Hydrogeomorphic Evaluation of Ecosystem Restoration Options for

Cypress Creek National Wildlife Refuge, Illinois

Prepared For:

U. S. Fish and Wildlife Service
Division of Refuges, Region 3
Minneapolis, Minnesota

Greenbrier Wetland Services
Report 12-05

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Karen E. Mangan

July 2012

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Prepared For:

U.S. Fish and Wildlife Service
National Wildlife Refuge System, Region 3
Minneapolis, MN
and
Cypress Creek National Wildlife Refuge
Ullin, IL

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FRANK BELLROSE WATERFOWL RESERVE


Jan Sundberg

Michael Jeffords

EXECUTIVE SUMMARY

This report provides a hydrogeomorphic (HGM) evaluation of ecosystem restoration options to assist future management of the Cypress Creek National Wildlife Refuge (NWR) located in the Lower Cache River Valley (CRV) of southern Illinois immediately above the confluence of the Ohio and Mississippi Rivers. The CRV contains about 474,000 acres including about 16,000 acres within Cypress Creek NWR currently owned in fee-title by the U.S. Fish and Wildlife Service, ca. 16,000 acres in the Illinois Department of Natural Resources Cache River State Natural Area, and 3,000 acres in The Nature Conservancy's Limekiln Springs Preserve. The CRV supports important ecological and economic functions, values and services that have been compromised by various alterations and degradations from human developments, contaminants, and invasive plant and animal species. In 1991, the Cache River Wetlands Joint Venture Partnership was formed to promote ecosystem restoration in the CRV. The many public and private partnership groups are interested in restoring parts of the CRV ecosystem and conservation partners share a common goal of restoring and enhancing natural resources within the region through direct management of public lands and promoting conservation efforts on private lands. This goal depends on understanding the historical and contemporary vegetation community types and distribution in the CRV and the ecological attributes that are associated with each type.

This report has three objectives:

1. Identify the Presettlement ecosystem condition and ecological processes in the Cypress Creek NWR region.
2. Evaluate differences between Presettlement and current conditions in the Cypress Creek NWR ecosystem with specific reference to alterations in hydrology, vegetation community structure and distribution, and resource availability to key fish and wildlife species.

3. Identify restoration and management approaches and ecological attributes needed to successfully restore specific habitats and conditions within the Cypress Creek NWR region.

The HGM approach used in this study obtained and evaluated historical and current information about: 1) geology and geomorphology, 2) soils, 3) topography and elevation, 4) hydrological regimes, 5) plant and animal communities, and 6) physical anthropogenic features of landscapes in the CRV. A primary part of the HGM approach was the development of a matrix of understanding, and prediction, of potential historical vegetation communities using scientific data discovery and field validation using published literature, vegetation community reference sites, and state-of-the-understanding of plant species relationships to system attributes.

Major natural communities/habitat types that historically were present in the Cypress Creek NWR region included: 1) the main channel of the Cache River and its major tributaries, 2) bottomland lakes, 3) riverfront forest, 5) baldcypress/water tupelo swamp forest, 6) floodplain bottomland hardwood forest (BLH), 7) terrace hardwood forest, 8) mixed hardwood slope forest, and 9) mesic upland forest. A description of these community types and relationships with HGM attributes and a map of potential distribution of the community types during the Presettlement period are provided in the report.

Many past studies and contemporary photographs and maps have documented the extensive changes to the CRV ecosystem. This report generally describes these alterations in land form, hydrology, and vegetation communities to understand how Presettlement community distribution and extent have changed and to identify options and opportunities for restoration. Some landscape changes have included large hydrological infrastructure projects (such as the Post Creek Cutoff) that are unlikely to be removed or significantly modified (to facilitate restoration of former hydrological conditions) at least in the foreseeable future. These hydrological infrastructure developments have caused extensive alterations to natural water flow and drainage patterns in the system. The large infrastructure projects coupled with the extensive system-wide drainage ditches, channelized and disconnected natural stream channels, and sediment and erosion issues have effectively created a new "hydrology system" in the region. Generally, seasonal floodplain hydrology is changed throughout the CRV, including lands within the Cypress Creek NWR acquisition boundary. The historic patterns of Mississippi and Ohio River overbank flooding along with altered Cache River and tributary hydrology has altered the timing, depth, and duration of river flows and flooding in the CRV depending on the location of levees and other flood-protection structures in various locations. Large areas of the CRV have been cleared and converted to agriculture. Floodplain bottomland hardwood forest, terrace hardwood forest, and slope forest have been especially destroyed. Bottomland lakes have been drained and altered in most CRV ecoregions. River channels and sloughs are greatly reduced in area and connectivity.

Restoration and sound ecological management of the CRV is important to sustain and provide critical natural resources and ecological functions and values that effect the Middle Mississippi River, Lower Ohio River, and local Cache River Basins including floodwater transport and storage, nutrient cycling, filtration and transformation of nutrients and contaminants, groundwater recharge, carbon sequestration, quantity and quality of surface waters, fish and wildlife habitat, education, and recreational opportunities. This report supports the many previous protection and restoration plans for the CRV and provides new information about the historical distribution of ecological communities and potential restoration opportunities. It also identifies, and reaffirms previously identified, management options that will be needed to restore and sustain communities and resource values.

Generally, this study evaluates restoration options, and subsequent management needs, to improve natural ecosystem processes, functions, and values rather than to manage for specific plant/animal species. This study focuses primarily on restoration of floodplain ecosystems in the Cypress Creek NWR acquisition boundary, but recognizes the hydrological and ecological connections between the Cache River floodplain and current Ohio and Mississippi River channels and identifies basic landscape and hydrological mechanisms for both the floodplain and main channel that must be considered in restoring the integrity of the entire ecosystem. The strategic conservation basis inherent in the HGM approach used in this study is scientific information on landscape and floodplain ecology that identifies how the "complex" of communities, rather than individual parcels, ultimately provides the diversity and distribution (spatial and temporal) of resources to sustain the productivity, diversity, and integrity of the entire CRV ecosystem.

The many diverse entities and groups interested in conservation of the CRV provide strength in promoting conservation actions, yet each group may have different capabilities and objectives. This study does not address where, or if, the sometimes competing objectives of the interest groups occur, but rather focuses on protection, restoration, and management within the Cypress Creek NWR. Future conservation actions throughout the CRV and specifically within the Cypress Creek NWR acquisition boundary should seek to:

1. Protect and sustain existing floodplain areas that have plant communities similar to Presettlement conditions.
2. Maintain and restore the physical and hydrological character of lands within the Cache River Basin.
3. Restore plant and animal communities in appropriate topographic and geomorphic landscape position.
4. Restore the natural topography, physical integrity of water flow patterns, and water regimes where possible.

Specific recommendations to meet these goals are provided in this report.

INTRODUCTION

Cypress Creek National Wildlife Refuge (NWR) is located in the lower portion of the Cache River Valley (CRV) in southern Illinois immediately above the confluence of the Ohio and Mississippi Rivers (Fig. 1). Established in 1990, the refuge was authorized under the Emergency Wetlands Resources Act of 1986 (16 U.S.C. 3901b, 100 Stat. 3583, PL 99-645) with primary purposes to: 1) protect, restore and manage wetlands and bottomland forest habitats in support of the North American Waterfowl Management Plan; 2) provide resting, nesting, feeding and wintering habitat for waterfowl and other migratory birds; 3) protect endangered and threatened species and their habitats; 4) provide for biodiversity; 5) protect a National Natural Landmark; and 6) increase public opportunities for compatible recreation and environmental education. The refuge acquisition boundary covers about 35,320 acres; about 16,000 acres currently are owned in fee-title by the U.S. Fish and Wildlife Service (USFWS) (Fig. 2).

The headwaters of the CRV originate in the Shawnee Hills of southern Illinois and the Cache River historically flowed south into and through an abandoned channel of the historic Ohio River course, which runs west and then south to its confluence with current Ohio River near Mounds, Illinois. The CRV region contains diverse river and associated floodplain geomorphic surfaces, landforms, and plant and animal communities (Illinois Department of Natural Resources (IDNR) 1997). The majority of the CRV and lands within the acquisition boundary of Cypress Creek NWR historically was covered with floodplain Bottomland Hardwood (BLH) forest habitats intermixed with active river and creek channels, abandoned channel oxbows and sloughs, deepwater baldcypress (*Taxodium distichum*)-water tupelo (*Nyssa aquatic*) swamps, shrub/scrub margins of bottomland lakes and deeper floodplain depres-

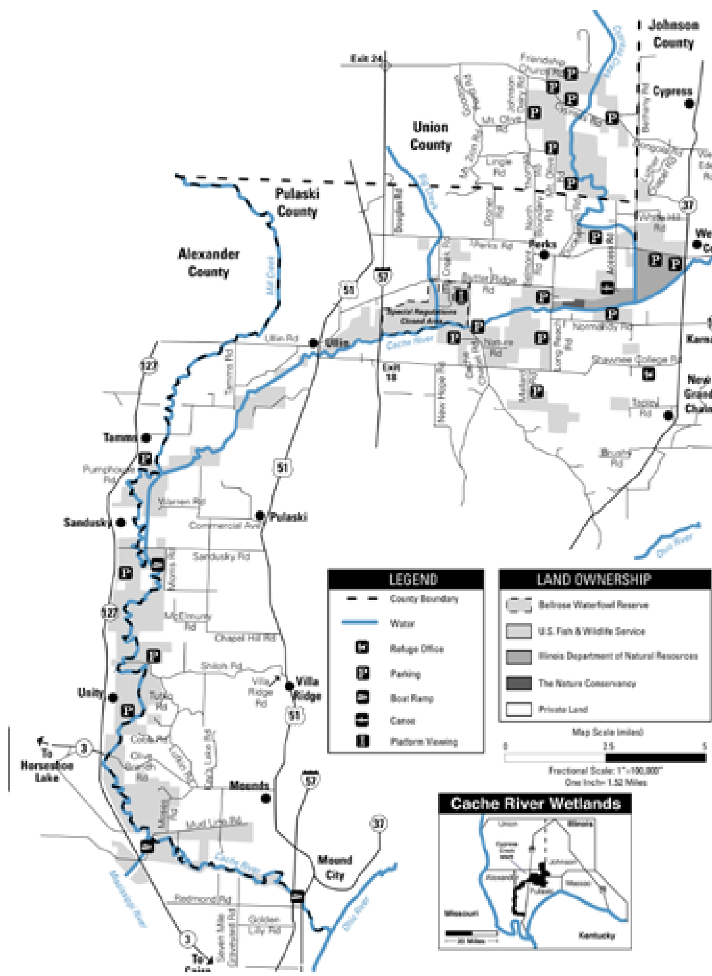

Figure 1. General location of the Cypress Creek National Wildlife Refuge Acquisition Boundary and proximity to other local conservation lands.

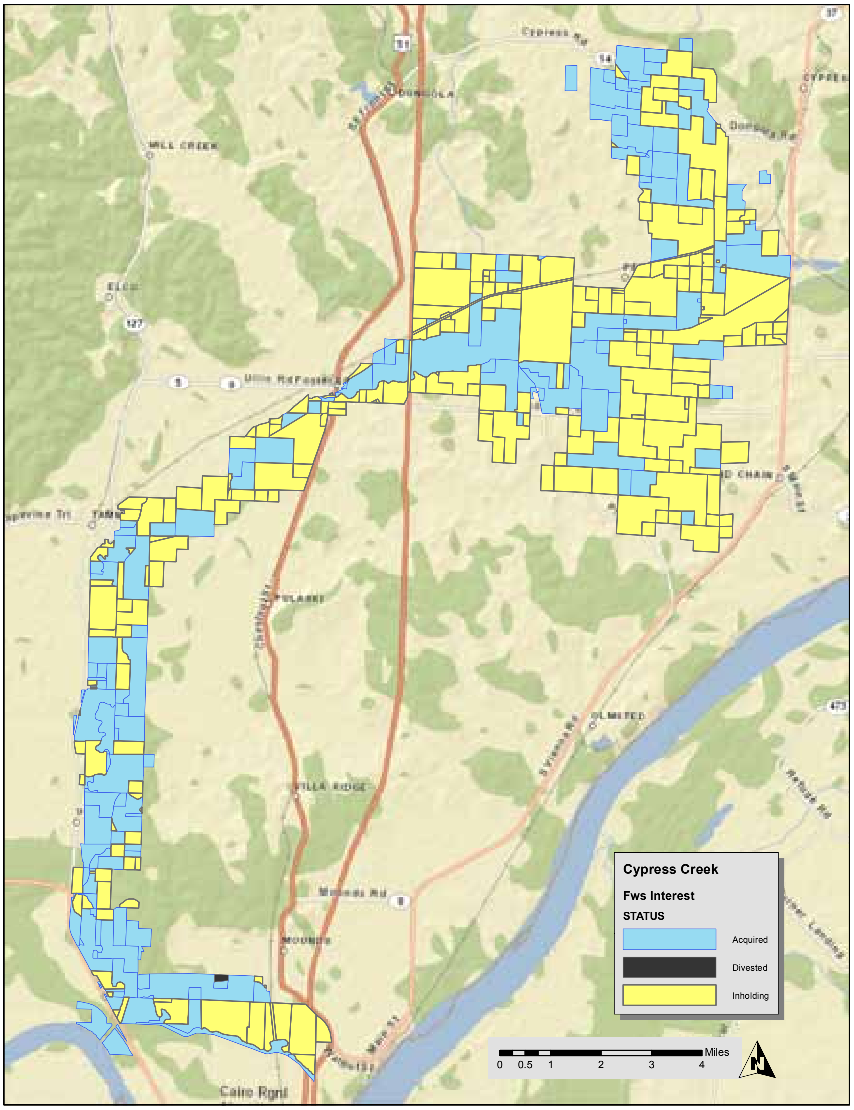

Figure 2. Lands owned in fee-title by Cypress Creek National Wildlife Refuge.

sions, and seasonal herbaceous wetlands. The Cache River watershed is located at the intersection of the Central Lowlands, Interior Low Plateaus, Ozark Plateau, and Coastal Plain physiographic provinces and contains representative plant and animal species common to each region (The Nature Conservancy (TNC) 1995). Seven federally listed and 102 state listed endangered or rare plant and animal species are found within the Cache River watershed (USFWS 1996).

Alterations to the physical and ecological integrity of the CRV began in the mid 1800s as European settlement increased in the region (Hutchinson 2000). The vast forest resources in the CRV and surrounding hills supported a large timber/lumber industry in the region, and by the early 1900s much of the old-growth forest in the area had been harvested. Following clearing the former forested lands gradually were converted to agricultural production and drainage and flood control projects were initiated. By the 1920s, the upper portion of the Cache River was diverted to the Ohio River by the Post Creek Cutoff, portions of the Cache River and tributary creeks were straightened and channelized, and levees were constructed along many rivers and creek stretches. In the early 1950s, the lower Cache River was diverted to the Mississippi River through the Mounds Diversion Ditch leaving the lower nine miles of the Cache River as a shortened channel that drains directly into the Ohio River. The large Karnak Levee in the upper portion of the CRV was constructed in 1952.

By the late 1960s, the ecological condition of the entire CRV was highly degraded and conservation interests began efforts to protect and restore the CRV ecosystem. The first lands along the Cache River were acquired in 1965 to protect natural areas. Subsequent acquisitions of small tracts and the formation of the Citizens Committee to Save the Cache River stimulated eventual, more landscape-scale, conservation actions in the region (Corzine 2007). In 1991, following authorization of Cypress Creek NWR, the Cache River Wetlands Joint Venture Partnership was formed between the USFWS, IDNR, Ducks Unlimited Inc. (DU), and TNC to promote ecosystem restoration in the 474,000-acre CRV. The Joint Venture Partnership established a goal of protecting and restoring a 60,000-acre wetland corridor along the lower 50 miles of the Cache River, about ½ of which would ultimately be in the Cypress Creek NWR. To date about 35,000 acres of land has been protected in the CRV including the current Cypress Creek NWR acquisitions (16,000 acres); lands in the IDNR Cache River State Natural Area including the Lower Cache River Swamp National Natural Landmark Area and Little Black Slough-Heron Pond Natural Areas (total of about 16,000); and the TNC Limekiln Springs Preserve (about 3,000 acres). Also, the Horseshoe Lake Conservation Area (13,638 acres) owned and managed by IDNR is near the southern part of the CRV. The Cache River-Cypress Creek region is designated as a "wetlands of international importance – especially as waterfowl habitat" under terms of the Ramsar Convention. In 1994, the USFWS, IDNR, Illinois Preserves Commission, TNC, U.S. Forest Service, DU, Natural Resources Conservation Service (NRCS), U.S. Army Corps of Engineers (USACE), and Southern Illinois University united as the Cache River Consortium through a memorandum of understanding to address natural resource management issues in the Cache River Basin. In 1996, a Comprehensive Management Plan (CMP) was developed for Cypress Creek NWR, and preparation of a step-down Habitat Management Plan (HMP) for the refuge was initiated in 2011.

The HMP for Cypress Creek NWR seeks to articulate the management direction for the refuge for the next 15 years and the HMP helps develop goals, objectives, and strategies to define the role of the refuge and its contribution to the regional Cache River watershed and the overall mission of the NWR system (http://www.fws.gov/policy620fw1.html). Future management planning for Cypress Creek NWR is being facilitated by an evaluation of ecosystem restoration and management options using Hydrogeomorphic Methodology (HGM). HGM evaluations obtain and analyze historic and current information about: 1) geology and geomorphology, 2) soils, 3) topography and elevation, 4) hydrologic condition and flood frequency, 5) aerial photographs and maps, 6) land cover and vegetation communities, 7) key plant and animal species, and 8) physical anthropogenic features of ecosystem regions. HGM has been used to evaluate ecosystems in the Middle Mississippi River region and Upper Mississippi Alluvial Valley (MAV) portions of Missouri and Illinois (e.g., Heitmeyer et al. 2006, Heitmeyer and Westphall 2007, Heitmeyer 2008, Heitmeyer and Bartletti 2012) and provides a context to understand the physical and biological formation, features, and ecological processes of lands within the NWR and surrounding region. This historical assessment provides the foundation, or baseline condition, to determine what changes have occurred in the abiotic and biotic attributes of the ecosystem and how these changes have affected ecosystem structure and function. Ultimately, HGM helps define the capability of the area to provide key ecosystem functions and values and identifies options that can help to restore and sustain fundamental ecological processes and resources.

This report provides HGM analyses for Cypress Creek NWR acquisition boundary with the following objectives:

1. Identify the pre-European settlement (hereafter Presettlement) ecosystem condition and ecological processes in the Cypress Creek NWR region.
2. Evaluate changes in the Cypress Creek NWR ecosystem from the Presettlement period with specific reference to alterations in hydrology, vegetation community structure and distribution, and resource availability to key fish and wildlife species.
3. Identify restoration and management options and ecological attributes needed to successfully restore specific habitats and conditions within the Cypress Creek NWR region.

While the focus of this report is evaluation of lands within the Cypress Creek NWR acquisition boundary, the hydrogeomorphic information obtained for this study provides ecological context for the larger CRV and its watershed. This broader geographical scale context helps identify system-wide conservation needs and actions that will be required to ultimately restore the form and function of the Cypress Creek NWR ecosystem.


Michael Jeffords

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Karen Kyle

THE HISTORICAL
CYPRESS CREEK/CACHE RIVER VALLEY ECOSYSTEM

GEOLOGY AND GEOMORPHOLOGY

Cypress Creek NWR is located within the lower 50 miles of the CRV; this river stretch is a former course of the Ohio River carved between the sharply uplifted Shawnee Hills to the north and the gently sloping hills of the Coastal Plains region to the south (Schwegman 1973). The bedrock of the region is comprised of about 330 million year old Mississippian and older age rock that includes limestone, dolomite, chert, shale, and sandstone (Fig. 3, Nelson and Williams 2004). These geologic strata were sediment deposits within or around the shallow seas that occupied much of the North American Midcontinent of the time. During Cretaceous time, the bedrock was raised and tilted toward the northeast by the uplift of the Pascola Arch and when ancient seas retreated from the area the bedrock was eroded and Devonian rocks were exposed in the southwest part of Alexander and Pulaski Counties and Mississippian rocks were exposed in northeastern areas (Nelson et al. 1999). These bedrock exposures subsequently were covered by younger sediments. During the late Cretaceous Period, about 70-80 million years before the present (BP), the Mississippi Embayment formed as a northeast arm of the Gulf of Mexico and extended into southern Illinois (Saucier 1994). About 50 million years BP, the Gulf withdrew from southern Illinois and erosion of rock strata resumed.

During the Tertiary time about 2-10 million years BP large amounts of sediment were deposited when the large rivers, related to the ancestral Mississippi and Tennessee Rivers, flowed across the lowlands of the northern Mississippi Embayment. These rivers deposited coarse texture

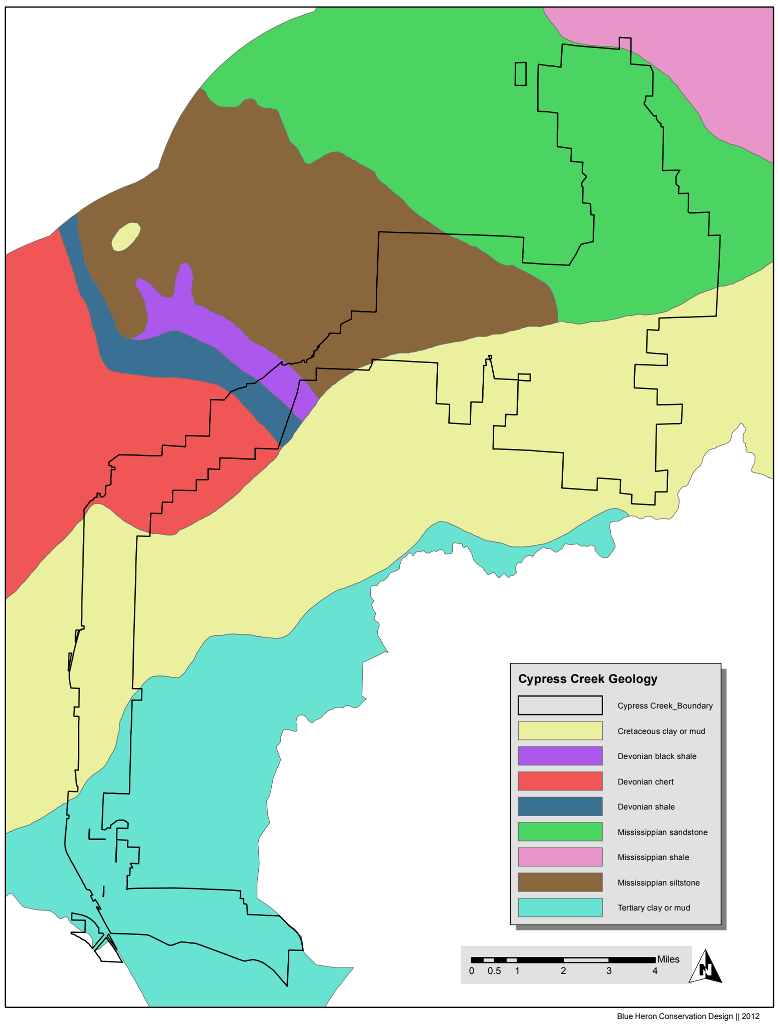

Figure 3. Bedrock geology of the Cypress Creek National Wildlife Refuge region.

red and brown sand and gravel now known as the Mounds Gravel (Nelson and Williams 2004). The floodplain then eroded to about the 400 foot elevation contour of today. Toward the end of this period, the ancestral Tennessee River eroded a broad valley near the modern Ohio River from Paducah, Kentucky to Cairo, Illinois and passed through the Cypress Creek NWR area. Mounds Gravel was deposited on this river valley floor. When the Tennessee River shifted eastward, only small meandering creeks occupied the older river valley. The mostly fine-grained deposits of these old small streams are mapped as Metropolis Formation (Nelson et al. 1999).

While these geological events were occurring, the Ohio River was flowing north of its present course through the Teays-Mehomet bedrock valley in east-central Illinois. When Pleistocene glaciers advanced across central Illinois, the Teays-Mehomet Valley was buried in glacial drift and the Ohio River shifted to the south. The new course of the Ohio River was close to its current position, but in southern Illinois the Ohio River carved a deep and wide valley now known as the CRV. Flooded periodically by glacial melt water, the Ohio River deposited thick sand and gravel (Pearl and Henry Formation) within the main river floodplain (Fig. 4; Esling et al. 1989; Devera and Nelson 1995, Nelson et al. 1999; Nelson and Williams 2004). The Henry Formation consists of up to 180 feet of sand and has lenses of gravel, silt, and clay from glacial and local sources (Fig. 5). During periods of high discharge, the CRV was overwhelmed with sediment and the tributary valleys (such as Cypress Creek) were essentially dammed to create slackwater lakes into which fine-grained silt and clay Equality Formation sediments were deposited. The Equality Formation contains up to 100 feet of stratified silt and clay and has lenses of sand and gravel derived from local valley slopes. This unit intertongues with the Henry Formation (Fig. 5). Loess deposition accompanied each glacial advance and retreat, and today this loess, greater than 30 feet thick in places, blankets the uplands (Shawnee Hills) that surround the CRV (Nelson and Williams 2004). During the Pleistocene Period, sediment carried by the glaciers aggraded the CRV, blocked tributaries to the Cache River, and formed slack water lakes. The ancestral Cache River was blocked near the present site of Forman, Illinois forming a lake upstream of this area. The Little Black Slough-Heron Pond area apparently is a remnant of this ancient glacial-derived lake.

Sometime between 8,000 and 13,000 years BP, the Ohio River abandoned the CRV and established its present course to the east (Esling et al. 1989). When this abandonment occurred, local streams and overflow from the former Ohio River floodplain

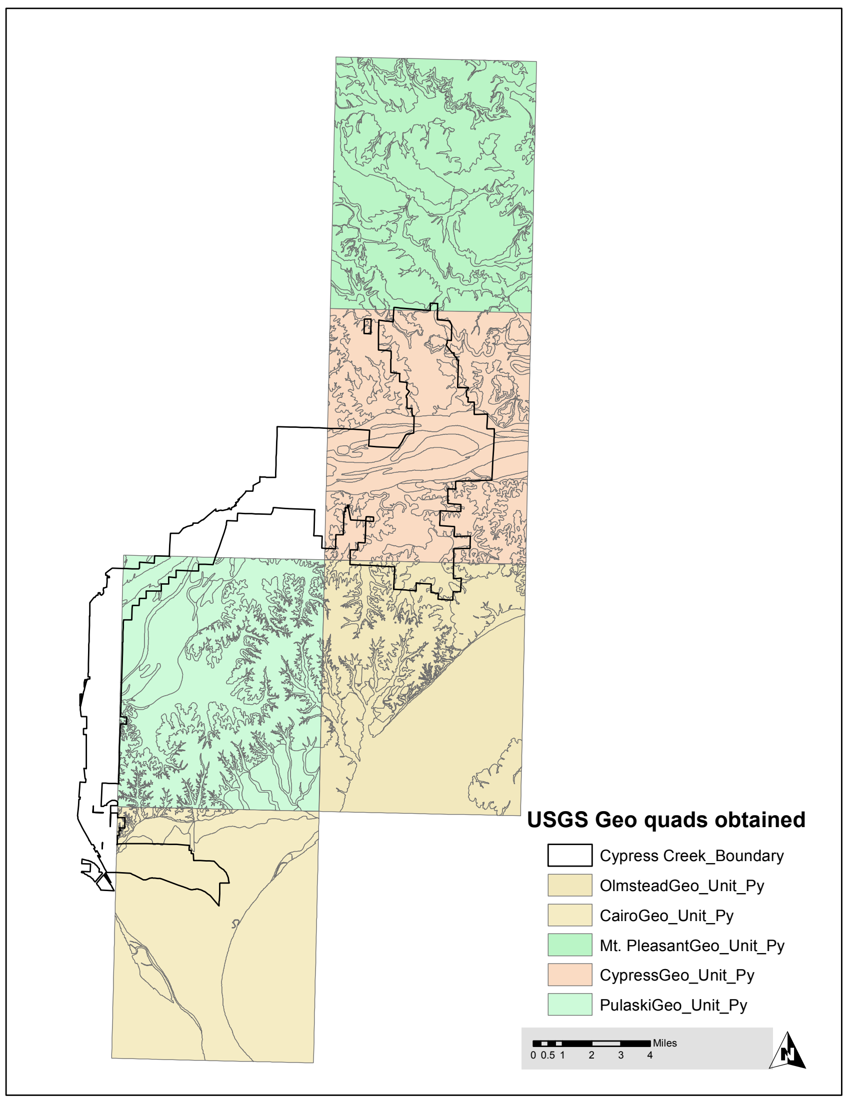

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Figure 4. Surficial geology of U.S. Geological Survey Quadrangles in the Cypress Creek National Wildlife Refuge region (from Nelson and Williams 2004, Nelson et al. 1999).

reworked the glacial outwash and loess, creating the Cahokia Formation in the CRV (Esling et al. 1989). Cahokia deposits generally are 5-20 feet thick, but in the ancestral Ohio River channel, they may be up to 60 feet thick and have lenses of gravel. Holocene-age streams were sometimes controlled by the ridge-and-swale topography of the glacial outwash and established well-developed meander belts within the larger swales. In other locations, Holocene streams cut across the trend of the ridges-and-swales and incised into the Cahokia and Henry Formations. Alluvial fans formed at the mouths of the tributary valleys that joined the Cache River.

After the lower CRV was abandoned by the Ohio River, the Cache River occupied the abandoned course and flowed west. The present day Bay Creek was once part of the headwater of the Cache River. Gradually, sediment deposited in the Cache River headwaters formed a "whaleback" depositional ridge across the valley near the present site of Reevesville, Illinois (Nelson and Williams 2004). The low ridge divided the old Cache River drainage, causing water east of the ridge to flow into the Ohio River near the present day site of Bay City, Illinois. The main stream in this eastern abandoned course is now called Bay Creek. West of Reevesville, water in the Cache River flowed west and remnant bottomland sloughs from the former occupation of the Ohio River joined the Upper Cache River and moved sluggishly through a low elevation gradient channel toward the present day site of Tamms, Illinois. At this point the Cache River turned south running close to the Mississippi River and then turned east to enter the Ohio River above Cairo, Illinois.

Few tectonic faults occur in the CRV, but the Commerce Geophysical Lineament is located immediately to the west of the valley in the Shawnee Hills (Fig. 6). This lineament is a 600 km long and 5- to 10-km wide, northeast trending magnetic and gravity anomaly that extends from northeastern Arkansas to central Indiana and is associated with Quaternary deformation northwest of the New Madrid seismic zone (Baldwin et al. 2008). In southern Illinois, Quaternary sediments became deformed across the Penitentiary Fault, which is a northeast-striking fault coincident with the Commerce

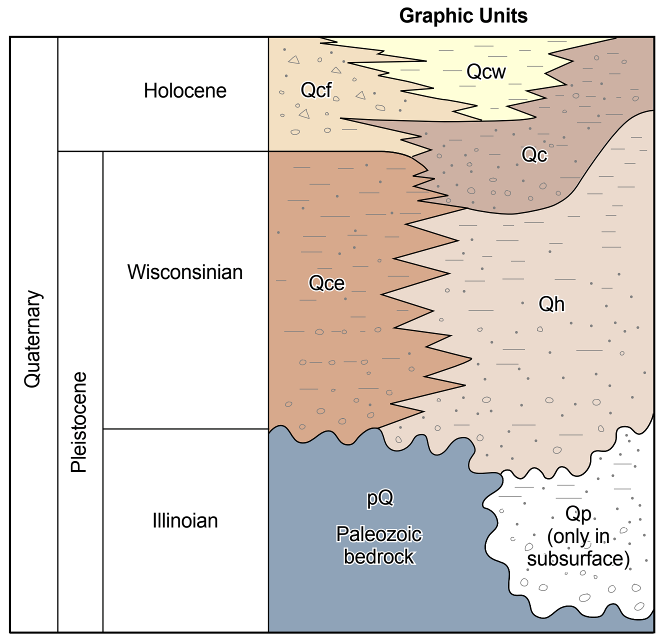


Figure 5. Geomorphic stratigraphy of Cache River Valley (from Baldwin et al. 2008).

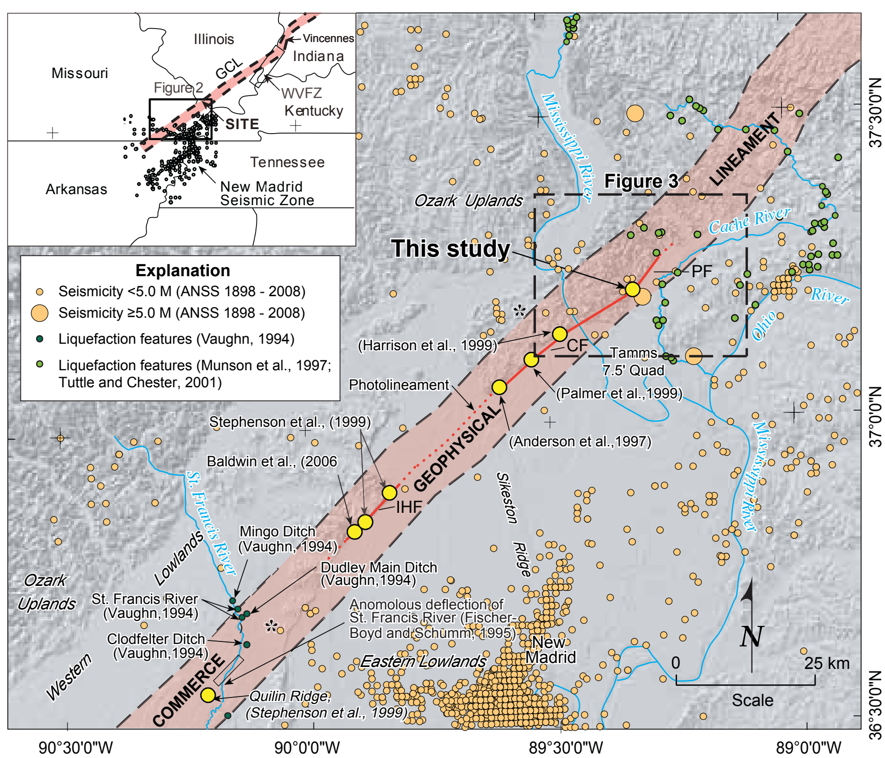


Figure 6. Location of the New Madrid seismic zone and the Commerce geophysical lineament in the Lower Cache River Valley (from Baldwin et al. 2008).

Geophysical Lineament. The 7 km long Penitentiary Fault is an east-facing bluff line that separates the late Quaternary CRV deposits on the east from Paleozoic upland rocks on the west. As recently as the early 1800s, tectonic shifting along the New Madrid Fault line caused both minor uplifting and adjacent depression of geomorphic surfaces in the CRV. Tectonic shifting, dissolution of underlying limestone, and souring by flood flows may be responsible for the formation of some floodplain depressional "lakes" and "sunken" sections of the Cache River within the CRV (Guccione et al. 2002).

SOILS

Soils in and adjacent to the CRV reflect the interesting geological and fluvial history of the region along with climate, biota, and topography in the Holocene period (e.g., Parks 1979, NRCS 1999). Parent materials of soils in the region include loess, loess over bedrock, loess over coastal plain sediments, colluvial sediments, sediments on terraces and benches, sediments and detrital matter in bottomland lakes, and alluvial deposition (Fig. 7). The thick loess deposits occur as bluffs adjacent to the CRV and include Alford, Menfro, and Winfield types (Fig. 8). Zanesville, Alford, Wellston and Berks soils occur in higher uplands where a thin layer of loess covers bedrock. Coastal plain sediments occur in the southern part of the valley and are stratified, noncemented, gravel and sand with some interbedded silt and clay. These areas are commonly covered with thick increments of loess and include Hosmer and Stoy soils. At the base of loess bluffs, colluvial sediments occur from material eroded from steeper upper portions of loess bluffs. Alluvial sediments (alluvium) are more recent silt and clay deposits on floodplains. Birds, Wakeland, Haymond, Dupo, Bonnie, Cape, Petrolia, and Hurst soils are common alluvial soils. Terraces and floodplain benches usually have loamy and sandy soils in upper soil strata and silt, sand, and gravel in lower strata. Lamont, Wheeling, Racoon, and Sciotoville soils occur in these terrace sites. Some terraces in lower elevations have soils with high silt content in

General Soils	General Landform	Parent Material	Surface Color	Degree of Development	Natural Internal Drainage Class			
					Well	Moderately Well	Somewhat Poor	Poor
Upland (Deep Loess)	Bluffs Loess over Limestone	Loess> 60 in. thick, calcareous at > 42 in. (5- > 20 ft. thick)	Light	Moderate	Menfro	Winfield		
	Coastal Plain	Loess> 50-70 in. thick on gray paleosols in Illinoian drift	Light	Strong		Hosmer	Stoy	
Upland (Moderately Deep Loess)	Uplands	Loess 24-48 in. thick on acid residuum and on sandstone, shale and siltstone at 40-80 in.	Light	Moderately Strong	Zanesville			
	Moderately Thick Loess Uplands	Loess 20-40 in. thick on > 10 in. residuum on shale, siltstone, and sandstone, limestone at > 48 in.	Light	Moderate	Westmore			
	Pennsylvanian or Mississippian Bedrock	Channery shale, siltstone, and sandstone residuum; acid shale, sandstone, and siltstone at 20-40 in.	Light	Weak	Berks			
		Loess < 20 in. thick on channery, flaggy residuum on acid sandstone and siltstone at 40-80 in.	Light	Weak-Moderate	Neotoma			
		Loess 20-40 in. thick on acid residuum (< 35% clay) and on sandstone, shale, and siltstone at 40-72 in.	Light	Moderate	Wellston			
	Mississippian Bedrock	Loess < 10 in. thick on thick, cherty, clayey, acid residuum, limestone at 60+ in.	Light	Strong	Baxter			
	Footslopes	Silty colluvial sediments > 60 in. thick formed at the base of bluffs	Light	Weak	Drury			
Terrace	Thin Loess or Silty Alluvium	Loess 30-55 in. thick on gray paleosols in Illinoian till or local wash	Light	Strong B, Thick A				Racoon
	Ohio River & Stream Terraces	Fine sand, sand, or loamy fine sand > 60 in. thick, 50-90% fine sand	Light	Weak B, 40-60 in.	Bloomfield			
	Interfluve Summits & High Stream Benches	Sandy loam of fine sandy loam 20-40 in. thick on leached sand, loamy sand, fine sand, and loamy fine sand	Light	Weak B, 15-30 in.	Lamont			
	Low Stream Terraces Second Bottom	Sandy loam of fine sandy loam 20-40 in. thick on leached sand, loamy sand, fine sand and loamy fine sand	Light	Moderate B, 15-30 in.	Alvin		Roby	
	Ohio River Terraces	Silty and loamy material on 30-50 in. thick on stratified, micaceous silt, sand, and gravel	Light	Moderately Strong		Sciotoville	Weinbach	Ginat
	Ohio River Terraces Clay Lacustrine	Medium-textured material < 20 in. thick on silty clay or clay, calcareous at < 42 in.	Light	Moderate	Markland			
		Medium-textured material < 20 in. thick on grayish silty clay or clay, calcareous at > 42 in.	Light	Moderately Strong			Hurst	Okaw
	Low Stream Terraces Second Bottom	Very strong-strong acid silt loam > 40 in. thick on silt loam with sandy lenses	Light	Weak			Banlic	
Floodplain	Mississippi & Ohio River Tributaries	Medium acid-moderate alkaline silt loam > 40 in. thick on silt loam with sandy lenses	Light	None		Haymond	Wakeland	Birds
		Medium acid-mildly alkaline silty clay loam > 40 in. thick	Light	None				Petrolia
	Ohio River Contrasting Textures	Medium acid-mildly alkaline silt loam 20-40 in. thick on dark silty clay, clay, or silty clay loam	Light	None			Dupo	
	Mississippi & Ohio River Soils	Medium acid-mildly alkaline silty clay loam > 40 in. thick on stratified, medium-textured material	Dark to 10-24 in.	None-weak				Beaucoup
		Strong to medium acid silty clay or clay (45-60% clay) > 40 in. thick	Light	None-weak				Karnak
		Medium acid-mildly alkaline silty clay or clay (45-55% clay) > 40 in. thick	Dark to 10-24 in.	None-weak				Darwin
		Medium acid-mildly alkaline silty clay loam 20-40 in. thick on stratified sandy material	Dark	None-weak				Gorham

Figure 7. Conceptual array of soils for the Cypress Quadrangle (from NRCS 1999).

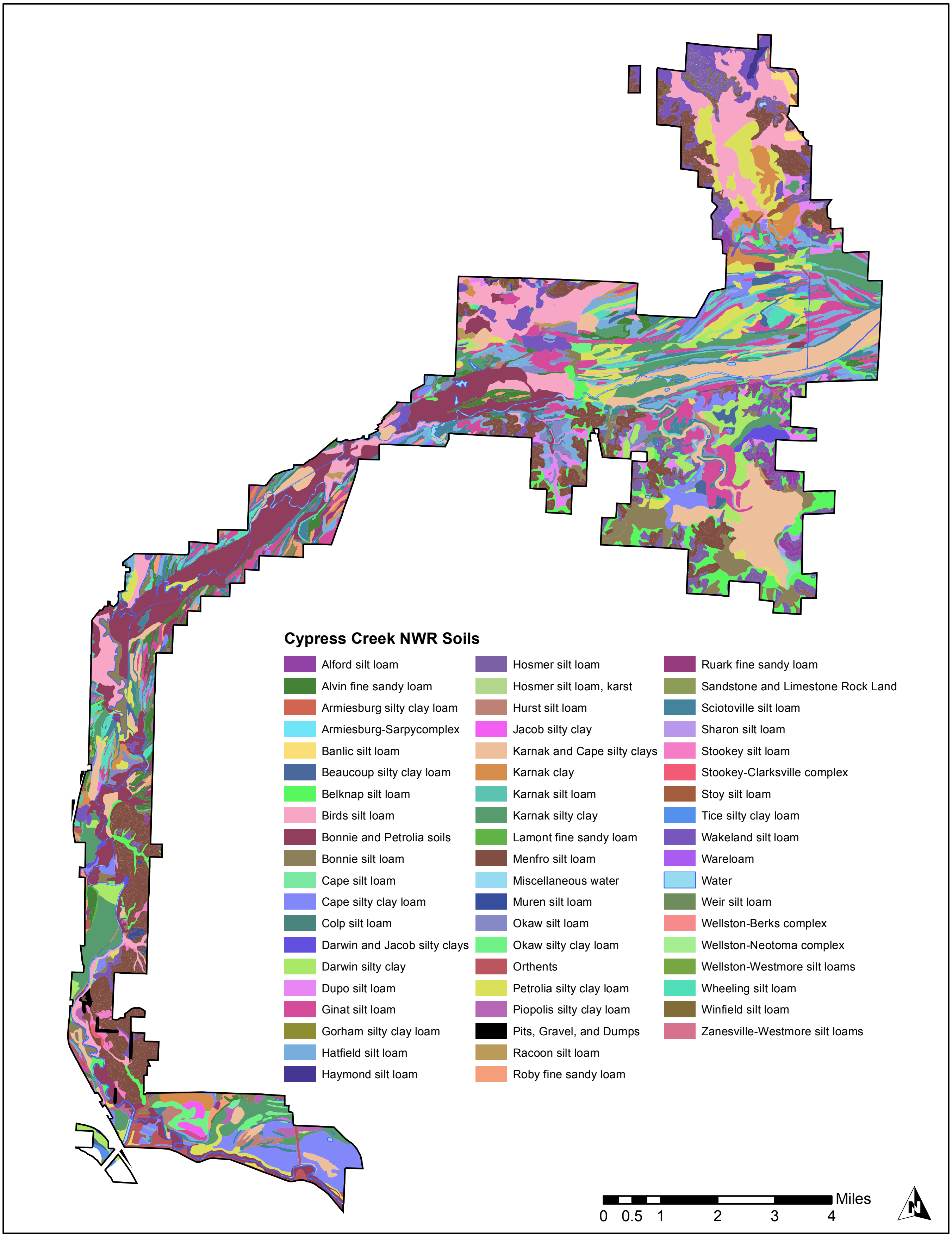


Figure 8. Soils present in the Cypress Creek National Wildlife Refuge.

the upper strata and clay in lower strata. Abandoned channel "lakebed" soils include Karnak, Darwin, Jacob, and Gorham types. Newly deposited sandy soils near the edges of river bars and natural levees include Roby, Ruark, and Alvin soils.

Almost all soils in the CRV, except for old lakebed types that historically supported open water and herbaceous marsh communities, formed under forest vegetation and have a light colored surface layer (NRCS 1999). A few Mollisol soils with dark surface layers have more organic material in the surface layers and may have been herbaceous wetland communities, such as seasonal herbaceous marsh or bottomland prairie, at some time. Darwin soils are often indicative of former shrub or herbaceous communities in old abandoned river channel depressions. The humid and warm climate of the region has favored rapid breakdown and weathering of soil material, the formation of clay, and the downward movement of these materials in soils (Fehrenbacher et al. 1984). The historic frequent, and sometimes extended, flooding of the region also has promoted the establishment of hydric soil types throughout the valley. For example, of the ca. 20,000 acres of prime farmland in the Cypress Quadrangle, about 17,000 acres is considered hydric (NRCS 1999).

TOPOGRAPHY

Topographic relief in the CRV area that includes the acquisition boundary of Cypress Creek NWR ranges from about 280 feet above mean sea level (amsl) in the southern part of the valley to about 600 feet amsl at the top of Shawnee Hills bluffs in the northeast part of the region (Fig. 9). The major landforms of the region include the ancient Ohio River floodplain and terraces, the steep and highly dissected Shawnee Hills to the north, and the gently rolling hills of the Coastal Plains physiographic Province to the south. Other lower gradient topography includes current and former river channels, oxbows and relict floodplain depressions, ridge-and-swale meander scrolls on inside-bend point-bar areas of the former Ohio River and current Cache River, and remnant terraces left from eroded surrounding material during Holocene glacial outwash periods (Saucier 1994, NRCS 1999).

CLIMATE AND HYDROLOGY

The climate of the CRV is characterized by warm summers and relatively mild winters (IDNR 1997). Mean maximum/minimum temperatures in July at Anna, Illinois are 89/67^o Fahrenheit (F) while similar mean maximum/minimum temperatures in January are 41/23^o F (Table 1). Mean annual precipitation is about 48 inches and is highest from March through May and lowest in October and January (Table 2). Precipitation occurs on average about 110 days per year. Humidity is muggy from late spring through early autumn, with daytime humidity 60-80%. Thunderstorms and associated heavy showers are major sources of summer precipitation, with gusty wind, hail, and occasional tornados possible. Snow cover seldom lasts for more than a few days and constitutes only 12% of total average winter precipitation.

Long-term trends in precipitation at Anna indicate relatively regular 15-20 year patterns of greater annual precipitation in the 1920s, 1940s, late 1950s to early 1960s, the 1980s, and 2000s that alternated with lower precipitation amounts in the 1930s, early 1950s, 1970s, and 1990s (Fig. 10). The recurring regular patterns of alternating peak and low precipitation suggests at least some long-term regular dynamic pattern of local water inputs to the Cache River ecosystem. Long-term historic records for the Mississippi and Ohio Rivers indicate an approximate 11-15 year cycle of increasing discharge followed by declining flow and drought (Knox 1984, 1999, Franklin et al. 2003, see below discussion).

The Cache River watershed covers parts of six Illinois counties (Union, Johnson, Alexander, Pulaski, Massac, and Pope) and has a total drainage area of 737 square miles (Fig. 11). Since the construction of the Post Creek Cutoff in 1915, the Cache River Basin has been divided into two subwatershed areas; the Upper Cache subwatershed located above the Post Creek Cutoff has a drainage area of 369 square miles and drains directly into the Ohio River, while the Lower Cache subwatershed drains about 358 square miles into the Mississippi River at Mississippi River mile (RM) 13.2 through the Mounds Diversion ditch channel at the downstream end of the river. About 11 square miles of the Lower Cache River watershed continues to drain directly into the Ohio River at Ohio RM 974.7. The natural drainage and flow pattern of the Cache River prior to 1915 included inputs from several creeks originating from the Shawnee Hills north of the river valley (Cypress, Big, Mill, Wolf, Lick, Dutchman) and Boar Creek and Limekiln Slough from the Coastal Plain hills south of the Cache River (Figs. 11,12).

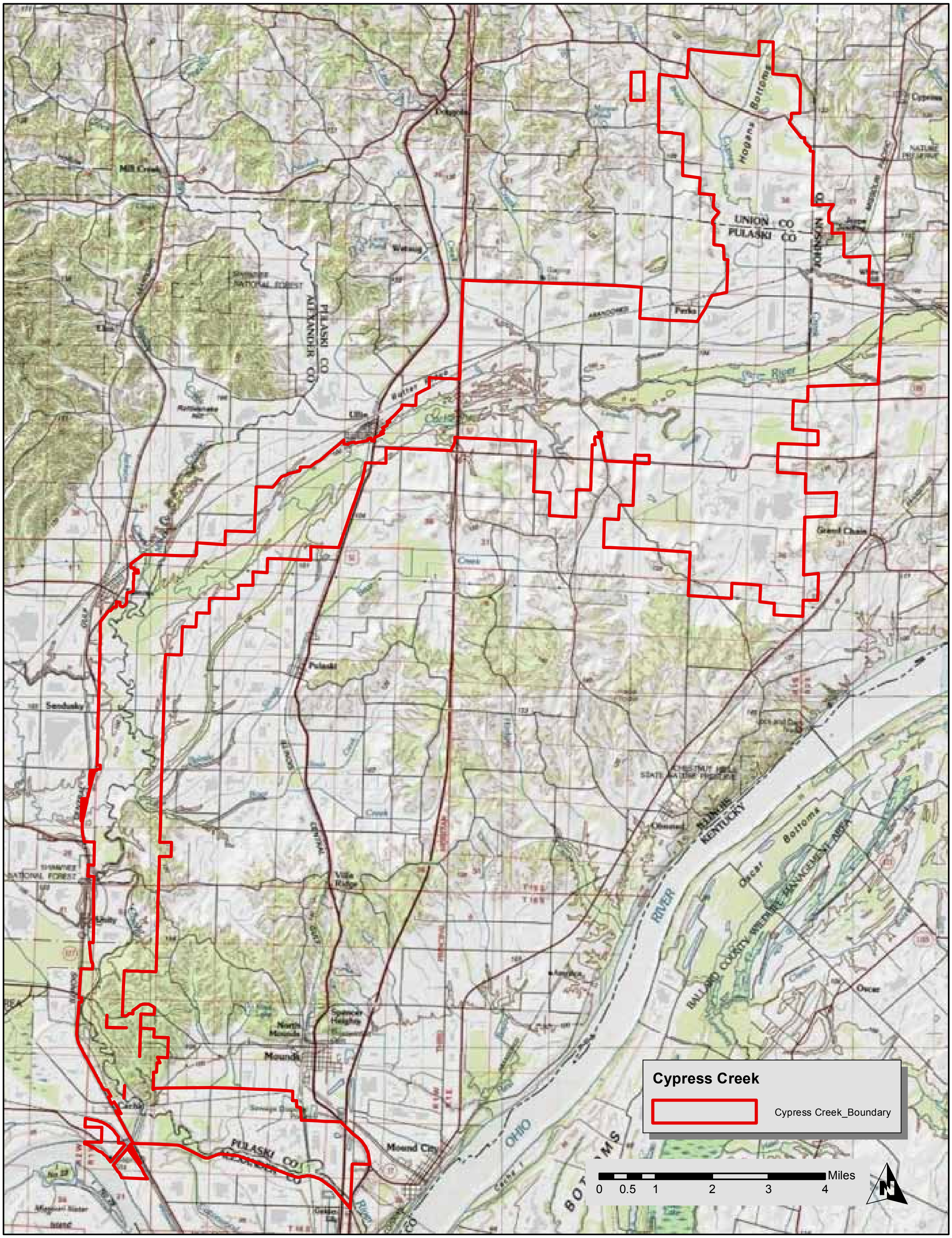


Figure 9. U.S. Geological Survey 7.5 minute topography maps for the Cypress Creek National Wildlife Refuge region.

Table 1. Temperature summary for Anna, Illinois. (Averages are from 1961-1990 and extremes are from 1901-1996. Temperatures are in ^{0}F.)

Month	Avg high	Avg low	Record high (year)	Record low (year)	# of days with high ≥90°F	# of days with low ≤32°F	# of days with low ≤0°F
January	40.8	22.5	76 (1909)	-20 (1918)	0.0	23.0	1.1
February	45.9	26.3	78 (1917)	-13 (1905)	0.0	19.0	0.4
March	57.2	36.3	91 (1910)	0 (1960)	0.0	12.0	0.0
April	68.4	46.4	92 (1915)	21 (1996)	0.1	2.1	0.0
May	77.5	54.9	98 (1911)	31 (1903)	1.2	0.0	0.0
June	85.9	63.3	105 (1936)	42 (1903)	9.0	0.0	0.0
July	89.1	67.2	112 (1901)	46 (1947)	17.0	0.0	0.0
August	87.5	65.3	110 (1930)	45 (1918)	13.0	0.0	0.0
September	80.7	58.6	107 (1925)	32 (1995)	5.5	0.0	0.0
October	70.4	46.8	95 (1910)	20 (1981)	0.3	1.5	0.0
November	57.2	37.8	83 (1902)	-5 (1991)	0.0	11.0	0.0
December	44.7	27.4	76 (1982)	-14 (1989)	0.0	20.0	0.5

Average annual surface water runoff from local streams in the CRV is about 1/3 of annual precipitation (IDNR 1997). About 70-80% of gauged floods in the Cache River floodplain occur from March to June when local rainfall is heaviest (Gough 2005). Much of the Cache River and tributary headwaters originate from the steep Shawnee Hills, while the Lower Cache River has much flatter morphology created by the ancient Ohio River floodplain (Fig. 13). About 8 miles of the Lower Cache River historically had somewhat subsided or "sunken" areas, which created "flat" or "depressed channel profiles that are not in fluvial equilibrium with the rest of the Cache River (Fig. 14). These flat areas may have subsided during regional earthquakes (Guccione 2002) and also likely were sites of major debris and sediment deposition. The low elevation gradient of the Cache River coupled with frequent debris and sediment deposits caused historic flows in these sections of the Cache River to be greatly reduced and river channel water may have been stagnant during very low flow periods of summer and fall (Bell 1905). One such sunken river channel area is within the Lower Cache River State Swamp National Natural Landmark Area (Fig. 1, Gough 2005, Guetersloh 2012). The variance in river gradient profiles creates accelerated runoff in the Upper Cache River Basin due to the steeper topography, while runoff is attenuated in the gentle slopes and broad floodplain wetlands of the Lower Cache River Basin (Hutchinson 2000).

During major floods, the Ohio River historically overflowed through the CRV towards the Mississippi River, and when in flood stage, the Mississippi River also caused water to back up into at least the Lower Cache River region (Fig. 15). In effect, during high Ohio River flows, the Presettlement CRV was an intermittently occupied "overflow channel." Gauge data on the Ohio River prior to completion of the Reevesville Levee, which now blocks backwater flooding of the Ohio River into the CRV, indicates large volumes of water from the Ohio River flowed through the CRV in 1883, 1884, 1898, 1907, and 1937, an average return interval of 9-10 years (USACE 1945, Gough 2005). Certain other data suggest the lower portion of the CRV was flooded by overbank flows of the Ohio River about once every 9-18 years (Demissie et al. 1990, Gough 2005). The periodic Ohio River overflows through the Lower CRV probably rearranged sediments and deposited large woody and other debris in the flatter parts of the river channel and floodplain (Gough 2005). Deeper floodplain depressions

Table 2. Precipitation summary for Anna, Illinois. (Averages are from 1961-1990 and extremes are from 1901-1996. Precipitation is in inches).

Month	Avg. preclp.	Record high (year)	Record low (year)	Largest one-day amount (year)	Snow-fall	# of days w/ preclp.
January	3.03	16.55 (1950)	0.35 (1943)	4.22 (1950)	5.5	8
February	3.40	8.59 (1989)	0.28 (1947)	4.04 (1945)	4.8	7
March	5.17	13.69 (1945)	0.10 (1910)	5.40 (1964)	2.4	10
April	4.61	12.07 (1911)	0.73 (1915)	3.63 (1948)	0.2	9
May	5.26	13.80 (1957)	0.30 (1925)	4.75 (1973)	0	9
June	3.76	18.21 (1928)	0.25 (1933)	4.86 (1983)	0	8
July	3.86	13.57 (1958)	0.18 (1974)	6.15 (1909)	0	7
August	3.88	12.77 (1985)	0.34 (1936)	4.45 (1959)	0	6
September	3.29	11.65 (1965)	0.00 (1928)	4.45 (1993)	0	6
October	3.07	11.43 (1910)	0.00 (1908)	5.10 (1910)	0	6
November	4.16	9.28 (1934)	0.26 (1910)	5.05 (1934)	0.5	8
December	4.34	13.01 (1982)	0.18 (1925)	5.15 (1918)	2.7	9

and perhaps some river channel areas blocked by debris dams or "sunken" by tectonic activity, likely had more permanent water regimes, while other floodplain depressions and surfaces were only seasonally flooded by onsite precipitation, local runoff, and short duration overbank flows of the Cache River. Higher floodplain elevations and terraces may have been flooded for short durations in wet years and when the Ohio River flooded into the CRV.

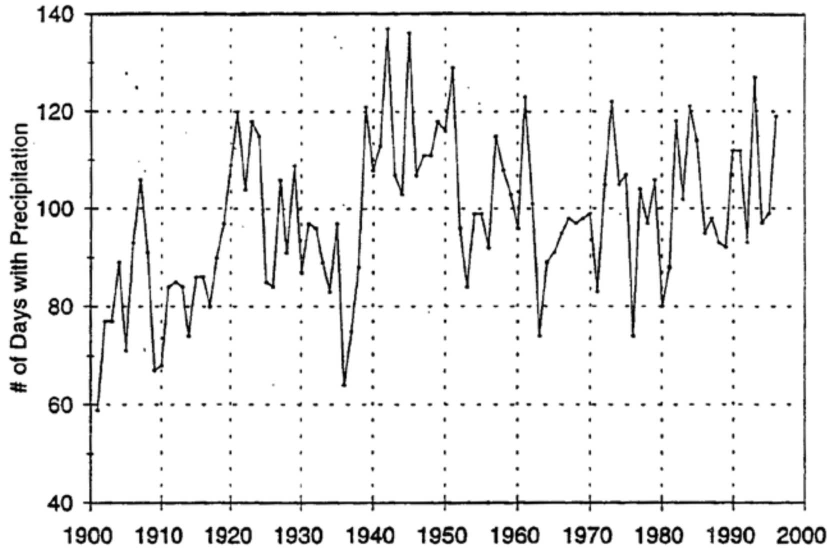


Figure 10. Annual number of days with measurable precipitation at Anna, Illinois, 1901-1996 (from Wendland and Angel 1997).

Overbank flooding of the Mississippi River (in association with Ohio River flows) into the lower CRV prior to the presence of mainstem river levees and interior floodplain levees apparently followed natural seasonal and annual patterns of alternating high vs. low and wet vs. dry discharge and precipitation patterns locally and in the large Mississippi River watershed above the region. Long-term trends in river gauge data from New Madrid suggest that some spring backwater flooding into lower elevations and presumably back up the Lower Cache River floodplain occurred in most years (see Heitmeyer 2010). Higher flood events also caused regular, sometimes prolonged flooding, of higher elevations. All of the Mississippi River floods in the Ohio-Mississippi River confluence area have occurred in spring and early summer; only two overbank stage river levels occurred at New Madrid from December to February since 1939-40 (Heitmeyer 2006).

Surface inundation and water elevations in the Cypress Creek NWR area are not totally dictated by local surface water runoff or overbank and backwater flooding of rivers. The relatively porous nature of geomorphic surfaces that contain deep sand stratigraphy layers (Fig. 5, Saucier 1994) causes groundwater levels in many locations to rise and fall in correspondence to Cache, Mississippi and Ohio River levels (e.g., Luckey 1984). Consequently, river levels that are above floodplain land elevations can create a hydraulic pressure head sufficient to cause groundwater to move from the Mississippi and Ohio Rivers into and through sub-surface land/gravel layers and discharge into CRV areas. It is common for certain wetland depressions such as point bar swales next to the Ohio River to

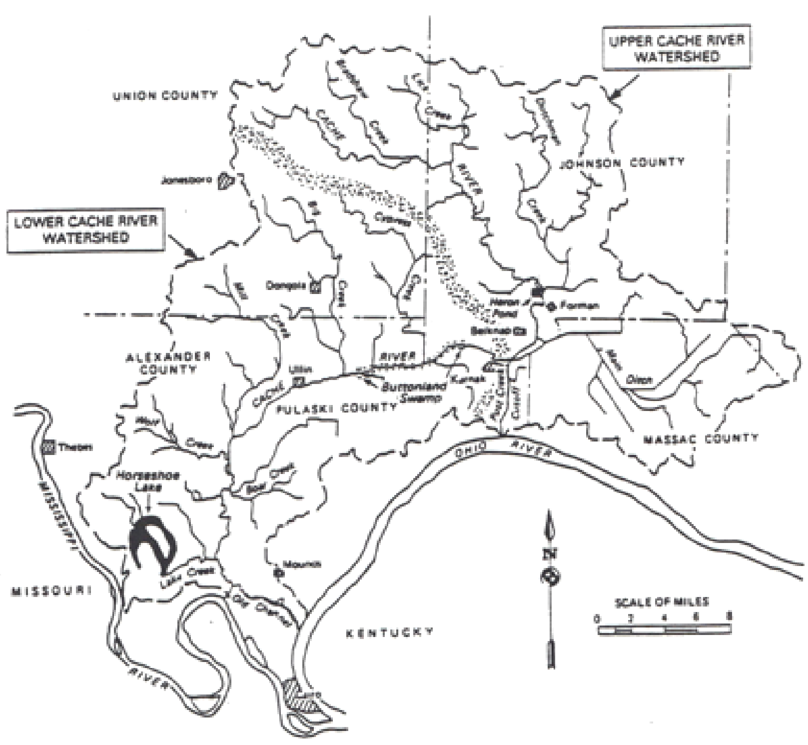


Figure 11. Location of hydrological features in the Cache River Basin (from Illinois Department of Natural Resources 1997).

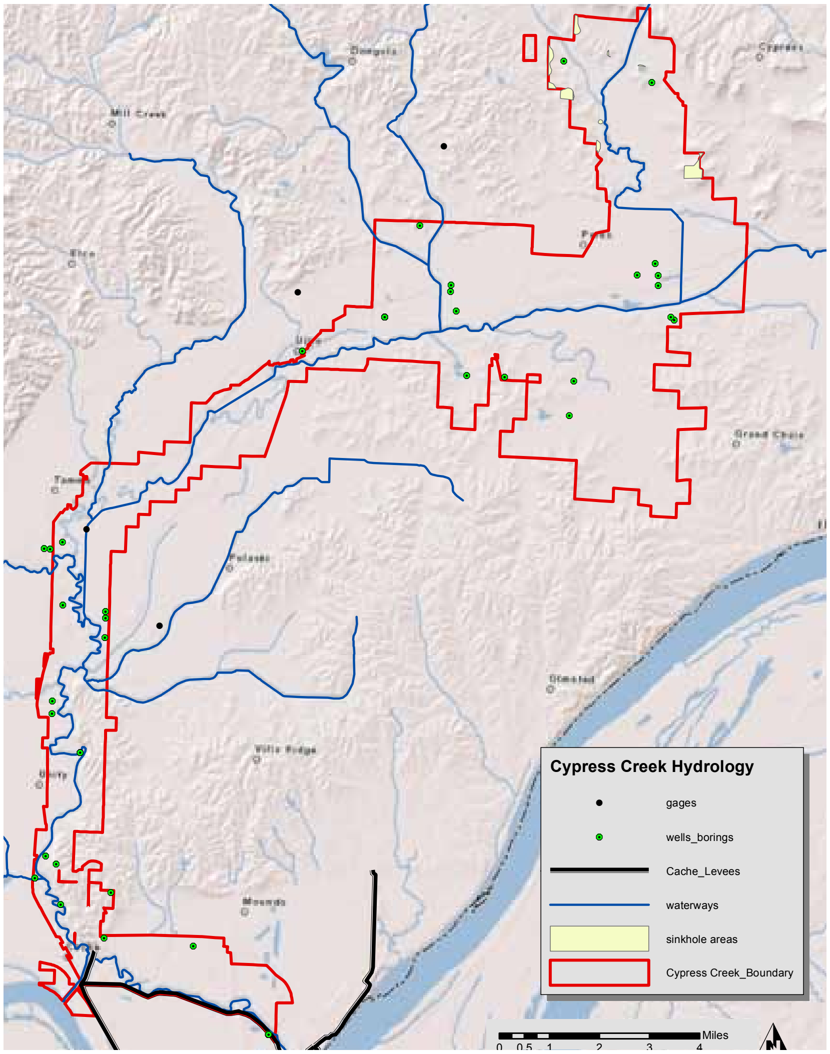


Figure 12. Location of major tributaries to the Cache River in the Cypress Creek National Wildlife Refuge Acquisition Boundary.

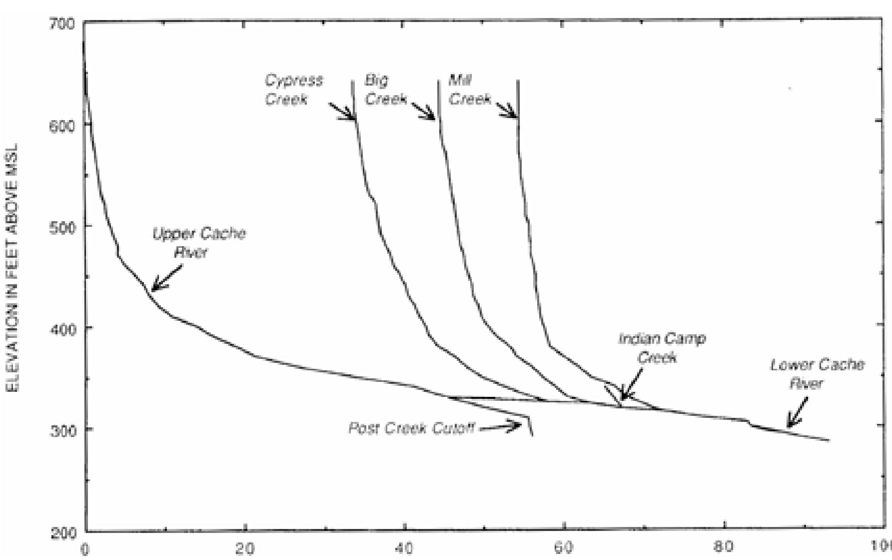


Figure 13. Long profile elevation gradients of the Cache River and its tributaries (from Demissie et al. 1990).

be shallowly flooded by groundwater discharge when Ohio River levels rise even if no local/regional precipitation has occurred for some time.

The CRV is underlain by sand and gravel aquifers, most of which are 20-50 feet below the surface and are annually recharged from the Mississippi, Ohio, and Cache Rivers and from downslope discharge from upland aquifers in the Shawnee Hills. The potentiometric surface of the alluvial aquifer is near the ground surface in many locations. Deeper aquifers of Paleozoic age and unconsolidated aquifers of Mesozoic and Cenozoic age also are present (Luckey 1984, Woerner et al. 2003). The older McNairy aquifer ranges from 0 to 600 feet thickness. This aquifer has a large artesian head and low iron and hardness concentration (Luckey 1984). The Mounds, Henry, Equality, and Cahokia formations often lie above the McNairy material and are of variable depth and quantity; most are at least 150 feet below the floodplain surface. Several freshwater springs occur in the Cache River Basin, including one spring located on the Cypress Creek Unit of Cypress Creek NWR (Phillips 1994, 1996). This spring is about six miles north of the Cache River and flows into a slough in Hogan's Bottom. Over 25 other springs are located in the immediate Cache River region.

Water quality in the Cache River is affected by many factors in the local and large Mississippi and Ohio River watersheds. Undoubtedly, sediment loading in tributary streams that originate from loess hill slopes historically brought significant amounts of suspended sediments and other chemical compounds into the river. Further, large flood events on the Mississippi and Ohio Rivers carried large quantities of sediment (e.g., Davinroy 2006). Inputs of sediments to river flood-

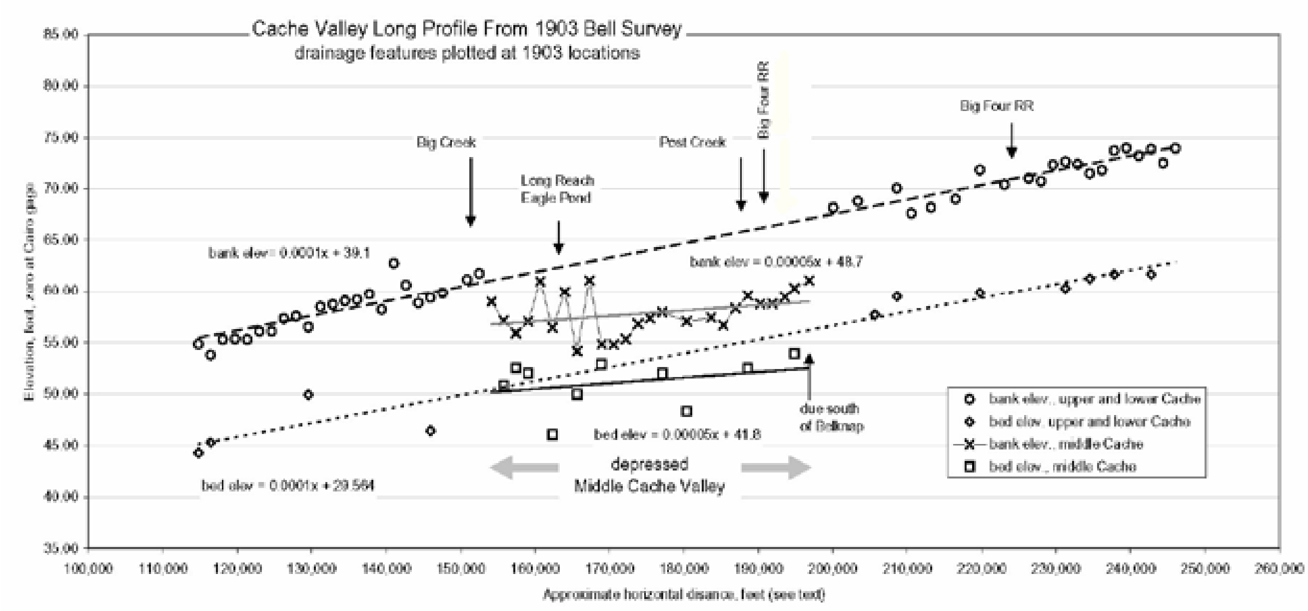


Figure 14. Long profile elevation gradient plot of the Cache River taken from the 1903 Bell survey (Bell 1905, Gough 2005).

plains are natural and help replenish nutrients and productivity to these systems. However, if excessive sedimentation occurs, extensive degradation to floodplains and rivers can occur (e.g., Bellrose et al. 1983, Bhowmik and Demissie 1986, Heimann 2001). Historical amounts of sedimentation in the CRV are unknown, but recent sedimentation rates have ranged from a low of 0.2 cm/year in forested floodplains near Highway 37 to greater than 2 cm/year in the edge of the river channel in the Long Reach area (Allgire and Cahill 2001).

VEGETATION AND ANIMAL COMMUNITIES

Paleoclimate Vegetation

During the late Wisconsin full-glacial interval (ca. 18,000 BP), the Upper MAV including the CRV was covered mostly by boreal forest communities (Delcourt and Delcourt 1981, Delcourt et al. 1999). A spruce (*Picea* spp.)-jack pine (*Pinus banksiana*)-willow (*Salix* spp.) forest type was present on braided stream terrace geomorphic surfaces of the region that was created by glacial melt water flowing down the Mississippi and Ohio River corridors. Post-glacial warming of the region about 14,000 BP caused the jack pine-dominated community in the Upper MAV to recede northward, however some evidence suggests that considerable spruce and willow communities were retained at least in areas east of Crowley's Ridge in Missouri (Delcourt et al. 1999). By 12,000 BP, warming temperatures allowed expansion of oak (*Quercus* spp.)-hickory (*Carya* spp.) forests onto CRV abandoned stream terraces. Subsequently, by 10,000 BP vegetation in the region had shifted to temperate to warm temperate types and a sweetgum (*Liquidambar styraciflua*)-elm (*Ulmus* spp.) forest type perhaps similar to contemporary floodplain forest communities apparently occupied areas along the Mississippi River channels; some giant cane (*Arundinaria gigantean*) likely was present on natural levee locations. Willow and early succession tree species including cottonwood (*Populus deltoides*), sycamore (*Platanus occidentalis*) and maple (*Acer* spp.) similar to the contemporary Riverfront Forest (see below) occupied newly scoured and regularly inundated areas along the active river channels (Delcourt et al. 1999). Baldcypress and water tupelo along with water tolerant shrubs occupied edges of abandoned channels and other deeper depressions including relict valley train channels (Saucier 1994). An oak-hickory forest similar to the contemporary high elevation BLH communities appears to have expanded onto higher elevation braided stream terraces at this time.

Beginning about 8,000 BP, continental climate warmed and dried and created the "Hypsithermal" or "Altithermal" period through about 4,000 BP (Saucier 1994, Delcourt et al. 1999). Drought-

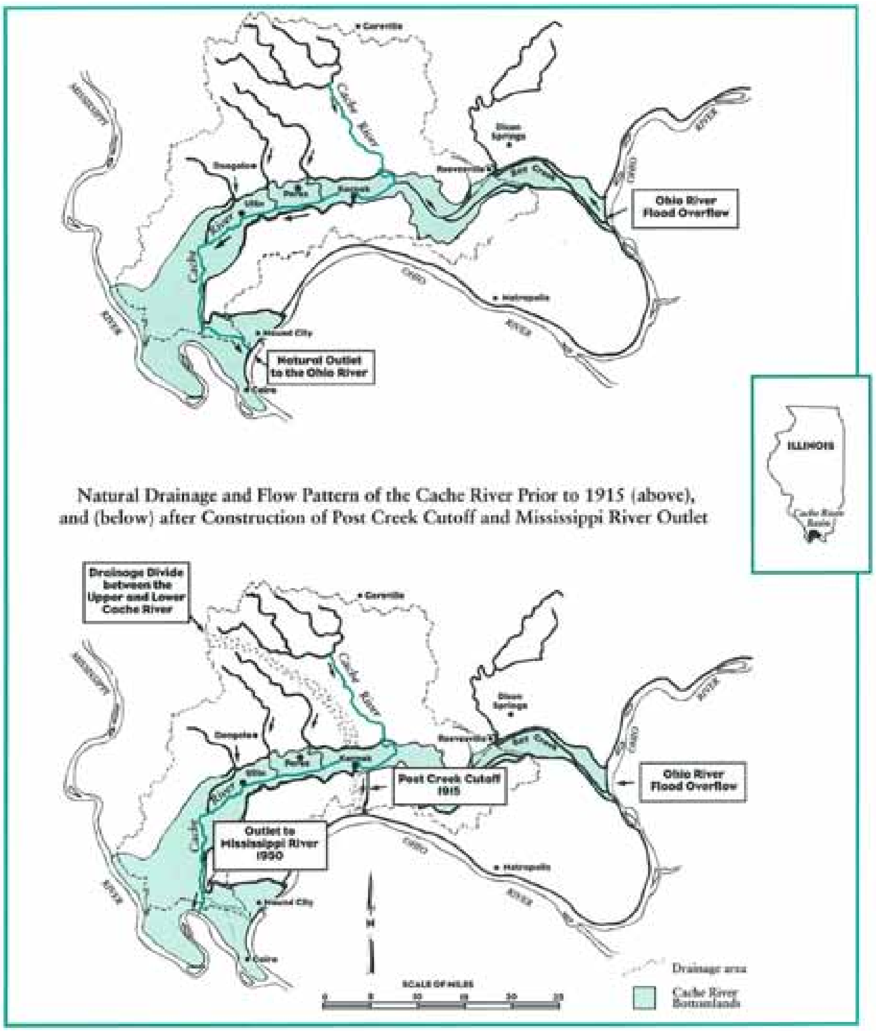


Figure 15. Natural drainage and flow pattern of the Cache River prior to 1915 (above) and after construction of the Post Creek Cutoff and Mississippi River Outlet (below) (from Illinois Department of Natural Resources 1997).

tolerant tree species expanded and most of the oak-hickory forest that had previously dominated higher elevations probably shifted to a savanna community with interspersed prairie occurring on higher and drier elevations and soils (King 1981). Wetter areas along the Mississippi and Ohio Rivers probably contained a diverse BLH community likely dominated by sweetgum, elm, ash (*Fraxinus* spp.), and willow with giant cane present on natural levees and some floodplain ridges (Delcourt et al. 1999). Baldcypress and water tupelo also apparently remained in floodplain depressions and abandoned channel locations.

Starting about 4,000 BP, climate in the Upper MAV moderated to a milder and wetter condition (Delcourt et al. 1999). The sweetgum-elm forest apparently re-expanded onto lower floodplain terraces and Riverfront Forest communities widened along active river channels. A diverse Terrace Hardwood Forest community likely expanded on higher elevation terraces and prairie and savanna areas likely decreased in extent at this time. The continuous channel migrations of the Mississippi and Ohio Rivers in the CRV region undoubtedly shifted the positions of Holocene floodplain vegetation communities regularly as water flow pathways, sediment, and scouring actions reworked and redistributed soils and water regimes. By about 1,000 BP certain portions of higher elevations in the CRV may have been covered by perennial grass and old field vegetation (Delcourt et al. 1999). These areas may have been sites disturbed or farmed by Native people and represented succession of abandoned fields (Kullen and Walitschek 1996).

Presettlement Period Vegetation

The heterogeneity of geomorphic surfaces, soils, and topography in the CRV in the late 1700s and early 1800s created diverse and highly interspersed vegetation communities distributed across elevation and hydrological gradients (Fig. 16). Major natural community/habitat types that were present in the CRV during the Presettlement period included: 1) the main channel of the Cache River and its major tributaries, 2) bottomland lakes often referred to as oxbows or abandoned channel depressions, 3) riverfront forest, 4) baldcypress/tupelo "swamp" forest, 5) shallow, high elevation, BLH forest, 6) low elevation BLH, 7) terrace hardwood forest, 8) mixed hardwood "slope" forest, and 9) mesic upland forest (Telford 1926, Miller and Fuller 1921, Voights and Mohlenbrock 1964, Leitner and Jackson 1981, Robertson et al. 1984, TNC 1995, Brugam and Patterson 1996, IDNR 1997, Hutchinson 2000). Lists and scientific names of fauna and flora for these habitats are provided in TNC (1995), IDNR (1997), and Battaglia (2007).

The main channel of the Cache River and its major tributaries contain open water with some aquatic vegetation and bald cypress trees in flatter, low gradient reaches. Some river chutes and old side channels are disconnected from main channel flows and have semipermanent water regimes that support woody shrub/scrub (S/S) and herbaceous "moist-soil" plant assemblages that germinate on periodically exposed mud flats. During high river flows chutes and side channels historically were connected with the main channel. Hydraulic connectivity may have been more prolonged in certain areas of the middle Cache River reach where subsidence occurred (Hutchinson 1984, Gough 2005). The extent and duration of river connectivity is the primary ecological process that controls nutrient inputs and exports, primary and secondary productivity, and animal use of chutes and side channels. A wide variety of fish historically were present in the Cache River and tributary rivers and these habitats also were used by many amphibians, a few aquatic mammals, and some water and shorebirds (IDNR 1997, Shasteen et al. 1999).

Bottomland lakes were present in the CRV during the Holocene period and occupied abandoned Mississippi, Ohio, and Cache River channels (U.S. Government Land Office (GLO) 1804-1840, Hutchinson 1984). These old lakes included The Scatters, Grassy Slough, Long Reach, Round Pond, Cypress Pond, Fish Lake, Long Lake, and Horseshoe Lake known to early settlers (Hutchinson 2000). The location, age, and size of bottomland lakes determined depth, slopes, and consequently composition and distribution of vegetation communities. Bottomland lakes in the CRV historically were surrounded by BLH Forest and usually contained embedded or narrow bands of baldcypress, water tupelo, and/or S/S vegetation along their edges (e.g., Robertson et al. 1978, Middleton and McKee 2004). S/S communities represent the transition area from more herbaceous and emergent vegetation in the aquatic part of bottomland lakes to higher floodplain surfaces that support trees. S/S habitats typically are flooded a few inches to 2-3 feet deep for extended periods of each year except

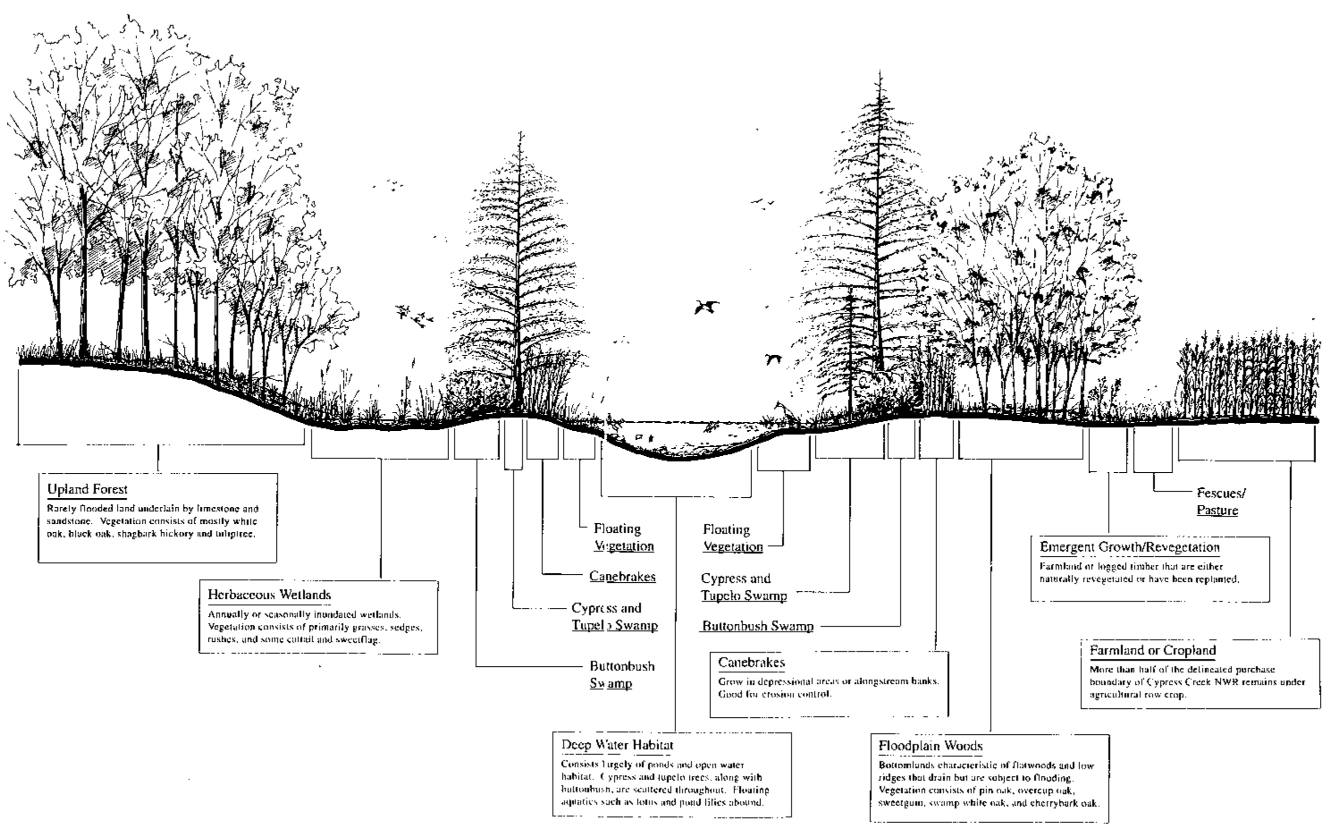


Figure 16. Topography and geomorphic cross-section of major vegetation community types in the Cypress Creek National Wildlife Refuge region.

in extremely dry periods. S/S habitats in the CRV are dominated by buttonbush (*Cephalanthus occidentalis*), swamp privet (*Forestiera acuminate*), and willow (TNC 1995, Middleton and McKee 2004). A natural levee usually is present along the edges of larger bottomland lakes and these areas support a diverse composition less water tolerant BLH forest species (e.g., Robertson et al. 1978). The ends of some bottomland lakes contain riverfront forest species (Heitmeyer 2008) that germinate on coarse-grain materials that had "plugged" the old abandoned channel (Saucier 1994).

Most newer and deeper bottomland lakes in the CRV contain central areas of permanent "open water" that contained abundant aquatic "submergent" and "floating-leaved" vascular species such as pondweeds (*Potamogeton* spp.), coontail (*Ceratophyllum demersum*), water milfoil (*Myriophyllum* spp.), American lotus (*Nelumbo lutea*), spatterdock (*Nuphar microphyllum*), and duckweeds (including *Lemna, Spirodella, Wolfia* spp.) (TNC 1995). The edges of these lakes historically dried for short periods during summer (Hutchinson 2000) and likely supported S/S and some herbaceous wetland vegetation and minor components of emergent wetland plant species. Emergent vegetation in these areas includes arrowhead (*Sagittaria latifolia*), cattail (*Typha* spp.), rushes (*Juncus* spp.), river bulrush (*Scirpus fluviatilis*), sedges (*Carex* spp.), and spikerush (*Eleocharis* spp.). Herbaceous vegetation is dominated by smartweed (*Polygonum* spp.), millet (*Echinochloa* spp.), panic grass (*Panicum dichotomiflorum*), sprangletop (*Leptochloa fasicucularis*), sedges, spikerush, beggarticks (*Bidens* spp.), and many other perennial and annual "moist-soil" species. The distribution of emergent and herbaceous communities in bottomland lakes depended on length and frequency of summer drying. In drier years, herbaceous communities would have expanded to cover wide bands along the edges of bottomland lakes, while in wetter periods herbaceous plants were confined to narrow bands along the edges of deeper open water.

Bottomland lakes support a high diversity of animal species. Historically, fish moved into these lakes for foraging and spawning (Jackson 2005) when they became connected with the Mississippi or Ohio Rivers during flood events. Many fish subsequently moved back into the main channel when flood water recedes or after they spawn or fatten during flood events; some fish then remain to populate the deeper lakes (e.g., Sparks 1995). Bottomland lakes also support high density and diversity of amphibian and reptile species and some species, such as turtles, move into and out of these lakes similar to fish (e.g., Tucker 2003). Aquatic mammals regularly use bottomland lakes and more terrestrial mammals travel in and out of these areas for seasonal foraging, breeding, and escape cover during dry periods. Bird diversity in these lakes is high, and extremely high densities of waterfowl, rail, shorebirds, and wading birds use these habitats for foraging, nesting, and resting sites (Heitmeyer et al. 2005).

Forest covered most of the CRV and other nearby Mississippi and Ohio River floodplain areas during the late 1700s (Hutchins 1784, Collott 1826, GLO 1804-40, Nuttall 1821, Leitner and Jackson 1981). The distribution of tree and woody shrub species was arrayed along geomorphic/topographic and hydrological gradients (e.g., Coulter 1904, Hosner and Minckler 1963, Voight and Mohlenbrock 1964, Robertson et al. 1978, Leitner and Jackson 1981, Fredrickson 1989, Mohlenbrock 1989, Conner and Sharitz 2005). Generally, a continuum of riverfront forest, BLH and terrace hardwood communities was present from the edges of the Cache River channel up to mixed hardwood mesic forests in uplands that bound the CRV (Fig. 16). These communities transcend the riverfront forest, wet bottomland to mesic bottomland forest, and bottomland flatwood forest categories described in various botanical literature (see Robertson et al. 1984:99-100).

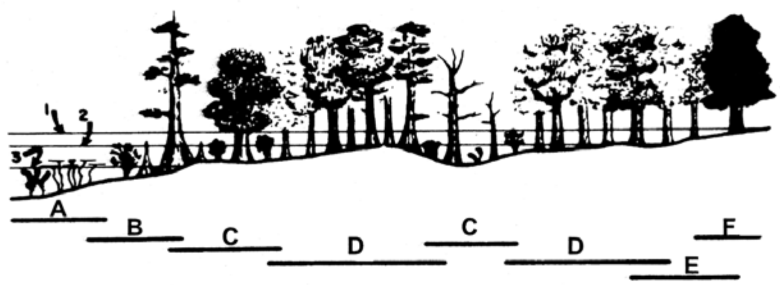
Riverfront forest (also called "river-edge forest" in some older botanical literature) was present on recently deposited and/or scoured coarse sediment chute and bar surfaces, some point bar areas near the current channel of the Mississippi, Ohio, and Cache River, and along the edges of some abandoned channels (Klimas 1987a, Mohlenbrock 1989, TNC 1995, Heitmeyer 2008). These geomorphic surfaces contain recently accreted lands and were sites where river flows actively scour and deposit silt, sand, gravel, and some organic debris. Soils under riverfront forest communities, especially on recently created chute-and-bar surfaces (Woerner 2003), are relatively young, annually overtopped by flood waters, highly drained, influenced by groundwater dynamics as adjacent river levels rise and fall, and often contain thin veneers of silt over sands and gravel. The most common soil types under riverfront forest in the Cypress

Creek NWR area is Alvin, Roby, and Ruark sandy loams (Fig. 6).

Riverfront forest communities are dominated by early succession tree species and range from water tolerant species such as black willow and silver maple along the river channel and in low elevations and swales to intermediate water tolerant species such as green ash (*Fraxinus pennsylvanica*), cottonwood, sycamore, box elder (*Acer negundo*), pecan/water hickory (*Carya aquatic*), and sugarberry (*Celtis* laevigata) on ridges. Pin oak (*Quercus* palustris) occasionally is present in higher elevations in riverfront forest areas, but this species has high mortality during extended flood events and oak patches in historic Riverfront Forest communities probably were small and scattered (e.g., Bell and Johnson 1974, Black 1984, Nelson and Sparks 1998). Shrub and herbaceous vegetation cover in riverfront forests is sparse near the Mississippi River but dense tangles of vines, shrubs, and herbaceous vegetation are present on higher elevations away from the river where alluvial silts were deposited. Typical shrub and vine species are poison ivy (*Toxicodendron radicans*), Virginia creeper (*Parthenocissus quinquefolia*), grape (*Vitis* spp.), and dogwood (*Cornus* spp.). Giant cane occasionally is present on these higher elevations, but repeated river flooding and scouring limit its occurrence and persistence (e.g., Gagnon 2007). The dynamic scouring and deposition in chute and bar areas also limits the tenure of many woody species except on the highest elevation ridges where species such as cottonwood and sycamore often become large mature stands (e.g., Hosner and Minckler 1963).

Riverfront forests are used by many animal species, especially as seasonal travel corridors and foraging sites. Many bird species nest in riverfront forests, usually in higher elevation areas where larger, older, trees occurred (Papon 2002). Arthropod numbers are high in riverfront forests during spring and summer and these habitats also contain large quantities of soft mast that is consumed by many bird and mammal species (e.g., Knutson et al. 1996). Few hard mast trees occur in riverfront forests, but occasional "clumps" of pecan or oak provide locally abundant nuts. The very highest elevations in chute and bar areas provide at least some temporal refuge to many ground-dwelling species during flood events (Heitmeyer et al. 2005).

BLH and cypress/tupelo forest communities historically covered extensive areas of the CRV (e.g., Leitner and Jackson 1981). These forest types occurred in several soil types and contained diverse mixtures of species (Conner and Sharitz 2005,



Duration of Flooding	Woody Vegetation
A - Permanent	Common baldcypress, *Taxodium distichum*
B - Semi-permanent	Common baldcypress Water tupelo, *Nyssa aquatica* Water elm, *Planera aquatica* Common buttonbush, *Cephalanthus occidentalis*
C - 3-8 Months	Common baldcypress Overcup oak, *Quercus lyrata* Red maple, *Acer rubrum* Water hickory, *Carya aquatica* Possumhaw holly, *Ilex decidua*
D - 1-6 Months	Willow oak, *Q. phellos* Pin oak, *Q. palustris* Cherrybark oak, *Q. pagoda* Sugar hackberry, *Celtis laevigata* American sweetgum, *Liquidambar styraciflua* Blackgum tupelo, *Nyssa sylvatica*
E - 0-2 Months	American sweetgum Blackgum tupelo Sugar hackberry Shagbark hickory, *Carya ovata* American elm, *Ulmus americana* Swamp chestnut oak, *Q. michauxii*
F - Once in 10 years	American sweetgum Shagbark hickory White oak, *Q. alba* Flowering dogwood, *Cornus florida*

Figure 17. Bottomland hardwood forest species composition across elevation and hydrology gradients (modified from Fredrickson and Batema 1982).

Heitmeyer et al. 2006). Tree species composition in BLH communities in the CRV can be separated along elevation and flooding gradients (Fig. 17). Cypress/tupelo, also called "swamp forest" communities occur in floodplain sites, and some sluggish low gradient Cache River channel areas, that range from being flooded for extended periods each year, and occasionally year round, to being flooded for 4-6 months in winter and spring. The lowest elevations in the CRV historically contained baldcypress, water locust, pecan, elm and water tupelo (e.g., Robertson et al. 1984). Soils in forested swamp settings were Karnak, Piopolis, Petrolia, and Birds types. Edges of cypress/tupelo forests near more permanent waters included bands of S/S vegetation. At slightly higher elevations in the CRV, Low BLH (sometimes called "deep floodplain") communities are present and contained slightly less water tolerant trees such as overcup oak (*Quercus lyrata)*, green ash (*Acer rubrum drummondii*) red maple, and pecan with scattered tupelo and baldcypress present in low elevation inclusions (Robertson et al. 1984). Woody shrubs in low elevation more prolonged flooded BLH sites include buttonbush, swamp privet, and planer tree (*Planera aquatic*). Many understory vines typically are present in low BLH communities and include rattan vine (*Berchemia scandens*), ladies eardrop (*Brunnichia ovate*), greenbrier (*Smilax retundifolia*), and poison ivy. Ground herbaceous cover usually is sparse in low BLH because of extended flooding, but sedges, beggarticks, smartweed, and rice cutgrass (*Leersia oryzoides*) often are abundant during dry periods. Soils in cypress/tupelo and low BLH communities in the CRV are Birds, Petrolia, Dupo, Bonnie, and Cape clays.

Shallow floodplain BLH (similar to the wet-mesic bottomland forest category in some botanical literature, e.g., TNC 1995, Nelson 2005) in the CRV occurs mainly in floodplain areas that typically flood for up to 2-4 months annually during the dormant season and into early spring (Heitmeyer et al. 2006, Heitmeyer 2008). Soil saturation in these forests often becomes extended for 3-4 months in wet years, but surface flooding may not occur in extremely dry years. Soils in shallow floodplain forests in the CRV are dominated by silty-clay loams including Dupo, Wakeland, Haymond, Hurst, Banlic, Belknap, Ginat, Sharon, Okaw, and Ware types. Tree species composition in BLH is diverse and includes pin oak, swamp chestnut oak (*Quercus michauxii*), bur oak (*Quercus macrocarpa*), green ash, slippery elm (*Ulmus rubra*), pecan, sugarberry, American elm, box elder, sweetgum, and some widely scattered swamp white oak(*Quercus bicolor*) in areas that flood regularly for short durations during the dormant season. Small depressions in BLH zones, such as vernal pools, include overcup oak, green ash, maple, and pecan. Giant cane is occasionally present in some floodplain forest locations, mostly on higher ridges (Platt and Brantley 1999, Brantley and Platt 2001, Gagnon 2007). Common privet (*Ligustrum vulgare*), honeysuckle (*Ionicera japonica*), grape, trumpet creeper (*Campis radicans*), greenbrier, and poison ivy are common understory plants in Intermediate BLH. Early explorers often commented on the relatively "impenetrable" nature of these floodplain forests (e.g., Collot 1826). The shallow floodplain BLH along tributaries of the CRV resembles in many ways the floodplain forests, with low oak composition, that historically covered large expanses of the Middle Mississippi River Corridor floodplain on point bar surfaces and along tributary streams (Hus 1908, Telford 1926, Gregg 1975, Robertson et al. 1978, Klimas 1987, Brugam and Patterson 1996, Heitmeyer 2008). Typical floodplain BLH in northern parts of the MAV typically develop on mixed silt loam soils where older point bar "ridge-and-swale" topography occurred. Most of these older point bar surfaces were within the 1-2 year flood frequency zone. Some botanical literature also calls this forest type the "sugarberry-elm-sweetgum" zone (e.g., Lewis 1974, Gregg 1975).

Animal diversity is high throughout BLH community types because of the deep alluvial soils, seasonal flooding regimes, diverse plant communities, high structural complexity, and rich detrital food bases (Heitmeyer et al. 2005). Most foods within BLH become available in seasonal "pulses" that provide many different types of nutrients used by many trophic levels and within many niches. Consequently, this community supported large numbers of animal species and individuals. The primary ecological process that sustain BLH communities and their productivity is seasonal, mostly dormant-season, flooding. Regular disturbance events also help sustain this ecosystem through periodic extended flooding or drought, wind storms, and rarely fire in at least the higher elevations.

Terrace hardwood forest historically occurred in the CRV on the edges of floodplain surfaces where overbank and backwater flooding from the Mississippi and Ohio Rivers was rare (> 20-year recurrence elevations) and soils graded into sandier Entisols including Lamont, Sciotoville, Wheeling, and Racoon types (Fig. 8). These communities are often called "flats" (Klimas et al. 2009), "flatland hardwood" (Marks and Harcombe 1981), or "bottomland flatwoods" (Nelson 2005) because they occur on old high elevation terraces that often are subject to ponding of rainwater or short duration local stream flooding. During extremely high Mississippi and Ohio River floods, these high terraces are inundated, usually for short periods in spring. Dominant canopy trees in terrace hardwood forests are pin oak, cherrybark oak (*Quercus pagoda*), post oak (*Quercus stellata*), willow oak (*Quercus phellos*), hickory, winged elm, and persimmon (*Diospyros virginiana*) (Nelson 2005). Trumpet creeper and climbing dogbane (*Trachelospermum* dirrorme) are common shrubs and sedges, goldenrod (*Solidago* spp.), bedstraw (*Galium asprellum*), spider lily (*Lycoris* spp.), and wood sorrel (*Oxalis acetosella*) are common herbaceous species.

Slope forest occurred in the Cypress Creek NWR region on lower slopes of the Shawnee and Coastal Plain Hills and some alluvial fan areas. Slope forests contain unique mixes of trees representing both upland and floodplain communities that occur adjacent to alluvial fans (TNC 1995, Battaglia 2007). Some authors refer to this habitat as the "shatter zone" between upland and river valley floor plant associations (Gregg 1975). More typically, this community is referred to as mesic lower slope mixed hardwood (Robertson et al. 1984). The diverse tree species present in slope forests includes hickory, sugarberry, swamp white and swamp chestnut oak, white oak (*Quercus alba*), bur oak, southern red oak (*Quercus falcate*), black walnut (*Juglans nigra*), hawthorn (*Cretaegus* spp.), persimmon, honey locust (*Gleditsia triancanthos*), Kentucky coffeetree (*Gymnocladus*), and slippery elm. Many other woody species are present in the understory and as occasional canopy trees. Herbaceous cover often is extensive in slope forest (Chmurny 1973, Gregg 1975), especially on the lowest elevations of alluvial fans and includes columbine (*Aquilegia canadensis*), spikenard (*Aralia racemosa*), wild ginger (*Asarum canadense*), spring beauty (*Claytonia virginica*), pepperroot (*Dentaria laciniata*), cleavers (*Galium aparine*), sensitive fern (*Onoclea sensibilis*), sweet jarvil (*Osmorhiza Claytoni*), pokeberry (*Phytolacca americana*), may apple (*Podophyllum peltatum*), great Solomon's seal (*Polygonatum canaliculatum*), and false Solomon's seal (*Smilacina racemosa*) (Zawacki and Hausfater 1969).

Slope forests are not flooded except during extreme Mississippi River floods. Even during extreme floods, only the low elevation bottom parts of the hill slopes historically would have been inundated. Most water flows off alluvial fan slopes in a wide overland sheetflow manner and only minor drainages originate from these areas. Many alluvial fans have seep spring areas where upland groundwater exits (Phillips 1996). Soils in hill slope areas of the CRV region usually are deeper loess types such as Alford, Menfro, Winfield, and Hosner.

Higher elevation slopes of the Shawnee Hills contain a mesic hardwood forest overstory similar to those found in the Ozarks (Fralish 1976, Mohlenbrock 1989, Fralish et al. 1991). White, red, and black oaks are common dominant species in this community. Other forest species similar to mesic types found in the slope forest assemblages also are present. Soils in upland forest areas include Alford, Stoy, Zanesville, Wellston, and Berks types (Fig. 8).

Prairie and savanna communities historically may have occupied some terrace areas of the CRV in the post Wisconsin-age glacial period, especially during the Hypsithermal (Swayne 1973, King 1981, Leitner and Jackson 1981, Brugam and Patterson 1996), but most likely by the 1700s, these former prairie sites had shifted to savanna or forest habitats (Anderson and White 1970, Leitner and Jackson 1981). The forest composition of savanna areas, if they were present, is unknown, but most probably included terrace hardwood tree species, such as pin and willow oak, with understories of sedges and prairie cordgrass (*Spartina pectinata*). If areas were better drained, big bluestem(*Andropogon gerardii*) may have been present (Weaver 1954). The distribution of savanna or some type of prairie probably was determined by the dynamic "line" of where: 1) mollisols soils occurred, 2) floodwater ranged toward higher elevations in floodplains and 3) the elevation "line" where fires originating from uplands and higher elevations moved into the wetter lowlands (NRCS 1999). Historically, savanna vegetation was partly maintained by fire occurring at about 5-8 year intervals caused by lightning strikes or intentionally set by native people and by seasonal herbivory from elk, bison, deer, and many rodents (e.g., Nelson 2005). This herbivory cropped and recycled prairie vegetation and also browsed invading woody shrubs and plants. Bison (*Bison*

bison) and elk (*Cervus canadensis*) formerly were present in the region but apparently were extirpated by 1860 (Beckwith 1887 cited in Hendershott 2004). Other common upland species in these habitats are bobwhite quail (*Colinus virginanus*), grassland songbirds, northern fence lizard (*Sceloporus undulates hyancinthinus*), white-tailed deer (*Odocoileus virginanus*), numerous rodents, and eastern cottontail (*Sylvilagus floridana*).

Distribution and Extent of Presettlement Habitats

The exact distribution of specific vegetation communities (habitat types) in the CRV prior to significant European settlement in the late 1700s is not known. However, the above discussion identified the many sources of information about the geography and distribution of major vegetation communities for the CRV and similar nearby Upper MAV geomorphic regions. These data include historic cartography, botanical data and accounts, and general descriptions of landscapes from early explorers and naturalists. While the precise geography of early maps (e.g. river channel boundaries) is often flawed, these maps provide general descriptions of relative habitat types, distribution, and configuration.

Apparently, the first maps of the Mississippi River (and parts of its floodplain) including at least parts of the Lower CRV, were made during French governance of the region by the French cartographers Franquelin (produced in 1682), De L'Lsle (1703 and 1718), d'Anville (1746 and 1755), and Bellin (1755) (Wood 2001). When the British Regime succeeded French rule of the area in the mid-1700s, new maps of the Middle Mississippi River Valley including the CRV were prepared. The first known British map was drawn by Philip Pitman in 1765 and it essentially was a compendium of the earlier French maps (Thurman 1982). Although it was not highly original, the Pittman map became the accepted "standard" for geography of the Middle Mississippi River region; subsequent maps expanded coverage and descriptions to lower course tributaries (e.g., the Ross map produced in 1867) and floodplains (Hutchins 1784). The Hutchins' map relied heavily on Pitman's map and his book "A topographic description of Virginia, Pennsylvania, Maryland, and North Carolina" published in 1778 contained the most accurate map of the Illinois Country at that time. The journal from Hutchins' mapping trip and that of Captain Harry Gordon at the same period offered detailed description of many important floodplain features. Subsequent to Hutchins' map was the excellent map of General Victor Collot prepared from field surveys in the late 1790s and published in 1826. This "Collot" map provided expanded notes and coverage of vegetation and larger wetlands in the Mississippi River floodplain and became the basis for additional maps and naturalist accounts of Nicolas de Finiels in the early 1800s (Ekberg and Foley 1989).

In the early 1800s, following American occupation and rule, the Mississippi River Valley including the CRV was mapped by the U.S. Government Land Office (GLO) to establish a geometric system of land ownership and governance (i.e., the Range-Township-Section system developed by Thomas Jefferson and codified in the Land Survey Ordinance of 1785). These GLO surveys (also often called Public Land Surveys) established right-angle "section lines" in a geometric land grid system, and the surveyors also documented vegetation and "witness" trees at section corners and center points between the corners (GLO 1804-40). Consequently, the GLO maps and surveys established a "georeference" of locations and distribution of CRV features including general habitat types (Fig. 18, 19). GLO surveyors usually described vegetation communities in broad categories (e.g., forest, bottomland, barrens) and grouped witness trees in general taxonomic groups (e.g., black vs. white oak). Consequently, considerable interpretation often is needed to determine the exact species composition that was noted. Most likely, the "black oaks" described in GLO notes for the CRV were "red oak" species such as pin, willow, and cherrybark oaks because true black oak (*Quercus velutina*) does not grow in floodplains (Leitner and Jackson 1981) and the "white oaks" probably were a collection of overcup, swamp white, post, and swamp chestnut oaks. GLO notes that describe general habitat types of forest, bottomland, prairie, open water, etc. do not describe composition of forests nor do they delineate small areas of trees or herbaceous wetlands within bottomland settings (Bourdo 1956, Hutchinson 1988). GLO surveys probably mapped savannas as forest, but this is unclear because many savanna areas may have contained larger amounts of prairie or other grasses. In the CRV, GLO notes and maps often mix the terms "bottomland", "woodland", and "forest". Most "bottomland" appears to have been BLH communities, however, the scale of mapping,

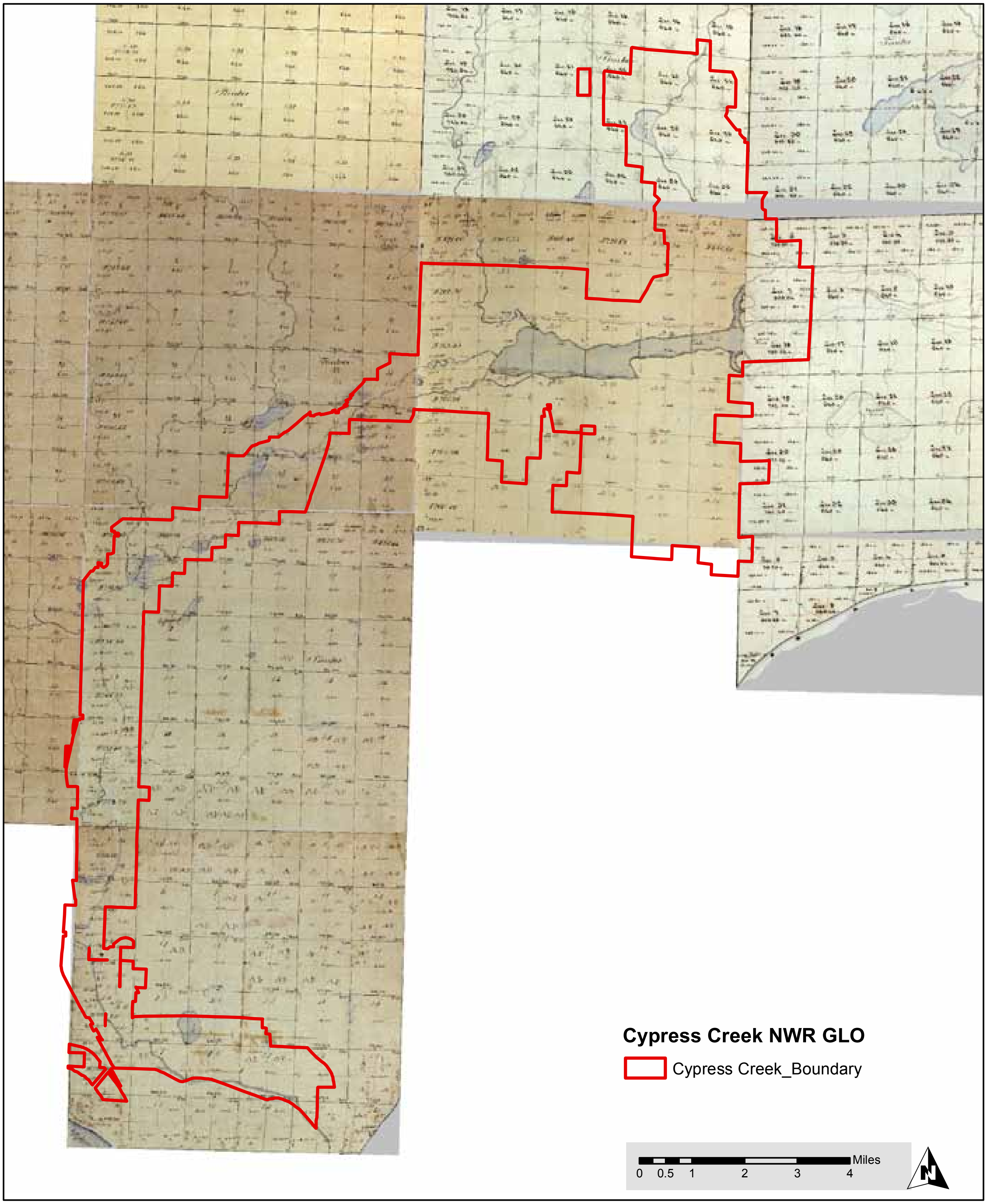


Figure 18. General Land Office (GLO) map of the Cypress Creek National Wildlife Refuge region in 1804 (from U.S. Government Land Office 1804-1840).

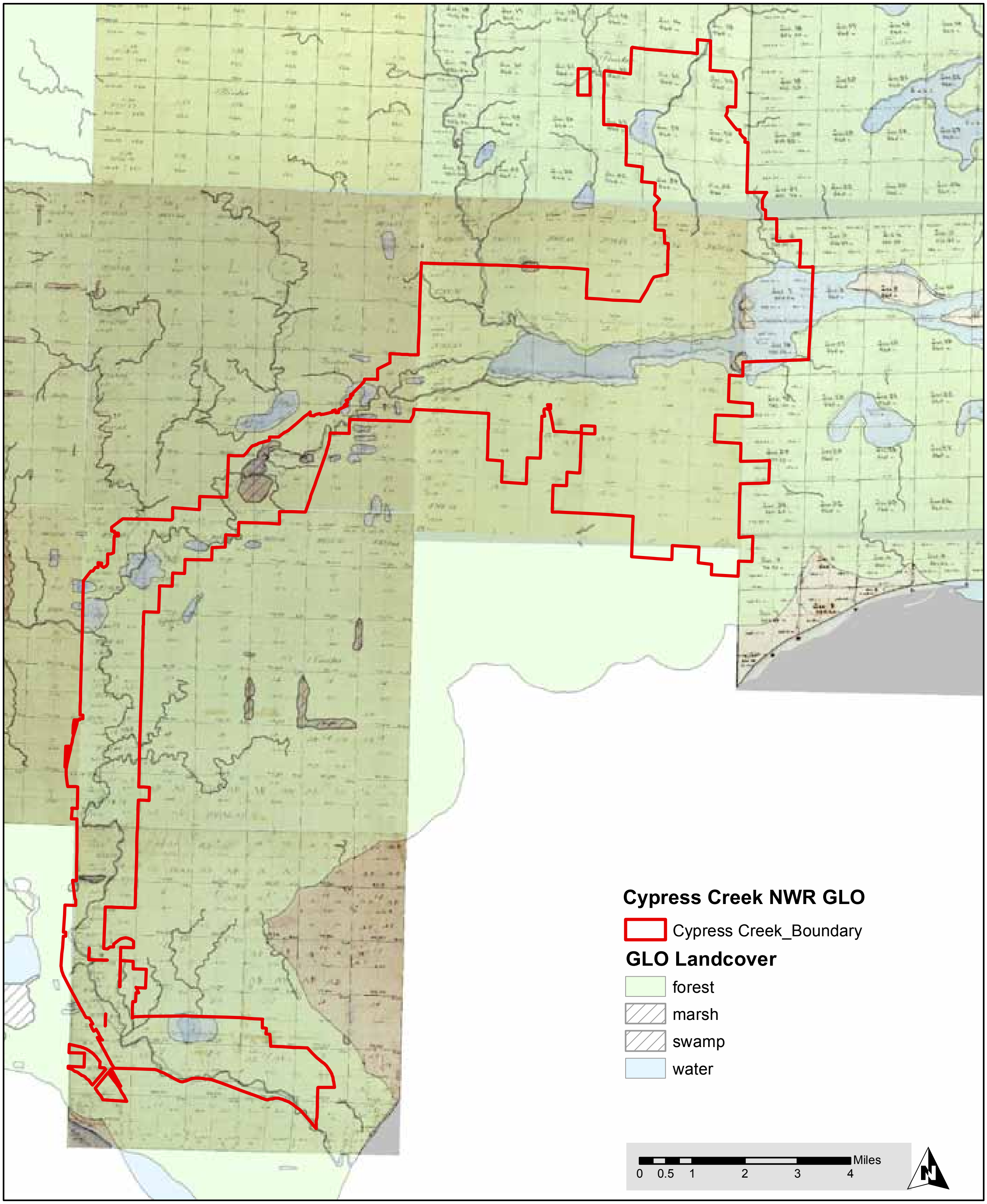


Figure 19. Landcover types mapped from the General Land Office (GLO) map of the Cypress Creek National Wildlife Refuge region in 1804 (from data in U.S. Government Land Office 1804-1840).

Figure 20. Map of the Cypress Creek National Wildlife Refuge region in 1876.

and definition of communities often is gross and inconsistent. Further, GLO notes suggest travel through, and precise documentation of, vegetation in low elevation, wet, floodplain locations (such as abandoned channels and floodplain depressions) was difficult and somewhat cursory. Notes in these areas often refer to lands simply as "water", "wet", "swampy", "marais", or "flooded."

In addition to the GLO surveys, many other cartographers, naturalists, and explorers produced maps (e.g., Fig. 20) and provided natural history accounts and botanical records for many southern Middle Mississippi and Upper MAV areas (see White 1997). In the late 1800s the Mississippi River Commission (MRC, 1881) produced the first complete set of maps for the Mississippi River from New Orleans to Minneapolis. This map set included detailed descriptions of the Mississippi River channel, side channels and chutes, tributaries, floodplain habitats (general habitat types), bottomland lakes, and settlements. Unfortunately, the MRC maps for southern Illinois do not extend into the CRV.

Collectively, the above maps, historical accounts, and published literature suggest historical vegetation communities in the CRV were distributed along elevation, geomorphology, and hydrological gradients similar to current plant physiographic of the community species. Similar community distribution associations also occur in other nearby Mississippi Valley floodplain areas and help validate information for the CRV (e.g., Heitmeyer et al. 2006, Heitmeyer 2008, Klimas et al. 2009, Heitmeyer 2010). The extensively documented relationships between community types and the abiotic attributes of Upper MAV geomorphology, soils, topography, and flood frequency zones were used to prepare Hydrogeomorphic matrices that identified the potential distribution, composition, and area of Presettlement habitats in the CRV (Table 3). The methods of determining these relationships are presented in Heitmeyer (2010) and involve a series of steps of overlaying data layers from historical and current maps and then validating relationships using remnant representative field reference sites (see Klimas et al. 2009; Nestler et al. 2010, Theiling et al. 2012). This methodology culminated in production of a map of

Table 3. Hydrogeomorphic (HGM) matrix of historical distribution of major vegetation communities/habitat types in the Cypress Creek National Wildlife Refuge Acquisition Boundary in relationship to geomorphic surface, soils, elevation, and hydrological regime. Relationships were determined from land cover maps prepared by the U.S. Government Land Office (1801-1840), historic maps, USDA soil data (Figs. 8), geomorphology maps (Fig. 4), botanical correlation (e.g., Robertson and Weaver 1978, Leitner and Jackson 1981, Robertson et al. 1984, TNC 1995, Brugam and Patterson 1996, Battaglia 2007) and various naturalist and historical botanical accounts (e.g., Coulter 1904).

Habitat type	Geomorphology	Soil types	Flood frequency[a]
Bottomland Lake	Alluvial floodplain	Karnak, Darwin, Jacob, Gorham	A-P to SP
Cypress/Tupelo Swamp	Alluvial floodplain, River channel	Karnak, Propolis	A-SP
Low BLH[b]	Alluvial floodplain	Petrolia, Dupo, Birds, Bonnie, Cape	A, 4-6 months DF
Shallow Floodplain BLH	Alluvial floodplain	Wakeland, Birds, Ginat, Haymond, Hurst Okaw, Ware, Belknap, Sharon, Baulie	A, 2-3 months DF
Terrace Hardwood	Floodplain terraces	Lamont, Wheeling, Racoon, Sciotoville	> 20-year
Slope Forest	Hill slopes and alluvial fans	Menfro, Winfield, Hosner	Onsite
Mesic Upland Forest	Shawnee Hills	Zanesville, Alford, Stoy, Wellston, Berks	Onsite

[a] A – annual, P – permanent flooding, SP – semipermanent flooding, DF – dormant season flooding.
[b] BLH – bottomland hardwood forest

potential Presettlement vegetation community distribution in the Cypress Creek NWR acquisition boundary (Fig. 21).

In the early 1800s, many "water" communities/habitats were noted and mapped near the Cache River channel (see, e.g., GLO survey notes and maps, Fig. 22, Gough 2005). Some of these "water" sites appear to have contained the Cache River channel and others apparently contained at least some open water, however, most of these "water" areas probably were cypress/tupelo swamp, S/S, open water, and edges of low elevation BLH habitats flooded at the time of the surveys based on the underlying soils and geomorphology (Leitner and Jackson 1981, Hutchinson 1984, TNC 1995, Table 3, Fig. 21). For example, the flat portion of the Cache River channel in Lower Cache River Swamp National Natural Landmark, historically probably held water for extended periods in and among years, and supported a swamp-like assemblage of cypress/tupelo, S/S, and maybe herbaceous wetland vegetation (Gough 2005, Guetersloh 2012). All historic off-channel bottomland lakes in the CRV, based on the GLO surveys, have Karnak, Piopolas, and Birds clay soils and apparently were historically

Table 4. Total acres of major vegetation community/habitat types present in the Cypress Creek National Wildlife Refuge region as mapped by HGM methods (see Table 3 and Figure 21).

Cypress-Tupelo Swamp	3027
Herbaceous and S/S	1483
Low BLH Floodplain	14413
Mesic Upland Forest	986
Open Water	610
Riverfront Forest	1360
Shallow BLH Floodplain	7590
Slope Forest	5641
Terrace Hardwoods	2455
Unknown	30
Total	37,595

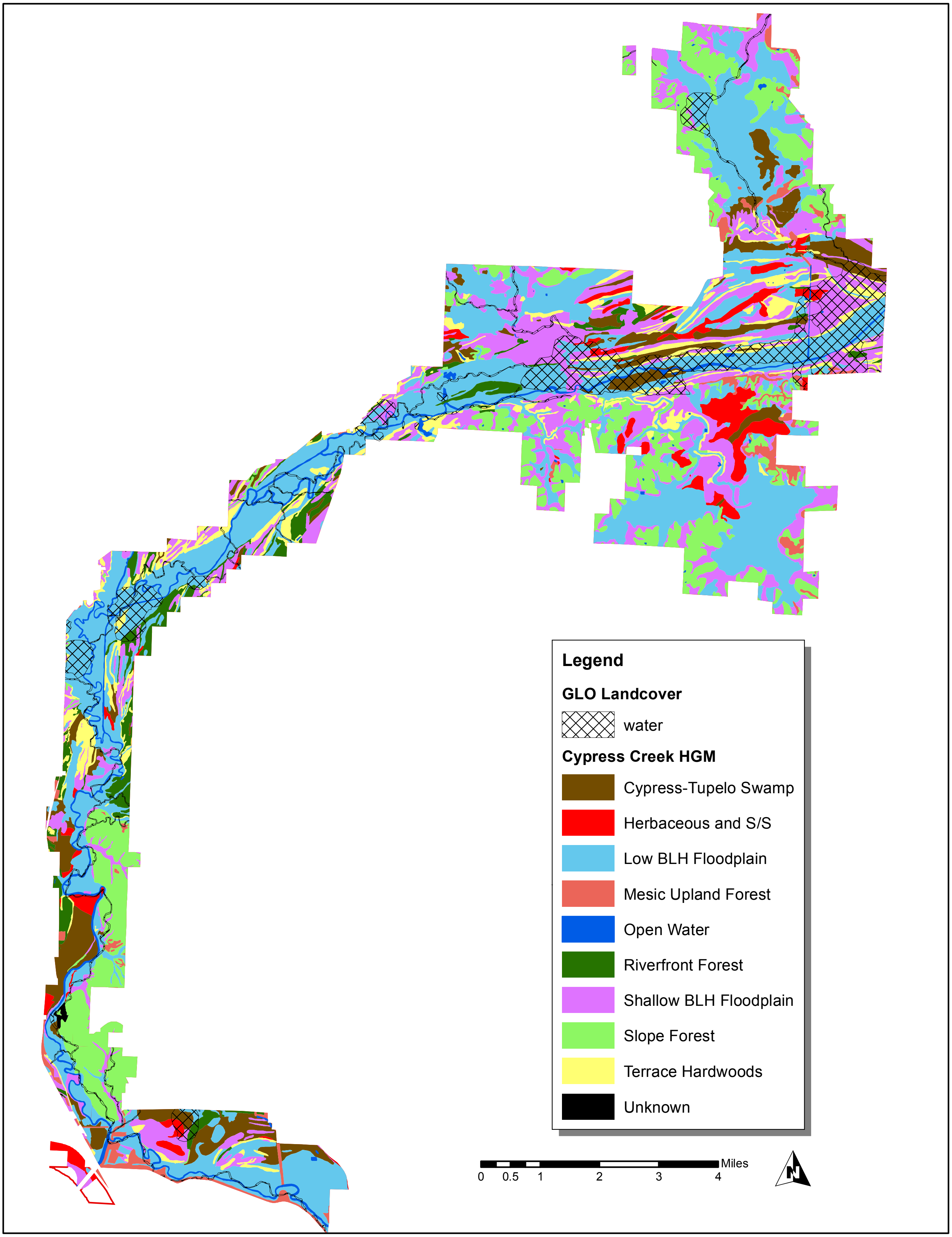


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Figure 21. Hydrogeomorphic map of potential distribution and types of major vegetation communities/habitat types in the Cypress Creek National Wildlife Refuge region (mapped from data in Table 3).

Figure 22. Major lakes, ponds, and swamps in the Cache River Valley in 1804 (from U.S. Government Land Office 1804-1840 and Hutchinson 1984).

flooded annually, sometimes for extended periods over several years.

BLH, terrace hardwood, and slope forests covered about 60% of the historic CRV within the Cypress Creek NWR acquisition boundary (Table 4, Fig. 21). Riverfront forest historically covered < 5% of the Cypress Creek NWR region and was distributed primarily on newly deposited point bar areas along the Ohio and Mississippi Rivers; it also occurred in limited sites in older abandoned channel locations and along basin tributaries. Most of the current "batture" lands inside the mainstem levee of the Mississippi River was historically riverfront forest and occurred on fine sandy loam soils (Klimas 1987). Cypress/tupelo habitats were present in the aforementioned channel and off-channel bottomland lake-type areas and also were present in lower elevation floodplain depressions that had semipermanent flooding regimes. Floodplain BLH forest was widely distributed over 25% of the Cypress Creek NWR region and contained gradients of forest species adapted to short duration and annually dynamic dormant season flooding. Terrace hardwood forest covered the higher elevation old Ohio and Mississippi River terrace surfaces that > 50 year flood recurrence and sandy-loam Entisol soils. Slope forest was present and lower upland slopes and mesic upland forests occupied the extensive higher dissected elevations of the Shawnee Hills. Information from the late 1700s and early 1800s, suggest that no prairie was present in the CRV, and that savannas, if they were present, were restricted to a few higher terrace or upland slope areas that may have burned regularly.

Michael Jeffords

CHANGES TO THE CYPRESS CREEK/CACHE RIVER VALLEY ECOSYSTEM

SETTLEMENT AND EARLY LANDSCAPE CHANGES

A general discussion of the presence and lifestyles of native people in the CRV and Cypress Creek NWR region during the Prehistory and History periods is provided in Kullen and Walitschek (1996). Additional information on post-European settlement of the region is provided in Hutchinson (2000) and in Table 5. Below, are highlights of human occupation and landscape changes up to the early 1900s.

Human occupation of the CRV dates to the Paleoindian Period 8,000 to 12,000 years BP (Meltzer and Smith 1986). At that time human population density was low and people were highly mobile bands that followed herds of game animals that roamed the grassland and parkland margins of the continental ice sheet. Numbers of native people in the CRV and southern Illinois region apparently increased by the end of the Paleoindian Period based on the presence and distribution of Dalton artifacts. During the Early Archaic Period (8,000 to 10,000 BP), hunting continued to be the primary subsistence activity, but some plant gathering also occurred. Early Archaic people had a less mobile lifestyle than in the Paleoindian Period and contended with major climatic shifts that occurred at the end of the Pleistocene. The Middle Archaic Period (5,000 to 8,000 BP) was characterized by more diverse subsistence that included hunting and collecting a wide variety of fish and wildlife species and fruit, nuts, and roots of many local plant species (Jefferies and Lynch 1983). Some camp sites apparently were occupied year-round especially those located on the margins of the many shallow lakes and cypress swamps, such as Horseshoe Lake. Other more distant camps were used seasonally (Robinson 1986). Native populations of people increased substantially during this time, perhaps related to the more prolonged dry Hypsithermal that created the Prairie Peninsula of Missouri and central Illinois and encouraged people to move to the more watered southern Illinois region (Jefferies 1983, Winters 1967). In the Late Archaic Period, continental climate ameliorated and human populations in the CRV apparently decreased as people dispersed to other areas. At this time, egalitarian bands of hunter-gatherer people moved across the landscape following a seasonal subsistence lifestyle.

In the Early Woodland Period (2,200 to 2,600 BP), people in the CRV continued seasonal subsistence and ceramic pottery became used (Butler and Jefferies 1986). Apparently, small groups of people resided in a few year-round sites or seasonal camps for a few years and then moved depending on resource availability. Harvesting and cultivation of certain native plants became common during this period. During the Middle Woodland Period (1,500 to 2,200 BP), Crab Orchard and Havana Tradition cultures occupied the CRV and occupation sites typically were small and often on the banks of the Mississippi and Ohio Rivers (Hargrave and Butler 1993). Interregional trade was common at this time. Settlements were seasonal and included some slash-and-burn horticulture. Common plants cultivated were sunflower (*Helianthus* spp.), marsh elder (*Iva frutescens*), and goosefoot (*Chenopodium* spp.) (Jefferies 1987). Burning and clearing of higher natural levee areas may have facilitated later establishment of giant cane (Brantley and Platt 2001). Human populations increased greatly during the Late Woodland Period (1,100 to 1,500 BP) and interregional trade decreased, which led to more homogenization of ceramic and technology attributes. Hunting and gathering were main subsistence activities, but planting of *Chenopodium*, may grass (*Phalaris caroliniana*), smartweed, squash (*Cucurbita* spp.), and maize (*Zea mays*) also occurred. Hunting at this time included significant use of elk. Occupation sites were

Table 5. Significant events in the history of the Cache River Valley (from Hutchinson 2000).

1,000,000 years BP	Ohio River formed
13,000 years BP	Cache Valley abandoned by Ohio
1673	Joliet & Marquette came down Mississippi River past what is now southern Illinois
1702	Juchereau established tannery at what is now mouth of Post Creek Cutoff
1711	Ford Massac established
1778	George R Clark left Ft. Massac and crossed Cache swamps on way to Kaskaskia
1795	First European settlers located near mouth of Cache River
1803	Land in Cache area purchased from Indians: first permanent settlers in Cache watershed
1804	Government land survey of Cache area began; most of Cache area completed by 1811
1811-12	New Madrid earthquakes impact southern Illinois hydrology and settlement
1816	First water powered mill on Cache, near where White Hill is today
1819	Dams planned for lower part of Cache River to improve navigation
1824	Land claimed and settled in Belknap area
1835	Few roads and towns scattered in region
1838	Cherokee Indians moved across southern Illinois along what became known as "Trail of Tears"
1840	Small patches of timber cleared for homes and farmsteads
1843	Cairo levee completed
1850	Few small sawmills established in southern Illinois; U.S. granted swamp lands to the states
1852	States granted swamp lands to the counties to be sold with proceeds to be used for drainage
1850's	Swamp lands in Cache area sold for as low as 25 cents per acre
1854	First railroad built across southern Illinois, an event significant for timber industry
1861-65	Civil War, an event impacting settlement in southern Illinois, both before and after war
1870	Commercial logging began; Bartleson mill at Oaktown (now Karnak)
1870-72	Big Four Railroad built through Cache area
1870's	First real drainage efforts made in swamps; first ideas of a cutoff to divert Cache water; cutting of best cypress stand began
1879	Steamboats plying waters of the Cache from Mississippi River upstream to Belknap
1880-90	Bell Lumber Co. at Ullin; extensive logging of cypress; Cache used to float logs; log booms across Cache
1888-89	Illinois Central railroad built through Reevesville; fill helped separate water of Bay Creed from Cache
1898	Main Brothers established sawmill along Cache River at Rago; began cutting tupelo timber
1900	Commercial hunting important in Cache area economy
1903	Belknap Drainage District formed; first drainage district on the Cache
1905	First report of a survey of Cache to recommend drainage by means of a cutoff
1905-10	Burlington Railroad built through Heron Pond and Cache area
1911	Cache River Drainage District formed
1912	Bends of Cache near Ullin straightened by local interest
1913	Limestone quarry at White Hill began operation; major Ohio River flood
1913-16	Construction of Post Creek Cutoff, Forman Floodway, Belknap Levee, floodgate through Belknap Levee near Karnak, Reevesville Levee and Cypress Creek Ditch by drainage districts
1916-24	Construction of ditches throughout watershed to transport logs and drain swamps, especially in Big Black Slough area
1920's	Period of extensive land clearing in Cache bottomlands following drainage
1927	Ohio River Lock and dam 53, below Grand Chain, completed; major Ohio River flood with Ohio water flowing through Cache Valley
1930's	Period of channel work and straightening of sections of Lower Cache and Big Creed; mostly a time of great economic depression resulting in much farmland and homes abandoned, a lot of timberland severely cut, extensive erosion with little care for the land, but also the beginning of conservation programs such as the Civilian Conservation Corps and government supported farm programs; great extremes in weather with both very dry and very wet years
1937	Greatest flood in recorded history for the lower Ohio and Cache area; followed by plans for extensive drainage work throughout the floodplain

(Cont'd next page)

Table 5. Continued

1941-45	Second World War; time of booming economy; emphasis on producing food and war materials
1946	Beaver reintroduced into Cache watershed after being gone for more than a hundred years; last log drives on Cache to Main Brothers sawmill at Karnak
1945-65	Period of extensive clearing of bottomland for agriculture; tractors, bulldozers, and other heavy equipment replacing horsepower for farming and logging; great emphasis nationwide on producing grain crops; escalating land prices
1949-52	Belknap Levee (along Forman Floodway) and Reevesville Levee (dividing Cache from Bay Creek waters) improved and raised by Corps of Engineers; floodgates through old Belknap Levee replaced by culverts; Mississippi River Cutoff diverting Lower Cache water constructed by Corp of Engineers
1950-60	Period of bottomland acquisition and land clearing in southern Illinois by out-of-state developers
1953-54	Severe drought years resulting in extensive clearing of dried swamp lands
1960-80	Period of increased drainage activity; Big Creed Drainage District particularly active; dredging and channel work on Lower Cache resulting in drying of swamps and ponds; wildlife and fish populations drastically reduced in region; hunting and fishing use declined
1964-66	First recognition of significant natural areas along Cache by Illinois Natural Preserves Commission
1970	First acquisition of land in Heron Pond area by state for protection of natural features
1972	First bridge constructed by state across Cache river at Heron Pond washed out
1972-74	Scouring of Upper Cache bed progresses upstream to Heron Pond; deepening of lateral ditches and development of underground d piping impacting perched swamps along Upper Cache
1975	First acquisition of land on Cache by the Nature Conservancy
1976-78	Illinois Natural Areas Inventory completed with nearly 60 significant natural areas identified in Cache watershed
1980	Local group of landowners organized to form Lower Cache River to Save the Cache; Lower Cache River Swamp and Section 8 Woods designated as National Natural Landmark
1982	Low water dam (Diehl Dam) constructed by Citizens Committee across Cache south of Perks
1986	State obtains court injunction to stop Big Creek Drainage District from dredging Lower Cache at Diehl Dam Site
1990	US Fish and Wildlife Services establishes Cypress Creed National Wildlife Refuge; also Cache River State Natural Area formed, and The Nature Conservancy establishes Cache Watershed as TNC project; Refuge begins acquiring land; Ducks Unlimite4d helps with early land acquisition and development of moist soil units at Bellrose Reserve

positioned on floodplain terraces, natural levees, and hills (Muller 1978).

The Mississippian Period (400 to 1,100 BP) was the final period of prehistory and represented the apex of cultural and political complexity among native people in southern Illinois (Jefferies 1987). The typical pattern appears to have been settlements located on floodplain terraces along major rivers. These native settlements included earthen mounds, residential dwellings, and palisade walls. Contact between settlements was extensive and trade items were widely exchanged. The major Mississippian settlement near the CRV was the Kincaid site located in the Black Bottom on the Massac-Pope County line near the confluence of the Ohio, Cumberland and Tennessee Rivers. During the Mississippian Period, native people commonly practiced local patch cultivation of at least some grains, such as maize, and native plants that produced seeds used for food.

After the early 1600s, the Mississippian mound-building culture declined and disappeared in many southern Illinois areas, including the CRV. At this time much of the current state of Illinois was under control of the Illiniwek tribes, including the CRV region (Temple 1966). Only one Illini occupation reference is known for the CRV and in 1803, the last remaining part of the Illini Confederacy still in Illinois ceded much of the southern end of Illinois to the U.S. Government at the Treaty of Vincennes (Boggess 1970). Beginning in the 1700s, other tribes periodically occupied southern Illinois including the Mascouten, Cherokee, and Chickasaw people (Alvord 1941, Temple 1966). By the early 1800s, the Shawnee people were present in southern Illinois along with Osage and Creek people. The last native tribal people in the CRV included the Trail of Tears movement of people from southern Appalacia to reservations in Oklahoma in 1838.

The government of France first established a post and tannery near the mouth of the Ohio River in 1702; the post apparently was near the present day Mound City, Illinois (Fortier 1969) and the tannery was near the mouth of the Post Creek Cutoff (Pearson 1989). The French established Fort Ascension, later renamed Fort Massiac in 1757; it was abandoned in 1764 upon notice that peace was reached with the British (Alvord 1941). The British gained control of Illinois after the Seven Years War, but European settlement in the region generally was discouraged to preserve relations with local Indian tribes. Following the American Revolution, the Americans rebuilt Fort Massac; it was a customs house that collected duty on goods carried on the Ohio River from 1799 to 1807. For Massac subsequently was abandoned in 1814.

The earliest European settlement of the CRV region apparently was in Union County in 1803 when Abram Hunsaker and George Woolf moved up the Cache River hunting and fishing (Hutchinson 2000). In 1805, James Conyers and family settled in what is now Pulaski County and the first known settlement along the Cache River was in 1806 by George Hacker. Information on European settlement of Alexander, Union and Pulaski Counties is provided in Perrin (1883) and this information describes the movement of several hundred "squatters" into the CRV region, followed by land application rights and further settlement along the Cache River. GLO survey maps prepared in 1804, indicate relatively extensive settlement along the Cache River. By 1876, extensive residences, farmsteads, schoolhouses, and other developments were present (Fig. 20).

The area now known as Mound City was first settled in 1807, but following an Indian assault, the area was vacated until 1836. This location became an important stopover site for Ohio River boats and it was platted as a town in 1854, with subsequent expansion and inclusion of a Navy Department station. The lower slopes of upland areas in the CRV were settled in the early and mid 1800s and many small towns were largely lumber-oriented; harvested old-growth trees were shipped on the newly built St. Louis and Cairo narrow gauge railroad. The towns of Sandusky (originally called "Helena") and Ullin, Illinois were created around sawmills and the lumber industry. Federal disposition of lands in the CRV occurred in the mid-1800s. Much of the land unsold after 1850 was transferred from the public domain to railroads, via the state of Illinois, through provisions of the Swamp Lands Acts of 1850 and 1860. Lands in the CRV were mainly purchased for speculation of the value of timber resources. By 1870, Pulaski County was second in the state of Illinois in the value of sawn lumber, with most processed trees being bald cypress and oaks from the Cache River floodplain (Telford 1926). An estimate of about 250,000 acres of BLH and cypress was present in southern Illinois, including the CRV, but by 1926, less than 21,000 acres contained commercially viable BLH and baldcypress tracts. The annual harvest of trees during the late 1800s and early 1900s, was from 1.4 to 2.2 million board feet per year (Telford 1926). In 1870, Pulaski County had 17 lumber companies with numerous sawmills, Alexander County had 8 lumber companies, and Union County had 12 companies (Warner and Beers 1876). In the Black Swamp area of the CRV, the Main Brothers lumber operation harvested about two million board feet per year from 1890 to 1910 (Perrin 1883).

The history of agricultural development in the CRV dates to the late 1850s, and cotton was a predominant crop in the Cache River Basin until about 1865, when the end of the Civil War increased competition from more southern markets and decreased the profitability of raising cotton in the north. Following the boom in cotton production, farmers began intensive row crop production, especially in cleared bottomlands. Hill farms were diversified small operations with grain, orchard, and livestock production. Many of the hill farms were severely damaged prior to World War I because of high erosion on cleared formerly timbered hills, and intensive wheat production. The large erosion of the Shawnee Hills contributed large quantities of sediment to the Cache River during this time and effectively silted in many low gradient stream channels and off-channel oxbows and sloughs (see discussion in Sengupta 1995 and data in Hughes 1996).

HYDROLOGICAL AND LATER LANDSCAPE CHANGES

The many hydrological changes to the CRV are chronicled in Hutchinson (2000), Corzine (2007), and other publications. A brief summary of the major changes is provided below:

Land drainage in the CRV and other Upper MAV areas dates to the mid-1800s. At this time, early settlement and drainage was facilitated by passage of the Swamp Land Acts of 1849, 1850, and 1860 and the Graduation Act of 1854 (Hutchinson 2000). These acts moved lands held by the government into railroad and other private ownership and proceeds from the sale of lands were applied to capital drainage improvement including ditches, levees, etc. to make lands usable for agriculture (Kullen and Walitschek 1996). In 1870, a survey of the Post Creek area was made to determine if a river "cut-off" could be constructed to divert water from the Upper Cache River watershed directly to the Ohio River (Unknown Author 1938). No project was built at that time but several small drainage districts were formed in the Cache River Watershed. The first drainage district organized along the Cache River was the Cairo Drainage and Levee District created in 1889. It was followed in 1899 by the establishment of the Big Creek Drainage Districts No. 1 and 2. In 1903, the General Assembly of the state of Illinois passed an act creating the Cache River Drainage Commission, whose duty was to employ engineers and determine feasibility and costs to straighten and dredge the Cache River (Unknown Author 1938). By 1929, nine drainage districts were located in the Cache River watershed. The largest district was the Cache River District that encompassed about 81,000 acres, and by 1929 The Cache River District had built about 100 miles of ditches and numerous other drainage/levee projects including the Foreman Levee and the Post Creek Cutoff.

The Cache River was modified beginning in 1912, when portions of the river channel were dredged from its mouth to about two miles below Ullin (Hutchinson 2000). Construction of the Foreman Floodway initiated water diversion out of the upper Cache River watershed. This floodway was a river channel diversion and straightening operation that reduced the length of the Cache River channel by routing the river from the Foreman vicinity to just east of Karnak, Illinois. At Karnak, the floodway linked up with the Post Creek Cutoff. This Cutoff was dug from 1913 to 1916 and followed a former tributary to the Cache River, called Post Creek. When completed, the Post Creek Cutoff diverted most of the water from the Upper Cache River watershed directly to the Ohio River and bypassed the old lower Cache River channel and route. A partial water flow connection currently exists from the Upper and Lower Cache Rivers through a breach in the Karnak Levee. Eventual deepening and widening of the Post Creek Cutoff ditch also eventually caused some Lower Cache River water to flow backwards into the ditch. It is estimated that the diversion reduced about 60% of natural flows through the Lower Cache River channel (Hutchinson 1984)

After the Post Creek Cutoff was completed, many other drainage projects were initiated in the Cache River watershed. The diversion of water from the Upper Cache Basin reduced water inputs to the Lower Cache River channel and many wetland areas were essentially dewatered. For example, the Big Black Slough was almost completely drained by the mid 1900s (Hutchinson 2000). The diversion coupled with extensive land clearing, tiling of farm fields, cleaning stream channels, and ditches dug in floodplain and hill slope areas that had been cleared and converted to agricultural production concentrated water flows which accelerated flows and contributed to incision and erosion of existing stream channels and banks. Portions of the Upper Cache River were channelized in the 1920s. In 1937-38, Dutchman Creek was altered significantly by channelization, dredging, and levees. A straight ditch was cut from a bend in Cypress Creek directly to the Cache River around 1915, which caused abandonment of the lower portion of the Cypress Creek channel. Big Creek was also channelized and ditched in the 1930s (Demissiee et al. 2001).

At the time the Post Creek Cutoff was being built, a small earthen levee was constructed near Reevesville along the divide between the Cache River and Bay Creek watersheds. This levee was raised and enlarged to create the "Reevesville Levee" during 1949-52 following efforts to prevent major flooding in the Upper MAV such as occurred in the large 1937 flood event (Hutchinson 2000). The Reevesville Levee prevented water flow over the low natural divide in the area and was constructed three feet above the highest Ohio River flood on record, which provided separation of the Bay Creek and Cache River watersheds. A levee was also constructed at that time on the right bank of the Cache River at the Forman Floodway near Belknap and was designed at the same height as the Reevesville Levee. This "Belknap Levee" divided the Upper and Lower Cache and essentially cut the CRV into two watersheds, the Upper and Lower Cache River watersheds of today (Fig. 15). Also during this late 1940s and early 1950s time, a ditch was constructed on the Lower Cache River north of Cairo to divert all of the Lower Cache River discharge upstream of the ditch directly into the Mississippi River. This Mounds Diversion Ditch cut the old natural channel of the Cache into two parts and left the lower part of the Cache to drain into the Ohio River. This Diversion Ditch shortened the Cache River channel outlet distance by several miles and increased the gradient of the lower part of the river. Early dredging also was done in the Cache River between Karnak and Perks and the spoil was place along the south bank where it formed an uneven river levee. This Karnak Levee was improved in 1952 and structures were installed to allow some Lower Cache River flows to backflood into the Post Creek Cutoff. This levee was breached by high flows in 2002 and recent proposals have been made to provide partial reconnection of the Upper and Lower Cache River areas to restore some base flow to lower river segments at this point (Guetersloh 2007; Demissie et al. 2008, 2010). Ditches were dug into the Cache River in many locations to drain floodplain wetlands and sloughs and the Belknap area, in particular was drained with many ditches.

As mentioned earlier, the extensive harvest of forests in the CRV starting in the mid to late 1800s enabled large-scale conversion of forest land to agriculture. The first comprehensive aerial photographs of the Cypress Creek NWR area were taken in 1938, and these photos show that only a narrow corridor of forest remained along the Cache River (Fig. 23). By the 1950s, most of the higher floodplain elevations in the Cypress Creek NWR region had been cleared of forest and converted to agricultural production (Hutchinson 1984, TNC 1999). Severe drought during 1953-54 also stimulated additional ditching and clearing of lower floodplain elevations and many remnant stands of bald cypress and overcup oaks were heavily cut at this time (Hutchinson 2000). Extensive dredging and channel work on the Lower Cache River occurred from 1960 through the 1980s by the Vienna, Cache River, Belknap, and Big Creek Drainage Districts. Landcover maps from 2008 indicate that corn and soybeans were the predominant crops grown in the region (Fig. 24) and that mostly small and highly fragmented remnant floodplain forest tracts remained in the Cypress Creek NWR acquisition boundary area (Figs. 25, 26). Many of the remnant forest tracts have been highly degraded either by infrastructure that has caused prolonged flooding (Corzine 2010), invasion and expansion of early succession species such as silver maple (Battaglia 2007), and disconnection of hydrology (TNC 1995, Hutchinson 2000).

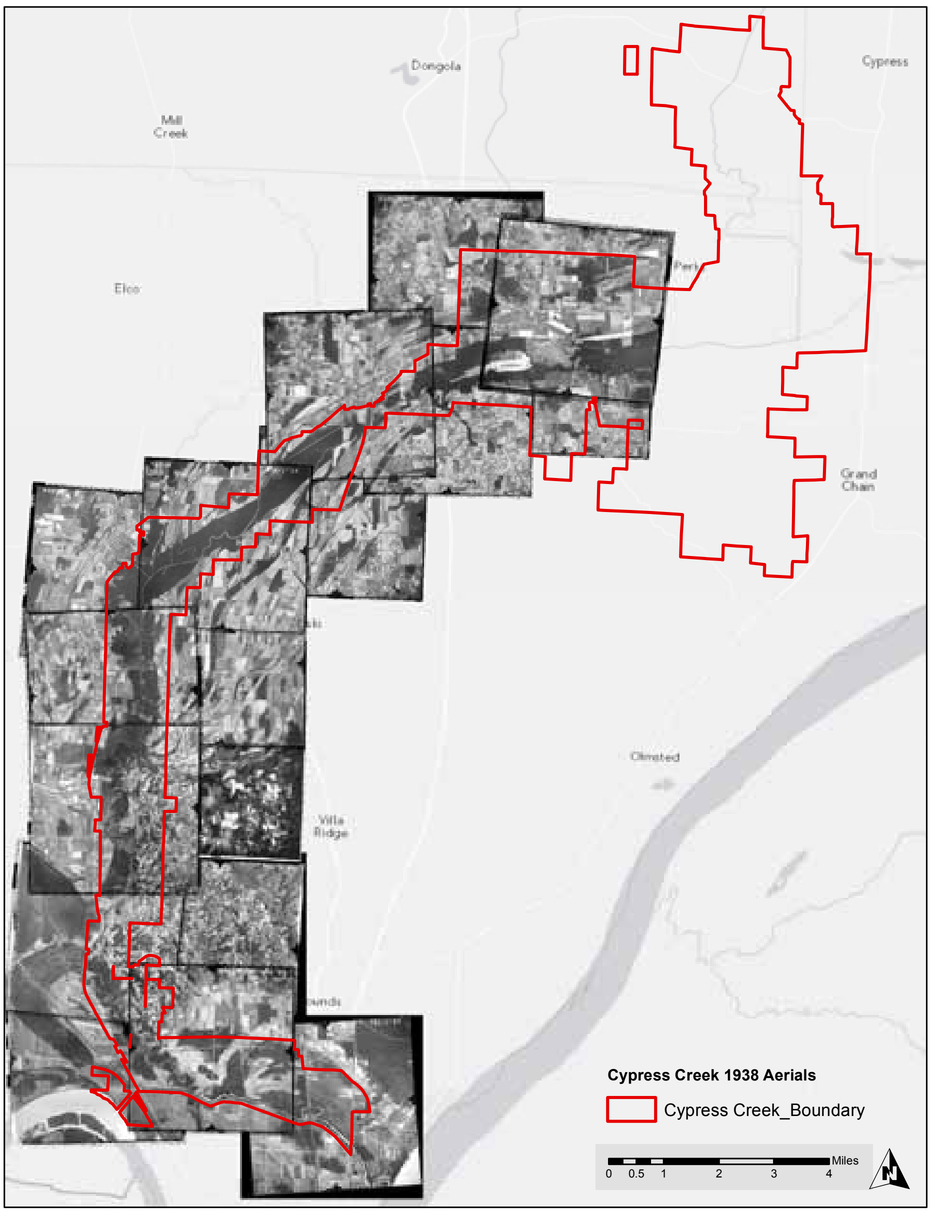

Figure 23. Composition aerial photographs of the Cypress Creek National Wildlife Refuge region in 1938.

Water quality in the CRV apparently has declined over time. The 2012 Environmental Protection Agency (EPA) 303d list of impaired

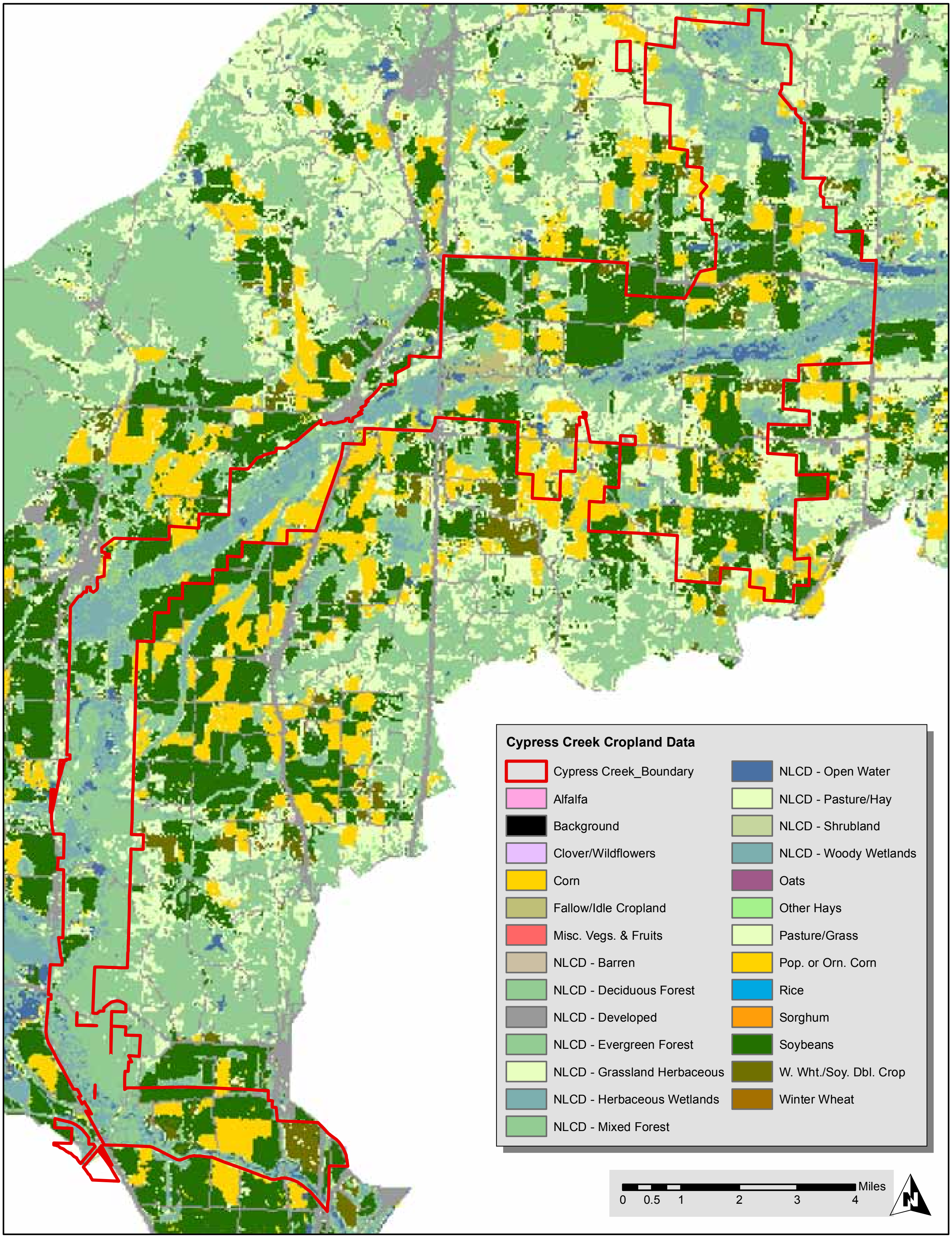

Figure 24. Landcover and agricultural crop types in the Cypress Creek National Wildlife Refuge region in 2008.

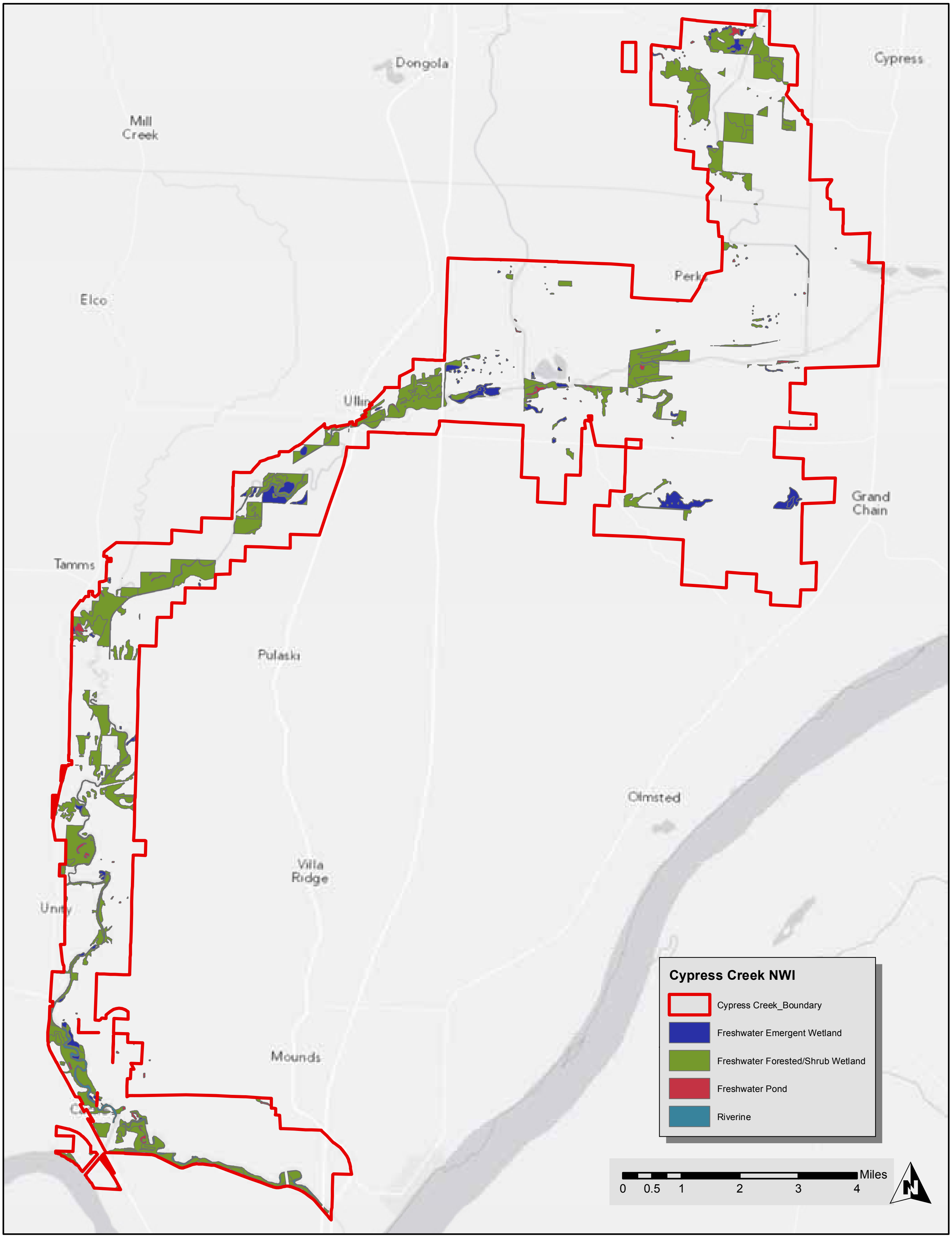

Figure 25. National wetland inventory types present on Cypress Creek National Wildlife Refuge.

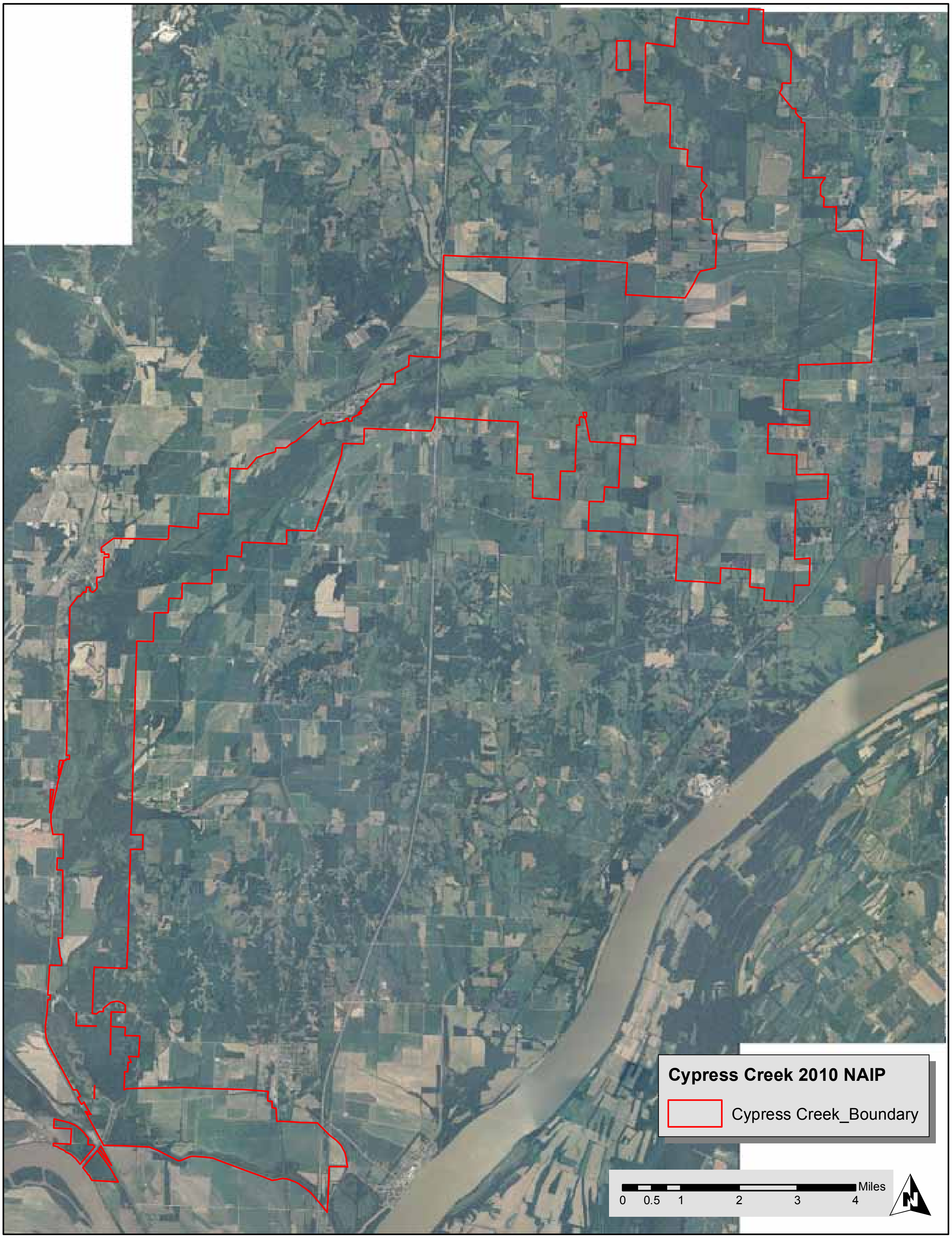

Figure 26. 2010 National Agricultural Inventory Program aerial photograph of the Cypress Creek National Wildlife Refuge region.

waters in Illinois identifies the Cache River reach that flows through Cypress Creek NWR as impaired and "does not support the designated use of aquatic life because of impairments of manganese, low dissolved oxygen (DO), and sedimentation/siltation" (http://www.epa.gov/waters/enviromapper/). The EPA also has issued fish consumption advisories for the area because of high levels of mercury in the Cache River. The Ohio River region bordering southern Illinois also is listed as impaired (as of 2006) by EPA for mercury and PCB. The Mississippi River reach bordering southern Illinois is listed as impaired because of high levels of specific herbicides, DO, coliform bacteria, certain heavy metals, nutrients, PCB, sediment, sulfates, total suspended solids, and pH (based on 2004 levels – see above referenced EPA website). Nutrients are also a well-documented problem throughout the Mississippi River corridor and contribute to hypoxia in the Gulf of Mexico. In addition, emerging contaminant issues such as pharmaceuticals are recognized as a major threat to aquatic species in large river systems.

CONSERVATION EFFORTS IN THE CRV

While the many unique resource values of the CRV were recognized by landowners and conservation interests dating to the early 1900s, it was not until the early 1960s that formal efforts were made to protect select lands (see discussion in Hutchinson 1984). In 1965, the Illinois Nature Preserves Commission took formal action to begin conservation and protection of the Cache River ecosystem and passed a resolution to support public land acquisition and nature preserve designation for the Heron Pond area (Table 4). The first land acquired along the Cache River was in 1969 by the Natural Land Institute and in 1970 the Illinois Department of Conservation acquired the first conservation land tract at Heron Pond. The Nature Conservancy became active in the CRV conservation efforts in 1975, with an initial land acquisition along the Cache River. In 1978, the Illinois Natural Areas Inventory was completed and documented 60 natural areas with state-wide ecological significance within the Cache River watershed. In 1979, a local group of landowners organized to form the Citizens Committee to Save the Cache River and in 1980 the Lower Cache River Swamp Section 8 Woods was designated as a National Natural Landmark by the National Park Service (Corzine 2007). In 1982, a low water dam (Diehl Dam) was constructed to impound water across the Cache River south of Perks in the Lower Cache River Swamp National Natural Landmark. The structural crest for the Diehl Dam was permitted for a 328.4 feet level and the area generally has been managed for this water level since (see discussion in Corzine 2010 and Guetersloh 2012). In 1986 the state of Illinois obtained a court injunction to stop the Big Creek Drainage District from dredging the Lower Cache River at the Diehl Dam site.

Cypress Creek NWR was established in June 1990. At this time the Cache River State Natural Area was formed and The Nature Conservancy established the Cache River watershed as a Bioreserve Project. The Cache River Joint Venture Partnership was formed in 1993 as a cooperative venture by the USFWS, IDNR, TNC, DU, and others. Subsequently, the Cypress Creek NWR and Joint Venture Partnership staff was housed at the Shawnee Community College. In 1991, DU assisted development of the Frank Bellrose Waterfowl Reserve on Cypress Creek NWR. In 1994, wetlands in the Cache River-Cypress Creek region were designated as a "wetlands of international importance" under the Ramsar Convention. By 1996, about 13,000 acres had been acquired for the Cypress Creek NWR, the Cache River State Natural Area contained about 10,500 acres, and TNC had purchased 1,300 acres along the Cache River. Currently, about 16,000 acres have been acquired and now are part of Cypress Creek NWR.

Cypress Creek NWR was established with a land acquisition boundary of 35,320 acres (Fig. 2). Land acquisition for the refuge was and is conducted on a willing seller basis. Land acquisition has been funded through the Land and Water Conservation Fund and various donations. The USFWS has partnered with TNC, DU, and the American Land Conservancy to acquire important land tracts. A chronology of land acquisitions, development projects, and management activities on Cypress Creek NWR is provided in Table 6.

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Table 6. Summary of management acquisitions and developments on Cypress Creek NWR.

Date	Acquisitions and Developments on Cypress Creek NWR	Acres Reforested	Acres Wetland Restoration
1990	June 26: Cypress Creek National Wildlife Refuge established First land acquisition: 322 acres	0	0
1992	USFWS assumes management of Ducks Unlimited Tract that will become Bellrose Waterfowl Reserve 90 acres of moist soil impoundments created at Brushy Bottoms 500 acres reforested	500	90
1993	Bellrose Waterfowl Reserve acquired from Ducks Unlimited. The Nature Conservancy and Ducks Unlimited raise $1 million dollars to complete waterfowl habitat development on 270 acres of the 2100 acre reserve. 300 acres reforested 20 acres of emergent wetlands created on the Kerley Tract.	300	290
1994	260 acres reforested A rock weir structure structure was constructed, just to the west of Highway 37 on IDNR land in order to help reduce sediment deposition in the river channel of the Middle Cache Valley and restore river bed elevations downstream in the Lower Cache Valley. Levee improvements completed at Bellrose Waterfowl Reserve Comprehensive management plan initiated	260	0
1996	Comprehensive Management Plan completed Cache River/Cypress Creek Wetlands designated as a RAMSAR Wetland of International Importance 15 acres of moist soil unit impoundment created at Schierbaum tract. Rollwing Slough restored (20 acres of forested wetland)	0	35
1997	350 acres reforested 150 acres of wetlands restored U.S. Army Corps of Engineers begin Alexander and Pulaski County (A & P) Study focused on sedimentation and incision issues on the Lower Cache River. 40 acres of moist soil unit impoundment created on the Poole Tract	350	190
1998	The west side of the Big Creek Levee is breached in order to allow peak flows to overflow into Refuge Property The west bank of Big Creek at the mouth is angled in order to allow flood water from Big Creek to move downstream, thereby reducing the congestion of water where Big Creek enters the Cache River. U.S. Army Corps of Engineers continues Alexander and Pulaski County Study focused on sedimentation and incision issues on the Lower Cache River.	443	0

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Karen Kyle

RESTORATION
AND MANAGEMENT OPTIONS

GENERAL RESTORATION GOALS

The CRV contains the largest ecological "corridor" of water, wetlands, and floodplain forests in southern Illinois and much of the Upper MAV (USFWS 1996, Hutchinson 2000). The ecological value of the CRV corridor has been recognized nationally and internationally, and significant progress has been made to protect CRV habitats and resources. Landforms, soils, and topography in this ecosystem were created by historical geomorphic and hydrological processes of the Ohio and Mississippi Rivers and plant communities were distributed along gradients of elevation, soils, frequency of flooding, and geomorphologic surfaces (Table 3). Consequently, the historic distribution and juxtaposition of plant communities within the CRV was highly heterogeneous (Fig. 21), and resources within these communities supported diverse and abundant animal species and populations at local, regional, and continental scales (TNC 1995, IDNR 1997).

Restoration and sound ecological management of the CRV is important to sustain and provide critical natural resources and ecological functions and values that effect the Middle Mississippi River, Lower Ohio River, and local Cache River Basins including floodwater transport and storage, nutrient cycling, filtration and transformation of nutrients and contaminants, groundwater recharge, carbon sequestration, quantity and quality of surface waters, fish and wildlife habitat, education, and recreational opportunities. This report supports the many previous protection and restoration plans for the CRV and provides new information about the historical distribution of ecological communities and potential restoration opportunities. It also identifies, and reaffirms previously identified, management options that will be needed to restore and sustain communities and resource values.

Many changes have occurred in the CRV ecosystem from Presettlement to current periods. Some landscape changes have included large and expensive hydrological infrastructure projects that are unlikely to be removed or significantly modified (to facilitate restoration of former hydrological conditions) at least in the foreseeable future. These hydrological infrastructure developments have caused extensive alterations to natural water flow and drainage patterns in the system. These large infrastructure projects coupled with the extensive system-wide drainage ditches, channelized and disconnected natural stream channels, and sediment and erosion issues have effectively created a new "hydrology system" in the region (Hutchinson 2000). Generally, seasonal floodplain hydrology is changed throughout the CRV, including lands within the Cypress Creek NWR acquisition boundary. Large areas of the CRV have been cleared and converted to agriculture. Floodplain bottomland hardwood, floodplain terrace, and slope forest communities have been destroyed at especially high rates. Bottomland lakes have been drained and altered in most CRV ecoregions. River channels and sloughs are greatly reduced in area and connectivity.

Despite the many alterations and degradations to the CRV ecosystem, many opportunities exist to restore at least some parts of this region to conditions at least somewhat similar to the Presettlement period. This report helps understanding of potential restoration opportunities and options in the CRV based on the HGM mapping of the relationships of historic vegetation communities to topography, soil, hydrology, and geomorphology attributes. The "HGM" process used in this report to evaluate ecosystem restoration options based on relative Presettlement conditions allows conservation interests to: 1) identify what communities "belong" in specific locations; 2) determine what ecological processes are needed to restore and sustain specific habitats; 3) determine the types and extent of alterations to historic communities, 4) determine constraints to restoration and management of specific sites, and 5) help identify priorities for restoration of specific habitats and locations.

Generally, this study evaluates restoration options, and subsequent management needs, to improve natural ecosystem processes, functions, and values rather than to manage for specific plant/ animal species. This study focuses primarily on restoration of floodplain ecosystems in the Cypress Creek NWR acquisition boundary, but recognizes the hydrological and ecological connections between the Cache River floodplain and current Ohio and Mississippi River channels and identifies basic landscape and hydrological mechanisms for both the floodplain and main channel that must be considered in restoring the integrity of the entire ecosystem. The strategic conservation basis inherent in the HGM approach used in this study is scientific information on landscape and floodplain ecology that identifies how the "complex" of communities, rather than individual parcels, ultimately provides the diversity and distribution (spatial and temporal) of resources to sustain the productivity, diversity, and integrity of the entire CRV ecosystem.

The many diverse entities and groups interested in conservation of the CRV provide strength in promoting conservation actions, yet each group may have different capabilities and objectives. This study does not address where, or if, the sometimes competing objectives of the interest groups occur, but rather focuses on protection, restoration, and management within the Cypress Creek NWR. Generally, this report provides information to support The National Wildlife Refuge System Improvement Act of 1997, which seeks to ensure that the biological integrity, diversity, and environmental health of the (eco)system (in which a refuge sets) are maintained (USFWS 1999, Meretsky et al. 2006). Administrative policy that guides NWR goals includes mandates for: 1) comprehensive documentation of ecosystem attributes associated with biodiversity conservation, 2) assessment of each refuge's importance across landscape scales, and 3) recognition that restoration of historical processes is critical to achieve goals (Meretsky et al. 2006). Most of the CCP's completed for NWR's to date have highlighted ecological restoration as a primary goal, and choose historic conditions (those prior to substantial human related changes to the landscape) as the benchmark condition (Meretsky et al. 2006). General USFWS policy, under the Improvement Act of 1997, directs managers to assess not only historic conditions, but also "opportunities and limitations to maintaining and restoring" such conditions. Furthermore, USFWS guidance documents for NWR management "favor management that restores or mimics natural ecosystem processes or functions to achieve refuge purpose(s)" (USFWS 2001).

Further, the HGM evaluation process used in this report is not species-based, but rather seeks to identify options to restore and maintain system-based processes, communities, and resources that ultimately will help support local and regional populations of endemic species, both plant and animal, and other ecosystem functions, values, and services. Management of specific land parcels and refuge tracts should identify key resources used and needed by native species, and support special needs for species of concern. The development of specific management strategies for Cypress Creek NWR requires an understanding of the historic context of the CRV relative to what communities naturally occurred there, the seasonal and interannual dynamics and thus availability of community resources, and when and where (or if) species of concern actually were present on the tract and what resources they used. Contemporary management also is based on understanding the regional context of the site, both historic and present, by understanding how, or if, the site historically, or currently, provided dynamic resources to species of concern – and attempt, where possible to continue to provide key resources in naturally occurring times and distribution consistent with meeting life cycle requirements necessary to sustain populations. Consequently, recommendations from the HGM evaluation in this study are system-based first, with the goal of maintaining the ecosystem itself, with the assumption that if the integrity of the system is maintained and/or restored, that key resources for species of concern can/will be accommodated. This approach is consistent with recent recommendations to manage the NWR system to improve the ecological integrity and biodiversity of landscapes in which they set (Fischman and Adamcik 2011). Obviously, some systems are so highly disrupted that all natural processes and communities/resources cannot be restored, and key resources needed by some species may need to be replaced or provided by another, similar habitat or resource. However, the primary objective for refuges should be to attempt to restore the basic features of former functional landscapes.

Many reports have evaluated natural resource problems and potential conservation actions for the CRV. Beginning with the 1965 resolution from the Illinois Nature Preserves Commission, a primary goal for conservation actions in the CRV has been to protect important remnant habitat tracts along the Cache River using fee-title acquisition and other land protection programs such as conservation easements. The Citizens Committee to Save the Cache River was established in 1979 and it promoted a goal "to promote conservation practices in the Cache River Basin and to preserve the natural values of the Cache River" with specific objectives to support: 1) land acquisition funding, 2) habitat protection and enhancement, 3) public hunting and other compatible public uses, 4) compatible development to boost the area economy, 5) information and education programs, 6) monitoring of regional resources, and 7) volunteering

In June 1982, the Governor of Illinois formed an interagency task force to coordinate agency efforts to find solutions to the complex problems in the Cache River Basin. This task force prepared an interagency statement that recommended a plan of action to address:

1. Agricultural Drainage
2. Erosion and Sedimentation
3. Natural Wetlands
4. Aquatic and Riparian Habitat

This statement led to subsequent data collection, analyses, and modeling efforts to determine suitable options in the CRV (Demissie and Bhowmik 1985).

In 1983, the USFWS prepared a "Water Resources Investigation Planning Aid Report" (USFWS 1983) for the USACE and recommended potential solutions to:

1. Reduce clearing and draining of wetland habitats.
2. Decrease sedimentation in the Lower Cache River Swamp National Natural Landmark Area.
3. Reduce entrenchment of the Upper Cache River system and potential drainage of the Little Black Slough-Heron Pond Area.

Specific actions recommended included:

- Reconnecting the Upper and Lower Cache River.
- Preventing sediments from entering tributaries.
- Changing the angle of entry of tributary streams.
- Removal of debris piles and dams in streams.
- Protection and restoration of floodplain wetlands.
- Voluntary and financially-assisted programs to encourage landowners to adopt more sustainable land use practices.

Subsequently, the USACE (1984) prepared an initial evaluation report of the water resources problems of the streams and tributaries in Alexander and Pulaski counties began feasibility studies to address both regional flooding and environmental problems. Management measures included considerations of:

- Flooding at Dogtooth Bend
- Flooding on the Lower Cache River and its tributaries
- Sedimentation in the Lower Cache River Swamp National Natural Landmark Area
- Entrenchment on Post Creek Cutoff and the Upper Cache River
- Interior Drainage at the Cache River Levee
- Flooding in Mounds, Mound City, and the Old Cache River
- Flooding at and above Cairo
- Seepage in the Mississippi and Ohio River Levees

In 1984, a Preservation Plan was prepared by TNC for the Lower Cache River (Hutchinson 1984) and recommended the following:

1. Protect the existing timberland within the Cache River Natural Area (defined as a linear corridor about 9.25 miles long and 0.5 miles wide, along both banks of the Cache River in Pulaski and Johnson counties) from further logging and land clearing activities.
2. Prevent further ditching and levee construction activities that are designed to drain the natural wetlands.
3. Re-establish a permanent vegetative cover on sites of critical erosion throughout the watershed.

4. Stabilize stream banks where gullies, slumping, and landslides are active.

5. Slow the velocity of water runoff and stream flows to reduce erosion and channel scouring.

6. Re-establish and maintain natural water levels in ponds and swamps, with artificial dams if necessary.

7. Encourage landowners to reduce the amount of row crop tillage in the watershed.

Additional evaluation of specific issues related to Cache River Hydrology was undertaken by TNC in 1987 to address protection and restoration of the Lower Cache River Swamp National Natural Landmark site (Guillou and Associates, Inc. 1987).

In 1993, the Cache River Joint Venture Partnership was formed to protect the biological diversity and improve the quality of the human environment in the Cache River Wetlands. Common purposes of partners were to:

- Protect natural habitat and endangered species and to restore and manage habitat for native species.
- Assist in accomplishing the objectives of the North American Waterfowl Management Plan and the Illinois Natural Areas Plan.
- Protect unique areas of ecological and cultural significance
- Protect important or unique natural features.
- Protect and improve the condition and functional integrity of the Cache River ecosystem.

This Joint Venture Partnership helped spawn the establishment of the Cache River Consortium between the IDNR, Illinois Environmental Protection Agency, DU, Illinois Nature Preserves Commission, TNC, U.S. Forest Service, USFWS, NRCS, Southern Illinois University, and the USACE.

Specific projects sponsored by the Joint Venture Partnership have assisted nearly 35,000 acres of land acquisition, 22,000 acres of reforestation, 8,000 acres of wetland restoration, 10 impoundments to reduce upland sediment erosion, and 27 riffle weirs and 13 gully plugs that begin efforts to reconnect the Upper and Lower Cache River segments and to eliminate channel incision and nick-point migration

In 1996, the USFWS prepared a general Conservation Management Plan for the newly established Cypress Creek NWR and recommended programs to protect, restore, and manage about 35,000 acres in the Lower Cache River Basin. Subsequently, many additional land acquisitions, development of water control infrastructure, afforestation, and restoration of natural Cache River and tributary channels has occurred.

Recently, as a key part of efforts to assist restoration of the natural hydrological character of the Cache River system, hydrologic and hydraulic models were developed to determine water levels associated with proposed restoration measures for the CRV (Demissie et al. 2008, 2010). These models evaluated the river hydrology under current conditions and various restoration scenarios and compared results to a reference/base condition. The reference condition is the hydrology of the Lower Cache River controlled on the east end by the Karnak Levee (composed of two 48-inch culverts that prevent flow from Post Creek Cutoff into the Lower Cache River) and on the west end by in-channel weirs located: 1) at Route 37 and 2) west of Long Reach Road, referred to as the Diehl Dam. Conclusions of the first analyses (Demissie et al. 2008) were:

1. The current physical and hydrological conditions exposes the Lower Cache River corridor, especially the eastern portion, including the community of Karnak, to more flooding during major floods, but also improves flood damage for some parts of the area during more frequent 1-, 2-, and 5-year floods.

2. Installing the East Outlet Structure with stop logs and three 72-inch culverts will lower flood elevations from the base condition for the river east of Karnak Bridge Road.

3. Moving the Diehl Dam 2,800 feet under current conditions will increase the area flooded by the 100-year flood by only 8 acres in small increments in the Cache River floodplain and water levels in the stream channel between current and proposed locations will be higher than the current condition during low- and moderate-flow conditions.

4. Partially reconnecting the Lower and Upper Cache Rivers by diverting some flows from the Upper to Lower river areas will not increase flood elevations from the base conditions during major floods but will raise flood elevations during the more frequent 1- and 2-year floods. During low- and moderate-flow conditions, reconnection will create slow-moving

westerly flow in the Lower Cache River and not cause flooding.

Additional modeling (Demissie et al. 2010) confirmed that under current conditions, with a levee breach, major floods in the Upper Cache River and Ohio Rivers would also flood the Lower Cache River. Alternative connection routes were considered to increase the capacity to transport water from the Upper to Lower Cache River and provided a guide on how diverted flows could split flows toward the west and east.

Collectively, the past recommendations for conservation of the CRV including the above mentioned modeling efforts and information gathered in this HGM study suggest that conservation actions throughout the CRV and specifically within the Cypress Creek NWR acquisition boundary should seek to:

1. Protect and sustain existing floodplain areas that have plant communities similar to Presettlement conditions.
2. Maintain and restore the physical and hydrological character of lands within the Cache River Basin.
3. Restore plant and animal communities in appropriate topographic and geomorphic landscape position.
4. Restore the natural topography, physical integrity of water flow patterns, and water regimes where possible.

Attempts to meet these conservation goals will require the following considerations:

1. Protect and sustain existing floodplain areas that have plant communities similar to Presettlement conditions.

All remaining habitats within the CRV are altered to some degree, usually because of changed hydrology; size, connectivity, and interspersion with other habitats; infrequent disturbance and regeneration mechanisms; and influences of adjacent lands, especially agricultural and urban uses. Despite alterations, some areas still retain relatively unchanged composition of vegetation communities compared to Presettlement periods. These remnant patches, especially areas that contain habitats that have been destroyed at high rates and extent such as cypress/tupelo, shallow BLH floodplain forest, bottomland lakes, and terrace hardwood communities deserve priority for protection. Many existing remnant tracts fortunately are now in public ownership and are protected. Future efforts must be made to complete acquisition of the Cypress Creek NWR and protect other lands identified in Cache River Joint Venture Partnership plans. Ownership, however, does not always guarantee restoration of historic communities or the management to sustain specific ecosystem types or complexes of historic habitats. All remnant habitats within the CRV (both protected and not protected) should be carefully evaluated to determine if future protection or changes in management are needed. On private lands, acquisition or securing conservation easements may be possible for some remnant patches. For other non-protected sites, discussions should begin with owners to identify conservation opportunities.

Conservation of existing habitat remnants should go beyond simply purchasing lands or securing deed/management restrictions for certain uses. Sustaining existing habitats also requires protecting or restoring the ecological processes that created, and can sustain, the habitat (e.g., see discussion and references in Hoyer 2005). Often these ecological processes are disturbance events such as flood and drought, fire, and periodic physical disruption of sediments or plant structure (Junk et al. 1989; Sparks et al. 1998; Middleton 1999, 2002; Heitmeyer and Westphall 2007). Unfortunately, most remnant habitats in the CRV have at least some disruption in these ecological "driving" processes and restoration of most habitats will require at least some active management, whether it be manipulation of local and regional water regimes (e.g., periodic drawdown of managed wetlands and restoration of historic dynamic seasonal and flood flows), periodic scouring or disturbance of sediments (e.g., dredging or removal of debris plugs in river channels), disturbance of vegetation (e.g., fire or timber management), or reduction in contaminant inputs from adjacent lands (e.g., construction of silt basins or vegetation buffers along edges of restored bottomland lakes and other floodplain wetlands).

2. Maintain and restore the physical and hydrological character of lands within the Cache River Basin.

Restoration of sustainable plant communities and the basic driving ecological process of seasonally and annually dynamic river flows and overbank and backwater flooding of the Cache River floodplain will require changes in inputs and exports of water, sediments, and nutrients to, and from, surrounding lands, which now primarily are in agricultural production and water systems controlled by extensive major infrastructure developments (see Opperman et al. 2010). Restoring the hydrology of entire Cache River watershed, and the wetland/floodplain systems, within Cypress Creek NWR, will require the restoration of more natural patterns of water entry into, through, and exiting the area. Currently, significant deterrents to restoring regional hydrology are the large infrastructure developments at the Post Creek Cutoff, Forman Floodway; Reevesville, Belknap, and Karnak Levees; in-channel weirs, Lower Cache River Diversion Ditch to the Mississippi River; levees along the Mississippi and Ohio Rivers near the Cache River confluence, and the multiple ditches and channelized sections of the Cache River and its tributaries. Also, regional hydrology is greatly affected by:

- Accelerated surface water runoff, including higher nutrient and sediment loading, from regional agricultural lands.
- Reduced infiltration and recharge of groundwater sources and levels, including saturation zones in floodplains, from agricultural tile drainage, ditches, and channelized sections of streams.
- Altered topography and an extensive system of roads, levees, rail beds, and ditches through the watershed.

While the root causes of these watershed degradations are not under the control of the USFWS, nor can Cypress Creek NWR protect the entire area, the USFWS should continue to encourage private lands programs, and work with regulatory and drainage district entities, to create more sustainable land uses, and restore more natural hydrology, especially water flow and drainage patterns and amounts to the region. Another important, yet mostly uncertain, consideration for future conservation and management strategies at Cypress Creek NWR (and other Upper Midwestern landscapes) is how climate change may alter future hydrological conditions, and subsequently affect regional land uses and vegetation communities. Generally, climate data suggest a trend toward increasing precipitation (number of days with precipitation, mean annual amounts, timing, etc.) in the Upper Midwest (Knox 1984,1999; West Consultants, Inc. 2000) and other models suggest gradual increases in long-term mean temperature regimes. If climate conditions continue to warmer and wetter in the region, more water may enter the Mississippi and Ohio River and land use practices will greatly influence the timing and magnitude of surface water runoff throughout the watersheds. Consequently, engaging conservation programs both on and off the refuge to restore native forestland, reduce surface runoff and groundwater discharges, restore the integrity and storage capacity of small and large historic wetlands, and restore wetland vegetation in the region is imperative. In this light, conservation programs could entail additional conservation easements and restoration of native wetland and upland forest habitats, support for removal of tile drains, restoration of surface sheetwater flow and restoration of historic floodway corridors including allowing large Ohio River floods to enter and be stored in the CRV. These measures ultimately can assist efforts to retain and slow regional surface water runoff that contributes to downstream flooding and nutrient loading issues in the Lower Ohio and Mississippi River systems.

3. Restore communities in appropriate topographic and geomorphic landscape position.

The historic distribution of vegetation communities in the CRV was determined by regional climate, geomorphic surface, elevation, soils, and hydrological regime. The HGM matrix produced in this report (Table 3) provide information about the abiotic features that are associated with each community/habitat type in the CRV ecosystem. Attempts to restore specific habitat types must "match" the physical attributes of a site with requirements of each community, and not try to "force" a specific habitat type to occur on a site where it cannot be sustained.

This study produced a map of the potential distribution of major Presettlement community/habitat types in the Cypress Creek NWR acquisition boundary (Fig. 21). This map broadly identifies locations that have HGM characteristics associated with specific communities. For many habitats, potential restoration sites essentially mirror historical distribution because these are the only locations that have appropriate geomorphology, soils, and landform characteristics associated with the habitat. For example, slope forest was always on alluvial fan and hill slope surfaces with highly erodible soils; bottomland lakes were in abandoned river channel floodplain depressions; and riverfront forest was present on young and highly scoured chute and bar surfaces. Potential restoration sites for other communities such as BLH also basically mirror historic distribution but contemporary potential restoration sites must consider recent and cumulative systemic and local landscape changes. The most obvious change to landscapes that formerly supported BLH communities is altered hydrology, especially alterations in river-floodplain connectivity and changed seasonal and long-term hydroperiod and flood frequency caused by extensive levees, ditches, roads, and topography changes.

Currently, many sites within the CRV now are so highly altered that historic communities cannot be restored on that site. For example, large areas that formerly supported terrace and shallow floodplain BLH now have reduced capability for periodic flooding during wet periods. In other areas, changes have occurred (e.g., lands protected behind large levees) so that historic hydrological or physical disturbance events cannot occur, however the new condition of these sites may be able to support another system community type (e.g., expanded distribution of forest behind mainstem Mississippi River levees). Current landscape features (e.g. levees, ditches, etc.) and flood frequency data can be used to determine potential contemporary floodplain elevations associated with 1-, 2-, 5-, 10-, 20-year etc. flood frequencies throughout the CRV under different water management regimes (e.g., Demissie et al. 2008, 2010) and to understand how current landscapes match the HGM matrix conditions for community establishment. Consequently, the HGM map (Fig. 21) that identifies the general locations of Presettlement communities is an important tool to make system-wide strategic decisions about where to target restoration activities to restore functional distributions of communities on Cypress Creek NWR.

Sustainable restoration of most CRV communities will require a combination of works that includes revegetation (through natural or artificial means), restoring topographical features (e.g., Stratman and Barickman 2000), and recreating basic processes such as flooding, fire, soil disturbance, etc. (Hoyer 2005). The degree that landscapes and processes have been altered will influence the difficulty and cost of both restoring and managing the site in the future. For example, in the CRV, restoration of higher elevation terrace and floodplain BLH may be more difficult than restoring riverfront forest or slope forest. The geomorphic surfaces and fundamental processes that created and maintained shallow floodplain BLH (2-year overbank flood frequency, clay soils, slow backwater dormant season flooding) are more highly destroyed and degraded than the topography and processes that sustained riverfront forest (chute and bar surfaces that remain connected to Mississippi River overflows in batture lands) and slope forest (alluvial fans where upland sheetflow of water drains onto and off of these slopes).

The diversity and heterogeneity of habitats within the CRV enabled the region to provide critical ecological functions and support diverse and abundant animal populations. Many large spatial "gaps" now exist in the historic distributions of CRV communities (see Fig. 26; e.g., the nearly nonexistent remnant terrace BLH forest), remnant habitats are highly fragmented (e.g., small disjunct patches of floodplain forest), seasonal or long-term connectivity to the Ohio and Cache River is reduced or eliminated, and linear habitat and travel corridor connectivity and continuity are reduced or eliminated (e.g., the patchy distribution of BLH in the Lower Cache River floodplain).

Where possible, habitats should be restored where they can: 1) occur in larger patches, 2) connect remnant or other restored patches, 3) provide physical and hydrological connectivity, 4) emulate natural water regimes and flooding dynamics, and 5) fill critical gaps in former distribution patterns of communities (e.g., Noss and Cooperrider 1994, Shafer 1995, Gurnell 1997, Falk et al. 2006, Heitmeyer 2008). This will be difficult in some locations and for some habitats. Despite difficulties, some priority should be given to restoring at least some functional patches of all historic habitats to restore parts of the integrity of the entire CRV.

4. *Restore the natural topography, physical integrity of water flow patterns, and water regimes where possible.*

The annual primary and secondary production of CRV habitats was among the greatest of any ecosystem in North America (e.g., Mitsch et al 1989). This production historically depended on seasonal and long-term flooding regimes and regular fire, wind, and soil disturbances. High primary productivity in the CRV was created by high fertility of alluvial soils (hence the large past conversion to agriculture), a Mediterranean to subtropical climate, and regular inputs of nutrients and sediments from floodwaters of the Ohio, Mississippi, and Cache Rivers and their tributaries. High secondary production in the CRV was sustained by large inputs of nutrients and plant materials from diverse forest and wetland communities (e.g., Wharton et al. 1982). Protecting and restoring both ecological structure and processes in the CRV ultimately is critical to creating and sustaining rich seasonal pulses of resources in this floodplain system and the many potential foods and ecological niches occupied by diverse fish and wildlife species.

Food webs in floodplains are complex and highly seasonal (e.g., Sparks 1995, Heitmeyer et al. 2005). Most animals that historically were abundant in the CRV relied on multiple foods during the year, or they were present only during seasons when specific resources are present (e.g., hard mast, benthic invertebrates, moist-soil seeds, arboreal insects, etc.). A basic adaptation of many of these animals was high mobility and species also relied on connected water flow and habitat patches that enabled them to move throughout the system (e.g. during floods) to exploit resources. In floodplain ecosystems, the connectivity of terrestrial and aquatic habitats is an important aspect of disbursement and distribution of nutrients, water, and energy flow (Middleton 1999). Maintaining or restoring connectivity of water flow and habitats where possible in the CRV is critical for sustaining "traditions" of use by seasonal animal visitors, securing critical resources to meet annual needs of resident species, and reducing predation or other mortality agents. Restoring connectivity of the Upper and Lower Cache River Basins and between the CRV and Ohio and Mississippi Rivers, at least in some locations, is important, yet will be difficult to achieve in many areas where large river infrastructure is present. Nonetheless, opportunities to reestablish some connectivity, and to emulate natural seasonal and long term hydroperiods, should be pursued.

SPECIFIC RESTORATION OPTIONS WITHIN THE CYPRESS CREEK NWR ACQUISITION BOUNDARY AREA

This HGM study provides specific integrated hydrogeomorphic information to identify restoration options within the Cypress Creek NWR acquisition boundary, especially related to the ecosystem attributes that need to be considered and will be required to restore functional communities. The HGM process of identifying the matrix characteristics associated with specific habitats is useful in several contexts. For example, the HGM matrices produced in this report help decide what restoration options are most appropriate if: 1) sites are sought to restore specific habitat types including those that are greatly reduced in area and distribution (e.g., prairie), represent a key "gap" in coverage or connectivity (e.g., terrace and higher elevation BLH), provide key resources for animal species of concern (e.g., giant canebrakes within BLH forests), or are needed for mitigation; or 2) a site becomes available or offered to a resource agency and decisions must be made on what habitats can/should be restored on the site given budget, management, and development constraints. The specific HGM characteristics of the major habitat types within the Cypress Creek NWR acquisition boundary are discussed below:

Prairie and Savanna. — Prairie habitats apparently were absent from the CRV by the early 1800s, based on GLO and other historical information. It seems possible that a few hill slope and higher elevation terrace areas may have had a partial savanna context, but the typically wet climate of the region coupled with surrounding forest probably restricted grass cover and deterred fire that would have sustained grass and savanna communities. Also, by the 1800s, large herbivores, such as elk, were extirpated from the region. If any remnant grassland or savanna occurred, it probably was quickly converted to agriculture following European settlement. Given its uncertain presence, establishment of grassland and savanna at Cypress Creek NWR is not a priority, nor could it likely be sustained without significant artificial management.

Slope Forests. — Slope forest communities bordered many areas of the Cypress Creek NWR acquisition boundary on alluvial fans that originated from the Shawnee Hills to the north and west and the gently sloping parts of the Coastal Plains Hills on the south and east. Slope forests contained unique mixes of species associated with the adjacent upland mesic forests and the downslope higher elevations parts of the CRV floodplain that contained Terrace and BLH forest. Most alluvial fans in the CRV have been cleared for agriculture or are sites of small rural communities. A few remnant slope forest patches are present throughout the CRV and on the edges of Cypress Creek NWR. Restoring slope forests seems possible wherever the topography and soils of alluvial fans, sloping hills and high elevation terraces have not been highly disturbed. In some areas where adjacent stands of upland forest remains on the top part of the hill slopes, natural regeneration and expansion of these upland-type trees onto the slope may occur. In contrast, most of the bottom parts of alluvial fan and hill slopes now are cleared and are in agricultural production. Consequently, reintroduction of terrace hardwood and BLH species back onto at least the bottom parts of alluvial fans and terrace slopes probably will require direct planting.

Sites where slope forest should be restored include:

- alluvial fans, colluvial aprons, and bottoms of hill slopes
- high elevation edges of floodplain terraces
- areas with silt loam soils such as Menfro, Winfield, and Hosner types
- sites with few, or no, roads, ditches and levees that disrupt overland sheetflow of water over the alluvial fan and slope
- sites adjacent to remnant upland forests

Terrace Hardwood Forest. — Terrace hardwood forests historically were confined to the higher elevation remnant terraces within the CRV. These terraces are up to 6-7 feet higher elevation than adjacent floodplain surfaces and historically had a > 20-year flood frequency regime. Many terrace sites are long linear ridges parallel to the Cache River. Forest species on terraces typically are species that have relatively low water tolerance, but that can withstand occasional short dormant season flooding and extended soil saturation. The higher elevation and narrow configuration of terrace hardwoods on floodplain ridge surfaces have made them susceptible to clearing and conversion to agriculture; few terrace hardwood sites remain in the CRV. Efforts to restore terrace hardwood forests will require careful site selection in areas that have:

- floodplain terrace sites with > 5-year year flood frequency
- short duration dormant season flooding
- Lamont, Wheeling, Racoon, and Sciotoville soils

Shallow Floodplain BLH. — Shallow floodplain BLH historically was present in many locations in the Cypress Creek NWR acquisition boundary, especially in the north and east parts of the region near the confluences of Big and Cypress Creeks with the Cache River and along Limekiln Slough (Fig. 21). Unfortunately, this habitat type has been widely destroyed and only small scattered patches remain in the CRV. Shallow BLH occupied an intermediate elevation position between riverfront forests located on chute and bar surfaces next to river channels and low elevation BLH and cypress/tupelo communities in lower, more frequently flooded floodplain depressions. Shallow BLH contained diverse species that are tolerant of dormant season and short duration growing season flooding along with extended soil saturation. Historically, most of these floodplain forests would have been shallowly flooded in most years, with occasional years of complete drying. Occasional prolonged growing season flooding discourages survival and germination of most BLH species, especially pin oak, in these communities. Ridges in old meander scrolls commonly support this forest community. Small openings or "tree gaps" commonly occur in BLH as single trees or small groups of trees die, are broken, or are uprooted and wind-thrown. Data from other BLH areas suggest up to 3-5% of BLH forest area historically was in a tree gap state (e.g., Heitmeyer et al. 2006). These gaps typically have saturated soils, are not shaded, and have silt-clay soils that supported seasonal herbaceous plants until regenerating trees grow to shade the site. In effect, these tree gaps are small "moist-soil" habitats (Fredrickson and Taylor 1982) that added diverse seeds, roots and tubers, plant parts, and invertebrates to the ecosystem. Giant cane also was an important component of BLH habitats occurring on high elevation ridges and old natural river levee surfaces.

Restoration of shallow floodplain BLH is possible on sites that historically had this community, unless current water regimes now are highly altered such as having prolonged growing season flooding because of artificial dams, diversions, or structures such as levees and roads that deter drying of the site during the growing season. Also, some chute and bar surfaces (historically riverfront forest) that now are protected from annual Ohio and Mississippi River overflow and scouring may be restorable to floodplain BLH if soils and elevations are suitable. Ideally, restoration of shallow floodplain BLH could occur throughout Cypress Creek NWR as an integral part of restoring complexes of all historic communities in the CRV region. Floodplain forests historically were important habitat corridors from uplands along the edges of the CRV floodplain to the Ohio and Mississippi Rivers and were conduits for movement and dispersal of water, nutrients, plants, and animals. Afforestation of BLH should carefully plant higher zone less water tolerant species (including elm, oaks, and pecan) on the highest ridges and lower zone wetter species (including overcup oak, cottonwood, ash, sugarberry, and sycamore) in swales. In areas where reforestation is not possible or desired, moist-soil impoundments can be developed to emulate the "tree gap" habitats within these communities.

Generally, the locations that are most suitable for restoring shallow floodplain BLH are:

- point bar surfaces and tributary riparian zones
- relict natural levees and floodplain ridges with 1-2 year flood frequency elevations, preferably with dormant season flooding regimes
- areas with Wakeland, Birds, Ginat, Haymond, Banlic, Hurst, Okaw, Ware, Belknap, and Sharon soils
- sites that can enlarge and connect remnant or restored BLH patches
- sites that have few ditches, levees, or roads that disrupt overland sheetflow of water across the floodplain and that do not cause excessive ponding of water in swales or depressions.

Low BLH. — Low BLH communities historically covered large areas of the Cache River floodplain in the Cypress Creek NWR acquisition boundary and were especially common in the Limekiln Slough area, floodplain depressions in the lower Cypress and Big Creek areas, low river gradient floodplains in the Lower Cache River, and near the historic confluence area of the Cache and Ohio Rivers. These sites historically had annual flooding for up to 6 months annually, and in some extremely wet years, they may have been flooded for most of the year. While tolerant of regular flooding, trees in these habitats such as overcup oak, green ash, and maple cannot survive in permanently flooded areas and require drying periods to oxygenate roots and provide substrates for regeneration.

Restoration of low BLH in some sites may be accomplished simply by planting appropriate tree species. In some areas, hydrology will need to be restored in addition to planting trees so that prolonged growing season flooding is avoided and that up to 3 months of dormant season flooding can occur in most years. Water management in low BLH sites should emulate natural regimes and avoid stagnant and repeated-year flooding.

Where possible, the natural hydrology in all BLH habitats should be restored using the least amount of structural modifications possible and with water management infrastructure designed on natural contours (e.g., King and Fredrickson 1998). Some structural modifications may be needed in highly altered sites such as reconnecting sloughs and swales; filling of ditches; removing levees and roads in low areas; and restoring drains to major outlets in lower elevations. Wherever levees, ditches, and water-control structures are needed to restore and manage BLH hydrology they must be designed carefully so that they do not further fragment existing forests or disrupt sheet and backwater flood flows in the area. Additional levees and water-control structures have the potential to create pockets of standing water for extended periods that cannot be drained easily, thus further degrading BLH composition and functions. New ditches, roads, and levees can further fragment existing BLH forest areas and create entry corridors for exotic species, predators, and cowbirds that can impact local populations of plants and animals.

Appropriate locations to restore low BLH include:

- areas identified as historically being low BLH in Fig. 21
- sites that are inundated for an average of 1-3 months annually
- flood prone areas along tributaries
- areas with Petrolia, Dupo, Birds, Bonnie, and Cape soils

Cypress/Tupelo. — Cypress/tupelo habitats historically were present in older abandoned channels, low gradient portions of the Lower Cache River, larger floodplain swales and former bottomland lakes. Restoration of cypress/tupelo habitat is appropriate and probably can be accomplished relatively easily in many abandoned channels and swales that have been drained or cleared. Restoration of cypress/tupelo communities will require reestablishment of dominant trees and restoring semipermanent water regimes to a site. In some locations, simply planting baldcypress and tupelo seedlings may be sufficient to restore trees. In sites that have been partly drained, regular flooding that persists at least 3 months of most years must be restored. Conversely, some former cypress/tupelo sites have been converted to mostly S/S and open water habitats because water is partly impounded and soils never dry such as in the Lower Cache River Swamp National Natural Landmark Area. In these wet areas, periodic drawdown that expose soils and allow germination of baldcypress and tupelo seedlings will be needed to maintain, regenerate and restore cypress/tupelo habitats (e.g., Middleton 2000; Middleton and McKee 2004, 2005, 2011). Restoration of natural seasonal water flows through the Cache River channel and allowing flood flows to move through the historic channel can assist efforts to restore and sustain cypress/tupelo habitats throughout the CRV.

Restoration of cypress/tupelo communities seems possible where the following combination of factors occurs:

- low elevation depressions, bottomland lakes, floodplain swales, and low gradient channel sections of the Cache River.
- annual, but semipermanent flood frequency zones
- wherever fringes of abandoned channels and swales have been cleared or drained
- Karnak, Propolis and Darwin soils
- in low depressions and water-logged sites some of which may be created by man
- sites where surface water stands 3-9 months of the year on average, and has the capability of being periodically drained during late summer

Riverfront Forest. — Riverfront forest communities historically were present on newly deposited sand-based chute and bar geomorphic surfaces along the Cache, Mississippi, and Ohio Rivers. This forest type contains early succession trees and shrubs that are adapted to extended growing season flooding and occur on coarse-grained soils that have been regularly scoured and reshaped by river flooding. Riverfront forest also occurs on the edges of larger tributary channels and the ends of older abandoned channels where coarse sediments were deposited. Riverfront forests have not been destroyed as extensively as other CRV habitats, partly because of their position next to the Mississippi and Ohio Rivers, the underlying sandy soils, and because much of this remnant habitat is within batture lands on the inside of mainstem levees that remain subject to periodic high flows and deposition/scouring of sediments.

Riverfront forests are not monotypic and they include a diversity of species stratified by elevation and flooding duration. Low elevation sites immediately next to river side channels and chutes contain mostly willow and silver maple along with some shrubs. Higher ridges and the low, newly formed, natural levees along the Mississippi River contain cottonwood, sycamore, silver maple and occasional sugarberry, ash, and pecan. Oaks rarely occur in riverfront forests, but historically some of the highest ridges and older natural levees supported scattered pockets of pin oak.

Restoration of riverfront forest may not be as high of a priority for the CRV simply because larger amounts of the historic distribution of this habitat type remains in place along the Mississippi and Ohio Rivers in southern Illinois (e.g., Heitmeyer 2008). However, in chute and bar areas that have been cleared, reestablishment of this community is desirable and probably can be done relatively easily. Tree species in riverfront forests are aggressive early succession varieties that have high dispersal capabilities and germinate on newly deposited or scoured surfaces. Consequently, riverfront species can quickly populate an area. The challenge in many areas will be to reestablish a diversity of species in riverfront forests and to sustain at least some higher elevation "ridge" species such as cottonwood and pecan. Planting of these higher zone species will require careful site selection.

Restoration of riverfront forest is possible:

- on chute and bar surfaces, especially within batture lands
- on sandy or sandy-loam soils (with silt veneers in swales) including Roby, Ruark, and Alvin types
- within the 1-2 year flood frequency zone for more water tolerant species and on ridges with 2-5 year flood frequencies for less water tolerant species such as pecan
- any cleared area immediately adjacent to the Mississippi and Ohio Rivers

Bottomland Lakes. — Most Bottomland lakes in the CRV were formed from abandoned channels of the Cache, Mississippi, and Ohio Rivers. The largest bottomland lake, Horseshoe Lake, was formed by an abandoned channel of the Ohio or Mississippi River (Saucier 1994). Some abandoned channels, especially newer ones, still retain at least some of their original topography, however, many have been at least partly filled with sediments and have altered hydrology. The 1804 GLO maps (Fig. 22) identify the historic location of bottomland lakes in the Cypress Creek NWR region.

Bottomland lakes in the CRV historically were forest-edge types, usually with cypress/tupelo stands in or adjacent to open water areas. The edges of some lakes probably contained S/S and some herbaceous communities. Consequently, the edges of some lakes probably had at least some emergent and herbaceous vegetation that essentially formed a "marsh" ecosystem. These sites usually are identified by the presence of Mollisol soils such as Jacob, Gorham, and Darwin types. Restoration of bottomland lakes should attempt to restore the appropriate surrounding vegetation that historically occurred at a site. Restoration of forest-edge bottomland lakes should include restoration of BLH along their edges and watersheds. Restoring more natural nutrient and water inputs to bottomland lakes may require restoration of watershed drainages and enhancing river connectivity during flood events. Restoring buffers (preferably at least 300 feet wide) of forest along the edges of these lakes also will be important to filter upland runoff and provide organic material for edge habitats.

Some bottomland lakes may need physical modifications to emulate more natural seasonal and long term water regimes. Most bottomland lakes historically had seasonal water regimes that created maximum flooding in late winter and early spring followed by gradual drying of edges during summer. Summer drawdowns allowed germination of both prairie herbaceous/emergent species and woody encroachment. Currently, most natural or semi-artificial bottomland lakes in the CRV now are seldom drawn down because of recreational uses and public demands for fishing or other activity (e.g., Horseshoe Lake WMA in Alexander County). Eventually, permanent water regimes in bottomland lakes will degrade diversity of plant communities and bind nutrients in emergent or woody vegetation (Klimas 1987b, Harms et al. 1980, Luftus 1994, Xiao et al. 2002, Middleton and McKee 2005). Food webs and fish community structure in bottomland lakes also becomes highly altered in permanent water regimes if invasive plants and animals become present. Generally, management of bottomland lakes should incorporate regular drawdown's that emulate both seasonal and long-term dynamics.

In contrast to more permanent flooding of larger remnant bottomland lakes, smaller natural lakes in the CRV have been at least partly drained and ditched. In these small former lake areas, restoration will require restoring water flow into, and holding capacity of, the basin. Construction of perpendicular "cross-levees" within degraded bottomland lakes usually is not desirable because it disrupts water flow through the old abandoned channel, stagnates water behind levees, often reduces drainage capabilities of the respective pools, and sometimes cuts through soil restrictive layers or veneers of clay and silt in the lake bottom to expose underlying sand deposits that will drain, rather than flood, a former lake (Heitmeyer et al. 2012). Nonetheless, sometimes, levees may be needed to restore hydrology of the site if it simply cannot continue to hold water without them. For example, if a large drainage ditch is present at the end of a former bottomland lake then some type of water-control structure, and perhaps a levee, may be needed to restore the hydrology to the site. Generally, restoration of bottomland lakes should be conducted with the least amount of physical development within the former channel bed as possible and in all cases extensive soil coring should be done to understand depth, permeability, and constituency of abandoned channel sediments.

Restoration of bottomland lakes can occur if:

- hydraulic connectivity with watersheds (direct drainage systems or overland sheetflow) or periodic flooding sources (such as the Cache River or tributary creeks) is restored
- water regimes can be managed for natural dynamics of periodic flooding and at least partial drainage (e.g., USACE 2003b)
- sediments, nutrients, and contaminant inputs are reduced or filtered (e.g., silt basins in watersheds)
- some portions of the bottoms of filled depressions are reshaped to more natural contours
- ditches that drain abandoned channels are removed and cuts that expose lower sandy soils under lakes are filled in with clay or water restrictive materials
- developments along the edges of lakes are reduced or restricted
- fringe vegetation communities are restored to historic conditions (herbaceous or forest types) and buffers of 100-300 feet wide surround the lake. Preferably, wider buffers and entire watershed patches, especially in main drainage input areas, could be restored.

RESTORING COMPLEXES

The key to ultimately improving ecological functions and values in the entire CRV ecosystem will be the restoration of at least some sustainable areas or patches of all habitat types that historically occurred in the region. The Cypress Creek NWR region historically contained significant amounts of all historical communities, except for upland mesic forest. Consequently, the refuge acquisition boundary offers opportunity for restoration of the diverse community types and can be a "core" part of efforts to restore at least partial ecological integrity to the CRV. A productive strategy for ecosystem restoration within Cypress Creek NWR will be to proactively seek sites that offer potential for restoration of habitat complexes that: 1) include habitat types that have been highly destroyed or degraded, 2) fill spatial "gaps" in both habitat type and area , 3) provide physical and ecological connectivity among habitats and patches, and 4) include restoration of the basic ecological processes needed to establish and sustain the respective vegetation or aquatic community. With this in mind, it is recommended that the following items be incorporated into a comprehensive ecosystem restoration and conservation strategy for the CRV and Cypress Creek NWR in particular:

1. Restore at least some functional areas of the most destroyed habitat types, especially terrace hardwood and BLH forest types
2. Expand remnant BLH patches and restore natural hydrological regimes that match natural dynamics of respective low to high elevation BLH communities.
3. Expand and diversify riverfront forest communities to create functional corridors along the Mississippi and Ohio Rivers and include some hard mast tree species on the highest ridges and natural levee elevations.
4. Reconnect natural river and creek channels, including removal or modification of in-channel weirs and flow diversion structures to emulate more natural seasonal and inter-annual dynamics of water levels and flow regimes.
5. Provide the potential for rare, but important, large flood events of the Ohio and Mississippi Rivers to enter and flow though the entire CRV.
6. Create buffers of habitat complexes around wetlands especially bottomland lakes, point bar swales, and backswamp depressions
7. Identify possibilities for restoring hydraulic connectivity between the Upper and Lower Cache River sections, restoring flows in historic river and creek channels, and reconnecting the Cache River and tributary creeks with adjacent floodplains.

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(Frog) Michael Jeffords

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