADI, QUNI, FRPE	Tensas-Sharkey clays, gently undulating
TRB	5	152	Oct - 2000	QUTE, QUPH, FRPE[1]	Sharkey clay
TRB	6	193	Apr - 1999	FRPE, CAIL, QUTE, QUNI, TADI, QUPA	Tensas-Sharkey clays, gently undulating
TRB	7	98	Jan - 2001	FRPE, QUTE, QUPH, TADI	Tensas-Sharkey complex, undulating
TRB	8	463	Jan - 1998	QUTE, QULY, QUPH, QUNI, QUPA, QUMI, CAIL, TADI, FRPE, LIST, CELA, NYSY, DIVI	Tensas-Sharkey clays, gently undulating
LWC	1	93	Jan - 1998	QUTE, QUPH, QUNI, QULY, QUPAL, QUSH, FRPE, DIVI, TADI, CAIL	Kobel silty loam, frequently flooded
LWC	2	92	Feb - 1997	QUTE, FRPE[1]	Commerce silt loam, frequently flooded
LWC	3	191	Feb - 1997	QUTE, FRPE[1]	Commerce silt loam, frequently flooded
LWC	4	1215	Dec - 2003	QUTE, QUPH, QUNI, QULY, QUPAL, QUSH, FRPE, DIVI, TADI, CAIL	Grubbs silt loam, 1 to 3 percent slopes; Overcup silt loam, 0 to 1 percent slopes
LWC	5	196	Jan - 2003	FRPE, QUSH, QUNI, QUPA, QUPAL, QULY, QUTE, DIVI	Earle clay, gently undulating
LWC	6	74	Jan - 1999	QUTE, FRPE[1]	Commerce soils, frequently flooded
LWC	7	48	Jan - 1998	QUPH, QUTE[1]	Sharkey silty clay
LWC	8	189	Dec - 2003	QULY, QUTE[1]	Sharkey silty clay
YRB	1	55	Feb - 2000	QUTE, QUSH, QUPH, FRPE, DIVI, CAIL	Dowling clay, 0 to 0.5 percent slopes
YRB	2	77	Apr - 1994 Feb - 2001	QUTE, QULY, QUNI, QUPH, FRPE, CAIL, CAAQ, TADI	Sharkey, Alligator, and Dowling soils
YRB	3	378	Jan - 2000	QUTE, QUPH, FRPE, DIVI, TADI	Sharkey and Dowling clays
YRB	4	57	Feb - 1994	QUTE, QULY, QUPH	Sharkey clay

Table I.1. Summary information for the WRP easements. Variables include WRP size, tree planting date, species planted, and dominant soil map unit names. Planting information was collected from the NRCS field offices, except were noted. Soil mapping units were determined from the NRCS digital soil maps for each county/parish. See Table III.13 for a key to the tree species codes.

River basin	Site #	Size (ha)	Date planted	Tree species planted	Dominant soil mapping unit
YRB	5	223	Apr - 2002 Jan - 2004	QUTE, QULY, QUMI, QUNI, QUPH, FRPE, DIVI, CAAQ, TADI	Alligator-Dowling clays, overflow phase
YRB	6	503	Dec - 2001	QUTE, QULY, QUNI, QUPH, FRPE, CAIL, CAAQ, TADI	Sharkey clay, 0 to 2 percent slopes
YRB	7	346	Mar - 2002 Jan - 2003	QUTE, QUMI, QUNI, LIST, FRPE, PLOC, DIVI, CELA	Crevasse loamy sand, 0.5 to 3 percent slopes; Dowling soils, overwash phases, 0 to 0.5 percent slopes
YRB	8	170	Mar - 2002	QUPA, QUTE, QUSH, QUMI, QUAC, QUNI, QUPH, CAIL, TADI, FRPE, DIVI, CELA, LIST	Sharkey clay, nearly level phase
YRB	9	68	Mar - 2003	QUTE, QULY, QUNI, FRPE, DIVI	Alligator clay, nearly level phase
YRB	10	249	Unknown	QUPA, QUTE, QULY, QUNI, QUPH, FRPE, CAAQ, TADI[1]	Alligator clay, 0 to 2 percent slopes
YRB	11	225	Mar - 2003	QUTE, QUNI, QUPH, DIVI, CELA, TADI, NYAQ	Sharkey silty clay, nearly level phase, 0.5 to 3 percent slopes
YRB	12	159	Dec - 2005	QUTE, QULY, QUNI, QUPH, FRPE, TADI[1]	Alligator clay, 0 to 2 percent slopes
YRB	13	101	Feb - 2005	QUTE, QULY, QUNI, QUPH, FRPE, PLOC, DIVI, LIST, CAAQ, TADI	Alligator clay, nearly level phase
YRB	14	51	Unknown	QUNI, QUPH, FRPE, CAAQ[1]	Alligator clay, nearly level phase
YRB	15	202	Dec. 2005	QUTE, QULY, FRPE[1]	Alligator clay, depressional
YRB	16	47	Jan - 2004	QUTE, QULY, QUNI, QUPH, FRPE, CAAQ, TADI, DIVI, PLOC, LIST	Alligator clay, nearly level phase
YRB	17	53	Jan. 2005	QUTE, QULY, QUNI, QUPH, FRPE, CAAQ, TADI, DIVI, PLOC, LIST	Alligator clay, nearly level phase
YRB	18	503	2005-07	QUTE, QUNI, QUPH, FRPE, DIVI	Sharkey clay
YRB	19	131	Unknown	QUTE, QULY, QUNI, QUPH	Sharkey, Alligator, and Dowling soils
YRB	20	124	Oct - 1995 Mar - 1997	QUPA, QUTE, QUSH, QUNI, QUPH, FRPE, TADI	Sharkey clay
YRB	21	298	Feb - 2003	QUTE, QULY, QUNI, QUPH, FRPE	Forestdale silty clay, nearly level phase
YRB	22	172	Unknown	QUTE, QUNI, QUPH, FRPE, TADI[1]	Sharkey, Alligator, and Dowling soils
YRB	23	346	Mar - 1999	QUTE, QUPA, QULY, QUNI, QUPH, TADI, FRPE, DIVI	Alligator clay, depressional, consociation

Table I.1. Summary information for the WRP easements. Variables include WRP size, tree planting date, species planted, and dominant soil map unit names. Planting information was collected from the NRCS field offices, except were noted. Soil mapping units were determined from the NRCS digital soil maps for each county/parish. See Table III.13 for a key to the tree species codes.

River basin	Site #	Size (ha)	Date planted	Tree species planted	Dominant soil mapping unit
YRB	24	304	Mar - 2001	QUTE, QUSH, QUMI, QUNI, QUPH, FRPE	Askew silt loam, 1 to 3 percent slopes, consociation
YRB	25	94	Feb - 2002	QUTE, QULY, QUNI, QUPH, FRPE, DIVI, TADI	Sharkey clay, nearly level phase
YRB	26	111	Feb - 2000	QUTE, QUPA, QUNI, QUPH, FRPE, TADI, CAAQ, DIVI	Alligator clay, 0 to 1 percent slopes, Consociation
YRB	27	156	Mar - 2001	QUTE, QULY, QUNI, QUPH, FRPE, DIVI, TADI, CAAQ	Tensas silty clay loam, 0 to 1 percent slopes
YRB	28	117	Mar - 2000 Jan - 2004	QUTE, QUNI, QUPH, FRPE	Dundee very fine sandy loam, nearly level phase, 0.5 to 3 percent slopes
YRB	29	399	Feb - 2001 Feb - 2002	QUTE, QULY, QUNI, QUPH, QUSH, QUPA, TADI, FRPE, CAAQ, LIST, DIVI, NYAQ	Sharkey clay
YRB	30	149	Dec - 2001 Jun - 2002	QUTE, QULY, QUNI, QUPH, FRPE, DIVI, TADI, CAIL	Dowling clay
YRB	31	252	Unknown	QUTE, QUNI, QUPH, QUAC, FRPE[1]	Sharkey, Alligator, and Dowling soils
YRB	32	261	Unknown	QUTE, QUNI, QULY, QUPH, QUAC, FRPE, CAAQ[1]	Sharkey and Dowling clays
YRB	33	397	Unknown	QUTE, QUPH, QUNI, FRPE, TADI[1]	Alligator silty clay loam

[1] Tree planting information derived from field surveys, information was not available from the NRCS field office.

Table III.1. Number of easements, total hectares of easements and number of hectares within high, medium, and low flood frequencies for a sample of lands enrolled in the Wetlands Reserve Program in Arkansas, Louisiana and Mississippi.

	Year							
	2001-2002		**2002-2003**		**2003-2004**		**2004-2005[3]**	
Number of easements sampled[1]	365		420		462		498	
Number of hectares in easements sampled	48,477		59,474		65,917		70,271	
Number of hectares analyzed within easements sampled[2]	48,382		58,798		65,382		69,738	
	Area	**Percent**	**Area**	**Percent**	**Area**	**Percent**	**Area**	**Percent**
Flood Frequency 0-6 Months	57,350	48.0%	69,233	47.7%	74,966	46.4%	78,349	45.5%
Flood Frequency 7-12 Months	28,110	23.5%	30,287	20.8%	31,254	19.3%	31,869	18.5%
Flood Frequency 13-18 Months	6,065	5.1%	6,582	4.5%	6,820	4.2%	6,888	4.0%
Flood Frequency 19-24 Months	1,374	1.1%	2,831	1.9%	2,967	1.8%	3,009	1.7%
Flood Frequency 25-36 Months	922	0.8%	1,273	0.9%	1,738	1.1%	1,778	1.0%
Flood Frequency >36 Months	3,181	2.7%	3,181	2.2%	3,637	2.3%	3,778	2.2%
No Flooding Observed	17,905	15.0%	25,991	17.9%	33,257	20.6%	39,113	22.7%
Flooding Observed Frequency Unknown	4,646	3.9%	5,915	4.1%	6,924	4.3%	7,541	4.4%

[1] The most recent updates for Arkansas and Louisiana WRP includes 2005 easements, whereas Mississippi is updated only through 2003-2004.

[2] The easement data set is comprised of vector data, whereas estimated flood frequency data set is comprised of raster data, hence the hectares in each flood interval category in the table do not sum to the total sampled easement hectares. Hence, we created the number of easement hectares analyzed row to reflect actual hectares sampled within easements.

[3] No updated easement data set was available for MS for 2005, therefore, MS data in this column are only for 2004.

Table III.2. Presence/absence of trees and shrubs in the natural forests (BLH) and WRP sites in each river basin (lower White/Cache (LWC), Tensas (TRB), Yazoo-WRP swale (YRB-WRPS), and Yazoo-WRP ridge (YRB-WRPR)), separated by size class.

		Mature Trees/Overstory (≥ 10 cm dbh)						**Midstory (2.5cm ≤ dbh < 10cm)**						**Sapling / Seedling (≥0.3m in height & <2.5cm dbh)**					
Species	**Common Name**	**LWC-BLH**	**LWC-WRP**	**TRB-BLH**	**TRB-WRP**	**YRB-WRPR**	**YRB-WRPS**	**LWC-BLH**	**LWC-WRP**	**TRB-BLH**	**TRB-WRP**	**YRB-WRP R**	**YRB-WRP S**	**LWC-BLH**	**LWC-WRP**	**TRB-BLH**	**TRB-WRP**	**YRB-WRP R**	**YRB-WRP S**
Acer negundo	boxelder	X		X		X	X	X		X	X	X	X	X		X	X	X	X
Acer rubrum	red maple	X		X				X	X	X	X	X		X				X	X
Acer Saccharum	sugar maple	X						X											
Albizia julibrissin	silktree											X							
Amorpha fruticosa	leadplant								X			X						X	X
Arundinaria gigantea	giant cane							X		X				X		X			
Asimina triloba	pawpaw							X						X					
Baccharis halimifolia	eastern baccharis								X	X	X	X			X			X	X
Betula nigra	river birch	X						X											
Broussonetia papyrifera	paper mulberry																		X
Callicarpa americana	American beautyberry									X	X			X		X	X		
Carpinus caroliniana	ironwood	X						X						X					
Carya aquatica	water hickory	X		X			X	X	X	X	X		X	X				X	X
Carya cordiformis	bitternut hickory							X						X					
Carya illinoinensis	sweet pecan	X						X	X		X	X						X	X
Carya laciniosa	shellbark hickory	X						X											
Carya ovata	shagbark hickory	X						X											
Celtis laevigata	sugarberry	X		X				X	X	X	X	X	X	X	X	X	X	X	X
Cephalanthus occidentalis	common buttonbush							X	X		X	X	X	X	X	X	X	X	X
Cornus drummondii	roughleaf dogwood			X						X		X	X					X	X
Cornus foemina	stiff dogwood			X				X		X	X			X		X			
Crataegus marshallii	parsley hawthorn									X						X			
Crataegus spp.	hawthorn	X		X				X				X	X	X				X	X

Table III.2. Presence/absence of trees and shrubs in the natural forests (BLH) and WRP sites in each river basin (lower White/Cache (LWC), Tensas (TRB), Yazoo-WRP swale (YRB-WRPS), and Yazoo-WRP ridge (YRB-WRPR)), separated by size class.

		Mature Trees/Overstory (≥ 10 cm dbh)						**Midstory (2.5cm ≤ dbh < 10cm)**						**Sapling / Seedling (≥0.3m in height & <2.5cm dbh)**					
Species	**Common Name**	**LWC-BLH**	**LWC-WRP**	**TRB-BLH**	**TRB-WRP**	**YRB-WRPR**	**YRB-WRPS**	**LWC-BLH**	**LWC-WRP**	**TRB-BLH**	**TRB-WRP**	**YRB-WRP R**	**YRB-WRP S**	**LWC-BLH**	**LWC-WRP**	**TRB-BLH**	**TRB-WRP**	**YRB-WRP R**	**YRB-WRP S**
Crataegus viridis	green hawthorn							X		X	X					X			
Diospyros virginiana	common persimmon	X		X		X		X	X	X	X	X	X	X		X	X	X	X
Forestiera acuminata	eastern swampprivet	X		X				X		X	X	X	X	X		X		X	X
Fraxinus pennsylvanica	green ash	X		X		X	X	X	X	X	X	X	X	X	X	X	X	X	X
Fraxinus profunda	pumpkin ash	X		X				X		X						X			
Gleditsia aquatica	water locust	X		X			X	X		X			X						X
Gleditsia triacanthos	honey locust	X		X		X		X		X	X	X		X		X	X	X	X
Halesia diptera	two-wing silverbell																	X	X
Hibiscus moscheutos	crimsoneyed rosemallow								X										
Hypericum crux-andreae	St. Peter’s cross										X						X		
Hypericum hypericoides	St. Andrew's cross										X								
Ilex decidua	deciduous holly	X		X		X		X		X	X	X		X		X		X	X
Juniperus virginiana	eastern red cedar					X						X	X					X	X
Ligustrum sinense	Chinese privet							X				X		X				X	X
Liquidambar styraciflua	sweetgum	X		X		X		X	X	X	X	X	X	X	X	X	X	X	X
Malus spp.	apple																	X	
Melia azedarach	Chinaberry											X						X	
Morus rubra	red mulberry	X		X				X		X						X			
Nyssa aquatica	water tupelo	X						X					X	X					
Nyssa sylvatica	blackgum												X						X
Pinus taeda	loblolly pine											X						X	X
Planera aquatica	Planertree / water elm	X					X	X	X			X	X					X	X

Table III.2. Presence/absence of trees and shrubs in the natural forests (BLH) and WRP sites in each river basin (lower White/Cache (LWC), Tensas (TRB), Yazoo-WRP swale (YRB-WRPS), and Yazoo-WRP ridge (YRB-WRPR)), separated by size class.

		Mature Trees/Overstory (≥ 10 cm dbh)						Midstory (2.5cm ≤ dbh < 10cm)						Sapling / Seedling (≥0.3m in height & <2.5cm dbh)					
Species	**Common Name**	**LWC-BLH**	**LWC-WRP**	**TRB-BLH**	**TRB-WRP**	**YRB-WRPR**	**YRB-WRPS**	**LWC-BLH**	**LWC-WRP**	**TRB-BLH**	**TRB-WRP**	**YRB-WRP R**	**YRB-WRP S**	**LWC-BLH**	**LWC-WRP**	**TRB-BLH**	**TRB-WRP**	**YRB-WRP R**	**YRB-WRP S**
Platanus occidentalis	American sycamore	X		X		X		X		X		X						X	X
Populus deltoides	eastern cottonwood					X	X		X			X	X					X	X
Populus heterophylla	swamp cottonwood								X						X			X	
Prunus serotina	black cherry							X											
Prunus spp.	plum																	X	
Pyrus spp.	pear											X						X	
Quercus acutissima	sawtooth oak					X						X	X					X	X
Quercus alba	white oak					X													
Quercus falcata	southern red oak	X		X				X	X	X		X			X				
Quercus laurifolia	laurel oak	X		X				X		X				X					
Quercus lyrata	overcup oak	X		X		X	X	X	X	X		X	X	X		X		X	X
Quercus michauxii	swamp chestnut oak							X				X		X				X	
Quercus nigra	water oak	X		X		X	X	X	X	X	X	X	X	X		X		X	X
Quercus pagoda	cherrybark oak			X		X	X			X		X	X					X	X
Quercus phellos	willow oak	X		X		X	X	X	X	X	X	X	X	X		X		X	X
Quercus shumardii	Shumard oak			X						X		X	X					X	X
Quercus texana	Nuttall oak	X		X	X	X	X	X	X	X	X	X	X		X		X	X	X
Quercus velutina	black oak			X						X									
Rhus copallinum	winged sumac									X	X						X	X	
Rhus glabra	smooth sumac							X	X									X	
Robinia pseudoacacia	black locust																	X	
Rosa spp.	rose																	X	
Sabal minor	dwarf palmetto							X	X	X	X					X	X		X

Table III.2. Presence/absence of trees and shrubs in the natural forests (BLH) and WRP sites in each river basin (lower White/Cache (LWC), Tensas (TRB), Yazoo-WRP swale (YRB-WRPS), and Yazoo-WRP ridge (YRB-WRPR)), separated by size class.

		Mature Trees/Overstory (≥ 10 cm dbh)						**Midstory (2.5cm ≤ dbh < 10cm)**						**Sapling / Seedling (≥0.3m in height & <2.5cm dbh)**					
Species	**Common Name**	**LWC-BLH**	**LWC-WRP**	**TRB-BLH**	**TRB-WRP**	**YRB-WRPR**	**YRB-WRPS**	**LWC-BLH**	**LWC-WRP**	**TRB-BLH**	**TRB-WRP**	**YRB-WRPR**	**YRB-WRPS**	**LWC-BLH**	**LWC-WRP**	**TRB-BLH**	**TRB-WRP**	**YRB-WRPR**	**YRB-WRPS**
Salix nigra	black willow					X	X					X	X					X	X
Sassafras albidum	sassafras	X		X				X		X									
Sesbania	riverhemp										X								
Sideroxylon lycioides	buckthorn bully							X		X									
Styrax americanus	American snowbell									X				X		X			
Taxodium distichum	bald cypress	X		X		X		X		X	X	X	X				X	X	X
Tilia americana	American basswood			X						X									
Triadica sebifera	Chinese tallow											X						X	X
Ulmus alata	winged elm							X				X	X					X	X
Ulmus americana	American elm	X		X		X		X	X	X	X	X	X	X	X	X	X	X	X
Ulmus crassifolia	cedar elm	X		X				X	X	X	X	X		X		X	X	X	

Table III.3. Bird species detected on agricultural (AG), Wetlands Reserve Program (WRP), and natural forest (BLH) sites in the Tensas, LA (TRB) and Lower White/Cache, AR (LWC) River Basins.

Common name	***Scientific name***	**Habitat Type**		
		AG	**WRP**	**BLH**
Resident Species				
Northern Bobwhite	*Colinus virginianus*	■		
Black Vulture	*Coragyps atratus*		■	
Great Horned Owl	*Bubo virginianus*			■
Barred Owl	*Strix varia*			■
Red-bellied Woodpecker	*Melanerpes carolinus*	■	■	■
Downy Woodpecker	*Picoides pubescens*	■	■	■
Hairy Woodpecker	*Picoides villosus*		■	■
Pileated Woodpecker	*Dryocopus pileatus*	■	■	■
Blue Jay	*Cyanocitta cristata*	■	■	■
Fish Crow	*Corvus ossifragus*			■
Carolina Chickadee	*Poecile carolinensis*	■	■	■
Tufted Titmouse	*Baeolophus bicolor*	■	■	■
White-breasted Nuthatch	*Sitta carolinensis*			■
Carolina Wren	*Thryothorus ludovicianus*	■	■	■
Northern Mockingbird	*Mimus polyglottos*	■	■	
Northern Cardinal	*Cardinalis cardinalis*		■	■
Nearctic-Neotropical Migrants				
Least Bittern	*Ixobrychus exilis*	■		
Great Blue Heron	*Ardea herodias*	■	■	■
Great Egret	*Ardea alba*	■	■	
Snowy Egret	*Egretta thula*		■	
White Ibis	*Eudocimus albus*	■		
Turkey Vulture	*Cathartes aura*	■	■	
Sharp-shinned Hawk	*Accipiter striatus*		■	
Killdeer	*Charadrius vociferus*	■	■	
Greater Yellowlegs	*Tringa melanoleuca*		■	
Lesser Yellowlegs	*Tringa flavipes*		■	
Short-billed Dowitcher[1]	*Limnodromus griseus*		■	
Yellow-billed Cuckoo	*Coccyzus americanus*		■	■
Chimney Swift	*Chaetura pelagica*		■	
Ruby-throated Hummingbird	*Archilochus colubris*	■	■	■
Belted Kingfisher	*Ceryle alcyon*		■	■
Yellow-bellied Sapsucker	*Sphyrapicus varius*			■
Eastern Wood-Pewee	*Contopus virens*		■	■

Table III.3. Bird species detected on agricultural (AG), Wetlands Reserve Program (WRP), and natural forest (BLH) sites in the Tensas, LA (TRB) and Lower White/Cache, AR (LWC) River Basins.

Common name	***Scientific name***	**Habitat Type**		
		AG	**WRP**	**BLH**
Acadian Flycatcher	*Empidonax virescens*			■
Least Flycatcher	*Empidonax minimus*		■	
Great Crested Flycatcher	*Myiarchus crinitus*			■
White-eyed Vireo	*Vireo griseus*	■	■	■
Bell’s Vireo[1,5]	*Vireo bellii*		■	
Yellow-throated Vireo	*Vireo flavifrons*			■
Red-eyed Vireo	*Vireo olivaceus*			■
Tree Swallow	*Tachycineta bicolor*	■	■	
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	■	■	
Bank Swallow	*Riparia riparia*	■	■	
Barn Swallow	*Hirundo rustica*	■	■	
House Wren	*Troglodytes aedon*	■	■	
Blue-gray Gnatcatcher	*Polioptila caerulea*		■	■
Wood Thrush[1,5]	*Hylocichla mustelina*			■
Gray Catbird	*Dumetella carolinensis*	■	■	■
Cedar Waxwing	*Bombycilla cedrorum*			■
Blue-winged Warbler[5]	*Vermivora pinus*			■
Orange-crowned Warbler	*Vermivora celata*			■
Nashville Warbler	*Vermivora ruficapilla*			■
Northern Parula	*Parula americana*			■
Magnolia Warbler	*Dendroica magnolia*			■
Black-throated Green Warbler	*Dendroica virens*			■
Blackburnian Warbler	*Dendroica fusca*			■
Blackpoll Warbler	*Dendroica striata*			■
Cerulean Warbler[1,5]	*Dendroica cerulea*			■
Black-and-white Warbler	*Mniotilta varia*			■
American Redstart	*Setophaga ruticilla*			■
Prothonotary Warbler[1,5]	*Protonotaria citrea*			■
Ovenbird	*Seiurus aurocapilla*			■
Louisiana Waterthrush[1]	*Seiurus motacilla*			■
Kentucky Warbler[1,4]	*Oporornis formosus*			■
Common Yellowthroat	*Geothlypis trichas*	■	■	
Hooded Warbler	*Wilsonia citrina*			■
Yellow-breasted Chat	*Icteria virens*	■	■	■

Table III.3. Bird species detected on agricultural (AG), Wetlands Reserve Program (WRP), and natural forest (BLH) sites in the Tensas, LA (TRB) and Lower White/Cache, AR (LWC) River Basins.

Common name	***Scientific name***	**Habitat Type**		
		AG	**WRP**	**BLH**
Summer Tanager	*Piranga rubra*		▨	▨
Savannah Sparrow	*Passerculus sandwichensis*	▨	▨	
Lincoln’s Sparrow	*Melospiza lincolnii*		▨	
Rose-breasted Grosbeak	*Pheucticus ludovicianus*			▨
Blue Grosbeak	*Passerina caerulea*	▨	▨	
Indigo Bunting	*Passerina cyanea*	▨	▨	▨
Dickcissel[1,5]	*Spiza americana*	▨	▨	
Temperate Migrants				
Wood Duck[4]	*Aix sponsa*		▨	▨
Mallard	*Anas platyrhynchos*	▨	▨	
Green-winged Teal[3]	*Anas crecca*		▨	
Northern Harrier[1]	*Circus cyaneus*	▨	▨	
Red-shouldered Hawk	*Buteo lineatus*	▨	▨	▨
Red-tailed Hawk	*Buteo jamaicensis*	▨	▨	
American Kestrel[2]	*Falco sparverius*	▨		
Mourning Dove[3]	*Zenaida macroura*	▨	▨	▨
Red-headed Woodpecker[1, 5]	*Melanerpes erythrocephalus*			▨
Northern Flicker	*Colaptes auratus*	▨	▨	▨
Eastern Phoebe	*Sayornis phoebe*		▨	▨
Loggerhead Shrike[1]	*Lanius ludovicianus*	▨	▨	
American Crow	*Corvus brachyrhynchos*	▨	▨	▨
Horned Lark	*Eremophila alpestris*	▨	▨	
Brown Creeper	*Certhia americana*			▨
Winter Wren	*Troglodytes troglodytes*			▨
Sedge Wren[1]	*Cistothorus platensis*		▨	
Golden-crowned Kinglet	*Regulus satrapa*			▨
Ruby-crowned Kinglet	*Regulus calendula*		▨	▨
Eastern Bluebird	*Sialia sialis*	▨		
Hermit Thrush	*Catharus guttatus*			▨
American Robin	*Turdus migratorius*			▨
Brown Thrasher	*Toxostoma rufum*		▨	▨
European Starling	*Sturnus vulgaris*	▨		
Yellow-rumped Warbler	*Dendroica coronata*		▨	▨

Table III.3. Bird species detected on agricultural (AG), Wetlands Reserve Program (WRP), and natural forest (BLH) sites in the Tensas, LA (TRB) and Lower White/Cache, AR (LWC) River Basins.

Common name	***Scientific name***	**Habitat Type**		
		AG	**WRP**	**BLH**
Eastern Towhee	*Pipilo erythrophthalmus*	▨	▨	▨
Field Sparrow	*Spizella pusilla*		▨	
Le Conte's Sparrow[1]	*Ammodramus leconteii*		▨	
Song Sparrow	*Melospiza melodia*	▨	▨	
Swamp Sparrow	*Melospiza georgiana*		▨	
White-throated Sparrow	*Zonotrichia albicollis*		▨	▨
White-crowned Sparrow	*Zonotrichia leucophrys*		▨	
Red-winged Blackbird	*Agelaius phoeniceus*	▨	▨	
Eastern Meadowlark	*Sturnella magna*	▨	▨	
Brown-headed Cowbird	*Molothrus ater*	▨		▨

Species of Conservation Concern
[1] USFWS, Bird of conservation concern at national level
[2] USFWS, Bird of conservation concern within region
[3] USFWS, Game bird above desired condition
[4] USFWS, Game bird below desired condition
[5] Partners in Flight watch list species

Table III.4. Bird species that were only detected on agricultural (AG), Wetlands Reserve Program (WRP) or natural forest (BLH) sites in the Tensas, LA (TRB) and Lower White/Cache, AR (LWC) River Basins.

Common name	Scientific name
AG Sites	
Northern Bobwhite	*Colinus virginianus*
Least Bittern	*Ixobrychus exilis*
White Ibis	*Eudocimus albus*
American Kestrel[2]	*Falco sparverius*
Eastern Bluebird	*Sialia sialis*
European Starling	*Sturnus vulgaris*
WRP Sites	
Black Vulture	*Coragyps atratus*
Snowy Egret	*Egretta thula*
Sharp-shinned Hawk	*Accipiter striatus*
Greater Yellowlegs	*Tringa melanoleuca*
Lesser Yellowlegs	*Tringa flavipes*
Short-billed Dowitcher[1]	*Limnodromus griseus*
Chimney Swift	*Chaetura pelagica*
Least Flycatcher	*Empidonax minimus*
Bell's Vireo[1,5]	*Vireo bellii*
Lincoln's Sparrow	*Melospiza lincolnii*
Green-winged Teal[3]	*Anas crecca*
Sedge Wren[1]	*Cistothorus platensis*
Field Sparrow	*Spizella pusilla*
Le Conte's Sparrow[1]	*Ammodramus leconteii*
Swamp Sparrow	*Melospiza georgiana*
White-crowned Sparrow	*Zonotrichia leucophrys*
BLH Sites	
Great Horned Owl	*Bubo virginianus*
Barred Owl	*Strix varia*
Fish Crow	*Corvus ossifragus*
White-breasted Nuthatch	*Sitta carolinensis*
Yellow-bellied Sapsucker	*Sphyrapicus varius*
Acadian Flycatcher	*Empidonax virescens*
Great Crested Flycatcher	*Myiarchus crinitus*
Yellow-throated Vireo	*Vireo flavifrons*
Red-eyed Vireo	*Vireo olivaceus*
Wood Thrush[1,5]	*Hylocichla mustelina*
Cedar Waxwing	*Bombycilla cedrorum*
Blue-winged Warbler[5]	*Vermivora pinus*

Table III.4. Bird species that were only detected on agricultural (AG), Wetlands Reserve Program (WRP) or natural forest (BLH) sites in the Tensas, LA (TRB) and Lower White/Cache, AR (LWC) River Basins.

Common name	Scientific name
Orange-crowned Warbler	*Vermivora celata*
Nashville Warbler	*Vermivora ruficapilla*
Northern Parula	*Parula americana*
Magnolia Warbler	*Dendroica magnolia*
Black-throated Green Warbler	*Dendroica virens*
Blackburnian Warbler	*Dendroica fusca*
Blackpoll Warbler	*Dendroica striata*
Cerulean Warbler[1,5]	*Dendroica cerulea*
Black-and-white Warbler	*Mniotilta varia*
American Redstart	*Setophaga ruticilla*
Prothonotary Warbler[1,5]	*Protonotaria citrea*
Ovenbird	*Seiurus aurocapilla*
Louisiana Waterthrush[1]	*Seiurus motacilla*
Kentucky Warbler[1,4]	*Oporornis formosus*
Hooded Warbler	*Wilsonia citrina*
Rose-breasted Grosbeak	*Pheucticus ludovicianus*
Red-headed Woodpecker[1, 5]	*Melanerpes erythrocephalus*
Brown Creeper	*Certhia americana*
Winter Wren	*Troglodytes troglodytes*
Golden-crowned Kinglet	*Regulus satrapa*
Hermit Thrush	*Catharus guttatus*
American Robin	*Turdus migratorius*

Species of Conservation Concern
[1] USFWS, Bird of conservation concern at national level
[2] USFWS, Bird of conservation concern within region
[3] USFWS, Game bird above desired condition
[4] USFWS, Game bird below desired condition
[5] Partners in Flight watch list species

Table III.5. Repeated measures analysis of variance (ANOVA) for mean observed bird species richness in AG, WRP, and BLH in the Tensas, LA and lower White/Cache, AR River Basins. Significant P values are in boldface type.

	Observed bird species richness		
Effect	df	F	P
Habitat Type	2	89.57	**<0.0001**
Sample Period	3	4.60	**0.0043**
Sample Period*Habitat Type	6	3.30	**0.0048**
State	1	14.61	**0.0002**
Habitat Type*State	2	0.09	0.9104
Sample Period*State	3	2.94	**0.0356**
Sample Period*Habitat Type*State	6	2.67	**0.0180**
Migrant	2	0.36	0.6966
Habitat Type*Migrant	4	31.67	**<0.0001**
Sample Period*Migrant	6	32.71	**<0.0001**
Sample Period*Habitat Type*Migrant	12	8.33	**<0.0001**
State*Migrant	2	0.67	0.5147
Habitat Type*State*Migrant	4	2.16	0.0774
Sample Period*State*Migrant	6	1.00	0.4272
Sample Period*Habitat Type*State*Migrant	12	0.88	0.5721

Table III.6. Bird species detected on Wetlands Reserve Program (WRP) sites in the Yazoo River Basin (YRB), Mississippi.

Common name	**Scientific name**
Resident Species	
Northern Bobwhite	*Colinus virginianus*
Black Vulture	*Coragyps atratus*
Eastern Screech-Owl	*Megascops asio*
Great Horned Owl	*Bubo virginianus*
Barred Owl	*Strix varia*
Red-bellied Woodpecker	*Melanerpes carolinus*
Downy Woodpecker	*Picoides pubescens*
Hairy Woodpecker	*Picoides villosus*
Pileated Woodpecker	*Dryocopus pileatus*
Blue Jay	*Cyanocitta cristata*
Carolina Chickadee	*Poecile carolinensis*
Tufted Titmouse	*Baeolophus bicolor*
White-breasted Nuthatch	*Sitta carolinensis*
Carolina Wren	*Thryothorus ludovicianus*
Northern Mockingbird	*Mimus polyglottos*
Northern Cardinal	*Cardinalis cardinalis*
Nearctic-Neotropical Migrants	
Blue-winged Teal[1,3]	*Anas discors*
Pie-billed Grebe	*Podilymbus podiceps*
Double-crested Cormorant	*Phalacrocorax auritus*
Anhinga	*Anhinga anhinga*
Great Blue Heron	*Ardea herodias*
Great Egret	*Ardea alba*
Snowy Egret	*Egretta thula*
Cattle Egret	*Bubulcus ibis*
White Ibis	*Eudocimus albus*
Turkey Vulture	*Cathartes aura*
Cooper's Hawk	*Accipiter cooperii*
Merlin	*Falco columbarius*
Killdeer	*Charadrius vociferus*
Greater Yellowlegs	*Tringa melanoleuca*
Wilson's Snipe[1,3]	*Gallinago delicata*
Yellow-billed Cuckoo	*Coccyzus americanus*
Chimney Swift	*Chaetura pelagica*
Ruby-throated Hummingbird	*Archilochus colubris*
Belted Kingfisher	*Ceryle alcyon*
Eastern Wood-Pewee	*Contopus virens*
White-eyed Vireo	*Vireo griseus*
Tree Swallow	*Tachycineta bicolor*
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*

Table III.6. Bird species detected on Wetlands Reserve Program (WRP) sites in the Yazoo River Basin (YRB), Mississippi.

Common name	**Scientific name**
Barn Swallow	*Hirundo rustica*
House Wren	*Troglodytes aedon*
Blue-gray Gnatcatcher	*Polioptila caerulea*
Gray Catbird	*Dumetella carolinensis*
Cedar Waxwing	*Bombycilla cedrorum*
Northern Parula	*Parula americana*
Magnolia Warbler	*Dendroica magnolia*
Palm Warbler	*Dendroica palmarum*
American Redstart	*Setophaga ruticilla*
Common Yellowthroat	*Geothlypis trichas*
Summer Tanager	*Piranga rubra*
Chipping Sparrow	*Spizella passerina*
Blue Grosbeak	*Passerina caerulea*
Indigo Bunting	*Passerina cyanea*
Dickcissel[1,5]	*Spiza americana*
Baltimore Oriole	*Icterus galbula*
Temperate Migrants	
Canada Goose[1,3]	*Branta canadensis*
Mallard	*Anas platyrhynchos*
Bald Eagle[1]	*Haliaeetus leucocephalus*
Northern Harrier[1]	*Circus cyaneus*
Red-tailed Hawk	*Buteo jamaicensis*
American Kestrel[2]	*Falco sparverius*
Mourning Dove[3]	*Zenaida macroura*
Red-headed Woodpecker[1, 5]	*Melanerpes erythrocephalus*
Northern Flicker	*Colaptes auratus*
Eastern Phoebe	*Sayornis phoebe*
Loggerhead Shrike[1]	*Lanius ludovicianus*
American Crow	*Corvus brachyrhynchos*
Sedge Wren[1]	*Cistothorus platensis*
Ruby-crowned Kinglet	*Regulus calendula*
Eastern Bluebird	*Sialia sialis*
Brown Thrasher	*Toxostoma rufum*
Yellow-rumped Warbler	*Dendroica coronata*
Eastern Towhee	*Pipilo erythrophthalmus*
Le Conte's Sparrow[1]	*Ammodramus leconteii*
Song Sparrow	*Melospiza melodia*
Swamp Sparrow	*Melospiza georgiana*
White-throated Sparrow	*Zonotrichia albicollis*
Red-winged Blackbird	*Agelaius phoeniceus*
Red-winged Blackbird	*Agelaius phoeniceus*

Table III.6. Bird species detected on Wetlands Reserve Program (WRP) sites in the Yazoo River Basin (YRB), Mississippi.

Common name	**Scientific name**
Common Grackle	*Quiscalus quiscula*
Brown-headed Cowbird	*Molothrus ater*
American Goldfinch	*Carduelis tristis*

Species of Conservation Concern
[1] USFWS, Bird of conservation concern at national level
[2] USFWS, Bird of conservation concern within region
[3] USFWS, Game bird above desired condition
[4] USFWS, Game bird below desired condition
[5] Partners in Flight watch list species

Table III.7. Estimated contribution of Wetlands Reserve Program Hydrology Management Units (HMUs) to Lower Mississippi Valley Joint Venture population-based foraging habitat objectives for Arkansas, Louisiana and Mississippi, 2001-2005.

				Habitat Management Classification[a] (DEDs)				
State/Year	**HMUs Sampled**	**HMU Area (ha)**	**HMU% Area Flooded**	**Active**	**Passive/None**	**% Foraging Objective[b] Provided**	**DED Pre-restoration[c]**	**DED Net Change Post-restoration**
AR 2001-02	544	6,666	62.3%	7,865,719	5,659,481	6.2%	369,726	13,155,474
AR 2002-03	579	6,996	49.5%	6,550,275	4,713,003	5.1%	307,894	10,955,384
AR 2003-04	623	7,340	20.1%	2,786,225	2,004,723	2.2%	130,966	4,659,982
AR 2004-05	640	7,473	52.0%	7,356,368	5,292,996	5.8%	345,784	12,303,580
LA 2001-02	1,008	6,239	35.6%	4,208,963	3,028,401	6.0%	194,841	7,039,523
LA 2002-03	1,144	6,952	44.0%	5,786,381	4,163,372	8.2%	271,987	9,677,765
LA 2003-04	1,185	7,312	28.8%	3,981,195	2,864,519	5.7%	187,135	6,658,579
LA 2004-05	1,185	7,312	13.4%	1,849,798	1,330,952	2.6%	86,949	3,093,801
MS 2001-02	964	6,658	61.9%	7,802,084	5,613,694	18.5%	366,735	13,049,043
MS 2002-03	1,024	7,055	54.1%	7,223,030	5,197,058	17.1%	339,517	12,080,571
MS 2003-04	1,037	7,098	34.0%	4,570,330	3,288,409	10.8%	214,827	7,643,912
MS 2004-05	1,037	7,098	28.8%	3,864,140	2,780,296	9.1%	181,633	6,462,802
Tri-State 2001-02	2,516	19,563	53.7%	19,876,766	14,301,576	8.3%	934,302	33,244,040
Tri-State 2002-03	2,747	21,004	49.2%	19,559,685	14,073,432	8.1%	919,398	32,713,720
Tri-State 2003-04	2,845	21,749	27.5%	11,337,751	8,157,650	4.7%	532,928	18,962,473
Tri-State 2004-05	2,862	21,882	31.6%	13,070,306	9,404,244	5.4%	614,366	21,860,184

[a] Satisfactory/Active management estimated to occur in 41% of area flooded with a DED value of 4616 DED/hectare. Unsatisfactory/Passive or Unmanaged estimated to occur in 59% of the flooded area with assumed DED value of 2308 DED/hectare.

[b] Population-based objective for Arkansas (219,427,337), Louisiana (120,913,290) and Mississippi (72,637,077) from LMVJV Waterfowl Working Group Memorandum, updated 2007.

[c] Habitat condition prior to restoration was assumed to be flooded harvested soybeans with a value of 89 DED/ hectares.

Table III.8. Estimated contribution of Wetlands Reserve Program reforested lands under intensive moist soil management to Lower Mississippi Valley Joint Venture population-based foraging habitat objectives for Arkansas, Louisiana, and Mississippi, 2001-2005.

State/Year	Easement Sampled	Easement Area Excluding HMUs (ha)	% Easement Acres Flooded	Total DEDs Provided	% Foraging Objective Provided	DED Pre-restoration	DED Net Increase 20-Years Post-restoration
AR 2001-02	228	32,907	45.3	10,096,208	4.6%	1,326,509	8,769,699
AR 2002-03	266	38,784	25.0	6,568,702	3.0%	863,041	5,705,661
AR 2003-04	310	44,217	10.8	3,233,093	1.5%	424,486	2,808,307
AR 2004-05	342	49,432	35.0	11,727,019	5.3%	1,540,776	10,186,243
LA 2001-02	447	45,141	21.0	6,426,423	5.3%	844,348	5,582,075
LA 2002-03	545	58,178	16.8	6,620,220	5.5%	869,810	5,750,410
LA 2003-04	600	63,641	10.5	4,527,018	3.7%	594,791	3,932,228
LA 2004-05	652	67,919	10.6	4,853,301	4.0%	637,660	4,215,641
MS 2001-02	371	37,186	39.2	9,865,470	13.6%	1,296,193	8,569,277
MS 2002-03	410	42,268	23.5	6,712,970	9.2%	881,996	5,830,974
MS 2003-04	437	45,123	12.2	3,731,034	5.1%	490,209	3,240,825
MS 2004-05	437	45,125	22.5	6,871,666	9.5%	902,847	5,968,819
Sum 2001-02	1,046	115,234	33.8	26,388,101	6.4%	3,467,050	22,921,051
Sum 2002-03	1,221	139,231	21.1	19,901,892	4.8%	2,614,847	17,287,044
Sum 2003-04	1,347	152,981	11.1	11,491,145	2.8%	1,509,785	9,981,359
Sum 2004-05	1,431	162,476	21.3	23,451,986	5.7%	3,081,283	20,370,703

Table III.9. Amphibian species detected on agricultural (AG), Wetlands Reserve Program (WRP), and natural forest (BLH) sites in the Tensas, LA (TRB) and Lower White/Cache, AR (LWC) River Basins in 2006-2007 and the Yazoo River Basin (YRB), MS in 2008.

		2006			2007			2008	
Species Name	**Common Name**	**AG**	**WRP**	**BLH**	**AG**	**WRP**	**BLH**	**AG**	**WRP**
Acris blanchardi	Blanchard's Cricket Frog			X		X	X	X	X
Anaxyrus americanus	American Toad							X	
Anaxyrus fowleri	Fowler's Toad	X	X	X	X	X	X	X	X
Gastrophryne carolinensis	Eastern Narrow-mouthed Toad		X	X		X	X	X	X
Hyla avivoca	Bird-voiced Treefrog			X			X		
Hyla chrysoscelis	Cope's Gray Treefrog	X	X	X	X	X	X	X	X
Hyla cinerea	Green Treefrog	X	X	X		X	X	X	X
Hyla squirella	Squirrel Treefrog		X	X					
Hyla versicolor	Gray Treefrog			X					
Lithobates catesbeianus	American Bullfrog	X	X	X	X	X	X	X	X
Lithobates clamitans	Bronze Frog		X	X		X	X	X	X
Lithobates palustris	Pickerel Frog							X	X
Lithobates sphenocephalus	Southern Leopard Frog		X	X	X	X	X	X	X
Pseudacris crucifer	Spring Peeper			X	X	X	X		X
Pseudacris fouquettei	Cajun Chorus Frog					X	X		
Total		**4**	**8**	**12**	**5**	**10**	**11**	**10**	**10**

Table III.10. Model selection table for occupancy modeling of the 5 anuran species with sufficient observations to reach numerical convergence. The difference from the minimum Akaike's Information Criterion value (ΔAIC), the AIC weight of the model (w_i), the number of parameters in the model (*K*), and the log-likelihood of the model are given. The model $\Psi_{hab}p.$ includes separate estimates of Ψ by habitat, where model Ψ.p. assumes a constant occupancy rate across all sites.

Species	Model	ΔAIC	w_i	*K*	-2Log-likelihood
Gray Treefrog	$\Psi_{hab}p.$	0.0	0.90	4	175.1
	$\Psi.p.$	4.5	0.10	2	183.5
Green Treefrog	$\Psi.p.$	0.0	0.56	2	316.9
	$\Psi_{hab}p.$	0.5	0.44	4	313.4
Bullfrog	$\Psi_{hab}p.$	0.0	0.96	4	182.8
	$\Psi.p.$	6.3	0.04	2	193.1
Bronze Frog	$\Psi_{hab}p.$	0.0	0.99	4	225.6
	$\Psi.p.$	9.2	0.01	2	238.8
Leopard Frog	$\Psi_{hab}p.$	0.0	0.99	4	159.3
	$\Psi.p.$	9.3	0.01	2	172.6

Table III.11. Total number of visual encounter observations at WRP (n=30) and agricultural (AG) (n=20) sites in the Yazoo River Basin (YRB), MS in 2008.

Species Name	**Common Name**	**WRP**	**AG**
Acris blanchardi	Blanchard's Cricket Frog	160	14
Anaxyrus americanus	American Toad	0	1
Anaxyrus fowleri	Fowler's Toad	28	86
Gastrophryne carolinensis	Eastern Narrow-mouthed Toad	5	4
Hyla chrysoscelis	Cope's Gray Treefrog	3	1
Hyla cinerea	Green Treefrog	192	39
Lithobates catesbeianus	American Bullfrog	108	13
Lithobates clamitans	Bronze Frog	19	4
Lithobates palustris	Pickerel Frog	9	2
Lithobates sphenocephalus	Southern Leopard Frog	260	102
Pseudacris crucifer	Spring Peeper	1	0
Total		**785**	**266**

Table III.12. The number of WRP and agricultural (AG) sites that each species was detected in at least once by visual encounter or vocalization surveys and its naïve occupancy rate in the Yazoo River Basin (YRB), MS in 2008.

Species Name	**Common Name**	**# WRP (n=30)**	**Naïve Occupancy**	**# AG (n=20)**	**Naïve Occupancy**
Acris blanchardi	Blanchard's Cricket Frog	29	0.97	7	0.35
Anaxyrus americanus	American Toad	0	0.00	1	0.05
Anaxyrus fowleri	Fowler's Toad	22	0.73	13	0.65
Gastrophryne carolinensis	Eastern Narrow-mouthed Toad	8	0.27	3	0.15
Hyla chrysoscelis	Cope's Gray Treefrog	6	0.20	1	0.05
Hyla cinerea	Green Treefrog	29	0.97	9	0.45
Lithobates catesbeianus	American Bullfrog	26	0.87	8	0.40
Lithobates clamitans	Bronze Frog	19	0.63	5	0.25
Lithobates palustris	Pickerel Frog	3	0.10	2	0.10
Lithobates sphenocephalus	Southern Leopard Frog	30	1.00	17	0.85
Pseudacris crucifer	Spring Peeper	1	0.03	0	0.00

Table III.13. Scientific and common names of the dominant tree species found on WRP and BLH sites (listed in Figures III.1 and III.6, and Table I.1).

Species Code	Scientific Name	Common Name
ACER	*Acer* spp.	maple spp.
ACNE	*Acer negundo*	boxelder
ACRU	*Acer rubrum*	red maple
BAHA	*Baccharis halimifolia*	eastern baccharis
CAAQ	*Carya aquatica*	water hickory
CACA	*Carpinus caroliniana*	ironwood
CAIL	*Carya illinoinensis*	sweet pecan
CALA	*Carya laciniosa*	shellbark hickory
CAOV	*Carya ovata*	shagbark hickory
CELA	*Celtis laevigata*	sugarberry
CEOC	*Cephalanthus occidentalis*	common buttonbush
CODR	*Cornus drummondii*	roughleaf dogwood
COFO	*Cornus foemina*	stiff dogwood
CRATA	*Crataegus* spp.	hawthorn spp.
DIVI	*Diospyros virginiana*	common persimmon
FRPE	*Fraxinus pennsylvanica*	green ash
GLED	*Gleditsia* spp.	locust spp.
GLTR	*Gleditsia triacanthos*	honey locust
ILDE	*Ilex decidua*	deciduous holly
LIST	*Liquidambar styraciflua*	sweetgum
NYAQ	*Nyssa aquatica*	water tupelo
NYSY	*Nyssa sylvatica*	blackgum
PLAQ	*Planera aquatica*	water elm
PLOC	*Platanus occidentalis*	sycamore
PODE	*Populus deltoides*	eastern cottonwood
QUAC	*Quercus acutissima*	sawtooth oak
QUFA	*Quercus falcata*	southern red oak
QULA	*Quercus laurifolia*	laurel oak
QULY	*Quercus lyrata*	overcup oak
QUMI	*Quercus michauxii*	swamp chestnut oak
QUNI	*Quercus nigra*	water oak
QUPA	*Quercus pagoda*	cherrybark oak
QUPAL	*Quercus palustris*	pin oak
QUPH	*Quercus phellos*	willow oak
QUSH	*Quercus shumardii*	Shumard oak
QUTE	*Quercus texana*	Nuttall oak
SANI	*Salix nigra*	black willow
TADI	*Taxodium distichum*	baldcypress
ULAL	*Ulmus alata*	winged elm
ULAM	*Ulmus americana*	American elm
ULCR	*Ulmus crassifolia*	cedar elm