Floodplain Ecosystems of the Southeast: Linkages Between Forests and People

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Floodplain forests entail greater value to society than any other type of forest ecosystem and that value will rise immensely in the coming decades as water becomes the most critical natural resource in our region. Although progress has been made in promoting the importance of floodplain wetlands to the public and in successfully manipulating systems toward particular goals, we are still quick to generalize and may hurry past some of the complexities of these systems during our research, management, and restoration efforts. Within the Southeast, floodplain hydrology varies from constant to no flooding and forest NPP ranges from near the highest of the temperate zone to among the lowest. The complex entanglements of hydrology and all other floodplain forest processes and traits are daunting. Nevertheless, these do not represent our greatest challenge, i.e. that of understanding and basing actions on the influences of human society and landscape evolution within watersheds and floodplains. It will become increasingly less relevant to study, manage, or try to restore portions of floodplains without due consideration of past, current, and future socioeconomic drivers and land use trends within basins and watersheds. The human footprint on these critical systems has been very distinct for the last 200-300 years; now, it is becoming enormous and must be fully taken into account if we are to be successful in maintaining significant amounts of floodplain forests in the Southeast.

Guidelines for Effective Restoration of River-floodplain Ecosystems

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Multi-million dollar, ecosystem-scale river restoration programs are underway for many of our nation's largest rivers, including the Colorado, Columbia, Mississippi, Missouri, and Rio Grande along with similar programs for river associated wetlands in the California Bay-Delta, Chesapeake Bay, coastal Louisiana, and Florida Everglades. The diversity of competing issues, significant social-ecological consequences of management decisions, and degree of scientific knowledge required have resulted in numerous uncertainties over what constitutes effective river-floodplain restoration. The following attributes of effective restoration are contrasted among Missouri River Biological Opinion Compliance, Upper Mississippi River Navigation and Ecosystem Sustainability Program (NESP), and other large-scale river-wetland restoration programs in the U.S.

- Understand principles for conflict resolution in high-profile water disputes.
- Set standards for ecologically successful restoration.
- Formalize a collective vision and a hierarchy of goals and objectives.
- Implement a system versus a species perspective and restore processes over places.
- Target ecosystem sustainability over ecological integrity.
- Adopt essential features of other successful large-scale river-wetland restoration programs
- Implement effective science and effective use of science.

Applying these attributes will increase the likelihood of achieving socially and ecologically successful restoration programs that secure authorization and maintain multiple-year funding.

Floodplain Geomorphic Processes, Sedimentation, and Ecological Impacts of Hydrologic Alteration along Coastal Plain Rivers

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Rivers on the Coastal Plain of southeastern United States develop the largest floodplains on the continent. The associated forested wetlands reveal a template of the landforms of those floodplains that represent in great ecological detail the ambient hydrogeomorphic processes of the system. Thus, alterations in the hydrogeomorphology of a reach can significantly affect these forested ecosystems. Depending on the geomorphic setting, land clearance and downslope aggradation, channelization, and flow regulation may lead to channel incision or filling. Such processes influence hydrogeomorphic thresholds and alter key functions of floodplain forests, including sediment trapping (and associated contaminants), which can subsequently initiate long-term shifts in forest composition. Floodplain sedimentation rates vary from 0 in levee crevasses to 400 mm/yr in backswamps with high degrees of connectivity to sediment laden river water; some recent historical sedimentation depths exceed 4m. In this paper we integrate and interpret general results from intensive studies of hydrogeomorphic processes, landforms, and riparian forests on the Roanoke River, NC where flow is tightly regulated by dams, throughout West Tennessee where most streams have been channelized, and in the Atchafalaya Basin where hydrologic alteration has been intense. Coastal Plain floodplains are especially significant because they represent the last place for substantial sediment trapping and biogeochemical amelioration of contaminants before water enters critical estuarine habitats. The functioning of Coastal Plain floodplain ecosystems may be critical in the future to maintain water quality and quantity, as well as to preserve biodiversity and other ecological and economic values of riparian wetlands. Ultimately, data and models of the hydrology and forests of these complex systems may be used to facilitate understanding and management of important floodplain ecosystem services.

Complex Effects of Channelization and Leveeing on Western Tennessee Floodplain Forest Structure, Composition and Function

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Abstract

In an effort to examine channelization effects on western Tennessee floodplains, we selected six rivers reaches (3-8 km long), including two non-channelized, two channelized and leveed, and two channelized but non-leveed. Data on vegetation composition and structure, herbaceous productivity, soil and leaf nutrient pools, soil redox potential, and surface water hydrology were compared among channelization treatments and floodplain microtopography (depression and nondepressional sites). Hydrology was significantly affected by channelization treatments, especially streams with levees. Disconnected floodplains were drier, maintained higher nutrient pools, and were more productive than floodplains still connected to channel hydrology. Channelized reaches were flashy in their response to rainfall events, their hydrologic stage rising quickly and falling quickly. Channel and floodplain hydrology were most strongly connected for unchannelized streams, and only connected during high flow events for channelized streams. As a result, unchannelized streams were extremely variable in soil redox potential and nutrient pools, and showed the greatest differences among depression and nondepression sites. Forest compositional differences among the three types of river reaches were confounded by disturbances (e.g., channelized sites had 20-40% more of their basins in agriculture than unchannelized sites) and the storage effect of long-lived tree species, although significantly correlated to hydrology. Results suggest both the subsidy (i.e., nutrient inputs) and the stress of flood events have been altered by anthropogenic activities, but these alterations were greatest in channelized systems compared to unchannelized systems. A conceptual model of the complex floodplain interactions due to anthropogenic alterations is offered.

Geomorphology, Plant Community Distribution, and Wetland Restoration in the Mississippi Alluvial Valley

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Alternating braided-stream and meandering-stream regimes of the Mississippi River throughout the Quaternary Period produced a subtly complex landscape of depositional features within the Mississippi Alluvial Valley (MAV), exhibiting highly variable soils and hydrology. Prior to European settlement, those variations produced tremendous spatial complexity and diversity within vast forested wetlands and extensive fire-maintained prairies and savannas, with the distribution of specific plant communities largely driven by abiotic characteristics of the site: geomorphology, soils, hydrology and topography. Agricultural development over the past century ─ facilitated by river engineering, flood protection, and drainage efforts ─ has destroyed most of the natural vegetation and obscured the patterns of community distribution.

The fundamental controlling influence of geomorphology in determining the distribution of plant communities provided the basis for a hydrogeomorphic classification and characterization of vegetation for the Mississippi and Arkansas portions of the valley. Detailed, spatially-explicit geomorphology and soils data are available for the entire MAV, and hydrologic mapping has been completed in many areas. Thus, the tools exist to apply the hydrogeomorphic classification to the modern, highly modified landscape, and to develop maps of potential plant community distribution based on identifiable combinations of abiotic characteristics of sites that are currently in agriculture. These Potential Natural Vegetation (PNV) maps provide an indication of the multi-scale complexity that once characterized the MAV, and serve as planning tools for restoration. PNV maps have already been completed in Arkansas; the approach currently is being applied to northeastern Louisiana, and can be expanded to the entire MAV.

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The Effects of Lateral Channel Migration Rates on Riparian Forest Structure and Composition, Congaree River, Congaree National Park, South Carolina

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Lateral channel migration initiates complex and dynamic biogeomorphic responses that are fundamental to the creation and maintenance of riparian habitats along low-gradient, coastal plain rivers. This research examines the effect of lateral channel migration rates on structure and composition of pointbar and cutbank forests along the Congaree River, Congaree National Park, SC. Lateral channel migration rates were measured in a GIS using geo-referenced aerial photos from 1938-2006. Forest structure and composition were measured in the field from a stratified-random sample of 50 sites, which included 25 paired edge-interior plots, and analyzed using Mann-Whitney tests, Spearman's Correlation Coefficients, and DCA ordinations.

Lateral channel migration produced a significant directional control on cutbank and pointbar forests through divergent successional responses. Pointbar forests exhibited a classic forward successional response, whereby one species assemblage replaced another dependant on spatial and temporal controls related to micro-topography and lateral migration rates. Cutbank forests exhibited a retrogressive, reverse successional response and increased in structural complexity with increasing proximity to the river; however vegetation indices varied inversely with lateral migration rates. Cutbank edges with low lateral migration rates allowed a longer time for trees to colonize and they contained greater density, basal area, and richness. Cutbanks characterized by high lateral migration rates contained lower tree densities, basal area, and richness. Habitat diversity and increased complexity along the river are especially important for providing feeding, nesting, and corridor habitat to a variety of riparian wildlife. Monitoring forest responses to lateral migration rates is necessary for managing river and floodplain resources.

Influence of Hydrologic Alteration on Floodplain Ecosystems in the Connecticut River Basin, Northeastern U.S.

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The floodplain ecosystems of the Connecticut River in New England share most of their species with the southeastern US. However, important differences in hydroclimatology, geologic setting, and patterns of hydrologic alteration, may provide insight into the ecology of these shared floodplain species. Due to geologic and topographic constraints, natural floodplain ecosystems are generally limited to large tributary and mainstem locations with highly altered hydrologic regimes. These threatened habitats, which are diversity hotspots in the New England region, have been further impacted by a suite of invasive species and by changes in land use. In this paper, we outline an interdisciplinary framework designed to evaluate the effects of hydrologic alteration on Connecticut River floodplain ecosystems. Our goal is to extend our understanding of population and ecosystem dynamics in diverse floodplain environments, and to provide context-specific guidance for ecological flow restoration.

Influence of Sediment Oxygen Demand in Seasonally Inundated Floodplain Swamps of the Georgia Coastal Plain

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Blackwater streams are found throughout the Coastal Plain of the southeastern United States. These streams are characterized by low slopes, high summertime temperatures, and extensive inundation of surrounding floodplains. Typically lasting from winter to early spring, the long inundation period creates a multitude of instream floodplain swamps that play a vital role in overall water quality. Over 90% of the blackwater streams listed as impaired on the Coastal Plain of Georgia are listed for violation of the state's dissolved oxygen (DO) standard. Generally assumed to be a consequence of increased biological activity from nitrogen and phosphorus enrichment, lowered DO may be a natural phenomenon within this system. A key influence on the DO levels within these floodplain swamps is sediment oxygen demand (SOD). Despite being a critical and dominant sink of oxygen in many river systems, SOD is often poorly investigated or estimated in oxygen budgets. Results show SOD rates ranging from 0.491 – 15.836 g O_2 m^{-2} d^{-1} which are up to 43 times higher than values reported for southeastern sandy-bottomed streams. A key cause of these elevated SOD rates may be the distribution of highly organic soils across the river continuum. When developing water quality models managers should pay closer attention to the influence of SOD, as when coupled with long residence times, it likely plays a central role in determining DO levels within these instream swamps and the river system as a whole.

Retention of Riverine Nutrient and Sediment Loads by Floodplains in the Chesapeake Bay Watershed

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Few quantitative estimates exist for the percent retention of annual river loads of nitrogen (N), phosphorus (P), and suspended sediment by wetlands. We measured depositional fluxes of nutrients and suspended sediment onto floodplain soil surfaces (g m^{-2} yr^{-1}; 1-6 yrs of accumulation) over a sampling network that included the Coastal Plain portion of seven rivers in the Chesapeake Bay watershed. For each river, the average N, P, and sediment depositional flux rates were multiplied by an estimate of floodplain area to calculate floodplain trapping rates (kg yr^{-1}), and then compared to average river loads. Median material retention among the rivers was 22% of N (range 5-150%), 59% of P (14-587%), and 119% of suspended sediment (35-690%). Uncertainty in retention estimates derive from several aspects related to permanency of the sink of deposited nutrients and sediment, relative importance of the rivers as the source of deposited material, adequacy of sampling network, measurement of river loads, and estimation of floodplain area. The percent retention of N, P, and sediment among rivers increased with floodplain area and decreased with river load. Coastal Plain floodplains in the Chesapeake Bay watershed likely function as an important long-term sink for material transported by rivers, greatly reducing loading rates to the Bay. Restoration activities that increase floodplain area or the hydraulic connectivity between floodplains and river channels most likely would enhance nutrient and sediment retention.

Nitrogen and Phosphorus Sequestration on the Floodplain: A Case for Restoring the Ecological Functionality of the Lower Mississippi River-Floodplain Ecosystem

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Alterations to the lower Mississippi River-floodplain ecosystem (LMRFE) have changed the hydrology to facilitate commercial navigation and to reduce flooding of agricultural lands and communities in the historic floodplain. As a result the flood pulse usually has a lower water level, is of shorter duration, has colder water temperatures, and a smaller area of floodplain is inundated. Several evaluations of the flood-pulse hypothesis in the Mississippi River have failed to support the concept, but other research that considered thermal coupling of the flood pulse found the flood-pulse concept affects fish growth. This presentation evaluates the effect of temperature and timing on nutrient dynamics on the active floodplain of the lower Mississippi River. Nitrogen (primarily as nitrate) and phosphorus transported by the Mississippi River are important contributors to hypoxic conditions in the Gulf of Mexico. Nitrogen and phosphorus sequestration by plants and aquatic biota increases when the water on the floodplain is warmer and the floodwaters remain on the floodplain longer. Thus, the floodplain and associated water bodies may provide an important management opportunity for limiting downstream transport of nitrogen and phosphorus in Mississippi River waters. Although restoring the historical hydrological conditions and floodplain inundation is unlikely, modifications of the currently active floodplain may restore ecological functionality to the LMRFE and reduce nutrients discharged into the Gulf of Mexico.

Wetland Assimilation of Treated Municipal Effluent: Wetland Restoration & Improved Water Quality in Louisiana

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Cypress-Tupelo dominated wetlands in much of southern Louisiana evolved with semi-annual flooding of nearby rivers, introducing substantial amounts of nutrients and sediments that promoted wetland growth and productivity. Relatively recent human modifications to the landscape have impounded vast areas of wetlands, hydrologically isolating them from riverine input, causing widespread degradation. We have found that the addition of nutrient rich treated municipal effluent to these wetlands stimulates plant productivity, increases organic matter production and deposition, and leads to increased wetland surface elevation that can offset regional subsidence, which is as high as 10 mm/yr in Louisiana. In addition, water exiting the wetlands has greatly improved water quality compared to that entering. Normally, treated municipal effluent is discharged directly into rivers and streams, often causing water quality problems. When effluent is discharged into wetlands first, water quality is greatly improved prior to discharge to rivers and streams. We present results from several wetlands in coastal Louisiana that have been receiving secondarily treated municipal effluent for a number of years. We have found increases in net aboveground primary productivity and surface accretion, as well as greatly improved water quality. The introduction of treated municipal effluent into the highly perturbed wetlands of Louisiana is a major step towards their ecological restoration, and is in addition to improving water quality in surrounding rivers and streams, as well as providing municipalities with an economical and energy efficient means to meet more stringent water quality standards.

Multiple-gear Assessment of Floodplain Lake Fish Assemblages of a Large River-floodplain Ecosystem

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Modern-day floodplain rivers are subject to a variety of environmental impacts mostly related to economic development. These impacts are especially evident in floodplain habitats where the effects of altered hydrology and associated nutrient exchange, sedimentation, water withdrawal, and reduced connection between the river and floodplain are most exacerbated. Our objective was to examine relationships between floodplain lake fish assemblages and environmental variables in a large river-floodplain ecosystem. Additionally, a multiple-gear approach was used that included high-pulse and low-pulse boat-mounted electrofishing, mini-fyke nets, and experimental gill nets. Across all gear types, multivariate direct gradient analyses indicated that lake size and depth, and water clarity were the most important factors in the structuring of lake fish assemblages. Fish assemblage structure was not strongly related to river-floodplain connectivity, though fish species richness in individual lakes was positively correlated with a qualitative measure flooding magnitude in those lakes. Procrustean analyses (H_o: Assemblages are different) indicated that the multiple-gear approach was warranted as lake-specific fish assemblages depicted by the different gear types were different in all cases ($P = 0.109$-0.576) except between the two electrofishing configurations ($P < 0.001$). Our assessment of empirical fish-environment relationships in a large river-floodplain system identified environmental factors important in the structuring of riverine fish assemblages communities, and underscored the need for multiple-gear assessments. Results can help guide future river-floodplain management and aid resource managers in species conservation efforts in these systems.

Patterns in Fish Community Structure and Diversity in Natural and Artificially-created Wetlands in the White River, Arkansas

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Evaluations of fish community responses to wetlands restored by the Wetland Reserve Program (WRP) are rare. Thus, this study examined fish communities of WRP-created wetlands of various ages and compared them to reference wetlands located in Arkansas' White River basin. Fish samples from pool and canal habitats of wetlands were collected from March through June 2003 using modified mini-fyke nets and experimental-mesh gill nets, with associated water quality and habitat variables measured concurrently. Sampling yielded a total of 8,988 fishes that comprised 49 species. Multivariate direct gradient analyses generally indicated that fish community structures differed among different-aged wetlands. In pool habitats, analyses suggested that community compositions exhibited a successional trend, whereby generalist-type species were replaced by specialist-type species as wetlands aged. Conversely, fish communities in canal habitats remained relatively unchanged as wetlands aged. Repeated-measures analyses comparing diversity, richness, and evenness between natural and WRP-created wetlands suggested that created wetlands were capable of supporting fish communities with levels of diversity and richness comparable to reference wetlands within one year. Overall, results suggested that WRP-created wetlands provide habitats and environmental conditions that mimic natural wetlands in a relatively short time period. Additional studies of similar scope would help validate current findings and better define benchmarks of future WRP projects.

Patterns of Macroinvertebrate Diversity and Community Structure across a Gradient of River-Floodplain Connectivity

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A limited number of studies have examined the effects of river-floodplain connectivity on macroinvertebrate diversity and community structure, and even fewer have utilized a multi-spatial scale approach. This study assessed these effects by sampling macroinvertebrates within the vegetated shoreline of eighteen riparian wetlands with different degrees of hydrologic connectivity to the Arkansas River. Analysis included core samples and habitat data taken from 6 backwaters contiguous with the main channel, 6 floodplain wetlands intermittently connected to the river by supra-bankfull flooding, and 6 floodplain wetlands isolated from the river by levees. A total of 93 taxa (28 non-insect and 65 insect taxa) were collected (59 from backwaters, 73 from intermittent floodplain, and 66 from isolated floodplain wetlands). Though there was no significant effect of connectivity on α diversity, overall β-1 and β-2 diversity was higher in isolated and intermittent floodplain wetlands than in backwaters. This indicated a greater degree of compositional dissimilarity among the wetlands comprising these regions, and that most of the diversity was maintained at the regional scale. Non-metric multidimensional scaling ordination combined with other analyses revealed a number of taxa with strong associations with each wetland type and that macroinvertebrate community structure was influenced by connectivity. The patterns of macroinvertebrate diversity and community structure and the mosaic of unique habitat types observed in the Arkansas River Floodplain are a product of dynamic hydrologic processes such as river-floodplain connectivity.

Fish Assemblages and Connectivity of Riparian Wetlands in the Lower Arkansas River Floodplain Ecosystem

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We initiated this study to provide more complete information on abundances and distributions of fishes in the Arkansas River floodplain ecosystem and to better understand patterns of assemblage composition and environmental gradients across wetland types. Fish and environmental data were collected at 49 riparian wetlands representing contiguous backwaters (perennially connected to the main channel), intermittent floodplain wetlands (floodplain waterbodies that are periodically flooded), and isolated floodplain wetlands (floodplain waterbodies that no longer connect with the main channel). A total of 220,116 individuals and 64 species were collected. New information was obtained for numerous species including four species of conservation concern: *Notropis maculatus*, *Erimyzon sucetta*, *Moxostoma pisolabrum*, and *Etheostoma fusiforme*. Ordination and associated analyses indicated contiguous backwaters, intermittent floodplain wetlands, and isolated floodplain wetlands had distinct fish assemblages. Contiguous backwaters were relatively open-water habitats lacking submerged vegetation taxa and inundated cypress trees. These wetlands were characterized by pelagic fishes and generalist species tolerant of reservoir-like conditions typical of the mainstem Arkansas River. In contrast, isolated floodplain habitats were heavily vegetated, cypress wetlands inhabited by fishes typical of southern bottomland hardwood wetlands. Intermittent floodplain wetlands contained elements of both assemblages. This study indicates the Arkansas River floodplain ecosystem, despite modification, continues to have a mosaic of wetland types supporting a diversity of fishes. These data underscore the value of cypress wetlands since they harbor a unique assemblage of fishes that enhances diversity within the Arkansas River ecosystem.

Population Structure of Adult and Juvenile Paddlefish in Floodplain Lakes along the Lower White River, Arkansas

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Paddlefish habitat use has been extensively studied for main channel and backwater areas of large rivers. However, little research has been done to address paddlefish use of natural floodplain lakes. Sixteen floodplain lakes in the lower White River, Arkansas were sampled using a boat electrofisher and gill nets during periods of river connection (April-May) and disconnection (June-July). Fifteen environmental variables were concurrently sampled in each lake that included water quality, lake morphometrics, and quantitative measures of connectivity. Of the 16 lakes sampled only seven lakes contained paddlefish. One paddlefish was observed during connection sampling. Forty-three paddlefish were observed during disconnection sampling with eye-fork lengths ranging from 348 mm to 1040 mm. Fish ranged in age from 1 to 11 years, suggesting that both adult and juvenile paddlefish were using floodplain lake habitat. Using stepwise linear regression, dissolved oxygen, variation in the start date of connection, and surface area were significantly related to catch per unit effort. Paddlefish catch per unit effort increased as lake size and dissolved oxygen levels increased and variability in the start date of connection decreased. Our research indicates that juvenile and adult paddlefish are using floodplain lakes despite the risk of being isolated in lakes for long periods of time, possibly during spawning periods.

Pervasive Hydrologic Effects on Freshwater Mussels and Riparian Trees in Southeastern Floodplain Ecosystems

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We present long-term growth trends of 13 freshwater mussel species from two unregulated rivers (St. Francis River, AR, Sipsey River, AL) and one regulated river (Little Tallahatchie River, MS) in southeastern USA. We also present long-term growth data for baldcypress (*Taxodium distichum*) from five unregulated rivers in the region (Cache River, IL, Choctawhatchee River, AL, Nottoway River, VA, St. Francis River, AR, Sipsey River, AL). We developed biochronologies for all taxa using standard dendrochronology techniques and examined the relationships of annual growth of each species to a suite of streamflow variables. Growth of 10 mussel species in unregulated rivers was negatively correlated with mean annual streamflow, and minimum and maximum streamflow, but was positively correlated with annual number of low flow pulses, and annual number of hydrographic reversals. Baldcypress growth in unregulated rivers was positively correlated to mean annual streamflow, minimum and maximum streamflows, and annual number of high flood pulses, but was negatively correlated to annual number of low flow pulses, mean annual hydrographic fall rate, and annual number of hydrographic reversals. Consistent trends across ecosystems suggest that taxa-specific growth responses to hydrologic variability are generalizable. Growth of the mussel, *Quadrula pustulosa* from the Little Tallahatchie River was not correlated to any streamflow variables suggesting that growth is decoupled from hydrology in this regulated system. This study highlights how interannual variability in streamflows benefits and maintains diverse taxa in bottomland rivers over long periods and shows that river regulation can disrupt these relationships.

The Degree of Co-occurrence between Zooplankton and Ichthyoplankton Shape the Year-class Recruitment in Newly Inundated Bottomland Hardwood Floodplains

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In temperate and sub-tropical floodplains, seasonal floodpulses influence a broad range of important subsides within newly inundated terrestrial systems (i.e., microbial, nutrient and invertebrate cycles). As floodwaters rise and systems shift from dry to lotic to lentic, access to newly flooded microhabitats is believed to significantly enhance reproductive opportunities for fishes. Yet post-flood conditions frequently offer sub-optimal physicochemistry and/or foraging opportunities for young-of-the-year fishes undergoing the ontogenetic shift from endogenous to exogenous feeding. The degree of overlap between zooplankton (primarily cladocerans and copepods) and ichthyoplankton should affect the survivorship of newly hatched fishes, following the assumptions of the match/mismatch hypothesis. However, few floodplain studies have concurrently described the structure of both communities as young fishes begin to actively search for food.

To better understand recruitment, we examined limnetic densities of zooplankton and larval fishes in the Atchafalaya River Basin (ARB), LA, over a 19-month period. Zooplankton abundance was primarily associated with areas of the floodplain that had high connectivity and stable water quality. The magnitude of the floodpulse did not result in increasingly robust zooplankton populations. Interestingly, both ichthyoplankton and zooplankton often exhibited limited overlap suggesting a potential food limitation following the onset of flooding. Therefore, it appears that a potential fish recruitment bottleneck could occur for: (1) species that reproduce discontinuously; (2) cohorts that exhibit highly variably individual growth; and/or (3) floodplain-dependent taxa that hedge on the arrival of a significant annual floodpulse.

The Significant Nexus of Science to the Future Protection of the Waters of the United States

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Our nation has long recognized the value of floodplain ecosystems to our economy and our way of life. Floodplains in many areas have been properly deemed "waters of the United States," which provide various important "functions and values" or "ecosystem services," the most obvious of which is flood control but also often includes some additional combination of water quality improvement, habitat for endangered and other species, recreational and/or educational activities and aesthetic values. Yet historical federal authority to protect such waters through the Federal Water Pollution Control Act (under which Congress sought to "restore and maintain the chemical, physical and biological integrity of our nation's waters") has come under attack in recent years. A 2006 U.S. Supreme Court interpretation (Rapanos v. United States) came to no majority opinion, with a resulting introduction of a new jurisdictional test based on findings of a "significant nexus" between a regulated area and a traditionally navigable water. During the summer of 2007, federal agencies issued "guidance" to interpret this decision (entitled Clean Water Act Jurisdiction Following the U.S. Supreme Court's Decision in Rapanos v. United States & Carabell v. United States). Yet this long and convoluted set of documents creates more questions than answers, and mandates fact-specific analysis to assess detailed hydrologic and ecologic factors. The role of scientists will thus be crucial in future regulatory efforts under the Clean Water Act, as well as attempts on a legislative or regulatory level to stabilize or increase floodplain protections the matter by enacting new laws.

Integrating Economics in Floodplain Restoration: An Analysis of The Nature Conservancy's Emiquon Project on the Illinois River

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Restoring natural services provided by floodplains may not be as simple as acquiring land from willing sellers and then simply breaching levees or otherwise reintroducing floods. Conversion of developed land to wetland reserves or wildlife refuges affects local jobs and tax revenues. The Emiquon Floodplain Restoration Project of The Nature Conservancy provides a good test case. Emiquon was a 2,125-ha agricultural drainage and levee district when it was purchased for $18.3 million in 2000 by the Conservancy. Emiquon is situated along the Illinois River, formerly one of the most biologically productive floodplain-river ecosystems in the United States. However, between 1890 and 1924, 64% of the total floodplain area was leveed and drained for farming. Although production of commodity crops increased, natural goods and services plummeted. Today, restoration of Emiquon would have reduced revenues to local taxing districts, but The Nature Conservancy has agreed to continue payments in lieu of taxes to local districts. In addition, some, but not all the jobs and output value associated with the former farm have been replaced by jobs and outputs related to management of Emiquon. Restoration could result in a substantial economic gain, if recreational development (compatible with restoration) were planned and promoted. Other approaches to financing restoration and compensating local taxing districts are being considered along the Illinois River, including floodplain "nutrient farms" that would be managed to remove nitrogen from river water. These new approaches are part of a worldwide trend toward payments for natural services, including services provided by restored floodplains.

Changes in Forest Management Practices Needed to Insure Timber Quality of Bottomland Hardwood Stands

John D. Hodges

Although the United States Forest Industry is currently in a state of flux, high quality hardwood veneer and sawtimber will always be in demand. However, the change in forest ownership provides both challenges and opportunities to insuring the production high quality hardwood products. Past forest management practices were originally limited as stands were typically high-graded and left to naturally regenerate from lower quality material. Information concerning natural stand management of bottomland hardwoods in the 1960's and 1970's led to new techniques of stand manipulation focused on production of quality material. Through the years artificial regeneration within plantation culture has been tried but results have been rather limited in the production of quality material. This is the result of a lack of knowledge of how to mimic natural stand progression in the production of quality stems and the overall excessive cost of plantation management.

(I would consider this paper to include some about older systems used but have gone by the wayside and new or even possible systems that would allow for improved timber quality)

Changing Landownership Patterns and the Hardwood Lumber Industry

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The forest products industry is going through some dramatic changes right now due directly to the effects of globalization. With the influx of wood, paper, pulp and other products, the reliance on domestic manufacturing has diminished, and domestic manufacturing along with it. Like all stagnant or mature businesses, the industry has to look at their model and make changes to stay competitive, and one of the most dramatic changes made has been in the area of forest land ownership.

When the forest products industry began their modern growth in the early 1900's, they determined that the only way to insure a steady supply of raw material was to acquire relatively cheap timberlands and manage them for long term benefits. The model worked well, and these companies purchased millions of acres of low value land that became quite productive through intensive management techniques. This served the industry well, and made them good neighbors as that steady ownership allowed communities to plan knowing that certain ownerships would remain as productive forests.

As these lands have gained value for other uses, corporate boards and accountants realized that the tremendous dollar investment in the lands might have better returns in other areas of their companies, and they began divesting of the land holdings. With the gigantic exception of Weyerhaeuser, almost all major pulp and paper companies have sold their properties, and some think it will not be too long before Weyerhaeuser will follow suit.

Most sales of land have been going to some major forest land investment groups also known as TIMOs – Timber Investment Management Organizations. These are groups seemingly committed to the same goals as the forest industry owners, those being forest health and forest productivity. They seem committed to the communities they are in, and in most cases have a staff of foresters to guide them. But what is the long term goal of these TIMO's, and how long will their investments last? Many have a promise with their investors that that the land ownership must turn over on a regular basis, but to who and for what use.

This talk will review the changing ownership patterns of forest industry lands, and what the long term prospects for use of that land for other purposes will likely be. The forest industry has been directly responsible for the management and use of forest lands in the United States by adding value to the forests. As that value is changed by the world markets, you will likely see some shifts in how the forests are managed.

Managing Bottomland Forest for Wildlife

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The conservation objective in the Mississippi Alluvial Valley is to provide forested habitat capable of supporting sustainable populations of all forest dependant wildlife species. However, forest loss, fragmentation, and hydrological change has markedly altered habitat conditions within bottomland forests such that some species of concern (e.g., ivory-billed woodpecker (*Campephilus principalis*), Louisiana black bear (*Ursus americanus luteolus*), and some migratory songbirds) have been severely impacted. To provide habitat for these and other priority wildlife species, we advocate forest conditions that are conducive to the continued viability of this suite of priority wildlife species. Many forest-dependent wildlife species are responsive to habitat conditions at multiple spatial scales (e.g., landscape quality and site quality). To address this issue, we define Desired Forest Conditions as those forested landscapes that meet both Desired Landscape Conditions and Desired Stand Conditions. Traditional forest management has focused on production of forest products (i.e., lumber or pulp) through silviculture that promotes optimal growth and vigorous health of economically desirable tree species. Often these traditional silvicultural methods are not optimal for forest-dependent wildlife. Indeed, quality habitat for priority wildlife species likely requires some sacrifice in timber production and the retention of less healthy trees. Even so, commercially viable, wildlife-oriented silviculture (i.e., Wildlife Forestry) employing variable retention harvests can be used in conjunction with forest restoration, regeneration, and natural processes to achieve Desired Forest Conditions within bottomland hardwood forests. The habitat conditions that result from wildlife forestry silvicultural prescriptions will vary among sites and forest types. For many forests, desired stand conditions are: an average of 60-70% overstory canopy cover which is heterogeneously distributed, a basal area of 60-70 ft^2 per acre, and 60-70% stocking. Desired midstory and understory cover are between 25-40%, respectively. At least 2 dominant trees (emergents) per acre should be retained. Some cavity trees (small and large) as well as dead and/or stressed trees should be retained. These stems will eventually contribute to coarse woody debris which should average >200 ft^3 per acre. To ensure future merchantability of stands, shade-intolerant regeneration should be present on 30-40% of the area. Implementation of these recommendations will ensure that habitat is being provided for the many priority wildlife species that inhabit bottomland forests.

The State of Knowledge Regarding Site Evaluation for Bottomland Hardwood Management

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Site is defined as an area considered in terms of its environment, particularly as this determines the type and quality of the vegetation the area can carry. Site should also indicate the quantity of desired products to meet explicit management objectives (site quality); therefore, a site represents the sum of the environmental factors, such as soils and climate, that affect the quantity and quality of vegetative growth. Site quality is important (1) to determine the suitability of a given site for recommending specific woody and non-woody plant species for afforestation or reforestation efforts, (2) to predict the quality and quantity of wildlife habitat, including browse, hard mast, and soft mast production, (3) to predict the quality and quantity of timber products, and (4) to assess the impacts of land-use activities on future production of desired products. In this paper, I will provide descriptions of seven methods for evaluating a bottomland site: (1) direct measurement, (2) species trials, (3) indicator species, (4) experience and judgment, (5) soil-site equations, (6) soil series, and (7) expert systems. Each method has its advantages and disadvantages. These, along with examples of use and the latest research results improving these methods, will be discussed. Knowledge of site quality is the necessary first step to management of the bottomland hardwood resource. Evaluating site quality will also allow forest resource managers to better manage forests to meet specific landowner objectives in bottomland hardwood ecosystems.

A Decision Support Tool for the Landscape Scale Management of Bottomland Hardwood Ecosystems of the Southeast

Aaron Hohl[6], Andrew Niccolai[7], Chad Oliver[8]

Ecosystem management of bottomland hardwood forests requires assessing the landscape scale effects of operational decisions made at the stand or management group level. The expected condition of individual stands and the landscape as a whole must be projected at various points in the future. We developed a decision support tool to facilitate the comparison of landscape scale management alternatives for periods up to 50 years. The tool facilitates the analysis of several ecosystem characteristics including carbon sequestration, coarse filter biodiversity, tree species diversity, standing and cut volume, and estimated economic returns from timber management. The stand level effect of an array of silvicultural pathways (e.g., no action, thinning, clear cutting) were modeled using FVS-SE. Individual stands were integrated into management groups and stand level results were converted into a state transition model. The landscape level effects of management can be tracked by specifying the proportion of the landscape represented by each management group and allocating each management group to one of the silvicultural pathways. The tool offers a flexible way for managers to assess tradeoffs between planned management alternatives.

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Floodplain Forest Development Models: Do Examples from Old-growth Forests Fit?

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Models of large river floodplain forest development for the southeastern United States have been based largely on historical patterns observed in the lower Mississippi River floodplain. The rate of sediment deposition is identified as the primary mechanism that produces shifts in species composition. In the absence of deposition, trade-offs between flood- and shade-tolerance, as well as reproductive mechanisms, may play a heightened role in determining species composition. With this in mind, we asked the question - do the few examples of later successional stage floodplain forests fit these models? To answer this question, we present data from old-growth floodplain forests across the Southeast including long-term data from the Congaree National Park, one of the best remaining old-growth floodplain forest on the Atlantic Coastal Plain. Historical patterns of floodplain forests are used to address how forest composition is changing through time and long-term data from the Congaree document the impact of natural disturbance on forest development patterns. Growing evidence suggests that lianas are a more prominent component of late successional floodplain forests than of younger forests.

Tree Survival and Growth Through 20 years of Green-Tree Reservoir Management

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Green-Tree Reservoirs, developed in Arkansas during the 1930s, are bottomland hardwood forest stands that are flooded during the late fall and winter to provide waterfowl habitat. Early reports suggested that these impoundments provide moisture that improved tree growth and mast production. More recent reports have shown that green-tree reservoir (GTR) management results in reduced vigor and tree growth. A 21,000 acre green-tree reservoir was completed at the Felsenthal National Wildlife Refuge in 1985 and has been flooded through management or heavy rainfall every year since that time. Trees on 54 study plots, established prior to initial flooding, were re-measured in 1990, 1995, 2001 and 2006 to follow the fate of impacted forest stands. Annual mortality rates over the 21 year period varied by tree size, species and elevation. Overcup oaks had the highest annual mortality at 4.6% while Nuttall and willow oak mortality was lower at 2.8 and 2.9%, respectively. Across species mortality rates were lowest at high elevation (2.3%) and highest at low elevations (4.7%). Low numbers of seedlings and saplings indicate that trees lost from the canopy are not being replaced.

A Century of Disturbance Regime Changes in an Ohio River FloodplainFforest: Implications for Wetland Conservation Area Management

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Many bottomland conservation areas in the Midwestern and Midsouthern United States share a similar land use and disturbance history of drainage, conversion to agriculture, and abandonment prior to inclusion in wetland conservation programs. This study examines changes in forest vegetation associated with 20th century land uses and the resulting variation in the disturbance regime at Mermet Lake State Conservation Area in southern most Illinois. These disturbances included clearing, drainage, and burning associated with agriculture, followed by abandonment and inclusion in a conservation area with partial restoration of hydrology and fire excluded. A 2003 tornado and subsequent salvage harvesting operation are recent occurrences shaping vegetation composition.

This study employed historic land use records, dendrochronological evidence, pre- and post-tornado vegetation, and post-salvage logging soil data. Since settlement of the area, forest vegetation at Mermet Lake has shifted from bald cypress to oak to mixed bottomland hardwood dominance. Within the developing forest, composition and diversity varies along a wind intensity gradient with diversity increasing as a function of wind-induced canopy failure. Species richness and community complexity further increased within the salvaged area in response to exposure of mineral soil and restoration of micro-topography by the salvage operation.

Our results suggest that historic changes in site conditions have been associated with complex changes in forest communities. These relationships need to be considered to more effectively manage wetlands conservation areas. Vegetation management strategies that address these changes within a wetland conservation context will be discussed.

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Structure and Growth of Tidal Freshwater Forested Wetlands in Relation to Salinity and Fertility

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Tidal freshwater forested wetlands comprise no less than 200,000 ha within the southeastern United States. These are productive ecosystems due in part to the quantity of nutrients received from upstream and marine sources during inundation by the flood effect of local tides. This study was designed to determine which factors are most important in controlling growth (past and present) and dictating the landscape position of tidal freshwater forested wetlands relative to marsh. First, we inventoried forest structure on several tidal freshwater forested wetland sites in South Carolina, Georgia, and Louisiana to make linkages among salinity, inundation, and site fertility. Second, we monitored basal diameter increment of dominant trees on these sites monthly, for over 4 years, to examine the inter-relationship with soil total nitrogen (TN), total phosphorus (TP), porewater salinity, and inundation (frequency, duration, and depth). Among all sites, salinity ranged from 0.1 to 3.2 ppt and bulk density ranged from 0.1 to 0.7 g/cm^3; bulk density was lowest at sites in Louisiana. The ratio of soil TN to TP varied among sites dictating different tree heights, basal areas, and growth rates. TN, for example, ranged from 1.2 to 4.0 mg N/cm^3 of soil volume. These data are important for understanding the role of edaphic conditions in setting growth limits in tidal freshwater forested wetlands and in structuring current forest condition. Although historic growth of these forests has been dictated by soil fertility, as salinity prisms shift inland with sea-level rise, current growth becomes more strongly linked to salinity.

Fire in Bottomland Forests: Insights from Disturbance Ecology of *Arundinaria*

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Multiple lines of evidence suggest that fire shaped bottomland forests in the Southeast. Two studies of canebrake ecology, and work by early USFS research foresters indicate that fire was a recurrent disturbance in these riparian forests. We examine the disturbance ecology of canebrakes as a case study of fire in bottomlands. We also examine research from the Lower Mississippi Alluvial Valley (LMAV) in the 1930s for insights about fire. Canebrakes were once prominent in bottomlands of the Southeast. Cane (*Arundinaria* sp.) is still common throughout its historic range, but the expansive, monotypic canebrakes are now exceedingly rare. Why have canebrakes not re-formed in the increasingly numerous holdings managed for bottomland forest restoration? Our own research with giant cane (*A. gigantea*) in Tensas Parish, Louisiana suggests fire may be necessary for small cane stands to amalgamate into dense and expansive canebrakes. Our findings parallel those from the 1950s by Hughes, who studied switch cane (*A. tecta*) in North Carolina. Both studies suggest that without fire or some other recurrent space-opening disturbance, small cane stands will never grow into canebrakes, but will instead decline. Fire-scar analyses by research foresters in the 1930s indicate that fires recurred in the LMAV during drought years every 5-15 years pre-dating the Civil War. We propose that in particular areas of the LMAV, high ground was subject to recurrent fires, and that canebrakes were dominant on these sites. Land managers seeking to optimize existing cane stands as wildlife habitat should consider fire as a tool.

Influence of Planting Stock, Planting Method, Fertilization, and Competition Control on Survival of Oak Seedlings Planted in Afforestation Areas – Second Year Results

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Thousands of acres in the Southeast have been planted with hardwoods (primarily oaks) unsuccessfully in the recent past. Seedling survival in these plantings has been unacceptably low and causes of the mortality are often unidentified, but land managers have recognized many factors as critical for survival. The relative merits of seedling size and number of first order lateral roots (FOLR) have long been discussed as relates to survival and early growth of oak seedlings. Proper planting, including the choice of method, has also been recognized as critical in seedling survival and control of competing vegetation is essential for higher survival and early growth in most afforestation. Large seedlings planted with augers and provided with total competition control and fertilization have been shown to achieve extremely high rates of survival and rapid growth. The purpose of this study was to evaluate the influence of the various planting/establishment components (planting stock, planting method, fertilization, and competition control regime) on the survival of Nuttall and white oak seedlings during the first two growing seasons at two planting sites. A total of 6,480 1-0,bareroot seedlings were planted and evaluated during the study (3240 of each species). One-half of these seedlings were grown under a special nursery protocol to produce a large seedling with an extensive root system and one-half were grown without any special protocol. Planting methods included hand planting in augered holes, hand planting in subsoil trenches, and hand planting in untreated areas (flat planting). Half the seedlings received slow-release fertilization at the time of planting. Herbaceous weed control was completed in three regimes: first-year preemergent only, one complete growing season, and total (two complete growing seasons). All combinations of planting stock and treatments were replicated at each site. Survival was evaluated monthly from May to September. Results provide an excellent comparison of the importance of each of the components in seedling survival for the two years, and quantifies the extent of mortality occurring by time during the growing season and by year. This information can be of great use to land managers working in afforestation efforts in the Southeast.

Conservation Practice Effects on Wetland Ecosystem Services in the Mississippi Alluvial Valley

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Forest and wetland ecosystems that historically dominated the Mississippi Alluvial Valley (MAV) provided an array of ecosystem functions and services. The conversion of these natural areas to row-crop agriculture has resulted in landscape-scale alteration of hydrologic and biotic functions. The objective of conservation programs, e.g., the Wetlands Reserve Program (WRP), Conservation Reserve Program (CRP), is to restore and protect wetland functions in agricultural landscapes. These programs have restored over 200,000 ha of wetlands in the MAV since their inception; however, their effectiveness in achieving their objectives is not known. One goal of the USDA Conservation Effects Assessment Program (CEAP) is to assess the effects of conservation practices on ecosystem services provided by wetlands. Forty-eight sites encompassing WRP, native forest, and agricultural fields were randomly located in AR and LA during April 2006. Site and landscape data were collected to quantify sediment retention, migratory bird and amphibian species richness, flooding extent, and waterfowl habitat. Significantly higher amphibian and migratory bird species richness was measured on WRP and CRP sites than adjacent agricultural fields. Approximately 70% to 77% of land enrolled in WRP in LA, AR, and MS was within the 0-24 month flood frequency. Based on flooding and food energy values, the WRP conservation practices in these three states increased migratory waterfowl foraging habitat by up to 54 million duck-energy days, accounting for 14 percent of the total foraging habitat target objectives for the tri-state area. Improvements in design and management could increase the amount of ecosystem services provided by conservation practices.

Hydrologic Controls on Swamp Forest Regeneration and Sustainability

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Coastal swamp forests occupy about 3000 km^2 of the Mississippi River Deltaic Plain, and are experiencing increased flooding and intrusion of salt water caused by rapid subsidence of the geologically young sediments and altered river flow patterns in the delta. These changes increasingly jeopardize long-term sustainability of swamps by reducing forest regeneration. Given their value for timber and multiple nontimber values associated with their coastal location, sustainability of forest management in swamps is an increasingly important public policy issue. Regeneration success hinges on hydrologic conditions, and any changes affect successional trajectories. Deep flooding in the growing season prevents regeneration from seed and favors shifts to marsh or open water, even though standing trees may remain productive for decades. Reduced flooding during the growing season favors regeneration of less flood-tolerant bottomland hardwood species. Hydrological variables that affect regeneration are depth, duration, frequency, and timing of inundation; the ecological importance of some variables is understood but interactions among variables combine to control regeneration in complex ways. Sustainable timber management in swamp forests requires site-specific knowledge of hydrologic processes, but also must include some concept of risk in obtaining natural regeneration because regeneration failures are common in flood-prone sites. We present a conceptual framework of the multivariate hydrologic control on regeneration, with applications for management decisions based on likelihood of regeneration success.

Floodplain Ecosystem Restoration: Commodity Markets, Environmental Services, and the Farm Bill

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Economic and cultural values, the same forces that have altered floodplain ecosystems, will be the forces that determine the extent of their restoration. Landowner investment in agricultural production and forest and hydrologic restoration will reflect perceived economic returns from investments, and personal preferences for ecosystem services each land use provides. If the 2007 Farm legislation increases returns from bottomland hardwoods relative to crop production, then more bottomland restoration will occur.

The crafting of the 2007 Farm Bill, particularly the language for the Conservation (Title II), Forestry (Title VIII), and Energy (Title IX) Titles, has been the primary focus for much of the conservation community over the past year. Federal programs and their effect on emerging bio-energy and environmental services markets have received attention as drivers for restoring bottomland ecosystems. Programs and emerging markets can encourage floodplain restoration, but will be effective only if they improve economic returns from bottomland management relative to other land uses.

The attention on the conservation, forestry, and energy titles has led some to ignore the Commodity Title (Title I). This is a mistake. Returns from bottomlands will be determined not only by Titles II, III, and IX, but also by commodity markets and Title I, which sets commodity price supports. Historically, Title I has had a far greater role in driving changes in land use, and therefore bottomland restoration, than other portions of the Farm Bill.

Past, Present and Future of Carbon as a Finance Tool for Bottomland Hardwood Restoration in the Lower Mississippi Valley

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The Lower Mississippi Valley (LMV) is increasingly recognized by investors and entrepreneurs as offering the most advantageous conditions for sourcing forest carbon offsets in North America. The presentation will relate experience to date with carbon as a forest restoration finance tool in the LMV and discuss its future potential in a changing economic landscape. Recent experience has been predominately on state and federal lands where carbon has not had to support substantial land acquisition costs. Continued access to carbon finance for restoration work will depend on the political certainty that carbon will have long-term value and investor confidence that can be increased by better-informed growth and yield projections. Proper project planning and implementation are also essential to address expectations of additionality and permanence that are peculiar to carbon offsets.

Early Successional Habitats in the Mississippi Alluvial Valley: Their Role in Meeting Conservation Objectives

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Although the Mississippi Alluvial Valley (MAV) was extensively forested at the time of European settlement, there were smaller areas of herbaceous wetlands associated with abandoned channels, beaver ponds, tree gaps, and native grasslands as well as sites that were recently scoured or subjected to fires or sever wind storms. Some of these sites such as Catahoula Lake were sizeable whereas individual tree gaps were small but collectively from 3 to 5 percent of the original forest may have been in this more open condition. The reduced flooding during the growing season provided optimal growing conditions for herbaceous plants on some sites annually within the MAV but following the growing season these sites were flooded at different times and for a variable duration during the winter months. Thus, sites with adequate sun light and a seasonal hydroperiod provided unique herbaceous resources as well as conditions associated with reestablishment of the forest. Foremost among the benefits was the provision of nutritionally important food resources for a wide suite of species adapted to this forested system. Among these were the extensive seed, browse, and below-ground resources produced by annual and perennial herbaceous plants that were essential for some species. Among the animal groups adapted to these conditions were migrant dabbling ducks that migrated from distant breeding sites to these wintering areas where nutritionally valuable foods were in abundance and essential for developing a physiological condition leading to reproductive success at a distant location. The extensive use by dabbling ducks is obvious and widespread but these sites also provide important habitats for a vast array of less mobile and more secretive resident species. Many of these sites have been lost to other uses and extensive man-induced modifications compromise the size, distribution, value, and function of the remaining sites. To assure that the species associated with these sites continue to have viable populations is an important conservation concern that is complex, costly, and constantly changing. This paper discusses the history and distribution of these sites, the factors that led to their loss and modification, and some thoughts on conservation strategies to assure that future generations continue to enjoy these habitats and the species that are adapted to them.

Wildlife Use of Back Channels Associated with Islands on the Ohio River

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The back channels of islands on the Ohio River are assumed to provide habitat critical for several wildlife species. However, quantitative information on the wildlife value of back channels is lacking but is needed to assist natural resource managers in conserving these forested islands and embayments in the face of increasing shoreline development and recreational boating. We compared the relative abundance of waterbirds, turtles, anurans, and riparian furbearing mammals during 2001 and 2002 between back and main channels of the Ohio River in West Virginia. Wood ducks (*Aix sponsa*), snapping turtles (*Chelydra serpentina*), beavers (*Castor canadensis*), and muskrats (*Ondatra zibethicus*) were more abundant on back than main channels ($P<0.001$). Anurans were more abundant on back than main channels in early spring ($P<0.05$). Conversely, belted kingfishers (*Ceryle alcyon*) and spiny softshell turtles (*Apalone spinifera*) were more abundant on the main than back channel during summer ($P<0.001$). These results provide quantitative evidence that back channels are important for several species of waterbirds, turtles, anurans, and furbearing mammals. The narrowness of the back channels, the protection they provide from the main current of the river, and their ability to support vegetated shorelines and woody debris, are characteristics that appear to benefit these species. We recommend conserving back channel areas as important riparian wildlife habitat by limiting the building of piers and development of the shoreline.

The Effects of Hydrologic Restoration on Birds Breeding in Forested Wetlands.

Dr. Jeff Hoover, Illinois Natural History Survey

Channelization of rivers and streams threatens bottomland forest bird communities because it can lead to the formation of lateral gullies that connect streams to adjacent wetlands and drain the wetlands when water levels in the stream drop below flood stage. These adjacent forested wetlands may fill during spring floods and be attractive breeding habitat for birds, but the unnaturally rapid draining of the wetlands early in the breeding season may expose some birds to high rates of nest predation. I studied how the hydrologic restoration of off-channel wetlands (plugging gullies that drain off-channel wetlands) affects the diversity, abundance, and nesting success of birds breeding within forested wetlands within the Cache River watershed in Illinois. I compared wetland size and hydrology, bird diversity, bird densities, and nesting success between treatment (gully plugs added) and control (gully plugs not added) wetlands, and between pre-treatment and post-treatment wetlands. Treatment wetlands showed larger increases in size and retained water for longer durations compared to control wetlands. The density and nesting success of Prothonotary Warblers was higher in treatment wetlands than in control wetlands. Other species dependent on forested wetlands (Wood Ducks and Yellow-crowned Nightherons) also increased in density within the treatment wetlands. Documenting changes in the bird community in response to conservation actions provides a means to measure the success of restoration activities in the Cache River watershed and inform conservation plans and restoration efforts in other bottomland forest ecosystems.

Response of Prothonotary Warblers to Flooding and Timber Harvest in a Bottomland Hardwood Forest.

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The prothonotary warbler (*Protonotaria citrea*) has been suggested as an indicator of ecosystem integrity for bottomland hardwood forest ecosystems. Many bottomland forests are actively managed for timber and have undergone significant changes in natural hydrological processes, and we suggest that prothonotary warbler demographic parameters would make suitable response variables in experiments involving those disturbances. Utilizing a manipulative experiment over 5 years, we examined the effects of two timber harvest techniques (single-tree selection, patch-cuts) on the reproductive biology of prothonotary warblers at White River National Wildlife Refuge, a managed, seasonally flooded, bottomland hardwood forest in southeast Arkansas. Timber harvests reduced the number of available nest cavities, reduced the density of breeding males on the plots and male territories were significantly larger on plots that were harvested. However, timber harvest technique had no obvious effect on nest depredation or brood parasitism frequencies. Productivity (number of fledglings per plot and per hectare) remained similar within suitable habitat regardless of treatment. Reproductive success was strongly influenced by annual variation, principally the timing and extent of annual flooding. Our findings indicate that hydrology had the largest influence on prothonotary warbler reproductive success and productivity and that continued anthropogenic alterations in flooding patterns may have a greater influence than current timber management on the future population levels of prothonotary warblers in the Mississippi Alluvial Valley.

Vegetation Characteristics Associated with Habitat Occupied by Swainson's Warblers at the White River National Wildlife Refuge: Implications for Management of Bottomland Systems

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Widespread clearing of bottomland hardwood forests has restricted Swainson's Warblers (*Limnothlypis swainsonii*; SWWA), a species of conservation concern, to seasonally-inundated zones in many floodplains. Given the ground-foraging behavior of this species, they likely are affected adversely by flooding. However, little is known about patterns of habitat occupancy by SWWAs at these wetland ecotones. We examined relationships between SWWA occupancy and vegetation structure at relatively high-elevation bottomlands at White River National Wildlife Refuge (WRNWR). In 2004 and 2005, we systematically surveyed 1453 sites using song playbacks and collected vegetation data at all 70 occupied sites (4.8% occupancy) and 106 unoccupied sites. Comparisons of occupied versus unoccupied sites revealed that mean density of cane (*Arundinaria gigantea*), shrub, and total stems; litter volume; understory density; and selected other measures of habitat structure were significantly greater in occupied than unoccupied sites. Based on 15 alternative *a priori* habitat models for predicting SWWA occupancy, we found the model that best fit the data contained the density of cane, vine, and shrub stems and it accounted for 83% of the total AIC_c weight of all models considered. However, cane stem density was the best single predictor of SWWA occupancy with a sumed AIC_c weight of 0.99 for all models including this variable. These results suggested that cane, dense understory structure, and a well-developed layer of leaf litter are key habitat components for SWWAs at WRNWR. Our findings are especially relevant given that the canebrake ecosystem is endangered and has declined substantially throughout the Southeast.

Reproductive Success and Causes of Nest Failures for Mississippi Kites in the White River National Wildlife Refuge: Response to Altered Hydrology?

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During a 2-yr study on the Mississippi kite (*Ictinia mississippiensis*), a species of conservation concern, in the lower White River system we documented one of the lowest reproductive success frequencies reported for this species. In 2004 and 2005, we located 39 Mississippi kite nests. We used infrared time-lapsed recording systems to monitor 16 nests 24 hr a day. The fates of the remaining nests were monitored periodically by observation with a spotting scope. Eleven of the 39 nests (28.2%) fledged one juvenile each. Two studies elsewhere in the southeastern U.S. reported nest success for Mississippi kites of 42 and 61%. By any assessment, a nesting success of 28% was not adequate to maintain the White River kite population. Predation was the most common cause of nest failure (57%, $N = 7$), with western rat snakes (*Elaphe obsoleta*) being the most common predator ($N = 3$) of eggs and nestlings. We propose that the modification of the hydrology of the White River system may be a key factor in low nesting success of kites and possibly other birds. Levees constructed along margins of the refuge in the mid 1960s to control flooding on agricultural lands restricts the natural flood regime during high flow periods, thereby increasing the depth and duration of the flood waters and altering the timing of floods. We offer several hypotheses how hydrological changes may have disadvantaged nesting birds and provided advantages to predators that may explain the high frequency of nest failures that we observed.

Wood Duck Duckling Mortality and Survival in Mississippi and Alabama Floodplain Ecosystems

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Floodplain ecosystems in southeastern United States provide critical habitats and resources for resident and migratory populations of North American wood ducks (*Aix sponsa*) yet little is known about mortality and survival of wood ducks in these systems. We studied radiomarked hen and duckling wood ducks that used palustrine and riverine wetlands in Noxubee National Wildlife Refuge (NNWR) in Mississippi in 1996-1999 and the Tennessee-Tombigbee Rivers and Waterway (TTRW) in Alabama in 1998-1999. We estimated cause-specific mortality rates for 234 and 90 mortality events of ducklings at NNWR and TTRW, respectively. Mortality of radiomarked ducklings (n) was caused primarily by avian and aquatic predators at NNWR in 1996-1999 and TTRW in 1998-1999. Other agents of mortality at both areas included snakes, mammals, exposure-related, and unknown causes. A composite estimate of duckling mortality among years and areas was avian (0.459; $n = 155$), aquatic (0.234; $n = 79$), snake (0.062; $n = 21$), mammalian (0.053; $n = 18$), exposure-related (0.021; $n = 7$), and unknown causes (0.130; $n = 44$). Our study was the first to quantify agents of mortality and habitat-specific survival rates of wood duck ducklings (Davis et al. 2007; *Journal of Wildlife Management* 71:507-517). Based on this and other recent research, we recommend the following to increase wood duck production and recruitment from nest boxes in the Southeast:(1) monitoring of nest boxes during spring and removal of down and unhatched eggs of completed nests, 2) erecting and maintaining dispersed rather than clumped nest boxes, and 3) promoting suitable brood habitats (i.e., scrub-shrub wetlands) without aggregations of nest boxes that may attract predators and dispersing nest boxes amid or adjacent to these habitats.

Habitat Factors Affecting Relative Abundance of Swamp Rabbits in a Floodplain Forest Ecosystem

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Destruction and fragmentation of floodplain forest ecosystems has resulted in population declines in swamp rabbits (*Sylvilagus aquaticus*) throughout the northern fringe of their range in North America. Furthermore, the patchy distribution of remaining habitat increases risk of local extirpations of swamp rabbits due to further habitat loss and stochastic events. Management of swamp rabbits and their habitat requires knowledge of which habitat factors, operating at multiple spatial scales, affect swamp rabbit populations. However, there are few such studies for swamp rabbits in floodplain forest ecosystems. During winter (Dec-Mar) 2005-06 and 2006-07, we conducted fecal pellet surveys at 29 bottomland hardwood forest sites in southern Illinois to determine relative abundance of swamp rabbits. We also collected site-level habitat variables (e.g., stem density) and calculated FRAGSTATS metrics (e.g., mean patch size) based on NWI data. We used multiple regression to model the relationship between habitat variables and relative abundance of swamp rabbits. We interpreted 3 models (R^2 = 0.63 - 0.66) based on AIC values. In all models, the density of tree stumps >10-cm in diameter and overall patch contiguity of sites and contiguity of upland cover patches within sites were positively associated with relative abundance of swamp rabbits. Larger sites and those containing high woody stem density also supported more swamp rabbits. Hence, for swamp rabbits, biologists should manage floodplain forests for large, contiguous sites containing early-successional characteristics and upland cover for use during flood events. These management recommendations will also benefit other small mammals in bottomland ecosystems.

Integrating Science Into the Restoration and Management of Floodplain Ecosystems of the Southeast

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(No abstract)