POTENTIAL NATURAL VEGETATION OF THE MISSISSIPPI ALLUVIAL VALLEY: OUACHITA BASIN, NORTHEASTERN LOUISIANA

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Prepared for the

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INTRODUCTION

Studies of wetland plant communities over the past decade in the Arkansas and Mississippi portions of the Mississippi Alluvial Valley (MAV) have produced a site classification approach based on hydrology and geomorphic setting (Klimas et al. 2005, Klimas et al. 2009). The approach is consistent with the “hydrogeomorphic” or HGM classification system proposed by Brinson (1993), but it has been adapted and refined specifically to support the development of detailed maps of the Potential Natural Vegetation (PNV) of the region. The purpose of PNV maps is to serve as a template for restoration planning and prioritization in a landscape that has been highly modified. Most of the bottomland hardwood forests and other native plant communities of the MAV were converted to agriculture during the 20th century, the remnants being largely those forest types adapted to the wettest sites where row cropping was infeasible. At the same time, tremendous local and federal effort has gone into drainage, flood control, and navigation projects that have permanently altered the hydrology of the floodplain and alluvial terraces in the region. Therefore, the PNV maps are not designed to represent the distribution of the original, pre-settlement vegetation, but rather they identify the natural communities that are appropriate to the altered site conditions ─ hence the “potential” designation. This means that persons interested in restoring particular tracts of land can identify the plant communities appropriate to the various site conditions present, or conversely, persons interested in restoring particular plant communities can identify parts of the landscape that could support those types. Because this information is available in GIS format, various other restoration scenarios can be explored, such as corridor reestablishment, and alternatives compared in terms of costs and ecological effectiveness.

This approach was developed and refined in Arkansas, where PNV mapping is underway or complete for all of the sub-basins within the Arkansas portion of the MAV. Mapping also has been completed for the Tensas Basin portion of northeastern Louisiana (Foti et al. 2011) and this report describes PNV mapping for the adjacent Ouachita Basin portion of Louisiana, including Macon Ridge. This report consists of a discussion of the methods used, descriptions of the site classification criteria and vegetation of the PNV community types, and metadata describing the content and structure of the accompanying shapefiles that comprise the PNV map. Readers are referred to the publications cited previously for details on the basic HGM classification approach and its application within the MAV. For additional information on geomorphic features, their ages, origins, and characteristics, all of which are primary considerations in the PNV mapping process, see Autin et al. (1991), Saucier (1994), and Rittenour et al. (2007). All discussions of geomorphology in the following sections are based on those documents, particularly the comprehensive treatment published by Saucier.

STUDY AREA – OUACHITA BASIN

Location, Boundaries and General Character

The study area is that portion of the MAV within Louisiana that includes the Ouachita River lowlands and Macon Ridge (Figure 1). Although the Ouachita River is the largest stream present, the lowland portion of the study area is considered to be part of the Bouef Basin, one of six major lowland areas that comprise the MAV (Saucier 1994). Macon Ridge is not normally considered part of any lowland basin but is included in this PNV mapping effort. Because most of the internal drainage of Macon Ridge flows to the Ouachita lowlands, we have designated the study area as the “Ouachita Basin” portion of Louisiana.

The Ouachita Basin lies directly to the west of the Tensas Basin, which is of particular interest today because it includes the site of the most comprehensively-studied population of Ivory-billed Woodpeckers (IBWO), in the “Singer Tract,” much of which is now the Tensas National Wildlife Refuge (Tanner 1942, see also U.S. Fish and Wildlife Service 2010). The reported rediscovery of IBWO in Arkansas in 2004 motivated renewed inventory efforts for the species in the MAV and elsewhere, and opened up the possibility of targeting ecosystem restoration efforts towards sites that would support potential IBWO habitat. The PNV map developed for the Tensas Basin was specifically intended to be used for that purpose, among others, and the adjacent Ouachita Basin might provide similar opportunities for IBWO recovery through restoration. Like the Tensas Basin PNV map, the Ouachita Basin map is designed to characterize the potential vegetation of cleared as well as currently forested lands, based on understanding of the relationships between vegetation and physical site characteristics, specifically geomorphology, soil and hydrology.

Figure 1. Location of the Ouachita Basin in northeastern Louisiana

Geomorphology

The study area consists of sedimentary deposits of widely varied ages, origins, and characteristics. The most extensive type of deposit is Early Wisconsin glacial outwash (or "valley train") that coursed through the Mississippi Valley on numerous occasions as the result of waning continental glaciations far to the north. The remnants of at least five such episodes remain as a series of levels or terraces that comprise Macon Ridge, which forms a broad interfluve between the Ouachita lowlands on the west and the Tensas basin on the east. On the eastern border, the older, higher terraces rise 30 feet or more above the Tensas lowlands, but on the western side where the most recent and lowest terraces occur they are often nearly the same elevation as the adjacent Ouachita River bottoms. The drainage patterns of modern streams on the surfaces of the outwash terraces tend to be oriented north-to-south, following the former braided outwash channels. Sediments in the former channels often are coarse sands, with finer or unsorted material making up the interfluves, but both surfaces tend to be blanketed with fairly fine-grained sediments laid down during waning flows, or later backwater flooding from streams, or by post-glacial erosion.

Several other major Pleistocene events produced unique and very different geomorphic landforms in the study area, all located in the northwestern corner of the area in the vicinity of the Ouachita River. On either side of the river, along the valley walls, are fairly extensive high terraces known as the Prairie Complex, which are understood to be remnant backswamp deposits of ancient river systems that flowed at a much higher level than the current base level of streams in the vicinity. Backswamp deposits are typically dense clays that drain poorly, but because the Prairie Complex terraces are relatively old and elevated, they are dissected and fairly well-drained along the margins and internal drainageways.

Somewhat lower in the landscape and nearer the modern Ouachita River are several extensive, very level areas known to geologists as "flatwoods terraces." These have been recognized in recent decades as lacustrine deposits, the remnants of an extensive ancient lake that formed when glacial outwash (now Macon Ridge) blocked the Ouachita River. Evidence of the resulting Lake Monroe persist as lacustrine plain, beach, and dune deposits with unique soil characteristics.

Lower and younger still and directly flanking the modern floodplain of the Ouachita River are two expanses of the Deweyville Terrace, a landform found along coastal plain streams throughout the southeastern US. Deweyville terraces consist of the classic sequence of meandering-river deposits such as point bars, natural levees, and backswamps, but the scale of these features is much greater than that of modern examples of the same features in the same landscapes. This is evident in the large lakes and swamps found on the Deweyville terraces within the study area, which are abandoned channels of a Pleistocene Ouachita River that clearly carried many times the flow of the modern river, due to complex climatic changes during periods of continental glaciation.

The remainder of the study area is made up of alluvial deposits of Holocene (post-glacial) age. However, they too are complex in origin and represent a variety of depositional environments. In general, the Holocene environments include the landforms typically found in association with meandering river systems: point bars deposited by meandering channels, forming ridge-and-swale topography; backswamps formed where slackwaters were trapped following floods, leaving poorly-drained flat basins; and short stretches of former river channels that were cut off or abandoned and are now occupied by lakes, depressions, or have captured the flow of other smaller streams. In many areas, these features are blanketed by a veneer of natural levee deposits formed during overbank flooding, such that the deposits nearest the stream channels are high and well drained, and the veneer blanket becomes thinner and more fine-grained with distance from the stream.

Remarkably, essentially no part of the Holocene environment within the study area fully conforms to the general model described above. As it enters Louisiana from Arkansas, the Ouachita River flows for a few dozen miles within a meander belt of its own point bar deposits, but the confining effects of the Pleistocene landforms described previously have restricted the extent of those deposits and precluded the development of backswamps. And downstream of that reach, the Ouachita enters an environment dominated by the influence of a much larger river, the Arkansas. Throughout the history of the MAV, both the Mississippi River and the Arkansas River established multiple different meander belts that took them far from their current paths. Even though today the Arkansas River is confluent with the Mississippi in Arkansas, in the past it has flowed deep into Louisiana, in the process shaping much of what today are the Boeuf lowlands.

Three separate Arkansas River meander belts are mapped within the study area and several major streams including the Ouachita River, Bayou Bartholomew, the Boeuf River, and Bayou Bonne Idee, flow for much of their length within the former channels of the Arkansas. Because the Arkansas was a much larger river, where these streams occupy former Arkansas channels they are mostly entrenched and not capable of meandering freely to create their own geomorphic features and instead they are flanked by the point bars, abandoned channels, and natural levees left behind by the Arkansas. Certainly the modern streams have contributed sediments to the floodplain over the centuries, especially the extensive backswamps, but the scale and form of those features all reflect the Arkansas.

Holocene alluvial deposits also occur in small valleys that have developed within the various Pleistocene terraces and along the western flank of the study area. In some cases those stream systems are large enough to have developed significant floodplains and alluvial terraces of their own. These features formed by the same processes as those in the lowlands, but are much smaller in extent and scale. Also found along the valley walls are alluvial fan deposits left by streams and runoff from the uplands, and occasionally these are large enough to be mapped as distinct landforms.

Soils

Soils within the study area generally reflect their geomorphic origins. For example, backswamps and filled abandoned channel segments are characterized by massive clays such as Alligator clays, while loamy soils such as Gallion and Rilla silt loams are typical of natural levee deposits. However, soil mapping within the study area has not been entirely consistent among parishes, and some soils span a variety of geomorphic settings and topographic positions. Therefore, in this project, soils are used in specific situations to add detail to the mapped geomorphic setting. For instance, Yorktown and Dowling soils consistently indicate depressional wetlands that may occur within a more variable geomorphic setting, such as point bar. Therefore the PNV map overlays polygons of these soils on the more general geomorphic unit and highlights the corresponding changes in vegetation.

It must be emphasized that soils cannot be used as a substitute for geomorphology in this PNV mapping process. Soil series as mapped in the study area are based on the physical and chemical parameters observed through the soil profile and follow accepted soil taxonomy conventions. In many cases these taxonomic differences may be of little importance in distinguishing plant communities at a useful level of distinctiveness, and in even more cases the specific relationships between a soil map unit and appropriate vegetation units may not be known. The mapping criteria in this project are based primarily on geomorphology with soils known to be associated with specific plant communities used as secondary mapping criteria.

Vegetation

The native vegetation of the study area is primarily bottomland hardwood forest, comprising a variety of community types distributed primarily along gradients of flood frequency, depth and duration, as well as soil drainage conditions and ponding. Since the area has been substantially cleared for many decades, there are few scientific studies of the vegetation, particularly of the vegetation prior to extensive alteration of the physical and biological features of the landscape. Perhaps the most useful as background for this study is a Forest Survey of the North Louisiana Delta by the Southern Forest Experiment Station (Winters et al. 1938). The study area of that report includes Macon Ridge and the Boeuf lowlands. The study area comprised 3,987,000 acres, of which 69% was forested and 29% agriculture. Of the forested land, 22% was uncut old growth, 26% partly cut old growth and 31% sawlog-size second growth.

Winters, et al. recognized 8 forest types and presented the composition and site affinity of each (Table 1, Table 2) and a general distribution map (Figure 2). The Louisiana Department of Wildlife and Fisheries has noted that there were areas of tallgrass prairie (Mississippi Terrace Prairie) on Macon Ridge that were similar to the prairies on Pleistocene terraces in Arkansas (http://www.wlf.louisiana.gov/fact-sheet-community/mississippi-terrace-prairie). These are assumed to be extirpated, but could be an additional restoration option if appropriate knowledge of the required site conditions were available.

Hydrology

Throughout the MAV, natural hydrologic patterns have been modified by man since the earliest settlers arrived and began draining and leveeing individual farms. The scale of those changes ramped up in the early 20th century with local drainage districts deepening and straightening small streams throughout the Delta region. However, the biggest changes began in the mid-20th century with authorization of the Mississippi River and Tributaries (MR&T) project that was implemented by the U.S. Army Corps of Engineers (USACE). For much of the MAV, the principal effect of the MR&T was a massive reduction in flooding that was accomplished primarily thorough a system of mainline levees on the major streams and reservoirs, and channel engineering on tributary systems. Within the study area for this project, both of these methods were used to reduce flooding, but the drainage projects and channel improvements played a particularly big role, and the resulting changes to natural flooding and drainage patterns are highly complex. Most of the study area is above or outside the influence of Mississippi River floods and backwater effects, but the hydrology of the area has been repeatedly modified by

Table 1. Composition of major forest types in northeastern Louisiana expressed in percent of total gross cubic volume (from Winters et al. 1938, Table 3.)

Species	Red gum-water oak	Hackberry-elm-ash	Overcup oak-bitter pecan	Cottonwood willow	Cypress-tupelo	Water oak	Mixed oak-mixed hardwood	Pine-hardwood	Average (weighted)[1] all types
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Red gum	39.3	1.6	0.6	1.5	1.8	3.4	17.3	12.5	13.9
Water oaks [2]	19.7	9.4	8.4	(3)	1.3	66.9	14.9	8.7	15.1
Overcup oak	6.8	6.5	36.5	0.1	2.2	3.6	3.9	2.7	13.9
White oaks [4]	0.4	0.1	(3)	----------------	(3)	2.0	17.2	10.7	1.3
Red oaks [5]	0.1	0.1	(3)	----------------	----------------	0.7	9.6	4.0	0.7
Bitter pecan	3.5	5.4	34.9	1.3	4.2	2.2	1.9	----------------	12.3
Sweet pecan	4.3	1.2	0.3	0.5	0.1	1.3	0.9	----------------	1.7
Green ash	5.1	18.2	4.9	0.6	4.0	3.5	----------------	----------------	6.0
White ash	----------------	0.5	0.1	----------------	----------------	1.0	3.3	1.2	0.4
White elm	4.8	9.0	1.8	0.3	0.8	4.7	2.8	0.9	3.8
Rock or cedar elm	2.9	19.0	2.6	----------------	----------------	1.9	3.3	----------------	4.6
Winged and red elm	0.1	1.2	----------------	----------------	----------------	2.2	4.8	2.8	0.7
Hackberry	4.7	20.4	3.3	0.5	0.2	2.4	0.7	----------------	5.6
Cottonwood	0.8	0.1	0.1	39.9	0.5	0.1	0.1	----------------	4.2
Willow	0.2	0.4	0.2	52.4	2.7	(3)	0.1	----------------	5.4
Cypress	0.8	0.1	1.5	0.6	40.2	(3)	0.3	----------------	2.4
Tupelo gum	(3)	----------------	(3)	0.1	37.4	----------------	----------------	----------------	1.5
Black gum	0.6	0.2	0.1	----------------	----------------	0.9	6.9	3.0	0.7
Hickory	0.1	0.1	(3)	----------------	----------------	0.4	7.6	4.5	0.5
Red maple, boxelder	1.3	1.9	(3)	0.2	1.0	0.6	0.8	0.5	0.8
Sycamore	0.5	0.8	----------------	0.8	----------------	----------------	----------------	----------------	0.3
Persimmon	0.9	1.0	2.6	0.3	1.1	0.6	0.6	----------------	1.3
Other hardwoods [5]	3.1	2.8	2.1	0.9	2.5	1.5	0.9	0.1	2.3
Loblolly pine	(3)	(3)	----------------	----------------	----------------	0.1	2.1	48.4	0.6

[1] Total gross cubic volume includes bark in stemwood of good trees 5 inches and over in diameter.

[2] Chiefly water oak, bottom land red oak and willow oak.

[3] Less than 0.1 percent.

[4] Cow oak, forked-leaf white oak and delta post oak.

[5] Chiefly cherry bark oak, southern red oak and black oak.

[6] Chiefly honeylocust, mulberry and water locust.

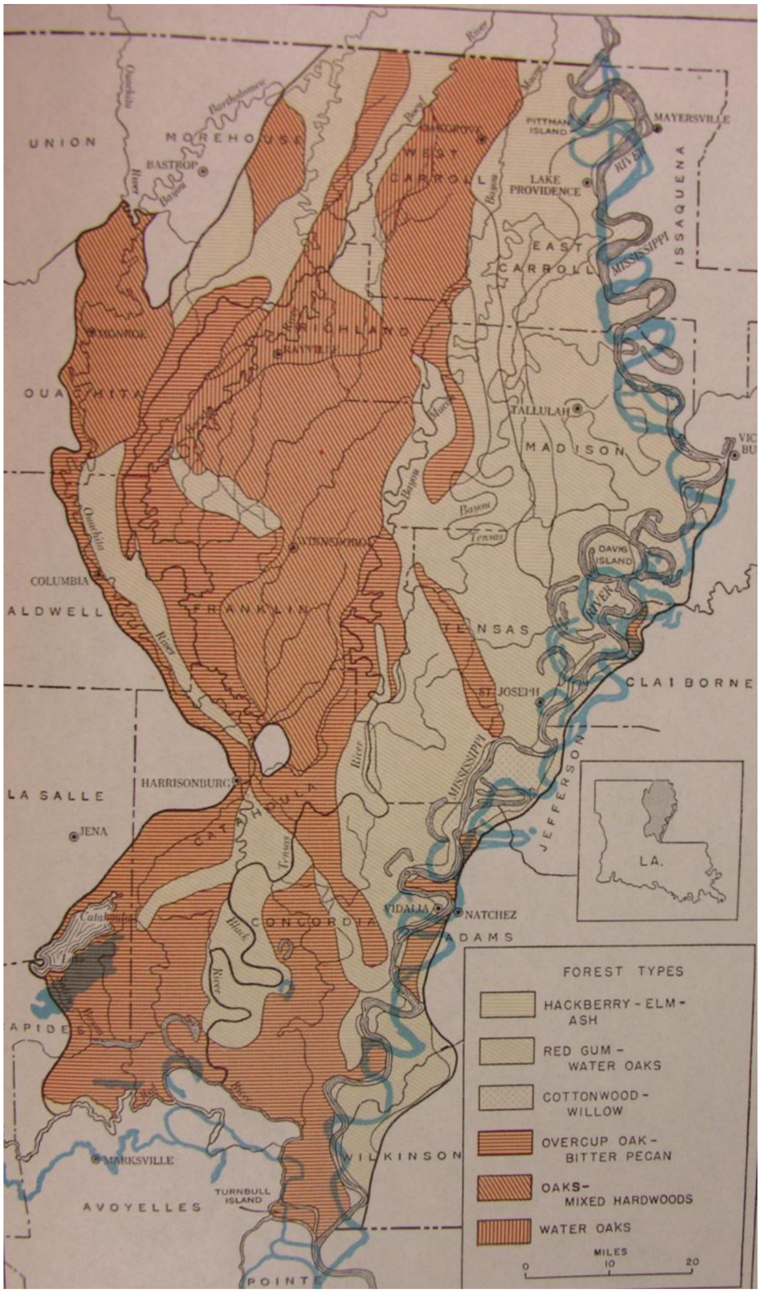

Figure 2. Distribution of Forest Types in northeastern Louisiana (from Winters et al. 1938)

Table 2. “Topographic situation” of each of the 8 forest types recognized by Winters, et al. (1938) in the North Louisiana Delta. The topographic situations are defined as follows: Swamp – Forested areas normally under water during the greater portion of the year; Terrace – Non swampy ancient floodplains now above the level of all but exceptional floods; River margin – Relatively high sandy areas adjacent to present or recent stream courses and comprising the most recent alluvial deposits in the delta; and Bottomland – Present floodplains which cannot be classified as swamp or river margin.

Forest Type	Bottom land	Terrace	Swamp	River margin	All Situations	
	Acres	Acres	Acres	Acres	Acres	Percent
Red gum-water oak	659,900	10,100	2,500	9,500	682,000	25.4
Hackberry-elm-ash	386,300	16,000	1,700	3,700	404,000	15.1
Overcup oak-bitter pecan	772,400	21,900	14,300	139,600	812,300	30.2
Cottonwood-willow	30,500		48,900		219,000	8.2
Cypress-tupelo	11,000	1,700	82,400		95,100	3.5
Water oak	135,000	59,000			194,900	7.3
Mixed oak-mixed hardwood	51,000	193,700	1,700		246,800	9.2
Pine-hardwood	----------------	28,600			28,600	1.1
Total	2,047,400	331,000	151,500	152,800	2,682,700	
All types, percent	76.3	12.3	5.7	5.7		100

private and federal projects both within the study area and upstream in Arkansas, including channel cutoffs, straightening, snagging, and deepening of major streams such as the Boeuf River, Bayou Bartholomew, Big Creek, and Bayou Lafourche. The Ouachita River itself is a major navigation channel that has been deepened and fitted with locks to allow barge traffic as far as Camden Arkansas. A flood control levee has been constructed that extends from Bastrop on Bayou Bartholomew to the Ouachita River and then south to a point more than 70 miles below Monroe.

METHODS

The PNV map for the Ouachita basin was developed using spatial data layers in a Geographic Information System (GIS) and field studies. The purpose was to identify and characterize relatively stable assemblages of tree species that consistently occur on particular combinations of site factors. The plant communities were classified based on hydrogeomorphic (HGM) criteria to maintain consistency with other PNV mapping conducted in the Delta Region of Arkansas. The details of the Arkansas HGM classification system and criteria are summarized in Klimas et al. (2005) and the PNV mapping approach is described in Klimas et al. (2009). The data layers and procedures used in the Ouachita basin study are detailed below.

Spatial Data Assembly and Preparation

This project uses a combination of three primary criteria (hydrology, geomorphology, and soils) to classify the potential natural vegetation of an area. Spatially representing these three criteria required the use of several datasets that were collected from existing publicly available sources and assembled in a Geographic Information System (GIS) by the U.S. Fish and Wildlife Service Lower Mississippi Valley Joint Venture Office (JVO). Some of these input data required significant preparation before modeling could begin. Primary inputs were geomorphology, soils, flood frequency and hydrography. Additional spatial data such as roads, political boundaries and aerial photography were used for orientation. All data were clipped to the study area and projected to UTM Zone 15 North (NAD83). The ModelBuilder application in ArcGIS 10 was used to create three custom models that streamlined this process of clipping and preparing these data. These models have been archived along with the final spatial layers in the JVO. Due to the relatively small study area for this project, the modeling was performed in a vector environment in an attempt to preserve some of the detailed linework of some input datasets.

Geomorphology

The main source of spatial geomorphology data for this project was a digital version of the 1:250,000 scale map prepared by Saucier (1994). These data were originally presented as a series of 1:64,000 scale maps (Saucier 1967, Fleetwood 1969) that were subsequently generalized to a scale of 1:250,000 and digitized by the USACE. Some edits were made to the digital version of this map to correct a few attribution errors where the digital data did not match the hard copy.

Three of the geomorphology features that were essential for HGM classification were not transferred to the 1:250,000 scale Saucier map when it was digitized. These features were natural levee veneer deposits, small abandoned channels and courses, and alluvial fans. To obtain those features the JVO obtained scans of the 1:62,500 scale geomorphology maps, geometrically corrected them using ground control points from 1:24,000 DRGs, and digitized the three relevant features. The geometric correction was completed using ERDAS Imagine 9.2 software. The RMS errors for these maps were below 3 meters, though in many areas it was challenging to find control points due to a lack of road infrastructure in parts of the study area. After the veneer, small abandoned channels and courses, and alluvial fans were digitized from the georeferenced 1:64,000 maps some additional editing was performed to correct edge mapping problems that arose from discrepancies in mapping of features along adjoining maps. These discrepancies were corrected by the authors of this report using expert opinion, aerial photography, and soils maps.

Soils

Soil data for this project were obtained from the 1:24,000 scale parish level Soil Survey Geographic (SSURGO) soils databases. For each individual parish an attribute join was performed to add the soil name to the attribute table associated with the soil map. Then all of the SSURGO maps for each parish in the study area were merged together and clipped to the project extent.

Hydrography

Stream and waterbody features for this project were extracted from the National Hydrography Dataset (NHD). Waterbodies were used to identify the fringe wetland class within the HGM classification system. Streams were extracted by selecting feature types of “stream/river,” “artificial path,” and “connector” from the flowline file. The latter two categories represent modified streams. These streams were used to differentiate between connected and unconnected fringe and depression wetland classes as well as to define some riverine backwater and riverineoverbank community types. Where these line features are used to define riverine backwater and overbank community types a standard 200 meter buffer was applied to the line to define the mapped polygon.

Hydrology

Processing of the hydrology data was by far the most complicated data preparation process in the study. Spatially explicit hydrology data was available for the area that falls within the Mississippi Alluvial Valley (MAV), which covers the majority of the study area.

Our available information for the MAV portion of the study area consisted of two datasets that had been assembled by the Southern Regional Office of Ducks Unlimited (http://www.ducks.org/conservation/southern-regional-office/southern-regional-office), which they had designated as the Flood Frequency and Observed Flood Models. Ideally we would have only used flood frequency data to supply the spatial flooding information because the HGM classification system uses 2, and 5 year events to separate certain wetland subclasses. However, the available flood frequency data did not exactly match those intervals for all parts of the study area, so we also used the DU observed flood index to supplement the frequency information. By combining these two datasets, we were able to develop reasonable approximations of the 2, and 5 year flood zones.

> **Flood Frequency.** The Flood Frequency Model is a dataset that covers most of the MAV. The dataset consists of a large collection of both tabular gauge data and spatial data created by classifying water from satellite imagery. The model is a living model and can continually be updated with new gauge and satellite data. In the model the MAV is subset using watershed boundaries that Ducks Unlimited created specifically for this project. The pour point (lowest point) of each watershed is a gauge where flood data has been recorded. Ideally each gauge would have sufficient gauge data to calculate frequency, but because some gauges have missing records or short period of records, sometimes watersheds are combined and the nearest downstream gauge with sufficient data is used to calculate frequencies for the combined watersheds. For each individual or combined watershed with sufficient gauge data, the gauge data is used to calculate flood frequencies associated with specific gauge heights. The calculated flood frequencies/gauge heights are then used to find frequencies we could use as surrogates for the flood extent cutoffs used in the HGM classification. The dates when the gauge was at or near that height are then used to locate classified satellite scenes in the DU Flood Frequency Model taken on that date. We can then use the flood extent captured

on that imagery as a surrogate for the flood extent cutoffs that are used in the HGM classification.

For this project, information from the DU Flood Frequency Model was used to create a surrogate HGM flood frequency raster for each watershed in the study area. This process included identifying dates of imagery that would be used as a surrogate for HGM flooding criteria, mosaicing several dates of imagery together for each watershed so that each watershed contains a surrogate for the 2 and 5 year events, cleaning up the imagery to remove suspected classification errors by performing a “clump and eliminate” to remove isolated pixels, recoding the original frequency values (in months) to the values that were ultimately used in the HGM model as surrogates for 2 and 5 year events, converting to a vector format, and cleaning up the attribute table in the vector format. However, for some watersheds this dataset did not capture any event that could be used as a surrogate for a 5 year event. Because of this we additionally used the DU Observed Flood Index to help create a surrogate for a 5 year event.

DU Observed Flood Index. The DU Observed Flood Index Dataset also used a combination of gauge data and satellite imagery to characterize flooding; however, it did not calculate values in terms of flood frequency. The values in this dataset show the ratio of how many times a pixel was classified as wet to classified as dry for each scene. For instance, a pixel with a value of 20% was classified as water in 2 of the 10 Landsat scenes for that path and row.

For this project, information from the DU Observed Flood Index was used as a surrogate for the 5 year flood. All pixels were reclassed as water/no water and all single pixel clumps were removed. Next, all polygons that did not intersect a stream (as defined by a subset of the National Hydrography Dataset which included Stream/River, Artificial Path, and Connector) were removed. This step was taken to eliminate sites where the presence of water was attributable to ponding of precipitation, and not overbank or backwater stream flooding.

Final Flood Layer. The final hydrology layer for this project was created by combining the final outputs of the flood frequency model for each watershed and the stream-intersected observed flood index. Three flood frequency categories were established (2, 5, and >5 year) that correspond to the HGM classification criteria, but which are not intended to directly reflect actual measured flood return intervals. Rather, they represent three categories of relative “wetness” that should be interpreted as; sites that flood in most years; sites that flood commonly; and sites where flooding is not common enough to strongly influence the composition of the vegetation.

In this study area, as a surrogate for the 2 year floodplain cutoff we used flooded extents calculated by the DU flood frequency model of 1 year and less. As a surrogate for the 5 year floodplain cutoff we used data from both the DU Flood Frequency model where it was available, and the DU Observed Flood layer where 5 year events were not captured by the Flood Frequency model.

The DU flood models did not include coverage of a relatively small part of the study are that lies to the north and west of Bayou Bartholomew, encompassing the upper reach of the Ouachita River and adjacent lowlands. Flood frequencies were assigned in this section based on patterns observed on contiguous landforms that were within the area of DU flood model coverage, extrapolated using topographic maps, landforms, soils, and direct field observations of flood indicators and plant communities (Figure 2).

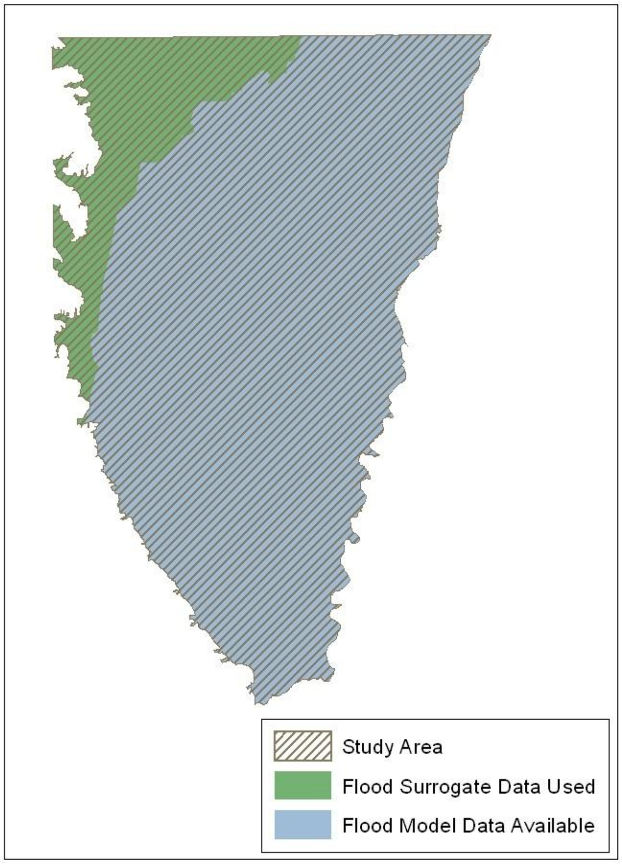

Figure 2. Flood model coverage within the study area.

Combined Base Data

After the all the above layers were created, they were combined into one vector file using the "union" tool in ArcGIS 910. This process preserved the linework from each layer and allowed the pertinent field information from each layer to be combined into one attribute table.

Four separate union processes were performed to create the base layer used as the first input into the model. Through trial and error we found that performing the unions separately allowed us to more carefully clean sliver polygons and control errors with topology. After each union, the "repair geometry" tool was used on the resulting layer to clean up some errors that were produced by the union. The "eliminate" tool was then used to remove sliver polygons that were less than 200 square meters in area. This process combined those sliver polygons with the adjacent polygon with the longest shared border. Sliver polygons were created when the linework of multiple input layers were so close together that for practical applications of this model they should be considered one line. The cutoff value was chosen because an exploration of the individual input layers revealed that none of the input layers contained polygons that were less than 200 square meters. Removing these sliver polygons proved essential to maintaining a vector dataset size that could be processed with the model. Like the data preparation mentioned above, this process was also streamlined using a custom, iterative model. This fourth model has been archived along with the final spatial layers in the JVO. The attribute data for the resulting file was then cleaned up to remove unnecessary fields and to ensure that the names of the fields which contained site factor data matched the codes used in the model.

The first union combined all of the geomorphology data into one layer. The second union combined the above geomorphology data with the NHD waterbodies. The third union combined the above geomorphology and NHD waterbodies layer with the final flood layer. And finally, the fourth union combined the above geomorphology, NHD waterbodies and flood layer with the buffered stream layer. This process combined all of the layers except for the soils, which are added in a separate step in the GIS model.

Field Studies

The field portion of this project involved stand-level characterizations of canopy composition and dominance. The objective was to locate and characterize as many stands as possible across a wide range of site conditions rather than to gather detailed structural data on a small number of stands, which would have precluded the kind of comprehensive overview required to assemble a complete PNV map coverage. Two field investigations were conducted; the first to develop the classification system and identify key site relationships for the major plant communities, and the second to fill in gaps, resolve discrepancies, and otherwise troubleshoot problems with the draft classification and map.

The field procedure involved locating mature forest stands on a wide range of site conditions, characterizing the dominance patterns and understory of each stand, and recording observations regarding the limits of distribution of the community and its adjacent communities. We identified specific sampling sites in the field using a laptop computer, linked to a Geographic Positioning System (GPS) that contained the GIS coverages for soils, geomorphology, flood frequency, and hydrography, as well as USGS topographic maps and recent aerial photography. The sampling strategy was to stratify the study area according to geomorphic setting, then by flood frequency, and identify mature forest tracts within each major combination of those categories. The GPS and GIS were used to select observation points in each target tract, and to identify variations in soils within those stands for additional observations. By this means, general conceptual models of community distribution relative to site conditions were developed and refined as the field surveys progressed, and recorded in a matrix format, where each HGM subclass designation was associated with a particular set of geomorphic and hydrologic conditions, as well as soils. The HGM community type was described in terms of dominant species and characteristic understory components.

Classification

HGM classification divides all wetlands into one of five classes (riverine, fringe, flat, depression, and slope), according to their hydrologic and geomorphic setting. The term “geomorphic” in HGM terminology, however, is somewhat misleading, in that it is intended to reflect topography rather than the age and origin of landforms. Thus, a depression can occur in a point bar swale, an abandoned channel segment, an upland sinkhole, or other settings where a closed basin is formed. Similarly, a fringe wetland can occur on the margins of an oxbow lake in an abandoned channel, as well as on the margins of a man-made body of water. However, the geomorphic mapping available for the study area had great utility for recognizing fundamental differences among sites above the level of the HGM classification. Past experience and the initial field studies showed major differences in plant communities and site characteristics on each of the Pleistocene terraces and Holocene meander belts described previously, and the classification system was stratified first on that basis. The HGM classes were superimposed below that level, based on topography and hydrology, and HGM subclasses and PNV communities were designated within those classes based primarily on hydrology, the presence of natural levee veneers, and soils. Thus, the classification hierarchy was General Geomorphic Setting – HGM Class – HGM Subclass/PNV Community.

Most PNV communities were associated with more than one soil, but not all possible unique combinations of soils and other site factors were observed in the field studies. Therefore, several soils with limited distribution within the study area and clear vegetation affinities were used in defining appropriate categories in the classification based on soil survey descriptions and our professional experience. The classification was revised and refined as the mapping process proceeded. The final classification system was structured to be consistent with the approach previously applied to the PNV maps developed for the Tensas basin.

Mapping & GIS Model

The classification system was constructed as a matrix of PNV community types and their associated site factors, and map assembly rules were developed that were designed to produce polygons that represented those specific combinations. Certain subclasses and communities were designated by only one or two site factors, and these were identified first and removed from further consideration. The remaining subclasses and community types were defined based on unique combinations of geomorphology, hydrology, and soils. The principal task in developing assembly rules was to specify a stepwise order of operations that produced a unique solution for each PNV community, and avoided conflicts or gaps.

The ModelBuilder application was used again to perform this mapping of the potential natural vegetation types. The model applies the information in the classification matrix (Appendix A) to the spatial layers representing geomorphology, soils, and hydrology listed above. The computer code used to perform the classification of this map was saved in two ArcGIS models (models 5 and 6), due to the large number of processes. These models are archived as part of the documentation of this product. They can be used in the future to run the model again on new input datasets if they become available. For instance, if improved flood data becomes available these models can be used to apply the same classification rules to the new data.

The fifth model uses the following data layers (described above) as inputs: the combined base data and NHD stream lines. This model performs the classification of all of the fringe and depression classes. The classification of fringe and depression PNV classes is more complicated than the other PNV classes. Both fringe and depression classes are further classified as “connected” or “unconnected” to a stream. This model creates a new spatial layer as an output.

The sixth model performs the classification of the remaining PNV classes. This model only has one input, which is the output spatial layer from the fifth part of the model. This model contains 48 processes, but all of them are simple “select by attribute” processes that select a set of polygons based on a combination of geomorphology, soils, and hydrology data and “calculate field” processes that write the correct PNV class into the attribute table. Due to the way the classification matrix uses combinations of geomorphology, soils, and flooding information to identify PNV classes, the order of operations for applying the mapping criteria is crucial. This order is captured in the two ArcGIS models saved as a part of this project.

Numerous iterations of test maps were developed and reviewed, and modifications were made to either the classification system or the map assembly rules as appropriate. Details of the final assembly rules and order of operations are contained in the archived ArcGIS models and in the metadata that describe the final PNV shapefile. In addition to the PNV class codes, the output of the model contains all of the linework and all of the attribute data from the input dataset. To create a final product that is more manageable for the user we used the “dissolve” process to limit the linework and the attribute data to the data that is necessary to see individual PNV classes.

RESULTS

Appendix A presents the final PNV classification for the Ouachita Basin portion of Louisiana. A total of 23 unique PNV community types were recognized. Appendix A includes the PNV and HGM community designations, a listing of common and dominant species characteristic of the type, and associated site factors and mapping criteria. The Appendix A classification uses the same community type designations as were used in the adjacent Tensas basin, such that a specific PNV community code (e.g., RB3) indicates a similar geomorphic and hydrologic setting and similar species assemblages and dominance patterns. Where there are gaps in the numbering sequence in Appendix A, it means that a community type that occurs in the Tensas does not occur in the Ouachita basin. For example, the Tensas classification system includes several community types restricted to recent Mississippi River sediments, which do not occur in the Ouachita study area.

The classification in Appendix A is organized according to HGM class and subclass, but the mapping criteria used geomorphology as the fundamental level of organization, as explained above. After summarizing the field data according to geomorphic settings and examining the results, four broad geomorphic groupings were established for detailed classification based on hydrology, the presence of natural levee veneers, and soils.

1. Abandoned channels and courses, large swales within point bar deposits, and water bodies.
2. Holocene point bar and backswamp deposits of the Arkansas and Ouachita Rivers.

3. Pleistocene terraces and included Holocene valleys and alluvial fans.

4. Pleistocene lake bed deposits.

Within each of these four broad groupings, HGM classes and subclasses were recognized based on hydrology and topographic setting, as follows:

1. Riverine and river-connected wetlands are restricted to the 5-year flood frequency zone.

2. Fringe wetlands are associated only with bodies of water identified as lakes on the NHD Coverage. They are further classified as connected or unconnected depending on whether they intersect perennial streams.

3. Depression wetlands are identified based on soils and are classified as connected or unconnected depending on whether they intersect perennial streams.

4. Flat wetlands are all remaining sites outside the 5-year floodplain, except those designated as upland types.

5. Uplands, which are not an HGM class because they are not wetlands, are included in this classification to provide seamless coverage of the entire study area, and because they are likely to be considered when using this mapping to plan landscape-scale restoration. They are above the 5-year floodplain, and are distinguished from flats and unconnected depressions and fringe wetlands based on geomorphology and soils. Uplands include alluvial fans, most of the older terrace sites, valley sideslopes, and similar well-drained areas.

Within the HGM subclasses, community types were recognized where specific combinations of soils, geomorphic setting, and hydrologic criteria consistently supported particular plant communities. Plant communities were defined in terms of overall physiognomy (i.e., forest, savanna, prairie) and composition, where the objective was to describe the typical characteristics of mature systems that are likely to occupy a particular site type under the natural disturbance regime typical for the site. In the case of prairie systems, the descriptions are based largely on experience in remnant prairies outside the study area, and assume that appropriate fire regimes would exist to restore and maintain the composition described here. In other complex and dynamic systems such as fringe wetlands, where subtle variations in water depth and fluctuation regimes can favor any of a wide range of structural and compositional combinations, we describe the most common variants but do not attempt to link them with specific site characteristics. However, the majority of the communities described in Appendix A are forested and we describe them consistently in terms of leading dominant trees in the canopy as well as characteristic secondary and understory species where those were consistently present.

This level of description is intended to support the primary objective of the study, which is to provide general guidance for planning and evaluating multiple alternative restoration options. The community types described here represent the predominant conditions that would be expected to exist indefinitely on the restored landscape, and to guide species selection and site preparation for establishing those communities. We recognize that under natural conditions there are multiple possible developmental stages and inclusions of earlier stages within canopy gaps in the community types we identify as “typical” of a site, but overall the composition and structure should be essentially stable over the long term and over large areas.

Appendix A is organized primarily in terms of the HGM classification described previously, therefore the same leading dominant species often appear in more than one community type. For example, communities dominated by baldcypress or co-dominated by baldcypress and water tupelo are identified in riverine overbank, riverine backwater, connected depression, unconnected depression, connected fringe and unconnected fringe HGM subclasses. These communities are all compositionally consistent with the descriptions of the Baldcypress (101) and Baldcypress-tupelo (102) types of the Society of American Foresters (Eyre 1980) as well as the Bald-cypress Semipermanently Flooded Forest Alliance (A.346) and Water Tupelo - (Bald-cypress) Semipermanently Flooded Forest Alliance (A.345) of NatureServe (Grossman et al. 1998; Anderson et al. 1998). They also fit the definition of the Cypress-Tupelo type of Winters et al. (1938). However, within the HGM classification these types all have different hydrologic regimes and varying degrees of connection to other aquatic systems, and therefore are identified as separate types reflecting their functional and structural differences. The other HGM community types listed in Appendix A can also be cross-referenced to their SAF, NatureServe, and Winters counterparts if that is desirable for management recommendations or for more detailed listings of associated plants, but for specific site affinities and the functional insights provided by HGM classification, the community types identified in Appendix A are more useful.

In addition to listing dominant and secondary species, Appendix A presents the principal criteria used to separate the community types. Some key characteristics of the classification system and certain unique community types are described below.

Riverine systems

The HGM classification distinguishes riverine overbank from riverine backwater systems based on the energy of the flowing waters during flood stages, and the related ability of the system to export organic material, deposit fine sediments, and similar functions. This distinction is reflected mostly in the separation of overbank community from backwater sites, and the further subdivision of backwater sites according to flood frequency, with frequently flooded areas (1 and 2-year floodplain) being dominated by species such as overcup oak, while less flooded sites (3-5-year floodplain) support a broader suite of species, usually including some combination of Nuttall, cherrybark, and willow oaks. However, in the Ouachita basin, the numerous abandoned courses of the Arkansas River that are currently occupied by smaller streams account for the widespread occurrence of a community type we refer to as the river swamp, a variant of the riverine overbank HGM subclass. The river swamp community type (RO2) usually consists of a baldcypress-dominated forest that is situated in the bottom of the former river channel, within and along the edges of the much smaller watercourse that now occupies it. Because the steep channel sides confine normal high flows, the river swamp is often flooded deeply and with high-velocity flows, but the trees may stand in nearly stagnant water at most times if the present stream is small. Because the sideslopes of the abandoned course also receive high-velocity flows but are relatively well-drained and even drought-prone the rest of the time, they tend to support a combination of somewhat resilient and broadly tolerant species such as sugarberry, box elder, and elms. Because most abandoned courses include this same combination of open water, baldcypress forest, and typical riverfront hardwoods, the entire complex is mapped as the river swamp type in this classification. Note that in some cases, the former large channel has been so completely filled that the river swamp community may be little more than a narrow band of trees in a shallow channel – nevertheless, the basic mechanism that maintains the type (sluggish, near-permanent flows) are usually present as long as a perennial stream occupies the abandoned river course.

An additional type of riverine overbank wetland (RO1) can be found on the floodplains and low Holocene terraces of the small drainageways that dissect the margins of the major Pleistocene terraces in the study area. These narrow valley bottoms support a suite of species that include most of the major dominants found on the large river deposits, such as cherrybark oak, water oak, and sweetgum. However, numerous other species such as sycamore, loblolly pine, American beech, and ironwood occur commonly in these small valleys but are typically localized or scattered in distribution elsewhere in the study area. In some instances, where lakes occupy the former stream valleys, a narrow band of the RO1 type still exists on the valley footslopes along the lake perimeter.

Appendix A includes 6 Riverine Backwater types. RB2, RB3, and RB4 are occasionally-flooded (2-5 year floodplain) communities of the large stream bottoms, with willow oak as a characteristic dominant. They differ primarily in their drainage characteristics and topography and the effects of those factors on community composition. For example, the ridge-and-swale terrain and natural levee veneers of RB2 sites account for a much greater importance of water oak (veneered ridges) and more pronounced development of vernal pools (swales) than are found in the other two community types. Vernal pools in the RB2 sites tend to be narrow, relatively deep, and typically have a variety of bottomland species (often including Nuttall oak) while those in the backswamp settings of RB4 are usually very shallow pools dominated by overcup oak. RB5 is also an occasionally-flooded, typically willow oak-dominated community, but it occupies a very different setting. It is found on the slightly elevated interfluves between the former outwash channels of the Pleistocene valley train terraces. The channels themselves, which are often long, interconnected, parallel-trending low areas, usually are flooded frequently (1-2 year floodplain) and like the most frequently-flooded sites in Holocene settings, they are classified as RB7. These sites most commonly support overcup oak-bitter pecan communities, but the community type includes wetter (cypress-tupelo) and drier (Nuttall oak – green ash) phases within that flood zone. The RB8 riverine backwater type is unlike any of the others. It is the sand prairie community which is restricted to the former beaches of Pleistocene Lake Monroe, all of which lie within the 5-year floodplain of the Ouachita River.

Fringe

Fringe wetlands include a wide range of potential compositional and structural expressions, for the reasons noted above. Nearly all water bodies in the study area are either man-made or have water control structures on them, therefore the structure, composition and distribution of fringing plant communities cannot be regarded as "stable" in the long term, since water regimes often don't follow natural fluctuation patterns and may be changed at any time. From a functional standpoint, the most important distinction among fringe communities is whether they occur along a water body that is connected to a perennial stream or not. If the water body is connected to a perennial stream, the slowing of water in the water body and the associated fringe wetland detain floodwater and export organic carbon, functions that unconnected wetlands do not perform.

There are two fringe types in the classification (Appendix A). FR1 occurs along water bodies connected to a perennial stream, and FR2 occurs along water bodies not connected to a perennial stream.

Depression

Depression wetlands are relatively consistent in composition and structure. Most are some combination of cypress-tupelo or overcup oak–water hickory, depending on the depth and duration of standing water. By HGM convention, depressions are less than 2m deep, therefore they do not often have an open water zone like fringe wetlands, but may include a buttonbush zone at the deepest point. Along the margins, depressions also often include fairly dense understories of water privet and water elm. The classic arcuate depression wetlands (D1 and D3) are Holocene features commonly found in geomorphic settings that were created by meandering rivers, rather than valley train areas, because that is where large closed basins remain in the remnants of abandoned channels and swales. D2 and D4 depressions are usually long, linear features that occur in the remnants of glacial outwash channels on Pleistocene valley train terraces. As with fringe wetlands, function is highly influenced by whether the depression is connected to a perennial stream or not. Connected depressions have functions (detention of floodwater and export of organic carbon) that unconnected depressions do not have.

Flats

Flat wetlands are defined as being unflooded by the 5-year event, and many have never been flooded in recent geologic history. However, most flats are on river-deposited sediments that are poorly-drained and which pond water sufficiently to sustain wetland characteristics and functions. Thus, the old valley train and meandering river terraces of Pleistocene age, which are elevated well above the modern floodplain level, are the expected locations for flat wetlands. And in fact, most wetlands on those surfaces are classified as flats, and support a variety of plant communities depending on soil characteristics. Typically, the forests of the F7 Pleistocene flats include cherrybark oak and Delta post oak among the dominants, but a variety of other species occur there. This is the “matrix” forest of the valley train terraces, and also occurs on some sites on the Deweyville and Prairie terraces where poor drainage and microsite variation lead to ponding and prolonged sol saturation. Vernal pools dominated by wet-site species such as overcup oak are common on the younger, lower valley train terraces. The F9 and F10 flat types are variants of the true “flatwoods” forest type, which occur on specific poorly-drained soils, usually with extensive vernal pools and a variety of tree species. Flatwoods are precipitation-driven wetlands, typically on terraces, with a pronounced wet-dry seasonal variation. Species have a broad range of moisture tolerance ranging from very wet (e.g. overcup oak) to upland (post oak, southern red oak). Species requiring greater moisture probably regenerate during wet cycles and those requiring less moisture regenerate during dry cycles, resulting in this high diversity. Fire historically played an important role in these communities because of the summer-fall drought that is typical, often resulting in a woodland physiognomy – relatively open tree canopy allowing light to the ground that resulted in a dense, diverse, herbaceous and often prairie-like ground flora. Although flatwoods in the study area occur on all Pleistocene surfaces, they have been considered particularly characteristic of the Pleistocene Lake Monroe lacustrine plains, also known as the "flatwoods terraces."

One additional unique flat type is the alkali prairie/savanna (F11) that is found only on a specific soil on the Pleistocene terraces. The relative importance of trees versus herbaceous plants is dependant in part on fire frequency and soil properties (salinity and alkalinity) in this community, and in some settings the highly saline soils form salt slicks where the federally endangered plant, *Geocarpon minimum*, is found.

Uplands

The plant communities that we have included in the HGM classes described above are designated as wetlands because they are prone to periodic flooding or they are on alluvial surfaces with topography and soils that promote prolonged soil saturation. They are in that sense ecological wetlands, regardless of whether they meet the current criteria for jurisdictional wetlands under the Clean Water Act or other wetland definitions. However, there are a variety of sites within the study area that are clearly non-wetland. These are primarily on the highest Pleistocene terraces and the sideslopes of small valleys that have formed along the margins of those terraces, and on alluvial fans that occur along the valley walls. Vegetation on these sites is hardwood and pine-hardwood forest ranging from mesic to xeric in species composition. Although the HGM classification system was designed specifically to be applied to wetlands, these upland types have been included in the classification in Appendix A as type U2 in order to assure consistent and complete map coverage of the study area.

DISCUSSION

General Patterns of PNV in the Study Area

The following discussion references the PNV community type classification system presented in Appendix A. The geomorphic surface designations are from Saucier (1994) and are defined at the end of Appendix A.

The Ouachita basin PNV map reveals distinctive large-scale patterns across the study area. There are 4 general vegetation areas – Macon Ridge; the lowlands along Bayou Bartholomew,the lower Ouachita River and the Boeuf River ; The upper Ouachita River lowlands; and the western Pleistocene terraces. These are described below:

Macon Ridge

The PNV of Macon Ridge is a relatively simple pattern of F7 poorly-drained flats dominated by cherrybark oak, delta post oak and blackgum, with numerous D2 and D4 depressions in outwash channels potentially dominated by overcup oak, cypress and tupelo. This landscape is unlike any other in northeastern Louisiana, and is most like areas in northeastern Arkansas. Fire was probably frequent on these terraces, and much of the vegetation may have been woodland rather than forest. The scattered areas of the oldest, highest Pve5 terrace are upland forest dominated by southern red oak, white oak and other species not normally found in wetlands. Since flooding is of little concern on these terraces, they have been extensively cleared for agriculture and towns. Some soils that occur on Macon Ridge (Calloway, Calhoun and Loring series) are known to have supported tallgrass prairie on certain sites in Arkansas, however, these soils are widespread on Macon Ridge and certainly not always associated with former prairie. Furthermore, the soils that consistently support prairie in Arkansas (Crowley- sometimes classified as Overcup - and Stuttgart) do not occur on Macon Ridge. Therefore, although there may have been areas of tallgrass prairie on Macon Ridge, we were not able to identify any specific combination of soils and geomorphology that are sufficiently predictive of grasslands to justify mapping that community. If specific locations of former or remnant prairie can be identified, it may be possible to model their potential occurrence and modify the PNV map.

Lowlands along Bayou Bartholomew, the Lower Ouachita River and Boeuf River (and others)

In this section, “lower Ouachita River” refers to that reach of the Ouachita within the study area below the mouth of Bayou Bartholomew, near Bastrop. These lowlands, as discussed previously, were formed by the Arkansas River and their character is dominated by its influence. As such, the PNV of these lowlands is essentially the same as much of the Tensas basin, southeastern Arkansas and large parts of the rest of the MAV. They comprise a mix of frequently-flooded basins and depressions dominated by overcup oak, baldcypress, and associated species, and more diverse mixed-oak systems on less flooded sites. Natural levee communities dominated by water oak, cherrybark oak, sugarberry, and pecan occur along active and abandoned stream channels. Cottonwood and sycamore are characteristic of the most active streamfronts and bars.

Lowlands along the Upper Ouachita River

In this section, “upper Ouachita River” refers to that reach of the Ouachita within the study area above the mouth of Bayou Bartholomew. This reach has a very different character than that of the lower Ouachita River in that it is not occupying a meander belt formed by the Arkansas River. Furthermore, it is bounded on both sides by high terraces and Tertiary uplands. Therefore, flooding along this reach is more confined than along the lower river so in any substantial flood event, essentially the entire alluvial valley is flooded. Also sandy substrates are more limited than along the lower river. For these reasons, there are no F1 high, well-drained natural levees along the upper river; even the lower natural levees are moderately drained F4 flats occupied by Sugarberry-Elm-Ash forest. As described previously there are no geomorphic backswamp settings mapped along this reach, but there are extensive F7 backwater areas subject to extended inundation. There are also large areas of moderately drained point bars dominated by F3 Willow Oak forest. Furthermore, the distinctive PNV of the bed and beaches of Pleistocene Lake Monroe (discussed further below), much of which is within the floodplain of the Ouachita River, add to the distinctive character of this reach. Interestingly, this upper Ouachita reach is often not included within the MAV; for example, the U.S. Fish and Wildlife Service Lower Mississippi Valley Joint Venture designates the meander belt of Bayou Bartholomew as the western boundary of the MAV in northern Louisiana. The distinct change in PNV at that point as documented in this study provides support for that decision. However, all PNV mapping in the MAV has followed Saucier’s (1994) boundary, which includes the upper Ouachita and the adjacent Pleistocene Terraces, and for consistency we follow that convention. In addition, there are numerous restoration opportunities unique to those surfaces .

Western Pleistocene Terraces

These terraces lie to the west of the upper and part of the lower Ouachita River, and between the Ouachita River and Bayou Bonne Idee in Hpa3 and Bayou Coulee and others now occupying Hpa5. Bayou Bartholomew, in Hpa2, is east of these terraces at the state line, but cuts through them almost immediately upon entering the study area. The terraces include Lake Monroe, Deweyville and Prairie. The Prairie Terrace is the highest and oldest, and consequently the most dissected, with both flats wetlands – typically F10 Pine-Hardwood Flatwoods, and upland vegetation on better-drained, more sloping sites. Deweyville and Lake Monroe terraces have extensive areas of both F10 and F9, poorly drained flatwoods dominated by cherrybark oak and water oak, along with F7, poorly drained flats dominated by cherrybark oak and delta post oak with overcup oak in vernal pools, sometimes within the current (but >5 year) floodplain of the Ouachita River. A community unique to the Lake Monroe terrace is the Lowland Sand Prairie that occurs on former beaches of Lake Monroe. This community, despite its common name, is not a tallgrass prairie type but rather a "barrens" community that is adapted to the extremely droughty sandy sites that also have levels of aluminum in the soils that render them toxic to many plant species.

The PNV Map as a Model for Restoration

The PNV mapping process was conceived as a way to provide the best available representation of restoration potential for the natural plant communities of the Lower Mississippi Valley. The key aspect is that these maps reflect current, rather than historic, hydrologic patterns. The primary purpose is to support restoration planning and prioritization, and to help identify opportunities to address resource management and recovery objectives. There are many possible uses for the PNV maps, including the following:

Replacement of critical habitat

The Tensas Basin PNV map was developed specifically to address the loss of habitat for the Ivory-Billed Woodpecker (IBWO), and the Ouachita basin PNV map was created as an extension of that effort. The recent rediscovery of the IBWO in Arkansas prompted interest in restoring habitats that might support that animal. Until that rediscovery, it had been more than 60 years since a breeding population of the IBWO had last been known to exist in the MAV, and that group was in the Tensas Basin. Foti et al. (2008) present a discussion of how PNV mapping can contribute to both understanding of the habitat conditions preferred by the IBWO as well as help identify where those habitats might be restored in the modern landscape.

Site-specific restoration design.

Because the PNV maps often recognize mapping units of a fraction of an acre, they can normally inform restoration design even on relatively small or diverse sites. The site descriptions and geomorphic settings in Appendix A 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 pools in backswamps, and similar subtle variations in terrain that may have been moderated or eliminated by agricultural practices. Users should evaluate any particular site in light of these descriptions, and restore the appropriate topography prior to planting the area. The classification system in

Appendix A also contains the information needed to modify the prescribed plant community if hydrologic restoration can be accomplished on a site. If filling a ditch or breaking a levee is part of the restoration plan, the expected change in flood frequency should be applied to the Appendix A matrix to identify the appropriate community for the wetter site conditions. While all of these features will help 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 actual conditions in the field. In particular, it is important to recognize that the accuracy of the community boundaries on the PNV map are limited by the precision and resolution of the underlying geomorphic, soils, and hydrology mapping, and that actual transitions between communities are normally more gradual than community mapping implies. Appendix B presents an example of site-level restoration planning at the Mollicy Farm unit of Upper Ouachita NWR.

Landscape-level restoration planning

PNV maps can be useful for identifying restoration needs and opportunities where resource objectives involve the distribution of particular habitats over large regions. In a GIS environment, it is relatively simple to identify sites appropriate for the restoration of extremely rare communities (e.g., 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 directly reflect flood frequency, therefore restoration projects can be designed to assure that flood refugia 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 Connected Depressions and Unconnected Depressions. Though these sites support the same forest communities, the latter is far more suitable for restoring amphibian populations due to the lack of predatory fish. There are numerous similar types of applications that can add flexibility and insight to the restoration planning process.

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 required in federal programs. However, because the PNV maps use the HGM classification system, they can also be used in conjunction with HGM Regional Guidebooks to help calculate the amount of restoration of particular wetland subclasses that is required under any particular impact scenario. The HGM guidebooks for the LMV 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

Currently, there are PNV maps available or under development for all of the MAV in Mississippi, Arkansas, and in Louisiana north of the Red River. There are some fundamental and dramatic differences among the sub-basins across this large area. Pleistocene deposits are more extensive in Arkansas than Holocene deposits, while the opposite is true in Mississippi. Arkansas River deposits are more extensive than Mississippi River deposits across northeastern

Louisiana and southeastern Arkansas, but are nonexistent north and east of that zone. These types of patterns account for some observed variation in the distribution of community types throughout the region, but the classification system used here, being based on physical site characteristics rather than biota, allows consistent labeling and characterization within and across all sub-basins. Those differences within communities that relate to the range limitations of particular species and climatic influences are handled as general comments in the classification matrix for each basin (Appendix A in this report) rather than by creating entirely new community types. This characteristic of the classification system – basing community designations on site conditions rather than species composition – also prevents misclassification of sites based on past management practices or other historic influences that we are unable to characterize with much certainty. For example, water oak is a component of various community types throughout the MAV, but it is much more likely to dominate those communities in the Louisiana portions than in any area to the north. In fact, water oak is dominant or at least important on all sites except the very wettest in Louisiana, but the natural history and site preferences of several other species indicate that they would be expected to predominate on at least some of those sites, as they do elsewhere in the MAV. It seems likely that water oak is over-represented in many remnant forest tracts in the region as an artifact of past management and successional patterns. Being near the center of its range in northeastern Louisiana, and having a broad tolerance of disturbance and varied water regimes, may have given water oak an advantage over other species in the post-settlement environment. However, note that water oak was abundant in 1934 as well (Table 1), so its present dominance is not strictly due to recent changes in forest management or site conditions. The community type descriptions in Appendix A reflect our best estimate of the probable long-term dominance patterns, including the relative dominance of water oak, in the various communities of the Ouachita Basin under restored conditions. In the case of water oak, this is less than the current level of abundance, but more than that seen in most other examples of the same community types in MAV sub-basins in Arkansas and Mississippi.

These and other examples illustrate a basic characteristic of the PNV mapping approach, which is that sites designated as appropriate for establishment of a particular community type across multiple basins likely will vary somewhat in relative species dominance across that range. However, where a community type is mapped as occurring across the MAV, it can be assumed that it is fundamentally the same in terms of community structure, general composition, and site characteristics.

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APPENDIX A

Characteristic dominant and associated plant species and landscape settings of the Potential Natural Vegetation communities of the Ouachita River Basin of northeastern Louisiana in the Lower Mississippi Alluvial Valley; also included are the principal mapping criteria used to establish the distribution of the community types. Codes used to define geomorphic settings correspond to the map legend in Saucier (1994) and are defined below the following table.

HGM SUBCLASSES: CONNECTED AND UNCONNECTED DEPRESSION					
COMMUNITY TYPE	**CHARACTERISTICS**		**MAPPING CRITERIA**		
	TYPICAL VEGETATION	**DESCRIPTION**	**FLOOD ZONE**	**GEOMORPHIC SETTING**	**SOILS**
D1 **Stream-connected depressions in abandoned channels**	Dominants: Baldcypress Water tupelo Overcup Oak Bitter pecan Understory and associated species: Water elm Waterlocust Swamp privet Buttonbush Styrax	Topographic depressions with very poorly drained soils in former stream channels and large swales across most geomorphic surfaces other than valley train deposits. Connected to downstream systems by a perennial stream channel. Species composition is restricted to the most water-tolerant plants, which distinguishes true depressions from vernal pools. Vines and ground cover species are uncommon. In general, abandoned channels on the Deweyville terraces are occupied by cypress and tupelo, while the smaller-scale channels on other surfaces usually support overcup oak and bitter pecan.	Any flood zone; intersects a perennial stream	All Holocene, Deweyville, Lake Monroe, and Prairie Terrace settings with the listed soils; All Deweyville channels (Pdch) regardless of soils	Richland Parish- Yorktown Series Maurepas Series Ouachita Parish – Ac (Alligator clay), Af (Alligator clay, freq. flooded). Caldwell Parish–YO (Yorktown clay, freq. flooded) Catahoula Parish-Dowling clay (previously mapped as Fausse) Morehouse parish – Ad(Allamands muck, drained); Yo (Yorktown clay, freq. flooded)

HGM SUBCLASSES: CONNECTED AND UNCONNECTED DEPRESSION					
COMMUNITY TYPE	**CHARACTERISTICS**		**MAPPING CRITERIA**		
	TYPICAL VEGETATION	**DESCRIPTION**	**FLOOD ZONE**	**GEOMORPHIC SETTING**	**SOILS**
D2 **Stream-connected depressions on Pleistocene outwash terraces**	Dominants: Baldcypress Water tupelo Water elm Associates: Overcup oak Bitter pecan Drummond's red maple Green ash Persimmon Included Interfluves: Nuttall oak Willow oak Delta post oak Water oak Cherrybark oak Sweetgum Sugarberry	Depressions (valley train ponds) that occur in the remnants of glacial outwash channels on Pleistocene valley train terraces. The original coarse channel materials have mostly been veneered with fine-grained sediments and support swamp and floodplain species. Localized areas where the veneer is thin may be sandy and support individual trees or small groups of riverfront species such as river birch and sycamore. Small areas of higher ground (interfluves) not identified on soils maps are included in these units.	intersects a perennial stream	All Pleistocene Valley Train settings except Pve 5	Gilbert Calhoun

HGM SUBCLASSES: CONNECTED AND UNCONNECTED DEPRESSION					
COMMUNITY TYPE	**CHARACTERISTICS**		**MAPPING CRITERIA**		
	TYPICAL VEGETATION	**DESCRIPTION**	**FLOOD ZONE**	**GEOMORPHIC SETTING**	**SOILS**
D3 **Unconnected depressions in abandoned channels**	Dominants: Baldcypress Water tupelo Overcup oak Bitter pecan Understory and associated species: Water elm Water locust Swamp privet Buttonbush	Topographic depressions with very poorly drained soils in former stream channels and large swales across most geomorphic surfaces other than valley train deposits. No connection to downstream systems through a perennial stream channel. Species composition is restricted to the most water-tolerant plants, which distinguishes true depressions from vernal pools. Vines and ground cover species are uncommon. These depressions do not differ from connected depressions in the same settings except functionally, in that they have no significant interaction with downstream systems. In general, abandoned channels on the Deweyville terraces are occupied by cypress and tupelo, while the smaller-scale channels on other surfaces usually support overcup oak and bitter pecan.	no perennial stream present	All Holocene, Deweyville, Lake Monroe and Prairie Terrace settings with the listed soils; All Deweyville channels (Pdch) regardless of soils	Richland Parish-Yorktown Series Maurepas Series Ouachita Parish – Ac (Alligator clay), Af (Alligator clay, freq. flooded). Caldwell Parish–YO (Yorktown clay, freq. flooded) Catahoula Parish-Dowling clay (previously mapped as Fausse) Morehouse parish – Ad(Allamands muck, drained); Yo (Yorktown clay, freq. flooded)

HGM SUBCLASSES: CONNECTED AND UNCONNECTED DEPRESSION					
COMMUNITY TYPE	CHARACTERISTICS		MAPPING CRITERIA		
	TYPICAL VEGETATION	DESCRIPTION	FLOOD ZONE	GEOMORPHIC SETTING	SOILS
D4 **Unconnected depressions on Pleistocene outwash terraces**	Dominants: Baldcypress Water tupelo Water elm Associates: Overcup oak Bitter pecan Drummond's red maple Green ash Persimmon Included Interfluves: Nuttall oak Willow oak Delta post oak Water oak Cherrybark oak Sweetgum Sugarberry	Depressions (valley train ponds) that occur in the remnants of glacial outwash channels on Pleistocene valley train terraces. The original coarse channel materials have mostly been veneered with fine-grained sediments and support swamp and floodplain species. Localized areas where the veneer is thin may be sandy and support individual trees or small groups of riverfront species such as river birch and sycamore. Small areas of higher ground (interfluves) not identified on soils maps are included in these units. These depressions do not differ from connected depressions in the same settings except functionally, in that they have no significant interaction with downstream systems.	no perennial stream present	All Pleistocene Valley Train terraces except Pve 5	Gilbert Calhoun

HGM SUBCLASSES: CONNECTED AND UNCONNECTED FRINGE					
COMMUNITY TYPE	**CHARACTERISTICS**		**MAPPING CRITERIA**		
	TYPICAL VEGETATION	**DESCRIPTION**	**FLOOD ZONE**	**GEOMORPHIC SETTING**	**SOILS**
FR1 **Stream-connected lake and pond fringe wetlands**	Common dominants in systems with natural fluctuation patterns: Baldcypress Water tupelo Buttonbush Numerous herbaceous species Common dominants in systems with highly modified fluctuation patterns: Black willow Buttonbush American lotus	Wetlands within stream-connected permanent lakes and ponds, including borrow pits, but not aquaculture ponds. Natural systems typically support baldcypress and tupelo forests within the fluctuation zone and in the immediate lakefront zone where water tables remain near the surface. Buttonbush thickets may dominate in shallow, near-permanent water, and zones of emergent species are usually present, with erect rooted species in shallow water, floating-leaved species in deeper water, and submerged aquatics present throughout the open water area. Where water levels are manipulated, these patterns are usually altered in various ways. Because water depths and fluctuation patterns are unknown, the entire water body is mapped as fringe wetland.	Water body connected to a perennial stream	Permanent water bodies (not streams)	Mapped as water bodies on soils maps

HGM SUBCLASSES: CONNECTED AND UNCONNECTED FRINGE					
COMMUNITY TYPE	CHARACTERISTICS		MAPPING CRITERIA		
	TYPICAL VEGETATION	DESCRIPTION	FLOOD ZONE	GEOMORPHIC SETTING	SOILS
FR2 **Unconnected lake and pond fringe wetlands**	Common dominants in systems with natural fluctuation patterns: Baldcypress Water tupelo Buttonbush Numerous herbaceous species Common dominants in systems with highly modified fluctuation patterns: Black willow Buttonbush American lotus	Wetlands within permanent lakes and ponds that are not connected to perennial streams, including borrow pits, but not aquaculture ponds. Natural systems typically support baldcypress and tupelo forests within the fluctuation zone and in the immediate lakefront zone where water tables remain near the surface. Buttonbush thickets may dominate in shallow, near-permanent water, and zones of emergent species are usually present, with erect rooted species in shallow water, floating-leaved species in deeper water, and submerged aquatics present throughout the open water area. Where water levels are manipulated, these patterns are usually altered in various ways. Because water depths and fluctuation patterns are unknown, the entire water body is mapped as fringe wetland. Unconnected fringe wetlands do not differ from connected lake-fringe wetlands in the same settings except functionally, in that they have no significant interaction with downstream systems.	Water body not connected to a perennial stream	Permanent water bodies (not streams)	Mapped as water bodies on soils maps

HGM SUBCLASS: PRECIPITATION-MAINTAINED FLAT					
COMMUNITY TYPE	**CHARACTERISTICS**		**MAPPING CRITERIA**		
	TYPICAL VEGETATION	**DESCRIPTION**	**FLOOD ZONE**	**GEOMORPHIC SETTING**	**SOILS**
F1 **High natural levees**	Dominants: Cottonwood Water oak Sugarberry Pecan Associates: Cow oak Blackgum Cherrybark oak Sycamore Sweetgum Box elder Characteristic understory: Numerous vines Cane Paw-paw	High, well drained linear features that were formed along the banks of the Mississippi River. Near the modern river course they may have a strong riverfront character, being dominated by cottonwood and sugarberry, and with abundant vines usually including poison ivy, trumpet creeper, and river grape. On older deposits dominance shifts to water oak and pecan. Cow oak, blackgum, and cherrybark oak increase in abundance with increasing site age, but rarely dominate. Cane and paw-paw are characteristic understory plants.	Outside 5 year floodplain	High natural levee crests on holocene point bar and some backswamp deposits	Ouachita Parish: SrB **(**Sterlington silt loam, 1 to 3 percent slopes), RlB (Rilla silt loam, 1 to 3 percent slopes), Ga (Gallion silt loam) Caldwell Parish: Ga (Gallion silt loam), St (Sterlington silt loam Catahoula Parish: Ra (Rilla silt loam), St (Sterlington Silt loam).

HGM SUBCLASS: PRECIPITATION-MAINTAINED FLAT					
COMMUNITY TYPE	CHARACTERISTICS		MAPPING CRITERIA		
	TYPICAL VEGETATION	DESCRIPTION	FLOOD ZONE	GEOMORPHIC SETTING	SOILS
F3 **Ridge and swale topography in older alluvium in lowlands**	Dominants on ridges and flats: Cow oak Cherrybark oak Water oak Associated species: American elm Box elder Dominants in swales: Overcup oak Nuttall oak Characteristic understory species: Rough-leaf dogwood Deciduous holly Paw-paw Cane	Well-drained ridge and swale point bar deposits and natural levee deposits over backswamps. Typical natural levee species such as cow oak occupy the higher sites while most of the undulating terrain is dominated by cherrybark and water oaks. Nuttall oak and overcup oak usually dominate in ponded sites, which are most commonly point bar swales.	Outside 5 year floodplain	Veneered point bar	Any except high natural levee and depression soils

HGM SUBCLASS: PRECIPITATION-MAINTAINED FLAT					
COMMUNITY TYPE	CHARACTERISTICS		MAPPING CRITERIA		
	TYPICAL VEGETATION	DESCRIPTION	FLOOD ZONE	GEOMORPHIC SETTING	SOILS
F4 **Moderately drained lowlands**	Dominants: Sugarberry Green ash American elm Sweetgum Associates: Water oak Willow oak Persimmon Cherrybark oak Vernal Pools: Overcup oak Bitter pecan	Gently undulating, moderately drained point bars and veneered backswamps of various ages and origins. The characteristic community is sugarberry-elm-ash, but subtle site variations favor water oak on better drained ridges and Nuttall oak or willow oak on true topographic flats. Overcup oak usually dominates in swales.	Outside 5 year floodplain	Unveneered point bars Veneered backswamps	Any except high natural levee and depression soils
F6 **Poorly drained lowlands**	Dominants: Willow oak Nuttall oak Sweetgum Associates: Cherrybark oak American elm Vernal pools: Overcup oak Green ash	Poorly drained flats dominated by Nuttall and Willow oaks with large shallow vernal pools. Better-drained sites within this type often include cherrybark oak.	Outside 5 year floodplain	Unveneered backswamps and abandoned channels not otherwise classified	Any except high natural levee and depression soils

HGM SUBCLASS: PRECIPITATION-MAINTAINED FLAT					
COMMUNITY TYPE	**CHARACTERISTICS**		**MAPPING CRITERIA**		
	TYPICAL VEGETATION	**DESCRIPTION**	**FLOOD ZONE**	**GEOMORPHIC SETTING**	**SOILS**
F7 **Poorly drained undulating topography on Pleistocene terraces**	Dominants: Cherrybark Oak Delta Post oak Blackgum Associates: Willow oak Water oak Sweetgum Loblolly pine Winged elm American Elm Cow oak Sugarberry Vernal Pools in relict channels: Overcup oak Green ash Swamp cottonwood Characteristic understory: Palmetto	Typically found on the complex topography of valley train deposits. Plant communities are diverse and variable, with dominance shifting among a suite of common species depending on subtle variations in soils and ponding. The younger, lower terraces (Pve1 and Pve2) have a larger percentage of area with relict channels that act as vernal pools. Some channels with Gilbert soils are true depressions (valley train ponds) that are too small to map separately. Some sites on the Deweyville and Prairie Terraces are dominated by the "dry-end" components of this type.	Outside 5 year floodplain	Ppu, Pdp, Pve 1-4 (not 5) Primarily on outwash terrace interfluves and on some Prairie and Deweyville Terrace sites.	All soils not used elsewhere

HGM SUBCLASS: PRECIPITATION-MAINTAINED FLAT					
COMMUNITY TYPE	CHARACTERISTICS		MAPPING CRITERIA		
	TYPICAL VEGETATION	DESCRIPTION	FLOOD ZONE	GEOMORPHIC SETTING	SOILS
F9 **Flatwoods on poorly drained Pleistocene Terraces**	Dominants: Cherrybark oak Water oak Associates: Delta Post oak Loblolly pine blackgum Vernal pools: Willow oak Laurel oak Green ash Understory: Palmetto	Very flat terrain on the Prairie Terrace and the Lake Monroe Terraces where precipitation ponds shallowly but soils are not appropriate to sustain prairie. The terrain is primarily flat but includes numerous hummocks and extensive vernal pools which considerably increase the diversity of the forest. Very little pine is found in this type, mostly restricted to hummocks.	Any	Specific soils on the Prairie, Deweyville, and Lake Monroe Terraces regardless of flooding regime.	Morehouse Parish: Gu (Guyton silt loam), He (Haggerty silty clay) Union Parish: GO (Groom silty clay loam, frequently flooded), HA (Haggerty fine sandy loam freq. flooded), HB (Haggerty silty clay) Ouachita Parish: GU (Guyton Association), Wa (Waller loam), Wr (Wrightsville silo) West Carroll Parish: (Foley silt loam), (Memphis silt loam 0-2%slopes) Richland Parish: (Necessity) Catahoula Parish: Cw (Callaway silt loam), (Loring silt loam) (Memphis silt loam 0-2% slopes)

HGM SUBCLASS: PRECIPITATION-MAINTAINED FLAT					
COMMUNITY TYPE	**CHARACTERISTICS**		**MAPPING CRITERIA**		
	TYPICAL VEGETATION	**DESCRIPTION**	**FLOOD ZONE**	**GEOMORPHIC SETTING**	**SOILS**
F10 **Pine Flatwoods of the Pleistocene terraces**	Dominants: Loblolly pine Shortleaf pine Southern red oak Associates: Water oak Delta post oak White oak Post oak Blackgum Vernal pools Willow oak Nuttall oak	Pine flatwoods. Poorly drained flats with mixed pine-hardwoods and a wet or dry prairie groundcover. Most sites are currently pushed to greater pine dominance but would naturally be dominated by pine with regular burning, while fire suppression favors hardwoods. Nebkhas (prairie mounds) and vernal pools are often present, and local variation in drainage can result in distinctly upland or wetland plant communities. Near the dissected margins of the Plm terraces upland communities prevail, usually characterized by shortleaf pine.	>5	Plm1 and Plm 2 Ppu, Pdp	On the Plm1 and Plm 2: All soils not used to define other communities On the Ppu and Pdp: Morehouse Parish: Fr (Frizzell Silo) To (Tillou Silt Loam) Wr (Wrightsville Silt Loam) Gm (Groom very fine sandy loam) GO (Groom fine sandy loam occasionally flooded) Gp (Groom-Mollicy complex) Gs(Groom-Mollicy complex occasionally flooded) Hh (Haggerty silty clay, frequently flooded) Union Parish: Fr (Frizzell silo) Gm (Groom silo, occas flooded) Le (Libuse silo, 1-5% slopes) Sg (Savannah fine sandy loam 1-5% slopes) Sk (Sawyer silo, 1-5% slopes) Wr (Wrightsville silo, occfl) SaC (Savannah fsl, 1-5% slopes) Ouachita Parish: FrA (Frizzell silo 0-1% slopes) PvB (Providence silo, 1-3% slopes) (Savannah fsl, 1-5% slopes)

HGM SUBCLASS: PRECIPITATION-MAINTAINED FLAT					
COMMUNITY TYPE	**CHARACTERISTICS**		**MAPPING CRITERIA**		
	TYPICAL VEGETATION	**DESCRIPTION**	**FLOOD ZONE**	**GEOMORPHIC SETTING**	**SOILS**
F-11 Alkali Prairie/Savanna	Herbaceous dominants: three-awn grass poorjo little bluestem Shrubs: dwarf palmetto saltbush Marginal woodland dominants: delta post oak post oak, blackjack oak shortleaf pine loblolly pine	Expansive flats with saline soils that support Delta Post oak/three-awn savanna under natural conditions with fire present. The characteristic herbaceous and shrub species are present under the canopy of the woodland that forms a transition zone to the flatwoods that typically surround the saline flats. Where terrain is somewhat dissected or in the long-term absence of fire, the hardwood forest that replaces the savanna also includes willow oak, cherrybark oak, and winged elm. This community characteristically includes unique salt slicks with bare soil fringed with a cryptogamic lip of algae and lichens. This narrow cryptopgamic zone supports the federally endangered plant, Geocarpon minimum.	Any	Any surface	Lafe silo

HGM SUBCLASS: RIVERINE BACKWATER					
COMMUNITY TYPE	**CHARACTERISTICS**		**MAPPING CRITERIA**		
	TYPICAL VEGETATION	**DESCRIPTION**	**FLOOD ZONE**	**GEOMORPHIC SETTING**	**SOILS**
RB2 **Occasionally flooded, moderately drained lowlands**	Dominants: Willow oak Water oak Sweetgum Vernal pools: Nuttall oak Green ash	Relatively subdued ridge-and-swale landscapes predominantly occupied by willow oak and water oak with sweetgum as the only other common co-dominant. Occasional deep swales are dominated by Nuttall oak.	2-5 year floodplain	Veneered point bars and veneered backswamps	
RB3 **Occasionally flooded flats**	Dominants: Willow oak Sweetgum Associated species: Nuttall oak Overcup oak Green ash	Flat or gently undulating unveneered point bars strongly dominated by willow oak. Vernal pools typically not present but microsite variation maintains a consistent presence of associated wet-site species.	2-5 year floodplain	Unveneered point bars and Deweyville terraces	all not used elsewhere
RB4 **Occasionally flooded, poorly drained lowlands**	Dominants: Sweetgum Willow oak Green ash Overcup oak (on backswamp) Nuttall oak Associated species: Persimmon American elm Overcup oak Characteristic understory species: Styrax Deciduous holly	Wetter sites of the 2-5 year flood zone with poorly-drained soils and extensive ponding of precipitation. Typically a relatively diverse mix of species except where surface drainage is impeded sufficiently to favor strong dominance by overcup oak.	2-5 year floodplain	Unveneered backswamps, abandoned channels and abandoned courses without blue lines	all not used elsewhere

HGM SUBCLASS: RIVERINE BACKWATER					
COMMUNITY TYPE	CHARACTERISTICS		MAPPING CRITERIA		
	TYPICAL VEGETATION	DESCRIPTION	FLOOD ZONE	GEOMORPHIC SETTING	SOILS
RB5 **Occasionally flooded Pleistocene deposits**	Dominants: Willow oak (principal) Nuttall Oak (secondary) Associated species: Cherrybark oak Characteristic understory species: Hawthorn Palmetto	Interfluve areas of the Early Pleistocene outwash (valley train) deposits. The outwash deposits are separated into more frequently flooded braided channels and less flooded interfluves based on soils rather than flood frequency.	2-5 year floodplain	Interfluve areas of the Early Pleistocene outwash deposits Pve 1-4 (not 5)	All other soils

HGM SUBCLASS: RIVERINE BACKWATER					
COMMUNITY TYPE	**CHARACTERISTICS**		**MAPPING CRITERIA**		
	TYPICAL VEGETATION	**DESCRIPTION**	**FLOOD ZONE**	**GEOMORPHIC SETTING**	**SOILS**
RB7 **Frequently flooded lowlands**	Dominants: Overcup Oak Bitter pecan Understory: Swamp privet mayhaw Associates on wetter sites: Baldcypress Water tupelo Associates on drier sites: Nuttall oak Green ash Drummond red maple American elm Persimmon	This community type occurs on a wide variety of geomorphic settings and soil types where forest composition is strongly controlled by extended periods of backwater flooding in most years. The characteristic community is dominated by overcup oak, bitter pecan, and a limited group of associated canopy and understory species. Vines and ground cover species also are less abundant and diverse than on less flooded sites. Additional species occur in all strata on the less-flooded sites and upslope margins of the overcup oak zone. Dominance may shift to baldcypress and water tupelo in the deepest parts of abandoned channels and stream courses, and in localized sumps and along minor interior drainageways in backswamps, point bars, and Pleistocene outwash channels.	1-2 year floodplain	Abandoned channels and abandoned courses without a stream connection Backswamps Point bars Pleistocene outwash channels	All other soils

HGM SUBCLASS: RIVERINE BACKWATER					
COMMUNITY TYPE	CHARACTERISTICS		MAPPING CRITERIA		
	TYPICAL VEGETATION	DESCRIPTION	FLOOD ZONE	GEOMORPHIC SETTING	SOILS
RB8 Sand Prairie	Dominant herbaceous species: Little bluestem Switchgrass Poorjo wooly croton Woody dominants on margins: Buttonbush stiff dogwood mayhaw green haw honeylocust persimmon Stylisma aquatica is limited to and characteristic of this habitat.	Sand prairie wetlands are a unique wetland type that is associated with sandy deposits that accumulated along the shoreline of the Pleistocene Lake Monroe. The remnants of the former beach are now herbaceous-dominated gaps in the lowland forest system. The reason for herbaceous dominance on these sites is unclear, but may be related to droughtiness, salt and metal accumulations, fire, or all of these factors. Sand prairie wetlands often include uncommon species. They are regularly and deeply flooded by the nearby river.	Any	any	Haggerty loamy fine sand; Haggerty loamy fine sand frequently flooded

HGM SUBCLASS: RIVERINE OVERBANK					
COMMUNITY TYPE	**CHARACTERISTICS**		**MAPPING CRITERIA**		
	TYPICAL VEGETATION	**DESCRIPTION**	**FLOOD ZONE**	**GEOMORPHIC SETTING**	**SOILS**
RO-1 **Floodplains and terraces of small stream valleys**	Floodplains of small stream valleys: Dominants: Water oak Willow oak Sweetgum Cow oak Associates: Bitternut hickory Red maple Overcup oak Terraces within stream valleys: Dominants: Cherrybark oak Water oak Cow oak Laurel oak Blackgum Loblolly pine Delta Post oak Seeps on Terrace/Upland margins: Sweetbay magnolia Possumhaw viburnum Net-vein chain fern Royal Fern	Overbank zones of small stream valleys. Broader, well-defined valleys (mapped as Holocene Alluvium) typically include one or more terraces and support mesic communities similar to those in stream valleys of the nearby Tertiary uplands. Seeps often occur on the upland margins of terraces, particularly where stream valleys transit the Prairie Terrace. Less defined drainageways in Pleistocene terraces generally are swale-like, without distinct terraces parallel to the stream channel but with irregular terrain, and support plant communities similar to those in the Holocene Mississippi Alluvial Valley lowlands. Where smaller stream valleys broaden and flatten near their confluence with the floodplain of a large river, they often support stands of pure baldcypress."	Any	Hal Pleistocene terraces	On Hal: all soils On Pleistocene terraces: Any Guyton other than Guyton Association or Guyton silt loam in Morehouse Parish Any Guyton other than Guyton Association in all other Parishes

HGM SUBCLASS: RIVERINE OVERBANK					
COMMUNITY TYPE	**CHARACTERISTICS**		**MAPPING CRITERIA**		
	TYPICAL VEGETATION	**DESCRIPTION**	**FLOOD ZONE**	**GEOMORPHIC SETTING**	**SOILS**
RO-2 **River swamps in underfit channels**	Channel bottom zone: Dominants: Baldcypress Water tupelo Buttonbush Lower bank or narrow terrace adjacent to stream: Dominants: Overcup oak Water locust Bitter pecan Associated species: Nuttall oak Water elm Swamp privet Sideslopes of abandoned channel: Mixed hardwoods and riverfront species	"River swamps" of slow-moving streams that have occupied large abandoned courses of the Arkansas River. Typically a swamp forest of baldcypress dominates the zone occupied by the modern stream at normal flows. The rest of the former channel sideslope supports a series of forest species reflecting flood frequency, from overcup oak adjacent to the cypress community through natural levee species such as cow oak along the channel rim. A wide variety of other species may occupy the intervening zones. A standard buffer along the center lines of the abandoned courses as mapped on 1:62.5K quad sheets was used to delimit this type, and therefore the boundaries are less precise than other mapped features.	Usually near-permanent inundation in the active stream channel, grading to annual flooding in the adjacent zone through rarely flooded sites along the channel rim.	Abandoned courses of the Arkansas River and small streams (defined as 400m zone along mapped abandoned course line and indeterminate abandoned courses) with blue-line present	Not diagnostic,

HGM SUBCLASS: UPLAND					
COMMUNITY TYPE	**CHARACTERISTICS**		**MAPPING CRITERIA**		
	TYPICAL VEGETATION	**DESCRIPTION**	**FLOOD ZONE**	**GEOMORPHIC SETTING**	**SOILS**
U2 **Well-drained soils of the Pleistocene terraces**	Dominant species: Xeric sites: Post oak Blackjack oak Shortleaf pine Black hickory Red cedar Dry sites: Southern red oak Loblolly pine White oak Dogwood Shagbark hickory Mesic sites: Sweetgum Water oak Blackgum Willow oak White oak	Upland forests of the Pleistocene terraces and alluvial fans. Species composition can vary widely depending on local soils and drainage conditions, but generally is similar to other upland forests of the West Gulf Coastal Plain region. Species tolerant of highly xeric conditions are found on the oldest, highly dissected outwash surfaces (Pve5) and on remnant sand dunes mapped as Liddyville soils.	No flooding	All Pleistocene Valley Train Terraces and alluvial fans.	All soils not used to define other sites in Pve5 and on alluvial fans On Pve1-4: West Carroll Parish: Grenada silo, 3-5% slopes; Richland Par. - Grenada Series; Liddieville silo Catahoula Par – (Mh) Memphis silo, 2-5 % slopes; (Mm) Memphis silo 5-12 % slopes;(MP) Memphis-kisatchee-Oula assn 4-40% slopes; (MS) Memphis-Smithdale Assoc

Notes:

1. This Appendix describes the community types represented on the Potential Natural Vegetation map. It identifies groups of species–principally trees– adapted to specific combinations of soils and geomorphic settings within the hydrologic regimes that currently exist on the landscape. Species lists reflect principal dominants and associated species in mature, compositionally stable communities. The listed species do not necessarily occur together in a particular stand, but may be found on similar sites. In some instances, understory species or other characteristics strongly associated with the

particular community type are noted. No early successional communities are described, although seral patches exist in all of the community types, and in some settings, such as point bars within and along active channels, they may be extensive. Similarly, the community descriptions do not necessarily reflect the current vegetation found on many sites, which may have established under a previous hydrologic regime or been extensively manipulated. Because the purpose of the classification is to support restoration design and planning, the focus of this map is on the predominant long-term equilibrium condition best adapted to persist on each site under the current hydrologic and climatic regime.

2. Site characterizations in this table list the primary conditions associated with the community type. Minor inclusions of other geomorphic settings may occur, and the order in which the mapping rules were applied affected the final distribution of community types represented on the map. Consult the mapping metadata and assembly rules for a full presentation of the mapping criteria.
3. Flood frequency refers to the return interval of inundation originating within the stream channel (either overbank or backwater) but not inundation that occurs entirely as the result of ponding of precipitation. Flood zones are designated as 1-2, 2-5, 1-5, or >5 years. The sources for these categories vary by sub-basin and in some cases are not tied to gage data but are derived from images estimated to approximate the assigned frequency. Ponded sites are recognized by soils, geomorphology, and in some instances, the presence of standing water in particular satellite images. See report for further discussion of flood data sources and interpretation.
4. Geomorphic terminology reflects Saucier (1994), but has been modified for this application as follows:
    - Abandoned channels and courses of the Arkansas River are those labeled “A” on the Saucier basemaps and the associated point bar deposits are labeled Hpa 1-5. Abandoned channels and courses of “minor streams” and the northernmost reach of the Ouachita River are those labeled “S” on the Saucier basemaps and the associated point bars are labeled Hps. Backswamps (Hb) are not differentiated as to their origin.
    - Undifferentiated holocene alluvium (Hal) is mapped primarily in small tributary valleys where they are incised into Pleistocene terraces or Tertiary uplands.
    - Abandoned channels (cutoffs) on the Deweyville terraces (Pdch) are differentiated from all other abandoned channels of Arkansas River or smaller streams (Hch). Abandoned courses (Hco) are long channel sections left behind by avulsing streams rather than cutoffs, and are primarily of Arkansas River origin.
    - The original 1:62.5K geomorphic maps for the region (Saucier 1967, Fleetwood 1969) included a symbol for the presence of a natural levee veneer on top of the major geomorphic surfaces such as point bars and backswamps. The natural levee symbol was omitted when Saucier consolidated those quad sheets into a 1:250K coverage. For this study, the natural levee veneer deposits were digitized from the original source maps and are used as modifiers (“veneered”) to the geomorphic setting. Alluvial fans also were digitized and added to the geomorphic basemap.
    - Pleistocene Valley Train Terraces are glacial outwash deposits of various ages and relative elevations, mapped by Saucier (1994) as Pve1-5, where level 5 is the

oldest and highest. The Prairie Terraces (Ppu 1-2) comprise non-glacial Pleistocene alluvial deposits that are older and higher in the landscape than the outwash terraces.

   - Pleistocene lacustrine deposits – the Lake Monroe Complex – are mapped as two units. Plm 1 includes beaches and bars and Plm 2 is primarily lake plain.

5. Soils are used here as modifiers to geomorphic setting in certain wetland subclasses (e.g. depressions, sand prairies, the high crests of natural levees). Soils are represented in this table according to the standard soil series codes used in the official soil survey for each Parish.

APPENDIX B

Application of PNV to restoration – Mollicy Farm, Upper Ouachita Refuge

Mollicy Farm was acquired by the USFWS as a part of the Upper Ouachita National Wildlife Refuge. The farm was located in the floodplain of the Ouachita River and had been leveed and cleared for row-crop agriculture (Figure B-1, B-2). It is currently being restored for wildlife habitat. Restoration will include breaching the levees to allow natural flooding and planting as needed. Although this project is well along and many decisions have already been made, it may be useful to examine the potential natural vegetation as developed in the current project.

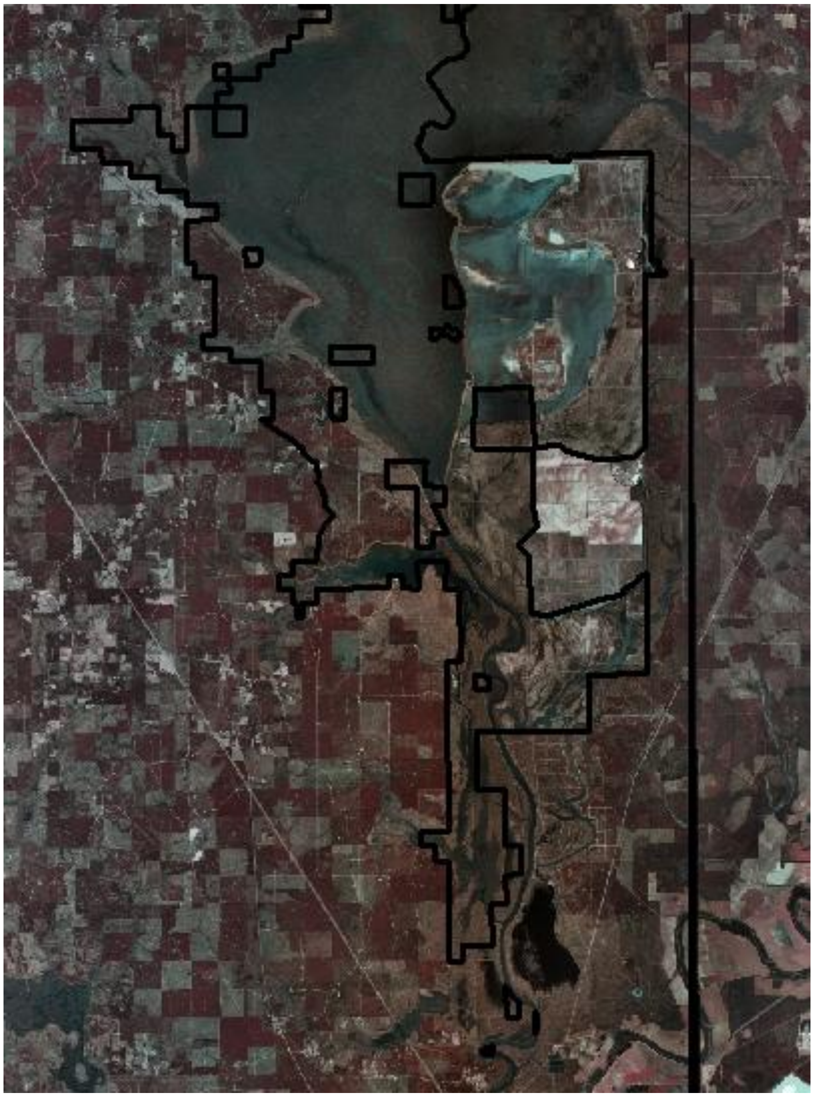

Figure B-1. Upper Ouachita National Wildlife Refuge – Mollicy Farm Unit on east side.

Figure B-2. Mollicy Farm Unit.

The aerial photo shows the portion of the unit that are subject to frequent flooding along with the microrelief remaining in this area that has otherwise been heavily modified. The Mollicy unit primarily occupies two geomorphic settings – small stream and river meander belt and Deweyville terrace (Figure B-3). However, there are abandoned channels and small areas of Lake Monroe terrace within it as well.

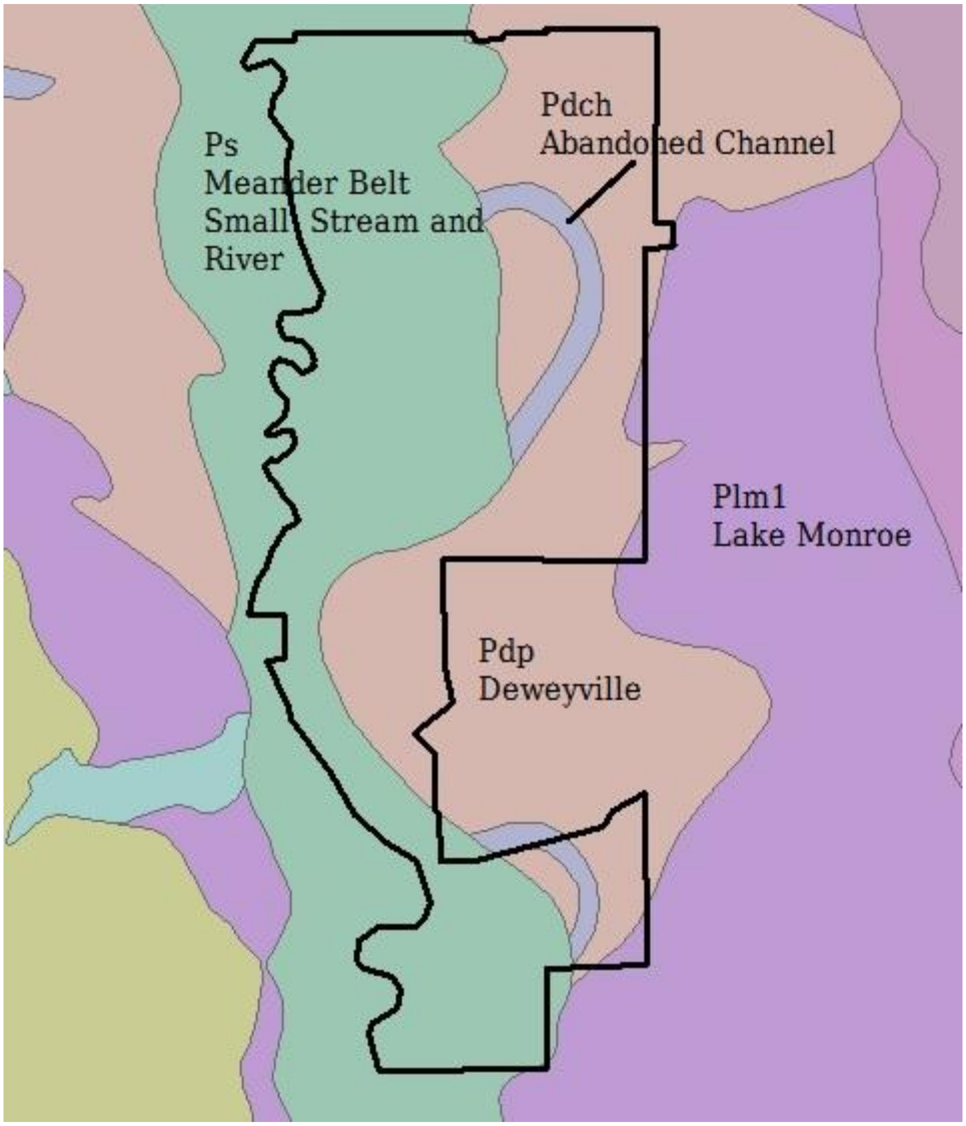

Figure B-3. Geomorphology of the Mollicy unit.

Soils of the Mollicy unit are relatively complex and provide additional basis for classifying sites for PNV (Figure B-4). In the frequently flooded bottomland (small stream and river meander belt) the most extensive soils are Litro clay, Perry clay and Portland clay. These soils indicate poorly drained, wet sites. On the Deweyville terrace the most extensive soils are Haggerty silty clay, Groom fine sandy loam, Groom-Mollicy complex and Haggerty loamy fine sand. These soils have high potential for loblolly and shortleaf pine, except that Haggerty loamy fine sand is indicative of the lowland sand prairie, typically herbaceous dominated.

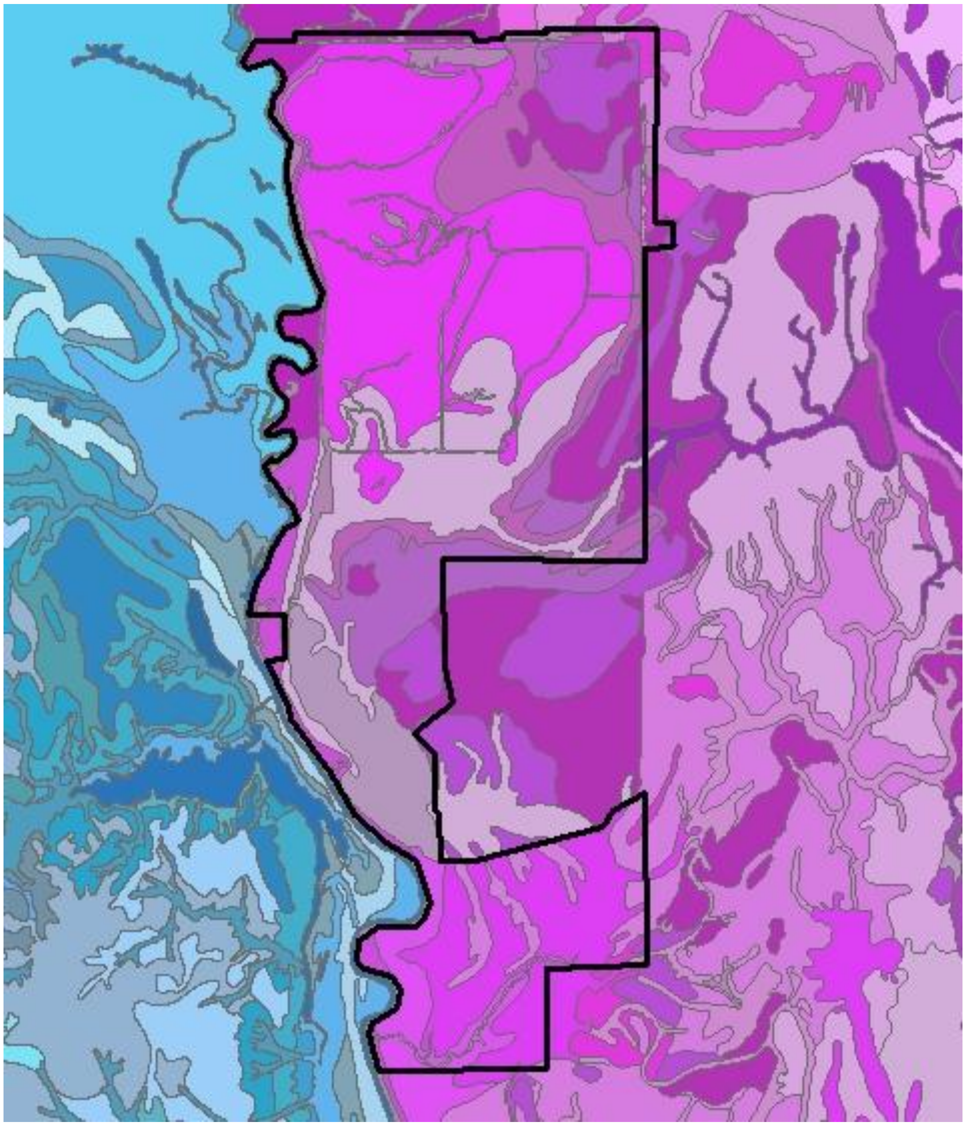

Figure B-4. Soils of the Mollicy unit.

The combination of differences in flood frequency, geomorphology and soils provide a diversity of potential natural vegetation over the Mollicy unit, ranging from wet to well-drained bottomland hardwoods, hardwood or pine-hardwood flatwoods to droughty lowland sand prairie (Figure B-5)

Figure B-5. PNV of the Mollicy unit

This exercise demonstrates that the PNV map may be used to provide diverse and appropriate restoration targets for an area the size of the Mollicy unit. Although these are by no means prescriptive, they may provide perspective on whatever restoration targets are selected.