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Potential Natural Vegetation Maps for Ecosystem Restoration in the Mississippi Alluvial Valley

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PURPOSE: This technical note describes a set of field atlases that have been developed to support ecosystem restoration in the Mississippi Alluvial Valley. It includes suggested applications for the atlases and provides links to downloadable files for both the printer-ready atlases and the GIS themes from which the maps were assembled.

BACKGROUND: The Mississippi Alluvial Valley (MAV) once contained the most extensive and diverse lowland forest in North America. The complexity and productivity of the ecosystem were the result of the influx of massive amounts of outwash from episodes of continental glaciation that occurred north of the region, as well as the dynamic behavior of the large rivers that have repeatedly migrated across the landscape, eroding and depositing sediments and regularly flooding millions of acres. Beginning with the arrival of the first European settlers, the rivers have been stabilized and prevented from inundating most of the former floodplain, and agriculture has largely replaced the native vegetation. The deforestation of the MAV has contributed to a variety of problems such as the extinction of wildlife species and pollution of receiving waters, including the Gulf of Mexico. Various government policies and private initiatives have been implemented to reverse this damage through restoration of native plant communities, particularly wetlands. Much of this work has been conducted through the Wetland Reserve Program, administered by the Natural Resources Conservation Service, and by the U.S Fish and Wildlife Service (FWS) Wildlife Refuge System. In addition, Corps of Engineers Planning and Regulatory responsibilities often include the development or evaluation of ecosystem restoration plans or compensatory mitigation proposals that involve wetland restoration, and large reforestation projects have been carried out in the region as a result.

As part of the increased focus on wetland restoration and assessment in recent decades, extensive field studies of wetland plant communities have been conducted in the MAV in conjunction with various research programs and Corps of Engineers project planning efforts. In the process, a wetland site classification approach has evolved based on hydrology, soils, and geomorphic setting. The approach is consistent with the "hydrogeomorphic" or HGM wetland classification system that is used in regional HGM wetland assessment guidebooks (Smith and Klimas 2002, Klimas et al. 2011), but it has also been expanded and refined specifically to support the development of detailed maps and descriptions of the Potential Natural Vegetation (PNV) of the region. The purpose of PNV maps is to serve as a blueprint for restoration planning and prioritization. Because the hydrology of the landscape has been permanently changed by major flood control projects, the PNV maps do not represent the distribution of the original, presettlement vegetation, but rather they identify the natural communities that are appropriate to the modern altered site conditions. Using these maps, persons interested in restoring particular tracts of land can identify the plant communities appropriate to the conditions present; conversely, persons interested in restoring particular plant communities can identify parts of the landscape that can support those types. Because this information also is available as GIS themes, various other restoration scenarios can be explored efficiently, such as development of wildlife travel corridors or refuge areas, and alternatives can be compared in terms of costs and ecological effectiveness.

This approach was developed and refined in Arkansas, where funding came from a variety of sources, including Corps of Engineers District offices, Region 6 of the U.S. Environmental Protection Agency (EPA), and the State of Arkansas. The U.S. Fish and Wildlife Service Mississippi Valley Joint Venture Office obtained funding for additional mapping in Louisiana and Mississippi. In 2011, the FWS converted the GIS output for the Louisiana and Mississippi PNV maps into spiral-bound, hard-copy books, similar to road atlases, for use by biologists evaluating potential restoration sites in the field. These products proved to be popular, and in 2012, the Ecosystem Management and Restoration Research Program converted the PNV maps for the four major MAV sub-basins in Arkansas to the same field-atlas format. Consistent PNV field atlases are now available for all of the MAV between the southern Missouri border and the Red River in Louisiana (Figure 1), an area of about 16.8 million acres – more than 26,000 square miles – spanning parts of three Corps of Engineers Districts. The atlases are specifically designed to

Figure 1. The Mississippi Alluvial Valley, showing areas where potential natural vegetation mapping has been completed as well as areas that can be mapped in the future using the same approach.

support restoration planning, and do not describe the field sampling, spatial data assembly, and mapping criteria behind the original PNV GIS projects. Those details are discussed in a separate publication (Klimas et al. 2009).

ATLAS CONTENTS AND APPLICATIONS: Each atlas is organized as a stand-alone field reference for a particular basin within the MAV. Like a road atlas, the PNV coverage for the basin is subdivided into individual maps at a scale of 1:63,360 (1 in.=1 mile). This has been a convenient scale for field use, but much more detail is available within the GIS themes if needed. Each map sheet in the atlas is paired with the corresponding aerial photo on the facing page. The road network is superimposed on both pages to aid in field orientation. A consistent legend applies across all of the atlases that identifies each PNV community type in terms of its HGM classification, site characteristics, and forest cover type classification (Figure 2).

POTENTIAL NATURAL VEGETATION MAP KEY, ST. FRANCIS BASIN, ARKANSAS		
HGM Subclass	**General Site Characteristics**	**Principal Dominant Species**
RIVERINE BACKWATER	**WETLANDS MAINTAINED BY RIVERINE BACKWATER FLOODING**	
RB2	Occasionally flooded, moderately-drained lowlands	Willow Oak–Water Oak
RB3	Occasionally flooded flats	Willow Oak
RB5	Occasionally flooded Pleistocene deposits	Willow Oak–Nuttall Oak
RB6	Frequently flooded Pleistocene deposits	Baldcypress–Overcup Oak–Bitter Pecan
RB7	Frequently flooded lowlands	Overcup Oak–Bitter Pecan
RB9	Post oak flatwoods (wet saline phase)	Delta Post Oak–Willow Oak
RIVERINE OVERBANK	**WETLANDS MAINTAINED BY RIVERINE OVERBANK AND HEADWATER FLOODING**	
RO2	River swamps in underfit channels	Baldcypress–Water Tupelo
RO4	Outwash channels in Late Pleistocene deposits and floodways	Mixed Lowland Hardwoods
FLAT	**WETLANDS MAINTAINED BY PRECIPITATION**	
F2	Well-drained recent alluvium in lowlands	Cherrybark Oak–Water Oak–Sweetgum
F6	Poorly-drained lowlands	Nuttall Oak–Willow Oak
F7	Poorly-drained undulating topography on Pleistocene outwash terraces	Willow Oak–Water Oak
F12	Alkali post oak flats	Post Oak–Willow Oak–Water Oak
F13	Hardwood flats, Early Wisconsin Valley Train and Deweyville Terraces (wet phase)	Delta Post Oak–Willow Oak
F14	Hardwood flats, Early Wisconsin Valley Train (dry phase)	Post Oak–Southern Red Oak–Shagbark Hickory
F16	Willow oak flatwoods (wet phase)	Willow Oak–Green Ash
F17	Willow oak flatwoods (dry phase)	Cherrybark Oak–Delta Post Oak–Willow Oak
F18	Post oak flatwoods (wet phase)	Delta Post Oak–Willow Oak
F19	Post oak flatwoods (dry phase)	Post Oak–Southern Red Oak
DEPRESSION	**WETLANDS IN DEPRESSIONS**	
D1	Stream-connected depressions in abandoned channels	Baldcypress–Water Tupelo
D2	Stream-connected depressions on Pleistocene outwash terraces	Baldcypress–Water Tupelo
D3	Unconnected depressions in abandoned channels	Baldcypress–Water Tupelo
FRINGE	**WETLANDS FRINGING WATER BODIES**	
FR1	Stream-connected lake and pond fringe wetlands	Baldcypress–Buttonbush–Emergents
FR2	Unconnected lake and pond fringe wetlands	Baldcypress–Buttonbush–Emergents
UPLAND	**UPLANDS**	
U2	Well-drained soils of the Pleistocene terraces	Mixed Hardwood and Pine
U4	Pleistocene dunefields and barrens	Black Oak–Post Oak–Southern Red Oak
WATER	**WATER**	
W	Permanent water bodies other than lakes and ponds (fringe)	Streams and major drainage ditches

Figure 2. Example map legend from the St. Francis Basin Potential Natural Vegetation Field Atlas.

An appendix describes each community type in greater detail, so that a restoration plan can be developed. For example, each site type is described in terms of the natural topography, because the composition, diversity, and function of wetlands in the MAV are often highly dependent on subtle variations in drainage characteristics and the occurrence of ponded water (vernal pools) in the winter and spring. Most candidate restoration sites in the region have been significantly modified by years of farming, and many have been completely land-leveled. Reforesting such sites without first restoring the natural topography is unlikely to produce a functional wetland. The site descriptions in the field atlases are intended to alert restoration planners to the scope of site preparation that will be required on a particular restoration project. Similarly, each community type description includes a suite of tree species that can be planted and would be likely to persist over the long term because they are adapted to the site, including the prevailing, modified hydrologic conditions. Most reforestation projects in the region tend to focus on planting just a few common dominant species. The PNV community descriptions are intended to give the project designer additional information to move beyond simple reforestation and establish a more complex and diverse ecosystem by including secondary tree species that are usually present but are unlikely to dominate, as well as understory species that are particularly characteristic of some communities.

Figure 3 illustrates the scale and detail of the information provided in each atlas. The aerial image on the left depicts a typical MAV landscape, where the majority of the native forest has been removed and the land has been converted to agriculture. The image on the right is the PNV map for the same landscape. The legend (Figure 2) identifies each color-coded community type, and an appendix to the atlas describes the topography and vegetation appropriate to each type, as a guide to restoration.

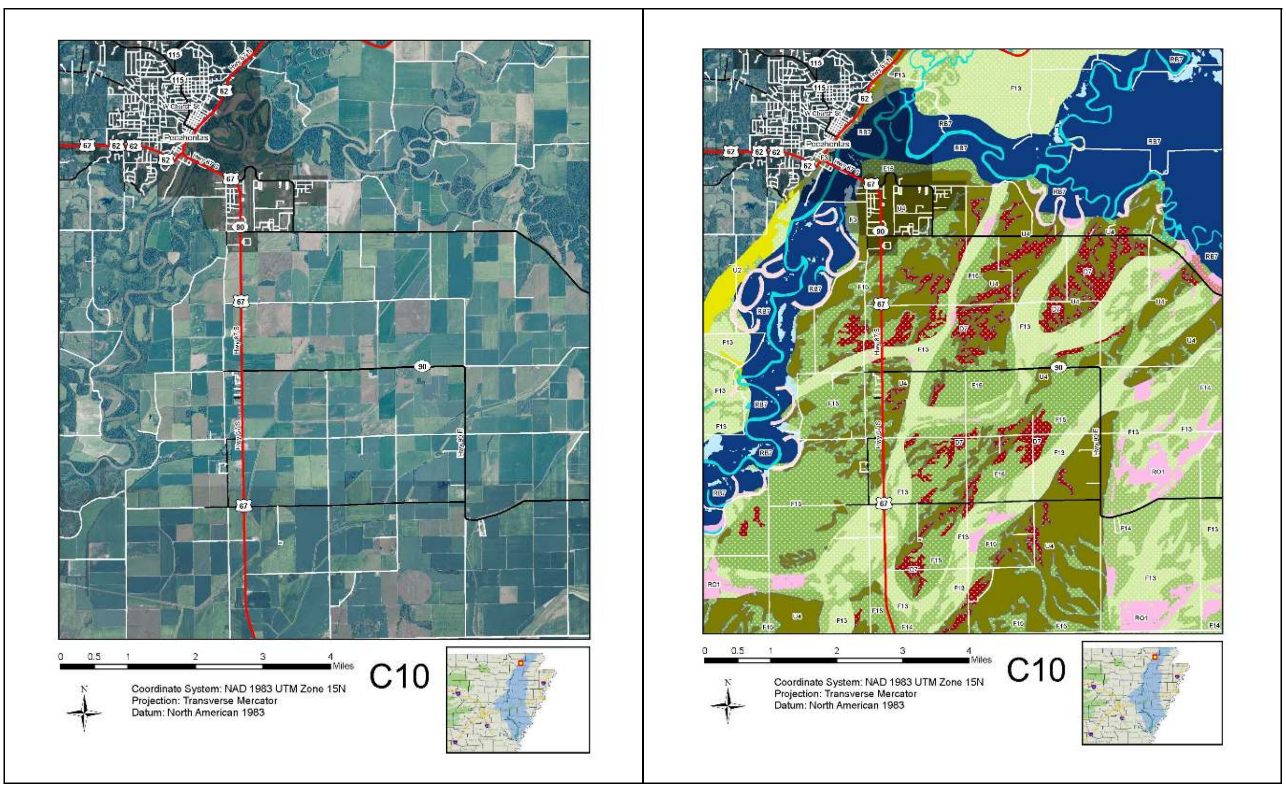

Figure 3. Example pages from the Western Lowlands Field Atlas, showing an aerial image of the current land use and the corresponding potential natural vegetation map.

Figure 3 illustrates why restoration planning in the MAV should consider more than reforestation with a few common dominant tree species if "ecosystem restoration" is the true goal. The dark blue zone along the convoluted, meandering river channel indicates that the appropriate restoration target is one of the more familiar floodplain forest types (overcup oak-bitter pecan) found along active streams in the region. Large curving "oxbow" depression wetlands typically occupied by baldcypress swamps also occur within the floodplain zone where the meandering stream has left behind abandoned channel segments. Outside that zone, however, the PNV map indicates a completely different pattern of relatively linear features trending northeast to southwest, with a complex pattern of wetland forest communities interspersed with upland forest types. This landscape was mostly formed during periods of waning continental glaciations far to the north of the Arkansas Delta region. During those episodes, vast quantities of meltwater and sediments coursed through the MAV, and the sediments left behind are often relatively coarse, with braided-stream patterns still evident on the surface in many places. While these two landscapes may have many species in common, the relative dominance of those species, the occurrence of uncommon or rare species, and spatial arrangement of communities are clearly very different, and should be reflected in a restoration plan.

Using the PNV map as a model for restoration. The PNV map legend and community descriptions classify the community types from several different perspectives: by HGM subclass, for use with the corresponding HGM functional assessment guidebook; by site characteristics, which can be used to help guide site preparation; and by species dominance type, which usually lists several species that frequently dominate on similar sites throughout the MAV. Each of these perspectives lends itself to application of the maps in different ways. Some example applications include the following:

Replacement of critical habitat. The PNV mapping effort in Louisiana was initiated specifically in response to the reported rediscovery of a species thought to be extinct, the Ivory-Billed Woodpecker. Foti et al. (2011) discuss how PNV mapping can contribute to understanding of the habitat conditions once preferred by that animal as well as help to identify where those habitats might be restored in the modern MAV landscape. In situations like that, where critical habitat for a particular species is dependent on the composition, structure, and distribution of specific plant communities, the PNV maps and community descriptions can be used to target the most effective sites for habitat restoration and population management and to assure that the appropriate community components are included in that plan. For example, the atlases describe a PNV natural levee community and note that it is the typical location for thickets of giant cane. Because canebrakes are considered to be important or essential habitat for some species, such as the endangered Bachman's Warbler, an ecosystem restoration plan that includes natural levee communities should incorporate giant cane reintroduction in addition to tree planting.

Site-specific restoration design. The PNV maps often recognize mapping units of a fraction of an acre, so they can inform restoration design even on relatively small or diverse sites (note that this level of resolution is usually best seen in the GIS environment). The site characteristics and geomorphic settings described in each atlas indicate the extent to which a particular community tends to be affiliated with the ridges or swales of point bars, or the almost-imperceptible vernal pool sites in backswamps, and similar subtle variations in topography that may have been modified or eliminated by agricultural practices. Users can evaluate a candidate restoration site in light of these descriptions and restore the appropriate topography prior to planting the area. If filling a ditch or removing a levee is part of the restoration plan, the expected change in flood frequency will indicate establishment of a plant community different from the mapped unit, and that new "target" condition can be readily identified by consulting an appendix to the atlas. While all of these features will help to guide restoration design, users are encouraged to adjust their site preparation and planting plans as needed based on their local knowledge, experience, and observations of conditions in the field.

Landscape-level restoration planning. PNV maps are particularly useful for identifying restoration needs and opportunities over large regions. This can be accomplished using the field atlases, or for some purposes, the GIS environment may be more efficient. Using GIS, it is relatively simple to identify sites appropriate for the restoration of extremely rare communities (e.g., wet prairies), sites that would support the maximum habitat diversity within a single large block of restored forest, or the appropriate forest communities for restoration within riparian corridors. PNV maps reflect flood frequency, therefore restoration projects can be designed to assure that infrequently flooded refuge areas are included in projects intended to provide habitat for terrestrial wildlife. Because the PNV maps use the HGM classification system, they reflect other wetland characteristics of potential interest. For example, the PNV map distinguishes between sites suitable for establishing depression wetlands that are connected to stream systems as well as depressions that are not normally connected to other aquatic environments. Though these sites support the same forest communities, the former may provide critical habitat for the numerous fish species that spawn in floodplain wetlands while the latter is far more suitable for restoring amphibian populations due to the lack of predatory fish populations. Numerous similar types of applications can add flexibility and insight to the restoration planning process (Klimas et al. 2009).

Mitigation design. The PNV maps have some obvious applications in meeting regulatory or planning requirements, such as finding suitable locations for in-kind mitigation of project impacts, or planning mitigation in a watershed context, as is currently encouraged in various federal programs. In addition, because the PNV maps cross-reference the HGM classification system, they can also be used in conjunction with HGM Regional Guidebooks to help calculate the amount of compensatory mitigation of particular wetland subclasses that may be appropriate under various impact scenarios. The HGM guidebooks available for the MAV include assessment models and recovery trajectories that can be used to estimate the degree to which restored wetlands perform certain functions over time. This means that restoration priorities can be adjusted to offset the loss of particular functions, or to favor restoration scenarios that will most quickly meet particular functional needs.

Product availability. The Arkansas atlases and GIS projects can be downloaded from the EMRRP webpage: *http://el.erdc.usace.army.mil/emrrp/analyt.html*

The Louisiana and Mississippi products can be downloaded from the Lower Mississippi Valley Joint Venture (LMVJV) webpage:

> Atlases and background reports are at *http://www.lmvjv.org/bookshelf.htm*
>
> GIS files are at *http://www.lmvjv.org/PNV_of_MAV.htm*

For field use, the atlases should be reproduced double-sided, so that the imagery and corresponding maps appear on facing pages, and the documents should be spiral-bound or placed in a three-ring binder.

ADDITIONAL INFORMATION: This technical note was prepared by Charles Klimas, Research Ecologist, Environmental Laboratory (EL), U.S. Army Engineer Research and Development Center (ERDC). Co-authors of the atlases described here were Thomas Foti (Arkansas Natural Heritage Commission, Little Rock); Jody Pagan (Five-Oaks Wildlife Services, LLC, Stuttgart, AR); Malcolm Williamson (Center for Advanced Spatial Technologies, University of Arkansas, Fayetteville); and Elizabeth Murray (EL-ERDC). The atlases were prepared under the Ecosystem Management and Restoration Research Program (EMRRP). For information on these products, contact the ERDC EMRRP Program Manager, Glenn Rhett (*Glenn.G.Rhett@usace.army.mil*). This technical note should be cited as follows:

> Klimas, C., T. Foti, J. Pagan, M. Williamson, and E. Murray. 2012. *Potential natural vegetation maps for ecosystem restoration in the Mississippi Alluvial Valley*. EMRRP Technical Notes Collection. ERDC TN-EMRRP-ER-16. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

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