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INTERIM REPORT
ASSESSEMENT OF ECOLOGICAL SERVICES DERIVED FROM U.S. DEPARTMENT OF AGRICULTURE CONSERVATION PROGRAMS IN THE MISSISSIPPI ALLUVIAL VALLEY: REGIONAL ESTIMATES AND FUNCTIONAL CONDITION INDICATOR MODELS

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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 Millenium 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 65,000 ac of National Wildlife Refuges in the LMV have been reforested with many projects related to carbon storage. An additional 24 million ac 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 Wetland Reserve Program (WRP) and Conservation Reserve Program (CRP) represent some of the most extensive restoration programs in the MAV. Reauthorization of the Wetland Reserve Program in the 2002 Farm Security and Rural Investment Act (Farm Bill) increased acreage enrollment by 2.27 million acres and funding by $11.5 billon. Nearly 475,000 ac of the total 1.47 million acres of WRP lands enrolled by 2003 are located in Louisiana, Mississippi, and Arkansas (NRCS, 2005). 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 and Farm Service Agency, the DOI U. S. Geological Survey National Wetlands Research Center and U. S. Fish and Wildlife Service, and Ducks Unlimited. The overall goal of this project is to quantify existing ecological services derived from USDA restoration programs in the MAV and develop indicators of wetland functions that can be used to quantify ecological services in the future. This interim report summarizes the work to date and the preliminary results.

APPROACH AND METHODS

The study area was located in the lower White/Cache River Basins, Arkansas, and the Tensas River Basin, Louisiana, which lie within the (MAV). Using spatially explicit GIS data documenting the location of WRP and CRP projects supplied by NRCS and FSA, sixteen study sites were randomly selected in each of three habitat types: agricultural crop land (AG), former crop land reforested under the Natural Resources Conservation Service (NRCS) Wetlands Reserve Program (WRP), and mature 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 occurred in the Tensas River Basin (n=24) and the other half occurred in the lower White/Cache River Basins (n=24) (Fig. 1). 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. Agricultural sites were in crop production during the study period with species including soybean, corn, milo, and cotton. The WRP's were all planted between 1995 and 2004. The majority of tree species planted were oaks (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*) (NRCS, unpubl. data). Other species included green ash (*Fraxinus pennsylvanica*), baldcypress (*Taxodium distichum*), sweet pecan (*Carya illinoinensis*), persimmon (*Diospyros virginiana*), sweetgum (*Liquidambar styraciflua*), hackberry (*Celtis laevigata*), and black gum (*Nyssa sylvatica*) (NRCS, unpubl. data). All WRP sites had undergone some form of hydrologic restoration. In 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 Arkansas, all of the BLH sites were on public land (i.e., Cache River NWR and White River NWR).

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

Carbon storage in soil and trees was calculated based on site-specific vegetation and soils data and primary scientific literature. Heights and diameters of trees were recorded at each site (see Biological Conservation, Sustainability, and Habitat Quality – Vegetation section below). Carbon storage in tree, understory, and forest floor pools was calculated using the site-specific data and allometric equations in Jenkins et al. (2003, 2004). Soil carbon in the upper 15 cm was calculated directly from soil samples randomly collected within the five 400-m^2 vegetation study plots using a slide hammer soil corer with brass ring inserts at depths of 0-5 cm, 5-10 cm, and 10-15 cm. The brass rings enabled volumetric determination of soil bulk density at each depth. A subset of each sample was used to measure carbon and nitrogen content. These sub-samples were oven-dried (105 °C), ground through a 2-mm sieve, pulverized, and sub-samples 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 was determined gravimetrically following Burt et al. (1993).

Average annual soil erosion was calculated using the USDA's Revised Universal Soil Loss Equation (RUSLE) standard soil loss equation. The official NRCS version of RUSLE2 Version 1.26.6.4 and its database were downloaded off the website 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. Under the location tab, climate data was imported based on the parish where the site was located. The climate data contains information for the average monthly temperature, precipitation and erosion density. Under the soil tab, the SSURGO 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 parish. The percent slope was extracted by soil type from the "wind erosion prediction system related attributes" report.

Under the Base management tab, three different templates were chosen based on NRCS zone location classification with guidance from Richard Aycock of NRCS. We assumed that single crop rotation was used for both Louisiana and Arkansas agriculture fields. The template "Soybeans full season with weeds; SD Z38" was used for Louisiana agriculture fields and "Soybean, grain; SD, Z-42" for Arkansas 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 for both the Louisiana and Arkansas WRP based on the recommendation of R. Aycock, NRCS. 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 DEA procedure (Groffman and Tiedje, 1989). Field moist soils were thoroughly homogenized by hand and brought to room temperature overnight before incubation. Fifteen milliliters of the following treatment solutions were added to 150 ml serum bottles and mixed to create a slurry (3 replicate bottles/treatment):

a. 10 mg l^{-1} NO_3-N
b. 3 mg l^{-1} NO_3-N
c. DI water (control)

Each bottle was sealed with a rubber septa and foil cap, wrapped in Al foil, and purged with O_2-free N_2 gas for 15 minutes 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 ~25^0C 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 38001GC equipped with an ECD detector. Corrections were made for dissolved N_2O with the Bunsen's absorption coefficient.

Flood Compatibility Of Land Enrolled In WRP

Our original intent was to quantify changes in flood storage capacity resulting from conversion of active cropland to WRP. This requires information on the spatial extent of flooding relative and changes in storage volume in the MAV. Calculating changes in storage volume at the

MAV scale is unfeasible at this time as the only data available documenting storage volume are the engineering files associated with individual WRP enrollments. Quantifying flood storage capacity resulting from conversion of active cropland to WRP also requires a detailed analysis of what actually constitutes a change in storage volume. An argument can be made that the total flood storage volume is fixed and what we are interested in knowing is the change from a land use that is incompatible with flooding (e.g., agricultural crops) to those land uses that are compatible with flooding (e.g., forested wetlands). We have focused on this latter issue with respect to lands enrolled in WRP. This is a significant undertaking which requires a landscape-scale estimate of flooding extent and frequency.

We are evaluating additional approaches necessary to calculate flood storage volume including LIDAR, synthetic aperture radar, and direct field measurements. This analysis also requires a landscape-level understanding of the spatial arrangement of the water sources, potential sinks associated with WRP flood-storage volumes, and connections via natural or artificial (e.g., ditches) water features.

The MAV High Frequency Natural Flood Model was developed from a synthesis of river gage data and the classification of satellite imagery. We used the river gage data from the New Orleans, Vicksburg, Memphis, and Little Rock Districts of the United States Army Corps of Engineers as these districts comprise the Lower Mississippi Alluvial Valley. In total, we acquired and analyzed POR data for 140 gage 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 period of record 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 gage 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 rolled up 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. These data loggings were rolled up into an ordered ranking of flood events for the period recorded, from which recurrence interval was estimated.

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 Mississippi Alluvial Valley for which adequate gage data were available to model flood frequency to compare WRP easements relative to the Flood Frequency Model output. The remaining 180 watersheds lacked adequate gage 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 gage data archives, and where gage 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; and (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 LMVJV WRP Easement Data Set into one of these 8 classes.

Biological Conservation, Sustainability, and Habitat Quality

We used the edaphic, vegetative, and morphological characteristics at both the patch scale and landscape scale to evaluate the effects of WRP on the following species groups: neotropical migratory birds, waterfowl, amphibians, and black bear. Preliminary results for neotropical migratory birds, waterfowl, and amphibians are included in this report. Work is continuing on the black bear efforts.

Vegetation

At each site (8 each in forest and wetland-reserve-program per state), the vegetation was sampled in 5 study plots (400 m^2 (478.4 yd^2) each; Fig. 2) that were spaced at 75 m intervals along a transect. 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 avian, amphibian and soils carbon components of the overall study, rather than to provide an in-depth analysis of the success or failure of the WRP tree plantings at each site. However, given the replication at the WRP-level, these data do provide a reasonable measure of species diversity and composition. The species, diameter at breast height (dbh, 140 cm (4.6 ft) above the soil surface), height, vigor, crown class and associated vines were recorded for every tree (≥ 10 cm (4 in) dbh) within the plot. Tree heights were measured to the nearest decimeter (4 in) with a Opti-LogicLH 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 (Fig. 2). 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 (Fig. 2). We recorded the cover class of all herbaceous species observed.

Neotropical migratory birds.

Variable-width line transects (Ralph et al. 1993) were used to obtain estimates of bird density, and species richness in three habitat types: bottomland hardwood forest, wetland restoration program (WRP) sites, and agricultural fields. Eight sites within each habitat were sampled in Louisiana and in Arkansas 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. 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 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), and 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. 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 Tensas River watershed 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 the one-hour periods of visible light before dusk and after dawn, birds in the radar area were visually detected with binoculars and recorded. In addition, 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.

The North American Waterfowl Management Plan of the LMVJV has established conservation objectives to provide foraging for approximately 469.3 million duck-energy-days (DED) (LMVJV Waterfowl Working Group Update 2007). 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. 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 DED resulting from converting cropland to WRP.

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 Mississippi Alluvial Valley and analyzed them to ensure that no significant precipitation events occurred 3 days prior to image acquisition (Wax et al. 1986).

The Wetland Reserve Program (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 Lower Mississippi Valley Joint Venture (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 acres and HMU acres. However, based upon information provided by the WRP Coordinators, an estimated 121,000 acres of managed seasonal wetlands have been restored through the Wetland 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 Mississippi Alluvial Valley on average have a waterfowl carrying capacity of 1,868 Duck-Energy-

Days (DEDs)/acre. Kross et al. (2006) surveyed a series of actively and passively managed moist soil units on state and federal lands in the Mississippi Alluvial Valley and found they provided a combined average of 1,528 DEDs/acre. More recently, Gann and Brennan (2007) estimated that WRP wetlands in Arkansas provided 958.4 DEDs/acre. Hence, to estimate the contribution of WRP HMUs to LMVJV Waterfowl Foraging Habitat Objectives we assigned a foraging habitat value of 1,868 DEDs/acre 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 934 DEDs/acre.

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

We focused on calling male anuran amphibians (frogs and toads), 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. These froglogger units consisted of hand-held computers (personal digital assistants or PDA’s), 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 a water tight Hardig Storm case that is 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.

RESULTS AND DISCUSSION

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

There was no difference in total carbon pools between the active crop land (AG) and restored forest (WRP), while the native forest (BLH) sequestered the greatest amount of carbon (Fig. 3). This result is not surprising given that most of the carbon is found in tree biomass and the trees planted on the WRP sites are all less than 15 years old.

Calculated sediment losses from erosion were much higher in the AG than the WRP sites (Fig. 4). The absolute amount varied by soil textural class, ranging from 1.41 tons/ac/yr for clay soils to 4.35 tons/ac/yr for silt loam soils. 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), was similar in both control (no NO_3 added) and NO_3-amended treatments (Fig. 5). Significantly 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). Additional research beyond this project is required to experimentally determine the primary controlling factors.

Flood Compatibility Of Land Enrolled In WRP

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, 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 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. 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.

Biological Conservation, Sustainability, and Habitat Quality

Vegetation

Comparisons of stem densities indicate differences between locations (LWC and TRB) and land use (AG and BLH). In the LWC, BLH sites were dominated by American hornbeam (*Carpinus caroliniana*), red maple (*Acer rubrum*), sugarberry (*Celtis laevigata*), followed by red oak (*Quercus* sp.), hickory (Carya sp.), and boxelder (*Acer negundo*) (Fig. 6, Table 2). The TRB forests were dominated by sugarberry, possumhaw (*Ilex decidua*), green ash (*Fraxinus pennsylvanica*), with some maples (Acer sp.). Green ash and water oak (*Q. nigra*) (both TRB and LWC) and water hickory (*Carya aquatica*) (TRB only) were the only species with comparable densities in both the BLH and WRP. In contrast, sweet pecan (*Carya illinoinensis*) and Texas red oak (*Quercus texana*) (both TRB and LWC) and willow oak (LWC only) found in much greater densities in WRP than BLH. If these species planting patterns continue, WRP sites will have less species diversity and a different forest composition than the native BLH forest.

Neotropical migratory birds.

Overall, 109 species were detected over the 2006 autumn migration season (Table 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 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 5). Throughout the study period, forested sites had greater mean species richness than WRP sites and agricultural fields (Fig. 7). The differences between WRP sites and agricultural 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. 7A). 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. 7B).

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 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. 8A). 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. 8B). 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. 8C). 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). Additional work will include relating these results to specific patch and landscape variables that affect migratory birds and other in-depth statistical analyses (e.g., comparing guilds to species responses, structural equation modeling, converting richness to bird density).

Waterfowl

We calculated the total contribution of WRP to LMVJV Foraging Habitat Objectives by summing the estimated contributions of HMUs 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 1,868 DEDs/acre, and it assumes and 5% of each unit is managed to provide unharvested corn in the form of food plots producing 28,591 DEDs/acre (Reinecke and Kaminski, LMVJV Waterfowl Working Group; Table 4). 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 14,790 acres to 25,911 acres of flooded potential foraging habitat in LA, AR, and MS (Table 6) 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 was managed passively or not managed at all, and that about 5% was actively managed. However, in terms of *total <u>area</u> of WRP HMUs,* we classified 41% of HMUs as Satisfactory-Active in terms of plant species composition and management, while 59% was 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 6). The net increase in potential foraging capacity resulting from restoration of marginal soybean agricultural land to emergent wetland ranged from 18.95 to 33.19 million DEDs (Table 6).

We also estimated, based upon the results of our remote sensing work, the maximum potential contribution that WRP could provide if HMUs in particular were intensively managed. We used the estimated flooded area within HMUs and assumed 95% was actively managed moist soil habitat and 5% was actively managed unharvested food plots comprised of corn. We then added the estimated contribution provided by reforested, naturally flooded WRP lands to estimate the maximum potential contribution of WRP to LMVJV foraging objectives in each state.

Under the scenario where 100% of HMUs are actively managed, with 95% dedicated to moist soil managed and 5% dedicated to waterfowl food plots consisting of flooded unharvested corn, the WRP provided an estimated 13.2% to 23.4% of the LMVJV foraging objectives in the tri-state area of AR, LA, and MS (Table 7). This represents a potential increase of approximately 52.62 to 92.78 million DEDs that could be realized from restoration activities as compared to prior condition as marginal, frequently flooded soybean agricultural land (Table 7). Importantly, active management of hydrology units alone could increase foraging value provided by WRP by 50-60%, or 25.7 to 43.15 million DEDs annually.

Amphibians

The maximum number of species found was 13 in 2006 and the BLH sites were the only habitat in which all species were found (Table 8). The BLH sites had a mean species richness of 12.0, however, species richness in the AG and WRP sites was 5.0 and 9.0, respectively. For both 2006 and 2007, 11 species (*Acris crepitans*, *Bufo fowleri*, *B. woodhousii*, *Gastrophryne carolinensis*, *Hyla chrysoscelis*, *H. cinerea*, *Pseudacris crucifer*, *P. feriarum*, *Rana catesbeiana*, *R. clamitans*, and *R. spehnocephala)* were found in both WRP and BLH habitats. This result 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.

Even though the use of frog-loggers to remotely record frog calls was a cost-effective initial approach, additional work will include night-time visual encounter surveys. This will allow us to catalogue non-vocal frogs and groups like salamanders and use these results to develop an occupancy model for these habitats.

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Figure 1. Location of study sites in the Lower White/Cache, AR (LWC) (A) and Tensas, LA (TRB) (B) River Basins.

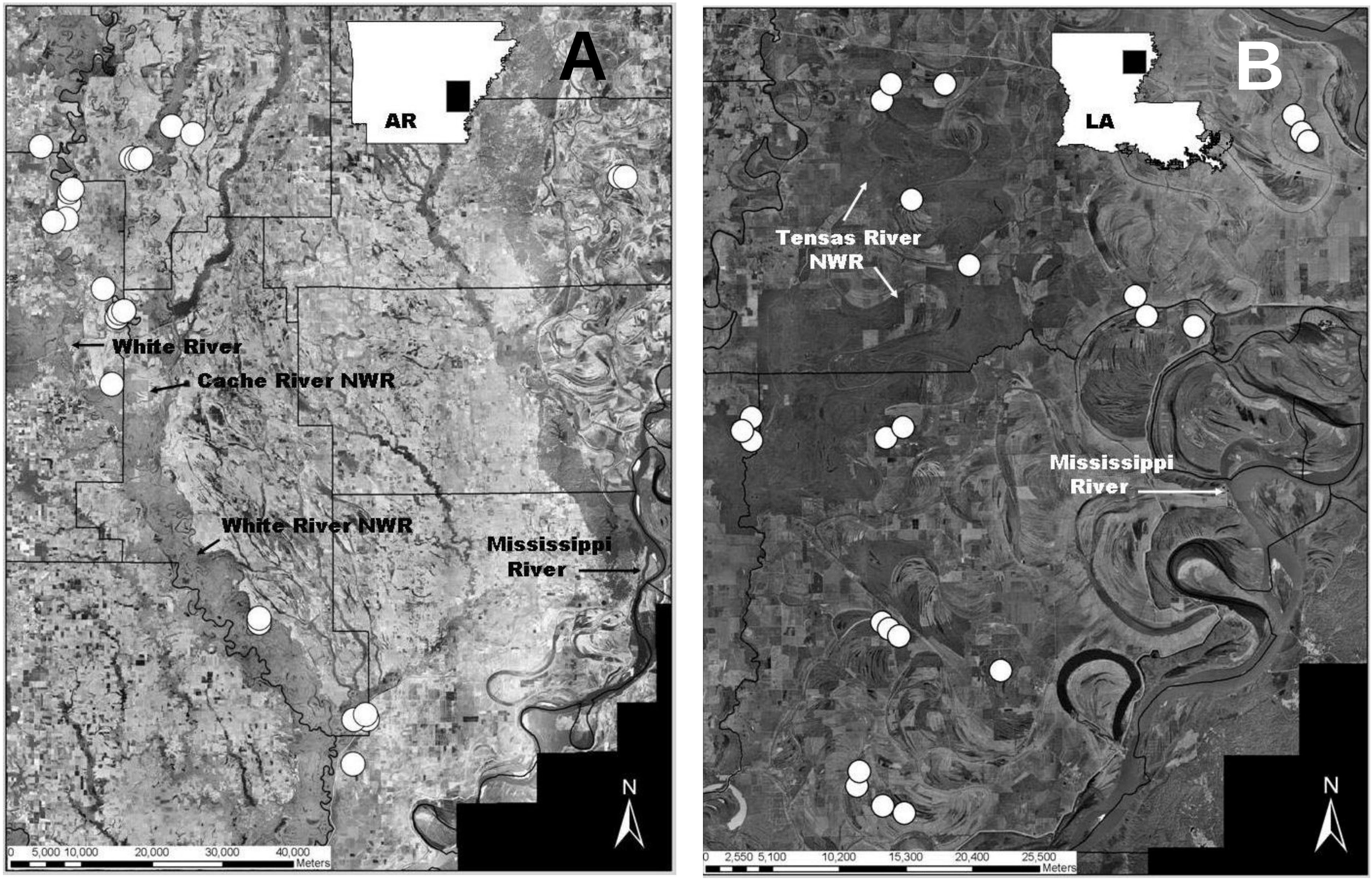

Figure 2. Layout of vegetation sampling plots.

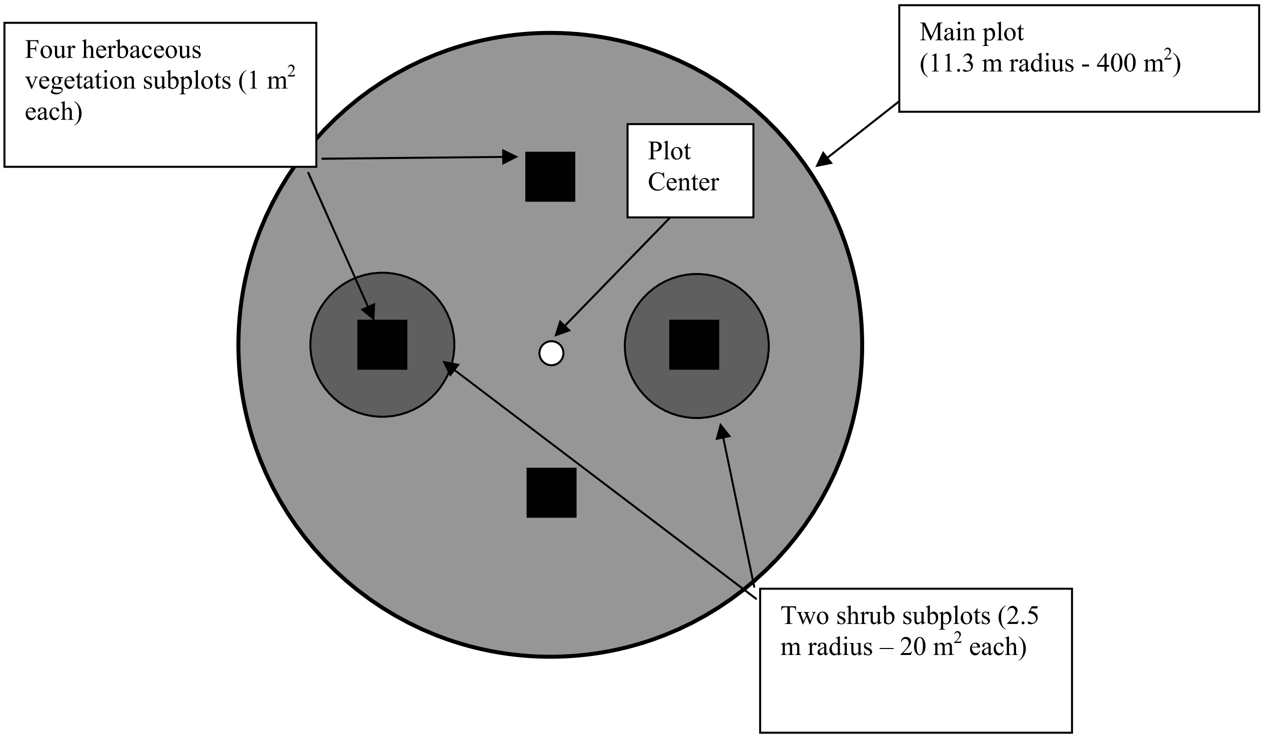

Figure 3. Carbon storage in active crop land (AG), Wetland Reserve Program (WRP), and native forest (BLH) in the Tensas, LA and Lower White/Cache, AR River Basins.

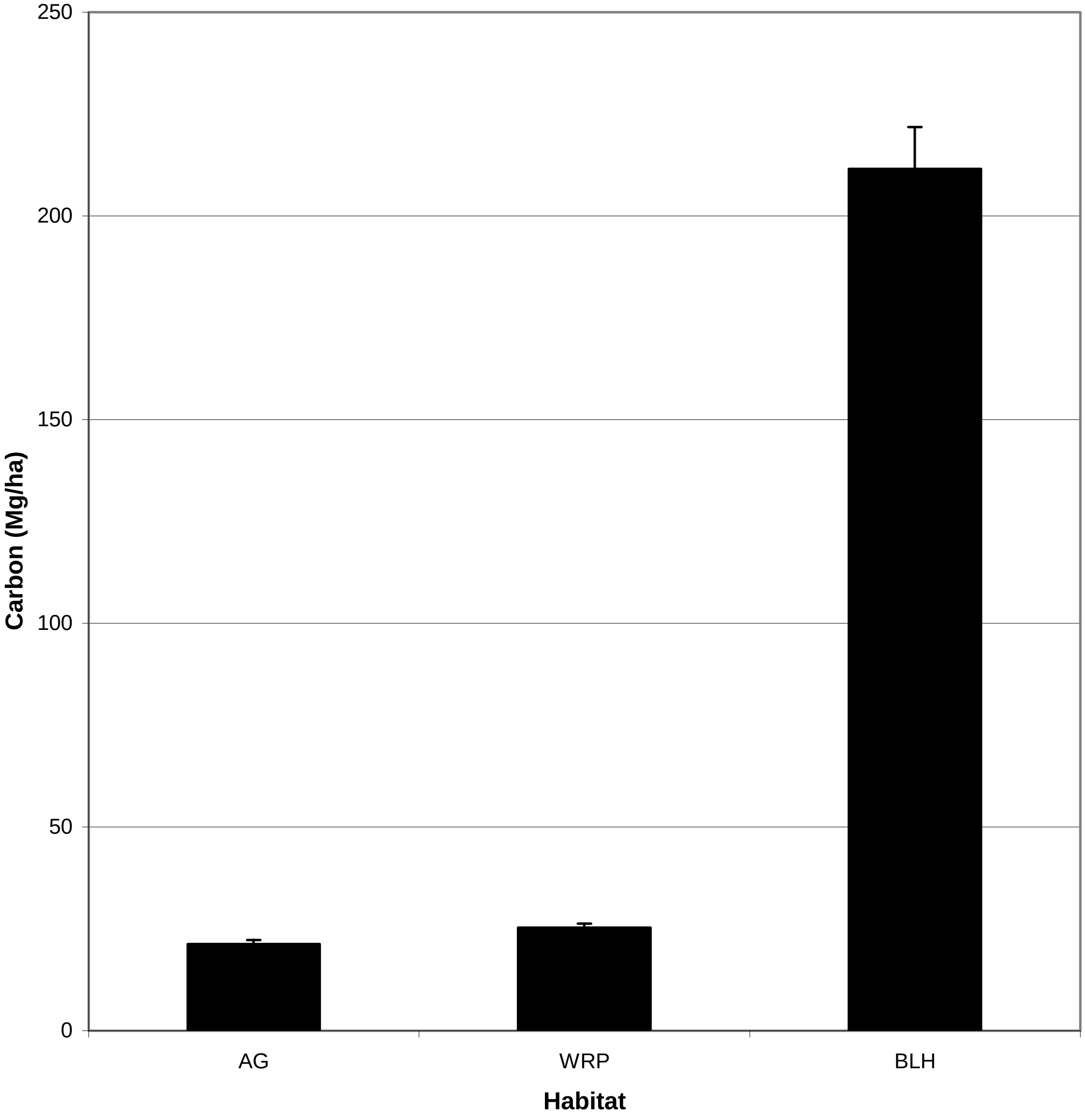

Figure 4. Sediment erosion losses by soil texture class from active crop land (AG) and Wetland Reserve Program (WRP) in the Tensas, LA and Lower White/Cache, AR River Basins.

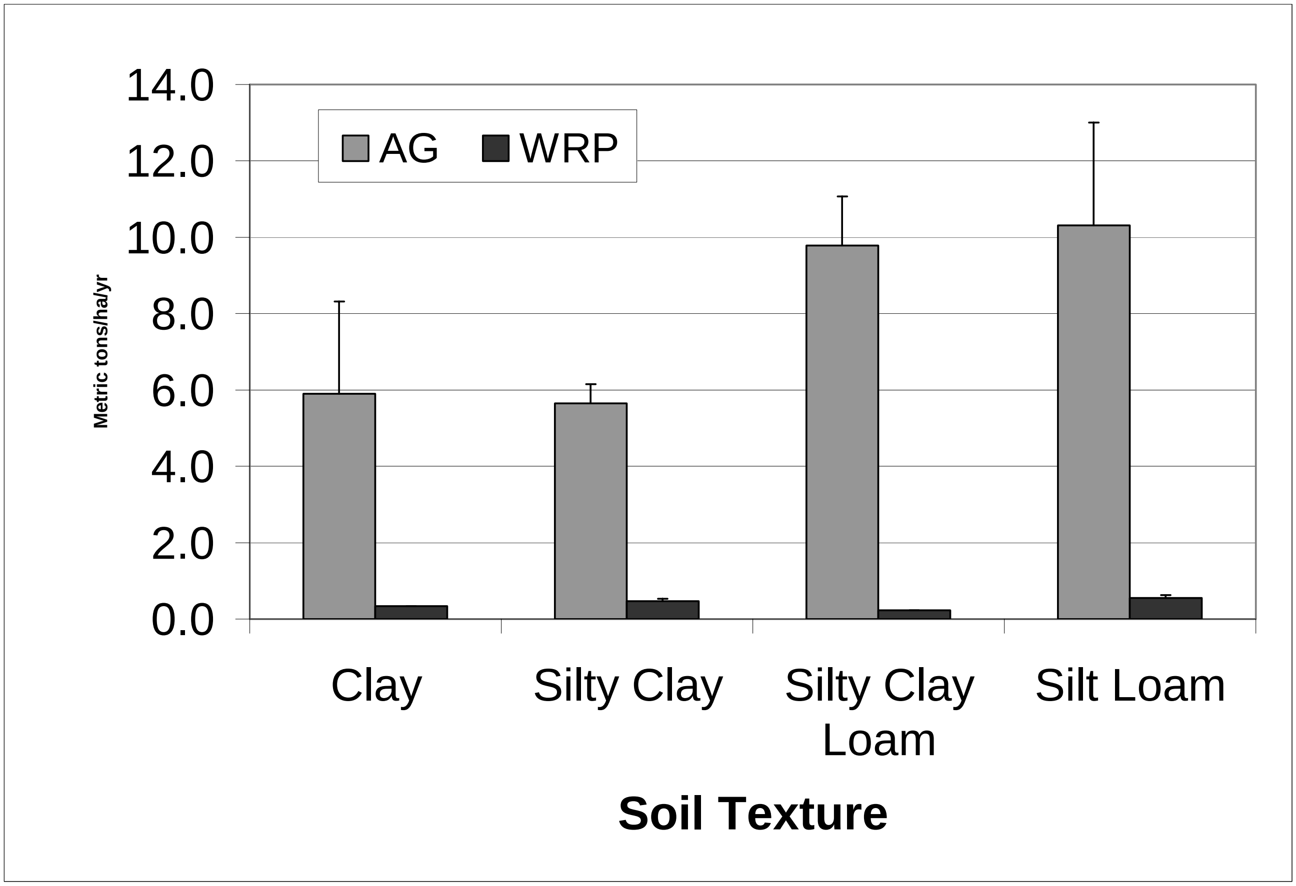

Figure 5. Soil denitrification potentials for active crop land (AG), Wetland Reserve Program (WRP), and native forest (BLH) in the Tensas, LA and Lower White/Cache, AR River Basins.

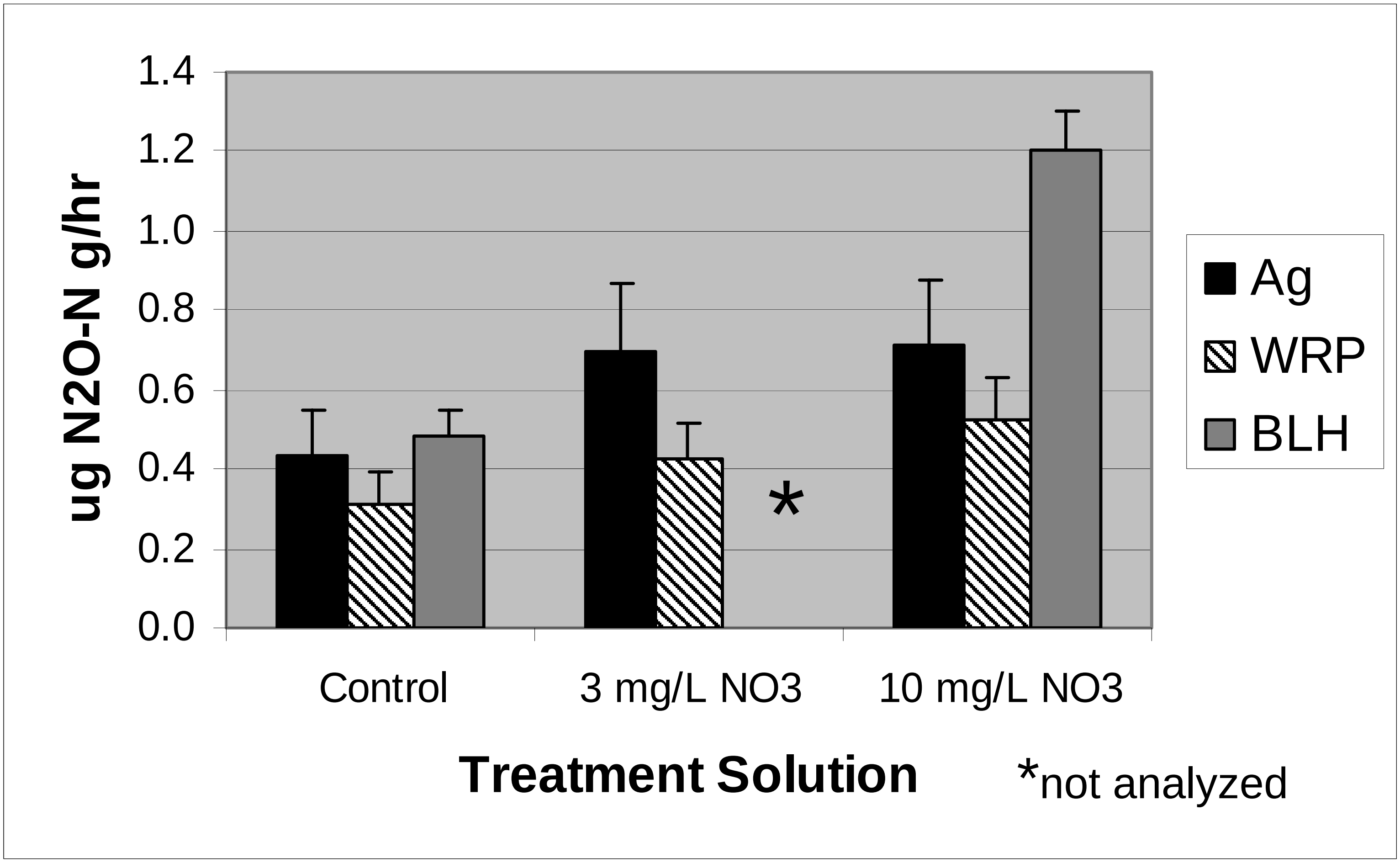

Figure 6. Stem density of trees in Wetland Reserve Program (WRP) and native forest in the Tensas, LA and Lower White/Cache, AR River Basins. AF – native forest, AR; AW – WRP, AR; LF – native forest, LA; LW – WRP, LA;

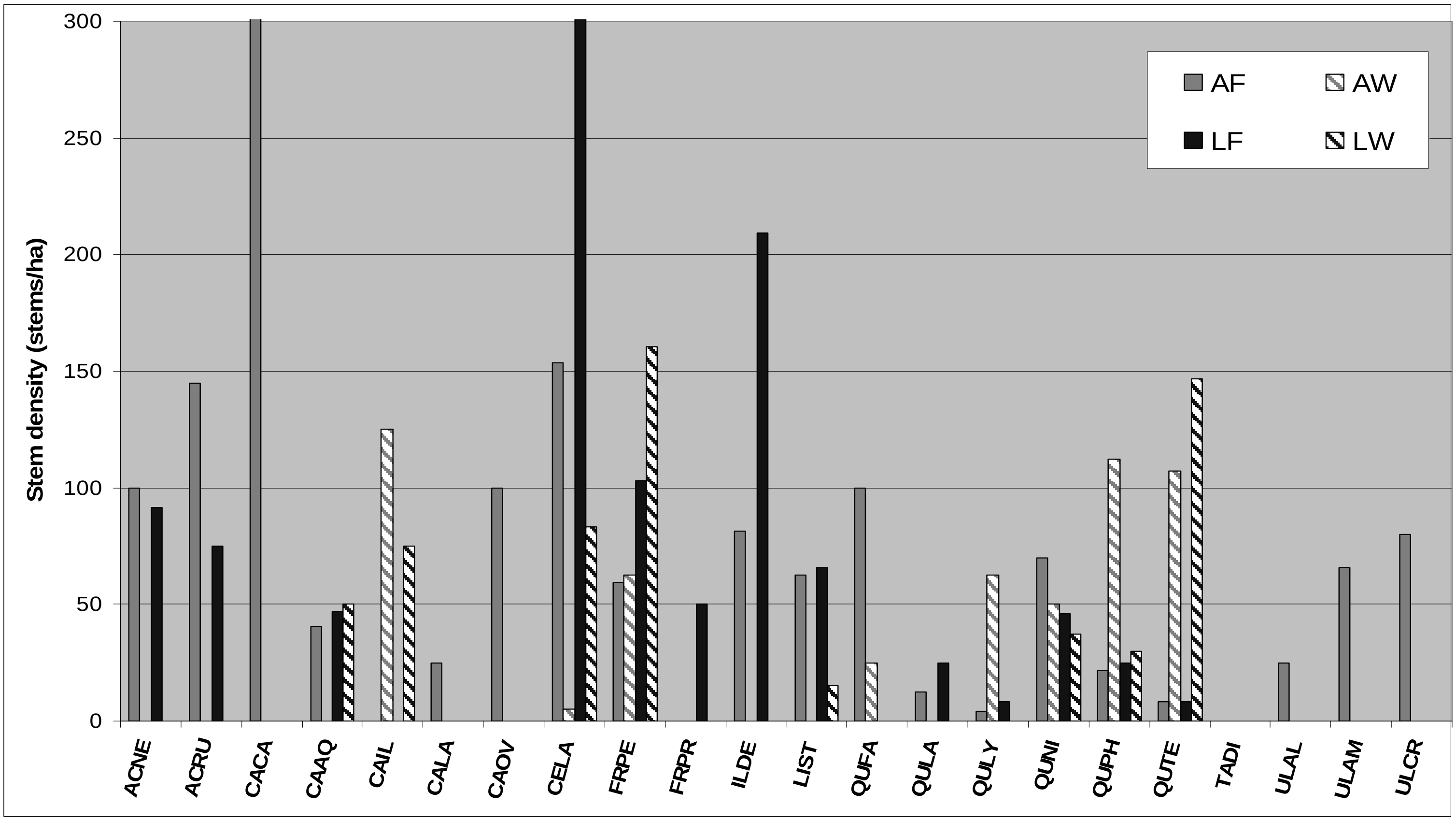

Figure 7. Mean observed bird species richness (± SE) by habitat type and sampling period the Tensas, LA (A) and Lower White/Cache, AR (B) River Basins. Asterisk denotes significant difference between WRP sites and AG sites.

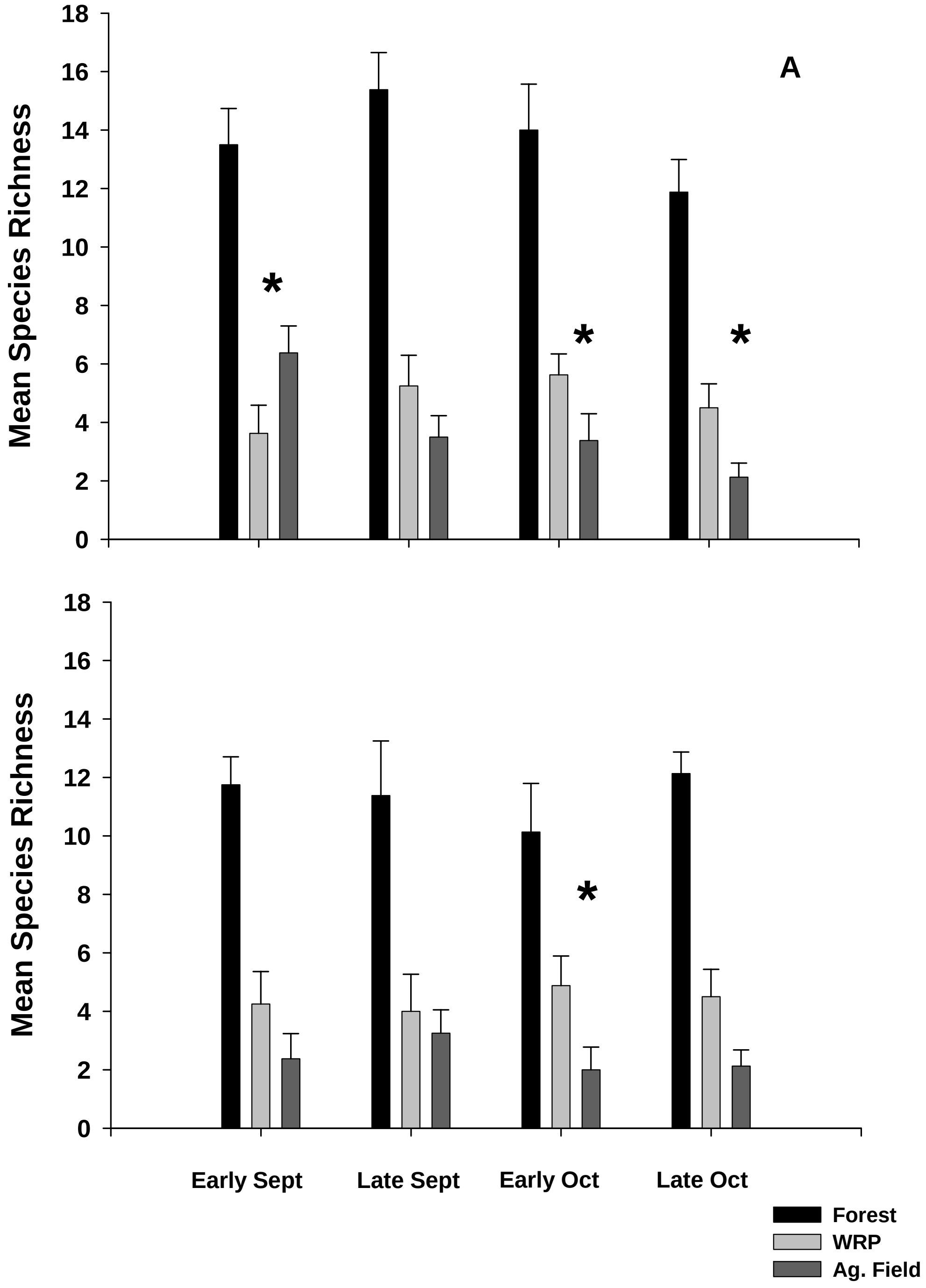

Figure 8. Mean observed bird species richness (± SE) by habitat type and sampling period for resident species (A), nearctic-neotropical migrants (B), and temperate migrants (C). Asterisk denotes significant difference between WRP sites and AG sites.

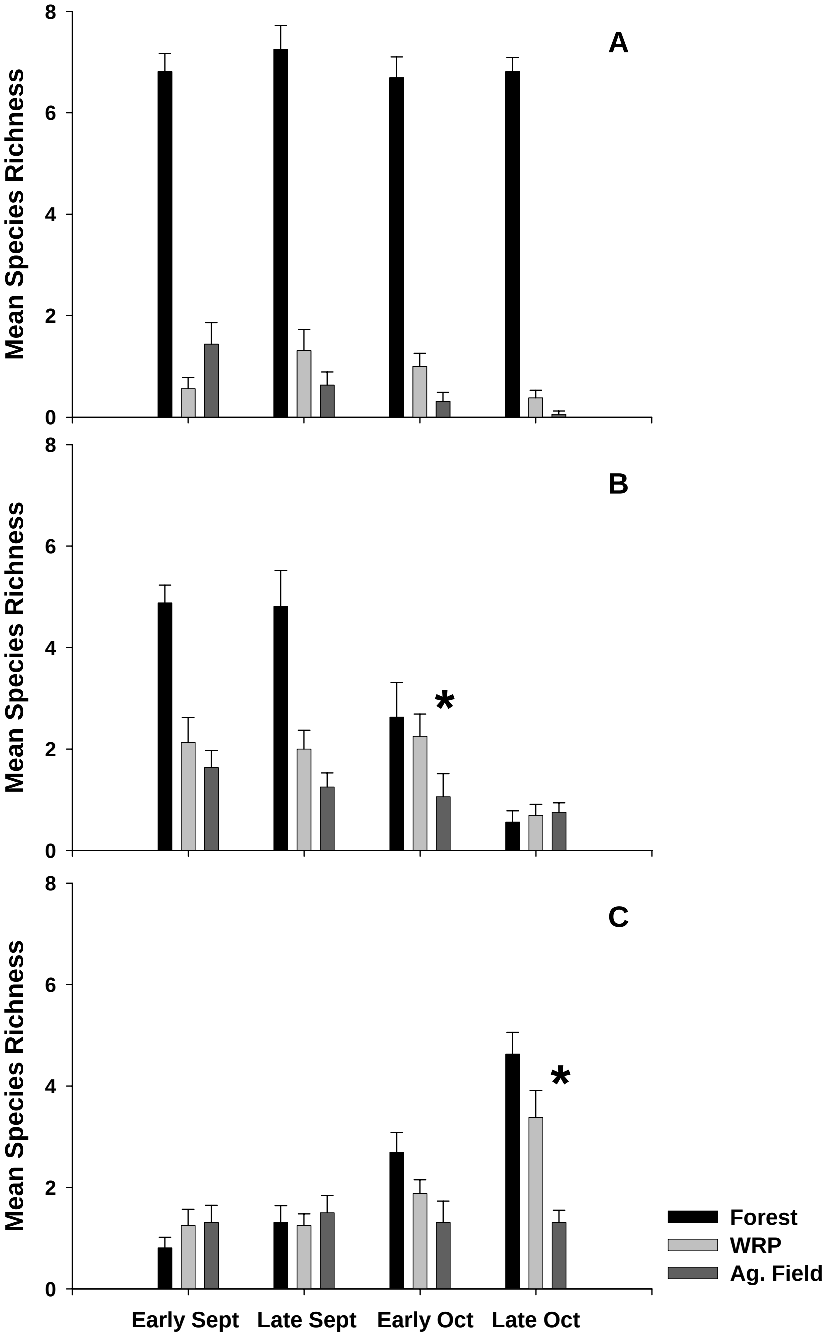

Table 1. Number of easements, total hectares of easements and number of hectares within high, medium, and low flood frequencies for a sample of lands enrolled in the Wetlands Reserve Program in Arkansas, Louisiana and Mississippi.

	Year							
	2001-2002		**2002-2003**		**2003-2004**		**2004-2005[3]**	
Number of easements sampled[1]	365		420		462		498	
Numbers 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 2. Scientific and common names of the dominant tree species found on WRP and BLH sites (listed in Figure 6) in the Tensas, LA (TRB) and Lower White/Cache, AR (LWC) River Basins.

Species Code	**Scientific Name**	**Common name**
ACNE	*Acer negundo* L.	Boxelder
ACRU	*Acer rubrum* L.	Red Maple
CAAQ	*Carya aquatica* (Michx. f.) Nutt.	Water Hickory
CACA	*Carpinus caroliniana* Walt.	American Hornbeam
CAIL	*Carya illinoinensis* (Wangenh.) K. Koch	Pecan
CALA	*Carya laciniosa* (Michx. f.) G. Don	Shellbark Hickory
CAOV	*Carya ovata* (P. Mill.) K. Koch	Shagbark Hickory
CELA	*Celtis laevigata* Willd.	Sugarberry
FRPE	*Fraxinus pennsylvanica* Marsh.	Green Ash
ILDE	*Ilex decidua* Walt.	Possumhaw
LIST	*Liquidambar styraciflua* L.	Sweetgum
QUFA	*Quercus falcata* Michx.	Southern Red Oak
QULA	*Quercus laurifolia* Michx.	Laurel Oak
QULY	*Quercus lyrata* Walt.	Overcup Oak
QUNI	*Quercus nigra* L.	Water Oak
QUPH	*Quercus phellos* L.	Willow Oak
QUTE	*Quercus texana* Buckl.	Texas Red Oak
TADI	*Taxodium distichum* (L.) L.C. Rich.	Baldcypress
ULAL	*Ulmus alata* Michx.	Winged Elm
ULAM	*Ulmus americana* L.	American Elm
ULCR	*Ulmus crassifolia* Nutt.	Cedar Elm

Table 3. Bird species detected on agricultural fields (AG), Wetland Reserve Program (WRP), and native forest (BLH) sites in the Tensas, LA (TRB) and Lower White/Cache, AR (LWC) River Basins. (Cont'd)

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*	■		

Table 3. Bird species detected on agricultural fields (AG), Wetland Reserve Program (WRP), and native forest (BLH) sites in the Tensas, LA (TRB) and Lower White/Cache, AR (LWC) River Basins. (Cont'd)

Common name	***Scientific name***	**AG**	**WRP**	**BLH**
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*		■	■
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*		■	■

Table 3. Bird species detected on agricultural fields (AG), Wetland Reserve Program (WRP) and native forest (BLH) sites in the Tensas, LA (TRB) and Lower White/Cache, AR (LWC) River Basins. (Cont'd)

Common name	***Scientific name***	**AG**	**WRP**	**BLH**
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*	▨	▨	▨
Summer Tanager	*Piranga rubra*		▨	▨
Savannah Sparrow	*Passerculus sandwichensis*	▨	▨	
Lincoln's Sparrow	*Melospiza lincolnii*		▨	
Rose-breasted Grosbeak	*Pheucticus ludovicianus*			▨

Table 3. Bird species detected on agricultural fields (AG), Wetland Reserve Program (WRP) and native forest (BLH) sites in the Tensas, LA (TRB) and Lower White/Cache, AR (LWC) River Basins. (Cont'd)

Common name	***Scientific name***	**AG**	**WRP**	**BLH**
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*			▨

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

Common name	***Scientific name***	**AG**	**WRP**	**BLH**
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*		▨	▨
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 4. Bird species that were only detected on agricultural fields (AG), Wetland Reserve Program (WRP) or native forest (BLH) sites in the Tensas, LA (TRB) and Lower White/Cache, AR (LWC) River Basins. (Cont'd)

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*
Orange-crowned Warbler	*Vermivora celata*
Nashville Warbler	*Vermivora ruficapilla*

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

Common name	***Scientific name***
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
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[4] USFWS, Game bird below desired condition
[5] Partners in Flight watch list species

Table 5. Repeated measures analysis of variance (ANOVA) for mean observed bird species richness. 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 6. Estimated contribution of Wetlands Reserve Program Hydrology Management Units to Lower Mississippi Valley Joint Venture population-based foraging habitat objectives for Arkansas, Louisiana, and Mississippi, 2001-2005.

State/Year	Total HMU Sampled	Total HMU Area (ha)	Total HMU Area Flooded[1] (ha)	Total HMU Area Flooded (%)	DED's Provided[2]		Estimated Total DEDs Provided	Estimated State Foraging Objective Provided[3] (%)	Estimated DED Value Prior to Restoration[4]	Net Change in DEDs Provided Post-restoration
					Satisfactory/ Active	Marginal/Passive /Unsatisfactory/ Unmanaged				
AR 2001-02	544	6,168	4,156	67.4%	19,434,054	13,983,040	33,417,094	6.2%	913,493	32,503,601
AR 2002-03	579	6,498	3,462	53.3%	16,189,013	11,648,193	27,837,205	5.1%	760,961	27,076,245
AR 2003-04	623	6,842	1,473	21.5%	6,886,140	4,954,661	11,840,801	2.2%	323,682	11,517,118
AR 2004-05	640	6,975	3,887	55.7%	18,178,126	13,079,384	31,257,511	5.8%	854,457	30,403,053
LA 2001-02	1,008	6,239	2,211	35.4%	10,341,623	7,440,924	17,782,549	6.0%	486,106	17,296,443
LA 2002-03	1,144	6,952	3,046	43.8%	14,242,408	10,247,587	24,489,996	8.2%	669,460	23,820,536
LA 2003-04	1,185	7,311	2,095	28.7%	9,800,363	7,051,480	16,851,843	5.6%	460,664	16,391,181
LA 2004-05	1,185	7,311	974	13.3%	4,553,581	3,276,357	7,829,938	2.6%	214,039	7,615,898
MS 2001-02	964	6,486	4,119	63.5%	19,260,649	13,858,272	33,118,921	18.5%	905,341	32,213,580
MS 2002-03	1,024	6,884	3,820	55.5%	17,864,566	12,853,773	30,718,339	17.1%	839,720	29,878,619
MS 2003-04	1,037	6,927	2,417	34.9%	11,304,194	8,133,506	19,437,699	10.8%	531,351	18,906,348
MS 2004-05	1,037	6,927	2,044	29.5%	9,557,511	6,876,745	16,434,256	9.2%	449,248	15,985,008
Total 2001-02	2,516	18,893	10,486	55.5%	49,036,329	35,282,236	84,318,565	8.3%	2,304,940	82,013,624
Total 2002-03	2,747	20,335	10,327	50.8%	48,295,987	34,749,550	83,045,540	8.1%	2,270,141	80,775,396
Total 2003-04	2,845	21,080	5,985	28.4%	27,990,697	20,139,646	48,130,343	4.7%	1,315,695	46,814,645
Total 2004-05	2,862	21,212	6,904	32.5%	32,289,218	23,232,486	55,521,705	5.4%	1,517,747	54,003,957

[1] Flooded hectares within WRP Hydrology Management Units as determined by remote sensing to detect presence of water within unit.

[2] Satisfactory/Active management is estimated to occur in 41% of area flooded with DED value is 4,616 DED/ hectares, Unsatisfactory/Passive or Unmanaged is estimated to occur in 59% of the flooded area with DED value is assumed 2,308 DED/ hectares.

[3] Population-based objective for Arkansas (219,427,337), Louisiana (120,913,320) and Mississippi (72,642,570) from LMVJV Waterfowl Working Group Memorandum, updated 2007.

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

[5] The WRP Hydrology Unit data set contains polygons for some HMUs for which the easement polygon was not provided in updates.

Table 7. 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	WRP Easement Area Flooded	Total DED-Naturally Flooded Area	WRP HMU Area Flooded	Total DED-Intensive Moist Soil Management[1]	Total DED-Post-restoration	Percentage Foraging Objective Provided	Total DED-Prior to Restoration	Net DED Increase Post-restoration
	--------------------------- ha -----------------------------							
AR 2001-02	13,776	3,802,277	3,900	30,878,394	40,273,986	18.40%	1,572,444	38,701,542
AR 2002-03	7,991	2,205,392	3,429	27,148,410	32,598,030	14.90%	1,015,844	31,582,186
AR 2003-04	4,095	1,130,340	2,119	16,773,725	19,566,845	8.90%	552,780	19,014,065
AR 2004-05	16,052	4,430,219	4,446	35,203,996	46,151,260	21.00%	1,823,436	44,327,824
LA 2001-02	8,585	2,369,358	1,902	15,062,709	20,917,497	17.30%	932,904	19,984,593
LA 2002-03	7,896	2,179,367	2,165	17,144,509	22,529,821	18.60%	895,058	21,634,764
LA 2003-04	5,356	1,478,154	1,561	12,361,611	16,014,195	13.20%	615,312	15,398,883
LA 2004-05	6,963	1,921,802	1,762	13,950,869	18,699,725	15.50%	776,160	17,923,565
MS 2001-02	13,058	3,604,132	3,365	26,645,711	35,551,679	48.90%	1,461,024	34,090,655
MS 2002-03	7,751	2,139,381	2,731	21,621,508	26,908,012	37.00%	932,471	25,975,541
MS 2003-04	3,961	1,093,258	2,026	16,039,975	18,741,463	25.80%	532,584	18,208,879
MS 2004-05	9,704	2,678,191	2,079	16,462,923	23,080,851	31.80%	1,048,176	22,032,675
Sum 2001-02	35,419	9,775,767	9,168	72,586,814	96,743,162	23.40%	3,966,372	92,776,790
Sum 2002-03	23,638	6,524,140	8,325	65,914,428	82,035,864	19.90%	2,843,373	79,192,491
Sum 2003-04	13,412	3,701,752	5,706	45,175,311	54,322,503	13.20%	1,700,676	52,621,827
Sum 2004-05	32,718	9,030,212	8,288	65,617,788	87,931,836	21.30%	3,647,772	84,284,064

[1] Intensively managed habitat includes 5% of flooded hectares as flooded un-harvested corn, remainder in intensively managed moist soil vegetation.

Table 8. Amphibian species detected on agricultural fields (AG), Wetland Reserve Program (WRP), and native forest (BLH) sites in the Tensas, LA (TRB) and Lower White/Cache, AR (LWC) River Basins.

	2006			2007		
Species	AG	WRP	BLH	AG	WRP	BLH
Acris crepitans			X		X	X
Bufo fowleri	X		X	X	X	X
Bufo woodhousii	X	X	X			
Gastrophryne carolinensis		X	X		X	X
Hyla avivoca			X			X
Hyla chrysoscelis	X	X	X	X	X	X
Hyla cinerea	X	X	X		X	X
Hyla squirella		X	X			
Hyla versicolor			X			
Pseudacris crucifer			X	X	X	X
Pseudacris feriarum					X	X
Rana catesbeiana	X	X	X	X	X	X
Rana clamitans		X	X		X	X
Rana spehnocephala		X	X	X	X	X
Total	5	8	13	5	10	11